FEBRUARY 2022

WESTERN OREGON STATE FORESTS HABITAT CONSERVATION PLAN

PUBLIC DRAFT

OREGON
DEPARTMENT OF FORESTRY

PUBLIC DRAFT

WESTERN OREGON STATE FORESTS HABITAT CONSERVATION PLAN

PREPARED FOR:

Oregon Department of Forestry
2600 State Street
Salem, OR 97310
Contact: Cindy Kolomechuk
503.945.7731

PREPARED BY:

ICF
1200 6th Avenue, #1800
Seattle, WA 98101
Contact: Melissa Klungle
360.485.5671

February 2022

ICF. 2022. *Western Oregon State Forests Habitat Conservation Plan*. Public Draft. February. (ICF 00250.19) Seattle, WA. Prepared for Oregon Department of Forestry, Salem, OR.

Cover photographs: Northern spotted owl: ODF File Photo; Oregon slender salamander: David Zippin; Oregon Coast coho salmon: Morgan Bond; Wilson River: ODF File Photo

Contents

Tables

Figures

Acronyms and Abbreviations

AIP	Aquatic Inventory Program
AOP	Annual Operation Planning
ARUs	autonomous recording units
BACI	Before-After-Control-Impact
BLM	U.S. Bureau of Land Management
BMPs	Best Management Practices
BO	biological opinion
BOF	Board of Forestry
BOFL	Board of Forestry Lands
CCAA	Candidate Conservation Agreement with Assurances
CFR	Code of Federal Regulations
cfs	cubic feet per second
CSFL	Common School Forest Lands
CWA	Clean Water Act
DBH	diameter at breast height
DDI	Diameter Diversity Index
DPS	Distinct Population Segment
DSL	Department of State Lands
eDNA	environmental DNA
EFH	essential fish habitat
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
ERZ	Equipment Restriction Zone
ESA	Endangered Species Act
ESMP	Endangered Species Management Plan
ESU	Evolutionary Significant Unit
FEMAT	Forest Ecosystem Management Assessment Team
FIA	Forest Inventory and Analysis
FMP	Forest Management Plan
FPA	Forest Practices Act
GBIF	Global Biodiversity Information Facility
GIS	geographic information system
HCAs	Habitat Conservation Areas
HCP Handbook	Habitat Conservation Planning and Incidental Take Permit Processing Handbook
HCP	Habitat Conservation Plan
HCP	Western Oregon State Forests Habitat Conservation Plan
HCP/NCCP or Plan	Western Placer County Habitat Conservation Plan and Natural Community Conservation Plan
HE	high energy
HSI	Habitat Suitability Index

HUC	hydrologic unit code
IP	Implementation Planning
ITPs	incidental take permits
LiDar	light detection and ranging
LSRs	Late Successional Reserves
Magnuson-Stevens Act	Magnuson-Stevens Fishery Conservation and Management Act
MBF	1,000 board feet
NEPA	National Environmental Policy Act
NOAA	National Oceanic and Atmospheric Administration
NTU	Nephelometric Turbidity Units
NWFP	Northwest Forest Plan
NWI	National Wetland Inventory
OAR	Oregon Administrative Rules
ODF	Oregon Department of Forestry
ODFW	Oregon Department of Fish and Wildlife
OHVs	off-highway vehicles
ORS	Oregon Revised Statutes
PCT	precommercial thinning
PDFT	potential debris flow tracks
PPZ	Process Protection Zone
RCAs	Riparian Conservation Areas
SAPs	Strategic Action Plans
SDI	Stand Density Index
SE	standard error
SHA	Safe Harbor Agreements
SLI	Stand Level Inventory
the Services	U.S. Fish and Wildlife Service (USFWS) and National Oceanic and Atmospheric Administration (NOAA)
TPA	trees per acre
U.S.C.	United States Code
UAS	Unmanned Aircraft Systems
USC	U.S. Code
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service

Executive Summary

The Western Oregon State Forests Habitat Conservation Plan (HCP) has been developed by the Oregon Department of Forestry (ODF) to support applications for federal Endangered Species Act (ESA) incidental take permits from the National Oceanic and Atmospheric Administration (NOAA) Fisheries and the U.S. Fish and Wildlife Service (USFWS). This HCP describes potential effects on a suite of 17 federally listed species potentially at-risk from ODF's forest management activities, including timber harvest, stand management, habitat restoration, and construction and maintenance of recreation facilities over a 70-year permit term. The HCP also describes a conservation strategy to avoid, minimize, and mitigate any effects from those activities during that timeframe.

This Executive Summary provides an overview of the HCP, including the following:

1. Overview of the Planning Process
2. Scope of the HCP
3. Conservation Strategy
4. Implementation, Cost, and Funding

ES.1 Overview of the Planning Process

In November 2018 the Oregon Board of Forestry (BOF) unanimously directed ODF staff to begin work on an HCP. The HCP would enable ODF to comply with the federal ESA when conducting land management activities on State Forests west of the Cascade Mountains. The HCP would also facilitate permit applications to the USFWS and NOAA Fisheries for programmatic take[1] authorization for those activities (covered activities) and for select species (covered species) over a 70-year permit term. Between November 2018 and March 2021 ODF staff completed this administrative draft HCP in coordination with state and federal environmental and wildlife agencies, and with engagement from counties, Tribal governments, members of the public, and representatives from key stakeholder sectors.

Throughout the development of the HCP, ODF provided updates and briefings to the BOF to help them assess the ability of a potential HCP to meet ODF's Endangered Species Act obligations and its Greatest Permanent Value mandate, which encompasses economic, conservation, and social outcomes. ODF implemented a structured public engagement process to facilitate an inclusive information sharing and feedback process. BOF checkpoints were built into this process where the BOF provided direction to ODF on the approach to the HCP and the strategy for public engagement. In October 2020, the BOF unanimously voted to direct ODF staff complete the administrative draft HCP and the National Environmental Policy Act (NEPA) assessment of the HCP. After the NEPA process and federal permit decisions, the BOF will determine whether to implement the incidental take permits associated with the r Western Oregon State Forests HCP.

[1] *Taking* is defined as, "to harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct" (16 U.S. Code [USC] 1532). *Harm* is further defined as including "significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering" (50 Code of Federal Regulations [CFR] 17.3).

ES.1.1 HCP Program Goals

ODF staff developed a set of six broad program goals for the HCP in collaboration with the Steering Committee. These program goals were used as a foundation to develop the biological goals and objectives and the conservation strategy described in Chapter 4, *Conservation Strategy*:

- Meet the regulatory requirements of the federal and state ESA through an approved HCP, using a multi-species approach to managing forest ecosystems across the landscape, in accordance with formal consultation with the Services under Section 7 and Section 10 of the ESA.
- Ensure active and sustainable management of state forest lands under a Western Oregon HCP and an associated Forest Management Plan designed to meet the social, economic, and environmental goals articulated in the Greatest Permanent Value Rule.
- Increase operational certainty, cost savings, and predictability of revenue generation (including related timber harvest, jobs, and other economic values) using the HCP as a programmatic approach to comply with the federal and state ESA over the permit term.
- Increase certainty for long-term persistence of covered wildlife species by protecting and maintaining high-quality habitats, conducting habitat enhancement activities in areas of lower quality habitat, and mitigating the impacts of covered activities on covered species.
- Advance partnerships and engagement related to management approaches and outcomes associated with, but not limited to, revenue generation and economic outcomes, conservation, forest conditions and health, tribal interests and traditional cultural uses, research, monitoring, education, recreation, and the equitable enjoyment of benefits that state public forests provide.
- Use science-based forestry to promote conditions that create sustainable, productive forests that are resilient to large fires, climate change impacts, and other disturbance events. Use an adaptive management approach to address uncertainty and change over time.

ES.1.2 HCP Planning Structure

The HCP was led by ODF and advised by a team of policy and technical experts who were organized into a Steering Committee and Scoping Team. The final decisions on the contents of the HCP were made by ODF. All other participants were engaged to provide technical and policy advice. Planning participants provided valuable input during the planning process, as described below.

ES.1.2.1 Steering Committee

The HCP Steering Committee consists of state and federal government agency representatives. Members worked together to provide advice on how ODF can achieve a mutually acceptable outcome that satisfies, to the greatest degree possible, the interests of all participants, while still meeting all regulatory requirements of the ESA. The role of the Steering Committee was to provide overall guidance for the HCP process and to provide direction and support to the Scoping Team. The Steering Committee met approximately bi-monthly during HCP development.

Member agencies of the Steering Committee are discussed in Chapter 1, *Introduction,* and include:

- Oregon Department of Forestry (convener)
- Oregon Department of State Lands

- Oregon Department of Environmental Quality
- Oregon Department of Fish and Wildlife
- Oregon State University
- U.S. Fish and Wildlife Service
- National Oceanic and Atmospheric Administration Fisheries

ES.1.2.2 Scoping Team

The HCP Scoping Team was composed of terrestrial and aquatic biologists and technical specialists from state and federal agencies. The role of the Scoping Team was to provide technical expertise and to develop technical recommendations for the Steering Committee to consider when advising ODF in the development of a potential HCP. The Scoping Team met twice monthly during HCP development. Member agencies of the Scoping Team were the same as those for the Steering Committee. Technical experts from Oregon State University provided review of key data and work products.

The Scoping Team provided input, guidance, and feedback on development of all aspects of the HCP. This important feedback included species to be covered, how to analyze effects on those species, and the type and extent of conservation actions described in the HCP. The Scoping Team also reviewed early drafts of the HCP to support ODF's development of a legally compliant, scientifically sound, and operationally feasible planning document.

ES.1.2.3 Public Engagement

During the development of the HCP, ODF hosted public informational meetings prior to each BOF meeting to provide an opportunity for the counties, Tribes, public, stakeholders, department staff, and consultants to share feedback, provide information regarding HCP development, and explore ideas for improvement. Follow-up meetings with these entities were also scheduled upon request to further discuss the information presented during the meetings open to the public and to provide more detail on the components of the HCP.

ES.2 Scope of the HCP

This section provides a summary of the scope of the HCP, including the location of the permit area and plan area, the activities and species covered by the HCP, and the duration of the permit requested.

ES.2.1 Permit Area and Plan Area

The location where the HCP and ESA permit coverage would apply must be defined and is called the *permit area*. The permit area in this HCP is defined as the area where incidental take is covered under the incidental take permit, which includes the portion of the plan area that ODF currently controls and where all covered activities will occur and where conservation measures will apply. This includes all Board of Forestry Lands acquired pursuant to Oregon Revised Statutes (ORS) Chapter 530 and Common School Forest lands owned by the Oregon Department of State Lands but managed by ODF pursuant to ORS 530.490 through 530.520. Collectively these lands encompass 639,489 acres. An 84,206-acre buffer surrounding parts of the permit area has been identified where ODF has the potential to acquire or exchange lands with neighboring landowners in the future. An additional 10,000 acres in the vicinity of ODF lands have not yet been identified in Land Acquisition and Exchange Plans but may be acquired by ODF. Following a land exchange, the HCP and permits would apply to any lands newly acquired by ODF, and permits would no longer apply to any lands that ODF no longer managed. The *plan area* encompasses the permit area plus this additional 94,206-acre buffer. Figure ES-1 shows the plan area and permit area for the Western Oregon State Forests HCP. Additional details on how the plan area and permit area were defined are provided in Chapter 1.

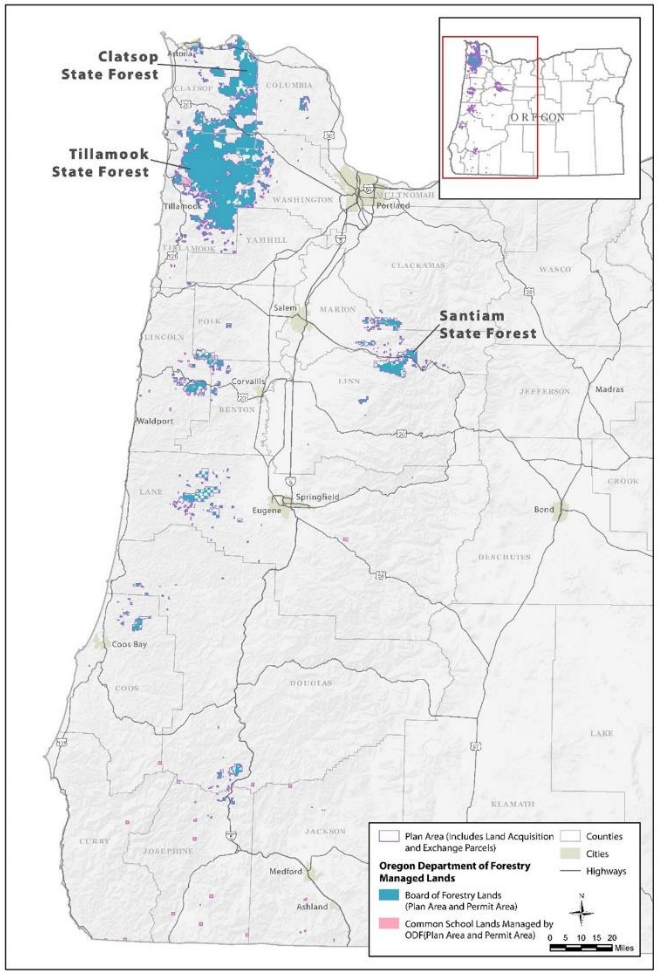
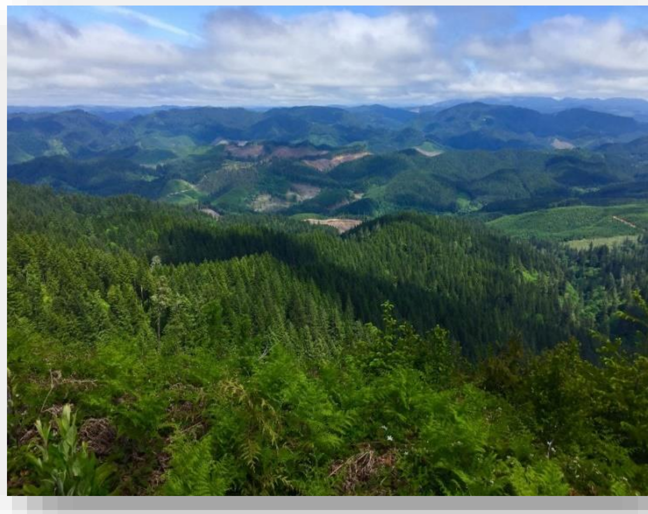


Figure ES-1. Plan Area and Permit Area

ES.2.2 Covered Activities

This HCP and permits are proposed to cover and provide incidental take authorization for ODF's land management activities in the permit area, other activities that ODF has jurisdiction over, and the activities needed to carry out the conservation strategy. Covered activities must be "under the control" of the permit holder and occur within the permit term and in the permit area in order to receive coverage. Broad categories of the covered activities are listed below; detailed descriptions of the selection process and all covered activities are provided in Chapter 3, *Covered Activities*.



Covered activity categories include:

- Timber Harvest
- Stand Management
- Road System Management
- Recreation Infrastructure Construction and Maintenance
- HCP Conservation Actions

ES.2.3 Covered Species

Covered species are those species for which USFWS and NOAA Fisheries will provide take authorization to ODF to authorize take that may occur during the implementation of covered activities. Species were selected for coverage if all four of the following criteria were met:

1. The species range overlaps with the permit area.
2. The species is currently listed under the ESA or is likely to become listed during the permit term.
3. The species is likely to be impacted by covered activities.
4. There is enough data available to adequately assess the potential for covered activities to impact the species and to create a conservation strategy for the species that will adequately avoid, minimize, and mitigate the impact of any taking of the species that occurs from covered activities.

There are 17 species proposed for coverage in the draft HCP: 10 fish, 2 birds, 3 salamanders, and 2 mammals (Table ES-1).

Table ES-1. Proposed Covered Species

Species	Listing Status: Federal	Listing Status: State	Federal Agency Jurisdiction
Fish			
Oregon Coast coho (*Oncorhynchus kisutch*)	FT	FT	NOAA Fisheries
Oregon Coast spring-run chinook (*O. tshawytscha*)	UR	UR	NOAA Fisheries
Lower Columbia River chinook (*O. tshawytscha*)	FT	--	NOAA Fisheries
Lower Columbia River coho (*O. kisutch*)	FT	SE	NOAA Fisheries
Columbia River chum (*O. keta*)	FT	--	NOAA Fisheries
Upper Willamette River spring-run chinook (*O. tshawytscha*)	FT	--	NOAA Fisheries
Upper Willamette River winter steelhead (*O. mykiss*)	FT	--	NOAA Fisheries
Southern Oregon/Northern California Coast coho (*O. kisutch*)	FT	--	NOAA Fisheries
Southern Oregon/Northern California Coastal spring-run chinook (*O. tshawytscha*)	UR	UR	NOAA Fisheries
Eulachon (*Thaleichthys pacificus*)	FT	--	NOAA Fisheries
Birds			
Northern spotted owl (*Strix occidentalis caurina*)	FT	ST	USFWS
Marbled murrelet (*Brachyramphus marmoratus*)	FT	SE	USFWS
Amphibians			
Oregon slender salamander (*Batrachoseps wrighti*)	--	ST	USFWS
Columbia torrent salamander (*Rhyacotriton kezeri*)	UR	ST	USFWS
Cascade torrent salamander (*R. cascadae*)	UR	--	USFWS
Mammals			
Coastal marten (*Martes caurina*) [a]	T	--	USFWS
Red tree vole, North Oregon Coast population (*Arborimus longicaudus*) [b]	--	--	USFWS

SE = State Endangered; ST = State Threatened; FT = Federal Threatened; UR = Under Review

[a] The full name of the listed entity is Pacific marten, Coastal Distinct Population Segment.

[b] ODF is proposing the red tree vole for coverage under this HCP despite red tree vole not being listed as endangered or threatened under the ESA. In 2019, the USFWS determined that red tree vole did not warrant listing as endangered or threatened (84 *Federal Regulations* 69707). The Center for Biological Diversity is currently seeking an

order to vacate USFWS's not-warranted finding and remand the matter to the Service to issue a new determination regarding whether red tree vole warrants protection under the ESA as an endangered or threatened species. ODF finds the likelihood of future listing of red tree vole to be high enough to propose the species for coverage under this HCP.

ES.2.4 Permit Term

The HCP and associated permits are proposed to have concurrent terms of 70 years. The 70-year permit term was selected to balance the risks associated with shorter and longer terms. A term of less than 70 years would limit ODF's ability to conduct long-term forest management practices, which are typically conducted on roughly 10-year management cycles. A term of more than 70 years would increase the risk that unpredictable ecological changes could adversely affect the status of the covered species in the plan area and increases the uncertainty associated with modeling those changes. Both of these items could compromise the conservation strategy. The level of certainty associated with a 70-year term enables ODF to make long-term plans and investments with the assurance that they will be able to continue managing the forest in a manner that complies with ESA requirements. In addition, the monitoring and adaptive strategy detailed in Chapter 6, *Monitoring and Adaptive Management,* outlines how implementation of the conservation strategy will be monitored and reported, and how changes will be made, if needed, in response to monitoring results, to manage in response to change. This will further allow ODF to manage uncertainty that may arise during the permit term.

ES.3 Conservation Strategy

The conservation strategy includes measures to avoid, minimize, and mitigate the impact of the taking on covered species from covered activities. The conservation strategy relies on (1) implementing best management practices when conducting covered activities to minimize effects on covered species, (2) designating areas on the landscape that will be managed for the benefit of covered species, and (3) creating a Conservation Fund that would be used to implement species and habitat management activities that would directly benefit covered species during the permit term.

The conservation strategy is best summarized by the biological goals and objectives for each covered species. Biological goals and objectives state the intentions of the HCP, and the measurable biological objectives become the threshold by which the success of the HCP will be judged. Biological goals and objectives for covered fish and aquatic salamanders focus on continual improvement of aquatic habitat quality. Specifically, biological objectives state intentions for improving instream habitat quality through the recruitment of large woody debris, execution of stream enhancement projects, removal of barriers to fish movement, and protection against sediment and stream temperature increase. Biological goals and objectives for terrestrial covered species focus on increasing habitat quality and quantity during the permit term. Commitments are made to initially conserve and maintain habitat that is currently suitable or occupied and then increase the total acres of habitat through enhancement, including both passive and active management.

Twelve conservation actions are described in the draft HCP that will be used to achieve the biological goals and objectives:

- Conservation Action 1: Establish Riparian Conservation Areas
- Conservation Action 2: Riparian Equipment Restriction Zone

- Conservation Action 3: Stream Enhancement
- Conservation Action 4: Remove or Modify Artificial Fish-Passage Barriers
- Conservation Action 5: Standards for Road Improvement and Vacating
- Conservation Action 6: Establish Habitat Conservation Areas
- Conservation Action 7: Manage Habitat Conservation Areas
- Conservation Action 8: Conservation Actions Outside Habitat Conservation Areas and Riparian Conservation Areas
- Conservation Action 9: Strategic Terrestrial Species Conservation Actions
- Conservation Action 10: Operational Restrictions to Minimize Effects on Covered Species
- Conservation Action 11: Road and Trail Construction and Management Measures
- Conservation Action 12: Restrictions on Recreational Facilities

ES.3.1 Aquatic Conservation Strategy

The centerpiece of the aquatic conservation strategy is the establishment of Riparian Conservation Areas (RCAs), which are stream buffers designed to protect against negative effects from increased sedimentation and stream temperature. RCAs are further designed to maximize the amount of large woody debris that could be naturally recruited into aquatic systems from streamside sources and from debris flows in the upper watersheds. RCAs vary by stream type, including stream size, seasonality, and whether it is a fish-bearing stream. Approximately 35,000 acres are proposed to be designated as RCAs across the permit area. There would be no forest management in RCAs. Activities would be limited to only essential activities needed to implement covered activities (e.g., road construction and maintenance) or to complete stream enhancement actions, including placement of large woody debris, channel restoration, and fish barrier removal. For additional details on covered activity occurrence within RCAs see the Frequency Table in Appendix E. Additional conservation actions create operational and design standards for roads, equipment use, and the timing of activities to minimize effects on covered species and the stream environment. Tables ES-2 and ES-3 summarize the RCAs by stream type and illustrate their location in northwest Oregon in Figure ES-2. For additional details on these and other aquatic conservation actions, see Chapter 4, *Conservation Strategy*, Conservation Actions 1 through 5.

Table ES-2. Buffer Widths (Horizontal Distance) for All Type F and Large and Medium Type N Streams

	Minimum Management Area Width (feet)[a]	
Stream Type	**Type F**	**Type N**
Large	120	120
Medium	120	120
Small	120	See Table ES-3
Seasonal[b]	120	See Table ES-3

[a] Distance will be measured horizontally, which results in the implementation of larger buffers in steeper terrain.

[b] Seasonal: A stream that does not have surface flow after July 15.

Table ES-3. Minimum Riparian Conservation Area Widths (Horizontal Distance) for Small Perennial and Seasonal Type N Streams

	Minimum Management Area Width (feet)[a]	
Stream Type	**Within 500-foot Process Zone**	**Upstream of 500-foot Process Zone**
Perennial small Type N	120	35
Potential debris flow track (Seasonal Type N)[b]	50	35
High energy (Seasonal Type N)[c]	50	35
Seasonal other (Type N)[d]	0[e]	0[e]

[a] Distance will be measured horizontally, which results in the implementation of larger buffers in steeper terrain.

[b] Potential debris flow tracks: Reaches on seasonal Type N streams that have the potential to deliver wood to a Type F stream.

[c] High Energy: Reaches on seasonal Type N streams that have the potential to deliver wood and sediment to a Type F stream during a high-flow event.

[d] Seasonal: A stream that does not have surface flow after July 15.

[e] A 35-foot equipment restriction zone will apply to these streams.

ES.3.2 Terrestrial Conservation Strategy

The centerpiece of the terrestrial conservation strategy is the establishment of Habitat Conservation Areas (HCAs), which are designed to conserve, maintain, and enhance habitat for the terrestrial covered species. HCAs comprise approximately 275,000 acres across 262 units to support the persistence of northern spotted owl, marbled murrelet, red tree vole, Oregon slender salamander, and coastal marten. These HCAs (and the portion of RCAs within them) represent 43% of the permit area that will be conserved, maintained, and enhanced to provide habitat for covered species throughout the permit term. The size of HCAs varies widely, due to land ownership patterns, habitat availability, and covered species needs. In locations where ODF land ownership includes large blocks (e.g., north coast), HCAs are generally larger (Figure ES-2). In locations where ODF land ownership is more scattered and intermixed with private and federal landowners, the HCAs are generally smaller. Smaller HCAs are found throughout the permit area, typically where ODF managed lands are smaller and more scattered. These smaller HCAs are designated to protect and enhance known species occurrence and provide connectivity between federal lands within smaller patchwork ownership patterns.

The HCAs are designed to:

- Conserve, maintain, and enhance existing habitat for terrestrial covered species in the permit area over the permit term.
- Improve low-quality habitat for the covered species and develop new habitat in HCAs, where necessary and where such treatments can be implemented effectively and efficiently. Treatments will include expanding and connecting existing habitat to improve landscape-level habitat function.
- Limit management activities in HCAs to those necessary and prudent to improve habitat quantity and quality over the permit term.

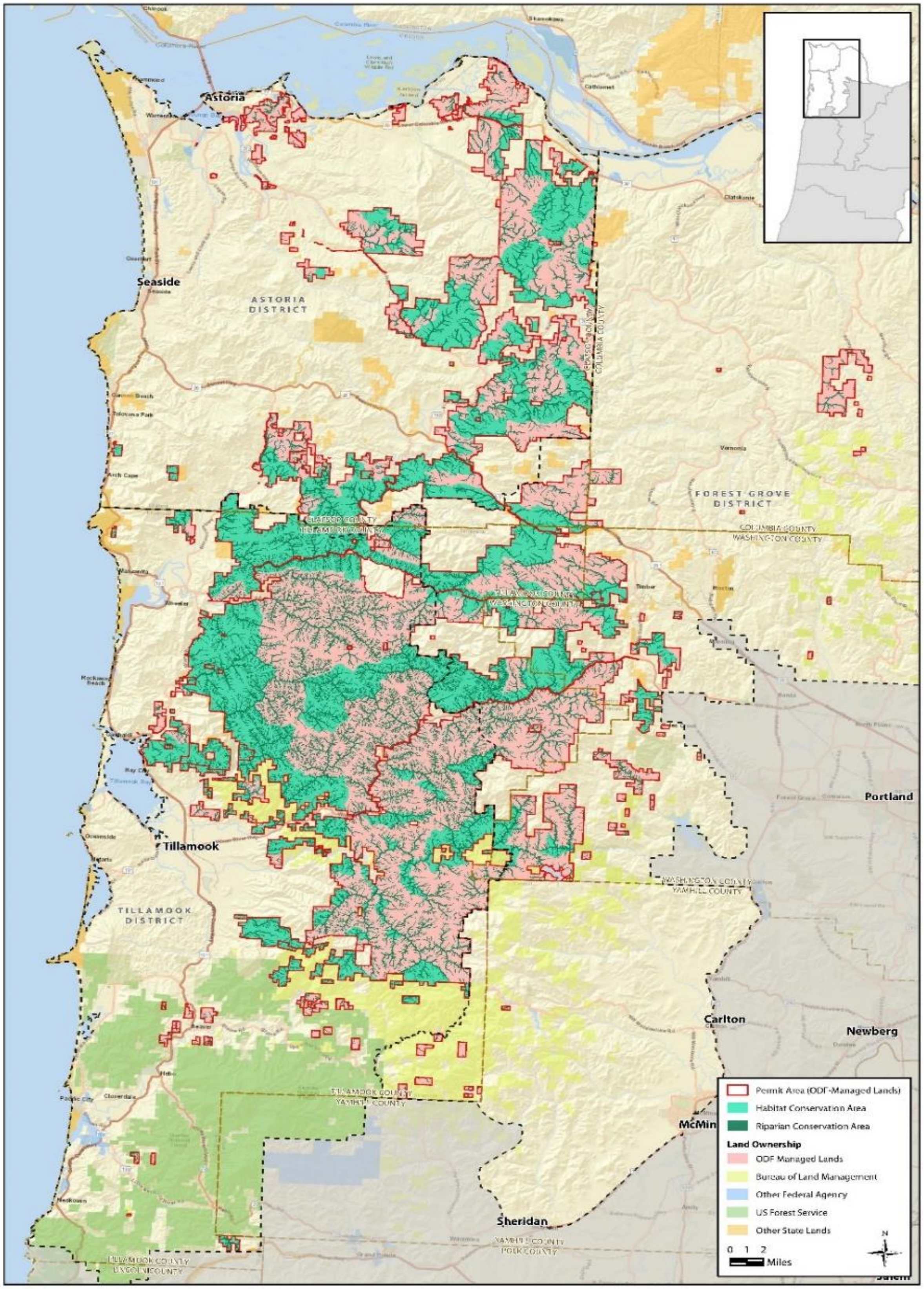


Figure ES-2. Habitat Conservation Areas and Riparian Conservation Areas in Northwestern Oregon

Within HCAs, all management activities are designed to promote and improve habitat. Both passive and active management will be used to increase habitat quality and quantity for terrestrial covered species over the 70-year permit period. Habitat for terrestrial species is estimated to increase in both quality and quantity during the permit term (Table ES-4). Those new acres of suitable habitat are primarily located inside of HCAs and are the result of passive management but also targeted active management of key stands to grow habitat faster. Active management will include treatment of Douglas-fir stands infected by Swiss needle cast and hardwood stands that are less likely to grow into habitat without intervention. Forest management prescription (e.g., thinning) will also be used to promote tree growth and understory diversity. The anticipated increase in the quality and quantity of habitat for covered terrestrial species is the primary tool used to offset the impact of the taking from continued habitat loss due to covered activities during the same period. For additional details on these and other terrestrial conservation actions, see Chapter 4, Conservation Actions 6–9.

In conjunction with the implementation of targeted management prescriptions to increase and improve habitat inside HCAs, additional conservation actions are included to retain important habitat features on the landscape outside of HCAs and RCAs. This includes retaining habitat trees and leaving downed wood during forest management activities. ODF will continue to minimize effects on sites known to support covered species, specifically by imposing seasonal restrictions on operations in known nesting locations for northern spotted owl and marbled murrelet.

ES.3.3 Conservation Fund

The conservation strategy will result in an increase in habitat for all of the terrestrial covered species, but other factors may remain that limit the ability of covered species to take advantage of the new habitat and for populations to increase. The Conservation Fund, described in Chapter 9, *Costs and Funding*, will provide funding on an annual basis to address these limiting factors. The priorities for how the Conservation Fund is used will change during the permit term, but ODF will work with species experts and other state and federal partners to identify where and how Conservation Fund monies are spent. Conservation Fund monies will be derived from ODF's share of timber sale revenues, at a rate of $5 per thousand board feet harvested. This fund will be used to implement three types of conservation projects to directly benefit the covered species: (1) aquatic habitat enhancement projects, (2) terrestrial habitat projects, and (3) strategic initiatives. Examples of aquatic habitat enhancement projects include placement of large wood into streams, side-channel reconnection projects, and fish passage improvements. Terrestrial habitat enhancement includes habitat restoration in HCAs and research on covered species response to management actions in HCAs. Strategic initiatives are projects designed to speed the recovery of covered species. For example, ODF has committed to participating in regional barred owl management to increase habitat availability for northern spotted owl. Strategic initiatives may also include facilitation of research and monitoring projects designed to better understand species distribution and conservation needs and species response to conservation actions.

The creation of the Conservation Fund allows ODF to meaningfully engage with partners to implement conservation projects to benefit covered species. Funds will be accrued annually, but there will be flexibility to roll funds over year to year in order to fund larger and more complex conservation projects. Based on modeled harvest estimates the Conservation Fund is estimated to accrue on average $1 million/year throughout the permit term. Expenditures of the Conservation Fund are expected to equally support aquatic and terrestrial species conservation needs. A more detailed description can be found in Chapter 9.

Table ES-4. Acres of Covered Species Habitat in Habitat Conservation Areas at the Beginning and End of the 70-Year Permit Term

Species	Habitat in HCAs at the Beginning of Permit Term	% of HCAs that are Habitat at the Beginning of Permit Term[f]	Habitat Commitment in HCAs at End of Permit Term[g]	% of HCAs that are Habitat at End of Permit Term[f]	% Increase in Habitat Acres During Permit Term
Northern spotted owl[a]	88,000[e]	32%	134,000	49%	52%
Marbled murrelet[b]	63,000	23%	142,000	52%	125%
Red tree vole[b]	53,000	19%	117,000	43%	120%
Oregon slender salamander[c]	16,000	6%	19,000[c]	7%	19%
Coastal marten[d]	27,000	10%	27,000	10%	0%

[a] Habitat includes modeled nesting, roosting, and foraging habitat.

[b] Habitat includes modeled suitable and highly suitable habitat.

[c] Habitat includes the extent of Oregon slender salamander range in the permit area. In addition to the 19,000 acres that will be managed as Oregon slender salamander habitat in HCAs, retention standards described in Conservation Action 8: *Conservation Actions Outside Habitat Conservation Areas and Riparian Conservation Areas*, will ensure that Oregon slender salamander can persist in areas that are subject to harvest within the species range.

[d] Any portion of the permit area from northern Lane County south to the California border, west of Interstate 5 is considered habitat. The amount of habitat in the permit area will not change substantially during the permit term unless ODF acquires new lands. All of the 27,000 acres of coastal marten habitat in HCAs are expected to be improved during the permit term, resulting in habitat quality at the end of the permit term that is expected to be higher than it is at the beginning of the permit term.

[e] 28 out of 31 active northern spotted owl activity centers are inside of HCAs.

[f] HCAs comprise approximately 275,000 acres. Species distribution does not cover the entire extent of HCAs so the percentage is not indicative of habitat quality. For example, Oregon slender salamander only occurs in the North Cascades, which comprises less than 15% of the permit area.

[g] Commitments to conserve, maintain, and enhance acres of covered species habitat are based on the assumption that at least 50% of nesting and roosting habitat and 80% of foraging habitat modeled to grow within HCAs over the 70-year permit term can be achieved.

ES.3.4 Monitoring and Adaptive Management

The HCP includes a monitoring program to demonstrate that ODF is operating in compliance with the commitments made in the HCP and associated incidental take permits. The monitoring program also helps to assess whether the conservation strategy is performing as expected. Compliance monitoring will focus on whether the HCP is being implemented properly and as required by the permits. Compliance monitoring results will be summarized in an annual report to USFWS and NOAA Fisheries. Effectiveness monitoring will be completed to track progress towards the biological goals and objectives. Effectiveness monitoring will include validation of habitat development as estimated by species habitat models and species response to changes in habitat quality. Collectively, these monitoring programs will track long-term trends in habitat quality to allow for an examination of whether the HCP is making progress towards the biological goals and objectives, or whether changes are needed through the adaptive management program. Monitoring and adaptive management are integrated processes, and monitoring will inform changes in management actions to continually improve outcomes for covered species.

The monitoring framework will be operationalized by ODF as part of each 10-year Implementation Planning cycle, during which ODF will assess monitoring priorities, using this framework as a guide. The adaptive management program is also generally aligned with these 10-year Implementation Planning cycles.

ES.4 Implementation, Cost, and Funding

ODF will oversee HCP implementation, including staffing internal positions, hiring consultants, reporting, monitoring, and maintaining all program records. ODF staff includes biologists, foresters, administrators, and other natural resource specialists who will carry out planning, monitoring, and adaptive management. ODF is also responsible for coordination with state and federal wildlife agencies during HCP implementation and providing regular reports to NOAA Fisheries and the USFWS. Implementation of the HCP will be integrated with existing State Forest Division planning cycles, grounded in the 10-year implementation planning periods associated with the forest management plan.

ES.4.1 Reporting

Reporting will occur on three timescales during implementation: (1) annual reports, (2) 5-year check-ins, and (3) 10-year comprehensive reviews. Annual reports will focus on assessing compliance with the HCP and permits. Longer term 5- and 10-year reviews will focus on assessments of the effectiveness of HCP conservation actions. The 10-year comprehensive reviews are specifically designed to inform the 10-year implementation planning process, which guides forest management planning for the State Forests Division. For more details on reporting, see Chapter 8, *Implementation*.

ES.4.2 Costs and Funding

Chapter 9 of the HCP details the cost of administering the HCP, including implementation of the conservation strategy and monitoring program. Chapter 9 also outlines how the HCP commitments will be funded for the duration of the permit term. Income from timber revenue on State Forests will provide the primary support for HCP implementation. The major cost categories described in the HCP include:

- HCP Administration and Staffing
- Conservation Strategy
- Monitoring and Adaptive Management

Chapter 1
Introduction

1.1 Overview

The Oregon Department of Forestry (ODF) has prepared this multi-species Western Oregon State Forests Habitat Conservation Plan (HCP) to support their request for incidental take permits (ITPs) under the federal Endangered Species Act (ESA) for Western Oregon State Forests that are managed by ODF. The HCP is a long-term plan that will support the conservation of threatened and endangered species, or those species that are likely to become listed as such, while allowing management of the forest, including ongoing timber harvest activities.

Section 9 of the ESA prohibits the taking of species listed as threatened or endangered. *Taking* is defined as, "to harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct" (16 U.S. Code [USC] 1532). *Harm* is further defined as including "significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering" (50 Code of Federal Regulations [CFR] 17.3). ODF cannot conduct forest management, road system management, and construction and maintenance of recreation facilities in state forests without removing or altering forested areas that may provide habitat for listed, proposed, or candidate species. To the extent this alteration injures or kills one of more of these species or results in "habitat modification or degradation that significantly impairs essential behavioral patterns," it may be considered take under Section 9 of the ESA.

In accordance with Section 10 of the ESA, ODF has applied to the U.S. Fish and Wildlife Service (USFWS) and National Oceanic and Atmospheric Administration (NOAA) Fisheries (collectively referred to as the Services) for ITPs that will allow specified levels of take of listed species. The goal of this HCP is to fully offset the impacts of the take to be authorized. To accomplish this, ODF will avoid and mitigate take of listed species to the maximum extent practicable in the management of state forestlands.

1.1.1 HCP Mission and Vision

ODF's mission statement for this HCP is as follows:

> To provide protection and conservation for selected listed species and species likely to become listed under the federal or state Endangered Species Acts during the permit term, while providing for long-term, multi-benefit management of the State's public forestlands subject to the Western Oregon State Forest Management Plan. The HCP will support the range of economic, social, and environmental benefits that ODF is statutorily required to provide under the Greatest Permanent Value rule and will help to meet fiduciary responsibilities for Common School Forest Lands (CSFL). It will also meet specific criteria that must be satisfied before NOAA Fisheries and USFWS can issue ITPs.

ODF has the following vision for the HCP, which defines the future outcome of state forests with the HCP:

> The Western Oregon HCP ensures species protection and conservation as well as increased certainty that working state forestlands will continue to benefit all Oregonians. Multi-objective forest stewardship activities provide revenue to counties, rural communities, the Common School Fund,

and ODF; create jobs; support resilient forest ecosystems, clean air, and high water quality; provide high-quality habitats for native fish and wildlife; and promote educational, recreational, and other partnership opportunities to enhance enjoyment of public forest benefits.

1.1.2 HCP Program Goals

ODF staff developed a set of six broad program goals for the HCP in collaboration with the HCP Steering Committee (Section 1.6.1, *Steering Committee*). These program goals were used as a foundation to develop the biological goals and objectives and the conservation strategy described in Chapter 4, *Conservation Strategy*.

1. Meet the regulatory requirements of the federal and state ESA through an approved HCP, using a multi-species approach to managing forest ecosystems across the landscape.
2. Ensure active and sustainable management of state forest lands under a Western Oregon HCP and an associated Forest Management Plan designed to meet the social, economic, and environmental goals articulated in the Greatest Permanent Value Rule.
3. Increase operational certainty, cost savings, and predictability of revenue generation (including related timber harvest, jobs, and other economic values) using the HCP as a programmatic approach to comply with the federal and state ESA over the permit term.
4. Increase certainty for long-term persistence of covered wildlife species by protecting and maintaining high-quality habitats, conducting habitat enhancement activities, and mitigating the impacts of covered activities on covered species.
5. Advance partnerships and engagement related to management approaches and outcomes associated with, but not limited to, revenue generation and economic outcomes, conservation, forest conditions and health, tribal interests and traditional cultural uses, research, monitoring, education, recreation, and the equitable enjoyment of benefits that state public forests provide.
6. Use science-based forestry to promote conditions that create sustainable, productive forests that are resilient to large fires, climate change impacts, and other disturbance events. Use an adaptive management approach to address uncertainty and change over time.

1.1.3 State Forest Management

ODF was created in 1911, with a primary purpose to control forest fires. In 1925, the Oregon Legislature passed a law allowing the Board of Forestry (BOF) to accept gifts or donations of forest lands. The State Forests Acquisition Act of 1939 created procedures for the BOF to acquire tax-delinquent forest lands from counties, manage the land, and return most net revenues from the land to the counties. Amendments to the State Forests Acquisition Act since then have adjusted the distribution of revenues and legal direction for forest management on these lands. Today, lands owned by the BOF are known as Board of Forestry Lands (BOFL). The lands are managed to secure the “greatest permanent value...to the state” (ORS 530.050) by providing “healthy, productive, and sustainable forest ecosystems that over time and across the landscape provide a full range of social, economic, and environmental benefit to the people of Oregon” (OAR 629-035-0020). BOFL are actively managed in a sound environmental manner to provide sustainable timber harvest and revenues to the state, counties, and local taxing districts.

Some lands managed by ODF are owned by the State Land Board, which consists of the Governor, the Secretary of State, and the State Treasurer. When Oregon became a state in 1859, the federal government granted sections 16 and 36 of every township[1] to the new state for the use of schools. Oregon's grant included 3.5 million acres of grazing and forest lands. Eventually, much of the land was sold for the benefit of schools. The state also exchanged some lands in order to consolidate land into larger blocks. The remaining forest lands owned by the Oregon Department of State Lands are known as Common School Forest Lands (CSFL). The State Forester is authorized to manage CSFL (ORS 530.490 through 530.520), consistent with the Oregon Constitution's objective of "obtaining the greatest benefit for the people of this state, consistent with the conservation of this resource under sound techniques of land management." Each land ownership has its own set of legal and policy mandates.

ODF manages state forests for multiple values including social, environmental, and economic values. Sustainable and predictable timber harvests provide revenues to counties, local taxing districts, and ODF, and jobs in rural communities. Timber production goals focus on growing stands that generate a product mix of predominately large and medium sawtimber. Prior to final harvest, young stand management and mature stand partial cutting entries provide habitat values for native wildlife species. At final harvest, retention standards for green trees, snags, and downed wood provide biological legacies for future stands. ODF provides diverse recreation, education, and interpretation opportunities for the public to enjoy state forests and learn about their ecology and management.

ODF is currently managing Western Oregon State Forests under the 2010 Northwest and Southwest Oregon State Forests Management Plans (Oregon Department of Forestry 2010a, 2010b), which provides management direction for all BOFL and CSFL in western Oregon. The forest management plans present guiding principles, a forest vision, and resource management goals. The plans describe each forest resource and explain the concepts for integrated forest management and management strategies. The resource management goals and strategies are intended to balance the resources and achieve the greatest permanent value through a system of integrated management.

Currently, ODF is managing state forests consistent with their forest management plans with an intent to avoid and minimize the risk of take of any listed species (Oregon Department of Forestry 2010a, 2010b). This management approach has been increasingly costly and disruptive to ODF planning and operations, given the uncertain legal and regulatory landscape, shifting or expanding species distribution, and potential for new listed species. In 2018, the BOF commissioned a business case analysis that examined the costs and economic benefits of preparing a regional HCP across all BOFL in Western Oregon with an assumed 50-year permit term (ECONorthwest and ICF 2018). This business case concluded that an HCP would provide economic benefits to the BOF and ODF, greatly reduce uncertainty, and improve the conservation of currently listed species and species that may be listed over the 70-year analysis period. As a result of this business case analysis, the BOF in October 2018 unanimously directed ODF staff to pursue an HCP.

1.2 Scope of the HCP

This section describes the scope of the HCP, including the plan area, permit area, permit term, covered activities, and covered species. Collectively these key elements of the HCP frame the analysis in the rest of this document. The analysis will only be conducted within the plan area on the activities proposed for coverage, and will be limited to the species included as covered species.

[1] A section is 640 acres, or 1 square mile. A township is a survey boundary that is typically 6 miles square, or 36 sections (23,040 acres).

1.2.1 Plan Area

The HCP plan area includes all state forestlands west of the crest of the Cascade Range that are managed by ODF (Figure 1-1). Most of these state forest lands are in northwestern Oregon in the Tillamook, Clatsop, and Santiam State Forests. Smaller blocks of state forest lands are located in the central Coast Range west of Corvallis and Eugene. In southern Oregon, state forest lands are found in southern Douglas and northern Josephine counties near the town of Glendale, and in tracts in Douglas and Coos counties near Reedsport and Coos Bay. Smaller tracts of state forest land are scattered throughout the plan area. State forest lands in the Klamath-Lake District or in eastern Oregon are not included in this HCP.

ODF currently manages 25,826 acres of land in Western Oregon on behalf of Oregon Department of State Lands. All of these lands are also included in the HCP plan area.

To allow for possible future changes in ODF's ownership, the HCP plan area includes areas not currently owned by ODF but that are identified in Land Acquisition and Exchange Plans published by many of the districts in the plan area. This additional area totals 84,206 acres (Table 1-1; Figure 1-1). Not all of that area will be acquired by ODF during the permit term; these lands represent a boundary in which acquisition will mostly likely occur. Net acquisitions are estimated to be on the order of 25,000 acres. Because ODF does not yet own these parcels, they are not part of the permit area. As soon as ODF takes ownership of these parcels they would become part of the permit area. Similarly, if ODF disposes of land as part of this routine land transfer and exchange process, lands no longer owned or managed under the authority of the BOF would not be covered by this HCP and therefore would be removed from the permit area.

The current Land Acquisition and Exchange Plans likely do not predict all of the acquisitions or transfers that ODF will undertake during this HCP. To account for additional shifts in land ownership, the plan area includes allowance for another 10,000 acres of forestland that could occur anywhere in the vicinity of current ODF ownership in the permit area. These areas are not shown in Figure 1-1.

The plan area includes a total of 733,695 acres (Figure 1-1), the components of which are summarized in Table 1-1.

1.2.2 Permit Area

The HCP permit area is defined as the area where incidental take is covered under the incidental take permit, which includes the portion of the plan area that ODF currently controls and where all covered activities will occur and where conservation measures will apply. The permit area includes a total of 639,489 acres (Figure 1-1): 613,663 acres of BOFL[2] and 25,826 acres of CSFL (Table 1-1). The HCP permit area includes all BOFL described above for the plan area. The HCP permit area also includes the 25,826 acres of CSFL managed by ODF. These CSFL are included in the permit area and covered by this HCP in order to provide ODF with take authorization for their activities on this land, but only as long as there is an enforceable agreement that provides ODF with the authority to manage those lands. The ITPs issued for this HCP would not provide take authorization for another land manager besides ODF to manage CSFL.

[2] There are approximately 200 acres of BOFL that are used for ODF administrative purposes. No covered activities will be occurring on those lands so they are not included in the plan area or permit area.

As part of its long-term planning efforts, ODF acquires or disposes of forest parcels in order to consolidate its ownership, increase public use opportunities of state forestland, improve management efficiency, reduce adverse environmental effects, and reduce neighbor conflicts. This is primarily accomplished through land exchanges with other forest landowners. Periodically, ODF identifies and publishes maps of the specific parcels that it is interested in exchanging or acquiring from willing sellers at fair market value. Over the last 20 years, for example, ODF has disposed of 12,125 acres and obtained 13,002 acres of forest relative to the permit area, for a net change of 877 acres added to state forests in this time period (a net change of about 0.1%). ODF expects this to continue into the future, so the HCP needs to be flexible enough to accommodate their shifting ownership.

The process for adding or removing land from the permit area is described in Chapter 8, *Plan Implementation*. The intention of the HCP is to cover any Western Oregon State Forests Lands managed by ODF, no matter where they occur in the plan area. The permit area will remain fluid during the permit term, as the land owned and managed by ODF changes through exchanges and acquisitions, but will never extend outside of the plan area.

The HCP will also be applied and permit coverage extended to covered activities that ODF performs on Bureau of Land Management (BLM) lands. ODF conducts activities on BLM lands adjacent to ODF-managed lands during the course of covered activities described in Chapter 3. In situations where covered activities would occur on BLM lands ODF would follow the terms of the HCP and permits. This work would continue to be managed under the 1960 right-of-way agreement between ODF and BLM (or later agreements that amend or replace this agreement). Under that agreement the BLM assesses ODF activities to ensure that activities are implemented consistent with federal law, including the ESA. Previous to this HCP ODF was managing that work using take avoidance strategies.

In other circumstances where covered activities occur within, but then continue outside of, the permit area (hauling, road maintenance, etc.), ODF will implement the terms and conditions of the HCP and permits within the permit area. If a covered activity, such as hauling, continues outside of the permit area and onto private or public land that ODF does not control, ODF will adhere to the terms and conditions of the agreement in place (e.g., easements) with the adjacent landowner(s). Notably, when the terms and conditions of the HCP and permits are applied to hauling in the permit area, they are being applied, by default, outside of the permit area. Essentially, if hauling is not initiated in the permit area it would not be occurring outside of it.

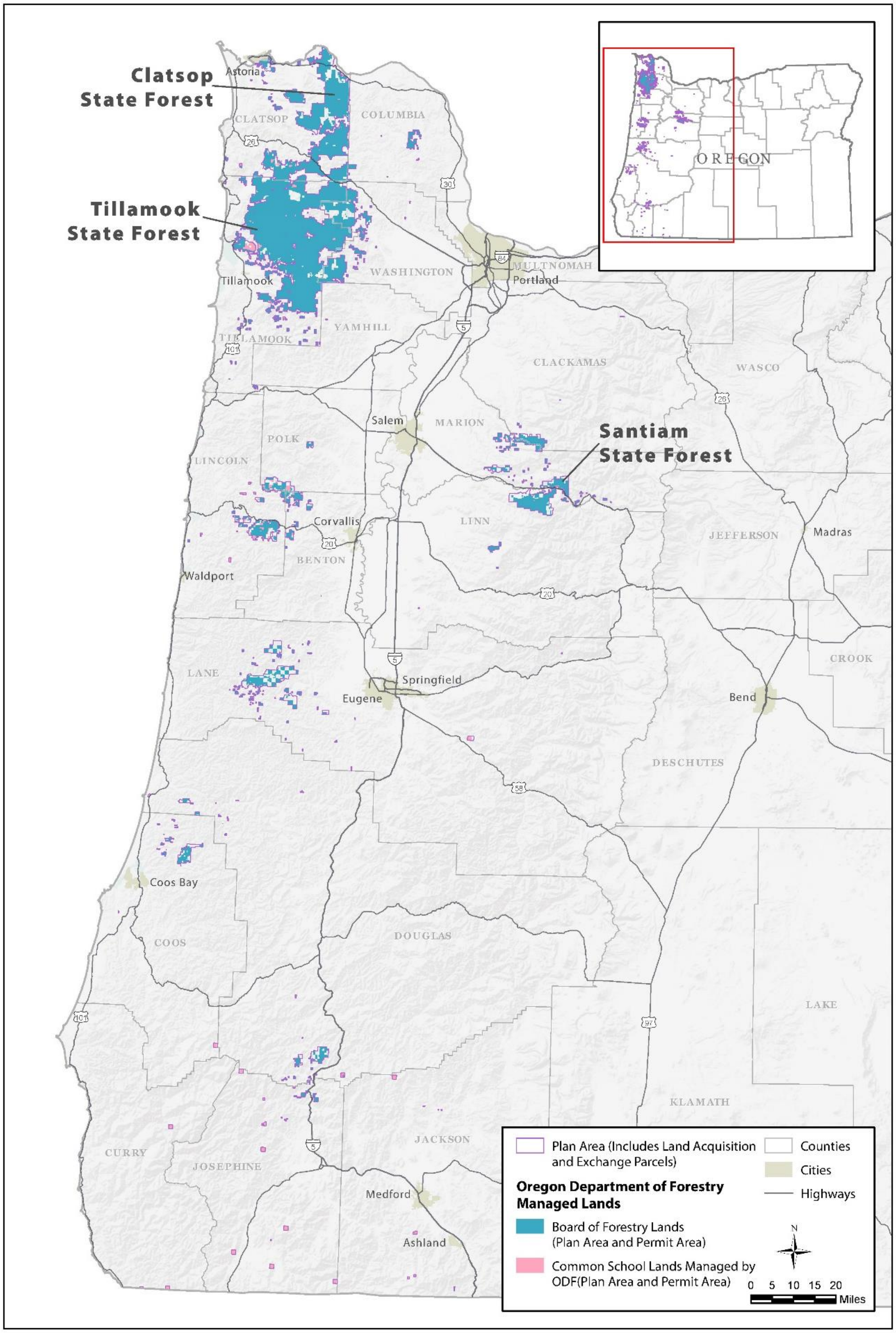


Figure 1-1. Western Oregon State Forests HCP Plan and Permit Area

Table 1-1. Lands in the Plan Area and Permit Area

Land Type	Amount in Plan Area (acres)	Amount in Permit Area (acres)	Explanation
Board of Forestry Lands in Western Oregon	613,663	613,663	In permit area as long as these lands are owned by the Board of Forestry. In the event of conveyance of portions of these lands to another party, conveyed parcels will no longer be part of the permit area and this HCP will no longer apply. If this conveyance is part of a land exchange, the lands will be incorporated into the HCP as indicated below.
State of Oregon Common School Forest Lands Managed by ODF in Western Oregon	25,826	25,826	In permit area as long as these lands are managed by ODF. If ODF ceases to manage these lands, or in the event of conveyance of portions of these lands to another party, conveyed parcels will no longer be part of the permit area and this HCP will no longer apply. If this conveyance is part of a land exchange, the lands will be incorporated into the HCP as indicated below.
Lands Identified by Land Acquisition and Exchange Plans	84,206	0	These plans identify potential exchange parcels, many of which never become involved in an actual exchange. As a result, only a fraction of this total is expected to be added to the permit area In permit area (and covered by HCP) only after being acquired by ODF.
Additional Lands in the Vicinity of Current ODF Ownership	10,000	0	Lands not yet identified in Land Acquisition and Exchange Plans but that may be acquired by ODF. In permit area (and covered by HCP) only after being acquired by ODF.
Total	**733,695**	**639,489**	

1.2.3 Permit Term

The Western Oregon State Forests HCP and associated ITPs will have concurrent terms of 70 years. The 70-year term was selected to balance the risks associated with shorter and longer terms. A term of less than 70 years would limit ODF's abilities to conduct long-term forest management practices, which are conducted in accordance with Implementation Plan cycles that are typically 10 years in length. A term of more than 70 years would increase the risk that unpredictable ecological changes could adversely affect the status of the covered species in the plan area and increases the uncertainty associated with modeling those changes. Both of these items could compromise the conservation strategy. The level of certainty associated with a 70-year term enables ODF to make long-term plans and investments through a multiple implementation cycles with the assurance that they will be able to continue managing the forest in a manner that complies with ESA requirements In addition, the monitoring and adaptive strategy outlined in Chapter 6, *Monitoring and Adaptive*

Management, outlines how implementation of the conservation strategy will be monitored and reported, and how changes will be made, if needed, in response to monitoring results, to manage in response to change. This will further allow ODF to manage uncertainty that may arise during the permit term.

1.2.4 Covered Activities

This HCP and the associated ITPs will cover and provide incidental take authorization for ODF's land management activities in the permit area (Figure 1-1), as well as the activities needed to carry out the conservation strategy, as described in Chapter 4. Broad categories of ODF's covered activities are listed below; detailed descriptions of the selection process and covered activities are provided in Chapter 3.

- Timber Harvest
- Stand Management
- Road System Management
- Recreation Infrastructure Construction and Maintenance
- HCP Conservation Actions

1.2.5 Covered Species

Covered species are those species for which USFWS and NOAA Fisheries will provide take authorization to ODF to conduct the covered activities. The plan area provides habitat for a variety of species, including species listed under state and federal endangered species protection laws, and others that are not yet ESA listed, but may become ESA listed during the permit term. ODF selected the covered species for the HCP based on review of all species of conservation concern known or suspected to occur in the plan area during the permit term. These species were then screened for coverage based on the four selection criteria described in Section 1.2.5.1, *Covered Species Selection Criteria*. A summary of that selection process is provided in Appendix D, *Species Considered for Coverage*. To be covered by the HCP, a species must meet all four criteria.

1.2.5.1 Covered Species Selection Criteria

Range

Based on a review of species distribution, review of scientific literature, and professional expertise it was determined that a species does occur or can be expected to occur in the plan area. In addition, species that are not currently known to occur in the plan area but are expected to move into the plan area during the permit term (e.g., through range expansion) were considered to meet this criterion.

Status

The species should be listed or proposed for listing under the federal ESA as threatened or endangered, should be a candidate species, or have a strong likelihood of being listed during the permit term. Potential for listing during the permit term is based on current listing status; consultation with experts and USFWS, NOAA Fisheries, or Oregon Department of Fish and Wildlife (ODFW) staff; evaluation of species population trends and threats; and best professional judgment.

Impact

The species or its habitat could potentially be adversely affected by covered activities in a manner likely to result in incidental take as defined by the ESA.

Data

Enough scientific data should exist on the species' life history, habitat requirements, and occurrence in the plan area to adequately evaluate potential effects from covered activities, and to develop adequate conservation measures to mitigate those impacts.

1.2.5.2 Proposed Covered Species

The review and selection process found 17 species meeting all selection criteria (Table 1-2). For details on the selection process, see Appendix D, *Species Considered for Coverage*.

Table 1-2. Covered Species

	Listing Status		
Species	**Federal**	**State**	**Federal Agency Jurisdiction**
Fish			
Oregon Coast coho (*Oncorhynchus kisutch*)	FT	--	NOAA Fisheries
Oregon Coast spring-run chinook (*O. tshawytscha*)	UR	--	NOAA Fisheries
Lower Columbia River chinook (*O. tshawytscha*)	FT	--	NOAA Fisheries
Lower Columbia River coho (*O. kisutch*)	FT	SE	NOAA Fisheries
Columbia River chum (*O. keta*)	FT	--	NOAA Fisheries
Upper Willamette River spring-run chinook (*O. tshawytscha*)	FT	--	NOAA Fisheries
Upper Willamette River winter steelhead (*O. mykiss*)	FT	--	NOAA Fisheries
Southern Oregon/Northern California Coast coho (*O. kisutch*)	FT	--	NOAA Fisheries
Southern Oregon/Northern California Coastal spring-run chinook	UR	--	NOAA Fisheries
Eulachon *(Thaleichthys pacificus)*	FT	--	NOAA Fisheries
Birds			
Northern spotted owl (*Strix occidentalis caurina*)	FT	ST	USFWS
Marbled murrelet (*Brachyramphus marmoratus*)	FT	SE	USFWS

Species	Listing Status: Federal	State	Federal Agency Jurisdiction
Amphibians			
Oregon slender salamander (*Batrachoseps wrighti*)	--	ST	USFWS
Columbia torrent salamander (*Rhyacotriton kezeri*)	UR	ST	USFWS
Cascade torrent salamander (*R. cascadae*)	UR	--	USFWS
Mammals			
Coastal marten[1] (*Martes caurina*)	T	--	USFWS
Red tree vole, North Oregon Coast population (*Arborimus longicaudus*)[2]	--	--	USFWS

SE = State Endangered; ST = State Threatened; FT = Federal Threatened; UR = Under Review

[1] The full name of the listed entity is Pacific marten, Coastal Distinct Population Segment.

[2] ODF is proposing the red tree vole for coverage under this HCP despite red tree vole not being listed as endangered or threatened under the ESA. In 2019, the USFWS determined that red tree vole did not warrant listing as endangered or threatened (84 *Federal Register* 69707). The Center for Biological Diversity is currently seeking an order to vacate USFWS's not-warranted finding and remand the matter to the Service to issue a new determination regarding whether red tree vole warrants protection under the ESA as an endangered or threatened species. ODF finds the likelihood of future listing of red tree vole to be high enough to propose the species for coverage under this HCP.

1.3 Regulatory Setting

1.3.1 Federal and State Species Laws and Regulations

1.3.1.1 Federal Endangered Species Act

The purpose of the ESA is to provide a means whereby the ecosystems upon which threatened and endangered species depend may be conserved, and to provide a program for the conservation of such species. The Services have responsibility for conservation and protection of threatened and endangered species under the ESA. NOAA Fisheries is responsible for enforcing the provisions of ESA for most marine and anadromous species. USFWS is responsible for all other terrestrial and aquatic species.

Section 7

ESA Section 7 requires all federal agencies, in consultation with the Services, to ensure that any action "authorized, funded, or carried out" by any agency "is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification" of critical habitat (16 USC 1536[a][2]). Before initiating an action, the federal agency must determine whether a proposed project may affect listed or proposed species or their critical habitat. If the agency determines that a project may have an effect, it is required to consult with the Services. If the agency determines, and the Services concur, that the project is not likely to adversely affect any listed species, proposed species or not likely to adversely modify designated critical habitat, the consultation is concluded. If the agency determines that a project is likely to adversely affect a listed species, proposed species, or designated or proposed critical habitat, a formal consultation process is initiated.

During formal consultation, the Services prepare a biological opinion (BO) in response to information provided by the action agency. The BO analyzes the effects of the proposed action on listed species and determines if the action is likely to jeopardize the continued existence of the species or destroy or adversely modify designated critical habitat. If the BO reaches a jeopardy or adverse modification conclusion, the opinion must include a "reasonable and prudent alternative."

If the BO concludes that the project, as proposed, would result in take of a listed species, but not to an extent that would jeopardize the species' continued existence, the BO includes an incidental take statement and specifies reasonable and prudent measures and terms and conditions to minimize the impact of the take. The incidental take statement specifies an amount of take that may occur as a result of the action. The statement may also include conservation recommendations, which are non-binding, such as identifying additional discretionary conservation measures to reduce adverse effects, or identifying additional needed studies, monitoring, or research that might assist species conservation in furtherance of ESA Section 7(a)(1). If the action complies with the BO and the incidental take statement, it may be implemented without violation of ESA, and the take is thereby exempted.

Section 10

Until 1982, state, local, and private entities had no means to acquire incidental take authorization as could federal agencies under Section 7. Private landowners and local and state agencies risked direct violation of the ESA no matter how carefully their projects were implemented. This statutory dilemma led Congress to amend Section 10 of the ESA in 1982 to authorize the issuance of an ITP to nonfederal project proponents upon completion of an approved "conservation plan." The term conservation plan has evolved into "habitat conservation plan," which is in common use today.

Under Section 10(a)(2)(A), a nonfederal party (such as ODF) may apply to USFWS or NOAA Fisheries for an ITP providing authorization to incidentally take listed species, meaning that the activity taking the species "is incidental to, but not the purpose of, otherwise lawful activities." The application for an ITP must include an HCP that describes the impacts that are likely to result from the incidental take and the measures the applicant will carry out to minimize and mitigate such impacts to the maximum extent practicable. In addition, the HCP must demonstrate that adequate funding is available to implement these measures and include a discussion of alternative actions to take that the applicant has considered, and the reasons these alternative actions are not being used. Finally, the HCP must include "such other measures that the Secretary [of the Department of Interior or Commerce] may require as being necessary or appropriate for the purpose of the plan." Each issuance of an ITP by the Services is subject to evaluation via the Section 7 consultation process described previously; thus, incidental take authorized pursuant to an HCP must be quantified, must not jeopardize the continued existence of the species, and must not destroy or adversely modify critical habitat.

Magnuson-Stevens Fishery Conservation and Management Act

The Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) established a management system for national marine and estuarine fishery resources. Pursuant to Section 305(b)(2), all federal agencies are required to consult with NOAA Fisheries regarding any action permitted, funded, or undertaken that may adversely affect "essential fish habitat" (EFH). Effects on habitat managed under any relevant Fishery Management Plans must also be considered. EFH is defined as "waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." This includes migratory routes to and from anadromous fish spawning grounds. The phrase "adversely affect" refers to the creation of any impact that reduces the quality or quantity of essential fish habitat. Federal activities that occur outside of an EFH but that may, nonetheless, have an impact on EFH waters and substrate must also be considered.

1.3.1.2 Oregon Endangered Species Act

Under the Oregon ESA (ORS 496.171 to 496.192 and 498.026), ODF must coordinate with the ODFW and the Oregon Department of Agriculture in developing plans that comply with the state ESA, and that are consistent with the constitutional mandate for CSFL.

The Oregon ESA was adopted in 1987 and included both plant and animal species. The act was amended in 1995 to outline listed species protection requirements. The northern spotted owl and marbled murrelet were listed as threatened under the Oregon ESA in 1988 and 1995, respectively. For threatened or endangered species listed after 1995, or those uplisted from threatened to endangered status, the Oregon Fish and Wildlife Commission must establish quantifiable and measurable guidelines considered necessary to ensure the survival of individual members of the species. These survival guidelines may include take avoidance and measures to protect resource sites (e.g., nest sites and spawning grounds) and only apply to state-owned or -leased land. Because the northern spotted owl and marbled murrelet were listed in or prior to 1995, state survival guidelines were not developed for these species. ODFW published advisory survival guidelines in 2018 for marbled murrelet.

The Oregon Fish and Wildlife Commission reclassified marbled murrelet as endangered on July 15, 2021. Because of this status change, survival guidelines under the Oregon ESA have become obligatory on state lands and ODF is developing a state Endangered Species Management Plan (ESMP) for marbled murrelet. Once approved, the measures in this HCP will supplant the survival guidelines and ESMP as the means of protecting these state-listed species. National Environmental Policy Act

The National Environmental Policy Act (NEPA), established in 1969, serves as the nation's basic charter for determining how federal decisions affect the human environment (42 USC 4332). Federal agencies must complete environmental documents pursuant to NEPA before implementing discretionary federal actions. Such documents help ensure that the underlying objectives of NEPA are achieved: to disclose environmental information, assist in resolving environmental problems, foster intergovernmental cooperation, and enhance public participation. NEPA requires evaluation of the potential effects on the human environment related to the proposed action, reasonable alternatives to the proposed action (if any), and a No-Action Alternative.

Any federal agency undertaking a major federal action that is likely to affect the human environment must prepare an environmental assessment. If any impacts on the human environment are found to be significant and cannot be mitigated to the point of insignificance, the federal agency must then prepare an environmental impact statement. The Council on Environmental Quality regulations define major federal actions as those actions with "effects that may be major and which are potentially subject to federal control and responsibility," including "projects and program entirely or partly financed, assisted, conducted, regulated, or approved by federal agencies."

Issuance by USFWS and NOAA Fisheries of ITPs under the ESA Section 10(a)(1)(B) are federal actions subject to NEPA compliance. Although ESA and NEPA requirements overlap considerably, the scope of NEPA goes beyond that of the ESA by considering impacts of a federal action not only on fish and wildlife resources but also on other resources such as water quality, air quality, and cultural resources. To satisfy NEPA requirements, NOAA Fisheries as the lead agency has prepared a joint Services draft environmental impact statement that accompanies this HCP.

1.3.2 Other Relevant State Laws

1.3.2.1 Oregon Forest Practices Act

The Oregon Forest Practices Act and its associated rules sets standards for all commercial activities involving the establishment, management, or harvesting of trees in Oregon forests.[3] The Forest Practices Act declares it public policy to encourage economically efficient forest practices that ensure the "continuous growing and harvesting of forest tree species and the maintenance of forest land for such purposes as the leading use on privately owned land, consistent with sound management of soil, air, water, fish, and wildlife resources and scenic resources in visually sensitive corridors…" (ORS 527.630(1)). The BOF is granted the exclusive authority to develop and enforce rules protecting forest resources and to coordinate with other agencies concerned with state forests. The Oregon Forest Practices Act and the standards included in the Act are referenced throughout the HCP. When the Oregon Forest Practices Act applies to a covered activity it is assumed that the most current version of the requirement will be used. The most current version of the requirement may not be the one referenced in the HCP, but nonetheless, the intent would be for the covered activities to comply with state law as it is currently written, at any point during the permit term.

1.3.2.2 Oregon Plan for Salmon and Watersheds

In 1997, the Oregon Legislature adopted the Oregon Plan for Salmon and Watersheds, which focused on coho salmon. In 1998, the Steelhead Supplement was added to that plan. The purpose of the Oregon Plan for Salmon and Watersheds is to restore Oregon's wild salmon and trout populations and fisheries to sustainable and productive levels that will provide substantial environmental, cultural, and economic benefits, and to improve water quality. The Oregon Plan for Salmon and Watersheds addresses all factors affecting at-risk wild salmonids, including watershed conditions and fisheries, to the extent that those factors can be influenced by the state.

The Oregon Plan for Salmon and Watersheds is a cooperative effort of state, local, federal, tribal, and private organizations and individuals. Although the plan contains a strong foundation of protective regulations—continuing existing regulatory programs and expediting the implementation of others—an essential principle of the plan involves moving beyond prohibitions and encouraging efforts to improve conditions for salmon through nonregulatory means. This HCP was prepared to be consistent with the Oregon Plan for Salmon and Watersheds.

1.3.2.3 Oregon Fish Passage

Fish passage barriers are prevalent throughout the Oregon landscape. Over time, despite fish passage rules and regulations, access to native fish habitats has been blocked or impaired by the construction of impassable culverts, dams, tide gates, dikes, bridges, and other anthropogenic

[3] Chapter 527 of the ORS and the OAR pursuant to these statutes.

infrastructure. Providing passage at these artificial obstructions is vital to recovering Oregon's native migratory fish populations (Oregon Department of Fish and Wildlife 2013).

As of 2001, ODFW requires the owner or operator of any artificial obstruction located in waters where native migratory fish currently or historically occur to address fish passage when certain activities are planned. If a proposed project is within current or historic native migratory fish habitat and if a fish passage trigger identified in the law (Oregon Administrative Rules [OAR] 635-412-0005(9)(d)) will occur, then fish passage must be addressed. Common triggers for fish passage include culvert and bridge construction, removal, replacement or major repair, and/or in-channel work for scour protection or grade control.

A Memorandum of Understanding between ODFW and ODF gives ODF jurisdiction over fish passage on their land so long as fish passage meets the requirements of the Oregon Forest Practices Act.

1.3.2.4 State Forest Enabling Statutes

Most northwest Oregon state forest lands are owned by the BOF. The statutes governing management of BOFL are contained in ORS Chapter 530, and state that they will manage the lands "so as to secure the greatest permanent value of such lands to the state." Oregon Administrative Rules direct that these lands will be actively managed. Active management means applying practices, over time and across the landscape, to achieve site-specific forest resource goals using an integrated and science-based approach that promotes the compatibility of most forest uses and resources over time and across the landscape.

The Forest Trust Land Advisory Committee is charged with advising the Oregon Board of Forestry and State Forester "on the management of lands subject to the provisions of ORS 530.010 to ORS 530.170 and on other matters in which counties may have a responsibility pertaining to forestland." Additionally, ODF has an obligation to "consult with the committee with regard to such matters."

ORS 530 authorizes the BOF to plan and carry out a land acquisition, disposal, and exchange program in accordance with the Real Estate Asset Management Plan or the Land Board's policies. The BOF may acquire, by purchase, donation, devise, or exchange from any public, quasi-public, or private owner lands which by reason of their location, or topographical, geological, or physical characteristics are chiefly valuable for forest crops production, watershed protection and development, erosion control, grazing, recreation, or forest administrative purposes. It is desirable that lands acquired be in the vicinity of ODF lands and be consolidated wherever possible through exchanges of land. The HCP plan area and permit area were designed to allow this activity to continue consistent with state enabling statutes (Sections 1.2.1, *Plan Area*, and 1.2.2, *Permit Area*).

1.3.2.5 Forestry Administration and Planning

ORS Chapter 526, *Forest Administration,* establishes the general duties of the Board (526.016) and State Forester (526.041), and the mandate to do forest planning. ORS Chapter 530, *State Forests*; *Community Forests* contains the authorities specific to state forests. The BOF supervises forest policy and management under their jurisdiction and ensures the State Forester enforces state forest laws relating directly to the protecting of forestland and conservation of forest resources.

The statutory mandate for forest planning is found in ORS 526.255. This law requires the State Forester to report to the Governor and legislative committees on "long-range management plans based on current resource descriptions and technical assumptions, including sustained yield calculations for the purpose of maintaining economic stability in each management region." In 1998, the BOF adopted a set of administrative rules that provide further direction to the State Forester in planning for the management of these lands. OAR 629-035-0030 states:

> In managing forest lands as provided in OAR 629-035-0020, the State Forester shall develop Forest Management Plans, based on the best available science, that establish the general management framework for the planning area of forest land. The Board may review, modify, or terminate a plan at any time; however, the Board shall review the plans no less than every ten years. The State Forester shall develop implementation and operations plans for forest management plans that describe smaller-scale, more specific management activities within the planning area.

A Forest Management Plan update was initiated by the BOF in June, 2013. It is being prepared concurrently with this HCP and the two documents are consistent, where applicable.

1.3.2.6 Scenic Waterways

The Oregon Scenic Waterways (ORS 390) system includes 19 rivers and 1 mountain lake (Waldo Lake) that possess outstanding scenic, fish, wildlife, geological, botanical, historic, archaeologic, and outdoor recreation values of present and future benefit to the public. Activities within scenic waterways cannot affect the free-flowing character of these waters and must be consistent with the maintenance of waters in quantities necessary for recreation, fish, and wildlife uses.

Scenic waterways and adjacent lands are administered by the State Parks and Recreation Department. State Parks and Recreation consults with BOF to adopt rules for management of related adjacent lands. Management principles, standards, and plans protect or enhance the aesthetic and scenic values of the waterway and permit compatible forestry and other land uses. Forest crops adjacent to designated scenic waterways may be harvested in a manner that maintains, to the extent practicable, the natural beauty of the waterway.

There are currently four scenic water designations that occur in or within 1/4 mile of the HCP permit area: Nehalem, Nestucca, Rogue, and the Little North Santiam River. Some scenic water designations associated with these waterways require an additional set of management and policy guidelines.

1.3.2.7 Oregon Water Quality Standards

The Oregon Department of Environmental Quality (DEQ) uses water quality standards to assess whether the quality of Oregon's rivers and lakes is adequate for fish and other aquatic life, recreation, drinking, agriculture, industry, and other uses. DEQ also uses the standards as regulatory tools to prevent pollution of the state's waters. The Clean Water Act (CWA) requires states to adopt water quality standards designating beneficial uses of the state's waters and setting criteria designed to protect those uses. States submit their standards to the federal Environmental Protection Agency for approval.

The HCP provides species and their critical habitat protection to comply with the ESA, not CWA. However, water temperature is a key water quality parameter for the suitability of aquatic habitat and an important limiting factor for the covered species. Therefore, achieving the water quality standard for temperature is a key part of protecting habitat for covered aquatic species and the HCP requirements may also serve as steps toward achieving CWA water quality standards.

1.3.2.8 ODFW Scientific Taking Permit

Additional Oregon Scientific Take or Collection Permits may be required to implement certain conservation measures, research, and monitoring for this HCP (e.g., barred owl control, fish salvage). Those permits are not part of the federal ITPs issued under this HCP, but will be obtained separately as needed.

1.4 Overview of Planning Process

The HCP was led by ODF and advised by a team of regulators and experts who were organized into a Steering Committee and Scoping Team. The final decisions on the HCP were made by the BOF. All other participants were engaged to provide technical and policy advice to ODF. Planning participants provided valuable input during the planning process, as described below.

1.4.1 Steering Committee

The HCP Steering Committee consists of government agency representatives. Members worked together to provide advice on how ODF can achieve a mutually acceptable outcome that satisfies, to the greatest degree possible, the interests of all participants, while still meeting all regulatory requirements of the ESA. The role of the Steering Committee was to provide overall guidance for the HCP process and to provide direction and support to the Scoping Team. The Steering Committee met approximately bi-monthly during HCP development. Member agencies of the Steering Committee were the following.

- Oregon Department of Forestry (convener)
- Oregon Department of State Lands
- Oregon Department of Environmental Quality
- Oregon Department of Fish and Wildlife
- Oregon State University
- U.S. Fish and Wildlife Service
- NOAA Fisheries

1.4.2 Scoping Team

The HCP Scoping Team was composed of terrestrial and aquatic biologists and technical specialists from state and federal agencies. The role of the Scoping Team was to provide technical expertise and to develop technical recommendations for the Steering Committee to consider when advising ODF in the development of a potential HCP. The Scoping Team met twice monthly during HCP development. Member agencies of the Scoping Team were the same as those listed for the Steering Committee. Technical experts from Oregon State University provided review of key data and work products.

The Scoping Team provided input, guidance, and feedback on development of all aspects of the HCP. This important feedback included species to be covered, how to analyze effects on those species, and the type and extent of conservation actions described in the HCP. The Scoping Team also reviewed early drafts of the HCP to support ODF's development of a legally compliant, scientifically sound, and successful document.

1.4.3 Stakeholder Engagement

During the development of the HCP, ODF hosted public informational meetings prior to each BOF meeting to provide an opportunity for the public, stakeholders, department staff and consultants to share concerns regarding HCP development and ideas for improvement. Meeting presentations were posted online on ODF's HCP Initiative website.[4] These informational meetings provided an opportunity for two-way dialogue between the public, stakeholders, department staff, and consultants to share concerns and ideas for improvement regarding conservation strategies and the overall content of the HCP. A summary of all stakeholder meetings is located in Appendix B.

1.5 Document Organization

This HCP and supporting information are presented in the following chapters and appendices.

- Chapter 1, *Introduction*, discusses the background, purpose, and objectives of the HCP; reviews the regulatory setting; and summarizes the planning process.
- Chapter 2, *Environmental Setting*, describes the existing conditions of the plan area relevant to the HCP, including overview of covered species.
- Chapter 3, *Covered Activities*, describes the activities covered under the HCP.
- Chapter 4, *Conservation Strategy*, summarizes the conservation strategy and describes the specific conservation actions to be implemented to mitigate the impacts of the covered activities. The chapter also describes the specific surveys and other actions required of all covered activities to avoid and minimize impacts on covered species, consistent with federal regulations.
- Chapter 5, *Effects Analysis and Level of Take*, presents the impacts of the covered activities.
- Chapter 6, *Monitoring and Adaptive Management*, describes the monitoring and adaptive management program.
- Chapter 7, *Assurances*, details the administrative requirements associated with HCP implementation and the roles and responsibilities of ODF and the Services. It also describes the regulatory assurances provided to ODF as well as the procedures for modifying or amending the HCP.
- Chapter 8, *Implementation*, details the administrative requirements associated with HCP implementation and the roles and responsibilities of the permittee and Services.
- Chapter 9, *Costs and Funding*, reviews the costs associated with HCP implementation and the funding sources proposed to pay those costs.
- Chapter 10, *Alternatives to Take*, describes the alternatives considered that would reduce take on one or more of the covered species, and why those alternatives were rejected.

[4] https://www.oregon.gov/ODF/AboutODF/Pages/HCP-initiative.aspx

- Chapter 11, *References,* lists all of the sources cited in the HCP in alphabetical order.
- Appendix A, *Glossary*, provides definitions for technical terms used in the HCP.
- Appendix B, *Stakeholder Engagement*, provides summary of stakeholder engagement during the HCP development process.
- Appendix C, *Species Accounts*, provides detailed ecological accounts of all covered species, including models of habitat distribution that were developed for select species.
- Appendix D, *Species Considered for Coverage*, provides details on which species were considered for coverage, which were selected, and why.
- Appendix E, *Effects Analysis*, provides detailed modeling data/results to support the effects analysis.
    - Fish Limiting factors table
    - Temperature protection memo
    - Frequency table
    - Terrestrial Modeling Information
- Appendix F, *Habitat Conservation Area Maps*, provides detailed maps of the habitat conservation areas that will be maintained under the HCP.
- Appendix G, *Hydrologic Unit Code 10 Analysis*, provides a detailed low flow analysis by HUC 10 watershed
- Appendix H, *ODF Roads Manual,* provides guidance and standards for road management in the permit area.
- Appendix I, *Potentially Unstable Slope Evaluation,* provides detailed description for how steep slopes are assessed and managed.
- Appendix J, *Habitat Conservation Area Management Decision-Making Process*, provides a graphic showing decisions that will be made by biologists and foresters inside habitat conservation areas during management activities.
- Appendix K, *Fish Passage Design Criteria*, provides fish passage design criteria.
- Appendix L, *Forest Matrix,* provides an overview of stand age inside and outside HCAs over the course of the permit term.

Chapter 2
Environmental Setting

2.1 Introduction

This chapter describes the existing conditions of the plan area. The plan area encompasses approximately 722,676 acres and includes all Oregon Department of Forestry (ODF)-managed lands, and potential land acquisitions or exchanges in western Oregon identified by ODF district plans. The plan area spans 17 counties; generally, from north to south they are: Clatsop, Columbia, Tillamook, Washington, Yamhill, Polk, Marion, Clackamas, Lincoln, Benton, Linn, Lane, Douglas, Coos, Curry, Josephine, and Jackson (Table 2-1).

The plan area is not evenly distributed among the 17 counties or in different regions of western Oregon. Approximately 65% of the plan area is found in only two counties: Tillamook and Clatsop. Approximately 80% of the plan area is found in only four counties: Tillamook, Clatsop, Washington, and Lane (Table 2-1a and 2-1b).

Table 2-1a. Plan Area by County and Ecoregion (approximate acres)

	Ecoregion				
County	**Coast Range**	**West Cascades**	**Klamath Mountains**	**Willamette Valley**	**Total (Percent)**
Tillamook	312,654	--	--	--	312,654 (43.3)
Clatsop	162,492	--	--	--	162,492 (22.5)
Washington	50,363	--	--	5,641	56,004 (7.7)
Lane	40,320	833	--	1,479	41,799 (5.8)
Linn	--	27,706	--	64	27,770 (3.8)
Lincoln	25,046	--	--	--	25,046 (3.5)
Marion	--	24,610	--	4	24,614 (3.4)
Douglas	2,874	--	11,697	--	14,571 (2.0)
Polk	11,782	--	--	--	11,782 (1.6)
Benton	10,120	--	--	128	10,248 (1.4)
Coos	10,441	--	--	--	10,441 (1.4)
Clackamas	--	8,421	--	--	8,421 (1.2)
Columbia	6,464	--	--	--	6,464 (0.9)
Josephine	--	--	6,489	--	6,489 (0.9)
Jackson	--	--	1,616	--	1,616 (0.2)
Curry	189	--	1,161	--	1,350 (0.2)
Yamhill	80	--		--	80 (<0.1)
Total (Percent)	**632,826 (87.6)**	**61,571 (8.5)**	**20,963 (2.9)**	**7,316 (1.0)**	**722,676**

Table 2-1b. Permit Area by County and Ecoregion (approximate acres)

	Ecoregion				
County	Coast Range	West Cascades	Klamath Mountains	Willamette Valley	Total (Percent)
Tillamook	302,949	--	--	--	302,949 (47.3)
Clatsop	147,064	--	--	--	147,064 (23.0)
Washington	41,408	--	--	5,375	46,783 (7.3)
Lane	23,781	532	--	944	25,257 (3.9)
Linn	--	21,187	--	41	21,228 (3.3)
Lincoln	20,004	--	--	--	20,004 (3.1)
Marion	--	18,985	--	4	18,989 (3.0)
Douglas	2,203	--	8,286	--	10,489 (1.6)
Polk	7,734	--	--	--	7,734 (1.2)
Benton	8,847	--	--	50	8,897 (1.4)
Coos	7,889	--	--	--	7,889 (1.2)
Clackamas	--	7,268	--	--	7,268 (1.1)
Columbia	6,464	--	--	--	6,464(1.0)
Josephine	--	--	6,425	--	6,425 (1.0)
Jackson	--	--	1,616	--	1,616 (0.3)
Curry	189	--	1,161	--	1,350 (0.2)
Yamhill	80	--	--	--	80 (<0.1)
Total (Percent)	**568,614 (89)**	**47,972 (7)**	**17,488 (3)**	**6,413 (1)**	**640,487**

Ecoregions are used as an organizing principle throughout the chapter to describe the plan area. Ecoregions are defined by biotic, abiotic, terrestrial, and aquatic ecosystem components, making them a useful tool to understand the physical and biological setting in different parts of the plan area. The geology, soils, vegetation, climate, land use, amount of solar radiation, and precipitation are all factors that influence how forest develops across western Oregon and what species it supports.

The plan area overlaps four ecoregions: Coast Range, West Cascades, Klamath Mountains, and Willamette Valley (Figure 2-1 and Table 2-1a/b).

- The **Coast Range ecoregion** includes the Oregon coastline and extends east through coastal forests to the border of the Willamette Valley and Klamath Mountains ecoregions.
- The **West Cascades ecoregion** extends from just east of the Cascade Mountains' summit to the foothills of the Willamette, Umpqua, and Rogue Valleys, and spans the entire north–south length of the state of Oregon, from the Columbia River to the California border.
- The **Klamath Mountains ecoregion** covers much of southwestern Oregon, including the Umpqua Mountains, Siskiyou Mountains, and interior valleys and foothills between these and the Cascade Range.
- The **Willamette Valley ecoregion** is an alluvial plain with scattered groups of low basalt hills that is bound on the west by the Coast Range and on the east by the Cascade Range (Oregon

Department of Fish and Wildlife 2016). The attributes of the western edge of the Willamette Valley ecoregion, where future land acquisitions or exchanges might occur, are similar to those described for the Coast Range ecoregion.

As shown in Table 2-1a, the majority of the plan area (87.6%) occurs in the Coast Range ecoregion. Smaller fractions of the plan occur in three other ecoregions: West Cascades (8.5%), Klamath Mountains (2.9%), and Willamette Valley (1%).

The environmental setting of the plan area summarizes the history of the forest, including pivotal natural events that have shaped the forest that exists today.

2.2 History of the Forest by Ecoregion

Oregon state forests were shaped by a few key natural events, in particular fire and storms. Fire and storm history not only influences the ecology of forests today, but also helps explain the current patterns of forest ownership. A brief history of major fires and other natural events, and the establishment of each state forest, is provided in this section. Additional history of northwestern Oregon state forests and disturbances can be found in Appendix H of the Northwest Oregon State Forests Management Plan (Oregon Department of Forestry 2010a).

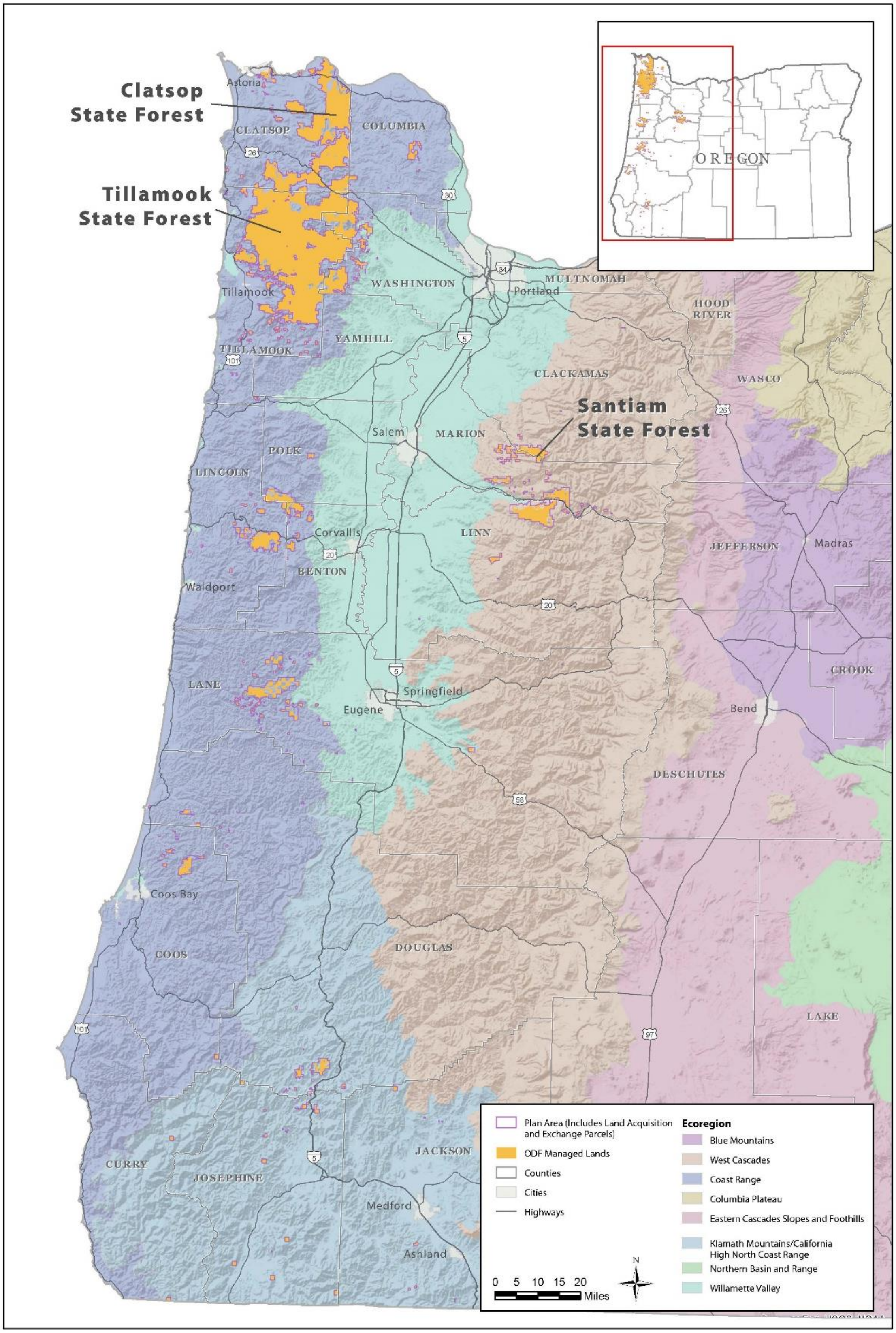


Figure 2-1. Plan Area, Permit Area, and Ecoregions

2.2.1 State Forestlands in the Coast Range Ecoregion

The permit area includes 568,614 acres of lands in the Coast Range ecoregion. Like the ecoregion itself, these state forestlands span the entire north–south length of the state, from Clatsop and Columbia Counties in the north to Curry County in the south. There are three notable state forests in the Coast Range ecoregion: the Clatsop State Forest, Tillamook State Forest, and Elliott State Forest. The histories of the Clatsop and Tillamook State Forests are described in more detail in Sections 2.2.1.1, *Clatsop and Columbia Counties*, and 2.2.1.2, *Tillamook and Washington Counties*. The Elliott State Forest is largely excluded from this Habitat Conservation Plan (HCP), except for a few Board of Forestry parcels that are managed as part of the Southern Oregon State Forests; thus, the Elliott State Forest is not described in detail. Table 2-1b summarizes state forestlands by county in the coastal range ecoregion. Most of these lands are found in Clatsop and Tillamook Counties in northwest Oregon and are associated with the Clatsop and Tillamook State Forests.

2.2.1.1 Clatsop and Columbia Counties

Clatsop and Columbia Counties contain approximately 153,528 acres of ODF-managed lands in the permit area. Most of the state forestlands in these two counties are part of Clatsop State Forest. The Clatsop State Forest is 98% Board of Forestry lands. The remaining 2% of the Clatsop State Forest is Common School Fund land owned by the Department of State Lands but managed by ODF. These lands were originally privately owned and logged between 1910 and 1940, and then became tax-delinquent. A large portion of the forest in southern Clatsop County burned in one of the Tillamook Burn events. Clatsop and Columbia Counties foreclosed on these lands when landowners could not pay their taxes, and ownership reverted to the county. Many landowners lost their land during the Great Depression. In 1939 Clatsop County became the first county in Oregon to deed its logged and unmanaged forestlands to the Board of Forestry to manage as a state forest. Columbia County first deeded lands to the Board of Forestry in 1942. According to the deed agreement, ODF would replant the lands, protect them from fire, and manage the new forest.

Today, Clatsop State Forest consists primarily of Douglas-fir, from 40 to 80 years old. The state forest has been progressively consolidated through a land exchange program that began in the mid-1940s. District staff are still actively pursuing land exchanges, working on a priority list of mutually beneficial exchanges with several private landowners in the area.

2.2.1.2 Tillamook and Washington Counties

Tillamook and Washington Counties contain 344,357 acres of ODF-managed lands in the permit area. Nearly all of that area is associated with the Tillamook State Forest. Much of the area that is now Tillamook State Forest burned in a series of major wildfires during the twentieth century. The first and biggest Tillamook Fire burned 240,000 acres of mostly old growth forest in August 1933. This massive wildfire ignited during a logging operation and spread rapidly as a result of a strong east wind event. New fires burned across the area every 6 years after that, in 1939, 1945, and 1951. Each fire burned some previously burned area and also consumed unburned forest (Figure 2-2). By the end of 1945, 355,000 acres had been burned at least once and 13.1 billion board feet of timber destroyed. Some areas had burned multiple times. Burned timber and snags were salvaged in an effort to reduce fuels and prevent future burns in the same area, resulting in a lack of legacy structure on the landscape. In many places the soil had been so severely burned that nothing grew there for many years. Streams and fisheries in these watersheds were severely affected by the loss of forest cover and the extensive erosion that occurred after the repeated fires.

Before 1933, almost all of the land that became the Tillamook Burn was privately owned. After the fires, many landowners allowed the forestlands to be foreclosed by the counties rather than pay taxes on land that no longer generated any income from timber harvest. Counties began to deed land in the Tillamook Burn to the Board of Forestry in 1940. Eventually, Tillamook and Washington Counties deeded about 255,000 acres to state ownership. Of the remaining 100,000 acres in the Tillamook Burn, most is owned by private timber companies and the Bureau of Land Management. In June 1973, the Tillamook State Forest was dedicated. The 364,000-acre Tillamook State Forest includes 255,000 acres from the Tillamook Burn (70% of the state forest), and other unburned forestland.

Salvage logging began after the 1933 fire and accelerated to meet the lumber demands of World War II. By 1948, 4 billion board feet of fire-destroyed trees had been recovered from the burn on state forestlands. An additional 3.5 billion board feet of fire-destroyed trees were removed from 1949 to 1955.

In 1948, Oregonians approved a bond issue to finance rehabilitation of the Tillamook Burn. ODF carried out a massive rehabilitation project in the burn area between 1948 and 1973. Over the next 24 years, tree planting crews planted 72 million Douglas-fir seedlings. In addition, 36 tons of Douglas-fir seeds were spread on the burn area through aerial seeding, pioneering the first use of helicopters in aerial seeding. Aerial seeding proved to be a mixed success in re-establishing Douglas-fir, with large patches of red alder pioneering significant portions of the landscape where Douglas-fir did not take hold. This effort was successful overall in reforesting and growing conifers in a denuded landscape that many thought would never grow trees again.

In recent years, Swiss needle cast (*Phaeocryptopus gaeumannii*), a native fungal disease, has increasingly affected Douglas-fir stands near the coast. The reasons for this are not fully known, but it may be connected to the widespread reforestation of the burn with Douglas-fir from other areas, which introduced a near-monoculture of trees poorly adapted to wet coastal conditions. Swiss needle cast stunts the growth of trees, in both diameter and height. Additional factors including climate change and severe damage to soils and nutrient pools from the fires may exacerbate the effects of the disease. ODF currently plants Douglas-fir derived from local seed sources that is selected for its resistance to Swiss needle cast, and is also exploring management strategies such as replacing severely affected Douglas-fir with other tree species. ODF is also a member of the Swiss Needle Cast Cooperative, which conducts research and assessments to better understand the disease and potential management options.

The first timber sale by ODF in the former Tillamook Burn, a commercial thinning, took place in 1983. Beginning a few years prior to adoption of the Northwest Oregon State Forests Management Plan in 2001, ODF has employed a variety of silvicultural strategies to improve both timber production and habitat. As the forest stands on this landscape continue to grow, there will be increasing opportunities to use silvicultural techniques to develop a diversity of stand structures for forest products, wildlife habitat, and other ecosystem services.

Today, ODF-managed lands in Tillamook and Washington Counties are predominantly Douglas-fir, from 60–80 years old.

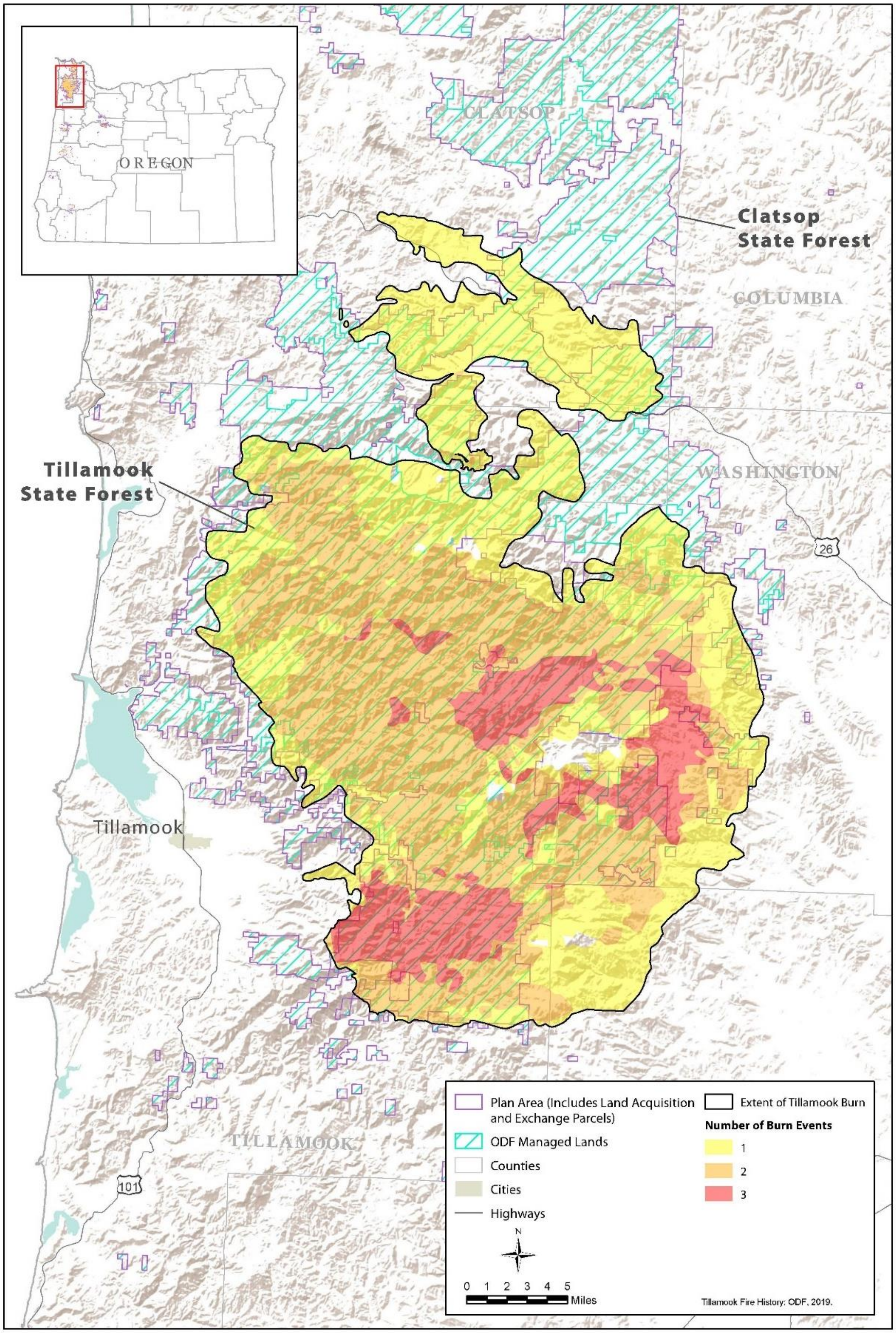


Figure 2-2. Tillamook Burn Fire History

2.2.1.3 Polk, Lincoln, and Benton Counties

Currently, there are approximately 36,585 acres of land in these three counties managed by ODF as the West Oregon District. Of that total, approximately 82% is Board of Forestry lands, and 18% is Common School Forest Lands.

During the Great Depression, most isolated farms in Polk, Lincoln, and Benton Counties were abandoned to the counties in place of back taxes. Some more desirable parcels of land were bought by T. J. Starker, John Thompson, and others who saw the lands' value for timber production. By the late 1930s, however, Benton, Lincoln, and Polk Counties had many parcels of land that they could not sell or manage. Between 1938 and 1948, most of this land was deeded to the Board of Forestry. During that same decade, several small parcels were also purchased by ODF. Between 1947 and 2011, ODF completed several land exchanges with private landowners. Today, ODF-managed lands in Polk, Lincoln, and Benton Counties are predominantly Douglas-fir, with a large component of stands from 20–60 years old and a wide distribution of stands from 70 to almost 200 years old.

2.2.1.4 Lane County

The Nelson Mountain Fire was one of many large fires in 1910 that motivated the State of Oregon to create ODF. The fire burned most areas that are now state forestlands in western Lane County. Large fires burned again in western Lane County in 1917 and 1922. In 1929, a number of large fires burned much of the central Coast Range in Lane County, covering nearly 80,000 acres. The fires burned some previously burned areas and burned some forests for the first time. With the timber gone, the Great Depression starting, and the land unsuitable for homesteading, many landowners allowed their land to revert to the county in place of back taxes. Lane County deeded its timberlands to the Board of Forestry between 1942 and 1958, managed as the Southern Oregon State Forests.

The land base remained constant for the next 50 years except for four small land exchanges in the 1950s and one in 1962. In the early 1990s, two larger exchanges reshaped state forestlands in the Southern Oregon State Forests by exchanging 25% of the acres. These exchanges increased the land base by 10% and started to consolidate state forestlands. Today, the 23,781 acres of state forestlands in the Southern Oregon State Forests are mostly covered by a 70- to90-year-old forest dominated by Douglas-fir, with some older stands ranging from 100 to 300 years old.

2.2.1.5 Douglas and Coos Counties

There are currently 10,092 acres of ODF-managed lands in the permit area in western Douglas and northern Coos Counties, mostly in scattered parcels around Common School lands that comprise the Elliott State Forest, which is owned and managed by the Department of State Lands. Douglas and Coos Counties donated some of their forestlands to the state.

Land exchanges have helped to consolidate some of these lands around the original exchanged Common School Forest Lands that comprised the Elliott State Forest. ODF no longer manages Common School Forest Lands in the Elliott State Forest, but still seeks to consolidate (block up) remaining Board of Forestry lands in Douglas and Coos Counties for more efficient management. State forestlands in these counties have been shaped by fire and wind. The principal wildfire event in this area occurred from September 15 to October 20, 1868. A high-intensity fire began a few miles northeast of Scottsburg, Oregon, and burned the coast from Lakeside to south of Coos Bay. The fire left few intact old-growth stands on the forest, although scattered residual trees and large stumps from this fire are still locally abundant and contribute to forest structure in the post-1868 stands. In addition, the Columbus Day storm on October 12, 1962, blew down an estimated 17 billion board feet of timber in western Oregon and Washington. Wind speeds associated with the storm are shown in Figure 2-3.

Today, ODF-managed lands in Douglas and Coos Counties are predominantly Douglas-fir, with the majority of forests ranging in age from 30–60 and 80–174 years old.

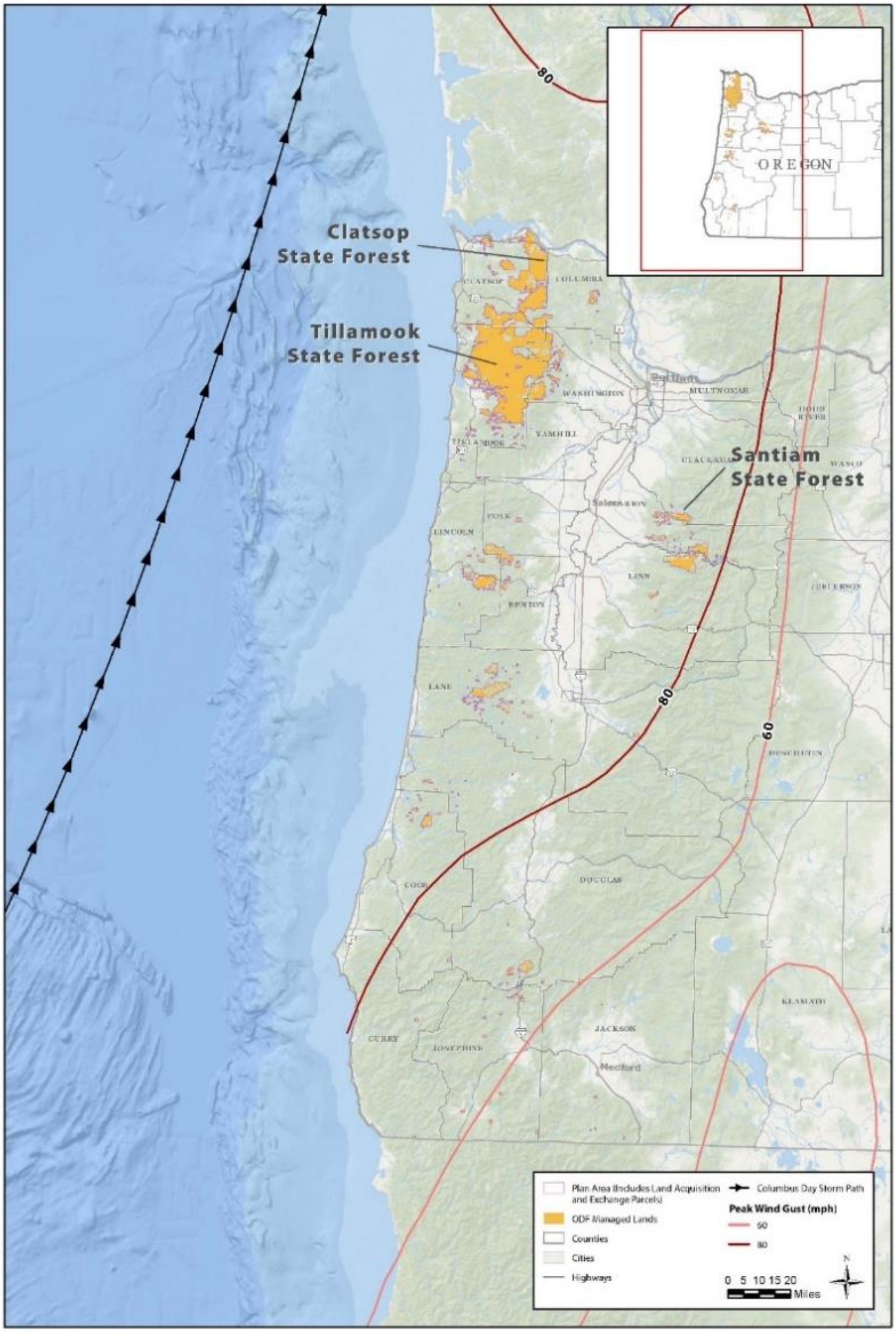


Figure 2-3. Columbus Day Storm

2.2.2 State Forestlands in the West Cascades Ecoregion

2.2.2.1 Clackamas, Marion, Linn, and Lane Counties

There are 47,972 acres of ODF-managed lands in the permit area in Clackamas, Marion, and Linn Counties. Much of the land now in the Santiam State Forest used to be owned by large timber companies, who typically also owned railroad assets for the transportation of logs and wood products. Some individuals and families also owned forestland. From about 1880 until 1930, most lands were logged. These lands were of little value to the owners once the timber was removed, so they were left unmanaged after clearcuts. As a result, forest fires burned large areas of young, dense forests that developed following the extensive logging. During the Great Depression, many landowners allowed their forestlands to be seized by Marion, Clackamas, and Linn Counties in place of back taxes.

The counties eventually deeded these lands to the Board of Forestry. State forestlands in Linn County was acquired by the Board of Forestry between 1939 and 1949, Marion County lands were acquired between 1940 and 1953, and Clackamas County lands between 1942 and 1950. Some land was also acquired from individuals through both charitable donations and purchases between 1943 and 1952. There were additional land exchanges completed between 1945 and 1968 in Linn and Marion Counties. Lands in these counties are managed by the North Cascade District.

Natural regeneration successfully reforested most of the Santiam State Forest. However, a fire in 1951 burned nearly half of the forest, and ODF replanted the most damaged areas. The Santiam State Forest was dedicated in 1974.

Today, ODF-managed lands in Clackamas, Marion, Linn, and Lane Counties are a mix of Douglas-fir and mixed conifer, generally from 60–90 years old but with some stands older than 90 years.

2.2.3 State Forestlands in the Klamath Mountains Ecoregion

2.2.3.1 Curry, Josephine, Jackson, and Douglas Counties

There are 17,488 acres of ODF-managed lands in the permit area in Curry, Josephine, Jackson, and southern Douglas Counties. The lands in southern Douglas and northern Josephine Counties are known as the Glendale block and comprise most of the plan area in these counties. Oregon counties sold forestlands to private timber companies or individuals to keep them on the tax rolls, or kept them to be managed as county forests. Later, parcels of private lands were purchased or donated to become state forests. In 1944, the Windy Creek property near the town of Glendale was deeded to the Board of Forestry, along with a few other parcels, for a total of about 3,600 acres.

The remaining acreage are in small, scattered parcels throughout the counties. Similar to the lands in other parts of Douglas County and Coos County, some of these lands were donated to the state. Some counties sold forestlands to private timber companies or individuals to keep them on the tax rolls or kept them to be managed as county forests. In southwest Oregon, ODF has a goal to consolidate state forests in the Glendale block through land exchanges or purchases.

Historically this area experienced low-intensity, high-frequency burns. Through fire suppression the area burned by these frequent fires was greatly reduced, increasing the amount of available fuels on the forest floor. As a result of these suppression efforts, fuels management is a primary concern in managing these lands to reduce the potential for large-scale fires. Today, ODF-managed lands in

Curry, Josephine, Jackson, and Douglas Counties are a mix of Douglas-fir and mixed conifer that are predominantly 80–120 years old.

2.2.4 State Forestlands in the Willamette Valley Ecoregion

There are approximately 6,413 acres (1%) of ODF-managed lands in the permit area in the Willamette Valley ecoregion (Table 2-1b) scattered in small parcels in five counties: Benton, Lane, Linn, Marion, and Washington Counties. The majority of these lands are located along the western border of the Willamette Valley ecoregion adjacent to the Coast Range ecoregion. The remaining acres are along the eastern border of the Willamette Valley ecoregion, adjacent to the West Cascades ecoregion. ODF-owned lands are predominantly Douglas-fir that are 60–80 years old. These lands were acquired during the same time periods as described for the counties in previous sections.

2.2.5 Oregon Forests Regional Planning

Several HCPs and other regional conservation plans are being implemented in western Oregon. These HCPs and conservation plans are potential sources of conservation actions and provide conservation context for the goals, objectives, and strategies included in this HCP. In addition, this plan may, during implementation, overlap with these HCPs and other conservation plans if they share covered species and occur on nearby lands.

2.2.6 Oregon Plan for Salmon and Watersheds

The mission of the Oregon Plan for Salmon and Watersheds (State of Oregon 1997) is to restore native fish populations and the aquatic ecosystems that support them to productive and sustainable levels, which will provide substantial environmental, cultural, and economic benefits. The Oregon Plan for Salmon and Watersheds organizes specific actions around factors that contribute to the decline in fish populations and watershed health, and focuses on improvement of water quality and quantity and habitat restoration. Private citizens, community organizations, special interest groups, and all levels of government may organize, fund, and implement the measures in this plan.

The Oregon Plan for Salmon and Watersheds includes four elements, including the following:

- Voluntary restoration actions by private landowners.
- Coordinated state and federal agency and tribal actions.
- Monitoring watershed health, water quality, and salmon recovery.
- Strong scientific oversight by the plan's Independent Multidisciplinary Science Team.

2.2.7 Oregon Conservation Strategy

The Oregon Conservation Strategy is a state-wide program managed by the Oregon Department of Fish and Wildlife (ODFW) that identifies key conservation issues, priorities, and strategies to maintain healthy fish and wildlife populations (ODFW 2016). Information in the Oregon Conservation Strategy was used as an initial filter for covered species selection. It was also used to inform species-specific strategies, including the following:

- Ecoregions used in the Oregon Conservation Strategy were used as the geographic basis for conservation planning in the HCP.
- Species and habitat conservation needs were identified and applied as applicable in developing goals, objectives, and conservation actions for the HCP.

2.2.8 Northwest Forest Plan

The 1994 U.S. Forest Service (USFS) Northwest Forest Plan (NWFP) (USDA and USDI, 1994) drew from best available science at the time (Thomas et al. 1990) and included strategies for conservation and restoration on federal lands, as well as mechanisms for subsequent research, learning, and adaptive management. Key elements of the NWFP include adoption of an ecosystem management approach, land use designations, an emphasis on effective consultation with over 70 federally recognized tribes and consideration of treaty rights, new monitoring programs, and adaptive-management measures.

2.2.8.1 NWFP Land Allocations

The NWFP structure includes the creation of a regional set of land allocations, each with associated management standards and guidelines (Table 2-2). The allocation includes a network of Late Successional Reserves (LSRs) designed to meet the habitat requirements of the northern spotted owl, marbled murrelet, and other species closely associated with late-successional forest, and Riparian Reserves to meet the habitat requirements of salmonids. Of particular importance to this HCP is that no federal lands or associated LSRs or Riparian Reserves are located in the northern portion of the Oregon Coast Ecoregion, meaning that state forest lands are of more importance to the persistence of covered species in this area than in other parts of coastal Oregon where these federal reserve lands are designated. Other portions of the permit area are located adjacent to federal lands, so the conservation strategy has been developed to align with federal conservation efforts in these areas.

Under the standards and guidelines of the NWFP, a management assessment is prepared for each large LSR (or group of smaller LSRs) before habitat manipulation activities can be designed and implemented. These LSR assessments were considered when evaluating the conservation strategy for permitted lands near LSRs.

Table 2-2. Northwest Forest Plan Allocations

Land Allocation	Original Acres	Percentage of Federal Lands	Description
Congressionally Reserved Areas	7,320,600	30	Lands reserved by the U.S. Congress such as wilderness areas, wild and scenic rivers, and national parks and monuments.
Late-Successional Reserves	7,430,800	30	Lands reserved for the protection and restoration of Late-Successional/Old-Growth forest ecosystems and habitat for associated species, including marbled murrelet reserves and northern spotted owl activity core reserves.
Managed Late-Successional Areas	102,200	<1	Areas for the restoration and maintenance of optimum levels of old growth stands on a landscape scale, where regular and frequent wildfires occur. Silvicultural and fire hazard reduction treatments are allowed to help prevent older forest losses from large wildfires or disease and insect epidemics.
Administrative Withdrawn Areas	1,477,100	6	Areas identified in local forest and district plans; they include recreation and visual areas, back country, and other areas where management emphasis does not include scheduled timber harvest.
Adaptive Management Areas–reserved	1,521,800 (combined reserved/non-reserved)	6	Identified to develop and test innovative management to integrate and achieve ecological, economic, and other social and community objectives. Emphasis on restoration of late-successional forests and managed as an LSR.
Adaptive Management Areas–nonreserved			Same as reserved Adaptive Management Areas but with some commercial timber harvest expected to occur with ecological objectives.
Riparian Reserves	2,627,500	11	Protective buffers along streams, lakes, and wetlands designed to enhance habitat for riparian-dependent organisms, provide good water-quality dispersal corridors for terrestrial species, and provide connectivity within watersheds.
Matrix	3,975,300	16	Federal lands outside of reserved allocations where most timber harvest and silvicultural activities occur.

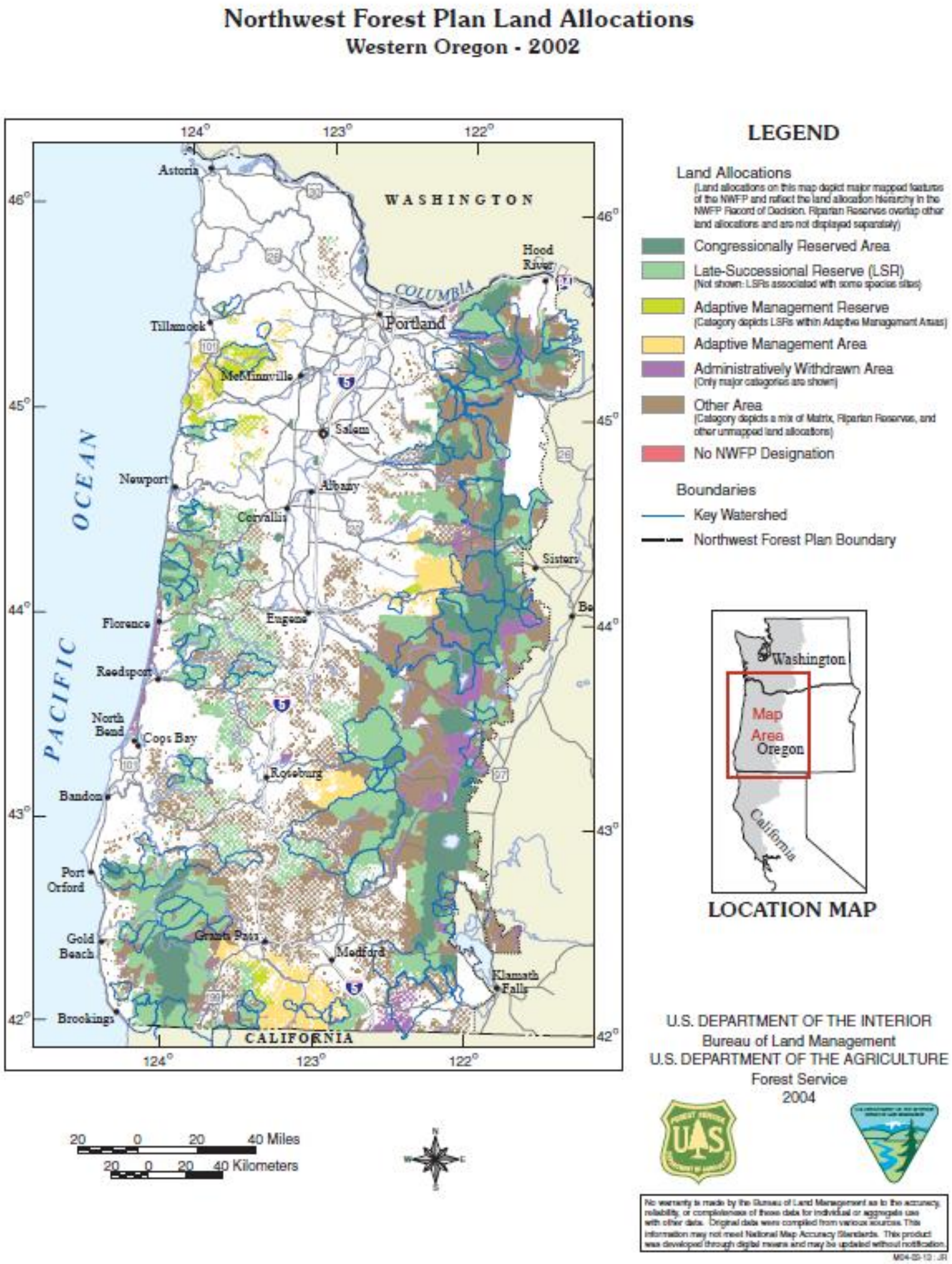


Figure 2-4. Northwest Forest Plan Allocations in Oregon

2.2.8.2 NWFP Effectiveness Monitoring

The Effectiveness Monitoring program initiated by the NWFP is used to assess progress towards meeting habitat requirements for species associated with late-successional forest, including northern spotted owl and marbled murrelets. Because the NWFP is a major component of recovery strategies for species to be covered under the HCP, the effectiveness monitoring provides important information that was used to determine the extent and area-specific needs for this HCP.

The 2018 NWFP Science Synthesis (Spies et al 2018) summarizes the results of effectiveness monitoring and provides a comprehensive overview of the science accumulated in the 24 years since the NWFP was first implemented. The purpose of the NWFP Science Synthesis is to provide resource managers with a scientific basis for assessment and updates to forest plans in the NWFP area. The NWFP Science Synthesis was prepared by request to inform the revision of land and resource management plans for 17 national forests in the footprint of the NWFP in Washington, Oregon, and northern California.

The conservation strategy of the HCP was greatly informed by the science presented in the science-synthesis, including information related to the biological needs, threats, and management recommendations for covered species, particularly covered fish, marbled murrelet, and northern spotted owl.

Effectiveness monitoring for marbled murrelets has included annual at-sea surveys that monitor marbled murrelet populations in the near-shore marine waters of Washington, Oregon, and northern California (McIver 2019).

2.2.9 Elliott State Forest HCP

The Elliott State Forest HCP is currently being developed by the Oregon Department of State Lands (DSL). The Elliott State Forest consists of forested Common School Lands (84,120 acres) that are overseen by the State Land Board and managed by DSL. There are 8,868 acres of Board of Forestry Land (BOFL) in and around the Elliott State Forest that are overseen by the State Board of Forestry and managed by ODF. The Elliott HCP plan area includes both types of land (Common School Forest Lands [CSL] and BOFL). The Elliott State Forest HCP and the associated incidental take permits will cover DSL's land management activities, which include activities similar to those covered in the Western Oregon State Forests HCP. The BOFL in and around the Elliott State Forest will be covered under this HCP.

The Elliott State Forest HCP proposes to cover three species, all of which are proposed for coverage under this plan: Oregon Coast coho salmon, northern spotted owl, and marbled murrelet. DSL is developing the HCP in close collaboration with Oregon State University.

2.2.10 Weyerhaeuser-Millicoma Tree Farm HCP

The Weyerhaeuser-Millicoma Tree Farm HCP includes covered lands located in Coos and Douglas Counties, covering 208,000 acres, and was established in February 1995 under a 50-year permit. The Weyerhaeuser-Millicoma Tree Farm HCP is adjacent to the Elliott State Forest and some ODF lands. This HCP provides protection for existing northern spotted owl nesting sites while also allowing for tree harvest in northern spotted owl home range. Under this HCP approximately 17,000 acres of land may be harvested in northern spotted owl nesting habitat, though with a greater amount of land being maintained in spotted owl dispersal habitat. This plan protects existing northern spotted owl nesting sites and dispersal habitats over a large landscape.

2.2.11 Candidate Conservation Agreement with Assurances for the Fisher in Oregon

A programmatic/template Candidate Conservation Agreement with Assurances (CCAA) was established in April 2017, for the fisher (*Pekania pennanti*) in western Oregon between the U.S. Fish and Wildlife Service (USFWS) and voluntarily participating non-federal landowners and managers. The enrollment areas cover the west coast distinct population segment (DPS) of fisher in Oregon over a 30-year permit term. On September 27, 2019, ODF enrolled approximately 183,932 acres of BOFL within the fisher's range; the permit expires June 20, 2048. ODF will implement the CCAA conservation measures on all enrolled lands to meet the CCAA standard. This CCAA aims to expand understanding of fisher distribution, densities, and forest-management activities; promote conservation measures and remove threats to the species; provide a voluntary recovery effort; and provide enrolled landowners assurances that they will not be held responsible for additional conservation measures if the fisher becomes ESA listed.

2.3 Physical Setting

This section describes the physical setting of the plan area including topography, geology, soils, hydrology, climate and watersheds by ecoregion. The physical setting descriptions are from the Northwest Oregon State Forests Management Plan (Oregon Department of Forestry 2010a) and the Southwest Oregon State Forests Management Plan (Oregon Department of Forestry 2010b) unless otherwise cited. Table 2-3 summarizes the physical setting of the permit area.

2.3.1 Physical Setting Overview

2.3.1.1 Geology and Topography

The geologic history and formations of Western Oregon continue to shape environmental conditions upon which forests grow. Topography, including elevation, slope, and aspect, have a major influence on forest growth and can affect temperature, sun exposure, soil moisture, and precipitation. Topography also affects the costs and feasibility of timber sales, as steeper slopes can increase costs or even make timber harvest commercially or environmentally infeasible.

2.3.1.2 Soils

Soil is a complex material made of decomposed and fragmented mineral rock, water, plant nutrients, organic material, and air and other gases in the spaces between mineral grains. The organic material consists of living, dead, and decomposed plants and animals. Forest site productivity is controlled by the soil depth, porosity, biology, and the availability of nutrients in the soil. All these factors are influenced by soil type.

Dynamic processes such as forest succession, tree and shrub species composition and abundance, wind, and fire affect the accumulation of organic matter in the soil. The amount and composition of organic matter affect soil fertility. Small materials such as needles and twigs have the highest concentration of nitrogen. Large materials such as down trees are important because they influence soil accumulation, nutrient availability, and soil nutrient availability and soil moisture.

Landslides are the dominant erosional process in the mountainous terrain of the northwestern state forests in the Coast Range and Klamath Mountains. Large, deep-seated slides can alter huge expanses over long time periods and may be influenced by a few of this HCP's covered activities. Shallow, rapidly moving landslides, known as debris flows, are the most frequent and noticeable type of slide. They can originate in headwalls or elsewhere on mountain slopes when soils on steep slopes become saturated and lose strength. Slides can occur in areas with no forest management activity, although slide frequency can increase due to recent harvest, natural disturbances, or road construction and drainage.

2.3.1.3 Climate and Climate Change

Temperatures across much of the plan area are moderated by coastal influence, especially for portions of the plan area on the west slope of the Coast Ranges. Summer temperatures are higher for the eastern slope of the Coast Ranges, Willamette Valley and western slope of the Cascades, and markedly higher for portions of the plan area in the Klamath Mountains Ecoregion (Figure 2-5).

During the twentieth century the average annual temperature in Western Oregon has increased by 1.6°F (0.9°C), with winter experiencing the greatest increase of 3.3°F (1.8°C) (Reilly et al. 2018). Oregon is projected to continue to warm between 4 and 9°F (2.2 and 5°C) by 2100, with an increase in hot days per year across most of the state (Mote et al. 2018). Oregon's coastal areas are expected to warm about 0.4°F (0.2°C) per decade, the rest of western Oregon around 0.7°F (0.4°C) per decade (Mote et al. 2018). Warming is projected to occur across all seasons, with the greatest increase occurring during summer months (Reilly et al. 2018).

Climate is fairly consistent across the plan area except for precipitation, which varies considerably from north to south and west to east (Figure 2-6) and creates a dramatic influence on forest conditions (Reilly et al. 2018) and habitat value for covered species. In addition to general regional variation in precipitation, summertime storm activity is distinctly different, with the northern Coast Range receiving relatively little lightning activity compared to the Klamath and western Cascades.

The variation in rainfall across the plan area is expected to increase over time with climate change. Projected changes in precipitation are uncertain (Reilly et al. 2018), but models generally project an increase in winter precipitation falling as rain instead of snow and a decrease in summer precipitation (Mote et al. 2018). Extreme precipitation may change more in eastern Oregon than western Oregon by mid-century. Heavy precipitation from warming and shifts in seasonal patterns, as well as rain on snow events, can shift the timing of seasonal streamflows and increase flooding (Reilly et al. 2018). Previously snow-dominated regions are likely to see an increase in winter flooding as a result of rapid rain runoff and reductions in summer flows (by up to 50%) due to the reduction in spring snowmelt (Mote et al. 2018).

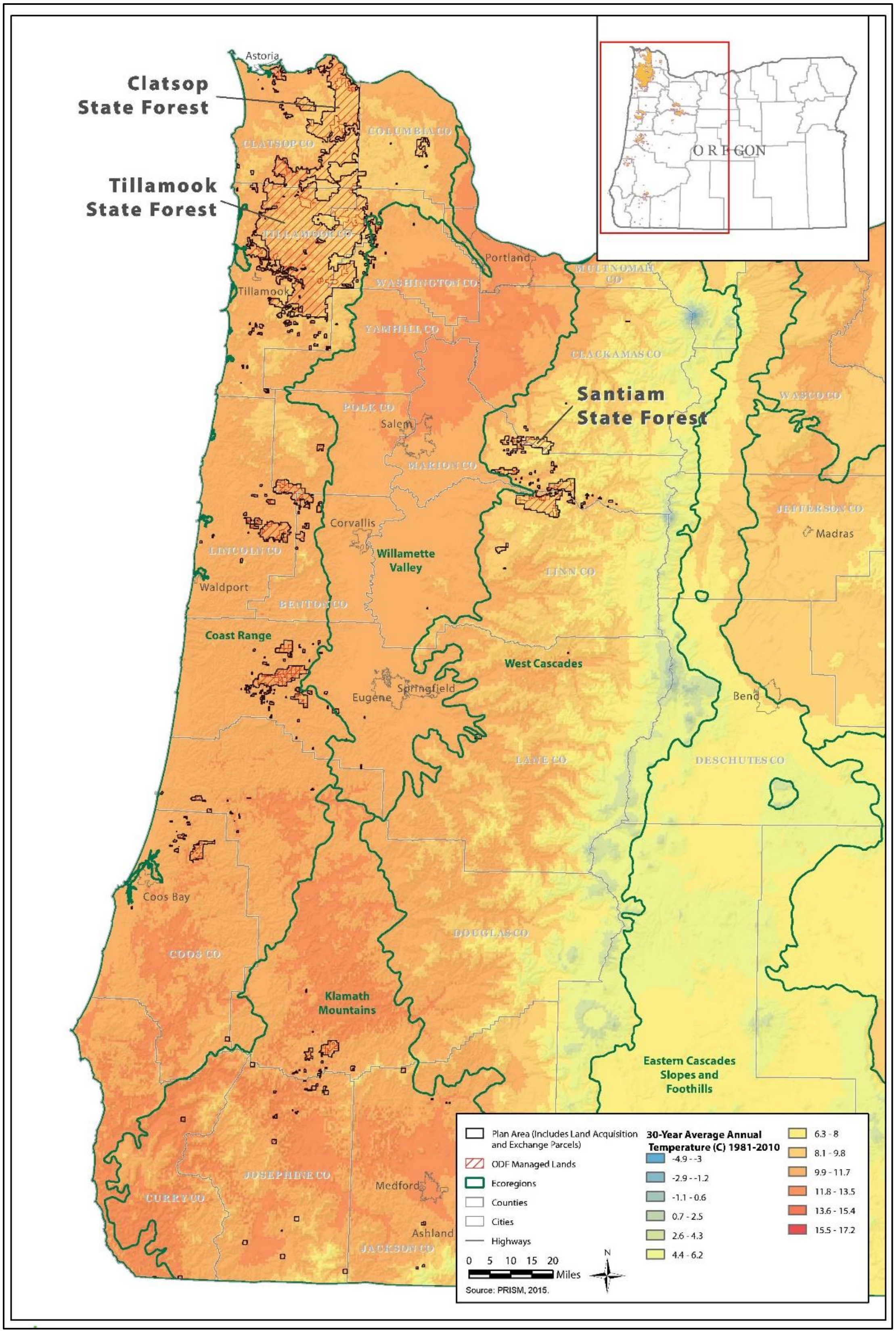


Figure 2-5. 30-Year Average Annual Air Temperature in Plan Area

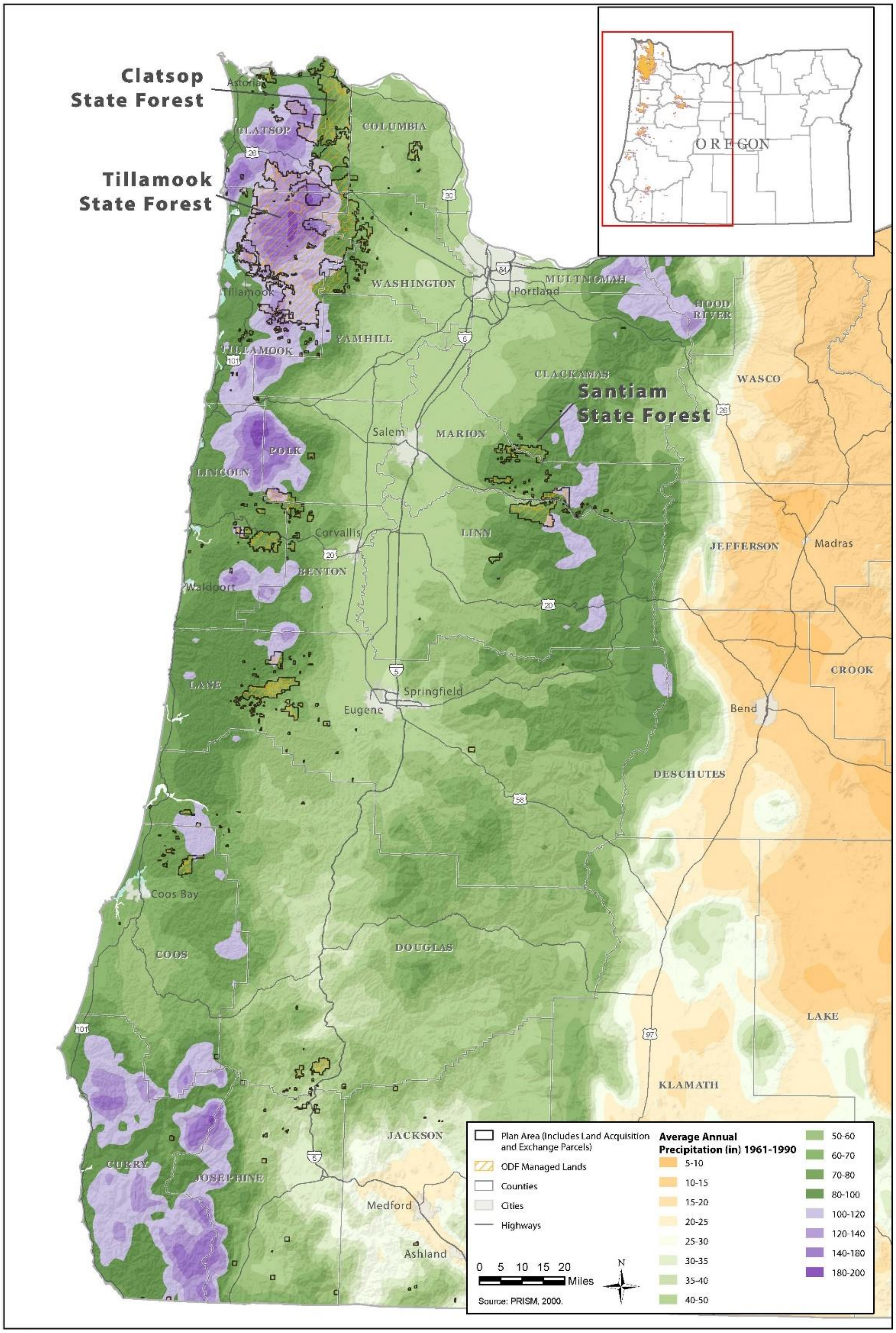


Figure 2-6. Average Annual Precipitation in Plan Area

Temperature and precipitation differences result in different moisture recovery rates for forest fire fuels, especially during summer and early autumn. In addition to this general regime, daytime and nighttime temperature differences between the ocean and eastern Oregon desert create strong, dry afternoon and evening east winds from early to mid-autumn. This can delay nighttime moisture recovery in forest fuels that might be expected in the absence of these winds. These differences in both temperature and precipitation produced starkly contrasting wildfire regimes prior to European settlement. Coast Range wildfire events tended to be infrequent, allowing forest fuel loads to build to levels that supported stand-replacing events over very large areas. Fire regimes in the western Cascades and Klamath ecoregions were more frequent, preventing fuel buildup, with less risk of stand-replacing events.

Climate change could directly and indirectly alter vegetation. The response of tree growth to climate change would vary by species and factors limiting their growth (Reilly et al. 2018). Overall, indirect effects such as frequency, severity, and extent of disturbance (e.g., drought, fire, pathogens) are expected to cause greater change than direct effects (e.g., CO_2 and climate on vegetation [Reilly et al. 2018]). The southern portion of the plan area in the Western Cascades and coastal and inland areas of the Klamath Mountains have the greatest vulnerability to climate change due to the greatest projected increase in the water-balance deficit[1] (Reilly et al. 2018).

2.3.1.4 Major River Basins

The United States Geological Survey has adopted a classification system for water resources over the continental United States. This system defines a nested series of “hydrologic units” that range from a larger “region” (21 total in the United States) to a smaller “sub-watershed.” Each hydrologic unit is identified by a unique hydrologic unit code (HUC). Using this scheme, the plan area falls within four subregions (HUC-6): Lower Columbia, Northern Oregon Coastal, Southern Oregon Coastal, and the Willamette. Streams within these subregions drain directly into either the Pacific Ocean, Columbia River, or Willamette River.

The plan area occurs in the North Coast, Mid Coast, South Coast, Willamette, Umpqua, and Rogue basins. Within each basin are smaller subbasins or HUC areas, which are further described in Section 2.3.2, *Physical Setting by Ecoregion*.

2.3.1.5 Hydrology and Water Quality

Streams in Oregon are grouped by the Forest Practices Act into the following categories based on their beneficial use (Oregon Administrative Rules 629-600-0100 and 629-635-0200). Streams are classified based on fish or domestic use, size, and flow duration.

Fish Use:

- **Type F:** Fish-bearing streams. These are streams and waterbodies that are known to be used by fish or meet the physical criteria to be potentially used by fish. Fish-bearing streams may or may not have flowing water all year; they may be perennial or seasonal. Type F streams also include a subcategory of “SSBT use” designations, which means a stream with salmon, steelhead or bull trout present or otherwise used by salmon, steelhead, or bull trout at any time of the year as determined by the State Forester (Rule 629-600-0100 Definitions).

[1] The difference between the atmospheric demand for water from vegetation and the amount of water actually available to use.

- **Type D:** Not a fish-bearing stream but in near proximity to a domestic water intake with an approved water right.
- **Type N:** Not a fish-bearing or domestic use stream.

Stream size: Streams are further classified by size as small, medium, or large based on estimated average annual flow. The following definitions apply to these size categories.

- **Small:** Average annual flow of 2 cubic feet per second (cfs) or less.
- **Medium:** Average annual flow greater than 2 cfs, but less than 10 cfs.
- **Large:** Average annual flow of 10 cfs or greater.

Flow Duration:

- **Perennial streams:** (defined as a stream that normally has surface flow after July 15) are streams that have flow year-round and may have spatially intermittent dry reaches downstream of perennial flow. These streams do not meet the physical criteria of a Type F stream. This also includes streams that have been proven not to contain fish.
- **Seasonal streams:** (defined as a stream that normally does not have summer surface flow after July 15) are streams that do not have surface flow during at least some portion of the year, and do not meet the physical criteria of a Type F stream. Some seasonal streams may have been proven to contain fish during the time they are flowing (see Type F, above).

Water that flows through state forestlands sustains ecosystems and provides for out-of-stream uses such as irrigation, domestic use, and municipal use. The Oregon Water Resources Department monitors stream flows, issues permits for water withdrawals from streams, and regulates water rights. Forest management activities influence water supply by affecting the age, species, and density of tree cover and other vegetation; the location and condition of roads; and the condition of the soil.

The Oregon Department of Fish and Wildlife (2019) (Appendix C) examines the status and trends of physical instream habitat conditions in across major land ownerships in western Oregon, including Board of Forestry Lands, from 1998 to 2018. The results of the Oregon Department of Fish and Wildlife's assessment elucidate habitat trends on Board of Forestry lands and helped to inform the aquatics analysis. The analysis compares trends on private forestland, agricultural land, and federal forestland, with trends on state forestlands across the following variables.

- Active channel width.
- Pool frequency.
- Channel shade.
- Fine sediment and fine sediment in riffles.
- Gravel.
- Large wood frequency and volume.
- Coho winter parr capacity (modeled—Habitat Limiting Factors Model).
- Substrate (%): Fine sediments, gravel, and bedrock.

- Channel morphology and pool habitat: % secondary channel, % pool, % deep pools.
- Wood: Volume, number of pieces, number of key pieces.
- Riparian: Shade, density of conifers by size class, as well as hardwoods by size class.

2.3.2 Physical Setting by Ecoregion

This section describes the physical setting of the plan area including location, topography, geology and soils, hydrology, climate and watersheds by ecoregion. The physical setting descriptions are from the Northwest Oregon State Forests Management Plan (Oregon Department of Forestry 2010a) and the Southwest Oregon State Forests Management Plan (Oregon Department of Forestry 2010b) unless otherwise cited. Table 2-3 summarizes the physical setting of the permit area.

2.3.2.1 Coast Range Ecoregion

Geology and Topography

Topography in the Coast Range ecoregion is moderately steep to gentle with frequent evidence of medium to large-scale ancient slide features. The Tillamook State Forest is particularly steep, with approximately half of state lands in that area greater than 60% slope (ODF 2019). Earthflows, slumps, and rock block slides are scattered through the landscape. There is also a wide distribution of low strength decomposed rock material that serves to produce potential landslide slip surfaces. There is moderately high potential for debris slides originating from headwalls and other points, especially in areas of predominantly sedimentary rock.

Soils

The soils in the Coast Range ecoregion are derived from sandstones, siltstones, weathered basalts, and volcanic breccias. Soils have developed in residual, colluvial, and alluvial materials and range from deep, rock-free materials to shallow, stony soil profiles.

The Coast Range soils vary from highly productive (Site Class I[2]) for Douglas-fir to moderate potential productivity (low Site Class III), depending largely on profile depth, stoniness, topographic position, and to some extent, soil parent material. However, in general, the parent materials of these soils all provide a potential basis for highly productive soils.

In areas where severe fires burned previous forests, as in 70% of the Tillamook State Forest, the productive potentials of some soils are likely degraded due to burning, loss of organically rich forest floors, and extended exposure to erosion. In places where the loss of organic materials and topsoil resulted from fires of 50 to 100 years ago, productive potentials may still be limited because soil-forming processes are not rapid enough to have rebuilt soils to productive states.

---

[2] Site class is a measure of an area's relative capacity for producing timber or other vegetation. It is measured through the site index. The site index is expressed as the height of the tallest trees in a stand at an index age (King 1966). In this document, an age of 50 years is used. The five site classes are defined below:
Site Class I = 135 feet and up
Site Class II = 115–134 feet
Site Class III = 95–114 feet
Site Class IV = 75–94 feet
Site Class V = Below 75 feet

Table 2-3. Summary of Physical Setting

Province	Geology	Soils	Climate	Hydrology
Coast Range	Steep to gentle slopes; periodic slope failures/slides	Sandstone, siltstone, weathered basalts and breccias. Generally potential for highly productive soils. Intense fires have affected productivity in some areas. Reforestation may be difficult on steep slopes.	The wet and mild maritime climate supports highly productive temperate rainforests. Rain dominated with 50–200 inches of precipitation annually.	Drains to Pacific Ocean, Willamette, and Columbia. Steep in headwaters and flat in lower reaches. High stream density (2–3 miles of stream/square mile). 8,220 acres of wetlands (75% riverine, 13% freshwater forest/shrub) and 8,759 miles of streams in the plan area (26% fish bearing, and 96% of Type F streams have perennial flow). Combination of shallow soils and rain dominated precipitation leads to rapid runoff with high flows during winter storms and low flows during the summer dry season.
West Cascades	Steep slopes with volcanic soils. Less dissected slopes than the coast. Less likelihood of slides than the coast, but still subject to slope failures.	Mostly derived from weathering of extrusive igneous rocks.	Snow dominated with 80–300 inches of precipitation annually.	High gradient streams that drain to Willamette, Santiam, Sandy and Clackamas. Stream densities range from 1.5- to 2-mile stream per square mile. Approximately 20% of the 491 miles of streams in the plan area are fish-bearing and 79% of those have perennial flow. 373 acres of wetlands (75% riverine, 13% freshwater forest/shrub). Hydrology strongly influenced by climate and soils. At higher elevations much of the precipitation falls as snow and a significant portion filters into highly permeable soil and rock.
Klamath	Mountainous. Metamorphic mosaic; serpentine bedrock containing heavy metals.	Weathered soils interspersed with peridotite or serpentine which are unproductive for tree growth.	Mediterranean climate with hot dry summers and moderate rainfall in winter; 25–118 inches of precipitation annually.	Rugged terrain with 190 miles of stream in the plan area. Of these, 10% of identified streams are fish-bearing and 99% of type F streams are perennial. 366 acres of wetlands (97% riverine).
Willamette	Broad, lowland valley.	Relatively deep alluvium, colluvium and glaciolacustrine deposits that overlie basalt and sandstone. Soils are productive.	Mediterranean climate with warm dry summers and mild wet winters; 35–63 inches of precipitation annually.	Surface water dominated by large rivers with a wide variety of ecosystems and habitats. 70 miles of streams in plan area with 36% of streams identified as fish-bearing. Virtually 100% of type F streams are perennial. 70 Acres of wetlands (98% riverine).

Climate

The Coast Range ecoregion has a maritime climate that is influenced by cool, moist air from the ocean, and is the wettest and mildest in the state. The ecoregion's mild, moist climate creates conditions for highly productive temperate rainforests. Precipitation occurs mainly as rainfall, averaging between 50 and 90 inches annually along the coast and east of the Coast Range crest, but totaling as much as 200 inches at higher elevations in the mountains (Beschta et al. 1995). The plan area within the Coast Range ecoregion occurs at all elevations, so it experiences the full range of average annual rainfall, from 50 inches to almost 200 inches at the highest elevations.

Major River Basins

The Coast Range Ecoregion includes three major basins:

- **North Coast:** The North Coast basin extends from the Columbia River to the southern Tillamook County line and is bound by the Pacific Ocean to the west and the crest of the Coast Range to the east. The basin consists of six watersheds: Necanicum, Nehalem, Tillamook Bay, Nestucca, Netarts/Sand Lake, and Neskowin. The three largest bays in the basin are Tillamook, Nehalem and Netarts. The outflow from rivers with headwaters in the Coast Range form estuaries along the North Coast. The North Coast basin drains to the Pacific Ocean and is within the Coast Range ecoregion.
- **Mid Coast:** The Mid-Coast basin encompasses four subbasins on Oregon's central coast: Alsea, Siletz-Yaquina, Siltcoos, and Siuslaw. The basin encompasses approximately 9,458 square miles. It is bound by the North Coast basin to the north, the crest of the Coast Range to the east, the South Coast basin to the south, and the Pacific Ocean to the west. The Mid Coast drains to the Pacific Ocean and is within the Coast Range ecoregion. The Coast Range ecoregion also includes part of the Umpqua basin, which also includes portions of the West Cascades and Klamath Mountains ecoregions. The basin comprises approximately 5,063 square miles of southwest Oregon. It is bound on the east by the Cascades and extends west to the Pacific Ocean. Three subbasins are contained within the Umpqua Basin: North Umpqua, South Umpqua, and Mainstem Umpqua/Smith. The headwaters of the North Umpqua River are located in the Umpqua National Forest and it flows generally west until it meets the South Umpqua River downstream from Roseburg. The South Umpqua River also has headwaters in the Umpqua National Forest, and generally flows west. It flows north after its confluence with Cow Creek, a major tributary. Downstream from the confluence with the North Umpqua is the Umpqua mainstem, which flows generally west until it meets the Smith River at the Umpqua-Smith estuary before emptying into the Pacific Ocean. The mainstem of the Umpqua River is within the Umpqua subbasin, which receives drainage from the other two subbasins as well as from smaller tributaries. It includes the drainages of the South Umpqua River, North Umpqua River, mainstem Umpqua River, and Smith River
- **South Coast:** The South Coast basin is located in southwestern Oregon. The basin encompasses over 2,973 square miles and consists of four subbasins—Chetco, Coos, Coquille, and Sixes—as well as a portion of the Smith subbasin. These subbasins are located on the west side of the Siskiyou Mountains. At the northern end of the basin, the Coos and Coquille Rivers headwater in the Coast Range and flow across relatively flat, low gradient, marine terraces to the Pacific Ocean. In the southern portion of the basin, numerous coastal frontal streams headwater primarily in the Klamath Mountain Province and discharge directly to the ocean (Oregon

Department of Environmental Quality 2013). The outflow from rivers with headwaters in the Coastal Ranges, which form estuaries along the south coast. The South Coast basin is within the Coast Range ecoregion.

Hydrology and Water Quality

Coast Range ecoregion streams and rivers generally have steep gradients in their headwater sections and very flat gradients in their lower reaches. Stream densities are high in this region, ranging from 2 to 3 miles of stream per square mile of land. Streams originating on the west slopes generally flow into the Pacific Ocean, and streams that drain the east slopes are tributaries to the Willamette River. On the North Coast, several streams drain north directly into the Columbia River. The combination of shallow soils and rain-dominated precipitation leads to flashy, rapid runoff with high flows during winter storms and low flow during the summer dry season.

There are approximately 8,759 miles of streams in the plan area of the Coast Range ecoregion. Of those, approximately 1,338 miles are fish bearing (15%; Type F) streams with 96% of these Type F streams having perennial flow, meaning they contain water throughout of the year, except during infrequent periods of severe drought. There are approximately 3,850 miles of non-fish-bearing streams (Type N) in the plan area. These streams do not meet the physical criteria of Type F streams but still provide downstream salmonid habitat values by contributing large wood, cold water through shading, and food resources, as well as habitat for other aquatic species, including torrent salamanders. The stream type of the remaining 3,571 miles is unknown.

There are approximately 8,220 acres of wetlands that occur in the plan area of the Coast Range ecoregion. Using the National Wetland Inventory (NWI) classifications, the majority acreage is represented by riverine (75%), which includes all wetlands and deepwater habitats contained within a channel and are analogous with the streams described previously. The remaining acreage is composed largely of freshwater forested/shrub (13%) where trees are the dominant life form, with at least 30% overall coverage. This wetland type occurs only in the Palustrine and Estuarine systems and normally possesses an overstory of trees, an understory of young trees or shrubs, and an herbaceous layer (Federal Geographic Data Committee 2013). Forested and smaller stream associated wetlands are not as well documented in the NWI, but are identified, and protections established, in the planning phases of management activities.

2.3.2.2 West Cascades Ecoregion

Geology and Topography

The topography of the West Cascades ecoregion has been shaped dramatically by its volcanic past. Geologically, the West Cascades ecoregion has two distinct areas: the younger volcanic crest (approximately 3 million years old) and the “old Cascades” to the west of the crest (at least 30 million years old). The topography is steep, i.e., the ecoregion is very long and has somewhat less dissected slopes than the Coast Range mountains. The probability of debris slides is less than the Coast Range ecoregion. There are rock block slides, deep-seated, large-scale landslides, and block slides, slump blocks, slump earthflows, and some very large earthflows scattered over the landscape. Fill loading and slope undercutting due to waste area fills, road and landing excavation, and filling can trigger renewed movement in these features. The risk of slope instability associated with timber harvest and road building is less than that of the Coast Range ecoregion.

Soils

Soils of the Santiam State Forest, which is where the bulk of the plan area occurs in the West Cascades ecoregion, are mostly derived from ancient andesites and their alluvial deposits. Other volcanic deposits may cap some soils. The soils are mostly gravelly with clay, clay loam, and sandy loam textures. They vary from shallow and skeletal on some slopes to deep and moderately well developed on gentle terrain. Rock volumes of 40 to 60% are common.

Site quality varies from high Site Class II for Douglas-fir to Site Class V for both Douglas-fir and western hemlock. Forest stands may range from being relatively windfirm to being highly susceptible to windthrow, depending on steepness of slopes and soil depth.

Reforestation may be difficult on some steep slopes. Silvicultural and harvesting systems must be thoughtfully designed and implemented to ensure the long-term productivity of these sites.

Climate and Climate Change

The western slopes of the Cascades receive most of their precipitation as snow, from November through March. At higher elevations up to 300 inches of precipitation may fall annually, and the lower slopes get at least 80 inches annually (Beschta et al. 1995). Temperatures in the West Cascades ecoregion are still influenced by the ocean but are more varied than the Coast Range ecoregion. The plan area is located in the western portion of the West Cascades ecoregion and extends from mid-to-high elevations and experiences higher precipitation levels associated with these higher elevations.

Major River Basins

The West Cascades ecoregion is part of the Umpqua basin, which also includes portions of the Coast Range and Klamath Mountains ecoregions. The basin comprises approximately 5,063 square miles of southwest Oregon and is described in more detail in Section 2.3.2.2, *West Cascades Ecoregion.* The North Santiam River Basin is located on the western slopes of the Cascade Range. The river flows west from Mount Jefferson to the Willamette River, draining 766 square miles. The basin contains the main-stem North Santiam River, its major tributaries: Breitenbush River, Blowout Creek, French Creek, and the Little North Santiam River.

Hydrology and Water Quality

West Cascades ecoregion streams and rivers usually have high gradients. Stream densities range from 1.5 to 2 miles of stream per square mile of land (Beschta et al. 1995). West Cascades ecoregion streams west of the crest flow westward and eventually join one of the major rivers draining the area (Santiam, Sandy, Willamette, and Clackamas). The hydrology of the West Cascades is strongly influenced by elevation, climate and soils. At higher elevations much of the precipitation falls as snow and a significant portion filters into highly permeable soil and rock.

There are approximately 491 miles of streams in the plan area of the West Cascades ecoregion. Of those, approximately 84 miles are fish bearing (15%; Type F) streams with the majority (79%) having perennial flow, meaning they contain water throughout of the year, except during infrequent periods of severe drought. There are approximately 359 miles of non-fish-bearing streams (Type N) in the plan area. The stream type of the remaining 48 miles are unknown.

There are approximately 373 acres of wetlands that occur in the plan area of the West Cascades ecoregion. Using the NWI classifications, the majority acreage is represented by riverine (75%), which includes all wetlands and deepwater habitats contained within a channel and are analogous with the streams described previously. The remaining acreage is composed largely of freshwater forested/shrub (13%). Forested and smaller stream-associated wetlands are not as well documented in the NWI, but are identified, and protections established, in the planning phases of management activities.

2.3.2.3 Klamath Mountains Ecoregion

Geology and Topography

ODF-managed lands in the Klamath Mountain ecoregion are mountainous, with little land located on the valley floors. The underlying bedrock is metamorphic on most of the lands and includes some of the oldest rock formations in Oregon.

The Klamath Mountain ecoregion has not been significantly shaped by volcanism. The geology of the Klamath Mountains can be better described as a mosaic rather than the layer-cake geology of most of the rest of the state. In the Klamath Mountains, serpentine mineral bedrock has weathered to a soil rich in heavy metals, including chromium, nickel, and gold, and in other parts, mineral deposits have crystallized in fractures (Oregon Department of Fish and Wildlife 2016).

Soils

Upland soils in the western half of the Klamath Mountains ecoregion are moderately deep reddish-brown silt loam or silty clay loam underlain by silty clay (Franklin and Dyrness 1988). These soils are interspersed with scattered areas of peridotite or serpentine, which are shallow and stony and underproductive for tree growth. There is a variety of valley soils, mostly dark-colored, well-drained silt loam underlain by a silty clay loam subsoil. Poorly drained streamside soils also occur.

In the eastern part of the ecoregion, principal upland soils are dry for most of the year and are generally reddish-brown with bedrock within approximately 3 feet of the surface (Franklin and Dyrness 1988). The texture tends to be loam underlain by clay loam subsoils. Shallow, gravelly soils of low fertility occur but are less widespread. Soils on flood plains and alluvial fans in the eastern half of the Klamath Mountains are principally well-drained prairie soils.

Climate and Climate Change

The Klamath Mountains ecoregion has a Mediterranean climate that is typified by hot, dry summers and moderate rainfall occurring abundantly in the winter months, making it unique from the rest of western Oregon. Snow occurs mostly above the 3,000-foot elevation and is generally short-lived. Average annual precipitation varies from 25 inches per year (near Rogue River and Shady Cove) to 118 inches per year (near the Cave Junction). Nearly 80% of the precipitation occurs in the winter months. Temperatures range from 9–116°F (-13 to 47°C). The plan area is the central portion of the Klamath Mountains ecoregion and experiences lower precipitation levels associated with this dryer portion of the state.

Major River Basins

Most state forest lands within the Klamath Mountains ecoregion are located within the Rogue River Basin. The basin contains 5,156 square miles in southwestern Oregon and northern California. The Rogue River Basin includes five subbasins: Lower Rogue River, Middle Rogue River, Upper Rogue River, Illinois, and Applegate. The basin is bound by the Siskiyou Mountains to the south and the Cascade Mountains to the east. The hydrology of the basin is strongly influenced by the climate and the soils. At higher elevations much of the precipitation falls as snowfall and a significant portion infiltrates into the highly permeable soil and rock. As a result, higher flows are seen in May due to snow melt. In contrast, the flow of the Illinois River is more typical of the coast range where most of the precipitation falls as rainfall and shallow soils lead to rapid runoff with high flows during winter storms and low flows during the summer dry period. The Rogue basin is within the Coast Range and Klamath Mountains/California High North Coast Range ecoregions.

Hydrology and Water Quality

Southwest Oregon state forest lands occur in the Klamath Mountains hydrologic region, which occupies most of southwestern Oregon and extends southward into northern California. They are rugged, have 2,000 to 5,000 feet of relief, and receive more than 120 inches of precipitation annually (McFarland 1983). The southwest Oregon state forests are in the Rogue and Umpqua drainage basins. The Rogue and Umpqua drainage basins are significant watersheds that are directly influenced by state forestlands in southwest Oregon.

There are approximately 190 miles of streams in the plan area of the Klamath Mountains ecoregion. Of those, approximately 17 miles are fish bearing (8%; Type F) streams with almost all (99%) having perennial flow, meaning they contain water throughout of the year, except during infrequent periods of severe drought. There are approximately 152 miles of non-fish-bearing streams (Type N) in the plan area. These streams do not meet the physical criteria of Type F streams but do provide habitat for other aquatic species including torrent salamanders. The stream type of the remaining 21 miles is unknown.

There are approximately 366 acres of wetlands that occur in the plan area of the Klamath Mountains ecoregion. Using the NWI classifications, almost all of the acreage is represented by riverine (97%), which includes all wetlands and deepwater habitats contained within a channel and are analogous with the streams described previously. The remaining acreage is composed of freshwater forested/shrub. Forested and smaller stream-associated wetlands are not as well documented in the NWI, but are identified, and protections established, in the planning phases of management activities.

2.3.2.4 Willamette Valley Ecoregion

Geology and Topography

The Willamette Valley ecoregion is mostly a rolling, broad, lowland valley. Elevations range from about 20 feet to over 1,970 feet on higher peaks, which are located along the western and eastern borders of the ecoregion. Landforms consist of terraces and floodplains that are interlaced and surrounded by rolling hills (Griffith 2010). The limited lands within the plan area are located outside of the valley floor along the eastern and western borders of the Willamette Valley ecoregion.

Soils

Soils in the Willamette Valley ecoregion include relatively deep alluvium, colluvium, and glacio-lacustrine deposits that overlie Miocene volcanic basalt and marine sandstone. Soils along the valley floor are productive, have a mesic temperature regime, and have a variety of texture and moisture characteristics (Griffith 2010). Soils associated with the plan area, which is situated in the foothills outside of the valley floor, consist of Ultisols and Alfisols.

Climate and Climate Change

The Willamette Valley ecoregion has a Mediterranean-type climate, with warm, dry summers and mild, wet winters. Average temperatures range from 50–55°F (10–13°C). The frost-free season is 5–7 months long. Average annual precipitation is 48 inches. In the mountainous foothills, which is where the plan area is located, precipitation ranges from 35 to 63 inches (Griffith 2010).

Major River Basins

State forestlands within the Willamette ecoregion are within the Willamette River Basin. Draining an area greater than 11,200 square miles, the Willamette basin is the state's largest. The basin begins south of Cottage Grove and extends approximately 187 miles to the north where the Willamette River flows into the Columbia River. It encompasses 12 subbasins: Lower Willamette, Tualatin, Molalla-Pudding, Yamhill, Clackamas, South Santiam, North Santiam, Middle Willamette, McKenzie, Coast Fork Willamette, Middle Fork Willamette, and Upper Willamette. The basin contains the broad Willamette River valley, which is flanked by the forested slopes of the Coast and Cascade mountain ranges. The Willamette River and its tributaries support a wide variety of ecosystems and habitats. The Willamette River stretches nearly 300 miles from its headwaters at Waldo Lake near Eugene to the confluence with the Columbia River in North Portland (Oregon Department of Environmental Quality 2020 and U.S. Army Corps of Engineers 2017). The Willamette basin is within the Willamette Valley ecoregion.

Hydrology and Water Quality

Surface water in the Willamette Valley ecoregion is dominated by large rivers and numerous streams flowing from the adjacent mountainous regions (Griffith 2010). Large rivers in the ecoregion include the Willamette, McKenzie, Santiam, Sandy, Mollala, Clackamas, Tualatin, Yamhill, Luckiamute, and Long Tom. There are also numerous seasonal wetlands and ponds along with a few reservoirs.

There are approximately 70 miles of streams in the plan area of the Willamette Valley ecoregion. Of those, approximately 14 miles are fish bearing (17%; Type F) streams with almost all (100%) having perennial flow, meaning they contain water throughout of the year, except during infrequent periods of severe drought. There are approximately 25 miles of non-fish-bearing streams (Type N) in the plan area. The stream type of the remaining 43 miles is unknown.

There are approximately 70 acres of wetlands that occur in the plan area of the Willamette Valley ecoregion. Using the NWI classifications, almost all the acreage is represented by riverine (98%), which includes all wetlands and deepwater habitats contained within a channel and are analogous with the streams described previously. The remaining acreage is composed of freshwater forested/shrub and freshwater emergent. Freshwater emergent wetlands maintain the same appearance year after year and are dominated by perennial plants (Federal Geographic Data

Committee 2013). Forested and smaller stream-associated wetlands are not as well documented in the NWI, but are identified, and protections established, in the planning phases of management activities.

2.4 Forest Conditions

This section describes the history of past disturbances in the permit area and associated forest conditions, including forest type, age, structure, and health. The 2010 Forest Management Plans (Oregon Department of Forestry 2010a, 2010b) and 2018 Forest Resource Assessment (Magby et al. 2018) describe forest conditions in the plan area and served as the basis of the following discussion, except as otherwise cited. Table 2-4 summarizes the ecological setting of the permit area.

2.4.1 Forest Data

ODF's forest inventory data characterize forest composition and structure in the permit area. Inventory data includes site-specific data on trees, snags, downed woody debris, and understory vegetation. These data are based on a field-measured sampling of selected forest stands. The number of stands sampled varies from year to year, depending on budgets and specific needs. Overall, approximately 50% of stands have been measured since 2001. Data from measured stands are used to extrapolate inventory information to stands that do not have field-measured data. ODF regularly maintains and updates inventory data, which serve as the information source on forest conditions for all lands managed by the State Forests Division. ODF uses inventory data to inform forest management analyses, assessments, activity planning, and status reporting.

2.4.2 Forest Conditions Overview

2.4.2.1 Historic Context

The forests in the plan area have been greatly influenced by historic landscape-scale disturbance events, as well as forest management. These overriding and important factors are summarized below.

Fires and Storms

- **Large fires.** The fires of the Tillamook Burn (1933–1951) greatly influenced the soil and forest trees of the Tillamook and Clatsop State Forests. This series of massive fires led to large-scale loss of timber and subsequent salvage harvest of what remained. Similar large-scale fires and subsequent salvage harvest occurred in Lane County with the Nelson Mountain Fire (1910), in the Santiam State Forest (1951), and in Douglas and Coos Counties (1868). The 2020 Labor Day fire event was the largest single fire event in a century in western Oregon. ODF is currently engaged in short-term post-fire harvest activities to address public safety concerns, recover economic value, and actively reforest burned areas on a portion of the affected landscape. This work is being done with greater sensitivity than large-scale salvage efforts of the past, with a focus on strong retention standards in riparian areas and for legacy forest components generally. ODF is also developing a long-term restoration strategy to continue restoration activities and develop monitoring to more fully understand the influence that the event had on the forest and how it responds to various restoration management pathways in the future.

- **Fire suppression**. Fire-suppression activities have been prevalent since the early part of the twentieth century. This, along with a lack of fuels management (e.g., prescribed burning) on large portions of the landscape has helped create forests of high fuel biomass that frequent, lower intensity fires would have historically consumed. This management paradigm on large portions of the landscape, coupled with other factors—including extended drought conditions, increased public use, and encroachment by development—increases the risk of large, catastrophic fires.
- **Windstorms**. The plan area, primarily in the Coast Range ecoregion, is subject to winter storms from the Pacific Ocean. Severe storms occasionally feature high wind velocities, the effects of which can be exacerbated by heavy rainfall that saturates soils, reducing tree resistance to windthrow. In northwest Oregon, periodic severe windstorms typically occur between October and March. Both the Hanukkah Eve Storm of 2006 and the Great Coastal Gale of 2007 exhibited extreme wind speeds and duration and blew down large stands of timber, resulting in the salvage of 17 million and 35 million board feet of timber on the Astoria District, respectively. The Columbus Day storm on October 12, 1962, which was powerful but relatively short in duration, blew down an estimated 17 billion board feet of timber in western Oregon and Washington. Other major windstorms in the last century occurred on January 9, 1880, in northern Oregon; December 4, 1951, in western Oregon; and the winter of 1995–1996 in western Oregon. The winters of 1949–1952 and 1955–1956 also had heavy winds.
- **Winter rainstorms.** Western Oregon, especially the Coast Range, has frequent, intense winter rainstorms. Severe floods usually result from rain-on-snow events, when heavy rain falls on low elevation snow, swelling the streams with melted snow and rain. Heavy rains also increase soil water levels, particularly where other disturbances such as fires or timber harvest have removed forest canopy and exposed the ground. The soils can give way in a landslide and start debris flows. Floods are more common in the cool, wet periods of climate cycles. Debris flows and major flooding cause small, localized disturbances that are important for forest regeneration and habitat creation.

Harvest

- **Extensive logging.** Logging for timber production has occurred in Oregon beginning with early settlement and trade activities in the early to mid-1800s. Much of the forestland now managed by ODF was inaccessible to these early activities, but the development of railroads around the turn of the twentieth century allowed for access and logging of mountainous areas on an industrial scale. In the early decades of the twentieth century, significant portions of what are now the Tillamook and Clatsop State Forests were logged using railroads and steam-powered yarding equipment. By the 1940s, forest roads and log trucks replaced railroads, chainsaws replaced crosscut saws, and diesel-powered yarding equipment replaced steam donkeys. Logging practices over the last century combined with extensive fires has resulted in few remaining old growth forests.

  In recent decades, timber harvest has been the primary agent of change in the plan area. Based on historic timber sale records from July 1979 to June 2018, approximately 150,000 acres of regeneration harvest and 215,000 acres of partial cut harvest have occurred in the plan area.
- **Intensive and selective forest management.** Plantation forestry began in Oregon on a very limited scale as early as 1901 but was only employed on 49,000 acres statewide over the next

40 years. Artificial reforestation was first encouraged by the Oregon Forest Conservation Act of 1941, with the recognition that Oregon forestlands should continuously grow timber into the future. Over the next 30 years, reforestation through the planting of seedlings became more economically feasible. Many of Oregon's largest reforestation efforts (both planting and seeding) were conducted on lands under ODF's management, primarily focused on rehabilitating lands deforested by wildfire and early industrial logging. The 1971 Oregon Forest Practices Act strengthened the mandate for reforestation after harvest, and modern plantation forestry centered on Douglas-fir became standard practice. There are now many acres of uniform stands, mostly of the commercially valuable Douglas-fir.

- **Reforestation.** Most reforestation has included planting Douglas-fir because of its relatively high commercial value and ability to rapidly grow in even-aged stands. Tree improvement programs and nursery technology advanced rapidly for Douglas-fir, so it also became the easiest and least expensive tree to plant and manage. The long-term effect, particularly in the Coast Range, was an increase in the quantity and density of Douglas-fir, often from non-local seed sources in the early years of restoration. Current ODF reforestation practices include the predominant use of Douglas-fir that has been improved through selective breeding for a variety of conditions at local and landscape scales. In addition to Douglas-fir, planting regimes also incorporate a component of other native conifers and hardwoods, including western hemlock, western redcedar, Sitka spruce, and red alder. Sites are closely evaluated for an appropriate mix of these other species to include, based on physical site characteristics, such as soil moisture and elevation. As regenerating trees grow and begin to compete with each other, pre-commercial thinning is used to maintain tree growth and vigor. As stands continue to mature, thinning prescriptions tend to favor opening stands up more, encouraging more re-initiation and development of both tree and non-tree vegetation in the understory.

Insects and Disease

A comprehensive inventory of pest and disease agents active in the plan area is presented in the 2010 Forest Management Plan (Oregon Department of Forestry 2010a, 2010b). Several diseases have reached noticeable levels of damage in recent decades and are discussed in this section. Climate change introduces additional uncertainty around the potential future extent of insects and disease. For instance, increased summer drought stress makes trees more vulnerable to these agents, and a lack of hard winter freezes may disrupt natural regulation of insect populations.

Most insect damage on state forests is caused by the Douglas-fir bark beetle (*Dendroctonus pseudotsugae*), which tends to affect low-vigor trees weakened by other factors. Beetle population buildup occurs on freshly downed Douglas-fir trees after significant disturbance events and can cause damage to healthy trees. Outbreaks typically last 2 to 4 years, though they can be prolonged when conditions are favorable.

Swiss needle cast, a native fungal disease, has increasingly affected Douglas-fir stands near the coast. The reasons for this are not fully known, but it may be connected to the widespread reforestation of the burn with Douglas-fir seed from other areas, which introduced trees poorly adapted to coastal conditions. Swiss needle cast causes premature dropping of needles, with severely infected trees retaining only the current year's needle growth. This reduces tree growth. The combination of off-site seed, Swiss needle cast and other factors has stagnated tree growth, particularly height growth. The geographic scope and severity of the disease complicates forest management activities due to reduced harvest volume and poor response to prescriptions intended to enhance habitat and stand growth.

Laminated root rot (*Phellinus weirii*), a native disease of conifers, has damaged Douglas-fir on some sites, but current management practices can stabilize or reduce unwanted effects of this disease. Black stain root disease (*Leptographium wageneri*) has reached epidemic proportions in some locations in southwest Oregon, and now can be found at low levels throughout young Douglas-fir stands in northwest Oregon forests. Armillaria root disease (*Armillaria* sp.) is far less abundant and damaging than laminated root rot but occasionally causes significant damage in young Douglas-fir plantations. Root disease surveys have shown that in the northwest Oregon state forests, armillaria is widely scattered and occurs in very small patches, usually affecting only a few trees.

Disease and insects combine with wind damage to create patchy stands. The interactions of wind, root disease, and bark beetles create canopy gaps, mix soils during tree uprooting, and increase structural and biological diversity in stands. Recent incorporation of multiple species into tree planting efforts may help decrease the impact of insects and disease in monocultures.

Legacy Forest Roads

Legacy road conditions from historical logging practices, including hauling and skid roads that were built before current Best Management Practices were in effect, have increased the probability of slope failure in some locations. The Tillamook State Forest has legacy road conditions throughout the forest. In some areas, the legacy conditions pose serious threats to water quality, fish, and aquatic habitats.

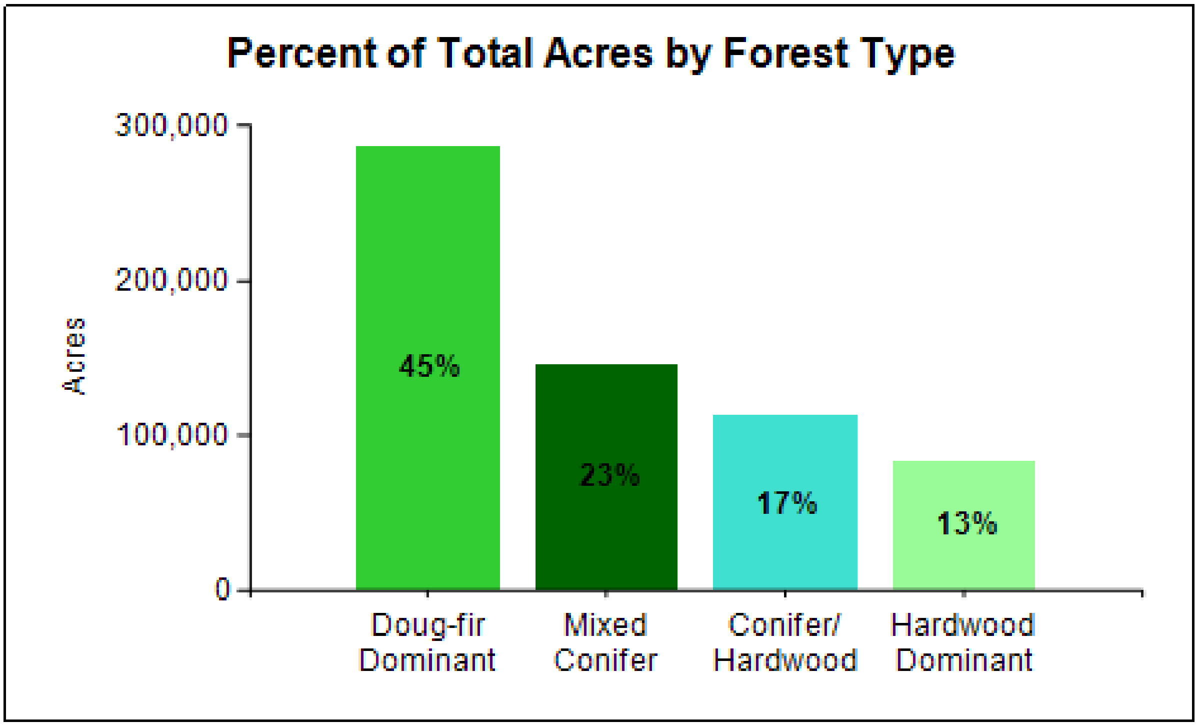
2.4.2.2 Forest Types

Grouping stands into forest types based on species composition is a useful tool that facilitates the observation of natural patterns that are exhibited across a complex landscape. These forest types provide information about a stand's potential future condition, and then stand age and management history can reveal where a stand lies on its developmental curve. The forest stands are predominantly conifer, although some portions of the landscape are dominated by hardwood stands, and many stands across the landscape have some hardwood component. Forest types can be broadly classified into four types:

- **Douglas-fir dominant stands.** Douglas-fir accounts for more than two-thirds of the standing volume on Oregon state forests (Figure 2-7). Overall, less than half of the total state forest acreage fits the definition of a single-species Douglas-fir-dominant stand.
- **Mixed conifer stands** typically include some combination of western hemlock (*Tsuga heterophylla*), Douglas-fir (*Pseudotsuga menziesii*), western redcedar (*Thuja plicata*), Sitka spruce (*Picea sitchensis*), and noble fir (*Abies procera*).
- **Hardwood dominant stands** are usually dominated by either red alder (*Alnus rubra*) or bigleaf maple (*Acer macrophyllum*).
- **Conifer-hardwood mix stands** are most commonly Douglas-fir or western hemlock mixing with red alder.

The four different forest types vary from one another with respect to their potential for wildlife habitat development. Complex forest habitat conditions uniquely benefit many native wildlife species and increase resiliency to disturbances. Compositional diversity, structural complexity, and spatial heterogeneity that benefit native wildlife are provided in forest stands with a diversity of tree species; an understory of trees, shrubs, and herbs; and ample amounts of snags and downed wood.

On Oregon state forests roughly 25% of the mixed conifer acres currently provide complex structure, as compared with less than 10% of the Douglas-fir-dominant acres. By definition, mixed conifer stands tend to be multispecies stands that are more prone to developing layered canopies. For similar reasons, the conifer/hardwood mix forest type also contributes disproportionately to the total acres with complex habitat conditions. Due to a variety of geographic and historic factors, these four forest types are not distributed evenly across the plan area.

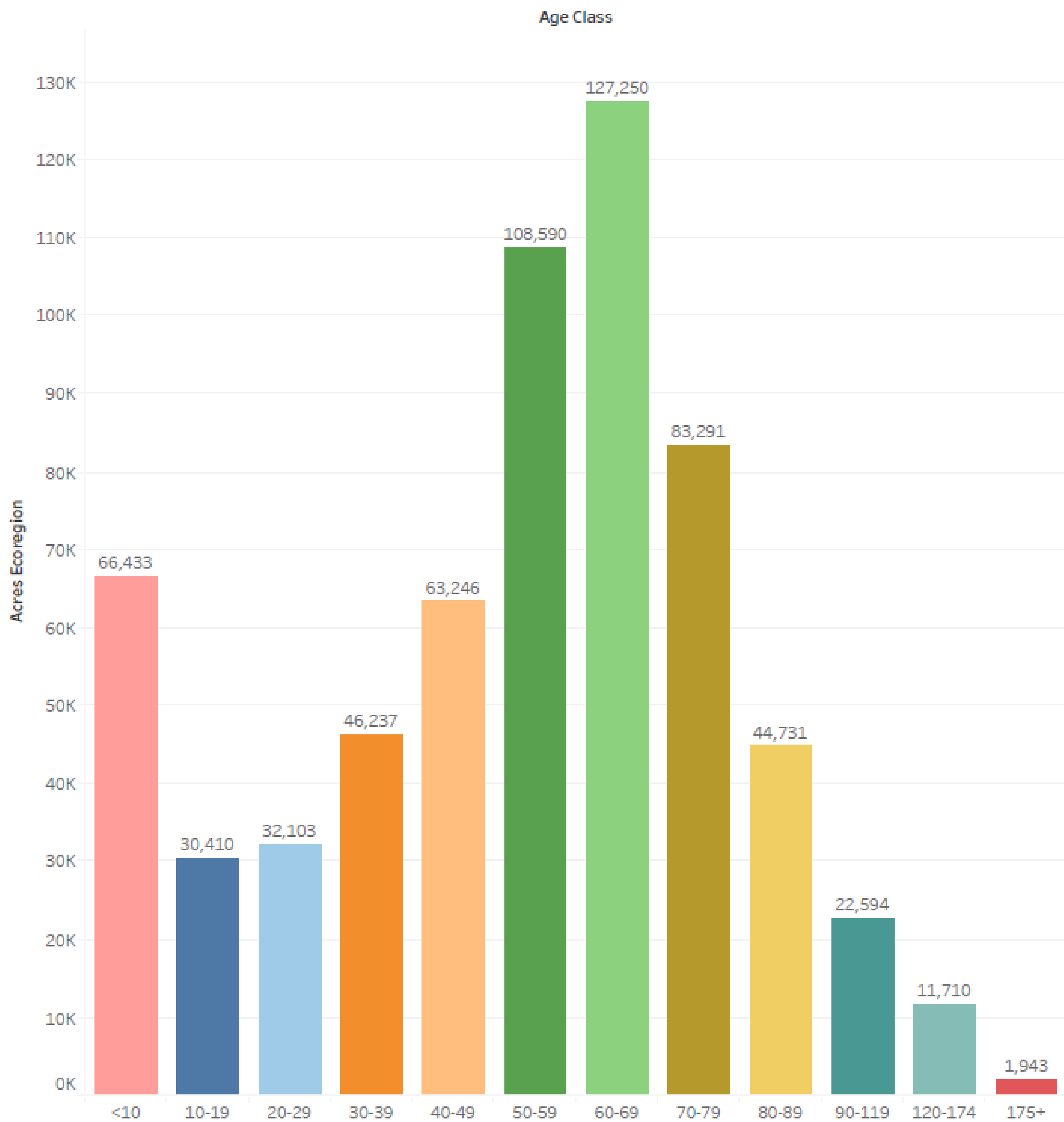


Source: ODF file information.

Figure 2-7. Overview of Western Oregon Forest Types within State Forests (Permit Area Only)

2.4.2.3 Forest Age

Forest age generally refers to the time elapsed since the last major disturbance that eliminated much of the previous forest and allowed regeneration of a new stand. As a result of their history of large fires, extensive logging prior to state ownership, and subsequent forest management, the current age distribution of Oregon state forests lands is not uniform (Figure 2-8). Stand age is a major indicator of current forest condition and this non-uniform age distribution has significant implications related to forest management planning. Forest stands in the 50- to 79-year-old range are the most abundant across the plan area and account for half of the total acreage and more than 60% of the standing volume. On portions of the Tillamook and Forest Grove districts, these acres coincide with periods of aggressive salvage logging and subsequent reforestation efforts that occurred after the Tillamook Burn. However, stand age is not the only factor that influences a current stand's condition. Site productivity, past management practices, and disturbance history have all interacted with one another to produce the forests that ODF manages today.



Source: ODF file information

Figure 2-8. Age Distribution of Forests on State Forestlands (Permit Area Only)

2.4.2.4 Forest Structure

In addition to age, forests can be described in terms of structure. Forest structure refers to the vertical and horizontal distribution of trees, presence of snags (standing dead) and logs (downed dead), structural diversity and spatial heterogeneity in the understory, and structural complexity of trees. Structure complexity of trees includes factors such as whether they have broken tops, large secondary limbs, cavities, and other features. Stand structural characteristics are important components for all of the species covered under this HCP. Northern spotted owl (*Strix occidentalis*), marbled murrelet (*Brachyramphus marmoratus*), slender salamander (*Batrachoseps wrighti*), coastal marten (*Martes caurina*), and red tree vole (*Arborimus longicaudus*) use these structures directly for habitat for nesting or other essential functions. These components also contribute to properly functioning aquatic and riparian habitats that benefit the covered fish and torrent salamanders (*Rhyacotriton* sp.). More detail on these species' life histories and habitat relationships is provided in Appendix C.

The permit area has a broad range of forest stand and structure types. The forest stands are predominantly conifer, although some portions of the landscape are dominated by hardwood stands, and many stands across the landscape have some hardwood component. Forest stands typically move through different structural stages as they age. ODF uses various silvicultural strategies to influence the development of forest stands and achieve desired forest structure across the landscape.

Structure types that occur in the permit area are classified as follows[3]:

- **Early Seral Forest Structure:** Early seral forests are young forests where the overstory has been removed through either harvest activity or natural disturbance. They begin at stand initiation and continue into canopy closure and subsequent suppression mortality. The degree of biodiversity and structural complexity in these stands varies greatly, depending on pre-disturbance conditions, the degree of post-disturbance legacy structure that remains, species diversity, and landscape context. Early seral stands generally fall into the stages of ecosystem reorganization and competitive exclusion as described by Carey (2007).
- **Ecosystem Reorganization:**
  - Simple early seral forests have little legacy structure, low tree species diversity, little shrub or herbaceous vegetation, and little downed wood. Clearcuts that have received intensive site preparation and planted to a high-density monoculture are a prime example. Conditions across the stands are relatively homogeneous.
  - Complex early seral forests have greater retention of remnant overstory trees and snags, a regenerating tree cohort with multiple native species at low to moderate density, and moderate to abundant shrub and herbaceous vegetation. Downed wood retained from the prior stand, or from retention of hard logs from harvested trees, may exist in various sizes and decay classes. Spatial heterogeneity in vertical and horizontal complexity and diversity are higher relative to more simplified stand conditions.
- **Competitive Exclusion:**
  - Simple structure results from high tree stocking and intense competition for light, water and nutrients. Dominant trees achieve full crown closure and shade out understory species and shorter trees. Shade tolerant trees and shrubs may persist below the dominant canopy, but not show significant growth. Dominant and co-dominant trees may self-thin, with surviving trees able to maintain relatively healthy crown ratios. Where self-thinning does not occur, overstory trees may become tall and spindly, with poor crown and height to diameter ratios.

[3] The use of seral stage to define forest structure is a new approach by ODF and differs from what is described in the Northwest and Southwest Forest Management Plan.

- Complex structure in this stage is still limited, as sapling and pole size trees compete for resources. Spatial heterogeneity provided by openings around legacy structures or brushy patches help maintain a greater degree of understory shrubs and herbaceous vegetation. Multiple young tree species with different growth rates and shade tolerance allow for greater canopy diversification which may result in a greater variety of diameters and heights across the stand. Legacy structures (large trees, snags, and downed wood) contribute to structural complexity.

- **Mid-Seral Forest Structure:** Mid-seral stands are generally 30 to 80 years old, but can be as old as 120 years, depending on disturbance history and stand density. They can vary greatly in structural diversity, depending on their site conditions, silvicultural entries and self-thinning. Several prescriptive options exist for stands in this general age range (e.g. rotation harvest, multiple commercial entries, variable retention harvest), and stand trajectories are heavily influenced by small-scale natural disturbance events. Structural stages for these stands fall in the biomass accumulation, understory reinitiation and understory development (Carey 2007).

- **Biomass Accumulation:**
    - Simple structure results from the competitive exclusion stage, where co-dominant trees continue to fully occupy the site and accumulate wood biomass. Inter-tree competition is high, and understory vegetation is further reduced, primarily due to a lack of sunlight penetrating the fully closed canopy.
    - Complex structure also has reduced diversity compared to the competitive exclusion stage, as dominant tree crowns reduce understory species growth. Dominant tree species diversity is generally maintained. Legacy structures still provide some openings that allow for persistence of understory vegetation.

- **Understory Reinitiation:**
    - Simple structure typically consists of an overstory of uniformly spaced codominant trees with little species diversity. Uniform self-thinning has left the site fully occupied, and the understory is reduced to shade tolerant species such as salal and swordfern.
    - Complex structure is marked by overstory canopy heterogeneity produced by variable density thinning or small-scale natural disturbance. Legacy components continue to contribute to this patchiness across the stand, which allows for a more diverse suite of understory species to persist. Conifer species that will eventually form a midstory compete with other trees and shrubs in the understory, but there is little vertical layering in the canopy.

- **Understory Development:**
    - Simple structure is defined by an increase in understory species, where self-thinning of larger trees creates more persistent gaps that allow sunlight to reach the forest floor. These gaps are still relatively uniform throughout the stand, and little vertical diversity has developed in the understory or tree canopy layering.
    - Complex structure stands have a variety of canopy closure, resulting from management or natural disturbance that has created and maintained a variable density of dominant and codominant trees. This horizontal diversity allows for a rich and varied understory, which has begun to develop vertically, with species such as vine maple growing several feet high.

Where gaps in the forest canopy are large enough, additional tree species begin to seed in naturally. Vertical canopy layering has begun, with shade tolerant species having deeper crowns than their shade-intolerant codominant neighbors. Breakage in tree tops, loss of larger limbs, and other damage agents begin to produce cavities and other nesting and roosting structures.

- **Late Seral Forest Structure:** Forest stands begin to move into a late seral condition between 80 and 120 years old, where many of the habitat components for covered species may be present, but the abundance or quality of those components are not equivalent to old growth stands (i.e., ≥175 years old). The structural characteristics of these stands vary greatly, depending on previous management activity and exposure to natural disturbance events. Localized, within stand disturbance events and individual tree mortality likely has occurred to some degree by this time, resulting in damage at the tops or in the boles of some trees, creating potential sites for cavity nesting. Large trees are present, and significant downed woody debris has begun to accumulate. Very large trees, snags, and downed logs associated with old growth are not yet present, but develop over time as the stand continues on a late seral pathway. A diverse understory has vertical development sufficient to meet the lower crown of shade tolerant tree species in some places. This phase is referred to as niche diversification (Carey 2007), and has the necessary structural and species diversity to support a variety of wildlife species.

  As these stands persist, disturbance (either natural or through active management) begins to play a larger role in maintaining diversity in the stand. This "gap dynamics" phase (Carey 2007) includes small scale, high intensity disturbances such as debris flows that create new openings for understory and tree seeding, and move large wood from upslope to riparian areas. Larger collections of downed trees create denning sites for larger mammal species, and increased biomass and biological diversity in general affords increased foraging opportunities for many bird species. The forest floor is diverse and supports healthy herbaceous and fungal communities.

2.4.2.5 Adjacent Ownership

Land ownership and management of parcels adjacent to the permit area have the potential to affect conditions in the permit area. Adjacent ownership, by ecoregion, is characterized below and depicted in Figure 2-19a through 2-19s at the end of this chapter.

2.4.3 Forest Conditions by Ecoregion

This section describes in forest conditions by ecoregion. Table 2-4 summarizes forest type, age, structure and adjacent ownership, by ecoregion.

Table 2-4. Summary of Ecological Setting by Ecoregion

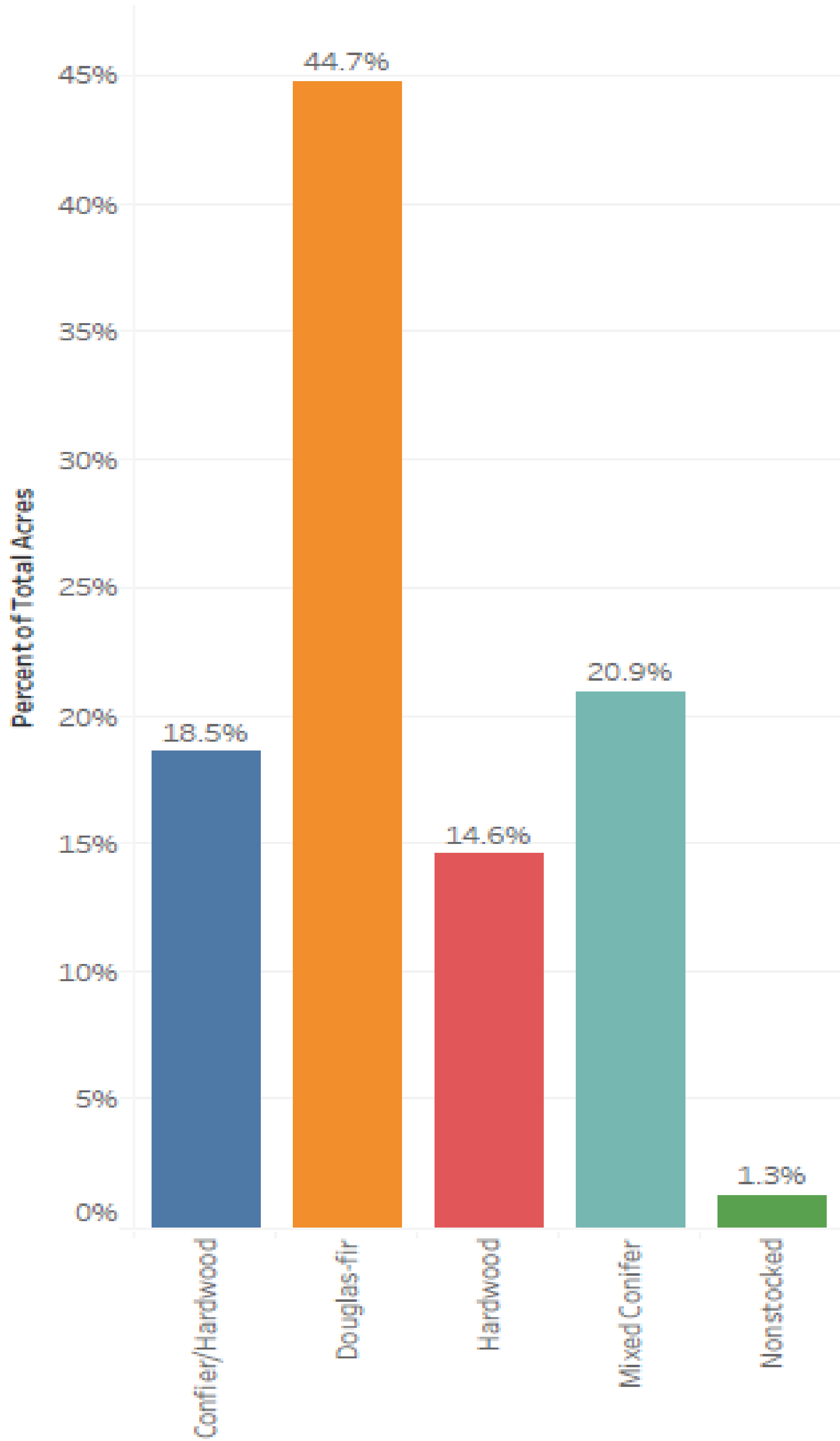
Ecoregion	Forest Type	Forest Age	Forest Structure	Adjacent Ownership
Coast	Dominated by conifers, especially Douglas-fir, along with a variety of hardwoods	Dominated by 50- to 69-year-old trees, with approximately 220,000 acres in this age range. Approximately 70,000 acres under ODF management in this ecoregion are 80 years and older	Mostly mid-seral stands with developing understories. Significant layering of tree crowns has not yet developed but many stands have good potential for increasing structural diversity. Some older stands may already have high structural diversity.	Approximately 1,539 miles of adjoining land ownership perimeter. The primary adjoining landowner type is private.
West Cascades	Almost entirely coniferous and dominated by Douglas-fir	More even spread across age classes compared to the Coast Range ecoregion, with the highest proportion occurring in 60- to 89-year-old trees	Mid-seral stands similar to other ecoregions	Approximately 251 miles of adjoining land ownership perimeter. The primary adjoining landowner type is private
Klamath	Almost entirely coniferous and dominated by Douglas-fir	Generally range between 20- and 119-year-old trees	Mid-seral stands similar to other ecoregions	Approximately 145 miles of adjoining land ownership perimeter. The primary adjoining landowner is the Bureau of Land Management
Willamette	Almost entirely coniferous and dominated by Douglas-fir	Dominated by 60- to 69-year-old trees	Mid-seral stands similar to other ecoregions	Approximately 63 miles of adjoining land ownership. The primary adjoining landowner type is private

2.4.3.1 Coast Range Ecoregion

Forest Types, Age, and Structure on State Forestlands

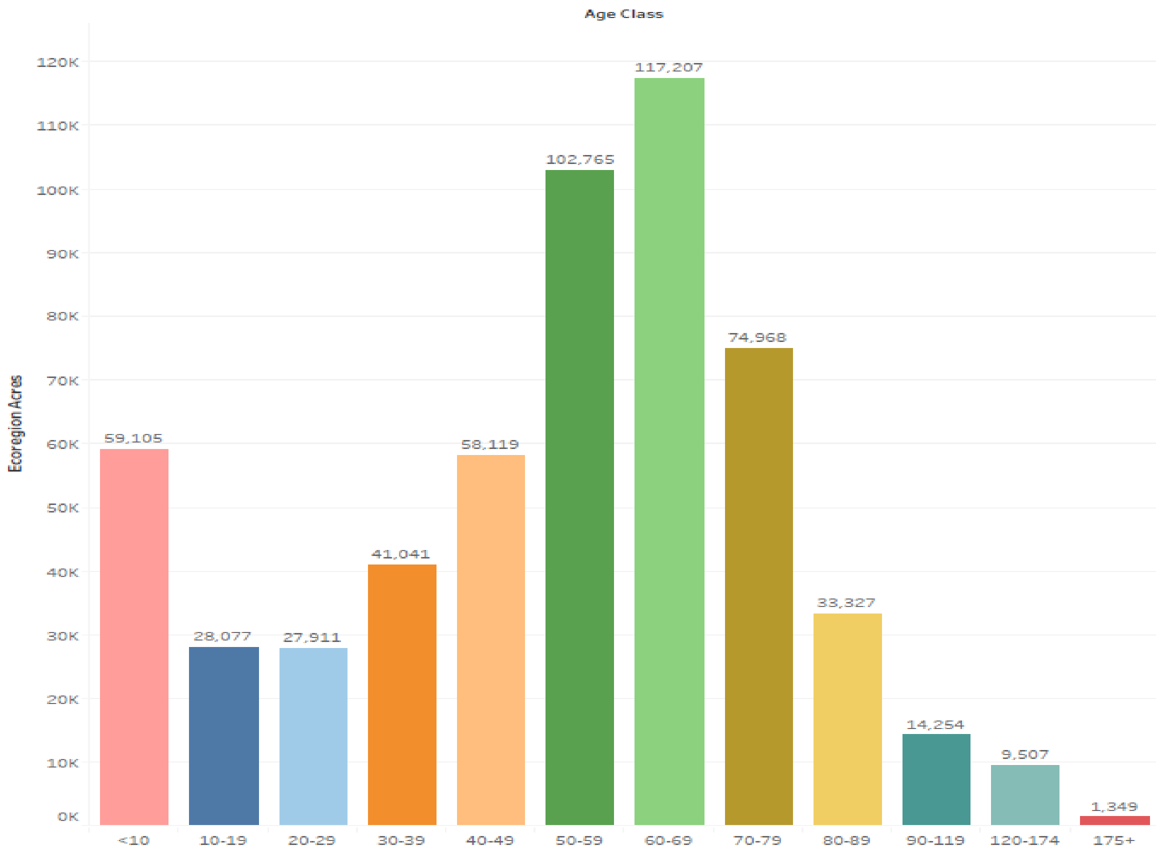
Forests in the Coast Range ecoregion[4] are dominated by conifers, especially Douglas-fir, along with a variety of hardwoods (Figure 2-9). State forest stands are dominated by the 50- to 69-year-old trees (Figure 2-10). The forest structure is largely composed of mid-seral stands with understory characteristics, such as diverse shrub and herb layers. Tree canopies may range from a single species, single-layered, main canopy with associated dominant, codominant, and suppressed trees, to multiple species canopies. However, significant layering of tree crowns has not yet developed. In these stands, the shrub and herb layers are likely to continue to diversify and maintain or improve their vigor. These stands offer good potential to develop into highly diversified vegetative communities. Depending on the intensity and timing of density-management activities, stands could continue in this condition, grow back into a closed single canopy state, or develop into late seral complex stands. Approximately 70,000 acres under ODF management in this ecoregion is in stands aged 80 years and older. These stands have a range of structural complexity dependent on management history, disturbance, and local growing site conditions.

[4] Forest age data are only available for Board of Forestry lands and Common School Forest Lands (i.e., the permit area). Data are not available for private or federal lands in the plan area.



Source: ODF file information
Note: percentages do not total 100% as non-forested vegetation types are not shown.

Figure 2-9. Forest Type in the Permit Area in the Coast Range Ecoregion



Source: ODF file information

Figure 2-10. Stand Age in the Permit Area in the Coast Range Ecoregion

Adjacent Ownership

There are approximately 1,539 miles of adjoining land ownership perimeter in the permit area of the Coast Range ecoregion. The primary adjoining landowner type is private (Table 2-5). A mapbook at the end of this chapter illustrates adjoining land ownership throughout the permit area (Figure 2-19a through 2-19s)

Table 2-5. Adjacent Land Ownership of the Permit Area in the Coast Range Ecoregion

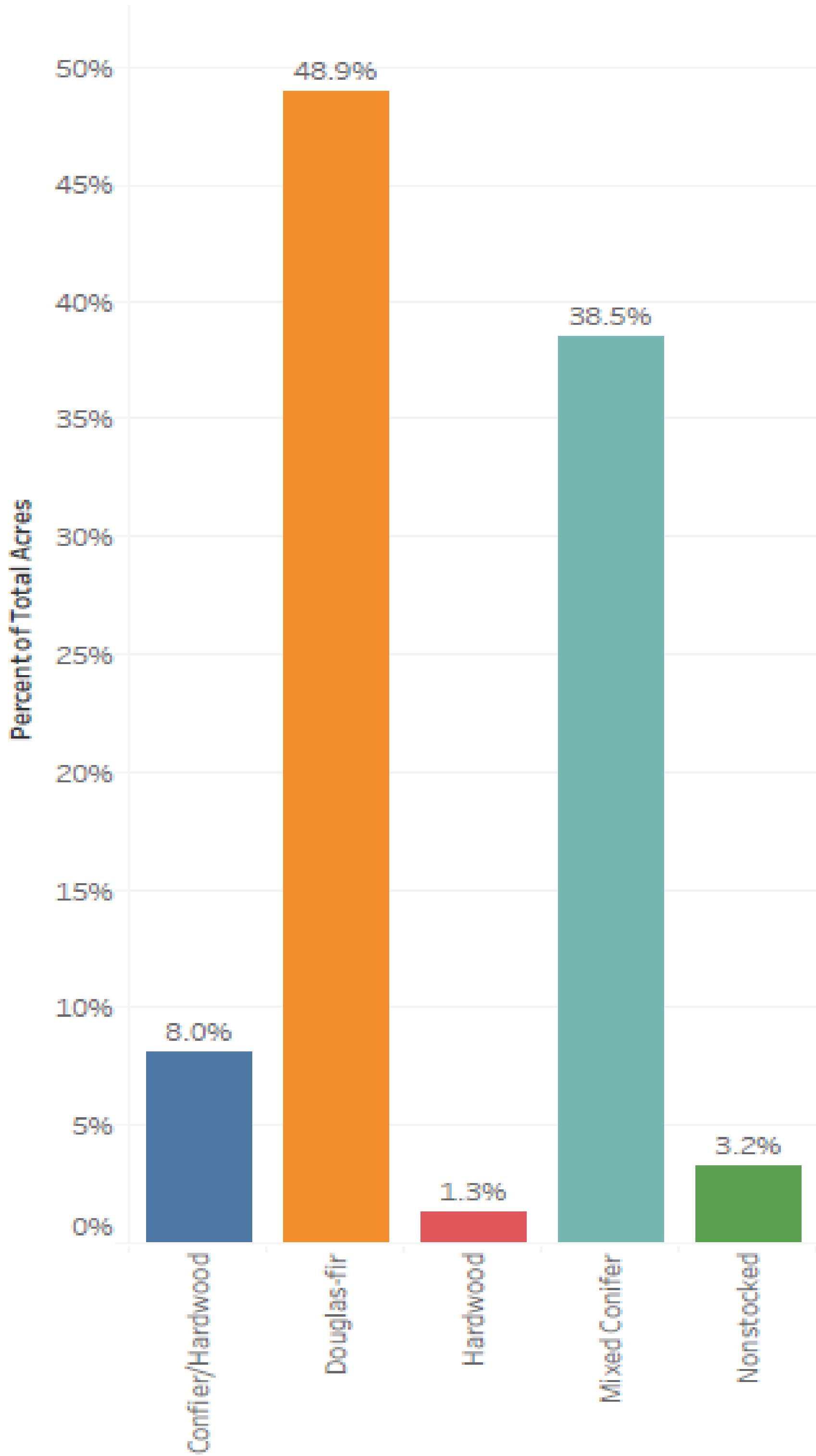
Adjacent Landowner	Miles	Proportion (%)
Private	848	55
Other State Lands	429	28
Bureau of Land Management	213	14
U.S. Forest Service	46	3
Other Federal Agency	3	0
Total	**1,539**	**100**

2.4.3.2 West Cascades Ecoregion

Forest Type, Age, and Structure on State Forestlands

State forests in the West Cascades ecoregion[5] are almost entirely coniferous and dominated by Douglas-fir (Figure 2-11). Forest stands have a more even spread across age classes compared to the Coast Range ecoregion, with the highest proportion occurring in 60- to 89-year-old trees (Figure 2-12). Forest structure is composed of primarily mid-seral stands with a diverse herb or shrub layer and contains trees larger than sapling size. Tree canopies may range from a single species, single-layered, main canopy with associated dominant, codominant, and suppressed trees, to multiple species canopies. However, significant layering of tree crowns has not yet developed. The shrub and herb layers are likely to continue to diversify and maintain or improve their vigor. These stands offer good potential for developing into highly diversified vegetative communities.

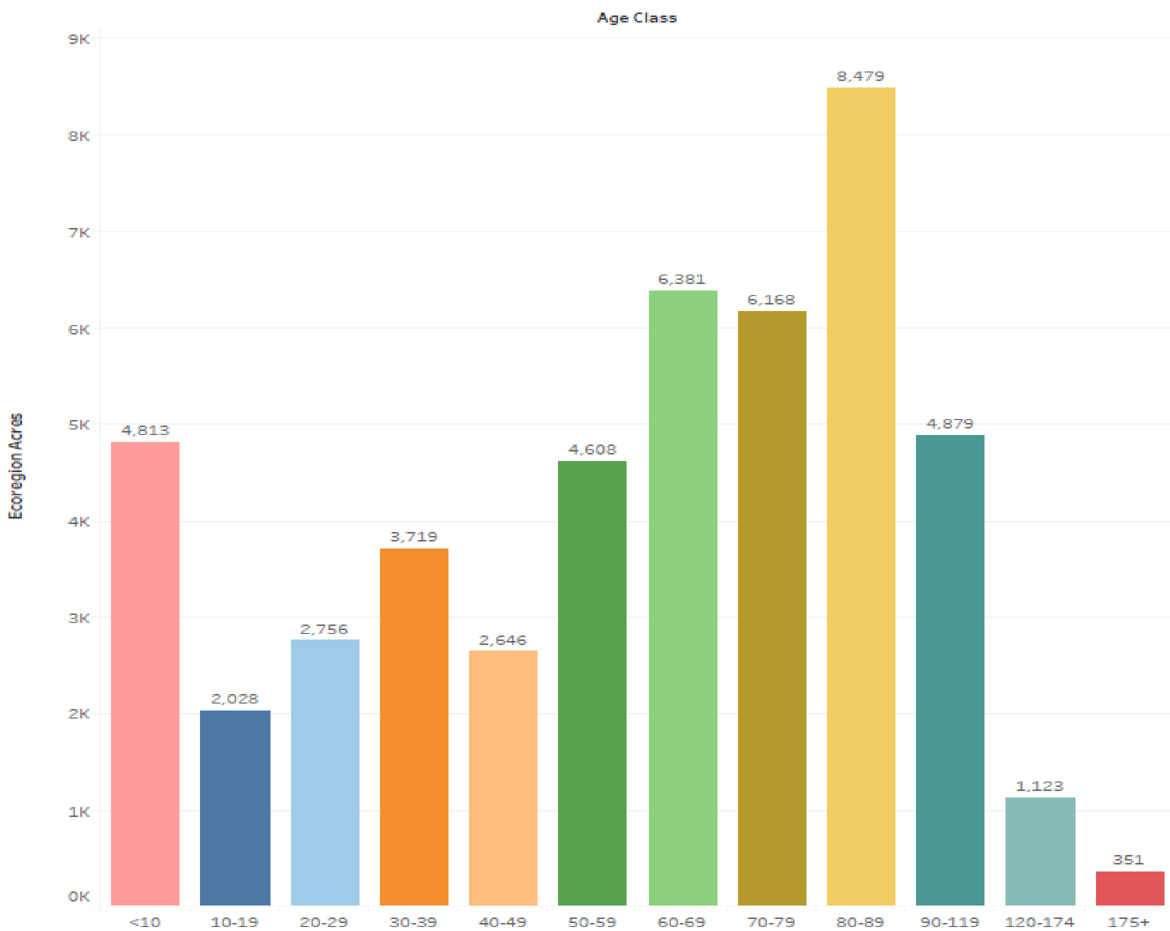
[5] Forest age data are only available for Board of Forestry Lands and Common School Forest Lands (i.e., the permit area). Data are not available for private or federal land in the plan area.



Source: ODF file information

Note: Percentages do not total 100% as non-forested vegetations types are not shown.

Figure 2-11. Forest Type in the Permit Area in the West Cascades Ecoregion



Source: ODF file information

Figure 2-12. Stand Age in the Permit Area in the West Cascades Ecoregion

Adjacent Ownership

There are approximately 251 miles of adjoining land ownership perimeter in the permit area of the West Cascades ecoregion. The primary adjoining landowner type is private (Table 2-6). A mapbook at the end of this chapter illustrates adjoining land ownership throughout the permit area (Figure 2-19a through 2-19s).

Table 2-6. Adjacent Land Ownership of the Permit Area in the West Cascades Ecoregion

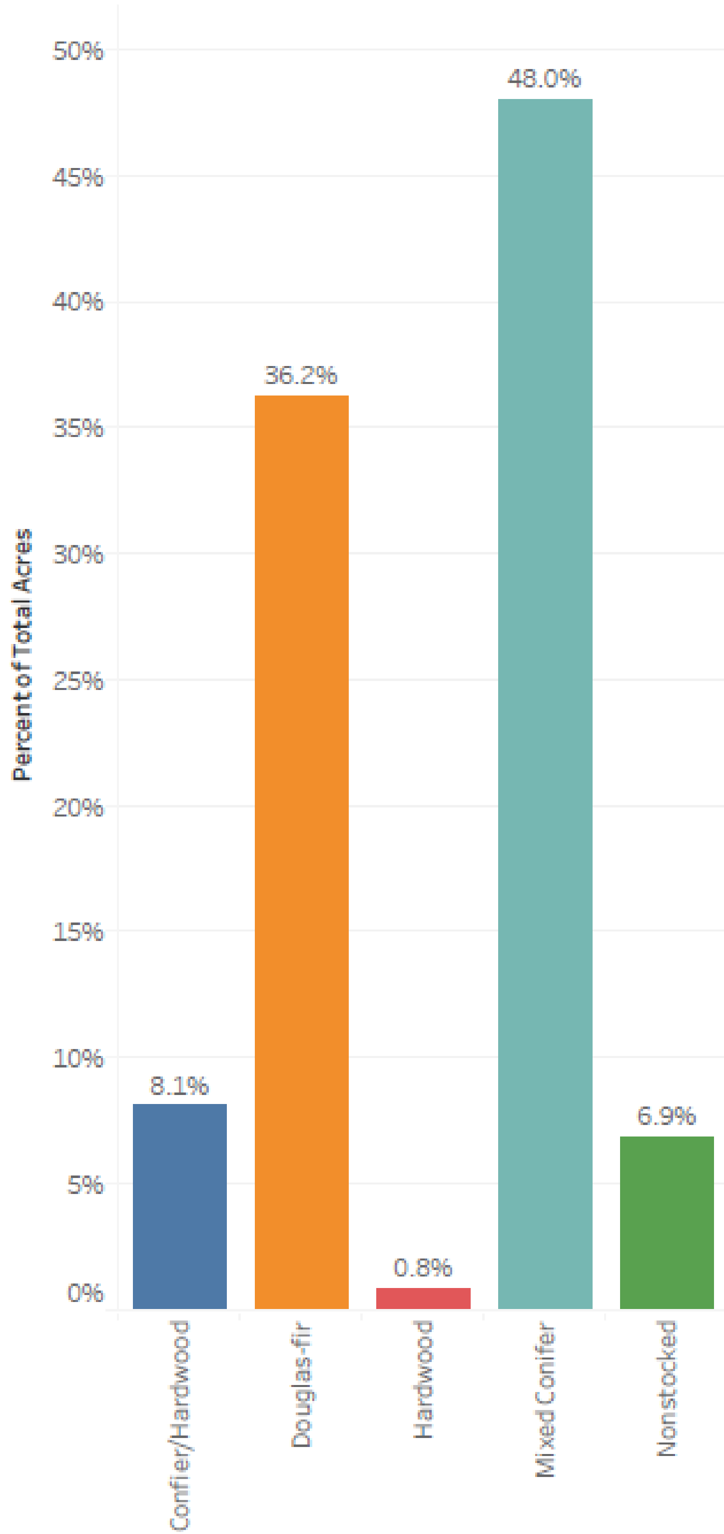
Adjacent Landowner	Miles	Proportion(%)
Private	152	61
Bureau of Land Management	63	25
U.S. Forest Service	22	9
State Lands	13	5
Other Federal Agency	1	0
Total	**251**	**100%**

2.4.3.3 Klamath Mountains Ecoregion

Forest Age and Structure on State Forestlands

State forests in the Klamath Mountains ecoregion[6] are dominated almost exclusively by Douglas-fir (Figure 2-13). Forest stands generally range between 20- and 119-year-old trees (Figure 2-14). Forest structure is composed primarily of mid-seral stands of closed canopy stand types, with little or no understory development. While these closed canopy stands are the primary stand type on this part of the permit area, overall species diversity is high. Douglas-fir and madrone are usually the dominant tree species, but ponderosa pine, sugar pine, incense cedar, and grand fir are common conifer components. Common hardwood species include canyon live oak, tanoak, and chinquapin on xeric sites, and red alder, black cottonwood, Oregon ash, willow, and Pacific yew in mesic areas. Soil types are diverse, including serpentine outcrops that support a distinctive array of trees and plants.

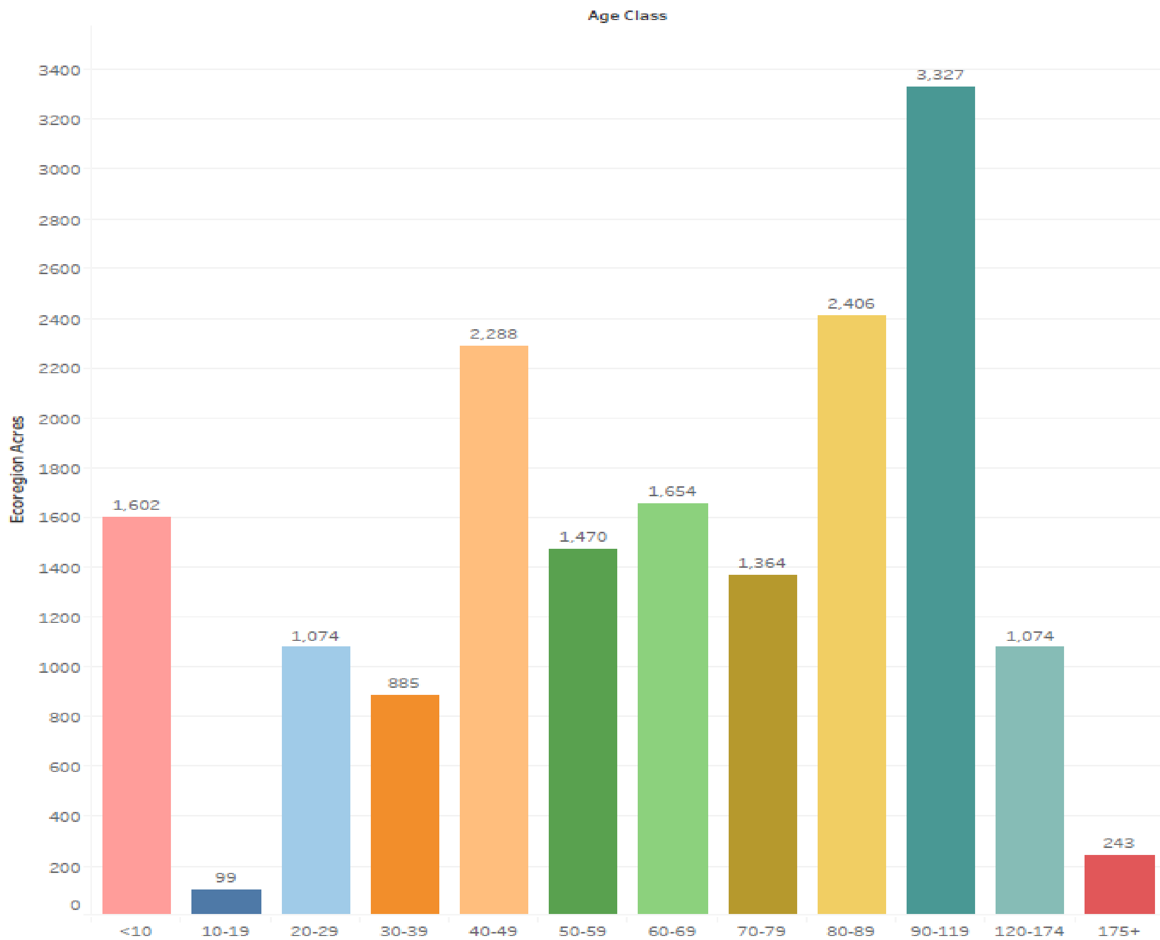
[6] Forest age data are only available for Board of Forestry Lands and Common School Forest Lands (i.e., the permit area). Data are not available for private or federal land in the plan area.



Source: ODF file information

Note: Percentages do not total 100% as non-forested vegetation types are not shown.

Figure 2-13. Forest Type in the Permit Area in the Klamath Mountains Ecoregion



Source: ODF file information

Figure 2-14. Stand Age in the Permit Area in the Klamath Mountains Ecoregion

Adjacent Ownership

There are approximately 145 miles of adjoining land ownership perimeter in the permit area of the Klamath Mountains ecoregion. The primary adjoining landowner is the Bureau of Land Management (Table 2-7). A mapbook at the end of this chapter illustrates adjoining land ownership throughout the permit area (Figure 2-19a through 2-19s).

Table 2-7. Adjacent Land Ownership of the Permit Area in the Klamath Mountains Ecoregion

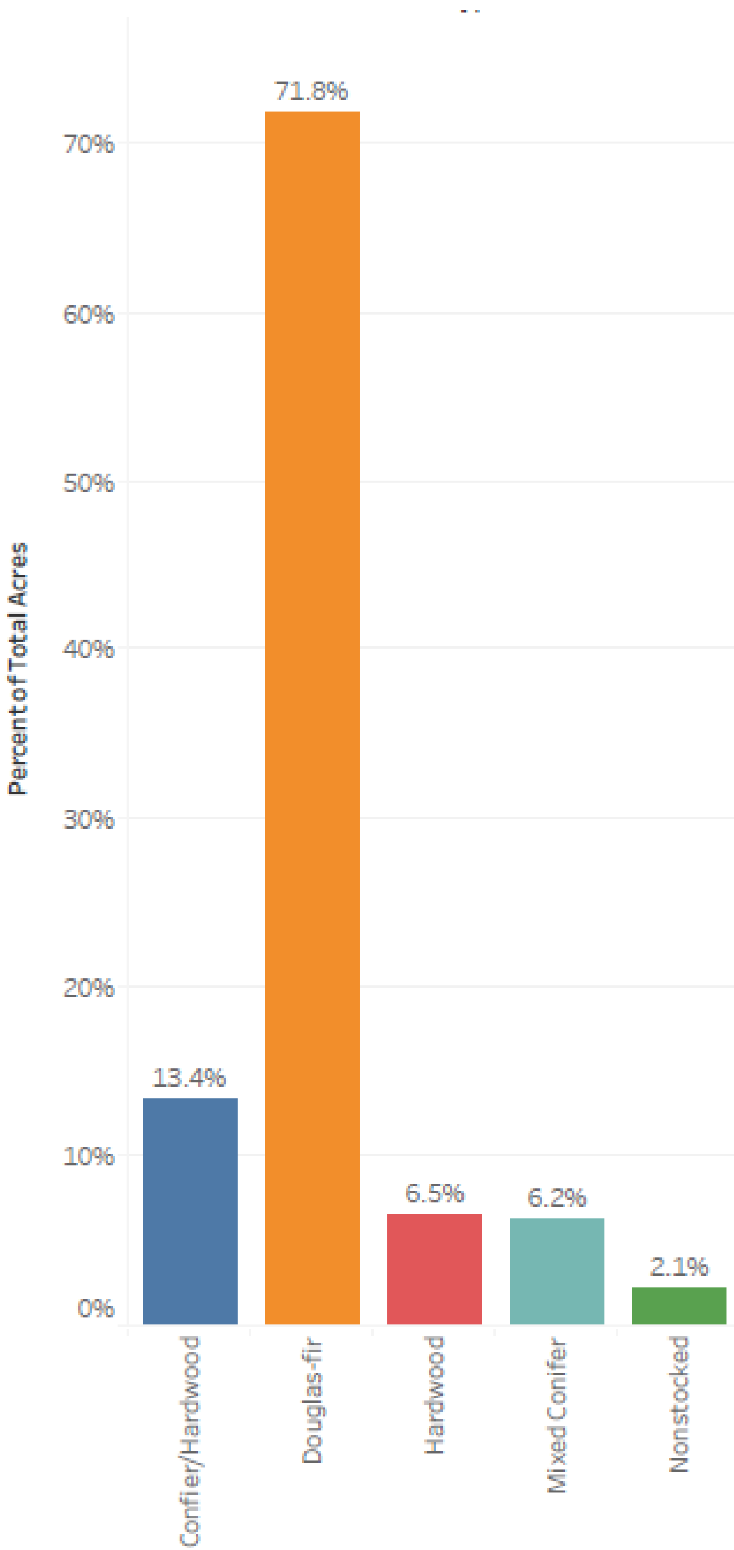
Adjacent Landowner	Miles	Proportion (%)
Bureau of Land Management	69	47
Private	47	32
U.S. Forest Service	26	18
Other State lands	3	2
Total	**145**	**100%**

2.4.3.4 Willamette Valley Ecoregion

Forest Type, Age, and Structure on State Forestlands

State forests in the Willamette Valley ecoregion[7] are dominated almost exclusively by Douglas-fir (Figure 2-15). Forest stands are dominated 60- to 69-year-old trees (35%; Figure 2-16). Forest structure is composed of mid-seral stands with a diverse herb or shrub layer and trees larger than sapling size. Tree canopies may range from a single species, single-layered, main canopy with associated dominant, codominant, and suppressed trees, to multiple species canopies. However, significant layering of tree crowns has not yet developed. The shrub and herb layers are likely to continue to diversify and maintain or improve their vigor. These stands offer good potential for developing into highly diversified vegetative communities.

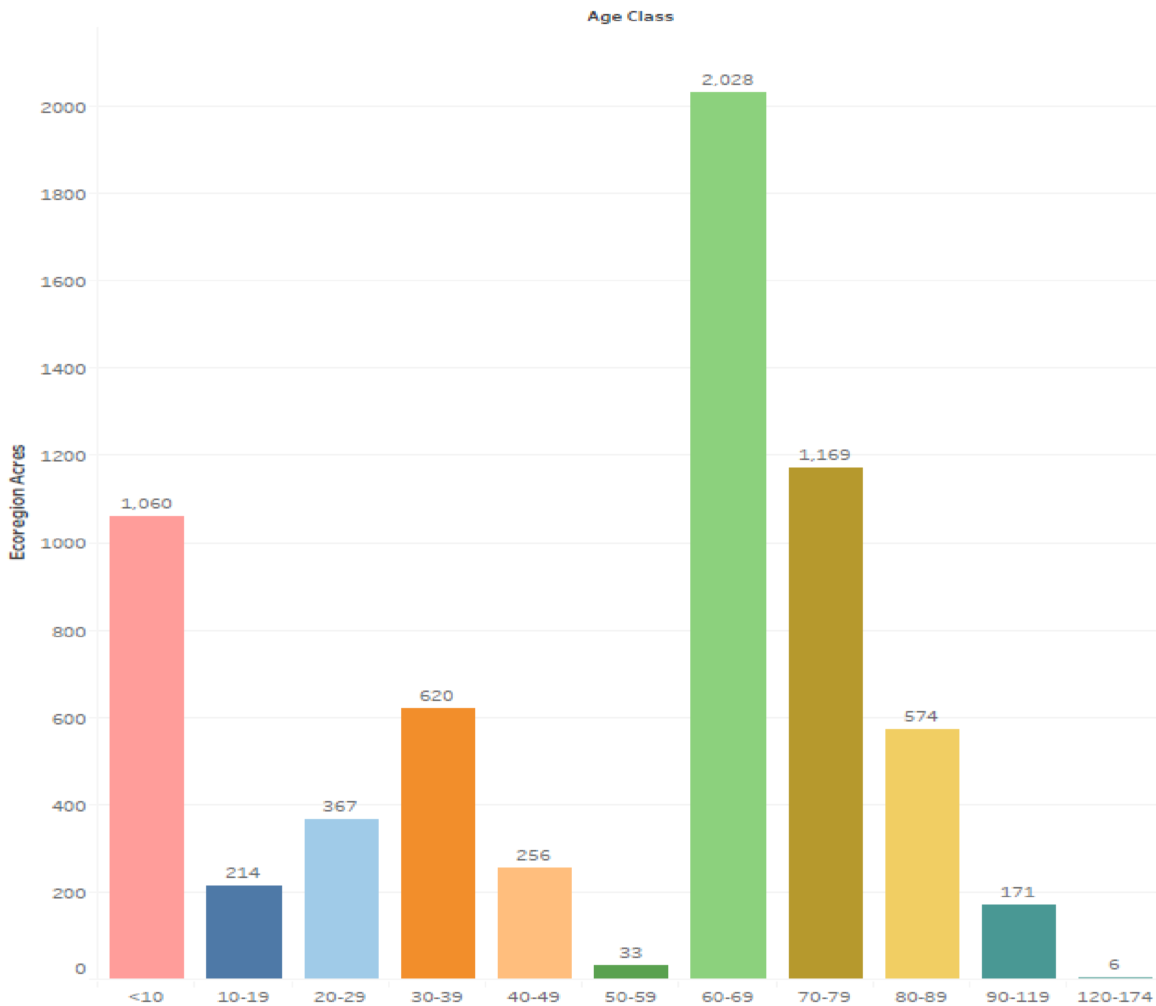
[7] Forest age and structure data are only available for Board of Forestry Lands and Common School Forest Lands (i.e., the permit area). Data are not available for private or federal land in the plan area.



Source: ODF file information

Note: Percentages do not total 100% as non-forested vegetations types are not shown.

Figure 2-15. Forest Type in the Permit Area in the Willamette Valley Ecoregion



Source: ODF file information

Figure 2-16. Stand Age in the Permit Area in the Willamette Valley Ecoregion

Adjacent Ownership

There are approximately 63 miles of adjoining land ownership perimeter in the permit area of the Willamette Valley ecoregion. The primary adjoining landowner type is private (Table 2-8). A mapbook at the end of this chapter illustrates adjoining land ownership throughout the permit area (Figure 2-19a through 2-19s).

Table 2-8. Adjacent Land Ownership of the Permit Area in the Willamette Valley Ecoregion

Adjacent Landowner	Miles	Proportion of Ecoregion (%)
Private	40	64
Other State lands	17	27
Bureau of Land Management	5	8
Other federal agency	1	1
Total	**63**	**100%**

2.5 Covered Species

As described in Chapter 1, ODF selected the covered species for the HCP based on review of all species of conservation concern known or suspected to occur in the plan area during the permit term. These species were then screened for coverage based on four selection criteria described in Section 1.2.5.1, *Covered Species Selection Criteria*. A summary of that selection process is described in Appendix D, *Species Considered for Coverage*. Table 2-9 lists covered species and habitat associations.

Detailed species accounts of each of the 17 covered species are provided in Appendix C. These accounts summarize ecological information, distribution, status, threats, population trends, and conservation and management activities in the plan area. The accounts represent the best available scientific data for each species on which this HCP is based. The species accounts are not intended to summarize all biological information known about a species. Rather, each account summarizes scientific information that is relevant to the analysis in the HCP. The biological data in these accounts form the basis for the conservation strategy (Chapter 4) and effects analysis (Chapter 5).

Table 2-9. Covered Species and Habitat Associations

Covered Species	Habitat Associations[a]
Fish	
Oregon Coast coho (*Oncorhynchus kisutch*)	Clean and relatively stable gravel streambeds for spawning and egg incubation, complex channel features, cool temperatures during juvenile rearing, access to backwater and off-channel features for winter rearing, access for anadromous migration.
Oregon Coast chinook (*O. tshawytscha*)	Clean and relatively stable gravel streambeds for spawning and egg incubation, complex channel features, cool temperatures during adult holding and juvenile rearing, access for anadromous migration.
Southern Oregon/ Northern California Coastal chinook (*O. tshawytscha*)	Clean and relatively stable gravel streambeds for spawning and egg incubation, complex channel features, cool temperatures during adult holding and juvenile rearing, access for anadromous migration
Lower Columbia River coho (*O. kisutch*)	Clean and relatively stable gravel streambeds for spawning and egg incubation, complex channel features, cool temperatures during juvenile rearing, access to backwater and off-channel features for winter rearing, access for anadromous migration.
Upper Willamette River spring-run chinook (*O. tshawytscha*)	Clean and relatively stable gravel streambeds for spawning and egg incubation, complex channel features, cool temperatures during adult holding and juvenile rearing, access for anadromous migration.
Upper Willamette River winter steelhead (*O. mykiss*)	Clean and relatively stable gravel streambeds for spawning, egg incubation, and juvenile overwinter, cool temperatures during rearing, access for anadromous migration.
Columbia River chum (*O. keta*)	Clean gravel streambeds in primary and side channels near tidewaters for spawning and egg incubation.
Southern Oregon/Northern California Coast coho (*O. kisutch*)	Clean gravel streambeds in primary and side channels near tidewaters for spawning and egg incubation. Juvenile overwinter, cool temperatures during rearing, access for anadromous migration.

Covered Species	Habitat Associations[a]
Lower Columbia River chinook (*O. tshawytscha*)	Clean and relatively stable gravel streambeds for spawning and egg incubation, complex channel features, cool temperatures during juvenile rearing, access for anadromous migration.
Eulachon (*Thaleichthys pacificus*)	Spawn in lower reaches of coastal rivers and Columbia River tributaries. Streamflow and tides carry larva to ocean soon after emergence.
Birds	
Northern spotted owl (*Strix occidentalis*)	Late seral forest or younger forest with residual late seral components, including moderate to high canopy closure, multi-layered, multi-species canopy with large overstory trees, open space among lower branches to allow for flight, large standing and downed trees, and trees with deformities that create structural diversity.
Marbled murrelet (*Brachyramphus marmoratus*)	Much of their lives spent on the ocean, but nest in late seral forests close to marine habitat (up to approximately 35 miles in Oregon) characterized by large trees, with large limbs for nesting platforms, multi-layered canopy, and moderate to high canopy closure. Can nest in younger forest with remnant large trees.
Amphibians	
Oregon slender salamander (*Batrachoseps wrighti*)	Late seral forest and younger closed canopy forests where there are abundant mid- to advanced-decay Douglas-fir logs and bark debris mounds at base of snags. Talus and lava fields that retain moisture.
Columbia torrent salamander (*Rhyacotriton kezeri*)	Cold mountain streams, seeps, and springs. Requires loose gravel stream beds with specific geologic characteristics (gradient).
Cascade torrent salamander (*R. cascadae*)	Cold, fast-flowing, clear, permanent headwater streams, seeps and waterfall splash zones in forested areas. Gravel or small cobble substrate with continuous but shallow water flow for larvae and adults foraging and hiding. Continuous access to cold water. Requires moist adjacent forest and micro-habitat features, such as basalt rock.
Mammals	
Coastal marten (*Martes caurina*)	Associated mostly with late seral, structurally complex mixed conifer forest with multi-layer stands but found in other forests providing there is a high density of snags and logs for denning and foraging, and extensive, robust understory cover.
Red tree vole (North Oregon Coast population) (*Arborimus longicaudus*)	Late seral, structurally complex conifer forest, prefers large stand size. Sometimes found in nearby, younger, closed canopy stands.

[a] See species accounts in Appendix C for the literature sources of habitat associations.

2.5.1 Species Occurrence Data

Data on the occurrence of each species in the plan area and permit area are an important input to the HCP. The following summarizes the data sources compiled for this HCP and used for the development of conservation actions in Chapter 4 and for the evaluation of adverse effects in Chapter 5. Survey data by species is also summarized in Table 2-10.

- **Northern Spotted Owl.** ODF has surveyed suitable habitat for northern spotted owls in state forests since 1992. Most recently, surveys for northern spotted owls were conducted on 80% or more of each district between 2014 and 2018 (Magby et al. 2018). Survey data results in the designation of activity centers, following the ODF Northern Spotted Owl Guidance document (ODF 2017). Activity centers are based on the most biologically significant observation during the nesting season (March through August), and are centered on daytime locations of individuals or pairs and, optimally, the nest tree, if found (Sovern et al. 2019).
- **Marbled Murrelet.** ODF has conducted over 32,000 individual surveys at more than 1,300 unique sites since 1992. This represents the largest survey efforts for marbled murrelets by any land manager in Oregon, Washington, or California. Marbled murrelet nest sites are extremely difficult to locate, so this HCP uses “occupied behavior” observations made during protocol surveys (Evans Mack et al. 2003) as a surrogate for nest sites as the best available science (ODF 2019).
- **Coastal Marten.** Coastal marten occurrences are based on the USFWS Species Status Assessment (2018) that compiles the historical (pre-1980) and current range and distribution (1980–current).
- **Red Tree Vole.** Red tree vole occurrences have been compiled from various sources, including surveys conducted by the U.S. Forest Service (USFS) and Forsman et al. (2016).
- **Oregon Slender Salamander.** Oregon slender salamander occurrences are based on Bureau of Land Management data collected from 1980 to 2016 and on a more recent 7-year cooperative study conducted by Oregon State University, ODF, and private landowners, including lands within the Santiam State Forest.
- **Torrent Salamanders.** Torrent salamander occurrences are based on surveys recently conducted by ODFW and summarized in an interim report (Thurman 2019).
- **Fish Species.** Fish occurrences are based on fish distribution data from the StreamNet cooperative information management and data dissemination project (https://www.streamnet.org/). This analysis includes all fish distributions for any subbasins (hydraulic unit codes [HUC-8]) that are at least partially in the plan area. The analysis also considered available information from ODF regarding stream blockages and associated upstream intrinsic potential fish habitat.

Species occurrence by ecoregion is provided in Table 2-10. Maps showing occurrence data in the plan area can be found in each covered species account (Appendix C). Because surveys for species occurrence have not been completed across the entire plan area, some assumptions were made about where species might occur and the quality of habitat in those locations. To overcome those data limitations on species occurrence, the covered species accounts include species distribution models to predict species occurrence across the entire plan area. These species distribution models are described in more detail in the next section.

Species presence is dynamic and always changing, and all potentially suitable habitat has not been recently surveyed for all species, so covered species occurrences may have changed, and species may be present within habitat that has not yet been surveyed. To address this, this HCP uses also forest and habitat data and species-specific habitat models to estimate the extent of species distribution, and the locations of likely suitable habitat. Based on these surrogate data, the conservation strategy defines the types and magnitude of conservation actions needed to fully offset the impacts of take on the species and ensure their continued presence in the permit area.

Table 2-10. Covered Species Occurrence by Ecoregion

Covered Species	Ecoregion[a]			
	Coast Range	West Cascades	Klamath Mountains	Willamette Valley
Fish				
Oregon Coast coho (*Oncorhynchus kisutch*)	✓	✓	✓	
Oregon Coast spring-run chinook (*O. tshawytscha*)	✓	✓	✓	
Southern Oregon/ Northern California Coastal spring-run chinook (*O. tshawytscha*)	✓		✓	
Lower Columbia River coho (*O. kisutch*)	✓	✓		✓
Upper Willamette River spring-run chinook (*O. tshawytscha*)		✓		✓
Upper Willamette River winter steelhead (*O. mykiss*)		✓		✓
Columbia River chum (*O. keta*)	✓			
Southern Oregon/Northern California Coast coho (*O. kisutch*)	✓	✓	✓	
Lower Columbia River chinook (*O. tshawytscha*)	✓	✓		✓
Eulachon (*Thaleichthys pacificus*)	✓			✓
Birds				
Northern spotted owl (*Strix occidentalis*)	✓	✓	✓	✓
Marbled murrelet (*Brachyramphus marmoratus*)	✓		✓	✓
Amphibians				
Oregon slender salamander (*Batrachoseps wrighti*)		✓		✓
Columbia torrent salamander (*Rhyacotriton kezeri*)	✓			
Cascade torrent salamander (*R. cascadae*)		✓		✓
Mammals				
Coastal marten (*Martes caurina*)	✓		✓	
Red tree vole (*Arborimus longicaudus*) (North Oregon Coast population)	✓			✓

[a] See species accounts in Appendix C for the literature sources range.

2.5.2 Species Habitat Distribution Estimates

Because of the large size of the permit area and the lack of consistent species surveys across this landscape, the HCP must also rely on predictions of species presence based on predictive models of habitat distribution and habitat suitability. Such models are commonly used in large-scale habitat conservation planning (ICF International 2012, ICF 2020). ODF has developed species accounts and habitat models for three of the species to be covered under the HCP: northern spotted owl, marbled murrelet, and red tree vole. For aquatic species, modeling was conducted to estimate the general benefit of conservation actions on the aquatic and riparian habitat, rather than for individual species. Discrete models were developed for four of the terrestrial species. Appendix C, *Species Accounts,* summarizes habitat model parameters developed for the species and the modeled habitat distribution in the permit area. The species accounts also document key information regarding each covered species, including taxonomy, distribution, habitat requirements, population status, and threats.

2.5.2.1 Covered Fish Distribution

For fish, a NetMap watershed analysis was prepared by TerrainWorks (2020) for the permit area. This analysis includes any subbasin (HUC-8) that is at least partially in the permit area. NetMap will provide a consistent synthetic stream layer that covers the permit area and will allow for the classification of stream reaches by vulnerability to increased stream temperatures and estimates of wood recruitment.

2.5.2.2 Torrent Salamander Distribution

A discrete habitat model was not developed for the torrent salamanders. Rather, all non-fish-bearing perennial streams from the NetMap synthetic stream layer within the range of each torrent salamander species were assumed to be potentially suitable habitat. Both torrent salamanders are associated with high-gradient, perennial, cool or cold-water sources such as seeps, headwaters, and edges of larger streams within forests (Stebbins and Lowe 1951, Jones et al. 2005, Lannoo 2005). Non-fish-bearing perennial streams are located in the upper reaches of watersheds, approximating suitable perennial headwater habitats.

2.5.2.3 Oregon Slender Salamander

A habitat model using the method described for northern spotted owl, marbled murrelet, and red tree vole was developed for Oregon slender salamander. However, due to limitations with how ODF's Stand Level Inventory (SLI) data tracks downed woody debris, one of the primary indicators of Oregon slender salamander habitat, the model ultimately proved ineffective at differentiating between habitat types and quality. Oregon slender salamander are thought to be widespread and ubiquitous in the permit area. This HCP assumes that all of the permit area in and around the Santiam State Forest that is within the range of Oregon slender salamander is suitable habitat.

2.5.2.4 Coastal Marten Distribution

A habitat model was not developed for coastal marten. Not enough is known about current coastal marten habitat relationships and distribution in the types of forests that occur within the permit area. Most information on coastal marten habitat relationships is from studies in the Central Coastal Oregon Dunes, Southern Coastal Oregon, and Northern Coastal California Extant Population Areas

(USFWS 2015). Multiple entities (e.g., USFWS, USDA Forest Service Pacific Northwest Research Station and Pacific Southwest Research Station, the National Council for Air and Stream Improvement, Oregon State University, and Humboldt State University) have been working to refine and improve existing habitat models to better inform conservation planning. All of the areas for which models are available have habitat characteristics different enough from the forests in the permit area to make extrapolating habitat relationships from Extant Population Areas to the permit area unreliable. This HCP assumes that all of the permit area from the northern boundary of Lane County south to the California border and west of Interstate 5 could provide suitable habitat for coastal marten.

2.5.2.5 NSO, MAMU, and RTV Habitat Distribution

Habitat distribution and suitability models were developed for northern spotted owl, marbled murrelet, and red tree vole to predict where they could occur based on habitat requirements known from field studies and as identified in published habitat suitability models. The models were used to assist in quantifying impacts of covered activities on covered species and to assist in developing the conservation strategy. Details of how the habitat distribution and suitability models (also called "habitat models") were developed, including model parameters and data sources, are summarized below and described in more detail in the Effects Analysis Approach (Appendix E).

The habitat models described in the species accounts were designed to estimate the extent and suitability of habitat in the permit area. The models use the best scientifically available information on the relationship between covered species' habitats and forest inventory metrics to assign a habitat suitability score to individual forest stands. These models are intended to be repeatable and scientifically defensible, while remaining as simple as possible, and relatable to ODF's forest inventory data.

SLI data on forest tree species composition and forest structure were used to characterize key habitat relationships for the terrestrial covered species. SLI data include attributes such as number of large trees per acre, density of trees, number of snags, and amount of downed wood, among other attributes, within a stand. The SLI data allow ODF to model covered species' habitat suitability using the same data that ODF uses to characterize its landscape for forest management and timber harvest. This approach will facilitate HCP implementation by integrating species habitat models with forest management planning, growth and yield estimates, and forest activity models. The three species for which habitat is modeled are strongly associated with late-seral conifer forests. As such, the models include parameters that characterize attributes of late-seral forests, particularly those that provide key habitat features, such as large, old trees used by marbled murrelet for nest platforms.

2.5.2.6 Methods

The following approach was used to develop the habitat models for the three terrestrial covered species. Additional details on model parameters unique to each species are found in Appendix E.

- **Step 1. Identify Parameters.** Based on the scientific literature, identify key habitat features to include as parameters in each species' model. Important sources of information include studies on habitat relationships, particularly existing habitat suitability models. Parameters were selected for the model that are reliable and consistent indicators of species presence in habitat found in the permit area and for parameters that can be reported at the scale of an individual forest stand by ODF. Parameters could not be used that are based on small-scale habitat features that cannot be feasibly represented at a stand level scale, such as tree limbs that provide nest platforms for marbled murrelet. Models include 3–4 parameters each.

Spatial and landscape-level parameters such as patch size and distance to other patches were not included in the models. The intent of the models is to characterize habitat suitability at the stand-level using SLI data. Rather, the conservation strategy seeks to improve important spatial and landscape-level habitat conditions by conserving, expanding, and connecting habitat patches. Important spatial and landscape-level features were assessed in combination with the habitat suitability models, occurrence data, and other sources of information when identifying habitat patches to conserve for the focal species.

- **Step 2. Select Data.** Select the SLI stand structure parameter that best characterizes each species' habitat parameter. For example, northern spotted owl needs multilayered, multispecies canopies with large (at least 20- to 30-inch diameter at breast height [DBH]) overstory trees for nesting and roosting (USFWS 2012). The number of trees per acre with a DBH of 30 inches or greater was selected as the stand structure parameter to characterize stands with large overstory trees. Other stand structure parameters, such as Diameter Diversity Index (DDI) (Spies et al. 2007), were used to characterize multilayered canopies. For covered species that occur in only a portion of the permit area, habitat data were clipped to the published range of the species, as described in each species account.

- **Step 3. Develop Logistic Models.** Model the relationship between each stand structure parameter and habitat quality. Logistic models were used to estimate suitability across a range of values for each stand structure parameter, with a probability between 0 and 1 (with an increasing probability corresponding with increasing habitat suitability for that stand structure parameter). Logistic models were built by first assigning habitat suitability probabilities to a stand structure parameter value where there is support in the literature for these assignments. For marbled murrelet and red tree vole habitat suitability probabilities were assigned to stand structure parameter values to correspond with thresholds for the following habitat suitability categories: highly suitable, suitable, marginally suitable, and not habitat. For northern spotted owl, habitat suitability probabilities were assigned to stand structure parameter values to correspond with thresholds to distinguish nesting and roosting habitat, foraging habitat, dispersal habitat, and not habitat. This was done to convert the continuous habitat suitability values to biologically meaningful categories that could be used in the HCP.

  A logistic equation was then created to connect those established data points and provide habitat suitability values for the range of possible stand structure parameter values. The shape of the logistic curve for each stand structure parameter illustrates the relationship between a range of habitat structure parameter values and habitat suitability probabilities.

  The logistic was fit to the assigned habitat suitability probability to selected stand structure parameter values by minimizing error. Assigned habitat suitability probabilities served as targets for the solver. The actual habitat suitability value computed by the solver function generally differed from the assigned target by less than ±0.1.

  Habitat suitability probabilities for stand structure parameter values were assigned depending on data from the scientific literature from ecological field studies, habitat models, and the expert opinion of ODF biologists and species experts external to ODF. For example, red tree vole generally requires a structurally diverse, multicanopy conifer forest with large trees (Forsman et al. 2016, Rosenberg et al. 2016). DDI provides a quantitative index of canopy layering. DDI describes the relative similarity of a given stand to an old growth stand in terms of the number of trees per acre in each of 4 diameter classes. Stands can range from a DDI of almost 0 up to a maximum of 10, with 0 representing the least layering and 10 representing the most layering. Forsman et al. (2016) found that red tree vole habitat suitability increased along a sigmoidal curve with increasing DDI. Habitat suitability probabilities were assigned to correspond to mean DDI values for four modeled suitability classes from the Forsman et al. (2016) model: highly suitable, suitable, marginal, unsuitable (Table 3-4 in Forsman et al. 2016). Mean DDI for highly suitable habitat in the Forsman et al. model is 6.6 (± 0.1 standard error [SE]), 6.0 (± 0.1 SE) for suitable habitat, 4.9 (± 0.1 SE) for marginal, and 3.7 (± 0.1 SE) for unsuitable. For this Plan's model, a DDI of 7.0 was assigned a habitat suitability probability of 0.8; a DDI of 6.0 was assigned a habitat suitability probability of 0.6; a DDI of 5.0 was assigned a habitat suitability probability of 0.4; and a DDI of 4.0 was assigned a habitat suitability probability of 0.2.

Rationales for assigning habitat suitability probabilities to parameter values are provided in Appendix E.

- **Step 4. Weight parameters.** For some species, certain habitat characteristics are more important than others in determining habitat suitability and probability of occurrence. In cases where the scientific literature supports weighting of an available habitat parameter, that parameter was given more weight in the model than other parameters. Weight of one parameter is relative to the other parameters in each model. Parameters were weighted equally if scientific literature did not strongly suggest weighting. Professional judgement by ODF biologists and species experts was used to weight one or more values more than others when supported by the scientific literature.

- **Step 5. Calculate habitat suitability.** Habitat suitability index is the weighted product of all of the model parameter suitability probabilities for a given stand. The total habitat suitability index is on a continuous scale of 0 (lowest suitability) to 1.0 (highest suitability). The habitat suitability index is interpreted as the probability that the forest stand provides suitable habitat for that species.

  The same suitability category threshold probability targets used for each parameter in each model were used to categorize total habitat suitability index scores for each stand. While the indices themselves are continuous, thresholds within the continuum were established to quantify acres of habitat in discrete categories, from highly suitably types to unsuitable (i.e., non-habitat).

- **Step 6. Test and refine models.** Each model was refined and tested by comparing model results to a variety of other data, including known occurrence records, existing habitat models based on other datasets such as USFS Forest Inventory and Analysis plot data, and ODF's mapping of forest structure in the permit area. Habitat suitability scores and parameter weights in this Plan's model were adjusted to improve overlap between the Plan's model and comparative data and models. The habitat models were also reviewed by wildlife agency staff and external species experts and refined in response to their feedback. Index thresholds that define habitat categories for each species were also adjusted to better capture the full range of habitat conditions that currently exist on the permit area.

See Appendix E for tables that summarize habitat features modeled for each species, the corresponding SLI variable used to model that habitat feature, habitat suitability probability assignments for parameter values, and rationales for the selection of each parameter and assignment of habitat suitability probabilities.

2.5.2.7 Model Uses and Limitations

The habitat suitability models are intended to be used only for planning purposes at the scale of the permit area. For example, the modeled suitability of habitat in an area does not necessarily mean that the species will be present or absent or that the habitat is fully developed or suitable today. Rather, modeled suitability means that a stand has a certain probability of being suitable for that species and therefore may be or is likely to be occupied by the species. Habitat suitability models were used to estimate the amount and location of take (i.e., loss of suitable habitat) and identify areas with high conservation value for each covered species. across the entire permit area. The habitat models were also used to project habitat development over time, through growth and implementation of habitat enhancement actions. The monitoring program, described in Chapter 6, *Monitoring and Adaptive Management*, includes the process to determine whether the important habitat parameters are present in areas identified as habitat for covered species (by the habitat models.). The monitoring program will also assess how those habitat parameters may change over time.

2.5.3 Recovery Plans for Covered Species

This section provides brief overviews of existing recovery plans relevant to the conservation of the covered species. These plans were used as guidance for the conservation strategy of this HCP in the ways described below.

2.5.3.1 Recovery Plans for Salmon

Four separate recovery plans for the covered fish identify key limiting factors. (ODFW and NOAA Fisheries 2011; NOAA 2013, 2014, and 2016) (see Table 2-11). These limiting factors are physical, biological, or chemical features that have the greatest impact on a population’s ability to reach a desired status. These recovery plans identify recovery strategies and actions, many of which are applicable to conservation strategies and actions in this HCP. Conservation actions under this HCP will improve limiting factors in the permit area and have a long-term benefit for the covered fish species. Limiting factors, by species, are provided in Table 2-11, these factors were a key component in developing the conservation strategy of the HCP and will help guide implementation of the conservation actions to elicit the greatest benefit for the covered salmonids.

Table 2-11. Key Limiting Factors for the Covered Salmon Species

		Limiting Factor					
Covered Fish Species	**Recovery Plan**	**Reduced Amount and Complexity of Habitat**	**Peripheral and Transitional Habitats: Side Channels, Wetlands, and Floodplains**	**Impaired Riparian Function**	**Degraded Water Quality**	**Blocked/Impaired Fish Passage**	**Adequate Regulatory Mechanisms to Protect Population**
Oregon Coast coho	NOAA 2016	X	X	X	X	X	X
Oregon Coast spring-run chinook	--		X	X	X		X
Southern Oregon/ Northern California Coastal spring-run chinook	--	X	X	X	X	X	X
Lower Columbia River coho	NOAA 2013	X	X	X	X		X
Lower Columbia River chinook	NOAA 2013		X	X	X		X
Columbia River chum	NOAA 2013			X	X		X
Upper Willamette River spring-run chinook	ODFW and NOAA Fisheries 2011		X	X	X	X	X
Upper Willamette River winter steelhead	ODFW and NOAA Fisheries 2011	X	X	X	X	X	X
Southern Oregon/ Northern California Coast coho	NOAA 2014	X	X	X	X	X	X

2.5.3.2 Recovery Plan for Northern Spotted Owl

The recovery plan for the northern spotted owl was first published in 2008 and revised in 2011 (USFWS 2011). The current recovery plan identifies recovery units essential for the survival and recovery of spotted owls, with five recovery units in Oregon: Oregon Coast Range, Willamette Valley, Western Oregon Cascades, Eastern Oregon Cascades, and Oregon Klamath. The permit area includes lands in all of these recovery units except the Eastern Oregon Cascades.

The 2011 recovery plan relies heavily on recovery of spotted owls on federal lands but also identifies the need to retain a spotted owl distribution across the range where federal lands are lacking, and noted as an example northwestern Oregon, "potentially including parts of the Tillamook and Clatsop State Forests." The recovery plan states that "managing to retain spotted owls at existing sites should be the most effective approach to conserving spotted owls" in these areas.

The 2011 recovery plan defines 33 specific recovery actions. Of those, six recovery actions are applicable to this HCP (Table 2-12).

Table 2-12. Recovery Actions Applicable to the HCP for Northern Spotted Owl (USFWS 2011)

Recovery Action	Summary
Recovery Action 6	In most forests managed for spotted owl habitat, land managers should implement silvicultural techniques in plantations, overstocked stands, and modified younger stands to accelerate the development of structural complexity and biological diversity that will benefit spotted owl recovery.
Recovery Action 10	Conserve spotted owl sites and high-value spotted owl habitat to provide additional demographic support to the spotted owl population.
Recovery Action 14	Encourage applicants to develop Habitat Conservation Plans and Safe Harbor Agreements that are consistent with the recovery objectives.
Recovery Action 19	The Service will request the cooperation of Oregon Department of Forestry in a scientific evaluation of (1) the potential role of state and private lands in Oregon to contribute to spotted owl recovery; and (2) the effectiveness of current Oregon Forest Practices in conserving spotted owl habitat and meeting the recovery goals identified in this Revised Recovery Plan. Based on this scientific evaluation, the Service will work with the Oregon Department of Forestry and other individual stakeholders to provide specific recommendations for how best to address spotted owl conservation needs on Oregon's non-federal lands.
Recovery Action 28	Expedite permitting of experimental removal of barred owls.
Recovery Action 32	Because spotted owl recovery requires well distributed, older, and more structurally complex multilayered conifer forests on federal and non-federal lands across its range, land managers should work with the Service to maintain and restore such habitat while allowing for other threats, such as fire and insects, to be addressed by restoration management actions. These high-quality spotted owl habitat stands are characterized as having large diameter trees, high amounts of canopy cover, and decadence components such as broken-topped live trees, mistletoe, cavities, large snags, and fallen trees.

2.5.3.3 USFWS Barred Owl Removal Experiment

As described in the 2011 northern spotted owl recovery plan, barred owls pose perhaps the most significant and immediate threat to spotted owl recovery (USFWS 2011). The recovery plan specified several substantive recovery actions to address this threat, including research on the competition between spotted and barred owls, experimental control of barred owls, and, if recommended by research, removal of barred owls using a combination of lethal and non-lethal methods.

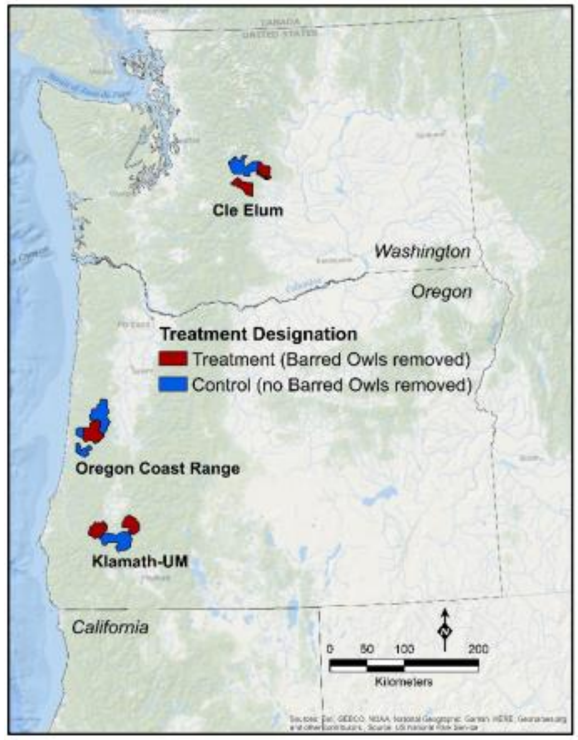


Figure 2-17. Barred Owl Study Areas in Washington and Oregon (from Wiens et al. 2019)

In 2013, the USFWS issued a Final Environmental Impact Statement and Record of Decision for the experimental removal of barred owls to benefit northern spotted owls (USFWS 2013a, 2013b). Under the experimental removal plan, barred owl removals have occurred at one study area in Washington, two in Oregon, and one in California (Figure 2-17).

As of October 2019, a total of 2,435 barred owls have been removed at the four study areas, with area-specific removals as follows (USFWS 2020):

- Cle Elum, Washington : 472
- Oregon Coast Range: 1,018
- Klamath-Union/Myrtle Study Area, Oregon: 536
- Hoopa, California: 409

The experiment has found reduced and declining barred owl populations in the removal areas, while barred owls continue to increase in control areas where no removals have occurred. Across all study areas, the USFWS believes that barred owl removal appears to have stabilized spotted owl populations, although total spotted owl numbers remain low (USFWS 2020). An analyses of individual study areas conducted by Wiens (2021) found that barred owl removal increased survival of individual spotted owls. In some cases, nonterritorial spotted owls were found to regain territories after the barred owl occupants had been removed. However, Wiens (2021) cautioned that low reproductive rates continue to be a major barrier to northern spotted owl recovery and that in addition to increased survival of northern spotted owls, reproduction rates will also need to increase so that young, nonterritorial recruits are available to fill territory vacancies once barred owl occupants are removed.

2.5.3.4 Safe Harbor Agreements for Barred Owl Removal Experiment

As part of the barred owl removal experiment just described, the USFWS has entered into Safe Harbor Agreements (SHA) with four land management entities.

- Oregon Department of Forestry SHA for the northern spotted owl in the Oregon Coast Ranges Study Area of the Barred Owl Removal Experiment.
- Weyerhaeuser Company SHA for the northern spotted owl in the Oregon Coast Ranges Study Area of the Barred Owl Removal Experiment.
- Roseburg Resources Company SHA for northern spotted owls in Douglas County, Oregon.
- Roseburg Resources Company SHA for northern spotted owls in Union/Myrtle (Klamath) Study Area of the Barred Owl Removal Experiment.

A SHA is a voluntary agreement involving private or other non-federal property owners whose actions contribute to the recovery of species listed as threatened or endangered under the act. In exchange for actions that contribute to the recovery of listed species on non-federal lands, the USFWS will not require any additional or different management activities by the participants without their consent.

These SHAs provided assurances to permit holders that they would not be prohibited from harvesting areas that may be recolonized by spotted owls due to the USFWS experimental removal of barred owls.

There are no other SHAs in Oregon for species covered under this HCP.

2.5.3.5 Recovery Plan for Marbled Murrelet

The recovery plan for marbled murrelet (USFWS 1997) identifies six Marbled Murrelet Conservation Zones, five of which are in the coterminous Pacific states: Puget Sound/Strait of Juan De Fuca; Western Washington Coast Range; Oregon Coast Range; Siskiyou Coast Range; and Mendocino (Figure 2-18).

Most of the permit area is in Zone 3, Oregon Coast Range. A portion of the permit area is in Zone 4, Siskiyou Coast Range.

Zone 3 (Oregon Coast Range) includes the majority of known marbled murrelet occupied sites in Oregon. The recovery plan includes the following description of recovery strategies for this zone:

Marbled murrelet occupied sites along the western portion of the Tillamook State Forest are especially important to maintaining well- distributed marbled murrelet populations. Efforts should focus on maintaining these occupied sites, minimizing the loss of unoccupied but suitable habitat, and decreasing the time for development of new habitat. Relatively few known occupied sites occur north of the Tillamook State Forest. Recovery efforts should be directed at restoring some of the north-south distribution of marbled murrelet populations and habitat in this zone. Maintenance of suitable and occupied marbled murrelet nesting habitat in the Elliott State Forest, Tillamook State Forest, Siuslaw National Forest, and BLM-administered forests is an essential component for the stabilization and recovery of the marbled murrelet.

Source: USFWS 1997

Figure 2-18. Marbled Murrelet Conservation Zones (Zone 6, Santa Cruz Mountains, not shown)

The 1997 recovery plan also lists the following actions needed for the recovery of the species, which were used to help design the conservation strategy for this HCP.

- Establish Marbled Murrelet Conservation Zones and develop landscape-level management strategies for each zone.
- Identify and protect terrestrial and marine habitat areas in each Marbled Murrelet Conservation Zone.
- Monitor marbled murrelet populations and habitat and survey potential breeding habitat to identify potential nesting areas.
- Implement short-term actions to stabilize the marbled murrelet population.
- Implement long-term actions to stop population decline and increase marbled murrelet population growth.

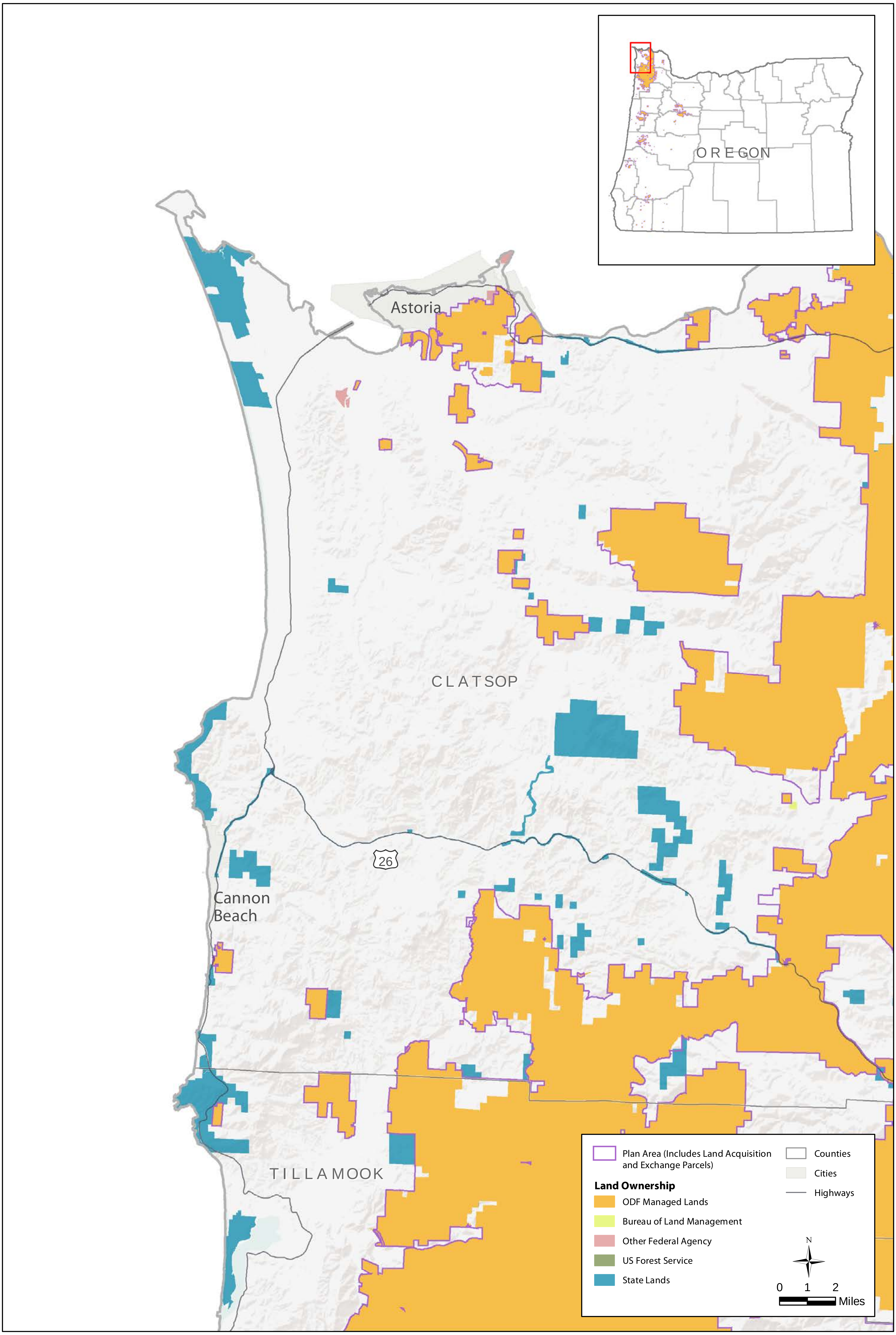


Figure 2-19a: Adjacent Land Ownership

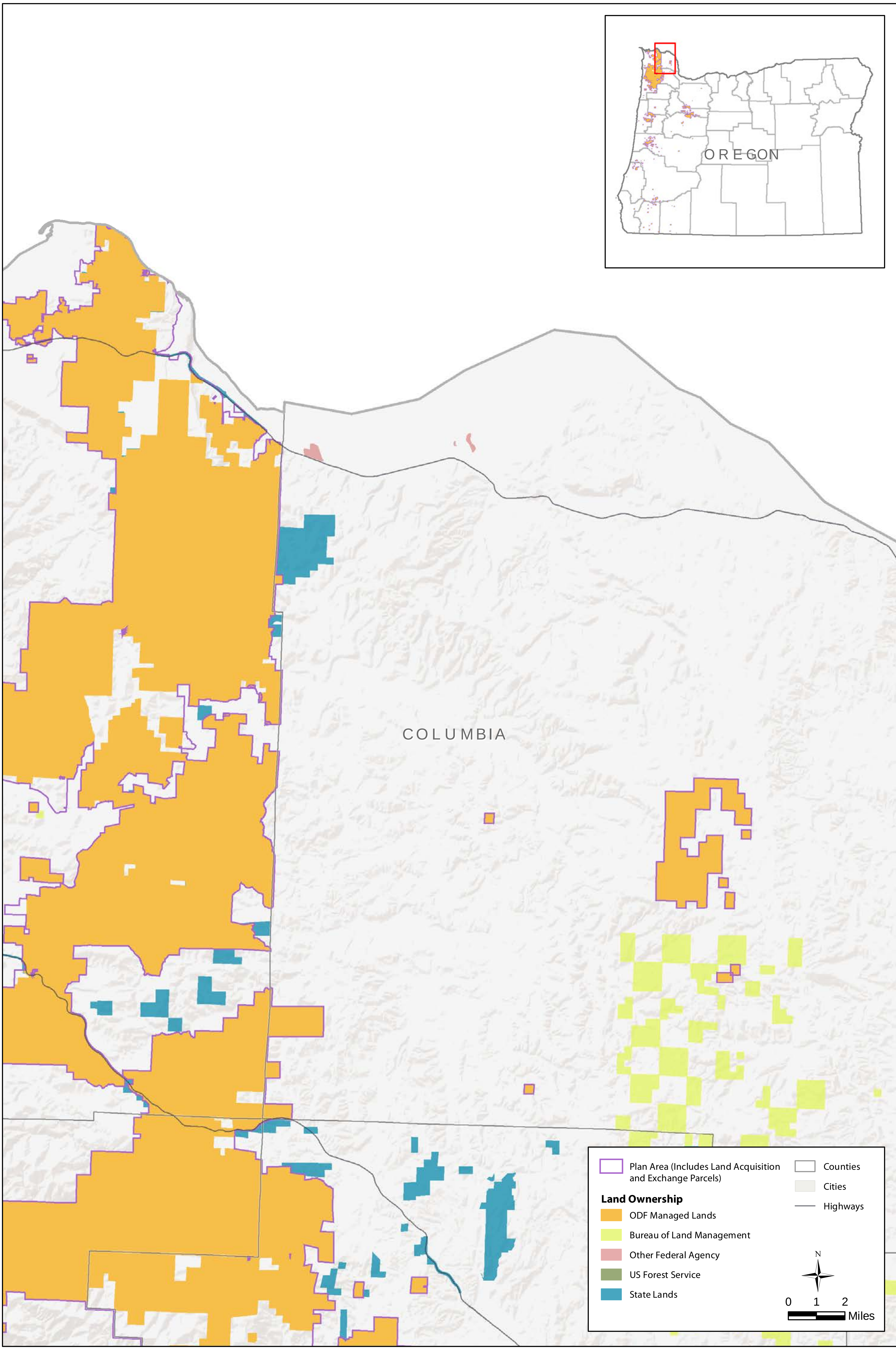


Figure 2-19b: Adjacent Land Ownership

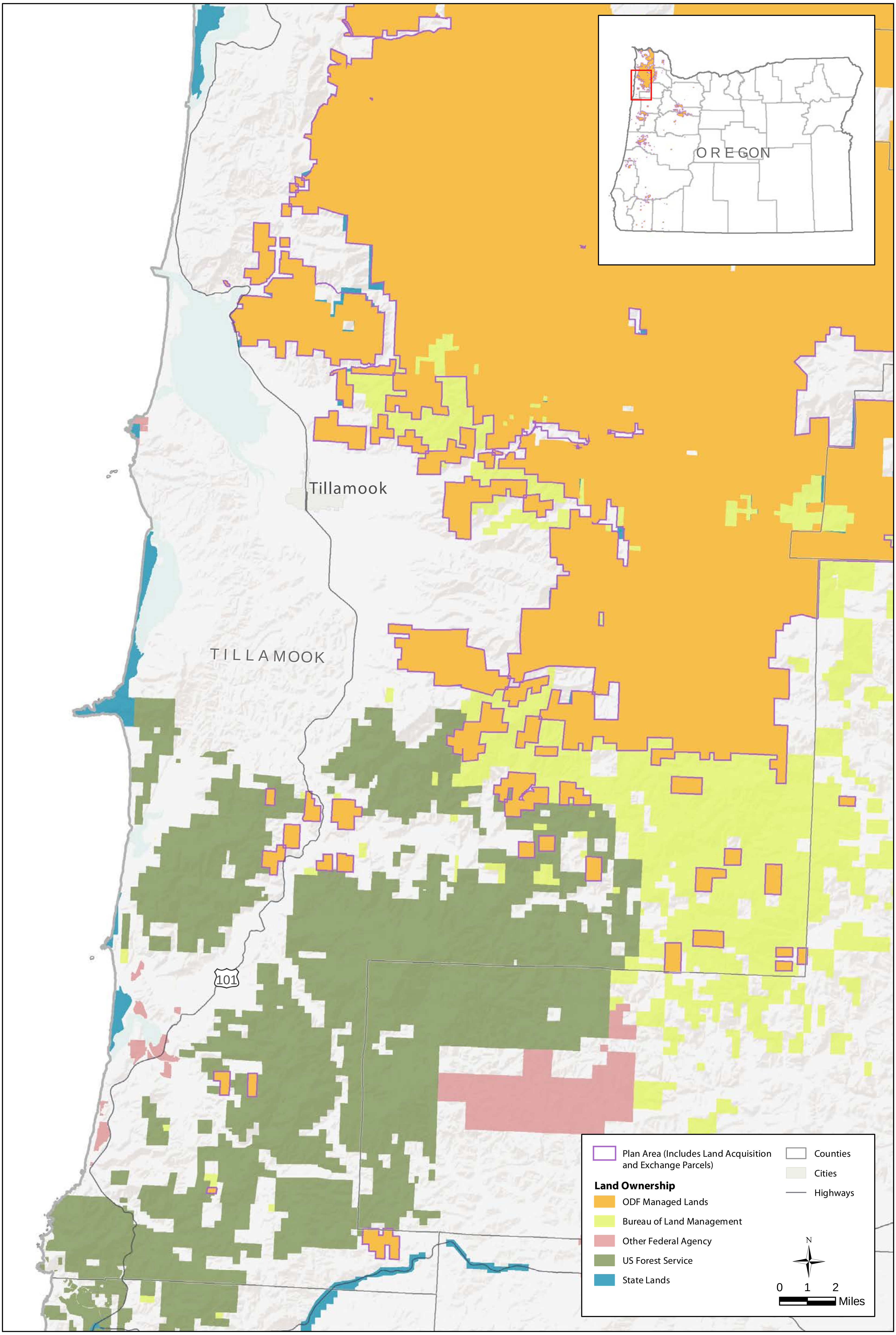


Figure 2-19c: Adjacent Land Ownership

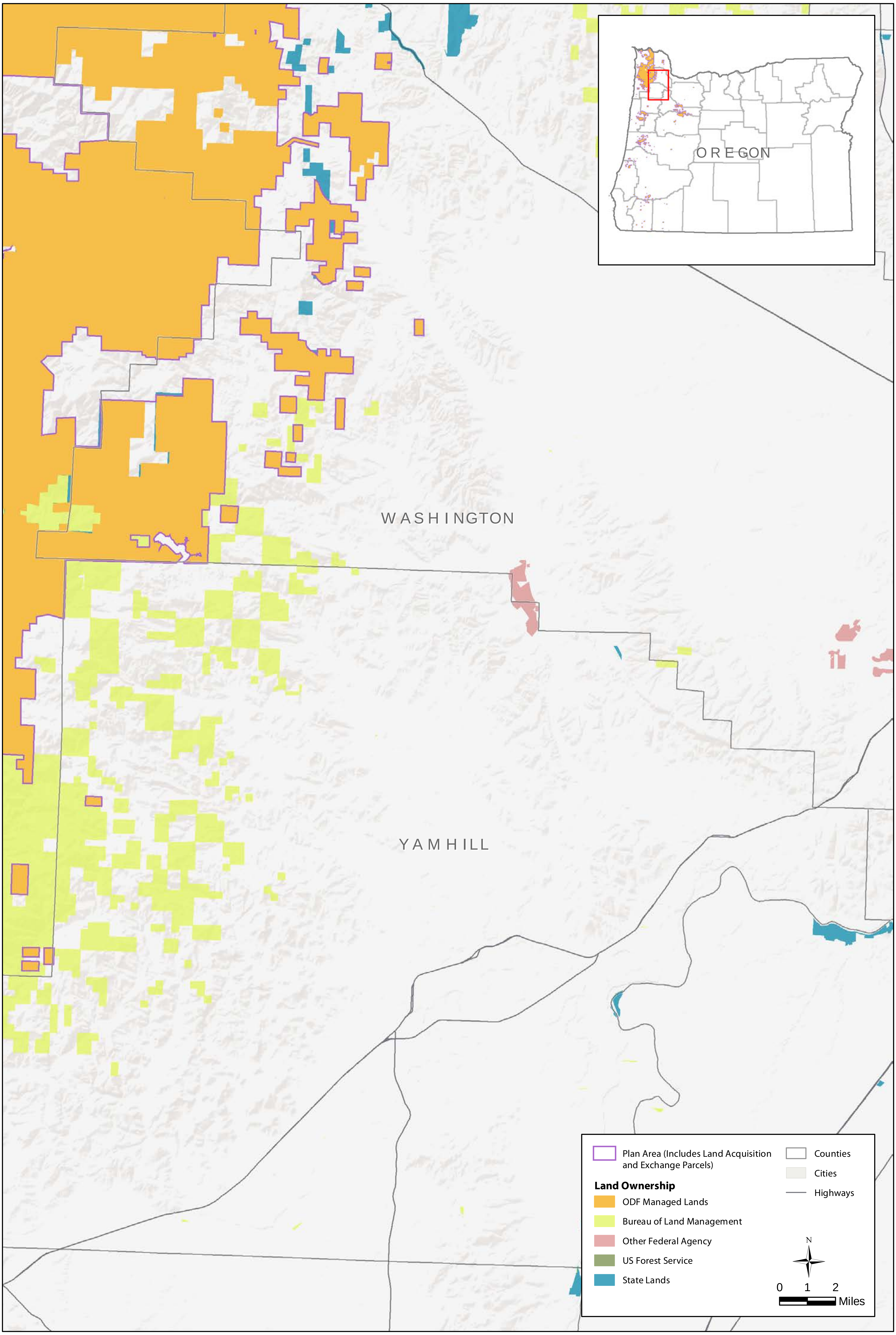
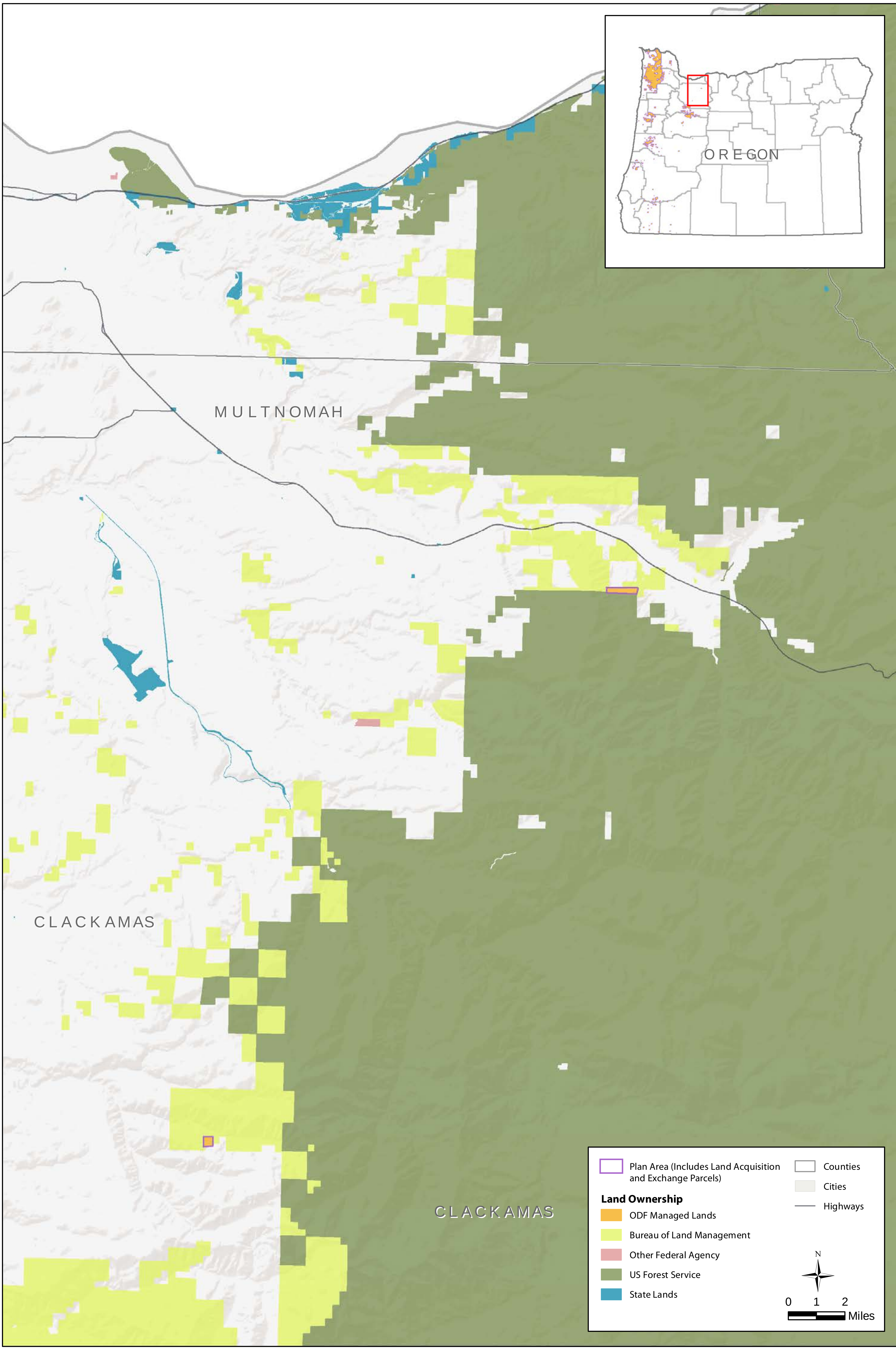
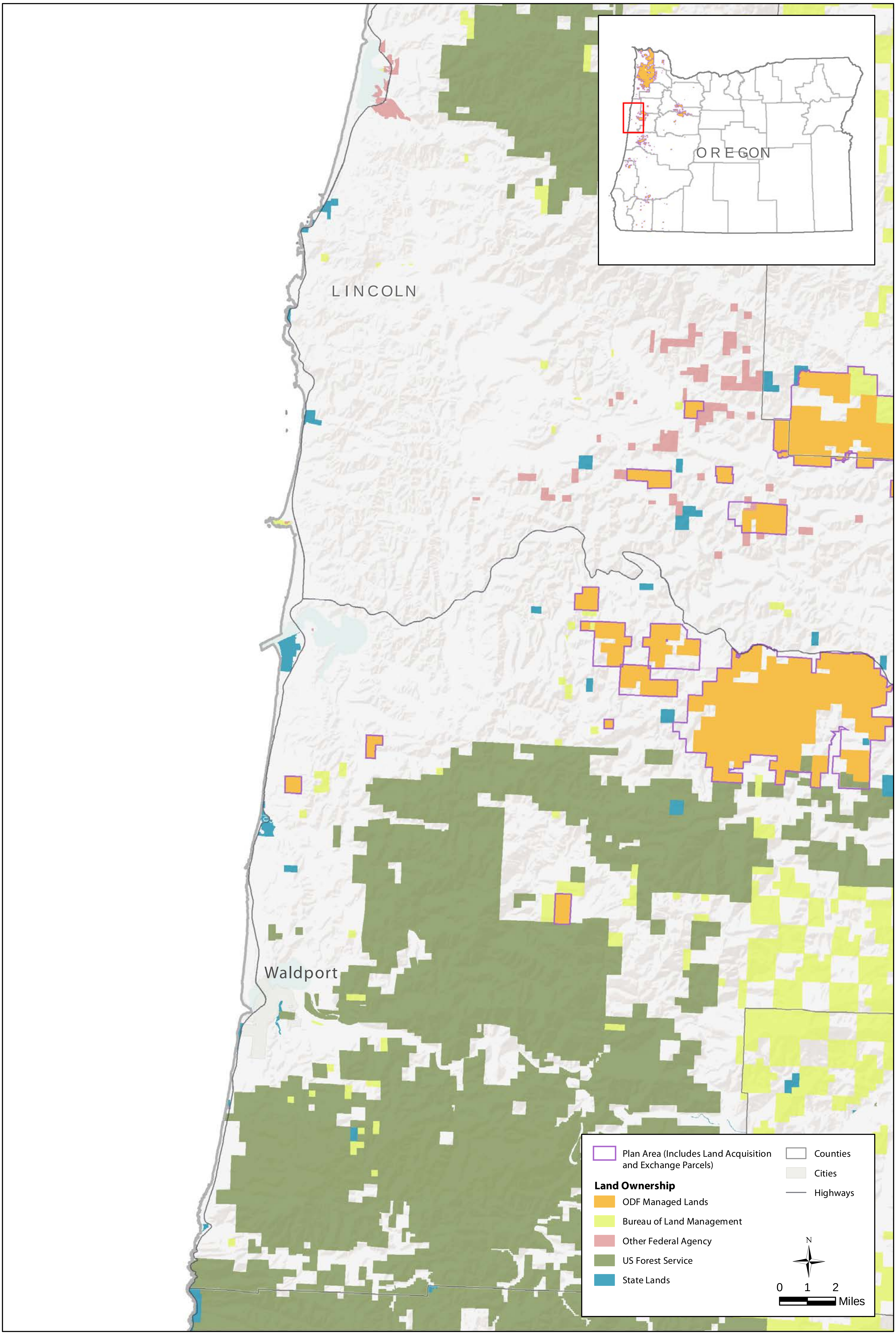


Figure 2-19d: Adjacent Land Ownership



ICF

Figure 2-19e: Adjacent Land Ownership



ICF

Figure 2-19f: Adjacent Land Ownership

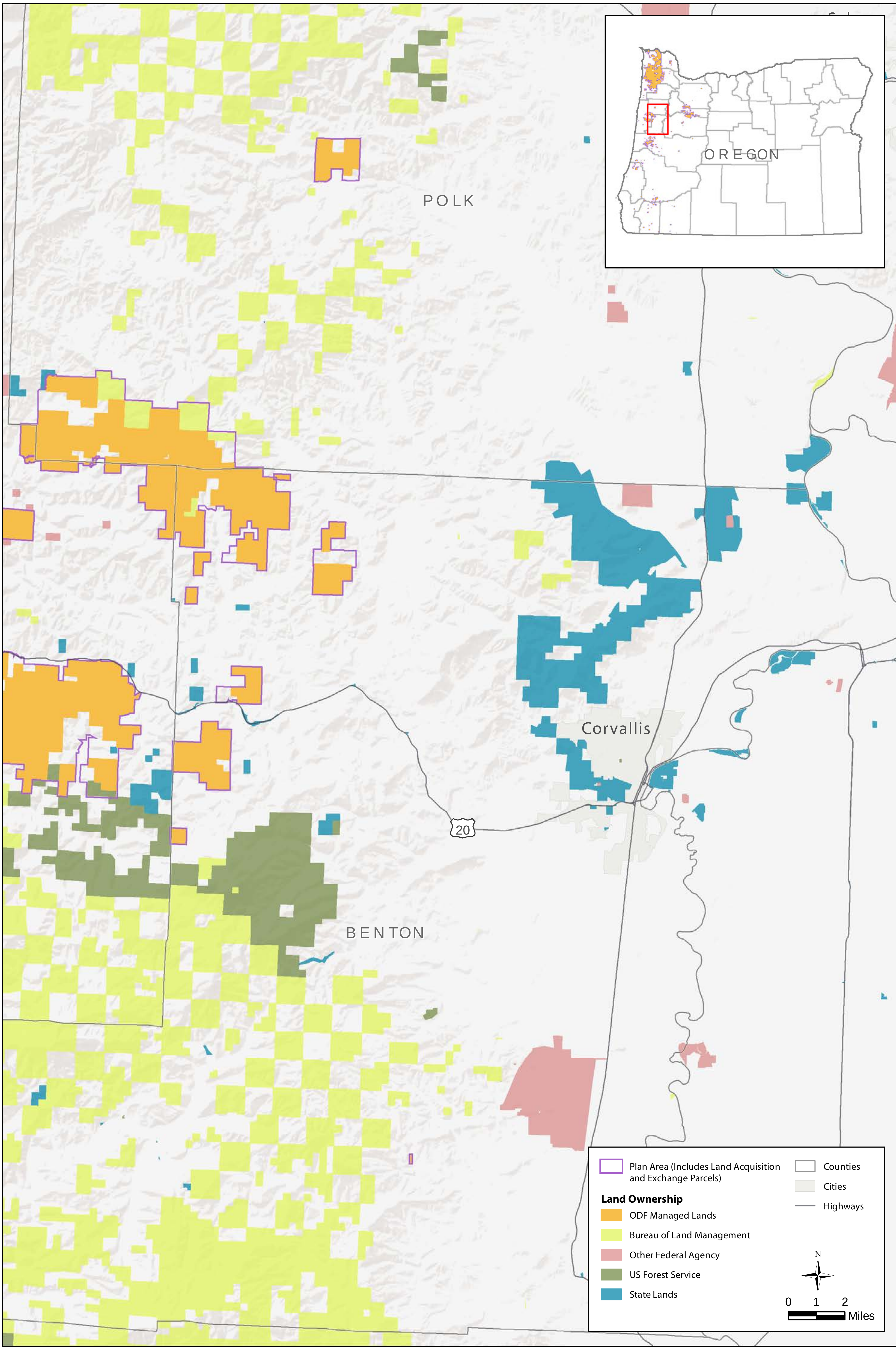


Figure 2-19g: Adjacent Land Ownership

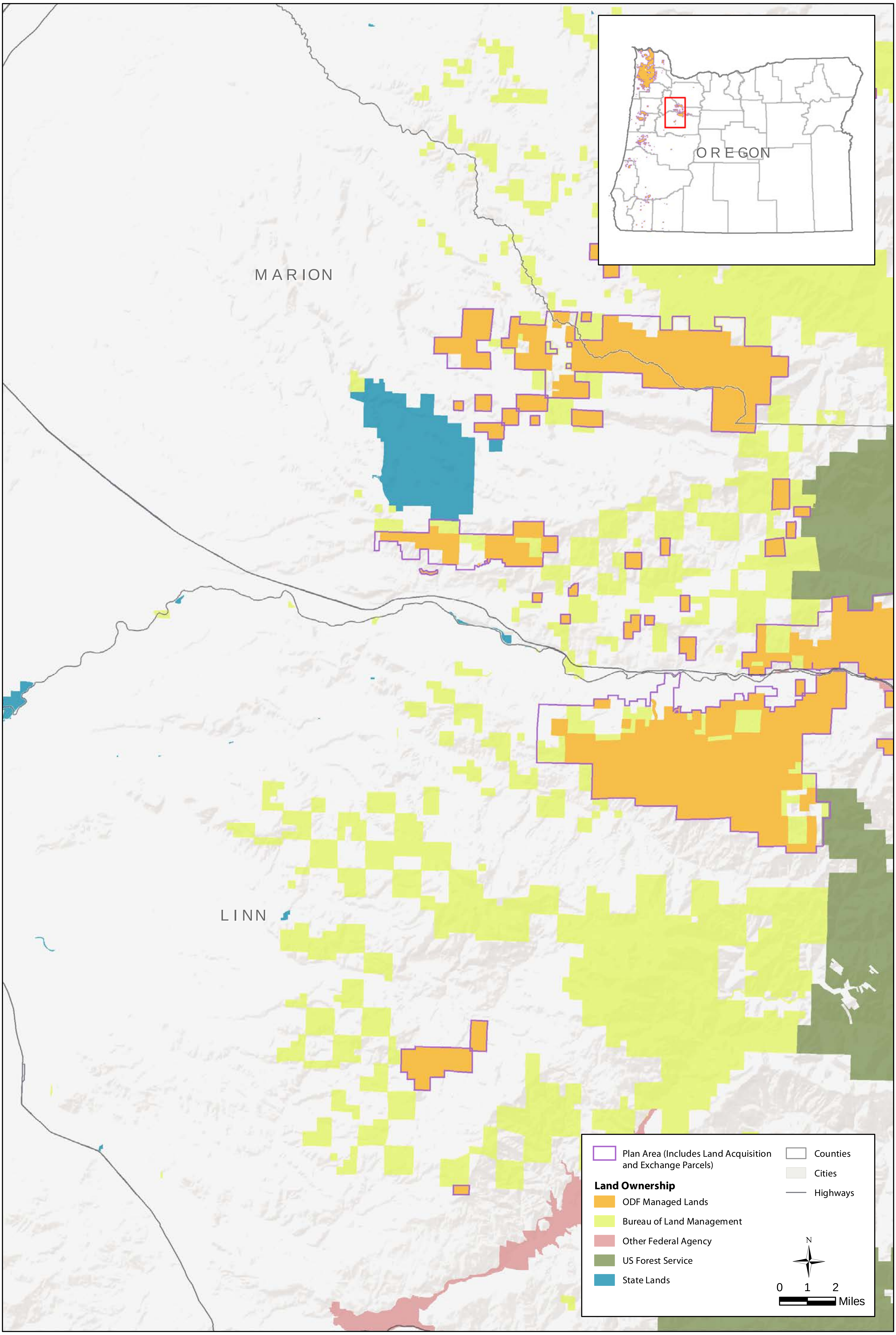


Figure 2-19h: Adjacent Land Ownership

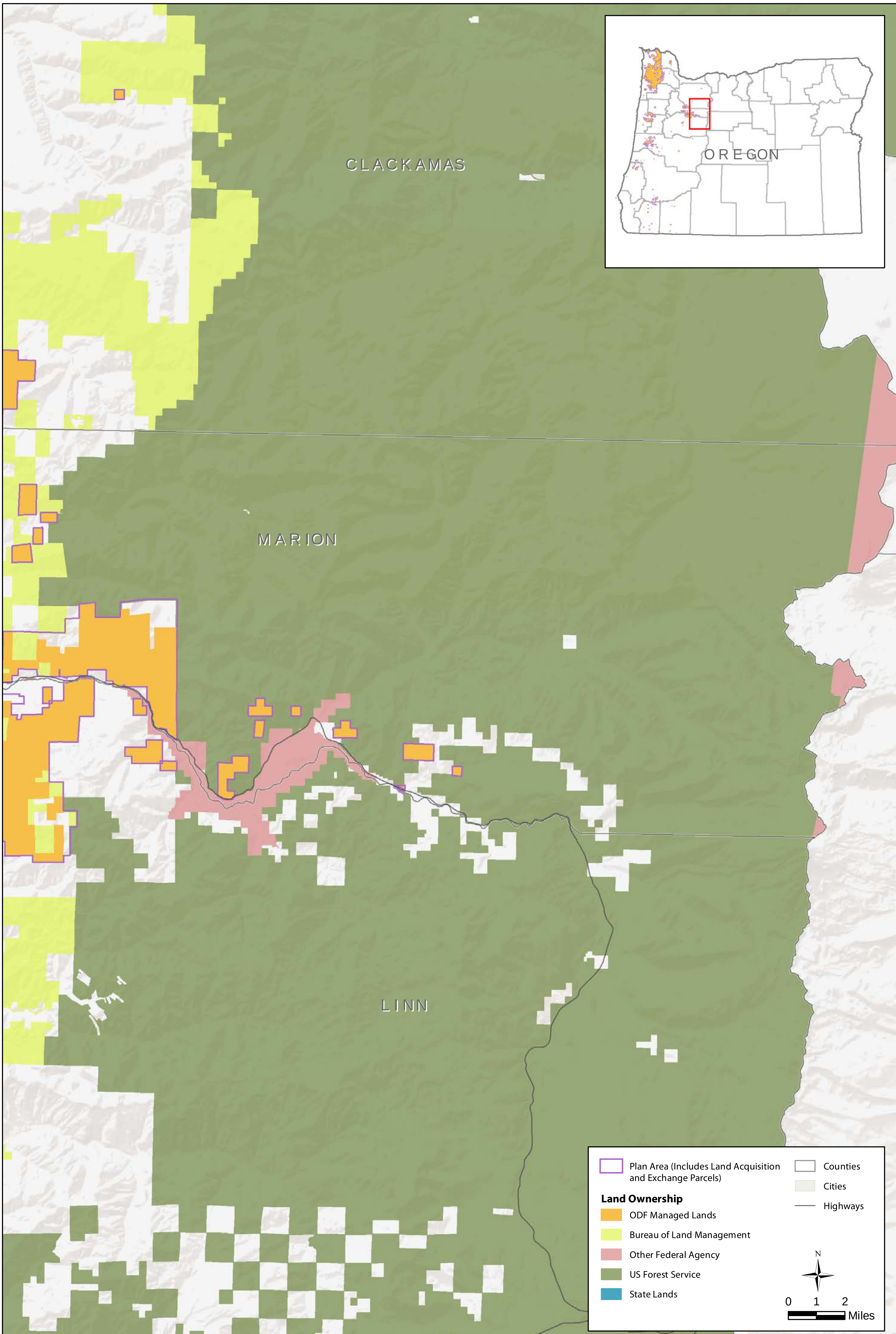


Figure 2-19i: Adjacent Land Ownership

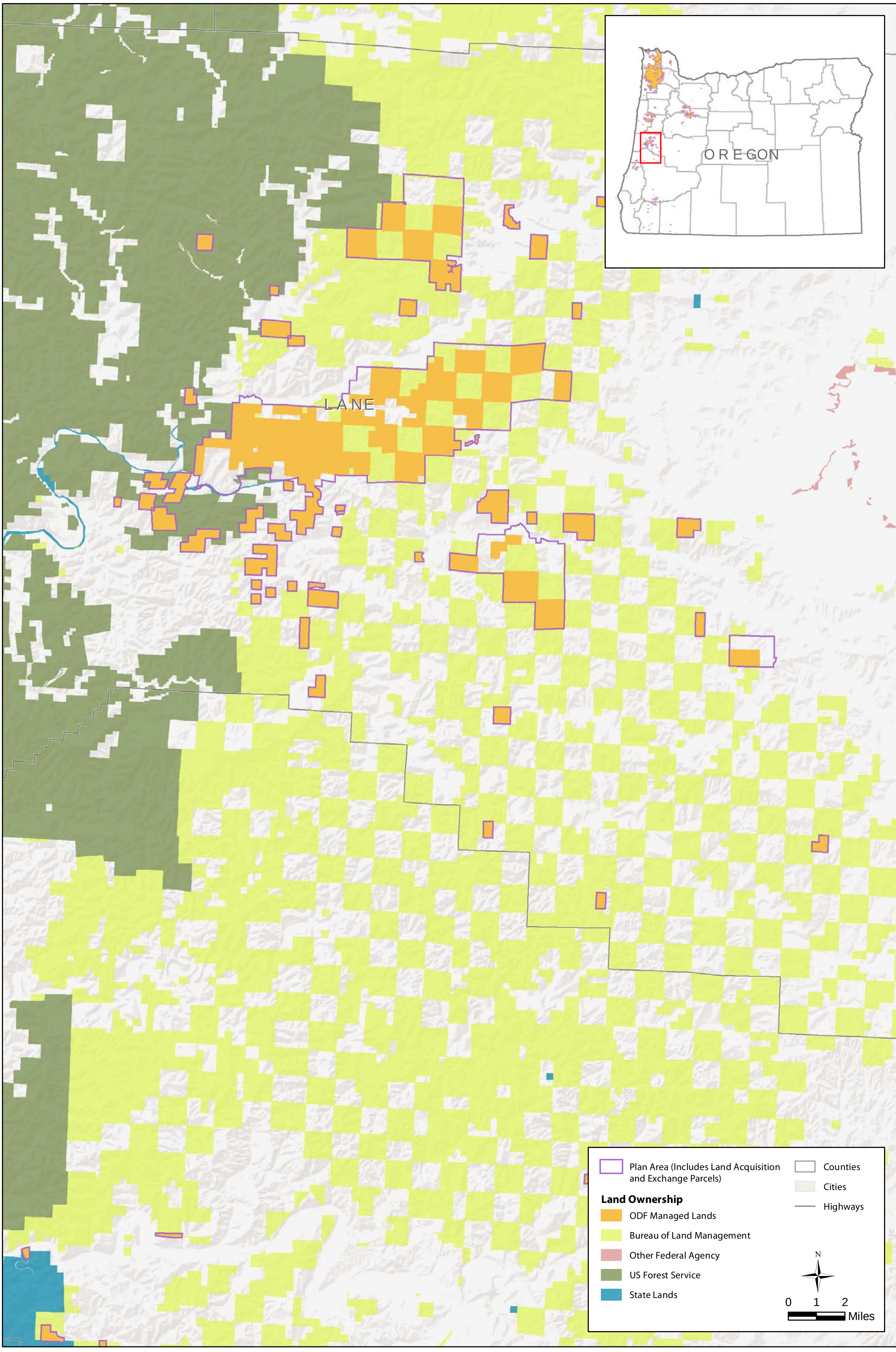


Figure 2-19j: Adjacent Land Ownership

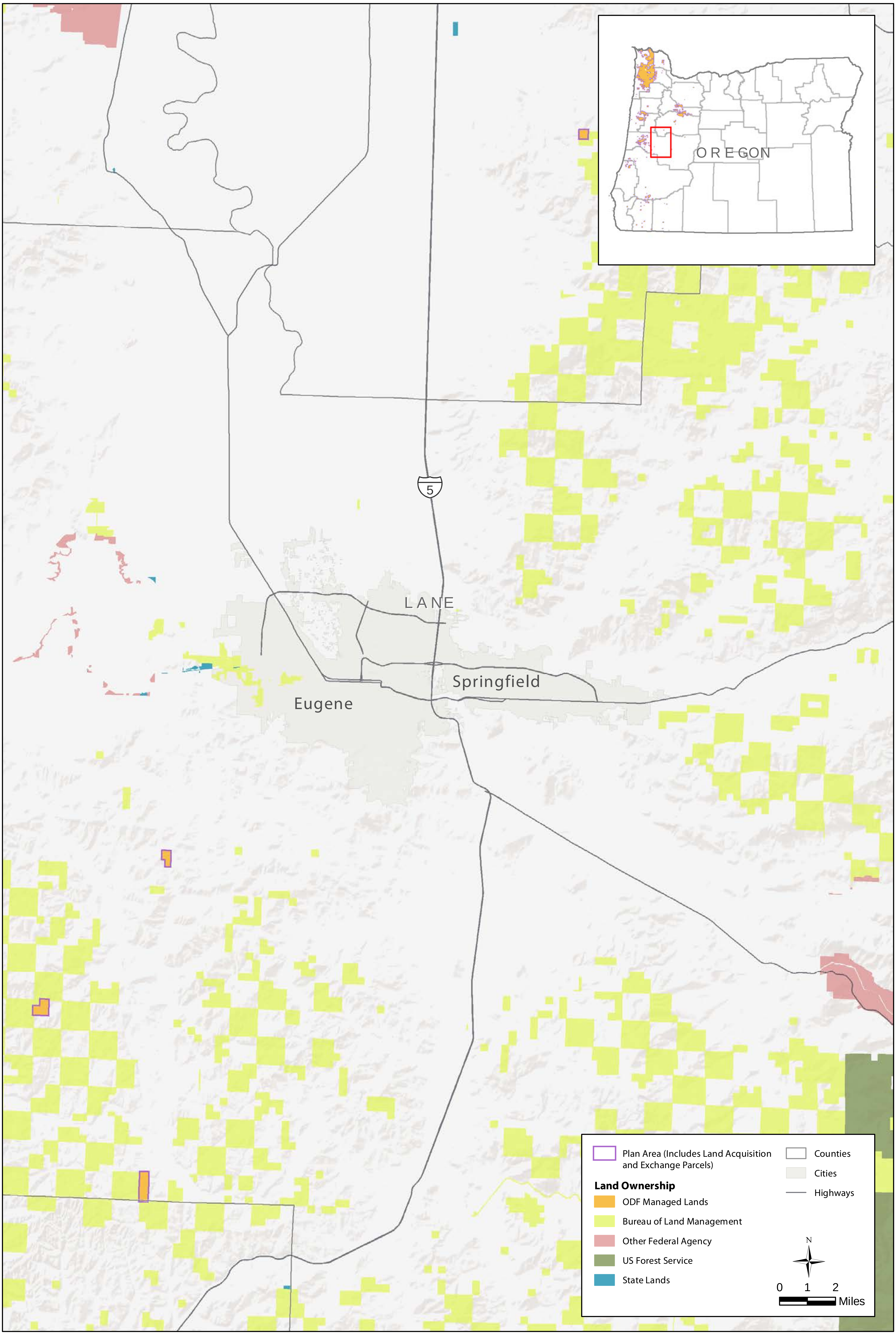


Figure 2-19k: Adjacent Land Ownership

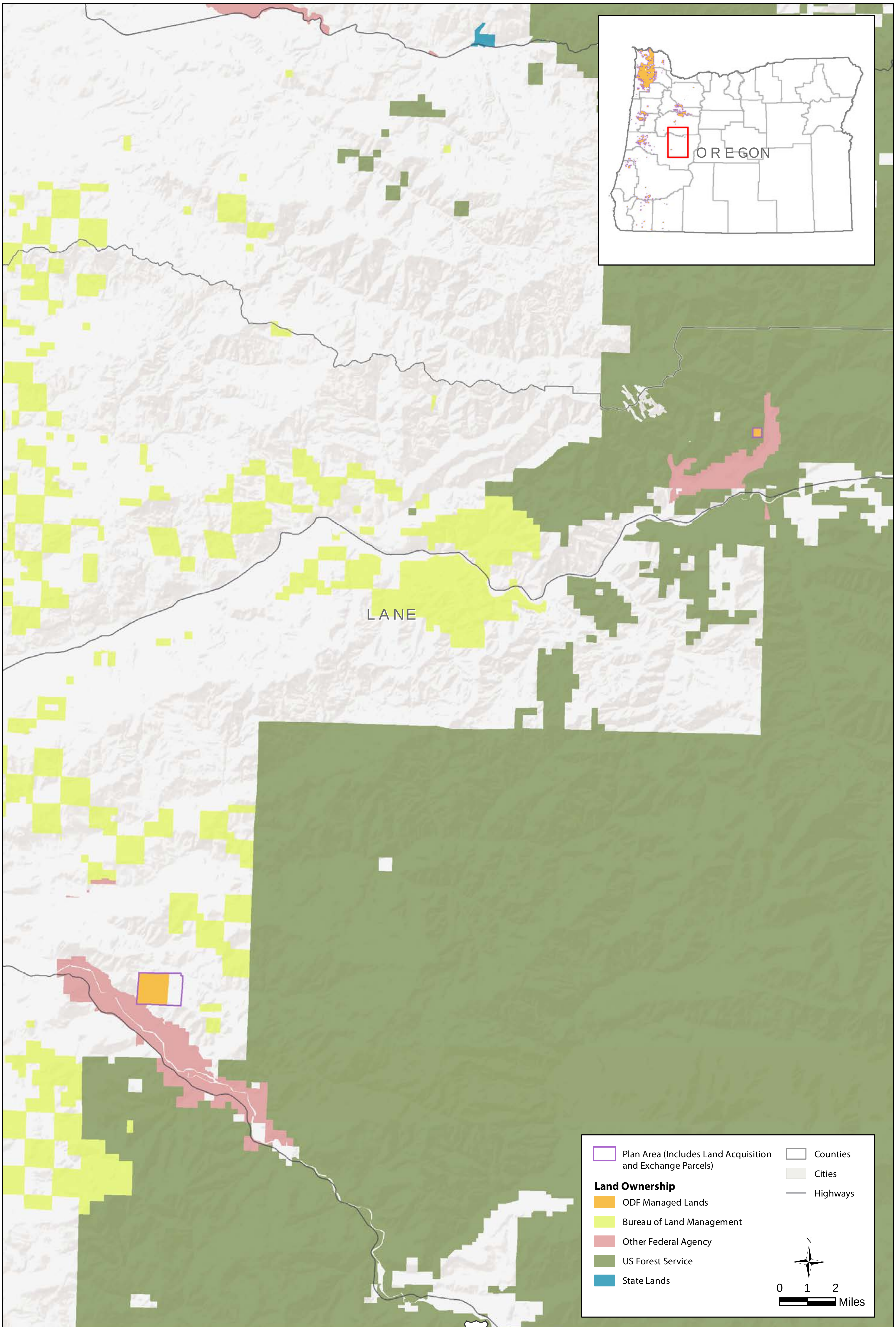


Figure 2-19l: Adjacent Land Ownership

ICF

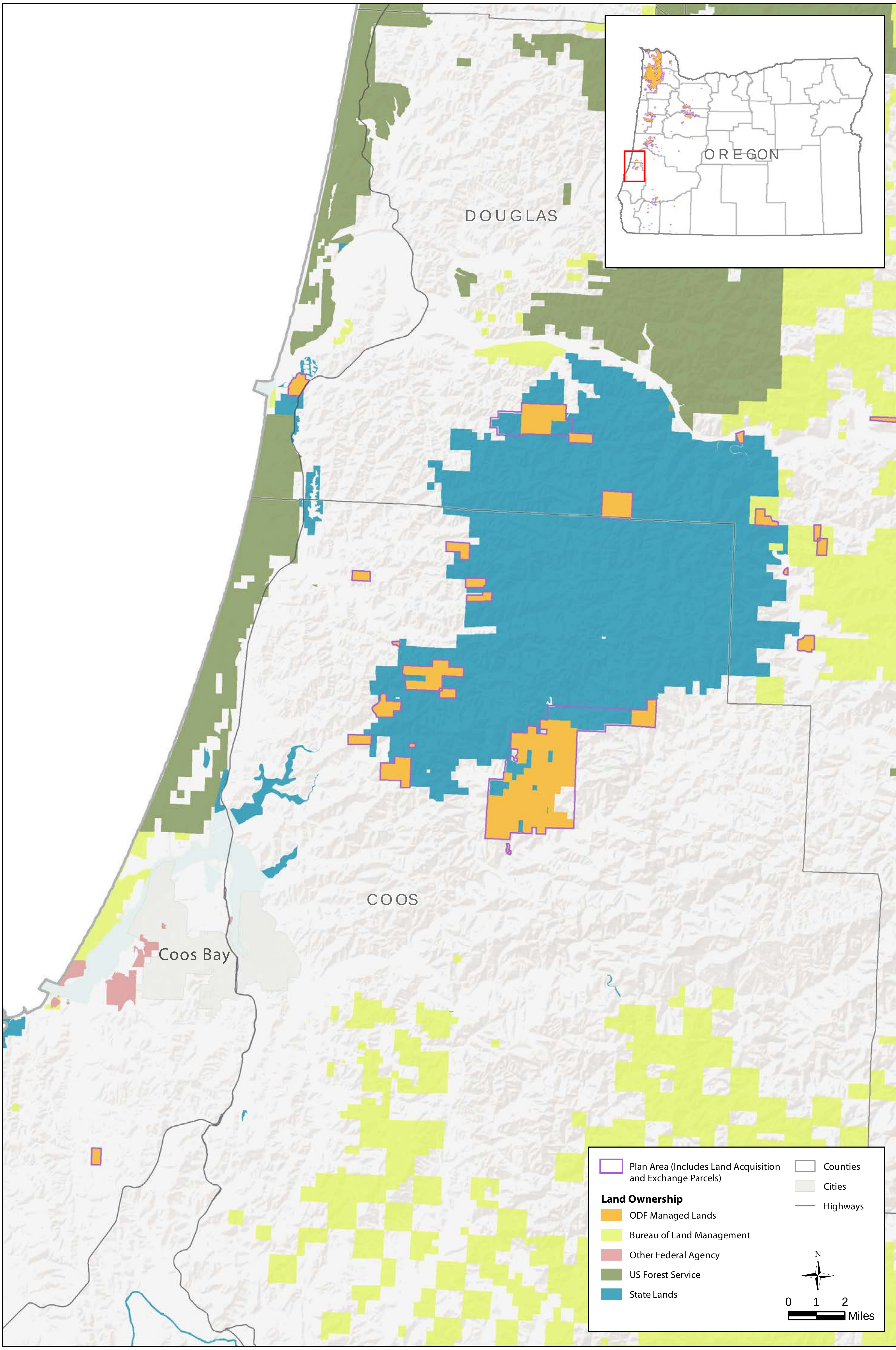


Figure 2-19m: Adjacent Land Ownership

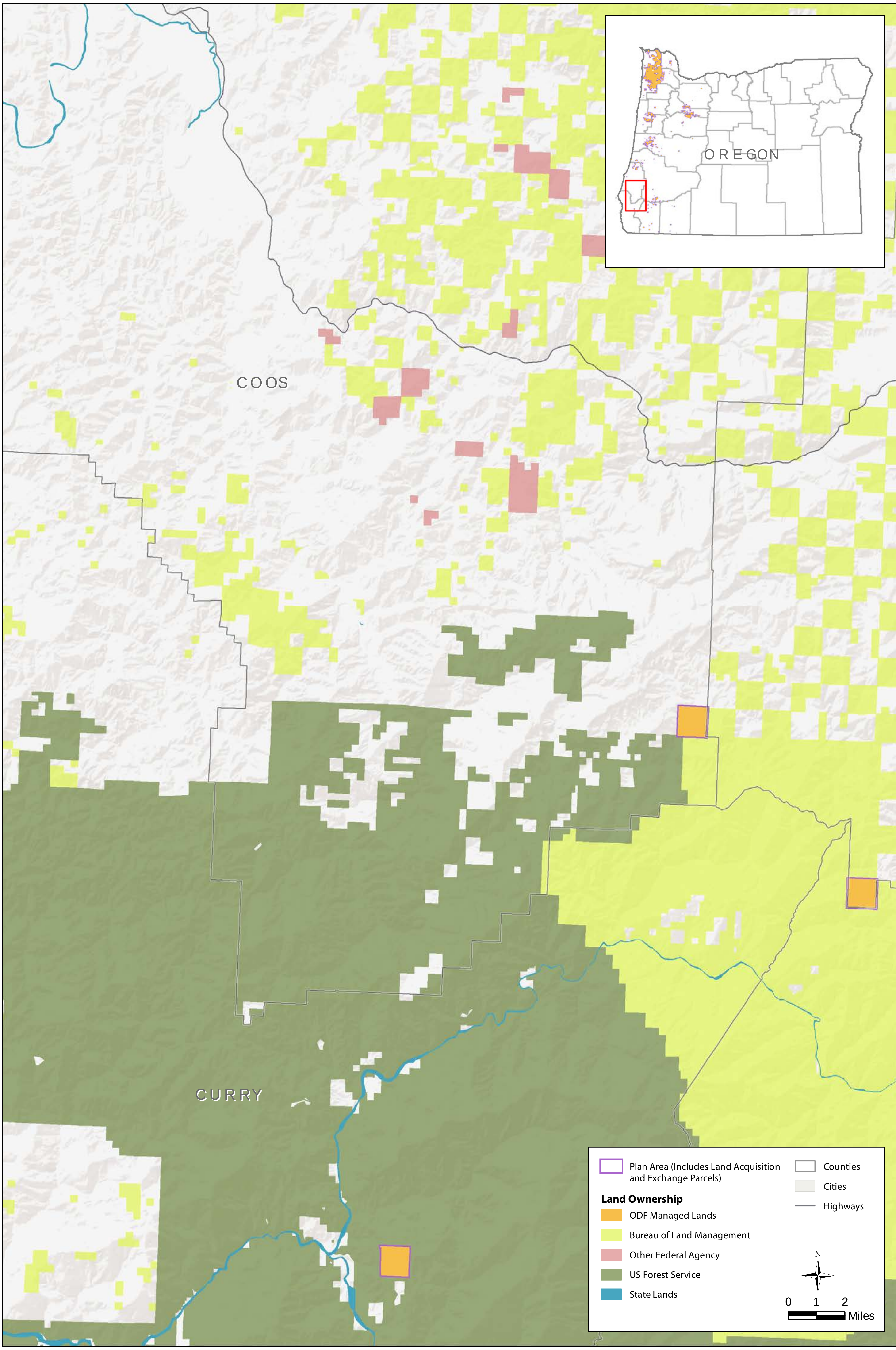
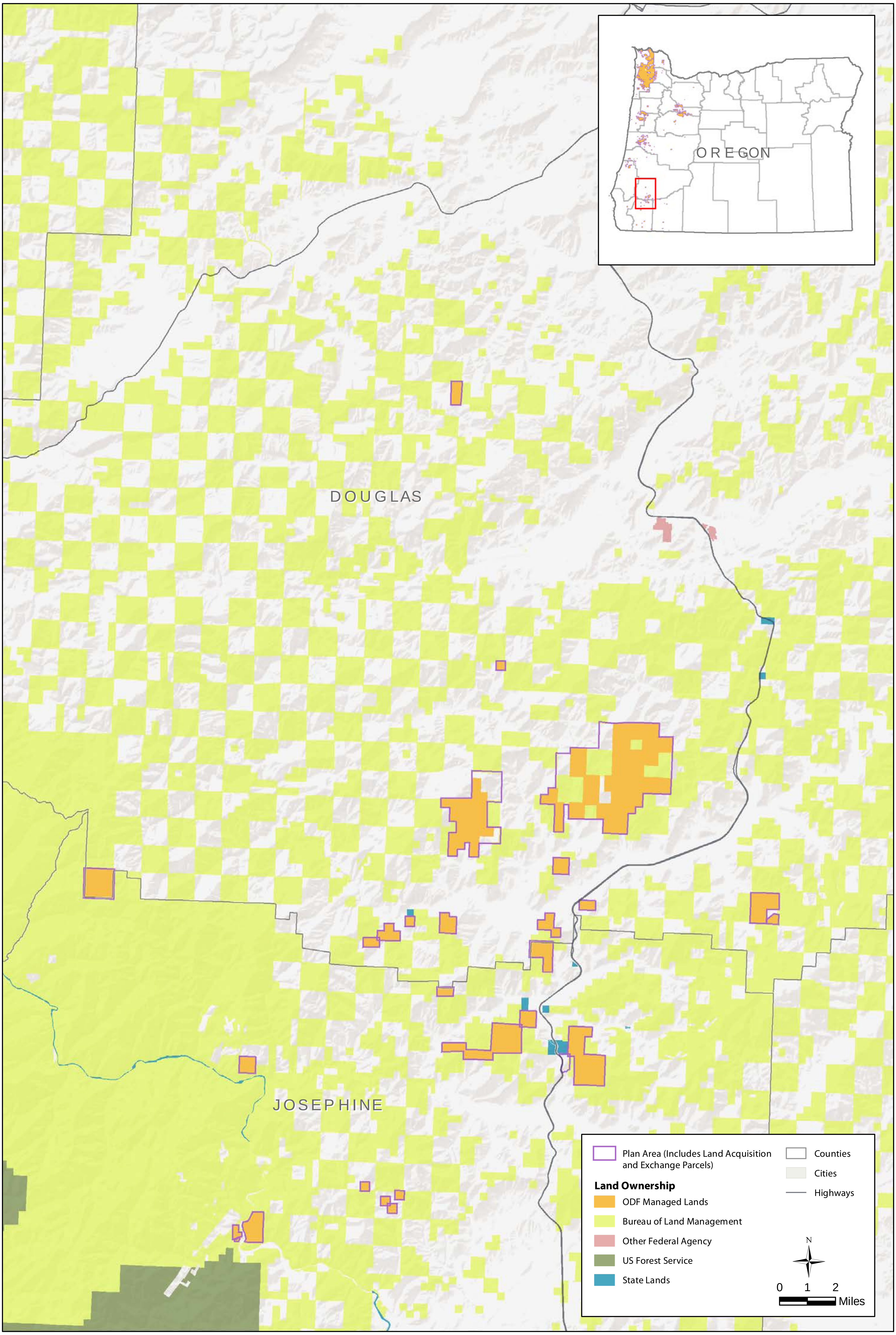
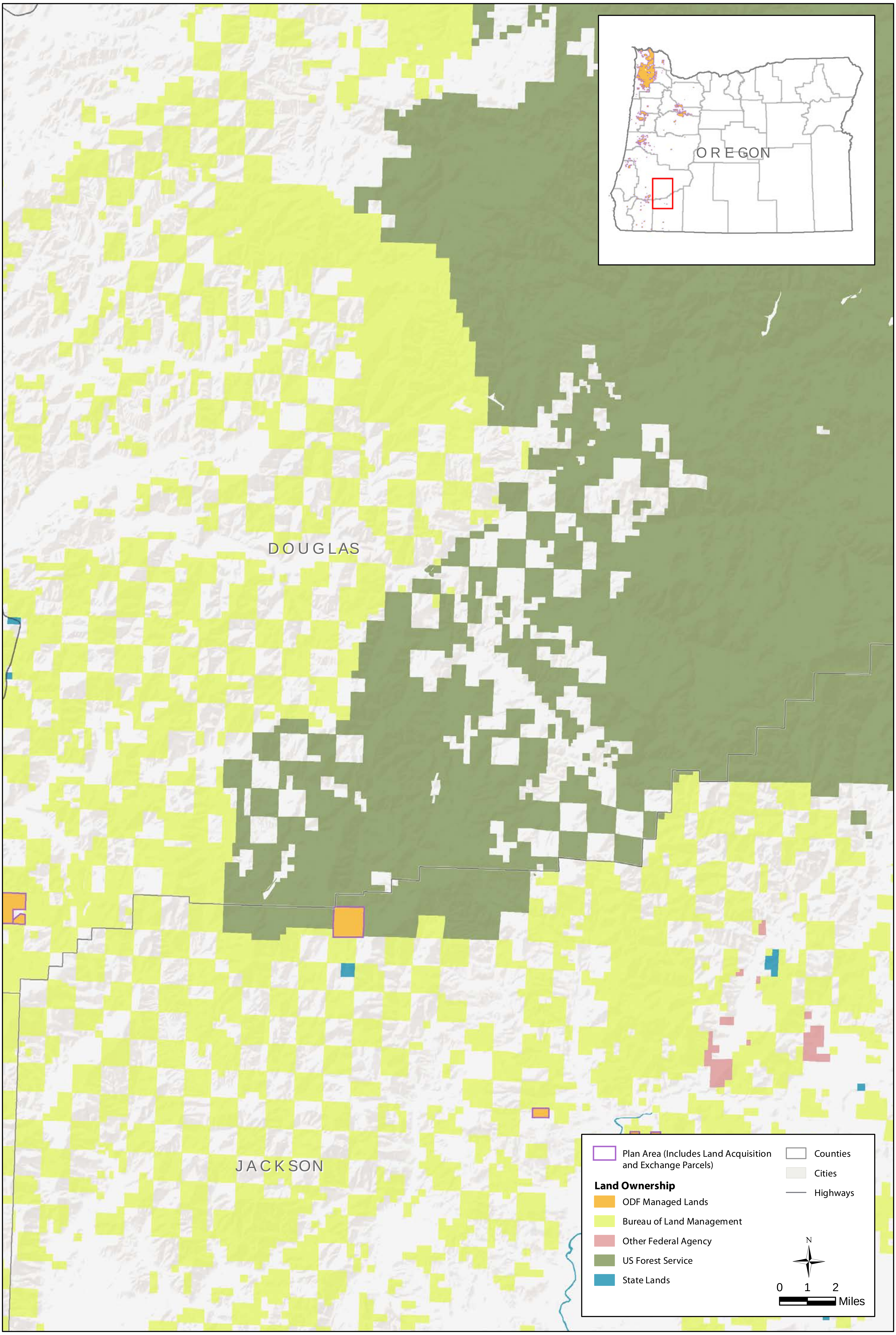


Figure 2-19n: Adjacent Land Ownership



ICF

Figure 2-19o: Adjacent Land Ownership



ICF

Figure 2-19p: Adjacent Land Ownership

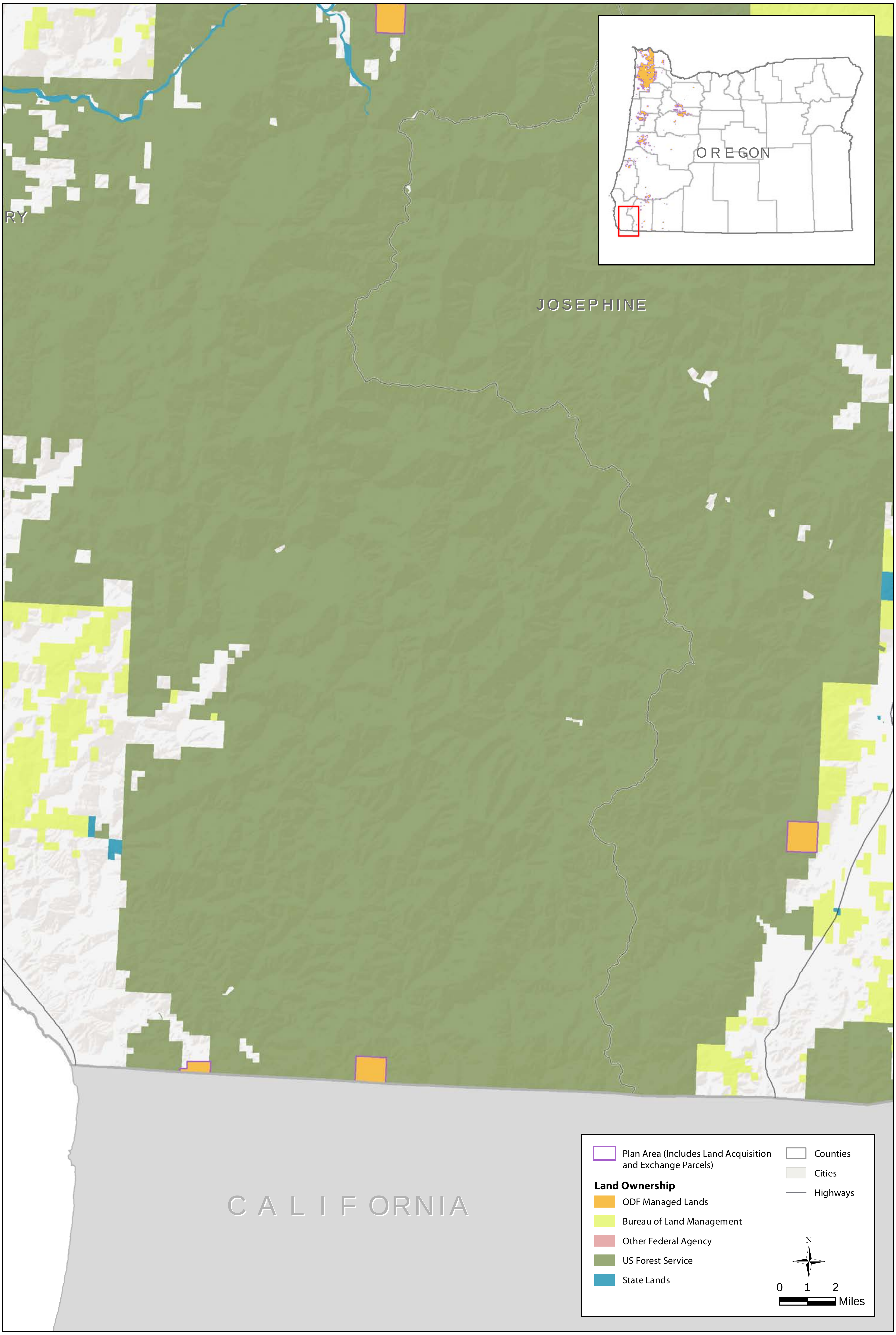


Figure 2-19q: Adjacent Land Ownership

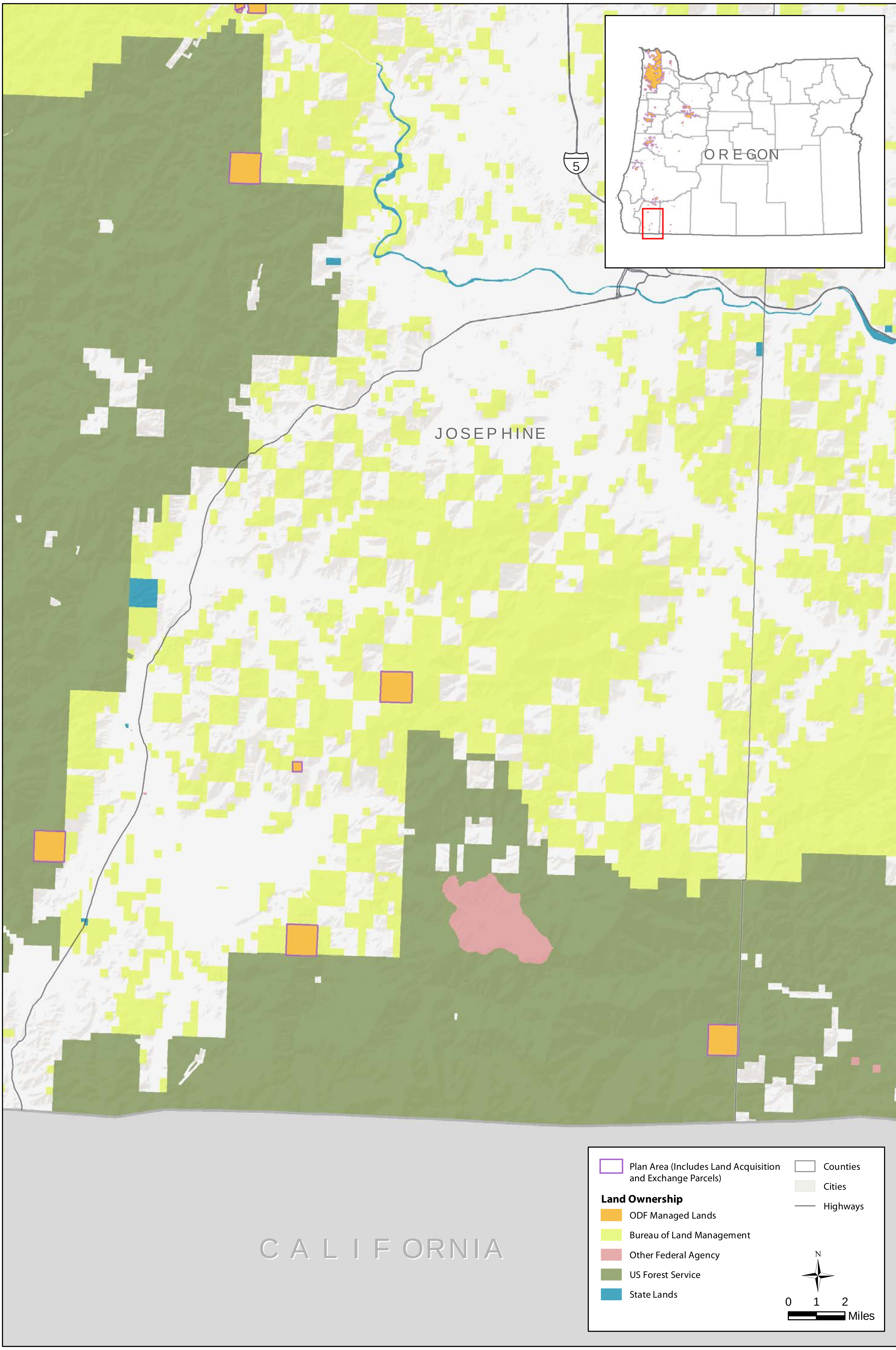


Figure 2-19r: Adjacent Land Ownership

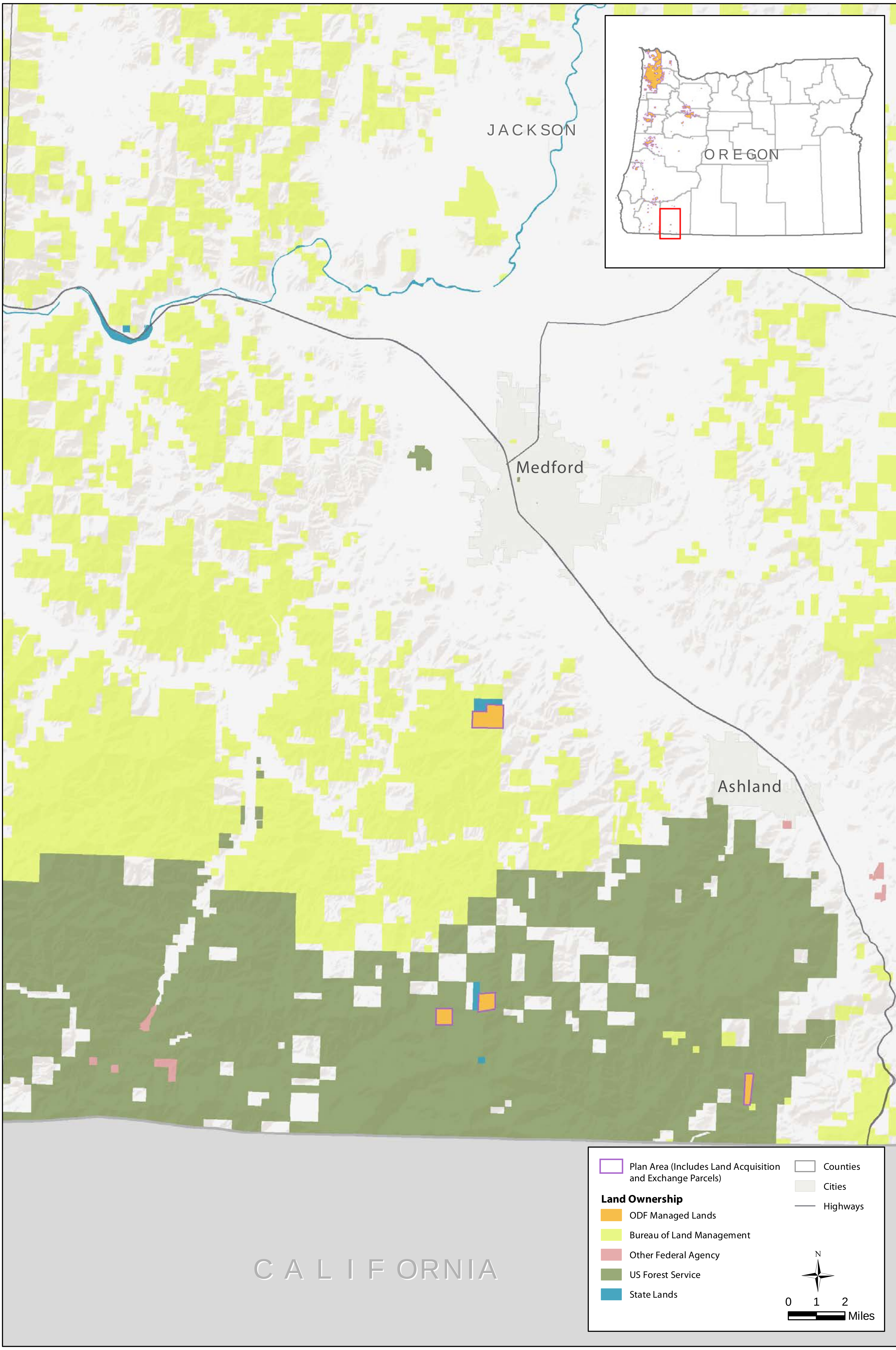


Figure 2-19s: Adjacent Land Ownership

Chapter 3
Covered Activities

3.1 Introduction

This chapter describes the projects and activities for which the Oregon Department of Forestry (ODF) proposes to receive take coverage, which are collectively called *covered activities*. This chapter describes ODF's forest and recreation management activities in the permit area, as well as the activities needed to carry out the conservation strategy as described in Chapter 4, *Conservation Strategy*. The descriptions in this chapter of the proposed covered activities are of sufficient detail to support the conservation strategy and the analysis of the effects described in Chapter 5, *Effects Analysis and Level of Take*.

Covered activities were determined using a systematic screening process. First, a list of screening criteria was developed. The draft list of potential covered activities was then evaluated against the following criteria to determine the need for coverage by the Habitat Conservation Plan (HCP). Activities must meet all five criteria to be identified as a covered activity in the HCP.

- **Control or Authority:** The covered activity must be under the direct control of the permittee (ODF) as a project or activity it implements directly, implements through contracts or leases, or controls through regulation (e.g., a permit or other authorization).
- **Location:** The covered activity must occur in the HCP permit area, as defined at the time the activity is executed.
- **Timing:** The covered activity must occur during the proposed permit term.
- **Impact:** The covered activity must have a reasonable likelihood of resulting in take of one or more covered species.
- **Project Definition:** The location, footprint, frequency, and types of impacts resulting from the activity must be reasonably foreseeable and able to be evaluated in the HCP.

Broadly speaking, the covered activities described here correspond to activities regulated through the existing Oregon Forest Practices Act (FPA) (Oregon Revised Statues [ORS] 527 and Oregon Administrative Rules [OAR] 629). In addition, the covered activities include HCP implementation actions, such as habitat restoration and covered species monitoring that have the potential to cause incidental take.

The covered activities described in this chapter are intended to be as inclusive as possible of the activities currently occurring or expected to occur in the permit area and that may result in take of the covered species. Future activities not described in this chapter may be covered by the HCP if the activity or project:

- Is under the direct control of ODF as defined in the first criterion above.
- Does not preclude achieving the biological goals and objectives of the HCP (see Chapter 4) as determined by ODF at the time the covered activity is proposed.

- Is within the bounds and types of impacts and take limits evaluated in the effects analysis of the HCP (see Chapter 4).

If there are uncertainties about whether an activity is covered, ODF will coordinate with the USFWS and NOAA Fisheries regarding the points above. A determination will be made about whether the activity can move forward under the terms and conditions of the HCP and permits. If it cannot, without violating the points above, an amendment will be sought following the process described in Chapter 8, *Implementation*.

Covered activities are described in this chapter using seven broad categories by type: harvest activities, stand management activities, road system management activities, minor forest-product harvest, quarries, recreation infrastructure and maintenance, and conservation strategy implementation. The descriptions of covered activities are based on existing plans and reports by ODF, as well as on similar activities described in forestry-related HCPs within the ranges of the covered species. Existing plans that were used to develop covered activities in the HCP include the following.

- *Northwest Oregon State Forests Management Plan, Revised Plan* (Oregon Department of Forestry 2010a).
- *Southwest Oregon State Forests Management Plan, Revised Plan* (Oregon Department of Forestry 2010b).
- *Astoria District, 2020 Annual Operations Plan* (Oregon Department of Forestry 2019a).
- *Forest Grove District, 2020 Annual Operations Plan* (Oregon Department of Forestry 2019b).
- *Draft Klamath Lake District, 2020 Annual Operations Plan* (Oregon Department of Forestry. 2019c).
- *North Cascade District, 2020 Annual Operations Plan* (Oregon Department of Forestry 2019d).
- *Tillamook District, 2020 Annual Operations Plan* (Oregon Department of Forestry 2019e).
- *Western Lane District, 2020 Annual Operations Plan* (Oregon Department of Forestry 2019f).
- *West Oregon District, 2020 Annual Operations Plan* (Oregon Department of Forestry 2019g).

3.2 Timber Harvest Activities

Harvest activities are associated with the harvest of timber and other forest products. Harvest activities on state forestlands managed by ODF are carried out under Forest Management Plans (FMP) developed by ODF and adopted by the Board of Forestry as administrative rules, as described in OAR 629-035-0030, and in accordance with the Oregon FPA, specifically including those identified in ORS 629 Division 630, *Harvesting*, but also including all other applicable rules. An updated FMP is being prepared that will incorporate the conservation measures of the HCP as part of addressing required FMP resource goals pertaining to providing properly functioning aquatic habitat and habitat for native wildlife species.

Sustainable and predictable timber harvests and revenue support jobs and counties and local taxing districts, and provide funds to support ODF operations, including implementation of the HCP.

Outside of HCAs and RCAs most stands will be managed for timber production, with a predicted focus on growing stands that generate a product mix of predominately large and medium sawtimber. Stands will be evaluated for precommercial thinning and will be considered for a commercial thinning entry prior to regeneration harvest. Depending on individual site conditions and management objectives, a stand may receive multiple commercial thinning entries, or none at all. This general management regime, in conjunction with retention standards described below, will help ensure that the area outside of HCAs and RCAs provide conservation value for other native wildlife that are not covered under this HCP.

3.2.1 Harvest Volumes

Timber sales to lumber and other wood products mills have been the primary commodity output sold from state forests in western Oregon. Table 3-1 presents harvest and revenue data for the last 9 years to illustrate the variability in year-to-year harvest levels and the resulting revenue that is both a function of harvest level and stumpage[1] price. Thinnings and regeneration harvests produce a supply of timber and revenue. Smaller-diameter wood is produced from thinnings in the early stages of stand development. High-quality timber is produced through silvicultural techniques and harvested through later thinnings and regeneration harvests.

Table 3-1. 2010–2020 Harvest and Revenue Summary for Lands in the Permit Area

Fiscal Year	Total Harvest (million board feet)	Average Stumpage Price (1,000 board feet)[a]	Total Revenue Generated[b]	Revenue Retained by ODF	Total ODF Costs	Total Number of ODF staff (number of FTEs)
2020	244	$443	$108,017,544	$39,774,454	$40,810,863	196
2019	302	$474	$143,049121	$55,187139	$36,097,407	182
2018	319	$408	$130,203,778	$48,496,211	$33,655,179	193
2017	267	$356	$95,169,183	$35,862,713	$34,348,943	188
2016	242	$401	$97,072,585	$35,712,861	$33,755,555	211
2015	266	$335	$88,993,923	$32,965,350	$32,172,533	218
2014	225	$345	$77,487,200	$28,660,675	$31,232,986	216
2013	236	$320	$75,479,129	$29,905,510	$27,376,168	214
2012	234	$257	$59,982,506	$23,536,011	$27,818,782	211
2011	244	$249	$60,774,964	$23,895,103	$24,690,524	202
2010	277	$252	$69,648,088	$27,936,988	$24,961,200	208

[a] Average stumpage is total revenue divided by harvest volume.
[b] Does not include project work (e.g., road construction and maintenance, brushing) associated with the sale.
FTE = full-time employees

[1] The price paid for the right to harvest timber from a given land base. It is paid to the current owner of the land. Historically, the price was determined on a basis of the number of trees harvested, or "per stump."

3.2.2 Harvest Methods

Harvest activities include the felling, bucking, yarding, processing, loading of logs, and hauling. *Felling* means cutting down trees. *Bucking* means cutting felled trees in the field into predetermined log lengths specified by the timber owner to maximize tree value. Trees may also be felled and yarded to be processed and manufactured into logs on a landing or road. The following techniques are used to fell and buck trees.

- On steep terrain, contractors fell and sometimes buck trees with handheld chain saws.
- Mechanical felling is done by a feller-buncher to fell trees when terrain is not steep. These machines are structurally similar to trackhoes and use an articulated attachment to grab, fell, and bunch the trees with other trees or logs for subsequent skidding (transporting) to the landing.
- A more complex machine, the cut-to-length, is used to grab, fell, delimb, and buck trees into logs using processor heads. These machines can operate on moderate slopes and have no blade or attachments capable of moving soil, which minimizes soil disturbance and compaction.
- All ground-based felling and skidding machines can be equipped with winches that allow for use on steep slopes. Tethered assist equipment and other advances in technology allow for ground-based harvest on steeper terrain. The use of tethered assist logging is still being evaluated and will only be employed where it does not increase sediment delivery to the aquatic system.

Yarding or *skidding* means moving logs from where they are felled to a landing using cable systems, ground-based equipment, helicopters, or other means. *Landings* are cleared areas where logs are stored (yarded, swung, skidded, lowered, or forwarded) for subsequent loading onto trucks for transport. The following techniques are used for yarding or skidding.

- Cable yarding employs wire ropes to move logs to a truck road or log landing, and are most often used to move logs uphill over steep terrain. Yarders use powered drums filled with rope and a vertical tower or leaning boom to elevate the cables as they leave the machine. On the opposite end the wire rope is anchored into a tree, known as a tail hold. These locations are often across a canyon or on another hillside that provides the proper deflection and lift to make cable yarding possible. Wire rope guy lines hold the tower in position while the machine is in operation. Aerial drones are often used to fly haywire (synthetic rope) above the canopy to tail hold points, after which wire rope is pulled through.
- A common technique employed is ground-based yarding. Ground-based yarding involves tracked or rubber-tired tractors (skidders) skidding logs to the landing. Machines are able to grasp the log using powered grapple attachments or wire rope winch lines. Ground yarding generally works on gentle to moderate slopes, but some of the modern ground yarding equipment can work on slopes up to 60%.
- Ground-based yarding can also be done by loader logging. A tracked hoe log loader physically picks up and swings the whole tree toward the landing. The tree may be picked up several times as the loader gets the trees to the landing for processing.
- Cut-to-length logs are skidded with a forwarder that is equipped with a grapple and bunks. This skidding system carries logs clear of the ground to the landing; this method minimizes ground disturbance. Aerial yarding may use a helicopter. This more costly technique typically occurs in

areas where access is limited or very expensive. In helicopter yarding, a cable extending from the helicopter is attached to the logs and used to suspend and move them to the landing area. This technique generally does not disturb soil, although large, separate, cleared landing areas are required for helicopter touchdown.

Processing includes limbing and bucking into logs. Some processing can occur on site where the tree is felled by chain saw or cut-to-length, though most is done at the landing or road. Processing is mainly done by stroke delimbers or dangle head processors mounted on trackhoes.

Loading means loading logs from the landing area to a truck for transport. Logs are loaded onto trucks using equipment such as hydraulic tracked hoe log loaders or heel-boom loaders, which may be used without leaving the road grade. Wheeled loaders have more limited mobility and functionality than tracked machines. Some log trucks are self-loading and are equipped with a log loader on the truck to both load and transport logs.

Hauling means transport of logs to mills by trucks. Road design and maintenance, including road surfacing, proper drainage, and overall stability support the ability to haul during different weather conditions and control for sediment delivery to the aquatic environment. Restrictions on hauling during wet weather (i.e., not allowing hauling activities during periods of wet weather) further prevents such sediment delivery.

3.2.3 Harvest Types

Silvicultural approaches described in this chapter are used when site-specific conditions warrant the need and would be applied in future harvests under similar circumstances. For example, clearcutting[2] provides for efficient harvest and regeneration of forest stands, and helps young trees reach a “free-to-grow” state that is not compromised by competition from a residual overstory of older trees or by the possibility of damage from the repeated site disturbance that is implicit in the application of other silvicultural systems. When applied, clearcutting would follow the rules described under *Clearcut* below.

3.2.3.1 Regeneration Harvest

The intent of a *regeneration harvest* is to develop a new stand. In general, residual trees left after a regeneration harvest are intended to remain on the site through the life of the new stand and subsequent stands. All types of regeneration harvests retain less than 80 square feet of basal area per acre (based on trees greater than 11 inches in diameter at breast height [DBH[). The Harvest Types (within the Regeneration Harvest Goals) are best defined using residual trees per acre or square feet of basal area per acre; in either case, only trees greater than 11 DBH are counted.

Clearcut

A *clearcut* removes all (or nearly all) trees in a stand; however, the FMP and the FPA require that at least a few live trees be retained in each unit. Clearcuts will provide the best conditions for successful establishment of forest stands for future timber production.

[2] Clearcutting removes most trees in a stand with the exception of residual components of reserved trees, snags, and downed wood. Clearcutting is one of several types of regeneration harvests, where a forest treatment is applied to a stand in order to improve its regeneration potential. Additional regeneration harvest treatments are described in Section 3.3, *Stand Management Activities*.

Requirements for the clearcut harvest type outside of designated Habitat Conservation Areas, as detailed in Conservation Action 8: Conservation Actions Outside Habitat Conservation Areas and Riparian Conservation Areas (Section 4.7.6), include:

- Subject to the FPA Rules for Type 3 Harvest (maximum size is 120 acres with green-up requirements).
- Retention of live green trees, snags and downed wood in the upland harvest unit, as described in Chapter 4 (Table 4-10).

Clearcut harvest will also occur within Habitat Conservation Areas (HCAs) to manage specific disease and forest composition issues. These harvests will exceed the above requirements, following the prescriptions detailed in Conservation Action 7: Management in HCAs, in Chapter 4 (Table 4-8).

Retention Cut

Retention cuts look more like a partial cut or the first stage of a shelter wood harvest than a clearcut; however, the focus of future management will be on the new/young trees in the stand, rather than the residual trees. At its highest density, a retention cut leaves nearly as much basal area as a heavy thinning, and the management focus may be on the existing cohort, the new cohort, or both.

In the retention cut harvest type, regeneration is more difficult, but still achievable, while complex stand structures are likely to develop much more quickly than after a clearcut. A retention cut will result in a stand with two or more distinct age classes that are well-distributed across the stand.

Requirements for the retention cut harvest type:

- Retains between 33 and 80 square feet of basal area per acre (on Site Class I, II, or III).

3.2.3.2 Partial Cut Harvest

The intent of a *partial cut* harvest is to manage the growth and density of an existing stand. A prescription for a partial cut may be designed to increase the structural complexity of a stand, maximize volume growth, or capture tree mortality. A stand may be partial cut several times throughout its life. All partial cut harvest types retain at least 80 square feet of basal area per acre of trees greater than 11 inches DBH. Improvements in markets for small wood and in the machinery used to harvest small stems may allow economic harvesting of younger stands, which would allow some stands to forego precommercial thinning and continue growing, with an early commercial thinning being employed instead.

There are several forms and intensities of partial cuts; however, the most common form is *thinning*. Thinning prescriptions are often designed using measures of Stand Density Index (SDI)[3] or Relative Density and remove a portion of the trees from a stand in a generally uniform pattern. Sometimes thinning prescriptions are developed to increase the horizontal diversity within a stand; a diameter limit prescription often results in a stand with variable density.

The structure of a stand immediately after a partial cut (1 to 3 years) is very dependent on both the harvest prescription and the structure of the stand prior to harvest. Generally, the stand structure

[3] Measure of the stocking of a stand of trees based on the number of trees per unit area and diameter at breast height of the tree of average basal area.

will remain the same or become more complex, though short-term reduction in canopy cover can reduce habitat suitability for some species (e.g., the covered ones).

Heavy Thinning

A *heavy thinning* approaches the harvest intensity of a retention cut, and the management focus will be on enhancing growth and structural characteristics of retained trees, releasing an existing cohort of suppressed trees, or initiating a new cohort to speed up understory development, which leads to an increase in vertical canopy structure throughout the thinning area. A heavy thinning results in the fast growth of individual trees, but reduces the total volume growth of the stand.

Heavy thinning retains an SDI% of less than 30.

Moderate Thinning

A *moderate thinning* provides for optimal stand growth and allows vigorous growth of the individual trees. Where an established understory tree component exists, vertical canopy structure will continue to develop with a moderate thinning, and depending on species composition and site index, a new cohort of trees may be initiated.

Moderate thinning retains an SDI% of greater than or equal to 30 and less than 40.

Light Thinning

A *light thinning* focuses on maintaining stand growth and health, however in order to achieve these goals, it must occur more frequently than a heavy or moderate thinning in the same stand. More complex stand structure may not be developed with a light thinning, and a new cohort of trees may not be initiated. Early commercial thinning falls under a light thinning.

Light thinning retains an SDI% of greater than or equal to 40 and less than 50.

3.2.3.3 Salvage Harvest

Salvage harvest is the removal of timber in the aftermath of a natural disturbance event that affects forest health, such as insects, disease, wildfire, or severe weather such as wind or ice. Salvage harvest uses the same equipment and methods as other types of harvest and ranges from selective harvest of individual trees to clearcut harvest depending on the magnitude of the disturbance event and forest management goals. During timber harvest and site preparation, many techniques are used to protect soils from compaction or from ponding water and causing excessive erosion. Common techniques include limiting ground equipment activity to gentle slopes and to time periods when soil moisture is low, and limiting the amount of area on which ground equipment may operate. Cable and ground equipment operations must minimize gouging and soil displacement. Logging systems that minimize disturbance to existing duff, litter, and woody debris, except where disturbance is desirable to facilitate regeneration, may be used during timber harvest. Live and dead tree retention is used to preserve some of the biological legacy of the previous stand. Logging residue (limbs, tops, cull logs, etc.) is retained to levels that do not prohibit reforestation and do not create an unacceptable fire hazard.

3.3 Reforestation and Young Stand Management

Stand management activities are those performed between the time when a stand has just been harvested and the time when the stand is ready for another harvest. This section describes these activities as well as certain other conservation actions, such as snag creation, that may be performed within a stand to enhance stand utility for covered species. These activities tend to be performed at certain times following stand removal (usually by clearcut harvest), as shown in Table 3-2. This section addresses activities that will occur outside of HCAs. A description of reforestation and young stand management inside HCAs is described in Conservation Action 7.

Table 3-2. Typical Timing of Harvest and Stand Management Activities

Treatment	Timing of Treatment Typically Occurs:
Site preparation	0–1 years post harvest
Tree planting	0–2 years post harvest
Release treatments	0–10 years post harvest
Animal damage control	3–6 months prior to planting, 1–3 years post-planting[a]
Precommercial thinning and pruning	10–20 years post-planting

[a] Only refers to mountain beaver control.

Stand management includes silvicultural practices designed to control the establishment, composition, growth, health, and quality of stands to achieve forest management objectives. Silvicultural activities include slash management, commercial and precommercial thinning, vegetation control, seed tree management, and active snag development using top cutting, girdling, or inoculation methods. Stand management activities are described in this section in the order in which they are typically performed.

3.3.1 Site Preparation

The majority of harvest units subjected to clearcuts, regeneration harvest, retention, or patch cuts will receive site preparation treatment. Site preparation is any planned measure to prepare a site for the favorable conditions for newly planted seedlings. Site preparation should not cause detrimental or excessive soil disturbance, and should be carried out in a cost-effective manner. Through site preparation, factors that are limiting for seedling survival and growth may be overcome. Such factors may include limited soil moisture, low light levels, and compacted soil. Logging slash can have positive and negative benefits and should be evaluated on a site-by-site basis. The three main site preparation techniques are mechanical, chemical, and broadcast burning. Chemical site preparation is not a covered activity (see Section 3.10, *Activities Not Covered*). Mechanical treatments and prescribed burning are covered activities and are described below.

3.3.1.1 Mechanical

Mechanical site preparation is the use of mechanized equipment to rearrange or alter logging slash and/or disturb the forest surface layer and vegetation to create seedbeds or planting spots. Mechanical site preparation reduces competition of other vegetation with crop trees for light, water and nutrients. It can alter wildlife habitat, both positively and negatively, and be a source of invasive species introductions; these should be taken into consideration before use at each site. It can also be used to treat the adverse effects of past activities, such as compaction.

3.3.1.2 Prescribed Burning

When properly applied on appropriate sites, prescribed burning can achieve many site preparation objectives. Fire can be used on steep terrain, does not compact the soil, and improves access for planting. Fire impacts can also improve seedling survival and growth by reducing competing vegetation. Prescribed burning is also used to remove slash piles and fine fuels throughout the site and on landings, while its controlled intensity preserves larger pieces of downed wood that are important habitat for many species of concern.

However, it also has disadvantages. The biggest disadvantage is the risk of fire escaping the harvest unit, which is minimized through best management practices for prescribed burning. In certain parts of the permit area, burning can also increase the amount of competing vegetation, *Ceanothus* and *Senecio* species.

3.3.2 Tree Planting

3.3.2.1 Initial Planting

Initial planting must occur within 2 years following a regeneration harvest. Planted seedlings will be well suited and adapted to the reforestation site, and, where appropriate, a mixture of species will be planted to increase diversity across the permit area. The ODF is required to meet certain stocking standards after harvest, as defined in the FPA (OAR 629-610-0000 – 629-610-0090). Planting density must be at least 200 trees per acre (TPA), but is more likely to range from 350–538 TPA). Seedlings will be well distributed, with greater than 80% of the harvest unit covered. Stock type will be site specific and consider factors such as soil type, soil quality, and animal browse potential. Species selection will be on a site-by-site basis with the goal of increasing diversity across the landscape to increase resiliency in the uncertainty of climate change. In areas of disease, such as Swiss needle cast or laminated root rot, planted species will be of tolerant stock or from a resistant species with an emphasis on resistant species. Finally, seedlings will be free-to-grow (seedlings are able to out-compete surrounding vegetation) within 6 years after harvest activity. If desired conditions will not be able to meet the above standards an Alternative Management Plan will be submitted prior to harvest.

3.3.2.2 Interplanting

Interplanting will occur when stocking levels fall below FPA minimums. In certain instances, interplanting will occur to increase stocking on high quality sites to fully occupy the site. In other areas, lower stocking will be acceptable as it will provide more complex early seral stand conditions while still meeting FPA requirements. Interplanting of units can occur even if the unit meets the requirements of the FPA to ensure the site is fully captured. Density will be site dependent, but range from 200–400 TPA.

3.3.3 Manual Release Treatments

Release treatments usually occur in young stands and are designed to reduce competition for desirable tree species. They can also be used to alter species composition under pressure from insect and disease and favor species that are tolerant or resistant to threat. Pre-commercial thinning mostly favors Douglas-fir and western hemlock outside of HCAs. In areas with disease (Swiss needle cast, laminated root rot), treatments will favor retention of species that are resistant or more tolerant to the target disease. Manual release treatments are used to reduce competition from trees and other vegetation, and is accomplished through precommercial thinning (PCT). PCT is used to manipulate the density, structure or species composition of overstocked young forest stands. Generally, the purpose of a PCT operation is to release the biggest and best growing trees so they can maintain their growth. This tool is used when ingrowth from planted trees and natural regeneration, both conifer and hardwood, creates competition that may reduce the growth and vigor of the most desirable tree species. PCT is normally conducted in a stand between the ages of 10 and 20 years. Remaining density should be appropriate for the site and range from 250–350 TPA. In areas of disease, such as Swiss needle cast, PCT can be used to favor western hemlock and other resistant species over Douglas-fir to help ensure a healthy future stand.

3.3.4 Animal Damage Control

Animal damage on newly planted seedlings reduces their overall size, health, and vigor. Extensive damage can lead to interplanting, extend the time to achieve free to grow, potentially violating the FPA. Animal damage occurs in many forms, but the most common is from ungulates (deer and elk) and mountain beaver.

Ungulate browse ranges from minor to severe. Minor browse damage usually has little impact on growth and survival. Repeated severe browse damage to seedlings, sometimes seen with western redcedar, can have major impacts on growth and occasionally lead to mortality. Mountain beavers clip the seedling at its base, causing mortality. As the seedling ages, the diameter becomes too large and the animal climbs the stem and clips branches. Mountain beaver browse will occur in most stands in the northern part of the permit area as well as some portions of the southern part.

Control measures are used when the negative impacts are expected to cross threshold limits. Common control methods include rigid seedling protector tubing and controlled hunts for ungulates and trapping for mountain beaver.

3.3.5 Precommercial Thinning and Pruning

Precommercial thinning involves thinning dense, young forest trees by mechanical means, including felling individual trees or mechanically sawing or chipping rows or groups of trees. For stands between 10 and 20 years old, precommercial thinning may occur to remedy overstocked conditions in which trees exceed target densities. Thinning reduces tree density so that remaining trees achieve optimum diameter growth. Thinning can also be done to reduce insect and disease issues and increase overall forest health. Trees felled during a precommercial thin are typically left on the ground because they are too small to meet current merchantable standards. This operation is generally performed only once in the life of a stand and only in those stands with an excess number of trees per acre.

Pruning removes the lower limbs of desirable tree species to increase the eventual product value of the pruned trees. Pruning is a rarely used activity, optimally performed when the trees are small enough to minimize the size of knots on the tree, and maximize the production of high-grade, knot-free wood at the time of anticipated harvest. Pruning can also be done for forest health—in western white pine stands removing the lower limbs decreases the white pine blister rust pathogen. Pruned trees must maintain a minimum of 50% of their live crowns. To maintain the live crown and minimize the size of knots, pruning is typically done several times as the tree grows. Pruning is typically conducted by hand with hand tools or a chainsaw.

Precommercial thinning and pruning would be performed in accordance with restrictions placed by all applicable rules under the Oregon FPA.

3.3.6 Salvage

Natural disturbance events, such as insect or disease outbreaks, wildfire, and weather events like windstorms or ice storms, can have severe effects on forest stand structure, and salvage harvesting may occur to accomplish overall management objectives. Significant natural events can present forest health and management challenges, and these events are occasionally at a large scale that would broadly affect the permit area.

Salvage activities would vary from selective harvest of individual trees to clearcut harvest, depending on the magnitude and severity of the disturbance event, pre- and post-disturbance stand conditions, and desired future conditions. Salvage occurs to provide access, safety, and economic returns, and to have some control over reforestation/restoration pace and outcomes. Roadside salvage occurs at a specific distance from one or more roads, rather than in a specific unit or area. Significant salvage acreages are grouped into harvest units that are treated similarly to other timber harvests.

Salvage harvest will not occur in riparian conservation areas or habitat conservation areas unless it is specifically to provide for the safety of the public, ODF employees, and contractors, co-operators, and volunteers, or to reduce risk to facilities and infrastructure. If salvage of trees occurs in RCAs felled trees will be left in the RCA and felled towards the stream so that they can eventually be recruited into the stream, or provide nutrients and sediment retention and routing to benefit covered aquatic species. In the event that a large disturbance occurs that affects a significant portion of the permit area, including RCAs and HCAs, ODF may propose to conduct salvage operations in HCAs or RCAs if doing so will decidedly benefit covered species through a technical assistance discussion with the U.S. Fish and Wildlife Service (USFWS) and National Oceanic and Atmospheric Administration (NOAA) Fisheries (collectively referred to as the Services). Any salvage operations in RCAs or HCAs that are not directly related to protecting public safety or facilities will be conducted with technical assistance from the USFWS, NOAA Fisheries, and ODFW. See Section 8.3 for more information on the Technical Assistance process during implementation.

3.3.7 Unmanned Aircraft Systems

Unmanned Aircraft Systems (UAS), also known as drones, are an emerging technology that will likely become more commonly used over the term of this HCP. As with any developing technology, new uses will be discovered as use becomes more common. ODF anticipates that UAS will be used to conduct a variety of field surveys including free-to-grow surveys, rock stockpile estimates, harvest unit closeout, contract administration and inspection, 3D modeling (LiDAR and Phodar), stream surveys, animal damage assessment, and adaptive management monitoring. UAS may also be used in harvest operations and research projects to fly tools, equipment, and ropes to set up projects or equipment.

3.4 Road System Management Activities

Road system management activities are those associated with construction, use, and maintenance of forest roads and associated facilities—chiefly landings, drainage structures such as bridges and culverts, and quarries. This category of covered activities also includes the vacating of such facilities.

3.4.1 Existing Road System

ODF has largely inherited an extensive road network that was built in the 1940s, 1950s, and 1960s to access and service large-scale timber salvage operations in northwest Oregon following four catastrophic wildfires between 1933 and 1951 (see Chapter 2, *Environmental Setting*). Over the years since then, ODF has, when funding allows, vacated or improved roads that did not meet current environmental standards, particularly when these roads intersect new timber sales.[4]

ODF maintains approximately 4,151 miles of road within the permit area (Table 3-3). Many of these roads were constructed under the Oregon FPA rules. This system is stable, with nominal mileages added or removed each year. The road system for the permit area is mostly in place, with most new road construction being short spurs for accessing individual harvest units or reroutes to better locations when roads have been vacated. The principal foreseeable changes to the system would consist of construction of short spur roads to access new timber harvest units. Spur roads may be closed once the unit has been replanted and the stand is free to grow. Where roads are fully vacated, they are rendered undrivable, cuts and fills are stabilized, culverts are removed, and natural drainage is ensured to minimize potential damage to resources, particularly waters of the state. It is estimated that up to 25.5 miles per year of road construction would occur under the HCP (Table 3-3). The majority of this construction will be spur roads, along with some collector roads, and would remain relatively constant over the permit period. Natural surface (i.e., not surfaced with rock) spur roads are typically closed after harvest and replanting activities are complete to prevent resource damage. In addition, it is estimated that on average 6 miles per year of roads would be vacated during the permit term (Table 3-3).

Table 3-3. ODF Road System Construction and Vacating in the Permit Area

Ecoregion	Total Road Miles (Existing)	Average Yearly Road Construction Estimate (miles)	Average Yearly Road Vacating Estimate (miles)
Coast Range	3,845	23	5
West Cascades	306	2.5	1
Total	**4,151**	**25.5**	**6**

3.4.2 Road Management

ODF manages its road system consistent with the FMP to do the following (Oregon Department of Forestry 2010a).

- Keep as much forest land in a natural, productive condition as possible.

[4] ODF funding from timber sales makes it economically feasible to improve roads that are directly related to the timber sale generating the revenue.

- Prevent water quality problems and associated impacts on aquatic resources.
- Minimize disruption of natural drainage patterns.
- Provide for adequate fish passage where roads cross fish-bearing streams.
- Minimize exacerbation of natural mass-wasting processes (e.g., landslides).

All road construction, use, maintenance, and vacating will be performed in accordance with the Oregon FPA (OAR 629) and other applicable statutes and described in detail in the *Forest Roads Manual* (Oregon Department of Forestry 2000 or most recent version). The Oregon FPA prescribes measures covering the following.

- Written Plans for Road Construction (OAR 629-625-0100)
- Road Location (OAR 629-625-0200)
- Road Design (OAR 629-625-0300)
- Road Prisms (OAR 629-625-0310)
- Stream Crossing Structures (OAR 629-625-0320)
- Drainage (OAR 629-625-0330 and 629-625-0420)
- Waste Disposal Areas (OAR 629-625-0340)
- Road Construction (OAR 629-625-0400)
- Disposal of Waste Materials (OAR 629-625-0410)
- Stabilization (OAR 629-625-0440)
- Vacating Forest Roads (OAR 629-625-0650)
- Wet Weather Road Use (OAR 629-625-0700)
- Stream Protection (OAR 629-625-0430)
- Rock Pits and Quarries (OAR 629-625-0440)
- Road Maintenance (OAR 629-625-0600)

Additional implementation guidance for ODF management of roads within the permit area is provided in the following ODF operational manuals and guides:

- *Forest Roads Manual* (ODF 2000).
- *Anadromous Salmonid Passage Facility Design*. NOAA Fisheries, Northwest Region, Portland, Oregon. 2011
- *Fish Passage Guidelines for New and Replacement Stream Crossing Structures*. Forest Practices Technical Note Number 4. Version 1.0: Effective May 10, 2002.
- *Determining the 50-Year Peak Flow and Stream Crossing Structure Size for New and Replacement Crossings*. Forest Practices Technical Note Number 5. Version 1.0: Effective May 10, 2002

- *Avoiding Roads in Critical Locations.* Forest Practices Technical Note Number 7. Version 1.0 Effective June 20, 2003.
- *Installation and Maintenance of Cross Drainage Systems on Forest Roads*. Forest Practices Technical Note Number 8. Version 1.0. Effective June 20, 2003.
- *Wet Weather Road Use*. Forest Practices Technical Note Number 9. Version 1.0 June 20, 2003.
- *Wet Weather Haul, Snow Removal/Plowing Operations and Freeze Thaw Cycles Requirements.*
- Seasonal road restrictions (defined at the District level).

3.4.3 Road Construction

Roads in the permit area are most commonly constructed by felling and yarding timber along a predetermined road alignment. This activity is followed by excavating or filling hillslope areas using bulldozers or excavators. Road construction also commonly involves clearing and grubbing, establishment of the road grade, shaping, compacting the road prism, constructing drainage ditches and ditch outs, installing ditch relief culverts, constructing stream crossings that use culverts and bridges, and disconnection of culverts. At times road construction requires blasting of rock features and/or removal of excess material to offsite waste areas to ensure slope stability, make grade or width, for water quality reasons, or to place material in suitable locations. Road construction may also involve surfacing soil roads with rock, lignin, pavement, or other surface treatments. Roads also include vehicle turnouts, turnarounds, and timber harvest landings. Landings are wide spots in the road that are used during harvest to yard felled logs and load them on trucks. Construction, maintenance, and vacating of landings is performed using the same techniques, is subject to the same regulatory constraints, and typically occurs at the same times as road construction, maintenance, use, and abandonment. Landing construction would be performed in accordance with restrictions placed by the Oregon FPA, specifically including those identified in ORS 629-630-0200 Landings, but also including all other applicable rules. Landings would be constructed at the minimum size necessary for safe operation, and average 0.75-acre in size. Landings are stable locations and will remain in places where roads are not removed. Spur roads and landings are generally left open for reforestation and young stand management activities until newly planted stands reach a "free to grow" state as defined by the Oregon FPA. After the planted stand reaches the "free to grow" state, spur roads are typically closed to prevent public access, culverts are removed, and water bars are created. Where spurs and landings have the potential to deliver sediment to water, they are reseeded with native vegetation and mulched with weed-free straw. Where spurs are stable they are allowed to naturally revegetate over time. If the edges of landings are found to not be naturally revegetating during reforestation inspections, they are replanted or revegetated.

Typically, roads would be constructed with a subgrade width of approximately 16 feet and a 3-foot-wide ditch, for a total typical width of 19 feet. If the road is out-sloped, a minimum width of 14 feet would be needed. The total disturbance area of the road, including cut slopes, fill slopes and clearing limits would depend on the steepness of the terrain, as well as the type of construction.

3.4.4 Road Use

The road system provides access for all management activities, fire suppression, and public use. Roads in the permit area are primarily used by utility vehicles accessing parts of the forest(s), heavy equipment (log trucks and heavy equipment trailers hauled by similar tractors), and recreational users in street legal vehicles, along with off-highway vehicles (OHVs) that are not licensed for public roadways. All such use is a covered activity under this HCP. Such use is a year-round activity and is unrestricted except in cases where roads are gated and locked. The use of gates is limited to only those areas that require restricted access—examples include, but are not limited to, capital facilities (e.g., transmission towers), off-season recreation sites, and walk-in hunting locations—or to reduce fire risk or minimize vandalism to natural resources.

3.4.5 Road Maintenance

Road maintenance is the maintenance and repair of existing roads that are accessible to motorized use. Road maintenance typically includes surface grading, clearing bank slumps, falling trees or snags that are safety hazards, repairing slumping or sliding fills, clearing ditches, repairing or replacing culverts and bridges, adding surface material, performing dust abatement, performing erosion control, and installing or replacing surface drainage structures. Road maintenance for fire prevention, public access, and timber management covered under the HCP includes mechanical control of roadside vegetation, such as grading, hand cutting, and using a road brusher, excavator, and other methods.

3.4.5.1 Beaver Management

ODF will encourage beaver damming activity within the permit area. However, beaver management will occur along sections of road in the permit area adversely affected by beaver activity. Beavers are drawn to the sound of running water, which can be caused by culverts, and react by constructing dams. These dams plug the culvert system, and, if not addressed, can result in the road being washed away due to flooding (USFS n.d.). In the permit area, beaver activity is most likely in lower gradient streams in the Coast Range. Outside the North Coast, it is less common for beaver to occur in the permit area, primarily because there are fewer low-gradient streams. On average, ODF addresses seven beaver-related road issues a year, with most of those occurring in Tillamook and Clatsop State Forests.

As part of regular maintenance, ODF will remove material deposited by beaver within or immediately upstream of culverts. In instances where there is persistent deposition of material from upstream, ODF will install devices such as fencing on the upstream side of a culvert to prevent the deposition of material within the culvert. Additionally, ODF will evaluate the consistent beaver occurrences, and utilize the best alternative to reduce conflict, which may include culvert replacement with a larger stream simulation culvert. ODF may remove beaver dams downstream of culverts where the beaver pond is backing up against road fill, in compliance with the FPA rules that allow removal of any beaver dam that is within 25 feet of a culvert, where it is considered necessary for road maintenance. Habitat enhancements in the area of the beaver occurrence will be developed to minimize road conflicts and optimize riparian habitat for beavers. ODF staff do not trap or remove beaver directly. In rare instances where trapping is required, ODF will contract with a wildlife control operator permitted through ODFW, who will be responsible for the removal of the individuals.

3.4.6 Road Vacating

Road vacating refers to the process of making a road impassable, including closing the road, stabilizing the roadbed surface, removing culverts and other drainage structures, and ensuring natural drainage. Roads are vacated if deemed non-essential to near-term future management plans or where unrestricted access would cause excessive resource damage. ODF determines which roads to vacate during Implementation Planning and Annual Operations Planning processes. Vacated roads and reclaimed roads are left in a condition that is stable and provides for adequate drainage. Roads will be vacated in locations where hydrological benefit will be higher with the road removed than it would be if the road was left in place. In situations where vacating the road would result in more hydrological damage than would be gained, the road would be stabilized and left in place.

3.4.7 Drainage Structure Construction, Maintenance, and Vacating

This activity includes the installation, maintenance, and removal of drainage structures on roads. Such structures are normally associated with roadways and include channel-spanning structures (culverts and bridges), roadside drainage ditches, and cross-slope drainage culverts. All such structures are installed and maintained in accordance with all applicable laws and regulations.

3.4.8 Water Drafting and Storage

Water drafting occurs throughout ODF lands. These locations provide a water source for road construction, improvement, and maintenance as well as assist in chemical mixing to be used on forest management sites and for firefighting, for filling water trucks, and for water trucks that may be on standby during controlled burning. Water developments are mainly located at creeks and rivers, with some at springs. Maintenance of existing water developments, including brushing for access, maintaining the integrity of the basin, and removing debris or sediment, are covered activities.

3.5 Minor Forest-Product Harvest

Many people collect or harvest special forest products for commercial income or personal use. These special or minor forest products within the permit area include a variety of products other than timber, including but are not limited to firewood, burls, stumps, boughs, edible fungi, and greenery such as western sword fern (*Polystichum munitum*), salal (*Gaultheria shallon*), and red huckleberry (*Vaccinium parvifolium*).

Within the permit area, ODF typically issues forest product harvest permits for beargrass, boughs, Christmas trees, cones, ferns, firewood, huckleberry, moss, mushrooms and truffles, posts and fenceposts, sagebrush, salal, and vine maple. The amount of harvest of these items varies from year to year based on public demand and resource availability.

3.6 Quarries, Borrow Sites, and Stockpile Sites

Quarries are generally multiple entry sites where specific rock products are developed primarily for use as road surfacing material. Rock products may also be developed for other uses such as culvert bedding, armoring, ballast, and drainage. Quarry development may include the use of drills, explosives, bulldozers, rock crushers, loading equipment, and trucks. Quarries typically remain active for many years. Quarry siting and operations are compliant with requirements of the Oregon

FPA rules (OAR 629-625-0500) and other applicable statutes. Any use of quarries for rock products obtained from any streamside or instream gravel mining will not be allowed.

Borrow sites are locations where native soil or rock is taken for use as fill material for road or landing construction. Borrow sites are typically discovered and accessed during road construction, resulting in a small expansion of the road prism. Borrow site development may include the use of bulldozers, loading equipment, and trucks. Borrow sites are typically single use sites or locations where very small quantities of material will be removed over a longer period. Borrow sites will typically be sited outside of RCAs. In instances where borrow sites may be located within RCAs, the Aquatic and Riparian Specialist will be consulted prior to any use of the site. If a borrow site is sited in an Equipment Restriction Zone (ERZ), it will be limited to a single use. All borrow sites will be hydrologically disconnected from aquatic resources and stabilized, compliant with requirements of the Oregon FPA rules (OAR 629-625-0500) and other applicable statutes.

Stockpile sites are locations where rock is stored for future use. They may also be used for the staging of equipment for other nearby projects. Stockpile sites are generally permanent parts of the transportation network and will be re-used over the course of the permit term. Stockpile sites will be sited outside of RCAs. New stockpile sites are reviewed by the Geotechnical Specialist for approval of siting and the amount of loading. All stockpile sites will be hydrologically disconnected from aquatic resources and stabilized, compliant with requirements of the Oregon FPA rules (OAR 629-625-0500) and other applicable statutes.

3.7 Fire Management

3.7.1 Controlled Burning

ODF and its state agency partners conduct controlled burns under specified conditions in order to accomplish stand management and other objectives. Burning is conducted under controlled conditions with little or no risk of catastrophic fire damage. As such, burning is considered fire hazard abatement because it greatly diminishes the available concentration of fuel sources. Fire season restrictions placed each year by ODF prohibit burning from approximately May/June until the beginning of the rainy season in approximately November. Controlled burning is performed in upland forest, outside of riparian conservation areas. Types of controlled burns conducted within the permit area include the following. The average number and size of these types of burns are summarized in Table 3-4. It is estimated that the level and type of controlled burning will be consistent through the permit term at the levels shown in Table 3-4.

- **Prescribed burning.** Prescribed burns are by definition pre-planned and done under strict environmental and personnel safety conditions that are meant to keep the fire confined to a predetermined area and occur under specific conditions. A prescribed burn improves seedling survival and growth while emulating natural processes. A prescribed burn is also intended to remove slash (see Section 3.3.1.3, *Prescribed Burning*) and other wildland fuels to reduce the risk of catastrophic wildfire.
- **Pile burning.** Following harvest operations, slash is machine piled along roads and around landings, may be scattered throughout harvest unit, covered with plastic to keep the core of the pile dry, and then burned when weather conditions permit. Pile burning will not occur within an RCA.

- **Underburn.** A controlled fire under a timber or brush overstory which serves as a method for removing wildland fine fuels and improving overall forest health. ODF traditionally employs manual fuels management techniques where smaller ladder fuels are piled and burned. As a result, underburning has not traditionally been employed within the permit area. Changing conditions due to drought and climate change may necessitate increased use of this tool in the future.

Table 3-4. Yearly Average (2008–2018) Controlled Burn Acres, by Type in the Permit Area

Controlled Burn Type	Times Conducted per Year	Average Size (acres)
Prescribed Burning	0–1	80
Pile Burning	70	20
Underburn	0	0

3.8 Recreation Infrastructure and Maintenance

Recreational activities by the public are not covered activities in this HCP, as described in Section 3.10, *Activities Not Covered.* There are diverse recreation activities in the permit area, with dispersed use throughout the forest. Activities include camping, picnicking, fishing, hunting, target shooting, driving on forest roads, hiking, OHV use on trails, horseback riding, mountain biking, swimming, paddling, rock climbing, nature study, and sightseeing. Public use rules for state lands (Recreational Use of State Forest Land, Chapter 629, Division 25) establish standards for recreational use. The rules regulate OHV use, camping, firearm use, disposal of garbage and human waste, and other activities associated with recreational activity. While ODF attempts to manage public recreation to maintain a safe environment for the public, the actions of individual members of the public are ultimately beyond ODF's control.

The HCP only covers ODF's siting, construction, and maintenance of recreational infrastructure, including maintenance and improvement of existing facilities and standards and guidelines for new developments. Facilities include but are not limited to the following.

- Campgrounds
- Day-use (e.g., picnicking)
- Parking
- Trailhead facilities
- Motorized and non-motorized trails (equestrian, mountain bike, foot)
- Boat launches
- Restroom facilities
- Target shooting lanes
- Education and interpretation facilities
- Administrative buildings

ODF staff maintain these facilities and patrol the recreation trail networks, striving to protect trail investments, provide for safety (including the felling of hazard trees[5]), address trail issues, and protect water quality. This is typically done on foot, bike, light trucks, or OHVs using established roads and trails within state forests. Heavy equipment is also used to complete maintenance, predominantly on motorized trails and in recreation facilities.

Most recreation trails and facilities in the permit area occur in the North Coast subgeographic area (Table 3-5). It is estimated that all recreational facilities will increase over time in response to an increase in recreational use. The largest increase is expected to occur in the North Coast due to the relative proximity to the greater Portland area and the Willamette Valley (Table 3-5).

Table 3-5. Estimated Increase in Recreation Use and Related Facilities During the Permit Term By Subgeographic Area

Recreational Use	Southern Oregon	Willamette Valley	North Coast
Non-Motorized Facilities (campgrounds, day use, designated dispersed)	10%	25%	90%
Motorized Facilities (staging areas, event sites, motorized camping)	5%	10%	90%
Non-Motorized Trails	10%	25%	90%
Motorized Trails (single track, quad, side-by-side, jeep)	5%	10%	50%
Education and Interpretation Facilities	--	--	--
Special Use Permits/Activities	10%	15%	35%

More specifically these changes over time will manifest in various ways across each subgeographic area. The following is a summary of expected changes in each district during the permit term.

Southern Oregon – Opportunities in the Southwest and Coos County portion remain dispersed or seasonal. Large surrounding federal ownership offers more formal/developed recreation opportunities. The Western Lane portion of the district has controlled access and scattered parcels. Control of roads is in partnership with the Bureau of Land Management (BLM) and private landowners. Dispersed camping will increase and hunting opportunities will persist. There may be some recreational infrastructure development over time, but currently there are no plans for formal site development. There will be pressure from population growth in the Eugene area.

Willamette Valley – ODF managed lands in this area exist as smaller consolidated blocks and scattered parcels, providing less opportunity for formal site development beyond existing conditions. Existing sites on the Santiam State Forest will continue to experience high use from Willamette Valley users. Some sites will be expanded or newly developed to address use levels. Motorized use has historically been lower than the North Coast, and growth is anticipated. Under the HCP, uses may be expanded while still observing necessary seasonal restrictions around known nesting areas. On the West Oregon District, it is expected that motorized use will continue at the current level at one site. There will be continued non-motorized development of a mountain bike

[5] A standing tree that presents a hazard to employees due to conditions such as, but not limited to, deterioration or physical damage to the root system, trunk, stem or limbs, and the direction and lean of the tree. As defined at: https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.266.

riding area and an expected increase in users over time. Further day use/parking development is expected. Dispersed camping will continue to occur seasonally. Opportunities will stay the same or decrease but will see pressure from the growing population of the Corvallis area. A large number of formal recreation opportunities exist on federal lands surrounding the Willamette Valley.

North Coast – State forestlands in the North Coast are proximal to the Southwestern Washington and Portland Metro areas. ODF is the largest public landowner in the North Coast and has the largest contiguous areas suitable for public recreation, while federal recreational opportunities are more limited. Current demand for recreational opportunities is very high and will increase into the future, requiring expansion of existing facilities and development of new ones. Demand for summer river access will continue to grow. Historic use of the subgeographic region has focused on the motorized trail system. Motorized and Non-Motorized use will continue to grow in the area. Demand will be high for types of use, number of users, and likely requests for new uses and developments. This area will also need to address the development of the Salmonberry Trail as a regional trail system, which is expected to have a high sustained use as a destination recreational opportunity. Designation of new target shooting sites will be required to reduce conflicts between target shooting and other management activities. This use is expected to continue to grow.

Other notable assumptions regarding recreation on state forest lands include the following.

- The Salmonberry Trail will be implemented, and use levels will continue to grow over time (Forest Grove/Tillamook districts).
- The number of hunters and fisherman will plateau or decrease over time.
- Dispersed (unregulated) camping will occur on every district and forest and increase over the planning period.
- Districts will receive applications and issue permits for events, guiding activity, filming, etc.

Further, ODF expects changes to the type of use and user during the permit term to include the following.

- Larger family and friend groups.
- Increased diversity of uses or permitted uses.
- Greater cultural diversity of users.
- Need for facilities to accommodate large group gathering areas or event venues.
- Progression in technological advancements of OHV equipment.

Due to the assumptions outlined above regarding an increase in recreational users over time and an expansion of the recreation program in response, ODF expects an increase in all facilities in all subgeographic areas. The level of increase varies, primarily dependent on the location of each subgeographic area relative to existing and future population centers (Table 3-6).

Table 3-6. Recreational Infrastructure in the Permit Area

Existing Miles of ODF Designated Recreation Trails[a]	Estimated Increase in Use[b]	Estimated Increase in Trail Miles During Permit Term	Existing Number of Other Recreation Facilities (2019)[b]	Estimated Increase in Use[c]	Estimate Increase in Number of Facilities During Permit Term
638	90%	421	850	90%	765

[a] Includes hiking, biking, OHV, and horse trails.

[b] Includes trailheads, day use areas, campsites, horse use, interpretative sites, fee stations and kiosks, and boat launches.

[c] An increase in use of 90% was used as a conservative estimate, knowing that the largest increase will likely be on the North Coast, which also currently has the majority of recreational facilities (see Table 3-5).

3.8.1 Target Shooting Lanes

Currently ODF maintains four designated target shooting lanes in the permit area, and there are two more under development. Over the course of the permit term it is expected that the need to establish more designated target shooting lanes will be needed in order to direct users to areas where there is less conflict with other uses and a reduced fire risk. ODF estimates the potential to establish approximately 40 new designated shooting lanes across the permit area by the end of the permit term. Most of these lanes are likely to be concentrated on state forest lands in northwestern Oregon due to the proximity to larger population centers. New shooting lanes will be located outside of HCAs and RCAs. Existing shooting lanes within HCAs may be maintained or improved for safety.

3.9 Conservation Strategy Implementation Activities

Conservation strategy implementation activities are those activities that are required as part of the HCP's conservation strategy (including the monitoring and adaptive management program) and have potential to result in take of one or more of the covered species. Some activities associated with the conservation strategy, such as stand management to accelerate development of late successional features and vacating of roads and associated facilities, have been described in the preceding sections. This section summarizes other plan implementation activities associated with the conservation strategy. For a complete description of these actions, see Chapter 4.

3.9.1 Aquatic Habitat Restoration

Riparian areas are the aquatic ecosystem and portions of the adjacent terrestrial ecosystem that directly affect or are affected by the aquatic environment. These areas include streams, rivers, and lakes, and their adjacent side channels, floodplains, and wetlands, as well as portions of hillslopes that serve as streamside habitats for wildlife.

Stream restoration projects within the plan area may include, but are not limited to, placement of logs or whole trees in streams to create pools and to retain spawning gravels, replacement or removal of stream crossing structures (i.e., culverts) that block fish passage, relocation or redesign of existing roads or trails, stabilization of sediment sources (i.e., cut bank improvement of road drainage systems), road and/or trail closure, and/or road and trail vacating. Larger scale restoration projects could include widening or deepening channels and side channel reconnection or reconfiguration.

3.9.2 Upland Restoration Activities

Upland restoration activities will be completed using the silvicultural techniques described in Section 3.3, *Reforestation and Young Stand Management*, but will be subject to the conditions described in Conservation Action 7.

3.9.3 Barred Owl Management

ODF will coordinate with partners to better understand the effects of barred owl presence on northern spotted owls within the permit area. Barred owl management activities may include lethal and nonlethal removal techniques, or a combination of the two approaches. The lethal approach involves attracting territorial barred owls with recorded calls and shooting birds that respond when they approach closely. The nonlethal approach involves attracting territorial barred owls with a recorded call and catching the responding birds in nets or other trapping devices. The birds are then transported to temporary holding facilities, checked for injuries or other health concerns, stabilized, and transported to permanent facilities or release locations. Barred owl management may also include habitat modification or other management techniques that align with the USFWS Barred Owl Management Strategy.

3.10 Activities Not Covered

Individual actions of members of the public are not covered, whether or not those activities are conducted in a manner that complies with applicable law. This includes, but is not limited to: hunting, fishing, shooting, driving automobiles or OHVs, operating machinery, hiking, horseback riding, swimming, and wading (as described in Section 3.8, *Recreation Infrastructure and Maintenance*). ODF assumes that these activities in the permit area would follow state regulations (when applicable).

Herbicide application using either aerial application methods (i.e., fixed-wing airplane, helicopter, unmanned aerial system) or ground methods as part of reforestation site preparation or release treatments is not a covered activity under this HCP. ODF may still use herbicide application in the permit area, but will do so in compliance with the Endangered Species Act through take avoidance.

Certain parties have easements or special use permits providing access and use of lands within the plan area. Use of lands within the permit area by easement holders or other parties who are not ODF representatives or contractors is not a covered activity. Third parties who access ODF lands consistent with easement terms are responsible for their own compliance with the federal Endangered Species Act.

Chapter 4
Conservation Strategy

This chapter describes the conservation strategy the Oregon Department of Forestry (ODF) will use to avoid, minimize, and mitigate impacts of *take*[1] on listed species as required under Section 10(a)(2)(A) of the Endangered Species Act (ESA) and its implementing regulations. Chapter 5, *Effects Analysis and Level of Take*, specifies the take that is predicted to occur by carrying out the proposed covered activities (Chapter 3, *Covered Activities*), the impacts of such taking, and the net effects following consideration of the proposed conservation actions described in this chapter. Chapter 6, *Monitoring and Adaptive Management*, specifies the monitoring and adaptive management program that will be implemented to help ensure the intended benefits of the conservation strategy are realized.

This chapter contains the following sections.

- Section 4.1, *Conservation Approach and Methods*, describes the overall conservation approach, data, species habitat models used, and the basis for developing proposed conservation actions.
- Section 4.2, *Data Sources*, describes the sources and types of information used to develop the conservation strategy.
- Section 4.3, *Developing Avoidance and Mitigation Measures*, describes how conservation measures were developed.
- Section 4.4, *Determining Mitigation Needs and Strategies*, describes how additional mitigation needs and strategies were identified.
- Section 4.5, *Considering Climate Change Effects*, describes how climate change was incorporated into the conservation strategy.
- Section 4.6, *Biological Goals and Objectives*, describes the long-term biological goals and measurable biological objectives for each covered species.
- Section 4.7, *Conservation Actions for Covered Species*, describes how ODF will meet the biological goals and objectives (i.e., the actions to be implemented to achieve the goals and objectives).

4.1 Conservation Approach and Methods

The conservation approach was developed in the context of a forested landscape that has been modified from historical conditions across the permit area. When the state acquired these lands, the majority of them had a history of early twentieth century railroad logging, splash dam logging, and repeated, large-scale wildfires, coupled with extensive salvage logging (Magby et al. 2018). This is particularly notable in the northwest portion of the permit area (i.e., the Tillamook and Clatsop State Forests). This land use and disturbance history dramatically altered forest development and associated forest structure, composition, and distribution. On the Tillamook State Forest, for

[1] "Take" is defined by the Endangered Species Act (ESA) as harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect any threatened or endangered species.

example, most older forest stands were lost in the repeated fires and extensive salvage operations that followed. As a result, many forest stands are now dominated by densely spaced, young conifer and mixed deciduous forest (for a detailed description of current conditions and their history, see Chapter 2, *Environmental Setting*).

Over the last few decades, ODF has worked to shift forest trajectories (primarily by thinning, regeneration cuts, and planting) to develop state forests into a landscape that contains a more natural forest structure, composition, and distribution that is resilient to disturbance such as fire, insects, disease, and drought (ODF 2010a, 2010b). The conservation approach of this habitat conservation plan (HCP) builds upon ODF's commitment to restore healthy, resilient, and sustainable forest ecosystems across western Oregon's state forest lands.

Responding to past disturbance, the conservation approach of this HCP prioritizes conserving remnant habitat occupied by the covered species, maintaining high-quality unoccupied habitat or habitat of unknown status (as needed to augment occupied habitat), ensuring habitat connectivity across the landscape, and enhancing habitat where habitat quality can be improved effectively through forest management activities. The conservation approach is balanced with other management activities across the permit area to help ensure social, economic, and environmental benefits provided by ODF lands in the permit area.

4.2 Data Sources

As presented in Chapter 2, covered species occurrence and habitat data used for this HCP are based on the following.

- Survey occurrence data for covered species, as collected by ODF and others, including Oregon Department of Fish and Wildlife (ODFW), U.S. Fish and Wildlife Service (USFWS), U.S. Bureau of Land Management (BLM), U.S. Forest Service (USFS), and private landowners.
- Published distribution data, such as presented for covered fish species through the StreamNet cooperative (https://www.streamnet.org/).
- ODF forest inventory data that document the age class distribution and provide insight into the range of habitat types available in state forests.
- Species-specific habitat models for terrestrial species, used to estimate the extent of species distribution, and the locations of likely suitable habitat in locations where survey data are limited or missing.

See Section 2.5, *Covered Species*, for details on these data sources.

As presented in Chapter 1, *Introduction*, other sources used to inform the conservation strategy include the following.

- Recovery plans, species status assessments, and related documents and plans (Section 1.5, *Document Organization*).
- Other conservation plans in Oregon (Section 1.4, *Overview of Planning Process*).
- Critical habitat designations.

4.3 Developing Avoidance and Minimization Measures

Avoidance and minimization measures are central to the conservation strategy to reduce effects on habitat occupied by the covered species, maintain suitable unoccupied or unsurveyed habitat, and minimize incidental disturbance of or harm to covered species. Avoidance and minimization measures were developed and refined based on input from USFWS, National Oceanic and Atmospheric Administration (NOAA) Fisheries, and ODFW; the consulting team; and ODF foresters and biologists with institutional knowledge of ODF forest lands and ODF forest-management practices. In addition, avoidance and minimization measures have been informed by other similar HCPs, including the Washington State Department of Natural Resources *HCP for State Trust Lands* (WDNR 1997), Montana Department of Natural Resources and Conservation *Forested State Trust Lands HCP* (MDNRC 2010), and the *Green Diamond Resource Company Forest HCP* (Green Diamond 2018).

The avoidance and minimization measures outlined in the conservation actions of this HCP also build on existing practices by ODF. As stated previously, ODF has made a long-term commitment to restoring forest habitats and associated ecosystem/watershed functions across ODF lands in western Oregon (Magby et al. 2018). Oregon Administrative Rule (OAR) 629-035 (Management of State Forest Lands) provides direction that allows ODF to develop policies and other measures that serve to avoid and minimize effects on terrestrial, aquatic, and riparian habitat important to ESA-listed and other sensitive species.

4.4 Determining Mitigation Needs and Strategies

Although the conservation strategy is largely designed to avoid or minimize incidental take of most known covered species sites, mitigation strategies will be used to offset the impacts of the taking of covered species that cannot be avoided. For example, over the life of the HCP, habitat for the covered species may be lost through timber harvest or other covered activities; however, habitat lost to covered activities will be offset by implementing conservation actions throughout the permit area that will increase habitat quality and, in some cases, quantity. For the terrestrial covered species, this will primarily occur in Habitat Conservation Areas (HCAs), as described in Conservation Action 6: Establish Habitat Conservation Areas, and Conservation Action 7: Manage Habitat Conservation Areas (Attachment A). For aquatic covered species, this will primarily be achieved through stream restoration and enhancement activities as described in Conservation Actions 3: Stream Enhancement, 4: Remove or Modify Artificial Fish-Passage Barriers, and 5: Standards for Road Improvement and Vacating.

The conservation strategy is intended to be considered in totality when assessing how conservation benefits will offset effects on covered species. In other words, the conservation program as whole, comprising avoidance, minimization, and mitigation actions, is designed to achieve the biological objectives for each covered species. These biological goals and objectives are described in Section 4.6, *Biological Goals and Objectives*.

4.5 Considering Climate Change Effects

Increases in atmospheric concentrations of greenhouse gases have exacerbated increases in global temperatures, contributing to changes in precipitation and disturbance regimes (e.g., fire, insects, pathogens, and windstorms) that have already begun to affect the health of western Oregon forests and their associated ecosystems. These changes may have profound effects on covered species in the permit area over the next century (Reilly et al. 2018). While projected increased temperatures may actually increase growth of Douglas-fir where soil moisture remains adequate (Albright and Peterson 2013), Reilley et al. (2018) reported mostly adverse climate change effects projected throughout the Pacific Northwest, including the following.

- Reduced tree growth and increased tree mortality due to drought.
- An increase in nonnative invasive species.
- Increased potential for wildfire.
- Potential loss of some native species.
- Potential loss of native habitat.
- Increased competition between nonnative and native species.

The HCP's conservation strategy considers the potential effects of climate change on state forest lands through management strategies at stand and landscape scales to reduce ecosystem vulnerability to the effects of climate change. The HCP is intended to build on the resilience that ODF addresses through strategies contained in its forest management plans to actively manage for a diverse and healthy forest ecosystem that is resilient to biotic and abiotic factors. The HCP conservation strategy is designed to increase resistance and resilience to disturbances caused by drought, pest infestations, and fire, all of which are expected to be more frequent and severe in the future (Spies et al. 2018).

The designation and active management of HCAs are designed to provide adaptation opportunities for the covered species against the expected effects of climate change, such as silvicultural treatments to reduce risks of habitat loss due to drought, fire, wind, insects, or disease. The HCAs emphasize the establishment and accelerated development of large blocks of late-seral forest habitat across a diversity of environmental gradients that will, over time, reduce habitat fragmentation, improve landscape connectivity, and improve carbon sequestration. Increasing the amount of late-seral forests and enhancing species corridors across the permit area will provide stand and landscape diversity and facilitate movement of covered species to future habitat, providing resilience to potential habitat shifts in response to climate change.

Concentrating HCAs in one or a few locations can reduce the resilience of conservation over time, because, when catastrophic disturbance occurs (i.e., fire) in these HCAs, their conservation values could be severely degraded or lost temporarily. To avoid this, the conservation strategy includes maintaining, enhancing, and increasing the amount and distribution of habitat for covered species over time to distribute risk and provide additional resiliency for covered species habitat to the effects of climate change. The conservation strategy achieves this by ensuring HCAs are distributed across the landscape within the permit area to ensure representation across latitudinal and elevational gradients. Ensuring connectivity of habitat across these latitudinal and gradients will enhance the ability of the covered species to respond to habitat shifts in response to climate change.

Enhancing adaptive capacity is essential to mitigate for the increasing threat of climate change (Siegel and Crozier 2019). Bottom et al. (2009) suggest that strengthening resilience for salmon populations to express their maximum life history variations will require expanding habitat opportunities. Changes in climate alter aquatic conditions across all life stages; however, the effects are not equally distributed. Changes have spatial and temporal variation depending on how the climatic regimen interacts with local conditions (Bottom et al. 2009). The HCP includes conservation actions that support long-term, natural stream processes to provide for salmon habitat, with special attention to wood recruitment, minimization of sediment delivery, and temperature protection. This is primarily accomplished through the designation of Riparian Conservation Areas (RCAs). Approximately 47% of RCAs are located within HCAs for terrestrial species, allowing upland conservation actions to complement the overall hydrologic regime across the permit area, by helping to moderate overall stream flow regimes, especially summer low flows. In addition, the HCP includes conservation actions that result in the enhancement of salmon habitat for all life history stages through stream and riparian habitat enhancement.

4.6 Biological Goals and Objectives

This section describes the biological goals and objectives that guide the HCP's conservation strategies for covered species. Biological goals and objectives for covered species are required to be included in HCPs by the *HCP Handbook* (USFWS and NOAA Fisheries 2016).[2] Biological goals are broad guiding principles based on the conservation needs of the resources. Biological objectives are expressed as conservation targets or desired conditions. Objectives are measurable and quantitative when possible; they clearly state a desired result that collectively will achieve the biological goals and that can be monitored over the permit term. In this HCP biological objectives are provided as a commitment to the number of acres and habitat quality for terrestrial species and for improvements to habitat quality for aquatic species. The success of the HCP will be measured against whether these objectives are met by the end of the permit term. Where appropriate, interim targets are provided in order for ODF, the USFWS, and NOAA Fisheries to ensure that the HCP is on track to meeting the objectives as stated, and, if not, that corrective measures can be taken by ODF during implementation.

The biological goals and objectives were developed collaboratively with the Scoping Team in a series of workshops. These goals and objectives were refined over time with stakeholder and public input and as the conservation actions supporting each objective were developed. Biological goals and objectives are provided in Table 4-1, followed by sections for each species or species group that provides the rationale for each biological objective. The biological goals and objectives are given unique numeric codes to enable easier tracking during implementation. For all of the covered fish, four biological objectives are grouped under a single goal because of the similarity in the fish species habitat needs. Subsequent tables detail specific population objectives where appropriate. The remaining covered wildlife species each have distinct biological goals and objectives.

Conservation actions designed to meet all biological objectives are found in Section 4.7. The contributions towards meeting the biological objectives will primarily come from areas defined as RCAs and HCAs (Attachment A), although lesser contributions will also come from the matrix

[2] The requirement for biological goals and objectives in HCPs was first published by USFWS and NOAA Fisheries in 2001 in what was then called the "5-Point Policy" (65 FR 35242).

outside of RCAs and HCAs, primarily from additional operationally limited areas and legacy component retention such as green trees, snags, and downed wood.

4.6.1 Definitions of Terms Used in Biological Goals and Objectives

The following terms are used in the biological goals and objectives and are defined below.

- **Persist:** To continue in existence.
- **Conserve:** To protect from harm and destruction.
- **Maintain:** Management, both active and passive, that enables favorable habitat conditions to continue at the current level of functionality.
- **Enhance:** Actions implemented in suitable habitat for a covered species that improve quality of certain habitat features.

Table 4-1. Biological Goals and Objectives for the Western Oregon State Forests Habitat Conservation Plan

Fish
Oregon Coast Coho, Oregon Coast Spring Chinook, Lower Columbia River Coho, Lower Columbia Chinook, Columbia River Chum, Upper Willamette River Steelhead, Upper Willamette River Chinook, Southern Oregon/Northern California Coast Coho, and Eulachon
Goal 1: Support the persistence and climate change resilience of Oregon Coast coho, Oregon Coast spring Chinook, Lower Columbia River coho, Lower Columbia Chinook, Columbia River chum, Upper Willamette River steelhead, Upper Willamette River Chinook, Southern Oregon/Northern California Coast coho, and eulachon in the permit area.
Objective 1.1: Conserve, maintain, and enhance riparian conditions that promote long-term wood recruitment in streams as measured by three sets of metrics: a) riparian forest structure, b) wood volume on potentially unstable slopes that have potential to deliver to fish-bearing streams, and c) long-term trends of instream large woody material (key pieces, size, frequency adequate to support the covered species). See Appendix E for specifics for each Evolutionary Significant Unit (ESU).
Objective 1.2: Conserve, maintain, and enhance overall stream channel complexity through targeted stream enhancement projects to address limiting factors for covered fish. See Appendix E for specifics for each ESU.
Objective 1.3: Maintain or enhance water quality and quantity conditions most important to covered fish as measured by current conditions and long-term trends in temperature, fine sediments in riffles, pool temperature and depth, and summer low-flow on ODF-managed lands. See Appendix E for specifics for each ESU.
Objective 1.4: Maintain or enhance fish passage to suitable spawning and rearing habitat by removing or modifying artificial barriers during the course of routine construction, emergency road repair, or maintenance work.
Amphibians
Columbia Torrent Salamander
Goal 2: Support the persistence of Columbia torrent salamanders in the Clatsop and Tillamook State Forests.
Objective 2.1: Conserve and maintain riparian habitat along 677 stream miles where Columbia torrent salamanders are likely to persist (high-gradient perennial streams with an adequate supply of downed wood, adequate water temperatures, and access to moist adjacent forests) through implementation of RCAs as shown in Table 4-3 and Table 4-4.
Cascade Torrent Salamander
Goal 3: Support the persistence of Cascade torrent salamanders in the Santiam State Forest.
Objective 3.1: Conserve and maintain riparian habitat along 76 stream miles where Cascade torrent salamanders are likely to persist (high-gradient perennial streams with an adequate supply of downed wood, adequate water temperatures, and access to moist adjacent forests) through implementation of RCAs as shown in Table 4-3 and Table 4-4.

Oregon Slender Salamander
Goal 4: Support the persistence of Oregon slender salamander in the Santiam State Forest.
Objective 4.1: Conserve, maintain, and enhance 16,000 acres of occupied habitat or suitable habitat for Oregon slender salamander and enhance 3,000 acres into suitable habitat during the permit term.
Objective 4.2: Maintain or enhance the abundance of large decayed downed wood in occupied or suitable but unsurveyed habitat to improve habitat quality in all HCAs within the range of Oregon slender salamander, including in locations subject to harvest to retain habitat value for Oregon slender salamander post-harvest.
Birds
Northern Spotted Owl
Goal 5: Support the persistence of northern spotted owl in the permit area.
Objective 5.1: Conserve, maintain, and enhance at least 15,000 acres of existing nesting and roosting habitat and 73,000 acres of foraging habitat.
Objective 5.2: Maintain at least 40% of the permit area outside of HCAs, measured by geography as described in Table 4-12, as dispersal habitat (nesting, roosting, foraging, or dispersal-only habitat) to allow diffuse movement across a permeable landscape.
Objective 5.3: Increase the quantity of nesting and roosting habitat by 69,000 acres, for a total of 84,000 acres by the end of the permit term, while maintaining 50,000 acres of foraging habitat. Total nesting, roosting, and foraging habitat at the end of the permit term shall be 134,000 acres.
Marbled Murrelet
Goal 6: Support the persistence of marbled murrelet in the permit area.
Objective 6.1: Conserve, maintain, and enhance at least 62,000 acres of existing suitable habitat and 1,000 acres of existing highly suitable habitat including locations where occupancy has been previously documented.
Objective 6.2: Increase the amount of habitat by at least 45,000 acres of suitable habitat and 34,000 acres of highly suitable habitat in locations that minimize patch edge : interior habitat ratios. This amounts to a total of 107,000 acres of suitable habitat and 35,000 acres of highly suitable habitat conserved by the end of the permit term.
Mammals
Red Tree Vole (North Oregon Coast Distinct Population Segment)
Goal 7: Support the persistence of red tree vole in the permit area.
Objective 7.1: Conserve, maintain, and enhance at least 48,000 acres of suitable habitat and 5,000 acres of highly suitable habitat, including areas where occupancy has been previously documented.
Objective 7.2: Increase the amount of suitable habitat by 30,000 acres and highly suitable habitat by 34,000 acres, for a total of 78,000 acres of suitable habitat and 39,000 acres of highly suitable habitat by the end of the permit term.
Coastal Marten
Goal 8: Support the persistence of coastal marten in the permit area.
Objective 8.1: Conserve, maintain, and enhance at least 27,000 acres of denning, foraging, and dispersal habitat (Appendix C).
Objective 8.2: Increase the quality of denning, resting, foraging, and dispersal habitat (Appendix C) within the 27,000 acres.

4.6.2 Goal 1: Support the Persistence of Covered Fish

Support the persistence and climate change resilience of Oregon Coast coho, Oregon Coast spring-run Chinook, Lower Columbia River coho, Lower Columbia Chinook, Columbia River chum, Upper Willamette River steelhead, Upper Willamette River Chinook, Southern Oregon/Northern California Coasts coho, Oregon Coastal spring Chinook, and eulachon in the permit area.

4.6.2.1 Objective 1.1: Wood Recruitment

Objective

Conserve, maintain, and enhance native riparian conditions that promote long-term wood recruitment in streams as measured by three sets of metrics: (a) riparian structure, (b) wood volume on potentially unstable slopes that have potential to deliver to fish-bearing streams, and (c) long-term trends of instream large woody material (key pieces, size, frequency adequate to support the covered species).

Rationale

Healthy riparian forests provide important stream functions such as large wood recruitment, shading, nutrient and energy inputs and moderation, bed and bank stability, and sediment filtration. Recruitment of large woody material has multiple ecosystem benefits for fish and other aquatic species. Its presence in stream systems forms pools for juvenile rearing, and it can create or enhance thermal and flow refugia for salmon to use as migratory or holding habitat. It promotes the habitat complexity required by juvenile and adult salmon for successful rearing and migration. In addition, large woody material increases ecosystem diversity across trophic levels, enhancing foraging opportunities for fish of all life stages (Thompson et al. 2018). Increased large woody material in permit area streams will benefit covered fish species, as well as other covered aquatic vertebrates.

A common issue in fish-bearing streams in western Oregon is a lack of instream wood. Reduced instream wood is the result of historical and widespread logging practices within the riparian zone around streams and rivers, as well as the long-standing practice of clearing debris and logjams from river channels (Bryant 1983). In addition, many watersheds in the permit area are naturally dynamic, with riparian areas subject to frequent disturbance events. In these watersheds, the natural development of large conifer trees is difficult to achieve. The resulting lack of instream large woody material is a limiting factor for covered species in many locations within the permit area (Appendix E). To remedy the scarcity of instream wood, riparian areas around streams will be managed to favor wood recruitment over time (Wooster and Hilton 2004). Specific measures will include riparian setbacks around streams and rivers, maintaining tree buffers along potentially unstable slopes, and providing deliberate large woody material inputs through targeted restoration projects (see Sections 4.7.1 and 4.7.2).

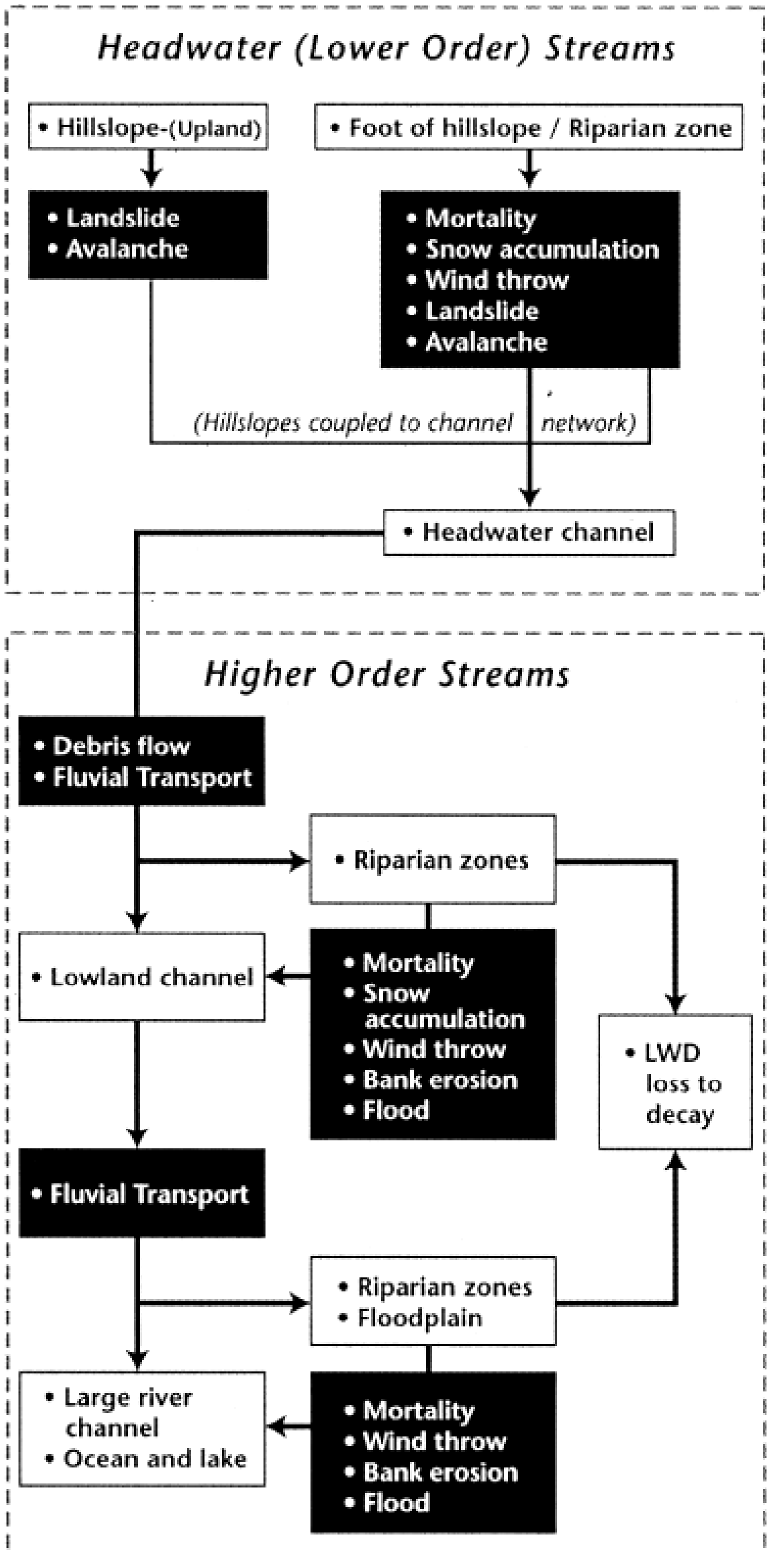
The mix of land ownership, land cover, and management regimes that overlap the covered fish species distribution (Appendix E) means that there is a dynamic mosaic of habitat conditions that continue to change over time. The permit area represents a small portion of the overall distribution of covered species (Appendix E). Within the permit area, the conservation, maintenance, and enhancement of RCAs[3] along fish- and non-fish-bearing streams during timber harvest will promote the development of larger coniferous trees. Large trees recruited from RCAs provide the most stable and key functional pieces of wood to streams (Montgomery et al. 1996, Wing and Skaugset 2002). Large conifer trees recruited from natural processes that retain their root and branch structure are more stable and persistent in stream environments and are associated with the creation and maintenance of important pool habitats (Rosenfeld and Huato 2003). All wood recruited from the RCAs plays a role in creation and maintenance of high quality, complex rearing habitats.

Landscape characteristics, such as riparian forest conditions, affect large wood recruitment and alter the habitat conditions of covered fish species (Beechie et al. 2000, Steele et al. 2003 as cited by Burnett et al. 2007). Per Spies et al. (2013), 95% of near-stream wood inputs come from the area between the streambank and 82 to 148 feet (horizontal distance) of the edge of the stream, with shorter input distances occurring in younger stands and longer distances in older, taller stands.

Headwater streams may comprise up to 80% of the overall length of a stream network. These headwater streams are important for collection and transport of material into higher-order downstream habitats that support the covered fish species (Bryant et al. 2007). Maintaining riparian forests on headwater streams allows channels to accumulate and store sediment and wood for future delivery to lower-gradient reaches of the river. In addition, actions performed in lower-order streams will benefit the covered amphibian species that use the habitat in and around these water bodies.

Figure 4-1 provides an overview of sources of a wood budget in a watershed. The open squares represent geomorphic areas related to the location for the sources and storages of wood, and filled squares represent the processes that affect wood transport. Landslides are a key component of wood delivery in large portions of the permit area; however, avalanche activity has not been noted.

[3] Riparian Conservation Areas are defined and described in Conservation Action 1: Establish Riparian Conservation Areas.



Source: Hassan et al. 2005

Figure 4-1. Flow Diagram for Wood Budget in a Watershed

4.6.2.2 Objective 1.2: Stream Enhancement Projects

Objective

Conserve, maintain, and enhance overall stream channel complexity through targeted stream enhancement projects to address limiting factors for covered fish.

Rationale

Stream complexity (e.g., presence of wood, pools, sinuosity, floodplain connection), which contributes to slow-moving water and sheltered conditions for juvenile rearing and overwinter habitat, is a limiting factor[4] for many of the covered fish species (NOAA Fisheries 2013, 2014; ODFW and NOAA Fisheries 2011). Stream enhancement projects, such as wood and boulder placement, can provide rapid improvements to physical habitat and fish production before conservation efforts detailed in Objective 1.1 enhance the underlying processes that deliver wood to streams in the permit area (Beechie et al. 2012).

The use of targeted enhancement projects to add large woody material to streams and rivers will provide structured channel morphology[5] and influence the formation of pools, sort sediments, and provide food and cover for covered aquatic species in much the same way that natural large woody material inputs do (Jones et al. 2014). The purposeful introduction of channel wood will help with pool development and sediment retention, provide cover and spawning habitat, potentially increase floodplain connection, and promote nutrient cycling. These stream enhancement projects will immediately improve local habitat conditions in the permit area, benefiting the covered species. However, in isolation such actions are unlikely to increase life history diversity or resilience of salmon populations (Beechie et al. 2012). Stream enhancement projects will be strategically located to efficiently provide the most comprehensive benefits to the covered species, such as in areas where species' intrinsic potential[6] is high or in proximity to previous projects. Riparian management actions, as described in Objective 1.1, will allow forests to become a long-term source of large woody material for the aquatic systems within and downstream of the permit area. Stream enhancement will be completed as described in Conservation Action 3: Stream Enhancement.

4.6.2.3 Objective 1.3: Water Quality and Quantity

Objective

Maintain or enhance water quality and quantity conditions most important to covered fish as measured by long-term trends in temperature, fine sediments in riffles, pool temperature and depth, and summer low-flows on ODF-managed lands.

Rationale

Stream ecosystems are dynamic and typically experience large fluctuations in water quality due to changing flow regimes (Armstrong and Schindler 2013). Protection of existing functional riparian systems and restoration of degraded systems can address water quality issues. Riparian areas

---

[4] Limiting factors are factors that constrain a population size and slows or stops a populations growth.

[5] Channel morphology influences river shape and directions.

[6] Intrinsic potential is the measure of a stream's capacity to provide high-quality habitat.

maintain ecological processes, such as regulating stream temperature, streamflow, cycling nutrients, providing organic matter, filtering chemicals and other pollutants, trapping and redistributing sediments, stabilizing stream channels and banks, absorbing and detaining floodwaters, maintaining fish habitats, and supporting the food web for a variety of biota (Buffler 2005).

Degraded water quality, especially elevated stream temperature (NOAA Fisheries 2013, 2014, ODFW and NOAA Fisheries 2011), is one of the primary threats to many of the covered fish species. Many of the covered fish species require cold water to maximize growth and survival of their younger stream dependent life stages. The restoration of riparian function, through the implementation of RCAs in the permit area, will help reduce stream temperature increases by maintaining and increasing shading (Beechie et al. 2012) and, subsequently, reducing thermal loading to permit area streams. This will benefit the covered species and provide longer-term climate change resilience.

In forested environments, sediment delivery is often increased through surface erosion on unpaved roads and disturbed riparian areas or landslides from roads or clearcuts (Beechie et al. 2012). A review of landslides in the permit area associated with the 1996 storm indicate the majority of landslides were not associated with roads; rather, they occurred in recent clearcuts (0 to 10 years after harvest) with steep slopes (over 70%). However, where road-associated landslides did occur, they were about four times larger in volume than non-road-associated slides (ODF 2017). The implementation of stand and road management conservation actions will reduce the risk of landslides and the associated effects of sedimentation in the permit area and benefit the covered fish species.

Forest roads, if not sited properly, can result in chronic inputs of sediment from all parts of the road prism that degrade water quality and affect the covered salmon and steelhead. Juvenile coho have been documented to avoid waters once turbidity reaches a level of 70 Nephelometric Turbidity Units (NTU; Boston 2016). The amount of sediment generated depends on the condition of the road, aggregate quality, maintenance practices, amount of exposed surfaces on the cut and fill slopes, soil texture, and climate as it influences type and intensity of precipitation events (Boston 2016). The review of roads in the permit area will identify those that are hydrologically connected and provide chronic inputs of sediment. These segments will be prioritized for improvement or vacating. In addition, construction of new roads will follow management measures, including requiring hydrologic disconnection and/or mitigation for roads that cannot be sited outside of RCAs, to reduce the potential for chronic sedimentation that could affect the covered salmon and steelhead.

Beechie et al. (2012) estimate that reduction in summer low-flows due to climate change will be greatest west of the Cascade Mountains, with monthly flow decreasing by 10% to 70% over the course of the twenty-first century. Forests have an effect on water yield through the interception of precipitation and transpiration by trees; in some forests, fog capture can be significant. Increased coarse sediment following logging can increase the effect of low flows by shallowing and widening stream channels (Hicks et al. 1991). Summer low-flows can negatively affect the covered salmon species by reducing the availability of rearing habitat in the permit area and increasing sensitivity to temperature changes. The implementation of conservation actions will limit sedimentation, benefiting the covered species by increasing habitat availability in the permit area. In addition, habitat restoration actions, such as the removal of nonnative plants, creation of deep pools, floodplain reconnection, and beaver enhancement could be used to improve summer low flows (Beechie et al. 2012).

Water quality and quantity will be protected through the designation and management of RCAs as described in Conservation Action 1: Establish Riparian Conservation Areas, Conservation Action 2: Riparian Equipment Restriction Zones, and Conservation Action 3: Stream Enhancement.

4.6.2.4 Objective 1.4: Fish Passage

Objective

Maintain or enhance fish passage to suitable spawning and rearing habitat by removing or modifying artificial barriers during the course of routine construction, emergency road repair, or maintenance work.

Rationale

The removal or modification of artificial barriers in the permit area will increase fish passage to upstream areas that could be used by salmonids for spawning and rearing and release gravels that have accumulated behind barriers to downstream locations. The access to additional, previously inaccessible habitat will increase the carrying capacity of the system, potentially increasing populations of covered fish. Barrier removal that increases longitudinal connectivity[7] and provides the covered species access to varied physical and thermal conditions can increase habitat diversity and allow expression of alternative life history strategies (Beechie et al. 2012). Increased fish passage will benefit the covered species as water warms during climate change by expanding available habitat, potentially increasing population resilience of the covered species (Beechie et al. 2012).

4.6.3 Goal 2: Support the Persistence of Columbia Torrent Salamander

The following objective is to support the persistence of Columbia torrent salamanders in the Clatsop and Tillamook State Forests.

4.6.3.1 Objective 2.1: Riparian Habitat within Species Range

Objective

Conserve and maintain riparian habitat along 677 stream miles where Columbia torrent salamanders are likely to persist (high-gradient perennial streams with an adequate supply of downed wood, adequate water temperatures, and access to moist adjacent forests) through implementation of RCAs as shown in Table 4-3 and Table 4-4.

Rationale

The Columbia torrent salamander is an aquatic, stream-adapted salamander that occurs in seeps, springs, small perennial high-gradient streams, and the margins of large streams with cold water (Hammerson 2004, Russell et al. 2004). Protecting such habitat that occurs in the permit area within the range of Columbia torrent salamander will support population persistence and provide room for

[7] Increase migratory pathways and restore natural streamflow, sediment, and organic matter transport (Beechie et al. 2012).

population expansion. In the permit area, lands in and around the Clatsop and Tillamook State Forests support populations of Columbia torrent salamander. Implementing RCAs as shown in Table 4-3 and Table 4-4 will maintain stream environments where torrent salamanders are likely to occur, ensuring that they persist on the landscape, even following implementation of covered activities.

Torrent salamanders are sensitive to forest practices in riparian areas that can degrade microhabitats though sediment deposition and elevated stream temperatures due to reduced stream shading (Vesely and McComb 2002, Russell et al. 2004). Due to the species' sedentary nature (Nussbaum and Tait 1977, Welsh and Lind 1996, Nijhius and Kaplan 1998) and limited dispersal capabilities, the torrent salamander exhibits limited movement and has small home ranges (Nussbaum et al. 1983). Retaining RCAs on perennial streams and seasonal streams immediately upstream from perennial streams allows for seasonal movements of salamanders within the riparian corridor.

In logged environments, riparian forests that are 20 meters (65.6 feet [slope distance]) wide have been found to contain approximately 80% of detectable torrent salamanders, with frequency of detection highest from 0–10 meters (0–33 feet) (Vesely and McComb 2002). Within the permit area, maintaining riparian forests in perennial, high-gradient streams close to the initiation of perenniality will help minimize the impacts of timber harvest on torrent salamanders (Steele et al. 2003, Howell and Maggiulli 2011). On seasonal streams that do not otherwise have a treed buffer, grouping leave trees around the junction of seasonal streams and perennial streams during timber harvest will retain locations where torrent salamanders are most likely to occur, even following harvest. This would not occur on every junction of this nature, but would occur as part of the normal variation of upland leave tree practices and be more prevalent within HCAs. HCAs within the torrent salamander range also provide upland dispersal habitat when they are connected to RCAs.

4.6.4 Goal 3: Support the Persistence of Cascade Torrent Salamander

The following objective is to support the persistence of Cascade torrent salamanders in the Santiam State Forest.

4.6.4.1 Objective 3.1: Riparian Habitat within Species Range

Objective

Conserve and maintain riparian habitat along 76 stream miles where Cascade torrent salamanders are likely to persist (high-gradient perennial streams with an adequate supply of downed wood, adequate water temperatures, and access to moist adjacent forests) through implementation of RCAs as shown in Table 4-3 and Table 4-4.

Rationale

As with the Columbia torrent salamander, the Cascade torrent salamander is a stream-dwelling amphibian that can be found along the edges of high-gradient, cold, rocky reaches and near seeps. Adults may also be found along streambanks, and during wet periods they may venture into upland areas (Howell and Maggiulli 2011). Protecting such habitat that occurs in the permit area within the range of Cascade torrent salamander will support population persistence and provide room for population expansion. In the permit area, lands in and around the Santiam State Forest are known to support populations of Cascade torrent salamander.

As described under Objective 2.1, torrent salamanders are sensitive to forest practices in riparian areas. In logged environments, riparian forests that are 20 meters (65.6 feet [slope distance]) wide have been found to contain approximately 80% of detectable torrent salamanders, with frequency of detection highest from 0 to 10 meters (0 to 33 feet) (Vesely and McComb 2002). The maintenance of riparian forests in perennial, high-gradient streams close to the stream origin in the permit area will help minimize the impacts of timber harvest on torrent salamanders (Steele et al. 2003, Howell and Maggiulli 2011).

4.6.5 Goal 4: Support the Persistence of Oregon Slender Salamander

The following objectives will support the persistence of Oregon slender salamander in the Santiam State Forest.

4.6.5.1 Objective 4.1: Existing Oregon Slender Salamander Habitat

Objective

Within HCAs, conserve, maintain, and enhance 16,000 acres of suitable habitat for Oregon slender salamander and enhance 3,000 acres into suitable habitat during the permit term.

Rationale

Due to the restricted distribution and limited dispersal capabilities of Oregon slender salamander (Clayton and Olson 2009, Garcia et al. 2020), it is important to conserve occupied habitat, or habitat that is likely to be occupied, to provide for population persistence. Contiguous suitable habitat will promote dispersal and reduce genetic isolation in a fragmented landscape. While larger HCAs will provide significant blocks of habitat, smaller HCAs distributed across the permit area can serve as refugia in more intensively managed landscapes.

4.6.5.2 Objective 4.2: Downed Wood

Objective

Maintain or enhance the abundance of large decayed downed wood in occupied or suitable Oregon slender salamander habitat.

Rationale

Retaining and creating downed wood of appropriate size and decay classes is necessary to ensure appropriate microhabitat conditions are present for Oregon slender salamander (Clayton and Olson 2009, Garcia et al. 2020). Leaving this substrate post-harvest will allow for the Oregon slender salamander to persist through harvest and ameliorates the disturbance effects on the species, thereby supporting the occurrence or abundance of the species. Management within HCAs will provide the greatest opportunity for the development of large downed wood within older stands. ODF will also implement silvicultural actions outside of HCAs, such as green tree and snag retention, to enhance growth of trees to ensure a supply of future large woody material. Conservation Action 8: Conservation Actions Outside Habitat Conservation Areas and Riparian Conservation Areas, describes downed wood retention standards in the permit area. During regeneration harvest, existing downed wood and snags that are not a safety hazard will be retained. In addition, 600 to 900 cubic feet of hard conifer logs (decay class 1 and 2) per acre in each harvest unit outside RCAs will be retained, including at least an average of two logs per acre greater than 20 inches in diameter (at the largest end), where available. Where this is not available, ODF will leave as many 20-inch-diameter logs as possible and consider additional green tree or snag retention for future natural downed wood recruitment. In addition, ODF will retain other nonmerchantable coarse woody debris on site; minimize the use of broadcast or pile burning to that needed to meet site productivity, reforestation, and fuels reductions goals; and retain wood piles for habitat values. Within the range of Oregon slender salamander ODF will ensure that downed wood left in harvest units has a trunk that is in contact with the ground to promote decay to better provide Oregon slender salamander habitat.

4.6.6 Goal 5: Support the Persistence of Northern Spotted Owl

The following objectives will support the persistence of northern spotted owl in the permit area and increase habitat quality and quantity over time.

4.6.6.1 Objective 5.1: Existing Northern Spotted Owl Habitat

Objective

Within HCAs, conserve and maintain at least 15,000 acres of existing nesting and roosting habitat and conserve, maintain, and enhance at least 73,000 acres of foraging habitat (note that nesting, roosting, and foraging habitat also functions as dispersal habitat).

Rationale

Conserving existing pair and resident sites and associated habitat is the most effective method to avoid further declines in northern spotted owl populations (USFWS 2011). Northern spotted owl was listed under the ESA in 1990 (USFWS 1990) because of widespread habitat loss across the range of the species. Past habitat and current habitat loss and increasing barred owl populations continue to threaten the spotted owl, and populations of spotted owl have continued to decline (Davis et al. 2016, Lesmeister et al. 2018).

Within the permit area, late-seral habitat used by spotted owls for nesting is limited in many areas due to past natural and anthropogenic disturbances (Chapter 2). Because of this, retaining existing habitat is essential to supporting the persistence of northern spotted owls. Moving north from the southern end of the Tillamook State Forest there is less federal land to provide habitat for demographic or dispersal support for northern spotted owls, making the conservation, maintenance, and enhancement of spotted owl habitat in the Tillamook and Clatsop State Forests particularly important (USFWS 2011).

Protecting northern spotted owl habitat in the permit area will help sustain survival and reproduction of northern spotted owls in currently occupied habitat, support and potentially improve persistent low densities in the northern Coast Ranges, and retain sufficient unoccupied habitat to accommodate potential future recolonization. Additionally, conserving, maintaining, and enhancing existing habitat will help offset threats from loss or alteration of habitat from stand-replacing fire, loss of genetic diversity, and climate change (USFWS 2011, Forsman et al. 2011).

4.6.6.2 Objective 5.2: Northern Spotted Owl Dispersal Habitat

Objective

Maintain at least 40% of the permit area outside of HCAs as dispersal habitat, as defined and quantified in Conservation Action 8, to allow diffuse movement across a permeable landscape.

Rationale

Maintaining sufficient dispersal habitat at the landscape level is vital to sustaining populations of northern spotted owl by allowing juveniles to disperse to temporary or permanent territories (Davis et al. 2016). Juvenile spotted owls disperse within their first year of leaving the nest. While northern spotted owls can disperse through highly fragmented forest landscapes, highly fragmented forest can reduce survival (Forsman et al. 2002). For example, dispersing birds are exposed to higher risk of predation (Forsman et al. 2002). The quality and distribution of dispersal habitat within a forested matrix can help reduce predation risk. The conservation strategy will reduce those risks by providing “dispersal-capable” lands across the permit area.

Dispersal habitat may also support movement of adult owls between suitable foraging habitat and inter-territory movement by adult spotted owls in response to the colonization of barred owls (Dugger et al. 2011, Olson et al. 2004).

HCAs are expected to develop significant amounts of nesting, roosting, and foraging habitat over the permit term. Area within HCAs that do not have all the components of nesting, roosting, and foraging habitat are still expected to develop into stands that will support dispersal. Outside of HCAs, dispersal-capable landscapes that support northern spotted owl movement will be maintained by maintaining at least 40% of the area outside of HCAs in stands having at least 11 inches DBH and 40% canopy cover. This includes areas of older trees that cannot be harvested for operational reasons, RCAs outside of HCAs, and retention standards outlined in Conservation Action 8 that emphasize leaving the oldest or largest legacy components during harvest (i.e., green trees, snags, and downed wood), thus enhancing the general functionality of the landscape as dispersal habitat.

4.6.6.3 Objective 5.3: Northern Spotted Owl Habitat Enhancement

Objective

Within HCAs, increase the quantity of nesting and roosting habitat by 69,000 acres, for a total of 84,000 acres by the end of the permit term, while maintaining 50,000 acres of foraging habitat. Total nesting, roosting, and foraging habitat at the end of the permit term shall be 134,000 acres.

Rationale

The 2011 recovery plan (USFWS 2011) encourages active management actions that restore, enhance, and promote development of high-value habitat, which, for this HCP, includes nesting, roosting, and foraging habitat. Habitat for late-seral species—including northern spotted owls—can be increased through both passive management (i.e., allowing the stand to develop over time naturally) or through active management, including "ecological forestry," which primarily involves partial cutting prescriptions that encourage the growth of larger trees while maintaining key habitat components to reduce short-term negative impacts (Kuehne et al. 2015). Specific standards for silvicultural activities to enhance northern spotted owl habitat are described under Conservation Action 6: Establish Habitat Conservation Areas.

Therefore, in addition to conserving known nesting, roosting, and foraging habitat as described in Objective 5.1, ODF will increase the amount of nesting, roosting, and foraging habitat that is available over the permit term. The areas that will be managed to enhance development and maintenance of northern spotted owl habitat will primarily be adjacent to existing habitat or in locations where northern spotted owls once persisted but have not been detected recently. This expansion of available habitat will be necessary to achieve Goal 5.

Growth of large trees and the development of snags, multilayered canopies, and other key elements of forest structure takes decades, particularly in stands that have little residual legacy structure and that lack large trees (Lindenmayer and Franklin 2002, Dodson et al. 2012), which is the case over much of the permit area. In addition, some stands may require multiple treatments over time. Therefore, this objective is intended to provide benefits during the middle to later periods of the permit term.

Improving the quality of existing northern spotted owl habitat will expand the availability of suitable habitat for the species and provide support for reducing key threats faced by northern spotted owls. This net increase in owl habitat is intended to result in a potentially wider and less-fragmented distribution of the species' habitat across the permit area and foster productivity on the North Coast.

Total habitat present within the permit area is projected to vary over time, with a long-term trend of increased stand age and structure within HCAs and a corresponding shift of habitat value from foraging to nesting and roosting. Figure 4-2 shows the total commitment acres of northern spotted owl nesting, roosting, and foraging habitat within HCAs under the HCP over the permit term, by decade. As also shown in Figure 4-2 and as described in Chapter 5, actual habitat quantities are expected to be higher, but the commitment quantities are the minimum amount to be maintained under the terms of the HCP, allowing for contingencies that may occur over time, including fire and wind disturbance or altered growth regimes due to drought. Commitments to conserve, maintain, and enhance acres of covered species habitat are based on the assumption that at least 50% of nesting and roosting habitat and 80% of foraging habitat modeled to grow within HCAs over the 70-year permit term can be achieved.

Within HCAs, projected habitat acres beyond the committed acres are not considered excess acres that could be subject to more flexible, intensive, or revenue-driven management. ODF's intent is to attain as much habitat as possible in HCAs, and management activities will be planned accordingly. As described under Conservation Action 7: Manage Habitat Conservation Areas, HCA standards will direct land-management activities in HCAs to improve long-term habitat values for covered species in HCAs while minimizing impacts in the short term.

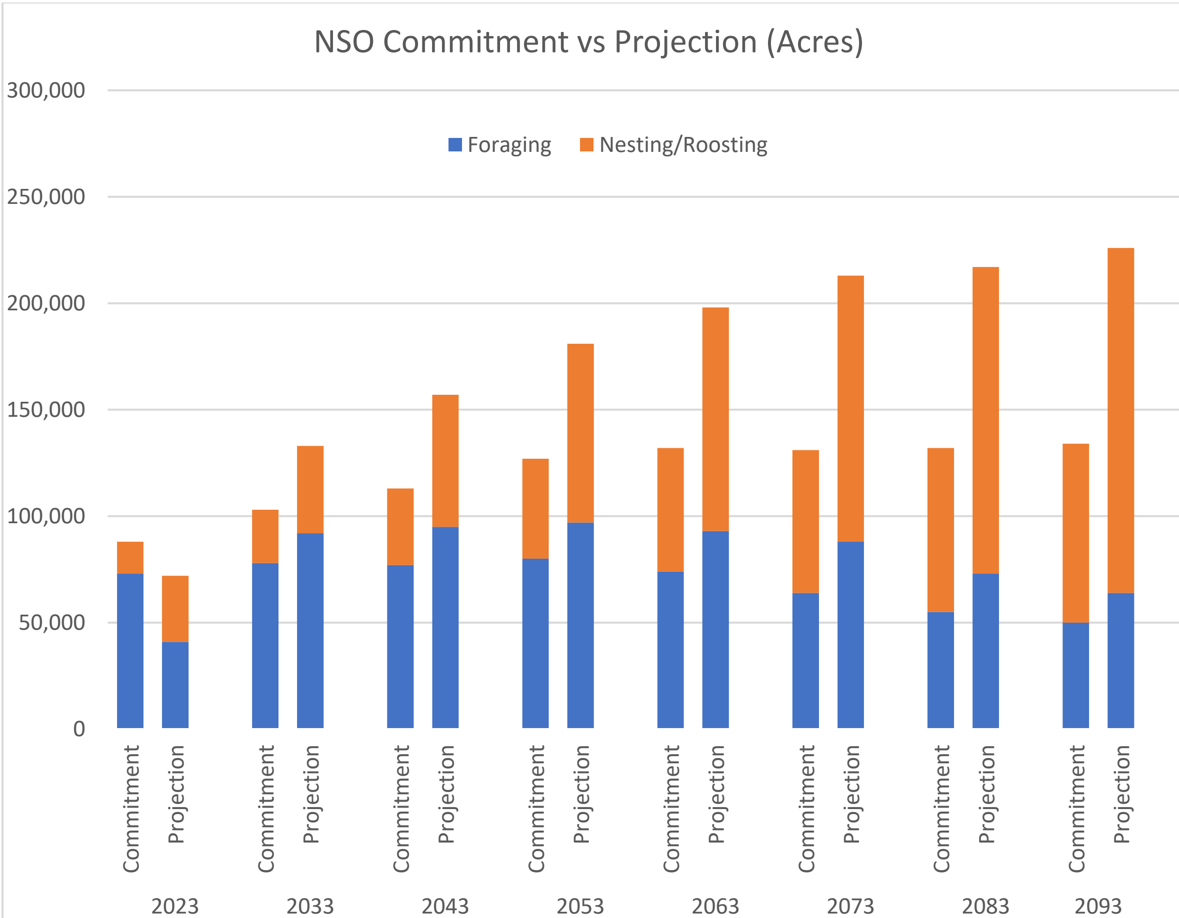


Figure 4-2. Acres of Northern Spotted Owl Habitat Commitments and Projected Habitat within HCAs, by Decade

4.6.7 Goal 6: Support the Persistence of Marbled Murrelet

Support the persistence of marbled murrelet in the permit area and an increase in quality and quantity of habitat over time.

4.6.7.1 Objective 6.1: Existing Marbled Murrelet Nesting Habitat

Objective

Within HCAs, conserve, maintain, and enhance at least 62,000 acres of existing suitable habitat and 1,000 acres of existing highly suitable habitat including locations where occupancy has been previously documented.

Rationale

Conserving existing occupied habitat is the most effective method to avoid further declines in marbled murrelet populations (USFWS 1997). As with the northern spotted owl, the marbled murrelet was listed as threatened due to widespread habitat loss (Betts et al. 2020). Past disturbance within the permit area has limited marbled murrelet nesting habitat and distribution.

Conserving, maintaining, and enhancing existing marbled murrelet nesting habitat within the permit area may help support or increase populations. Marbled murrelets are cryptic and elusive, often nesting high in the canopy where they are difficult to locate. As a result, forest stands where observations of murrelets suggest potential nesting (i.e., occupied stands) are protected and may encompass some actual nest locations or patches of likely nesting habitat.

Conservation of existing nesting habitat will provide particular conservation benefits in the Tillamook and Clatsop State Forests, which support small clusters of marbled murrelet nesting sites believed to be important to maintaining marbled murrelets in the northwest Oregon Coast (USFWS 1997). In other parts of the permit area, focusing conservation efforts on existing nesting habitat and on state forest lands that are adjacent to protected federal nesting habitat will support recovery efforts under the *Northwest Forest Plan* (USDA and USDI 1994) and BLM's *Western Oregon Resource Management Plans (*BLM 2016a, 2016b).

In addition, much of the remaining marbled murrelet nesting habitat occurs in relatively small patches, resulting in increased risks to marbled murrelet chicks and eggs being lost to predation (Weikel 2019). When HCAs were created consideration was given to include existing buffers around designated occupied habitat, or to include lower quality habitat areas adjacent to designated occupied habitat to provide a buffer against forest edge. Buffers reduce/minimize edge effects (i.e., windthrow, reduced development of epiphytes, and forest conditions that attract predators). They also increase interior habitat area, which can reduce predation risk. Thus, buffers maintain or enhance habitat quality and may improve nest success over time.

4.6.7.2 Objective 6.2: Marbled Murrelet Nesting Habitat Enhancement

Objective

Within HCAs, increase the amount of habitat by at least 45,000 acres of suitable habitat and 34,000 acres of highly suitable habitat in locations that minimize patch edge : interior habitat ratios. This amounts to a total of 107,000 acres of suitable habitat and 35,000 acres of highly suitable habitat conserved by the end of the permit term.

Rationale

Marbled murrelets nesting near "hard edges" created by clearcuts are vulnerable to increased risk of windthrow, potential degradation of microclimate, and nest predation by corvids and other edge-associated predators (Raphael et al. 2018;; Malt and Lank 2007, 2009). In addition, edges can create microclimates that limit development of the moss-covered branches used by nesting murrelets (Van Rooyen et al. 2011).

Under this objective, conservation actions will maintain and enhance quality and quantity of habitat adjacent to designated occupied nesting habitat within HCAs. This will increase the distance between nest sites and hard edges, which is expected to reduce predation risk and encourage the development of moss and associated nesting platforms. HCAs that support marbled murrelets were designed to support sufficient interior habitat area to reduce predation risks associated with fragmentation and hard edges and increase nest site productivity over time.

The intention of this objective is to expand marbled murrelet habitat over time through management actions that accelerate development of late-seral forest characteristics and, in particular, nest platforms and associated cover (Nelson and Wilson 2002). Management will be strategically focused in areas where the habitat suitability model predicts that habitat is likely to develop in the future, and actions will be aimed at developing that habitat faster. Designated occupied habitat or habitat that is current modeled as highly suitable will not be managed (see Conservation Action 7: Manage Habitat Conservation Areas). Light thinning will occur in buffers adjacent to designated occupied and highly suitable habitat. Management in these areas focuses on enhancing buffer function around designated occupied habitat or otherwise highly suitable habitat to increase habitat quantity and enhance functionality of existing habitat by reducing edge effects through the creation of larger blocks of suitable nesting habitat. Other stands will be managed consistent with provisions described in Conservation Action 7.

Total habitat present within the permit area is projected to vary over time, with a long-term trend of increased stand age and structure within HCAs and a corresponding shift of habitat value from suitable to highly suitable. Figure 4-3 shows the total commitment acres of marbled murrelet nesting habitat within HCAs under the HCP over the permit term, by decade. Also shown in Figure 4-3, and as described in Chapter 5, actual habitat quantities are expected to be higher, but the commitment quantities are the minimum amount to be maintained under the terms of the HCP, allowing for contingencies that may occur over time, including fire and wind disturbance or altered growth regimes due to drought. Commitments to conserve, maintain, and enhance acres of covered species habitat are based on the assumption that at least 50% of highly suitable habitat and 80% of suitable habitat modeled to grow within HCAs over the 70-year permit term can be achieved.

Within HCAs, projected habitat acres beyond the committed acres are not considered excess acres that could be subject to more flexible, intensive, or revenue-driven management. ODF's intent is to attain as much habitat as possible in HCAs, and management activities will be planned accordingly. As described under Conservation Action 7: Manage Habitat Conservation Areas, HCA standards will direct land-management activities in HCAs to improve long-term habitat values for covered species in HCAs while minimizing impacts in the short term.

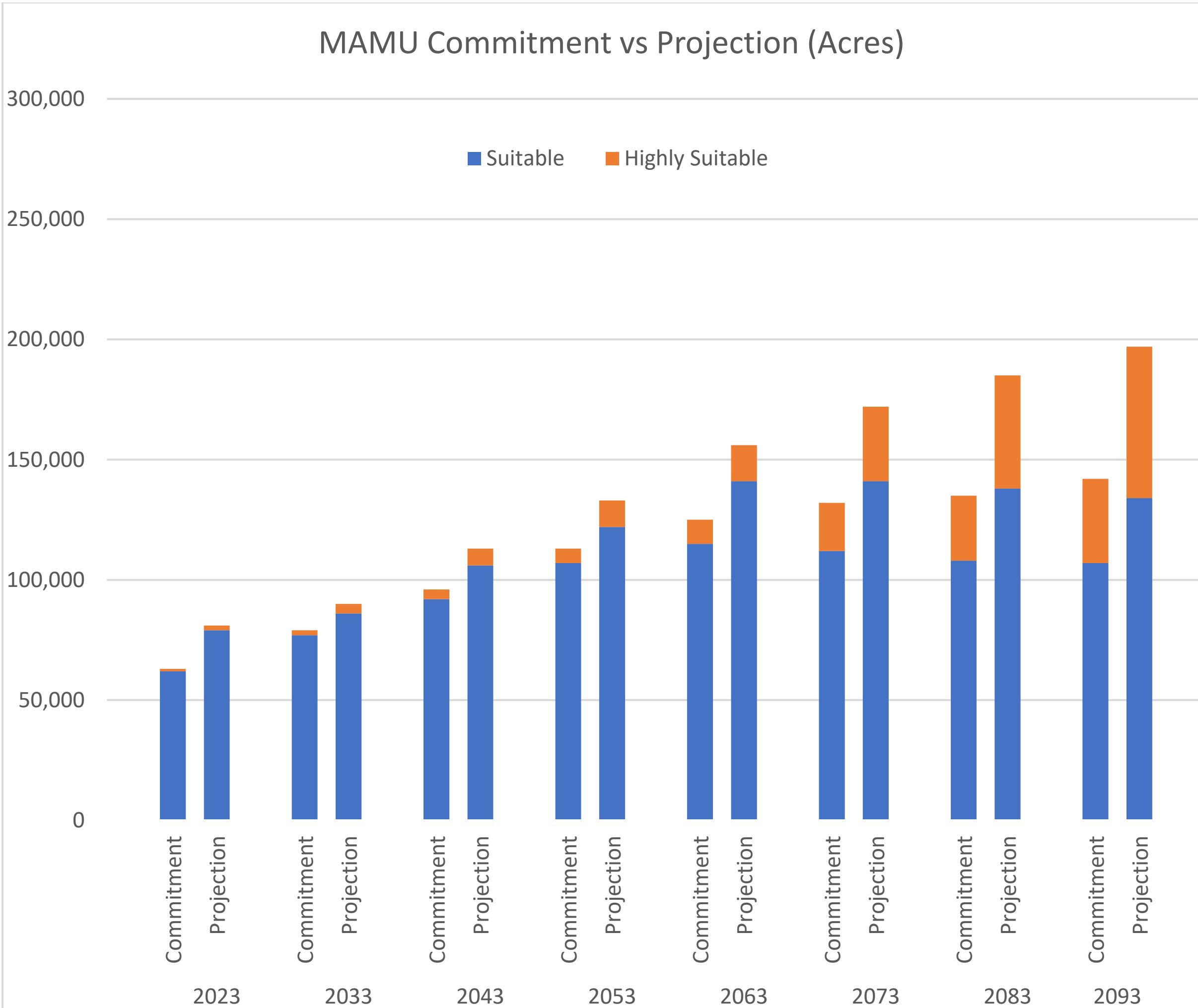


Figure 4-3. Acres of Marbled Murrelet Habitat Commitments and Projected Habitat Within HCAs, by Decade

4.6.8 Goal 7: Support the Persistence of Red Tree Vole

Support the persistence of red tree vole (North Oregon Coast Distinct Population Segment [DPS]) in the permit area and increase the quality and quantity of habitat over time.

4.6.8.1 Objective 7.1: Occupied Red Tree Vole Habitat

Objective

Within HCAs, conserve, maintain, and enhance at least 48,000 acres of suitable habitat and 5,000 acres of highly suitable habitat, including areas where occupancy has been previously documented.

Rationale

Conserving stands where red tree voles have been documented is a key first step in supporting the persistence of red tree voles within the permit area. Red tree voles occur at low densities distributed irregularly across landscapes of suitable habitat (Rosenberg et al. 2016). Although population size estimates are not available to estimate trends, data and anecdotal information strongly suggest that current North Oregon Coast red tree vole DPS populations are considerably lower than historical numbers (USFWS 2019). Therefore, conserving the few occupied sites confirmed within the permit area is a priority to be implemented in the HCP.

Most ODF lands in the range of the North Oregon Coast DPS have not been surveyed. In addition, determining red tree vole occupancy of a given forest is time-consuming, and detection rates are extremely low (Rosenberg et al. 2016, Marks-Fife 2016). If conservation is limited to occupied habitat identified by species presence at a given point of time, suitable habitat of unknown occupancy may be removed or modified, further contributing to population declines or inhibiting future recovery (Camaclang et al. 2015). Therefore, conservation of unsurveyed or unoccupied suitable habitat is important for supporting the persistence of red tree voles within the permit area.

4.6.8.2 Objective 7.2: Red Tree Vole Habitat Enhancement

Within HCAs, increase the amount of suitable habitat by 30,000 acres and highly suitable habitat by 34,000 acres, for a total of 78,000 acres of suitable habitat and 39,000 acres of highly suitable habitat by the end of the permit term.

Rationale

Red tree voles are associated with large blocks of late-seral conifer forests (Martin and McComb 2002, USFWS 2011). They also have very poor dispersal capabilities and are sensitive to habitat fragmentation. The probability of red tree vole occurrence in a given forest patch decreases with distance to suitable habitat (Rosenberg et al. 2016, Linnell et al. 2017). Increasing the number and size of patches of late-seral interior forest habitat between and adjacent to occupied habitat will reduce dispersal distances between late-seral forest patches, facilitate dispersal, and encourage colonization of unoccupied suitable habitat (Linnell et al. 2017). Enhancement of red tree vole habitat would be limited to using silvicultural actions to develop larger trees with more habitat structure over time, including an overall increase in canopy connectivity within the range of the species. Many of these benefits will be realized from the silvicultural prescriptions implemented for northern spotted owls and marbled murrelets.

As described later under Conservation Action 7, enhancement of red tree vole habitat will be limited to using silvicultural actions to develop larger trees with more habitat structure over time, including an overall increase in canopy connectivity within the range of the species. Habitat enhancement activities in HCAs where the permit area is adjacent to mature habitat on federal lands will provide additional habitat in areas where red tree voles are known or likely to exist, expanding local populations and associated resilience and long-term persistence of the species.

Total habitat present within the permit area is projected to vary over time, with a long-term trend of increased stand age and structure within HCAs and a corresponding shift of habitat value from suitable to highly suitable. Figure 4-4 shows the total commitment acres of red tree vole habitat within HCAs under the HCP over the permit term, by decade. As also shown in Figure 4-4 and as described in Chapter 5, actual habitat quantities are expected to be higher, but the commitment quantities are the minimum amount to be maintained under the terms of the HCP, allowing for contingencies that may occur over time, including fire and wind disturbance or altered growth regimes due to drought. Commitments to conserve, maintain, and enhance acres of covered species habitat are based on the assumption that at least 50% of nesting and roosting habitat and 80% of foraging habitat modeled to grow within HCAs over the 70-year permit term can be achieved.

Within HCAs, projected habitat acres beyond the committed acres are not considered excess acres that could be subject to more flexible, intensive, or revenue-driven management. ODF's intent is to attain as much habitat as possible in HCAs, and management activities will be planned accordingly. As described under Conservation Action 7: Manage Habitat Conservation Areas, HCA standards will direct land-management activities in HCAs to improve long-term habitat values for covered species in HCAs while minimizing impacts in the short term.

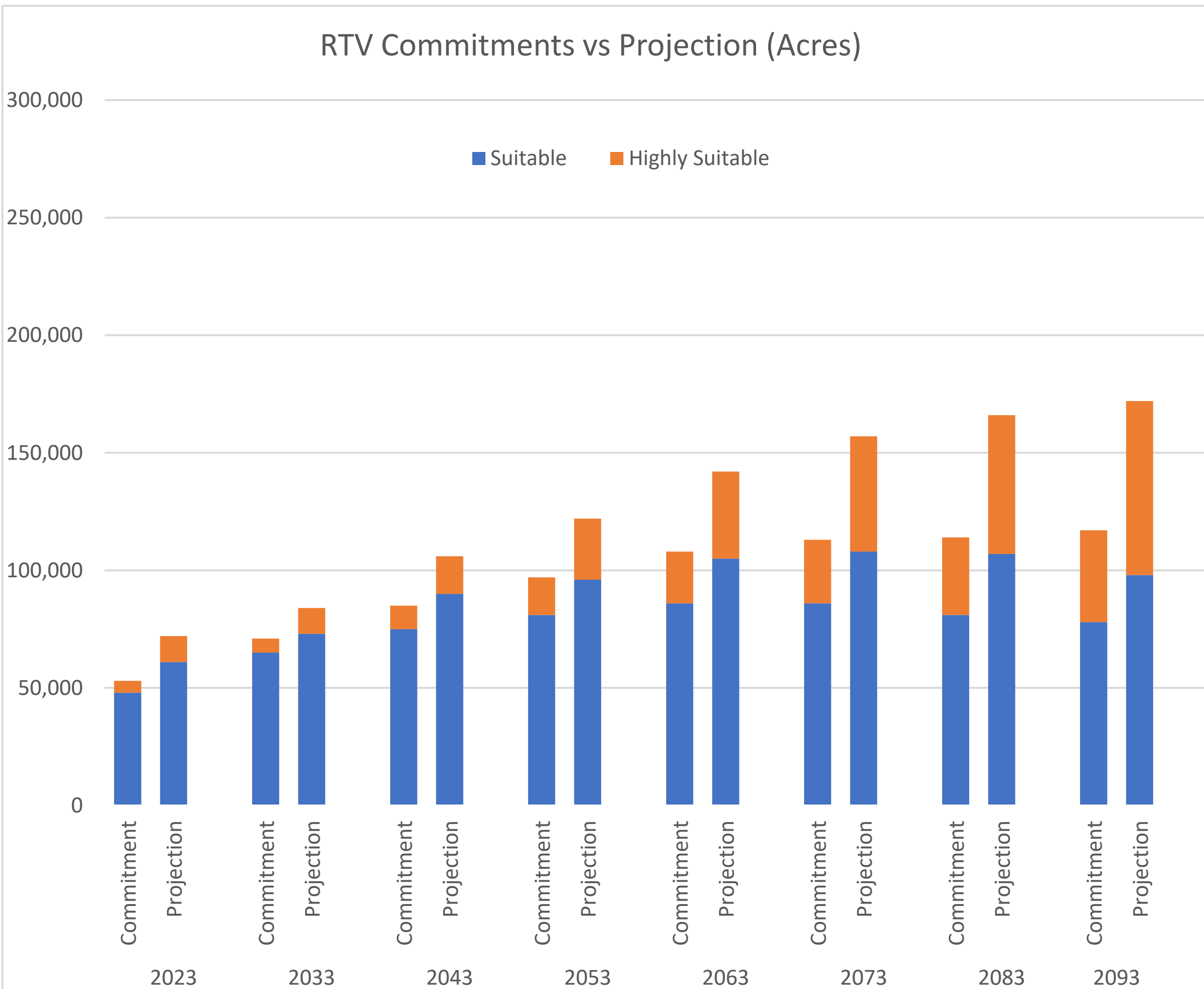


Figure 4-4. Acres of Red Tree Vole Habitat Commitments and Projected Habitat Within HCAs, by Decade

4.6.9 Goal 8: Support the Persistence of Coastal Marten

Support the persistence of coastal marten in the permit area and an increase in the quality and quantity of habitat over time.

4.6.9.1 Objective 8.1: Existing Coastal Marten Habitat

Objective

Within HCAs, conserve, maintain, and enhance at least 27,000 acres of denning, foraging, and dispersal habitat.

Rationale

Coastal marten exist in three isolated populations: north coastal California, southern coastal Oregon, and central coastal Oregon (Linnell et al. 2018, Moriarty et al. 2019). The Southern Coastal Oregon Extant Population Area delineated by Slauson et al. (2019)overlaps with ODF lands in Curry and Josephine Counties. Vegetation in this area is composed of mixed conifer forest (i.e., dominated by Sitka spruce, western hemlock, and Douglas-fir) interspersed with unique plant communities adapted to serpentine soils, including forests of widely spaced pines (*Pinus* spp.) with an understory of grasses and more mesic areas with dense and diverse shrub layer including tan oak (*Notholithocarpus densiflorus*) and huckleberries (*Vaccinium* spp.) (Moriarty et al. 2019). The Central Coastal Oregon Extant Population Area is near the permit area in Coos and Douglas Counties (USFWS 2018). Coastal martens in the central coastal Oregon population occupy shore pine and transitional shore pine/Douglas–fir–hemlock forests dominated by young stands of shore pine and young Sitka spruce. The understory is dominated by willow (*Salix* spp.) and ericaceous shrubs such as evergreen huckleberry and salal (Moriarty et al, 2016, USFWS 2018).

Moriarty et al. (2019) found martens using young forests with interconnected, dense patches of shrubs. Based on this finding, it is assumed that timber harvest practices that do not dramatically alter the dominant overstory cover (combination of both overstory and understory cover of at least 65%) while encouraging dense shrub growth, particularly salal (*Gaultheria shallon)* and evergreen huckleberry (*V. ovatum*), and retain or increase large woody material will benefit coastal marten populations. Moriarty et al. (2019) also found both spotted owls and martens in areas with many large and tall trees and suggest that retention and recruitment of large structures will benefit both species. Conservation of coastal marten habitat on ODF lands will therefore focus on identifying stands that currently provide, or could be enhanced to provide, these conditions.

4.6.9.2 Objective 8.2: Coastal Marten Habitat Enhancement

Objective

Within HCAs, increase the quality of denning, resting, foraging, and dispersal habitat within 27,000 acres over the permit term.

Rationale

The viability of coastal marten depends on maintaining the three existing isolated populations and potentially establishing new populations to restore connectivity between populations (Slauson et al. 2019). Current and projected future resiliency of the Southern Coastal Oregon Extant Population Area that overlaps the permit area is considered low because of small population size (less than 100 individuals), limited connectivity to the California–Oregon border population, and limited habitat for predatory avoidance (USFWS 2018). The Central Coastal Oregon Extant Population Area has limited overlap with the permit area. This population consists of a limited number of adults (71 individuals across two subpopulations) that are at an extinction risk in the next 30 years (Linnell et al. 2018). In all cases enhancement of habitat within the range of the species will provide higher quality habitat with the intent to stabilize existing populations and improve population trends. Silvicultural prescriptions will be used that promote the development of robust, diverse shrub-dominated understories that provide extensive, tall, dense cover (particularly where ericaceous shrubs are present). Increased stratification of canopy layering and midstory development will also be favored. Management activities in HCAs that occur in the range of coastal marten will be a combination of thinning, regeneration, and retention harvest that will open up areas to promote shrub growth both inside and outside HCAs. In areas where retention harvests are used, inside HCAs, they will be reforested using methods that support maintenance of a low shrub layer that will retain and promote marten denning structures.

4.7 Conservation Actions for Covered Species

This section describes the conservation actions that ODF will implement to achieve the biological goals and objectives described in Section 4.6, and to minimize and mitigate the impacts of covered activities on the covered species (Chapter 5). Most conservation actions are intended to benefit multiple species, including aquatic and terrestrial species.

The conservation actions to be implemented under the HCP fall into four general groups.

- Conservation Actions 1 through 5 and 12 target measures that ODF will implement to protect and enhance aquatic systems to primarily benefit covered fish and aquatic amphibians.
- Conservation Actions 6 through 9 are focused on the preservation and enhancement of the terrestrial environment to primarily benefit the covered birds, terrestrial amphibians, and mammals.
- Conservation Actions 10 and 11 address the minimization measures that ODF will implement throughout the permit area to minimize effects from timber harvest and road construction and maintenance on covered species.

Each conservation action will help to achieve more than one biological objective. The expected relationship of how conservation actions will achieve the aquatic biological goals and objectives is shown in Figure 4-5. The relationship of conservation actions and terrestrial biological goals and objectives is shown in Figure 4-6. A summary of relationships between biological goals and objectives and conservation actions is provided in Table 4-2. Note that objectives are generalized; see Table 4-1for species-specific goals and objectives.

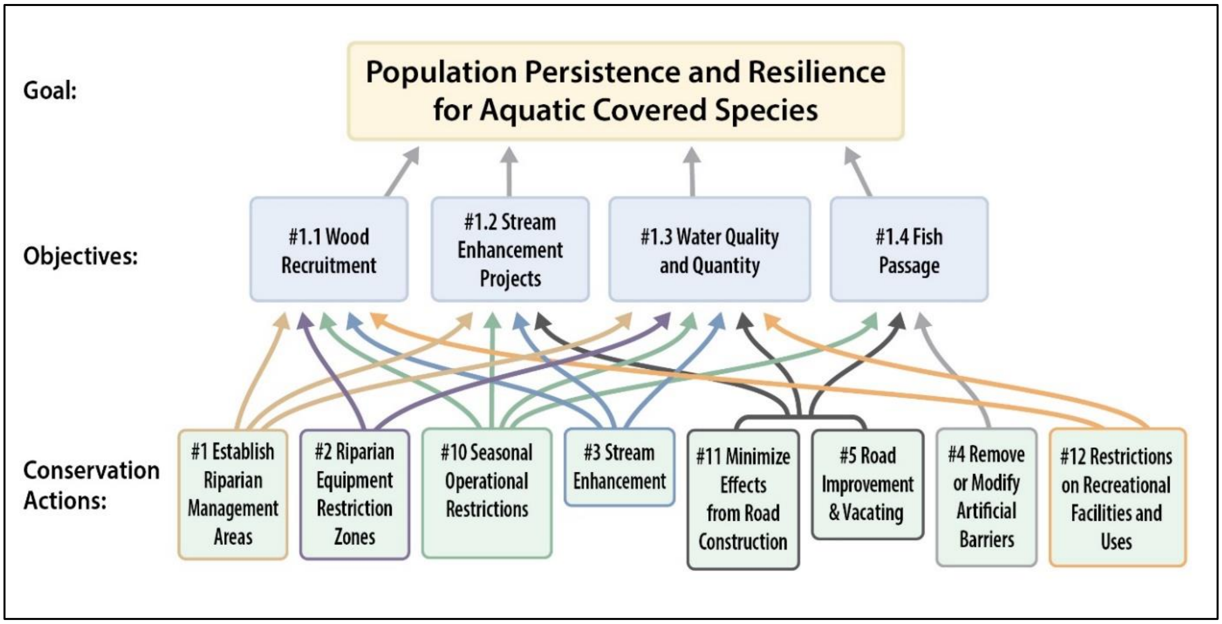


Figure 4-5. Aquatic Biological Goals and Objectives and Their Associated Conservation Actions

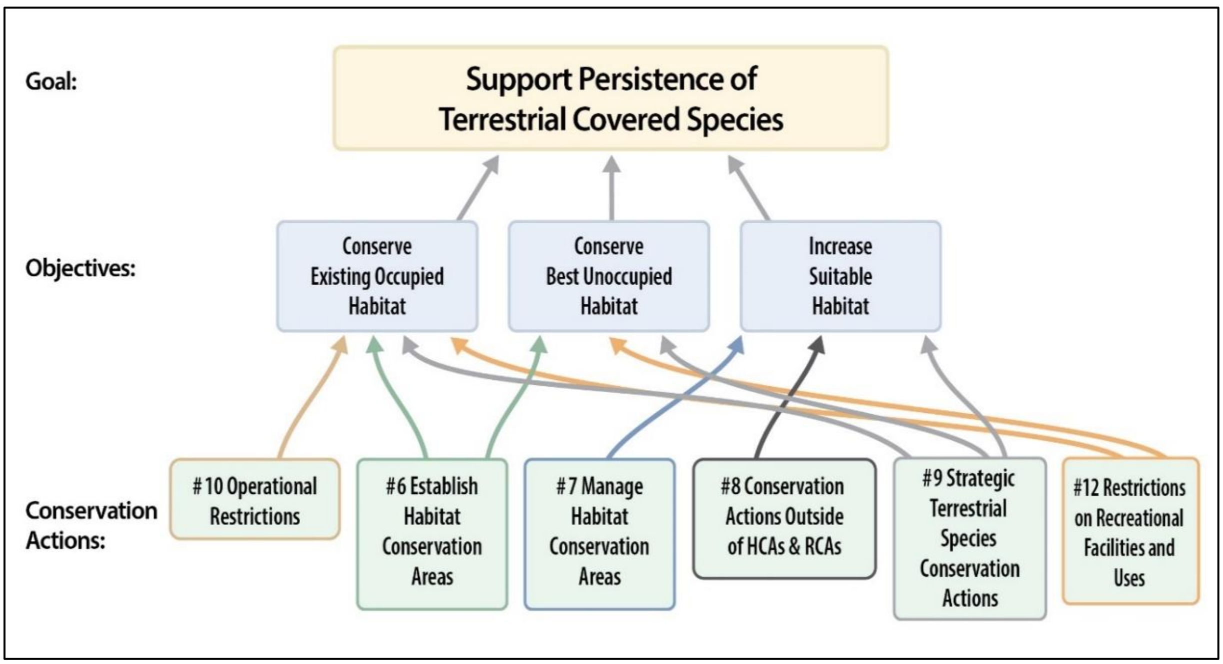


Figure 4-6. Terrestrial Biological Goals and Objectives and Their Associated Conservation Actions

Table 4-2. Relationship Between Biological Goals and Objectives and Conservation Actions

Biological Goal	Biological Objectives	Conservation Actions*	Specific Actions
Goal 1: Support the Persistence and Climate Change Resilience of Covered Fish	1.1 Wood Recruitment	1: Establish Riparian Conservation Areas	Establish and maintain RCAs.
		2: Riparian Equipment Restriction Zones	
		3: Stream Enhancement	Add large wood in select stream reaches.
		11: Road Construction and Management Measures	Limit new road construction in RCAs to situations where upland road placement options do not exist, are infeasible, or cost prohibitive.
		12: Restrictions on Recreational Facilities	Limit new recreational facilities in RCAs to boat ramps and non-motorized trails.[8]
	1.2 Stream Enhancement Projects	3: Stream Enhancement	Identify and prioritize stream reaches with high intrinsic potential for implementation of enhancement projects (rapid benefit) during each 10-year implementation planning cycle.
			Prioritize enhancement projects that benefit the covered species.
	1.3 Water Quality and Quantity	1: Establish Riparian Conservation Areas	Establish and maintain RCAs.
		2: Riparian Equipment Restriction Zones	Manage potentially unstable slopes for maintaining existing stability and wood delivery.
			Minimize effects immediately adjacent to streams by restricting ground-based equipment.
		5: Standards for Road Improvement and Vacating	Identify roads in the permit area that are high risk of sedimentation for improvement and/or vacating during each 10-year implementation planning cycle.
		11: Road Construction and Management Measures	Follow road design specifications and best management practices to reduce inputs of fine sediment.
		12: Restrictions on Recreational Facilities	Limit new recreational facilities in RCAs to boat ramps and non-motorized trails.[8]

[8] Motorized and non-motorized trails will be sited in RCAs when necessary to facilitate stream crossings.

Biological Goal	Biological Objectives	Conservation Actions*	Specific Actions
	1.4 Fish Passage	4: Remove or Modify Artificial Fish-Passage Barriers	Conduct fish-passage inventory and prioritization and identify projects to meet HCP targets. Design new and replacement stream crossings to meet NOAA Fisheries (2011 or most recent) passage criteria to maintain passage for covered fish species.
		5: Standards for Road Improvement and Vacating	Identify roads in the permit area that do not meet fish-passage requirements during each 10-year implementation planning cycle.
		11: Road Construction and Management Measures	Apply NOAA Fisheries (2011 or most recent) Fish-Passage Requirements to ODF-maintained roads.
		2: Riparian Equipment Restriction Zones	Limit work and ground-based equipment activity adjacent to streams.
		3: Stream Enhancement	Increase the amount of functional habitat.
Goal 2: Support the Persistence of Columbia Torrent Salamander in the Clatsop and Tillamook State Forests	2.1 Riparian Habitat within Species Range	1*: Establish Riparian Conservation Areas 2: Riparian Equipment Restriction Zones 12: Restrictions on Recreational Facilities	Establish and maintain RCAs. Minimize effects immediately adjacent to streams by restricting ground-based equipment and development of new recreational facilities.
Goal 3: Support the Persistence of Cascade Torrent Salamander in the Santiam State Forest	3.1 Riparian Habitat within Species Range	1: Establish Riparian Conservation Areas 2: Riparian Equipment Restriction Zones 12: Restrictions on Recreational Facilities	Establish and maintain RCAs. Minimize effects immediately adjacent to streams by restricting ground-based equipment and development of new recreational facilities.

Biological Goal	Biological Objectives	Conservation Actions*	Specific Actions
Goal 4: Support the Persistence of Oregon Slender Salamander in the Santiam State Forest	4.1 Existing Oregon Slender Salamander Habitat	6: Establish Habitat Conservation Areas	Include modeled high-quality habitat in HCAs.
		8: Conservation Actions Outside Habitat Conservation Areas and Riparian Conservation Areas	Establish downed-wood targets and leave tree strategies.
		12: Restrictions on Recreational Facilities	Minimize impacts associated with siting, constructing, and use of new recreational facilities.
	4.2 Downed Wood	8: Conservation Actions Outside Habitat Conservation Areas and Riparian Conservation Areas	Avoid damage to legacy structures (e.g., standing dead and downed wood) to the maximum extent practicable.
		10: Operational Restrictions to Minimize Effects on Covered Species	Retain green tree, snag, and downed wood in the Santiam State Forest to maintain and enhance downed wood recruitment.
Goal 5: Support the Persistence of Northern Spotted Owl in the Permit Area	5.1 Existing Northern Spotted Owl Habitat	6: Establish Habitat Conservation Areas 7: Manage Habitat Conservation Areas 8: Conservation Actions Outside Habitat Conservation Areas and Riparian Conservation Areas	Include currently active (i.e., <6 years with no response) activity centers on ODF lands in HCAs. Include activity centers in HCAs strategically that had a previous history of consistent occupancy or reproduction. Include habitat in HCAs in support of activity centers on adjacent (nonpermit) lands where ODF manages a significant amount of habitat within the provincial circle. Include nesting, roosting, and foraging habitat in HCAs.
		9: Strategic Terrestrial Species Conservation Actions	Participate in regional barred owl research and management activities with USFWS.
		10: Operational Restrictions to Minimize Effects on Covered Species	Prohibit activities near active nest sites during critical breeding period. Limit activities in nesting and roosting habitat in HCAs.
		12: Restrictions on Recreational Facilities	Minimize impacts associated with siting and constructing new recreational facilities.

Biological Goal	Biological Objectives	Conservation Actions*	Specific Actions
	5.2 Northern Spotted Owl Dispersal Habitat	8: Conservation Actions Outside Habitat Conservation Areas and Riparian Conservation Areas	Maintain 40% of the permit area outside HCAs in dispersal habitat as defined in Conservation Action 8. Prioritize downed wood and leave tree strategies to benefit covered species.
	5.3 Northern Spotted Owl Habitat Enhancement	7: Manage Habitat Conservation Areas	Manage to accelerate development of nesting, roosting, and foraging habitat.
Goal 6: Support the Persistence of Marbled Murrelet in the Permit Area	6.1 Existing Marbled Murrelet Nesting Habitat	6: Establish Habitat Conservation Areas 7: Manage Habitat Conservation Areas	Include nearly all occupied stands in HCAs. Include unoccupied or unsurveyed suitable and highly suitable habitat in HCAs in strategic locations of historically high murrelet activity. Include habitat of marginal and low suitability unoccupied habitat in HCAs strategically to improve habitat quality and connectivity over time.
		10: Operational Restrictions to Minimize Effects on Covered Species	Prohibit harvest activities near known occupied habitat during the critical breeding period. Prohibit activities near highly suitable habitat of unknown occupancy within HCAs during critical breeding period. Restrict management activities in designated occupied suitable and highly suitable habitat.
		12: Restrictions on Recreational Facilities	Minimize impacts associated with siting and constructing new recreational facilities.
	6.2 Marbled Murrelet Nesting Habitat Enhancement	6: Establish Habitat Conservation Areas 7: Manage Habitat Conservation Areas	Include suitable and highly suitable habitat in HCAs. Enhance unsuitable habitat within strategic locations to increase patch size and overall contiguity among suitable and highly suitable habitat patches. Manage strategically located young forest stands to favor development of large trees and nesting platforms.

Biological Goal	Biological Objectives	Conservation Actions*	Specific Actions
Goal 7: Support the Persistence of Red Tree Vole in the Permit Area	7.1 Occupied Red Tree Vole Habitat	6: Establish Habitat Conservation Areas 10: Operational Restrictions to Minimize Effects on Covered Species 12: Restrictions on Recreational Facilities	Include known occupied sites in HCAs. Restrict activities near known nest locations. Minimize impacts associated with siting and constructing new recreational facilities.
	7.2 Red Tree Vole Habitat Enhancement	6: Establish Habitat Conservation Areas 7: Manage Habitat Conservation Areas	Include highly suitable or suitable habitat unoccupied/ unknown occupancy in HCAs. Manage habitat to increase habitat quality over time. Restrict management in known occupied locations.
Goal 8: Support the Persistence of Coastal Marten in the Permit Area	8.1 Existing Coastal Marten Habitat	6: Establish Habitat Conservation Areas 10: Operational restrictions to Minimize Effects on Covered Species 12: Restrictions on Recreational Facilities	Include suitable habitat in HCAs. Restrict activities around know active maternal den sites. Minimize impacts associated with siting and constructing new recreational facilities.
	8.2 Coastal Marten Habitat Enhancement	7: Manage Habitat Conservation Areas	Manage to accelerate development of and specific habitat features known to be important to the species (e.g., denning structures, cover).

* See Figure 4-5 and Figure 4-6 to interpret numeric headings.

4.7.1 Conservation Action 1: Establish Riparian Conservation Areas

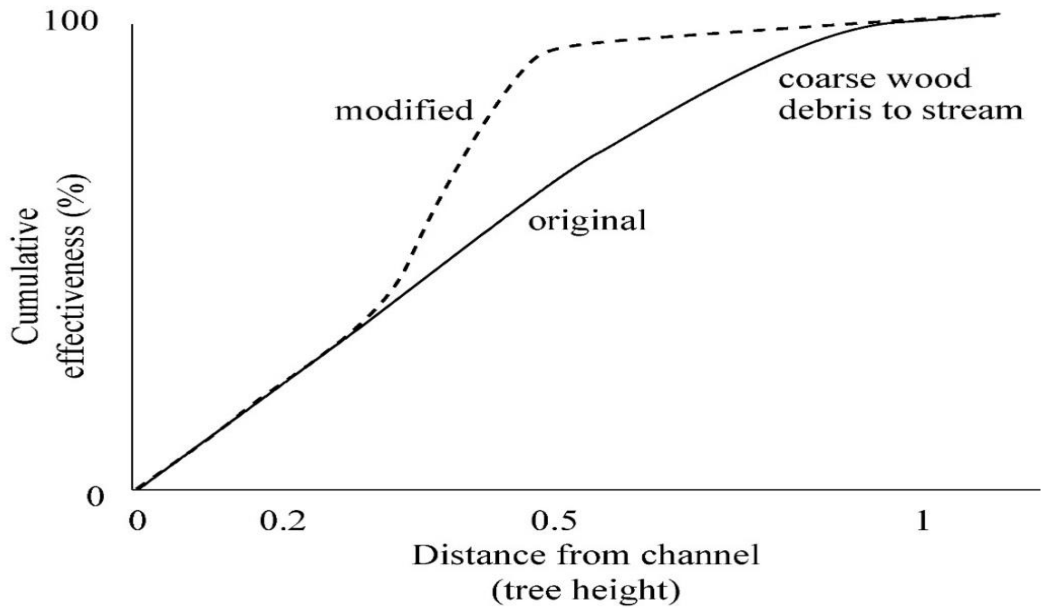
As shown in Table 4-2, Conservation Action 1 is intended to support the following biological objectives.

- 1.1 Wood Recruitment
- 1.3 Water Quality and Quantity
- 2.1 Riparian Habitat within Species Range

This conservation action describes how ODF will implement a riparian management strategy to ensure important riparian functions are maintained in the permit area to provide suitable habitat for the aquatic species covered under this HCP (covered fish and torrent salamanders). Riparian functions addressed in this action are large wood and gravel recruitment, stream shading, nutrient input, and streambank integrity, many of which are limiting factors identified for the covered species. Maintaining intact RCAs in the permit area will increase ecosystem resilience by buffering ecological function against changes in streamflow (Beechie et al. 2012). Stand-management activities will not occur in the RCAs.

Large woody material contributes to natural processes and promotes instream channel complexity by adding wood cover to streams and influencing channel form and function. Large woody material deposited in streams facilitates the creation and maintenance of hydrologic features, such as pools, gravel bars, and backwater areas, all of which provide essential habitat features for various life-history stages of the covered aquatic species. Large woody material changes sediment routing through the aquatic system, slowing the movement of bedload sediments and causing an increase in storage of sands and gravels. Field research and modeling demonstrate that approximately 95% of the total instream wood inputs from adjacent riparian areas to fish-bearing streams come from distances of 82 to 148 feet (slope distance) from the edge of the stream channel. This distance represents 0.6 to 0.7 of site-potential tree height[9] (Reeves et al. 2016; Figure 4-7) based on the modified effectiveness curve that has been developed since the original 1993 Forest Ecosystem Management Assessment Team (FEMAT) curve. The effectiveness curve shows the percent of instream wood delivery that would be expected based on the distance the riparian area extends from the stream channel.

[9] Site-potential tree height refers to the average maximum height of the tallest dominant trees (200 years or older) for a given site class.



Source: Reeves et al. 2016

Figure 4-7. Modified Effectiveness Curve for Wood Delivery to Streams as a Function of Distance from Stream Channel

Streamside riparian harvest reduces the number of trees available for large wood recruitment because those trees are removed from the riparian zone. The implementation of RCAs in fish- and non-fish-bearing streams that are wider than what is present currently and that limit harvest activities in RCAs will increase large wood input and benefit the covered species by increasing instream habitat complexity, channel stability, and channel form and function. This increase in large wood input and instream habitat complexity will occur because, as riparian stands mature unharvested, they will produce larger-diameter wood and a greater diversity of wood sizes and wood shapes. Large woody material also provides nutrients to streams, as well as substrate for aquatic invertebrate (e.g., food for covered fish and torrent salamanders) production.

Tree harvest in the riparian forest adjacent to streams can reduce canopy cover, which affects stream shading. Solar radiation is the main source of heat for small mountain streams. The implementation of an RCA will maintain and/or increase streamside canopy cover and shading to prevent increases in stream water temperatures for the covered cold-water aquatic species (covered fish and torrent salamanders). The riparian conservation actions described here will be complemented by management direction within designated HCAs (Conservation Action 6: Establish Habitat Conservation Areas), where appropriate, to benefit covered species in the permit area. This will include larger areas of passive management adjacent to many RCAs, as well as additional legacy retention for silvicultural prescriptions within HCAs, such as additional clustering of green trees at the junction of seasonal and perennial streams.

4.7.1.1 Delineation of Riparian Conservation Areas

ODF will establish RCAs adjacent to the aquatic zone, which includes the stream channel(s) and associated aquatic habitat features (beaver ponds, stream-associated wetlands, side channels, and the channel migration zone; Figure 4-8). The RCAs will benefit the covered fish species by conserving, maintaining, and enhancing riparian processes that create aquatic habitat. The functions of these streams will be maintained by retaining vegetation in riparian areas during adjacent harvest activities. No harvest or thinning will occur within the RCAs, including harvesting of standing or downed trees for salvage after disturbance events. Felling of hazard live or dead trees may occur in RCAs, where such trees threaten public safety or infrastructure (e.g., roads, trails, campgrounds). Where hazard trees are felled, they will be felled towards the aquatic zone and left in place wherever possible. RCA management direction and best management practices will apply to all RCAs, whether they are located within or outside of HCAs.

RCA buffer widths will be applied to stream reaches, dependent on the presence of fish, stream size (determined by average annual flow), flow period (perennial versus seasonal), and the potential for landslides (potential debris flow tracts) or fluvial transport during high-energy seasonal flow events. RCA buffer widths are reported in horizontal distances unless otherwise noted. Once the initial management area is determined, delineation and posting of RCAs will occur in and adjacent to the area. During this delineation, field staff will conduct surveys to determine fish presence, stream size and flow duration (i.e., perennial vs. seasonal), and identify any sensitive areas such as seeps, springs and potentially unstable slopes that may require further refinement or consultation. An aquatic biologist or geomorphologist will review these areas and conduct site visits, as necessary, to provide technical assistance in delineating RCAs and sensitive areas and applying riparian conservation area strategies. Assessment and delineation of these features may begin 1 to 3 years before a management activity will be implemented and continues up through the preparation of the area for operations (e.g., boundary posting for a timber sale).

The RCA width is applied and measured in the field horizontally, regardless of slope. It is measured beginning at the average high-water level of the water body, or the edge of the stream-associated wetland, side channel, or channel migration zone,[10] whichever is farthest from the waterway, and extended toward the uplands. As slope increases, width of the conservation area in the field (on slope), therefore also increases. For example, a 120-foot management area has an actual effective width as measured on the ground (i.e., along the slope) of 120 feet at 0% slope and 170 feet at 100% slope (Figure 4-9). Similarly, a 35-foot management area has an actual effective width of 35 feet at 0% slope and 49 feet at 100% slope (Figure 4-10). The width of these areas will be expanded to up to 170 feet in width to encompass sensitive sites (e.g., inner gorges) that occur (Figure 4-12).

[10] The area where the active channel of a stream or river is prone to move, and the movement results in a potential near-term loss of riparian function and associated habitat adjacent to the stream.

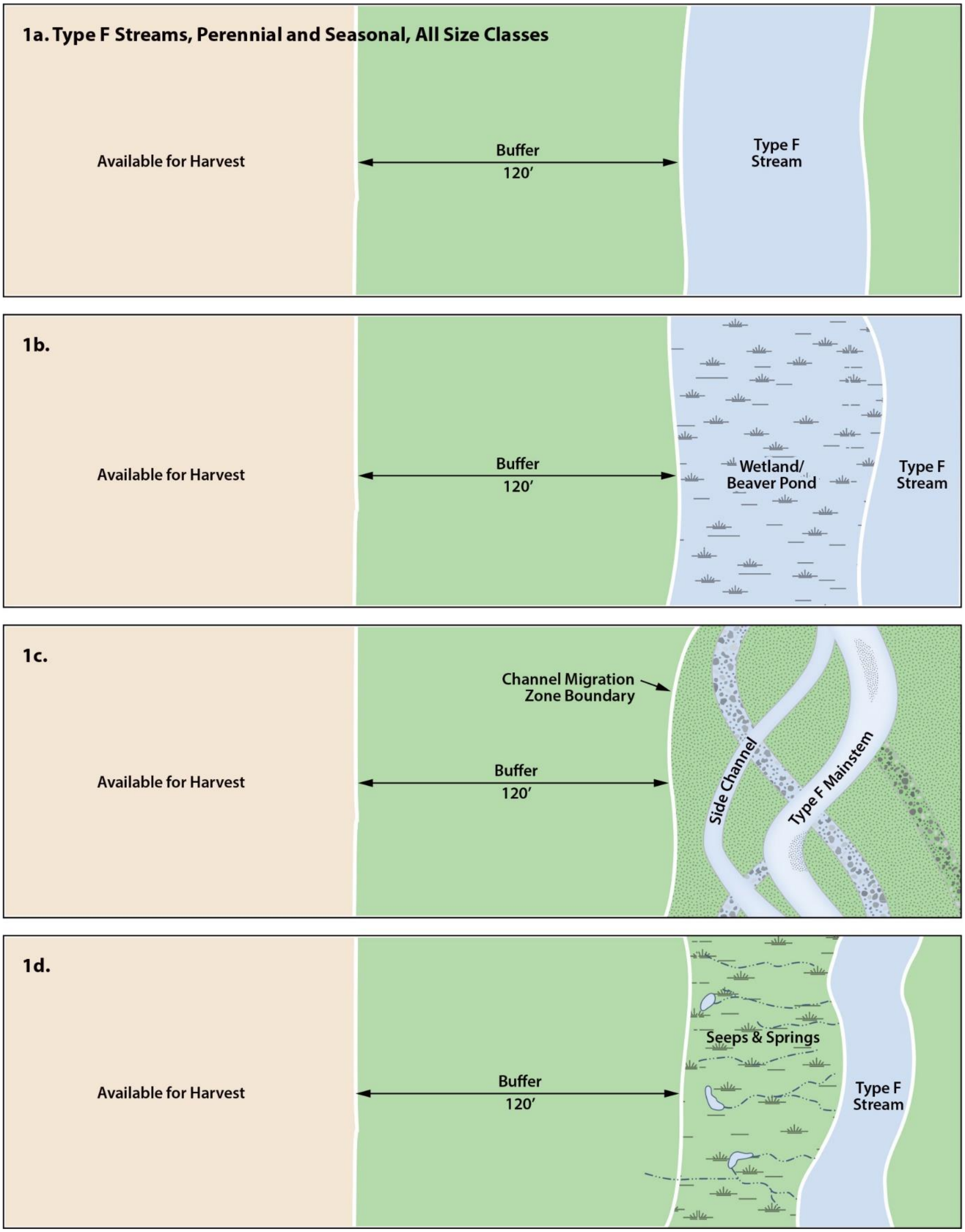


Figure 4-8. Effects of Aquatic Zone Designations on Riparian Conservation Areas

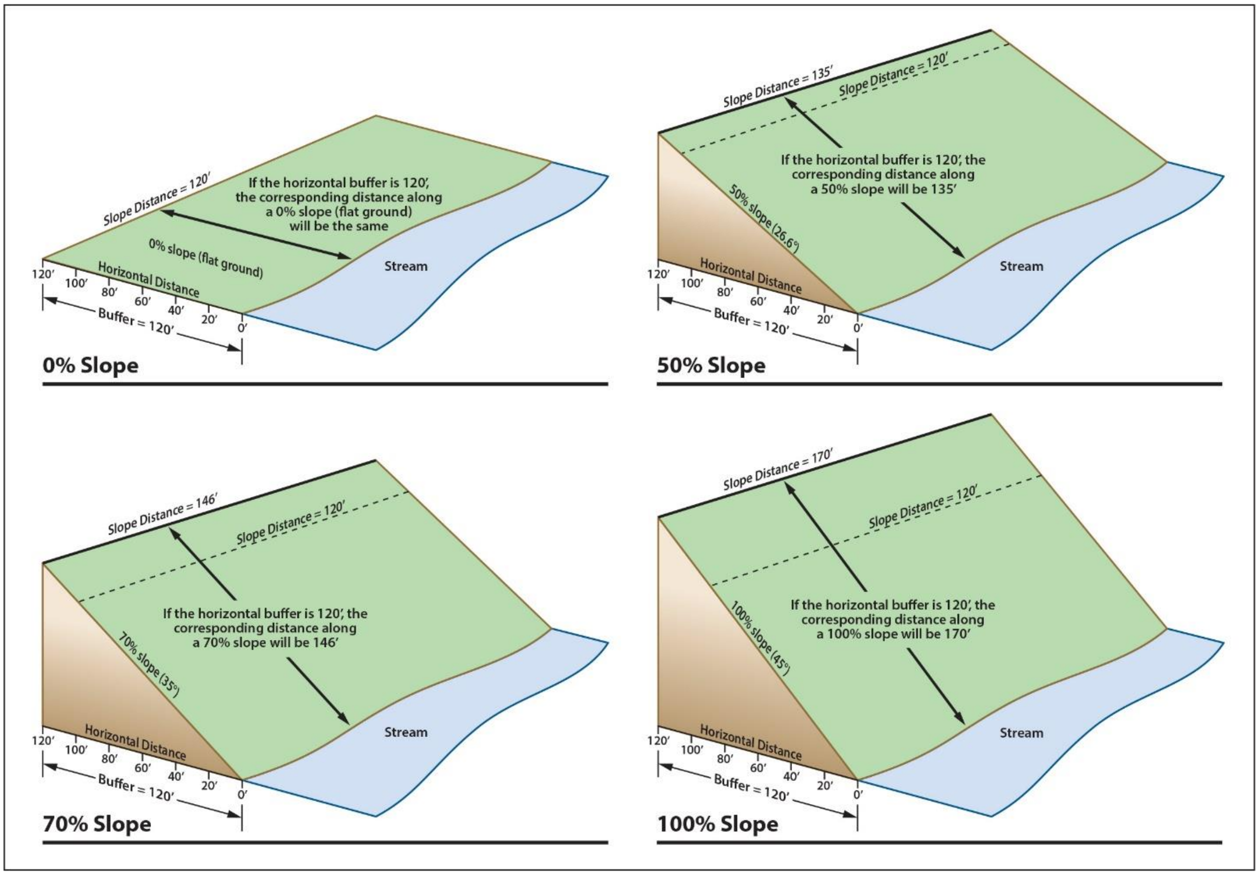


Figure 4-9. Examples of the Horizontal Distance Measurement of a 120-foot Riparian Conservation Area

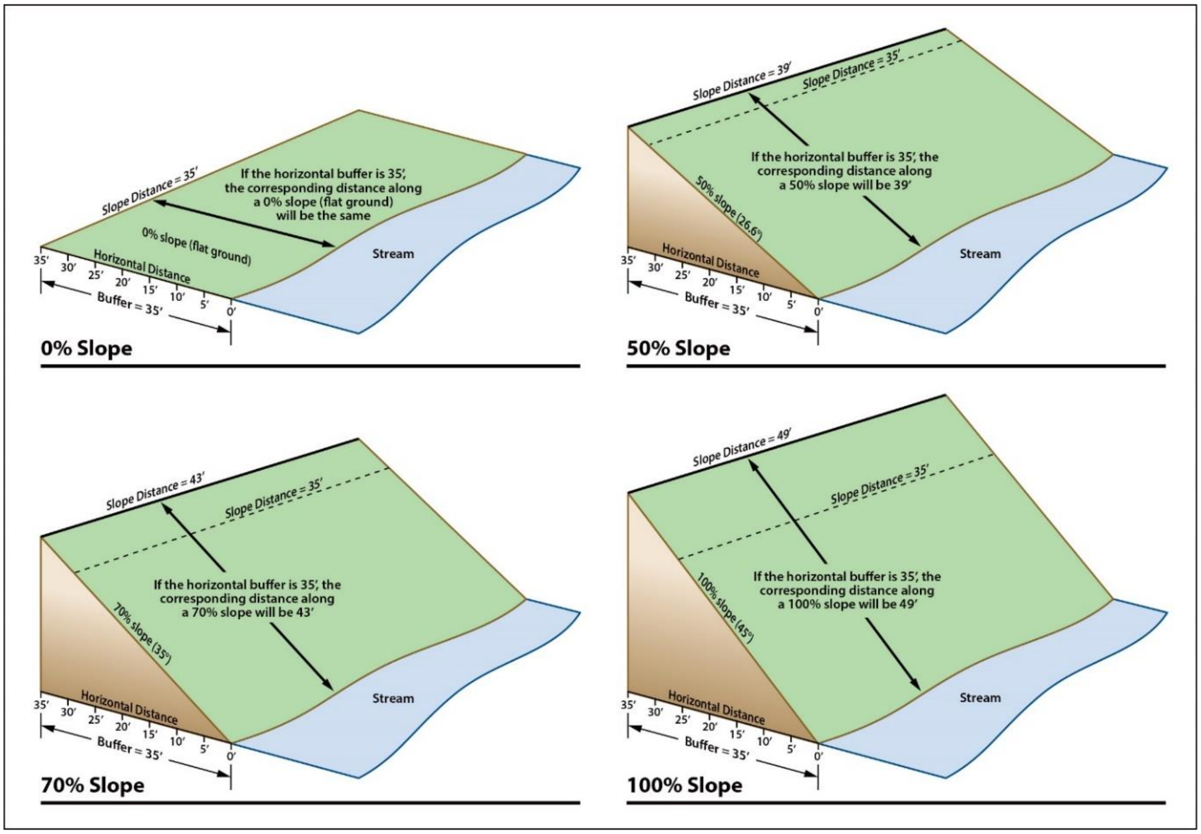


Figure 4-10. Examples of the Horizontal Distance Measurement of a 35-foot Riparian Conservation Area

4.7.1.2 Structure of Riparian Conservation Areas

The width of RCAs will vary based on stream size, stream type, and fish presence (fish versus non-fish) (Table 4-4 and Table 4-7; Figure 4-11). The structure of the RCAs is as follows:

- Large and medium non-fish-bearing streams will be treated the same as fish-bearing streams; all will have a 120-foot (horizontal distance) RCA that extends from the aquatic zone.
- Seasonal fish-bearing streams will have a 120-foot (horizontal distance) RCA for the entire stream segment (Table 4-3).
- Small, perennial non-fish-bearing streams will retain a 120-foot RCA (horizontal distance) for the first 500 feet upstream from the end of fish use on perennial fish-bearing streams, to create a process protection zone. The process protection zone will ameliorate the rise of stream temperature to less than 0.3°C above baseline prior to mixing with fish-bearing stream waters. Upstream of the 500-foot process protection zone, the buffer will be 35 feet (horizontal distance) from the aquatic zone.
- Seasonal non-fish-bearing streams that are potential debris flow track or high-energy reaches that have the potential to deliver to fish-bearing streams will have RCAs that extend 50 feet (horizontal distance) from the aquatic zone for the first 500 feet upstream of the end of fish use to recruit wood into streams from standing trees. Upstream of the 500-foot process-protection

zone, the buffer will be 35 feet (horizontal distance) from the aquatic zone, to the potential initiation site in potential debris flow track or high-energy reaches (Table 4-4; Figure 4-12). This length and width is sufficient to contain 98% and 93% of all debris flow impact widths, respectively, based on unpublished debris flow track data collected from two 1996 storms (Robison et al. 1999.). As a result, existing standing trees and downed wood within reaches identified as likely debris flow tracks will be available as large wood inputs to the aquatic system, mimicking the natural mass wasting regime.

- Seasonal non-fish reaches that are not potential debris flow tracks or high energy as described above will not have an RCA, but they will have a 35-foot equipment restriction zone (ERZ). Ground-based operations will be limited to only conservation actions, those actions required for felling and removal of trees, and road and trail building and maintenance. Disconnected sections of seasonal streams (e.g., no stream channel or evidence of surface flow) will not have RCAs except ground-based equipment restrictions. The ERZ is further described in Conservation Action 2: Riparian Equipment Restriction Zones. The differing buffer strategies for the three seasonal stream types is depicted in Figure 4-13.
- The approximate miles of stream in the permit area by buffer type described above are shown in Table 4-5.

Table 4-3. Buffer Widths (Horizontal Distance) for All Type F and Large and Medium Type N

	Management Area Width (feet)[a]	
Stream Type	**Type F**	**Type N**
Large	120	120
Medium	120	120
Small	120	See Table 4-4
Seasonal[b]	120	See Table 4-4

[a] Distance will be measured horizontally, which results in the implementation of larger buffers in steeper terrain (see Figure 4-10).
[b] Seasonal: A stream that does not have surface flow after July 15.

Table 4-4. Riparian Conservation Area Widths (Horizontal Distance) for Small Perennial and Seasonal Type N Streams

	Management Area Width (feet)[a]	
Stream Type	**Within 500-foot Process Zone**	**Upstream of 500-foot Process Zone**
Perennial small Type N	120	35
Potential debris flow track (Seasonal Type N)[b]	50	35
High energy (Seasonal Type N)[c]	50	35
Seasonal other (Type N)[d]	0[e]	0[e]

[a] Distance will be measured horizontally, which results in the implementation of larger buffers in steeper terrain (see Figure 4-10).
[b] Potential debris flow tracks: Reaches on seasonal Type N streams with potential to deliver wood to a Type F stream.
[c] High Energy: Reaches on seasonal Type N streams with the potential to deliver wood and sediment to a Type F stream during a high-flow event.
[d] Seasonal: A stream that does not have surface flow after July 15.
[e] A 35-foot equipment restriction zone will apply to these streams.

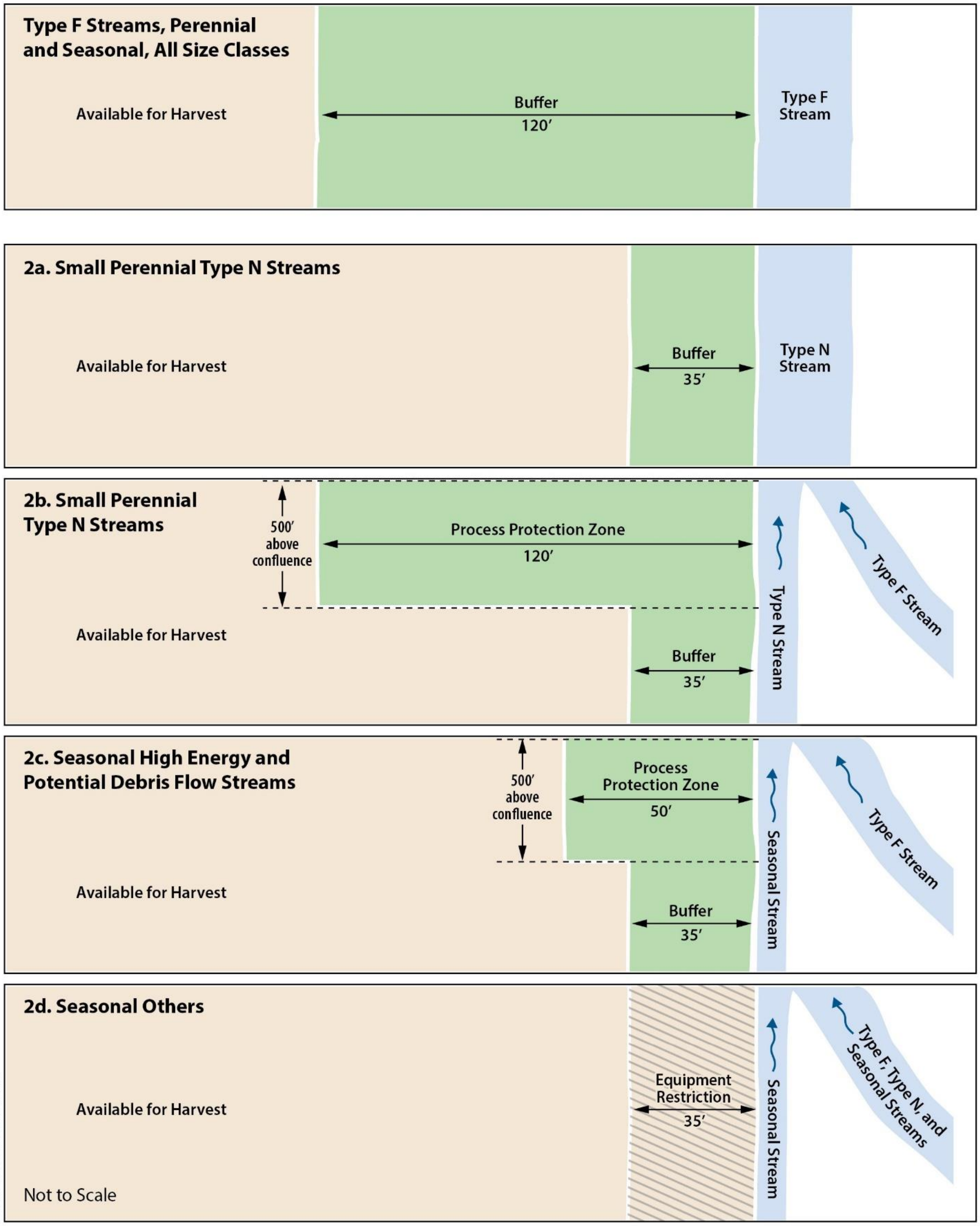


Figure 4-11. Riparian Conservation Areas on Type F Streams, Perennial and Seasonal, All Size Classes

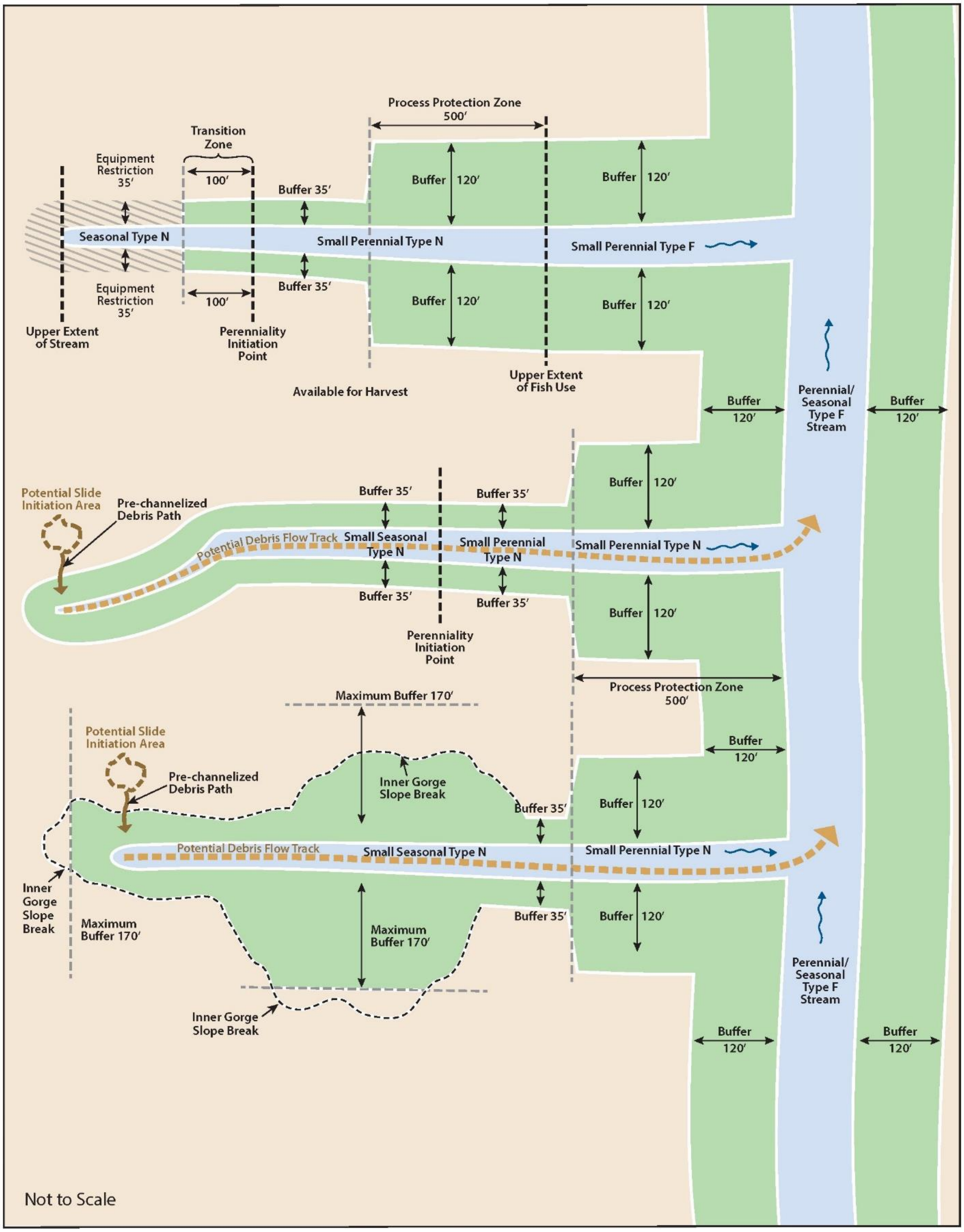


Figure 4-12. Riparian Conservation Areas in Process Protection Zones

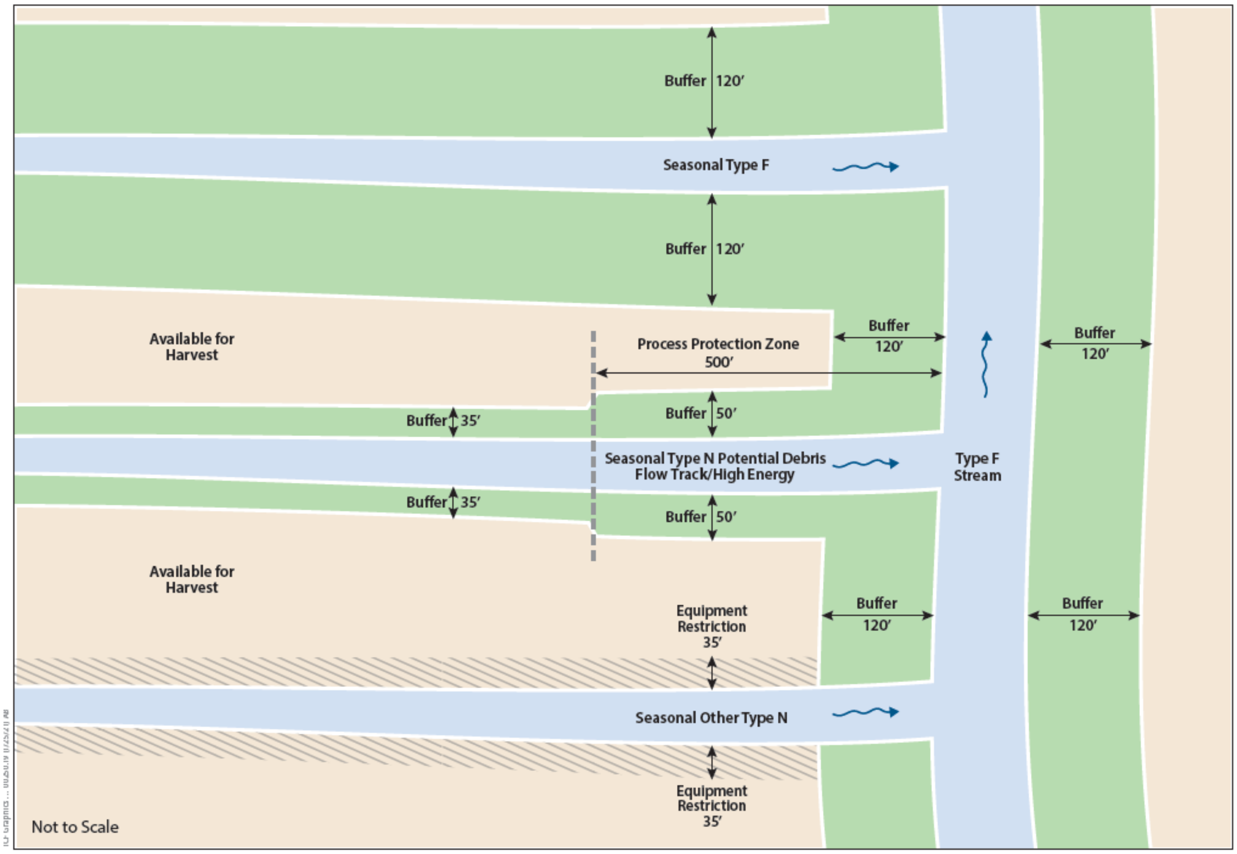


Figure 4-13. Riparian Conservation Areas Along Seasonal Streams

Table 4-5. Miles of Stream by Buffer Type in the Permit Area

Stream Type	Buffer Width (feet) Measured in Horizontal Distance	Stream Miles in Permit Area
Type F Perennial – Large, Medium, Small	120	1,190
Type F Seasonal	120	30
Type N Perennial – Large and Medium	120	110
Perennial Small Type N – In PPZ	120	105
Type N Perennial Small – Above PPZ	35	865
PDFT (Seasonal Type N) – In PPZ	50	700
PDFT (Seasonal Type N) – Above PPZ	35	1,955
HE (Seasonal Type N) – In PPZ	50	10
HE (Seasonal Type N) – Above PPZ	35	20
Transition Zone Between Perennial Type N and Seasonal	35	70
Seasonal Other (Type N)	--[a]	2,960

[a] 35-foot ground-based equipment restriction
PPZ = Process Protection Zone; PDFT = Potential Debris Flow Track; HE = high Energy

If stream-associated seeps and springs occur in a harvest unit, their extent will be evaluated when determining the RCA. Where a seep or spring is connected to a perennial stream, as determined by either surface flow or the presence of wetland plants or hydric soils, it will be included in the RCA buffer for that stream. Where the seep or spring is not fully encompassed by the RCA for the associated stream, the RCA will be extended to encompass it with a 35-foot buffer (Figure 4-14).

The width of the RCA will be expanded to a maximum of 170 feet, to more fully encompass nearby inner gorges and aquatic adjacent unstable areas, as described in Section 4.7.1.4, *Special Considerations for Potentially Unstable Slopes*. Where either of these slope features are identified, the RCA will be extended. The extension will go to the inner gorge slope break or the top of the adjacent unstable slope, up to a maximum of 170 feet (horizontal distance) from the edge of the aquatic zone, whichever occurs first (Figure 4-14). The additional RCA width in these areas will ensure that potentially negative impacts from landslides and other soil movement (i.e., sloughing) will be minimized and the RCAs will function to the benefit of the aquatic system through wood delivery and nutrient cycling, and provide additional shade to streams where slope aspect is favorable.

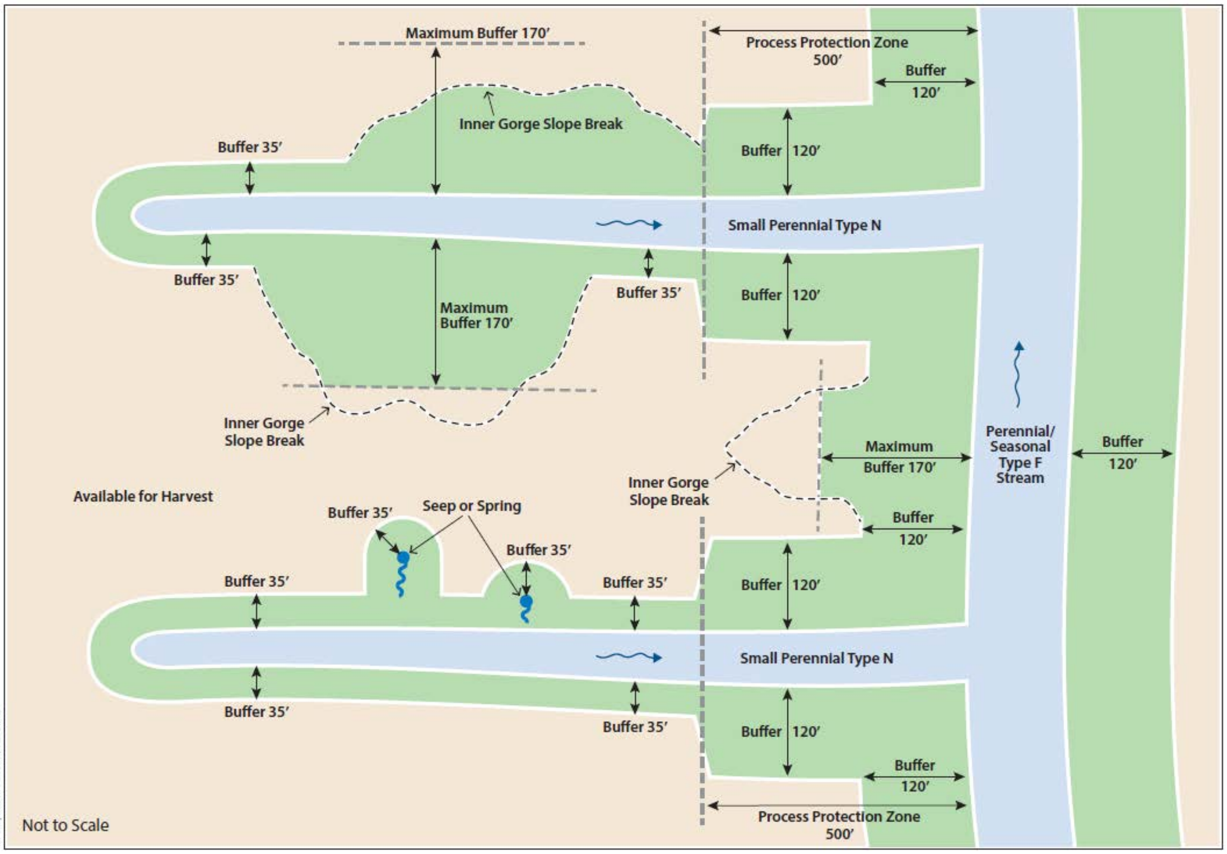


Figure 4-14. Effects of Seeps, Springs, and Inner Gorges on Riparian Conservation Areas

RCAs are intended to provide the ecological functions and processes required to create and maintain habitat for the covered fish species in the permit area (Reeves et al. 2016). The prescribed buffers in large and medium fish and non-fish streams, as well as small fish streams, are sufficient to capture large woody material projected to be available over the permit term, and provide shading to maintain cold stream temperatures (TerrainWorks 2020). The amount of shade provided by streamside vegetation is perhaps the most important variable affecting stream temperatures in a forested environment (Groom et al. 2011).

Headwaters that do not support fish typically drain at least 60% to 70% of a catchment area, constitute up to 90% of the stream network's length, and provide a prey base, source of downed wood, and sediment input for downstream fish reaches (Olsen et al. 2007, Reeves et al. 2003). Along small non-fish-bearing streams, the overall goal of RCAs is to retain and grow vegetation sufficient to support important functions and processes in the various types of streams and to contribute to achieving properly functioning conditions in downstream fish-bearing waters, as well as benefit the Cascade and Columbia torrent salamander. The functions of these streams will be maintained by retaining vegetation in riparian areas during harvest activities. This HCP recognizes that a variety of small non-fish-bearing streams exists across the forest landscape and that these streams may differ in their physical characteristics, dominant functional processes, and contribution to watershed-level processes.

As stated previously, headwaters, which include seasonal streams, provide numerous ecological services. Furthermore, coho use the upper portion of coastal stream networks, including seasonal streams, for spawning and high-flow refuge. Wigington et al. (2006) found that overwinter smolt survival rates for juvenile coho is higher in seasonal streams than mainstems and equivalent to survival in perennial streams. The function of these seasonal streams will be maintained by retaining vegetation, minimizing soil disturbance, and protecting channel morphology in riparian areas during harvest activities.

4.7.1.3 Special Considerations for Instream Temperature Protection

Harvest activities adjacent to fish-bearing streams can increase summer stream temperatures through reduction of shade allowing increased solar radiation to reach the water's surface. This can also occur on small, non-fish-bearing streams that flow into fish-bearing streams, particularly in stream reaches immediately above fish-bearing streams. Temperature increases, if not managed, can extend downstream into fish-bearing waters and affect the covered fish species.

RCAs adjacent to small non-fish-bearing perennial and seasonal streams will be narrower than RCAs adjacent to fish-bearing and medium and large non-fish-bearing streams. A Process Protection Zone (PPZ) will be maintained for the first 500 feet of stream upstream of the end of fish use. The PPZ will provide additional shading to promote the cooling of water prior to it entering a perennial fish stream. Upstream of the 500-foot PPZ, the buffer will be 35 feet (horizontal distance) from the aquatic zone (Table 4-4 and Figure 4-13). The 120-foot RCA (horizontal distance) within the 500-foot temperature zone at the intersection of fish and small perennial non-fish-bearing streams will help ameliorate any potential stream temperature increases from upstream and prevent any further addition of heat to the stream.

4.7.1.4 Special Considerations for Potentially Unstable Slopes

Landslides are the dominant erosional process in the mountainous terrain of the northwest Oregon State forests, with shallow, rapidly moving landslides being a common feature. These landslides have a depth comparable to the rooting depth of vegetation in steep terrain, which is usually constrained by a relatively hard, impermeable bedrock surface. Shallow slides usually only involve the upper weathered bedrock and overlying soil, are almost always less than 5 feet deep, and have been found to average only 2.5 feet deep at the initiation site (Robison et al. 1999). Because of these characteristics, they can be affected by timber harvest, road construction, and related ground-disturbing activities.

Debris flows can initiate in headwalls or elsewhere on mountain slopes. Steep and convergent terrain is more likely to be an initiation site for these landslides. Debris flows are triggered by saturation of soil causing slope failures. Some slides occur in the absence of forest-management activities, while some may be related to past logging practices or current management activities. Generally, vegetation removal and ground disturbance increase the likelihood of slope failure during triggering weather events. As landslides are initiated, debris moves downslope. In cases where the slide reaches a confined stream channel, it may continue, incorporating water and becoming a more fluid mass known as a channelized debris flow. Channelized debris flows can gather volume by adding soil, stream sediment, and woody material as they traverse the stream network to lower topographic positions. These flows are events that can shape stream habitat; however, not all debris flows reach the stream network, and not all channelized debris flows travel into fish-bearing streams. When a channelized debris flow enters a fish-bearing stream, increased sedimentation can deteriorate instream habitat and water quality (Ubechu and Okeke 2017). While channelized debris flows can travel to fish-bearing streams and scour or bury habitat (Thompson and Service 2008), they can also deliver large wood material along with gravels, sands, and silt-sized material to streams. These organic and inorganic materials are requirements for long-term aquatic health affecting processes such as food sources, nutrient cycling, sediment routing, channel morphology, and refugia (Bilby and Bisson 2001). ODF uses geotechnical expertise in planning and carrying out management activities to minimize the increased risk of slope movements that can result from forest-management operations.

The channel network in the permit area will be evaluated on a harvest unit basis to determine which hill slopes and headwater streams are potential sources of debris flows to fish-bearing streams. Other features, such as inner gorges and aquatic adjacent unstable slopes, are also identified during harvest planning and the field assessment. Aquatic resources are protected by standard stream buffers that relate the width of the adjacent buffer to stream size, flow duration (perennial versus seasonal) and fish presence. In the case of identified slope instability features, these will often add additional buffer width, buffer length, or establish harvest modifications upland not directly adjacent to an RCA. There are three types of these additional protections for aquatic resources that are slope stability related: aquatic adjacent unstable slopes, inner gorges, and upland potentially unstable slopes and their associated debris flow tracks (Table 4-6); these features are described in detail in Appendix I.

A three-part hazard-based approach (Appendix L) will be taken to determine the applicability of buffers for upland potentially unstable slopes: (1) is the potentially unstable landform present, (2) what is the potential for debris flow initiation (irrespective of forest management), and (3) if the site fails and a debris flow results will it deliver to a fish-bearing stream (typically via channelized debris flow)?

When evaluating this feature, the geotechnical specialist makes a determination of high, moderate, or low potential for slide initiation. A high hazard site is a location that has characteristics indicating a relatively high probability of failing. A moderate hazard site may have a relatively high probability of failing. Characteristics of low hazard. Characteristics of low hazard sites indicate a lack of potential slope instability. While various data sources, models, and other analytic products (e.g., the modeled stream network developed for this HCP [Terrainworks 2020]) are used in this assessment, the final determination of hazard level is based on professional experience and field observation.

The determination to buffer includes the likelihood of failure and likelihood of delivering debris to a fish-bearing stream. If a potential initiation site is deemed “high hazard” and there is any likelihood of delivery to a fish-bearing stream, then harvest modifications are required These modifications include leaving timber on the high hazard potential initiation site and establishing a 35-foot RCA along both sides of the potential channelized debris flow, where an RCA is not already designated. In the case of “moderate hazard” initiation sites, harvest modification is required that establishes a 35-foot RCA along both sides of the potential channelized debris flow, but not a buffer of the potential initiation site. In the case of a “low hazard” initiation site, no harvest modification or establishment of an RCA is required below the potential initiation site.

Table 4-6. Slope Buffers for Protection of Fish-Bearing Streams

Slope Classification	Characteristics	Management Practices	Buffer above Fish Bearing when:
Inner Gorge	Obvious slope breaks of >20% from moderate to steeper slopes of ≥70% and ≥15 feet in height. Not to exceed widths of 170 feet from water.	No harvest. Leave trees within one canopy width above the slope break, unless conifer already occupies the inner gorge, in which case leave timber only within the gorge.	Adjacent to: Type F; Perennial Type N; Seasonal High Energy; Potential Debris Flow Track
Aquatic Adjacent Unstable Slope	Unstable slope immediately adjacent to a channel, where the toe of the unstable slope interacts directly with erosive forces of a stream. Not to exceed widths of 170 feet from water.	No harvest. Buffer to leave trees within one canopy width above the unstable slope, unless conifer already occupies the unstable slope in which case leave timber only on the unstable portion of the slope.	Adjacent to: Type F; Perennial Type N; Seasonal High Energy; Potential Debris Flow Track
Upland Potentially Unstable Slopes and Debris Flow Tracks	High Hazard upland slopes: relatively high likelihood of slide initiation.	Buffer potential initiation site and underlying seasonal reaches (debris flow tracks). Buffer to leave trees within one canopy width above the potentially unstable slope, unless stand-age conifer already occupies the site.	Deliverable to Type F stream Debris-flow track may traverse other high-energy seasonal and perennial Type N segments between the potential unstable upland site and Type F stream. Debris may become entrained within downstream segments for a time before potentially delivering to fish.
	Moderate Hazard upland slopes: may have relatively high likelihood of slide initiation.	Buffer underlying seasonal streams (known as debris flow tracks).	
	Low Hazard upland slopes: do not have a relatively high likelihood of slide initiation.	No upland slope buffers required for potential initiation site or for any underlying seasonal stream.	N/A

Slope Hazard and Delivery Assessment Process

The assessment of slope hazard and potential delivery involve both a geographic information system (GIS) analysis and field visits, which help in understanding the various factors that could be present at a particular site that contribute to slope stability hazard. Since to have risk, there must be both a hazard (potentially unstable slope) and a resource at risk (fish-bearing stream), the geotechnical specialist will examine the landscape and consider multiple contributing factors to make a judgment as to the hazard (i.e., risk of slope failure) and the delivery (i.e., risk of debris flow reaching fish-bearing water) for the site.

All planned clearcut harvest units will undergo a GIS screening during the development of operations plans, which may take place 1 to 3 years in advance of harvest activities occurring. Across much of the permit area, there is a low chance of encountering potential sites that require further analysis; however, some areas of generally steeper terrain will require additional analysis and field work to accurately assess specific sites and designate protections. In addition to areas found during screening, field staff may become aware of additional potential slope issues during harvest unit preparation activities such as road design, stream classification and designation, boundary posting, and timber cruising. Any potential slope issues discovered at any point during the planning process or preparation of the harvest unit for auction will be brought to the geotechnical specialist for further review.

A GIS review is conducted on all proposed clearcut harvests and new road alignments using the ODF GIS system. Data reviewed include proposed harvest and buffer locations provided from harvest planners, orthophotographs, stream data (location, size, seasonality, fish presence), underlying geology, and digital elevation models (and associated products) derived from light detection and ranging (lidar). Paramount in the GIS review is the use of LiDAR topographic data, which exists for all lands west of the Cascades. Various renderings of the data are used to evaluate the steepness, shape, and texture of the ground surface, including: analysis of fine-scaled contours[11] at; multi-directional hillshade models; slope steepness categories (as percent slope); ODF's HLHL model[12]; and slopeshade (a continuous representation of slope steepness, as percent slope). The modeled stream network, developed for this HCP, showing landslide initiation and delivery risk GIS products, will also be used during this review (Terrainworks 2020). The desktop review often identifies locations of the four landforms described above and associated slope buffers. For upland potentially unstable slope features, delivery to fish-bearing streams can sometimes be determined during this stage of review as well. This review often identifies former landslides and areas of higher hazard that could be affected by harvest activities or that may fail in the future.

The GIS review may necessitate a field review to ground-truth a given site. Various indicators of slope hazard are not fully discernable by the desktop review and can be more fully understood in the field.

After determinations are made from either the GIS review and/or field visit, the landform is identified, and the appropriate vegetative buffer is applied. In the case of road alignments, recommendations often involve special best management practices (BMPs) or complete avoidance of an identified location. Retention of all trees on potentially unstable slopes with a high risk of failure that has any potential to deliver to fish-bearing streams will be mapped and posted, along with additional buffering for downstream debris flow tracks. Additional standing trees may be left adjacent to potentially unstable slopes, due to operational considerations. This tree retention can help reduce the near-term likelihood of landslides due to harvest and associated activities and support the delivery of large woody material to the aquatic environment if they do occur. While there is no retention requirement for a site with a moderate risk of failure that has any potential to

[11] Either 5- or 10-foot contours

[12] High Landslide Hazard Location (HLHL) GIS model. Created from Lidar DEM. Slopes longer than 30 feet and ≥ 80% or ≥70% for convergent topography. In forests underlain by the Tyee Formation slope thresholds are 5% less. Thresholds determined from recommendations from ODF's 1996 storm report and issue paper.

deliver to fish-bearing streams, the downstream debris flow track will be mapped and posted, and the site itself will be considered for upland green tree retention. As part of the monitoring plan, a subset of moderate and high risk sites will be identified for monitoring at 1-, 5- and 10-year intervals after harvest.

4.7.2 Conservation Action 2: Riparian Equipment Restriction Zones

As shown in Table 4-2, Conservation Action 2 is intended to support the following biological objectives.

- 1.1 Wood Recruitment
- 1.2 Stream Enhancement Projects
- 1.3 Water Quality and Quantity
- 1.4 Fish Passage

RCAs (Conservation Action 1: Establish Riparian Conservation Areas) will be in place to conserve and maintain the riparian process as described in the biological goals and objectives. However, in some cases covered activities will need to occur inside of RCAs. Activities that could occur inside of RCAs will include establishing yarding corridors, constructing or maintaining roads (including temporary roads and stream crossings), constructing and maintaining recreational trails, vacating or decommissioning roads, and conducting stream-enhancement activities (including tipping/falling trees into the stream). If heavy machinery is used for stream enhancement, line-pulling is preferred for large tree installation. Machinery access is permitted for placement of logs, rocks or trees, or other restoration work. Activities that require work in the aquatic environment will follow the established Oregon Guidelines for Timing of In-Water Work to Protect Fish and Wildlife (ODFW 2008).

Where these activities take place within an RCA, a 35-foot ERZ will be maintained, where vegetative, ground-disturbance, and tree-canopy removal will be minimized and best management practices followed. The ERZ will occur on both sides of the stream. This ERZ represents the land closest to the stream, including streambanks. Most riparian functions are supported to some extent by vegetation in this zone, including providing aquatic shade, delivering down wood and organic inputs (leaves and tree liter) to the stream and riparian area, stabilizing the streambank, contributing to floodplain functions, and influencing sediment-routing processes. To protect these processes ODF will minimize stream entry with machinery and choose locations to minimize the loss of riparian trees or cause increase erosion to the banks. Machinery access is permitted for stream enhancement and restoration work, as noted above for the RCA generally (see Conservation Action 3: Stream Enhancement).

The need for cable yarding corridors will vary, based on the location of the landing, relative to the RCA. Type F streams and large and medium Type N streams are most often located at the bottom of the slope that defines the boundary of a harvest unit. Where harvest units occur on both sides of streams in this location, they will normally be harvested from their respective sides, eliminating the need for yarding corridors. In steep terrain where one side is not directly accessible, or ODF seeks to minimize road building, skylines are anchored high enough on the opposite slope so that logs can be fully suspended, thereby minimizing the width of corridors. RCAs that are higher upslope in the harvest unit where they are closer to the yarder will require wider (20 to 35 feet wide) or more closely spaced corridors, versus RCAs lower in the unit far away from the yarder which can require fewer, smaller crossings widths (100 to 150 feet apart and 12 to 15 feet wide). Actual yarding corridor width will be determined by the size of the tree crowns, to allow for yarding lines to be lifted through the canopy without damaging the crowns of remaining standing trees, and to allow for felled trees to be yarded into and through the corridor without damaging or becoming hung up on remaining standing trees.

Management directions for how to operate inside of ERZs (0 to 35 feet) are listed below for each stream type.

All Type F Streams, All Sizes (Large, Medium, and Small)

- Road, trail, temporary stream crossings, culvert, and restoration activities:
    - Limit work location and activities to access, excavation, and other earth work needed for construction/removal of stream crossings, general road/trail maintenance, culvert installation/replacement, and instream restoration projects.
    - Minimize construction and project footprint, and limit tree and vegetation removal to not extend beyond what is necessary to accomplish the activity.
    - Follow best management practices identified in Conservation Action 11: Road and Trail Construction and Management Measures.
- Yarding activities:
    - No tree felling beyond what is necessary for safe, operational accommodation of the activity.
    - Full suspension required during cable yarding.
    - No ground-based equipment operation.
    - Leave any trees damaged or felled in RCAs from yarding activities, unless designated for in-water placement in other areas.
    - Where possible, fall trees toward the stream.
    - Average yarding corridors to be 15 to 20 feet wide, with a maximum of 35 feet (up to 10% of corridors on a given reach within a harvest unit), and be spaced no closer than 100 to 150 feet apart.

Large and Medium Type N Streams

- Road, trail, temporary stream crossings, culvert, and restoration activities:
    - Limit work to only those actions required for construction/removal of stream crossings, general road/trail maintenance, culvert installation/replacement, and instream restoration projects.
    - Minimize construction and project footprint, and limit tree and vegetation removal to not extend beyond what is necessary to accomplish the activity.
    - Follow best management practices identified in Conservation Action 11: Road and Trail Construction and Management Measures.

- Yarding activities:
  - No tree felling beyond what is necessary for safe, operational accommodation of the activity.
  - Full suspension required during cable yarding.
  - Average yarding corridors to be 15 to 20 feet wide, with a maximum of 35 feet (up to 10% of corridors on a given reach within a harvest unit), and be spaced no closer than 100 to 150 feet apart.
  - No ground-based equipment operation.
  - Leave trees damaged or felled from yarding activities.
  - Where possible, fall trees toward the stream (consistent with slash removal specifications outlined in OAR 629-630-0600).
  - Felling; Removal of Slash.

Small Perennial Type N, Small Seasonal Type N: High-Energy and Potential Debris Flow Track Streams

- Road, trail, temporary stream crossing, culvert, and restoration activities:
  - Limit work to only those actions required for construction/removal of stream crossings, general road/trail maintenance, culvert installation/replacement, and instream restoration projects.
  - Minimize construction and project footprint, and limit tree and vegetation removal to not extend beyond what is necessary to accomplish the activity.
  - Follow best management activities identified in Conservation Action 11: Road and Trail Construction and Management Measures.
- Yarding activities:
  - No tree felling beyond what is necessary for safe, operational accommodation of the activity.
  - No ground-based equipment operation.
  - Leave trees damaged or felled from yarding activities.
  - Average yarding corridors to be 15 to 20 feet wide, with a maximum of 35 feet, and be spaced no closer than 100 to 150 feet apart.
  - Where possible, fall trees toward the stream and leave in the RCA

Other Small Seasonal Type N Streams

- Road, trail, temporary stream crossings, culvert, and restoration activities:
  - Limit work to only those actions required for construction/removal of stream crossings, general road/trail maintenance, culvert installation/replacement, and instream restoration projects.
  - Minimize construction and project footprint, and limit tree and vegetation removal to not extend beyond what is necessary to accomplish the activity.

- Follow best management practices identified in Conservation Action 11: Road and Trail Construction and Management Measures.
- Maintain integrity of stream channel.
- Cover disturbed ground with limbs and branches as needed to prevent surface erosion.
- Leave existing down trees.

- Yarding activities:
  - Limit ground-based equipment operation to only conservation actions and those actions required for felling and removal of trees.
  - Less than 30% vegetative disturbance of the Equipment Restriction Zone.

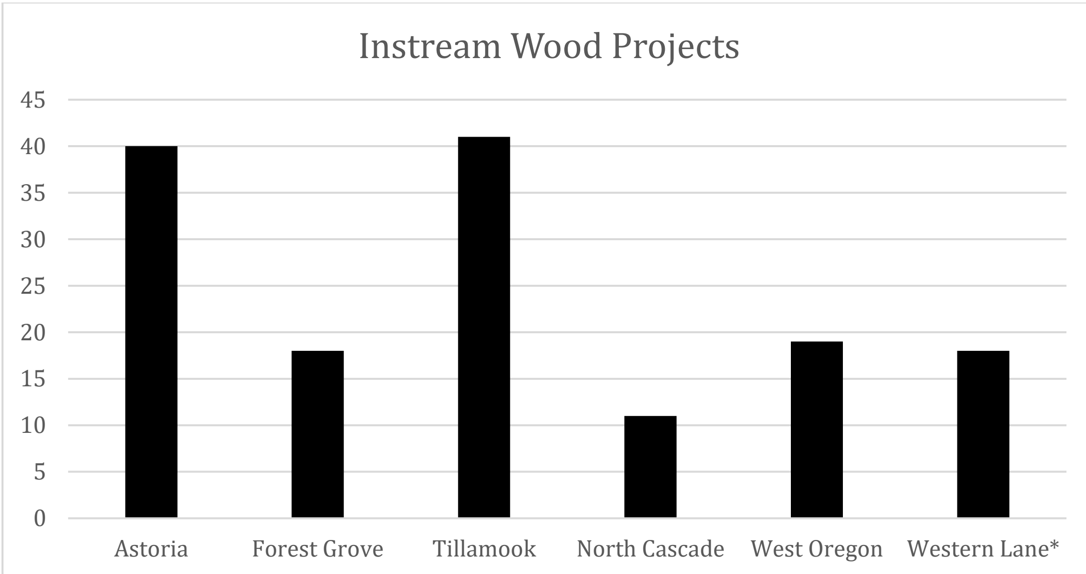
4.7.3 Conservation Action 3: Stream Enhancement

As shown in Table 4-2, Conservation Action 3 is intended to support the following biological objectives.

- 1.1 Wood Recruitment
- 1.2 Stream Enhancement Projects
- 1.4 Fish Passage

Stream enhancement projects will focus on restoring natural processes to create habitats that improve overall conditions for the covered species and other aquatic organisms in the permit area, allowing for immediate improvements to instream complexity, while the adjacent riparian forests are developing to provide long-term benefits. Appendix E provides an overview of fish populations in the permit area that could benefit from stream enhancement projects.

Over the course of 23 years (1995–2018) ODF has implemented 147 instream wood placement habitat projects in the permit area (Figure 4-15). These projects were designed and often implemented in collaboration with local ODFW biologists. Some projects were implemented during active harvest activities. Projects usually involved placing large woody material (typically at least five logs or trees per structure site with several sites per project) and/or boulders in streams to improve habitat conditions primarily for coho, but also for steelhead, or Chinook. During this same time period, ODF donated 7,009 logs to local watershed councils for use in similar stream enhancement projects that occurred throughout the species' range.



Source: OWEB 2020
*Western Lane totals represent data reported to Oregon Watershed Enhancement Board as Western Lane District, Coos District, and Grants Pass Unit, as all these lands are now managed out of the Western Lane District. Projects on Common School Forest Land in the Elliott State Forest are not reported in this graph.

Figure 4-15. Number of Stream Enhancement Projects Implemented by the Oregon Department of Forestry from 1995 to 2018 in the Permit Area, by Forest District

4.7.3.1 Commitment to Stream Enhancement Projects During the Permit Term

ODF will support restoration projects through the development of a Conservation Fund for ODF to execute restoration projects. For aquatics, the fund will focus on improvements that address limiting factors of the fish species covered by the HCP. Stream enhancement projects can range from installation of large woody material to more complex floodplain reconnections or channel restoration projects.

Project planning and design will consider basin, watershed, species action plans and assessments, local knowledge and expertise of current habitat conditions, intrinsic potential, stream processes, and the disturbance regime at the watershed and basin scale to identify areas best suited for enhancement (Appendix E). Projects will be designed and implemented consistent with the natural dynamics and geomorphology of the site and with the recognition that introduction of materials will cause changes to the stream channel. Projects will be selected that contribute to the timely improvement of desired aquatic conditions for the covered species within the permit area, described in the biological objectives. Depending on available resources, projects will be designed to create conditions and introduce materials sufficient to enhance or reestablish natural physical and biological processes.

Over the course of the permit term ODF will complete 440 instream improvement projects,[13] with an average of 60 projects being constructed per decade. Projects are expected to be located in areas where covered activities are occurring, with most work being focused in the northwest portion of the permit area (i.e., Clatsop and Tillamook State Forests). Ten-year restoration targets will be identified as part of the Aquatic Inventory Program (AIP) process using the identification of high-intrinsic-potential[14] stream reaches in the permit area so restoration projects target key areas that will produce the most beneficial response for the covered aquatic species (Burnett et al. 2007). Stream enhancement targets will be tied to and commensurate with the level of harvest expected in any one ESU during that 10-year implementation planning cycle. Chapter 6 describes how aquatic enhancement activities will be tracked during the permit term, including how Conservation Fund monies are expended on stream enhancement projects. Targeting specific limiting factors such as large woody material and overwinter habitat will achieve immediate benefits to salmon. Long-term benefits will be achieved through a focus on restoring habitat-forming processes, riparian vegetation, and connectivity in line with the reach's natural potential.

4.7.3.2 Beaver Management

Beaver (*Castor canadensis*) create ponds and other slow-water aquatic areas that provide important habitat for salmonids. Widespread commercial trapping in the 1800s resulted in declines in the beaver population. Today, beaver populations have rebounded, with populations occupying most of their former range (Naiman et al. 1998). The presence of beavers can strongly influence salmon populations in the side channels of large alluvial rivers by building dams that create pond complexes (Malison et al. 2016). Beaver ponds and slow-water habitat created by beaver provide important summer rearing and overwintering habitat (Castro et al. 2015). Pollock et al. (2004) found that smolt production increases significantly in systems where beavers are present. In coastal Oregon streams, reaches with beaver ponds and alcoves account for 9% of the habitat, but support 88% of the coho that were found in the system (Nickelson et al. 1992).

While beavers can occur in a variety of habitats, within the permit area they are likely to occur in small- to medium-sized, low-gradient streams that flow through unconfined valleys with a preference toward the lower gradient areas with *Populus* and *Salix* species (e.g., aspen, cottonwood, and willows; Castro et al. 2015 and Suzuki and McComb 1998). Quality beaver habitat can occur in all portions of the permit area; however, the majority of suitable beaver dam habitat, based on the Suzuki and McComb model, is located in the Clatsop State Forest and eastern portion of the Tillamook State Forest. Recent restoration work tends to rely on large wood to create salmon rearing habitat. A more cost-effective measure that would create the same types of pool habitat required by juvenile coho would be to promote existing populations of beaver, or introduce new individuals where beaver are currently absent (Pollock et al. 2004). Increasing the number of beaver dams in key areas could create high-quality rearing habitat that promotes stream complexity and increases smolt capacity (ODFW 2009).

---

[13] Projects are generally focused on increasing instream complexity and typically consist of at least five logs or trees per structure site with several sites per project. Other projects may include, but are not limited to, road decommissioning to reduce sedimentation, floodplain reconnection, and projects to promote the colonization of beaver.

[14] High-intrinsic potential is a measure of a stream’s capacity to provide high-quality habitat based on a fish species’ habitat requirement.

ODF will support the organic colonization and expansion of beavers in the permit area to promote watershed restoration and improvement of salmon and steelhead rearing habitat. During the first 10 years of implementation, ODF will use GIS to identify areas in the permit area with the potential to provide quality beaver habitat based on the following criteria from Suzuki and McComb (1998):

- Active Channel width – between 3 and 6 meters
- Valley Floor Width – >25 meters
- Channel Gradient – <3%

An additional 2 kilometers will be added upstream and downstream of the model reaches to encompass the average home range for a beaver colony. If natural disturbance occurs in areas where the presence of beaver and their associated dams would likely improve fish and aquatic habitat in the permit area, reforestation will occur in a manner that is beneficial to both the covered salmon and steelhead as well as beaver. A 50-50 mix of hardwoods and conifers will be planted with an emphasis on vine maple (secondarily willow, red osier dogwood, maple and red alder; Petro pers. comm.). Planting density will also be less than in non-beaver areas. If a beaver is found to continually dam a particular culvert, ODF will determine if that road crossing may be modified to reduce potential safety hazards that may be associated with beaver dam construction and other obstacles to water flow and debris movement. Increasing the size of culverts, the number of culverts, and/or suspending roads to eliminate culverts will increase road safety, reduce road maintenance costs, and reduce the frequency of responding to beaver-related flooding of roads. If a viable culvert update is not possible, the beaver(s) will be trapped and relocated to suitable habitat in the permit area for reestablishment based on the results of Suzuki and McComb (1998) and applied to the permit area.

Over the course of implementation, it may be decided that a beaver restoration project (e.g., installation of a beaver dam analog, beaver habitat enhancement, etc.) should be implemented to benefit the covered species. If such a project were proposed it would follow *The Beaver Restoration Guidebook: Working with Beaver to Restore Streams, Wetlands, and Floodplains* (Castro et al. 2015), or other relevant scientific literature, to develop achievable goals, strategies, and objectives that are in line with the HCPs Biological Goals and Objectives. Promoting the occurrence of beaver in the permit area, through both passive and active management will contribute to meeting Objective 1.2, *Stream Enhancement,* by improving floodplain connectivity, stream complexity, and slow-moving rearing habitat that would benefit the covered salmon and steelhead. ODF will coordinate this work with regional partners, ODFW, USFWS, and NOAA Fisheries to ensure beaver management actions fit into the larger context of salmonid recovery and statewide beaver management principles.

Aquatic Conservation Actions are focused on protecting and improving important watershed processes for the covered salmon, steelhead, and aquatic salamanders in the permit area. In addition to the Conservation Actions described above, aquatic species conservation activities that would benefit the covered salmon, steelhead, and aquatic salamanders as well as aquatic species of cultural importance could occur. Aquatic Conservation Actions are projects that would benefit covered species. The Conservation Fund is described in Chapter 9, *Costs and Funding*. The priorities for how the Conservation Fund is used will change during the permit term, but ODF will work with NOAA Fisheries, USFWS, and ODFW along with species experts and other partners to identify where and how Conservation Fund monies are spent. The actions described below are items currently known to benefit the covered salmon, steelhead, and aquatic salamanders. Other actions may emerge over the course of the permit term, so the items below should be treated as examples. The below actions are not expected to occur across the entire permit area, or with great frequency, rather they will be implemented on a case-by-case basis as determined by ODF during the 5-Year Mid-Point check-in and 10-Year Comprehensive Review.

4.7.3.3 Lamprey

In the permit area, Pacific lamprey are known or likely present within all watersheds where passage allows upward migration by adults (i.e., no impassable culverts, dams, or other barriers). Based on distribution data provided by the StreamNet database (2020), Pacific lamprey may be present in low-gradient streams throughout the plan area. Lamprey do not return to the streams they hatched in, but rather home in on pheromones released by larvae to reach spawning areas. Therefore, areas that do not have current larval populations may not attract returning adults (CRITFC 2011).

Conservation Action 1: Establish Riparian Conservation Areas, Conservation Action 2: Riparian Equipment Restriction Zones, Conservation Action 3: Stream Enhancement, Conservation Action 4: Remove or Modify Artificial Fish-Passage Barriers, Conservation Action 5: Standards for Road Improvement and Vacating, and Conservation Action 11: Road and Trail Construction and Management Measures will benefit lamprey by improving habitat conditions and access to previously inaccessible habitat. ODF understands that lamprey provide benefits to the covered species and properly functioning aquatic systems overall, and that they have cultural importance to the Tribes. As such, they will account for the presence of lamprey in lower gradient stream reaches as part of restoration project evaluation. If an evaluation identifies multiple projects that would have equal benefit, more weight may be given to a project in a location that would benefit lamprey in addition to the covered salmon and steelhead.

4.7.3.4 Selecting Stream Enhancement Projects

Stream enhancement projects will supplement benefits that will be realized from implementation of the Riparian Conservation Areas. The actions work together to avoid, minimize, and mitigate effects on covered species.

The implementation of RCAs will minimize increases in stream temperatures, minimize sediment transfer to streams from covered activities, and facilitate the recruitment of wood through natural tree fall and debris flow events. Therefore, the primary focus of stream enhancement projects will be to address areas that are slow to recover from disturbance or past land use or have deficient stream processes and/or habitat components that are required by the covered species. Stream enhancement projects, along with the remainder of the aquatic-related conservation actions, will collectively offset the impact of the taking of covered species over the course of the permit term.

ODF will consider the following factors when identifying, planning, and implementing stream enhancement projects:

- Ensure that stream enhancement projects are distributed in a fashion that addresses covered species at a level commensurate with the estimated level of effect from covered activities.
- Promote the recovery of the covered species by addressing a population(s) limiting factors.
- Promote the implementation of projects identified in local, state, or federal planning documents (e.g., recovery plans and watershed plans) that would provide the greatest benefit to the

covered species through partnerships with watershed councils, industry, Non-Governmental Organizations, and state and federal agencies (e.g., NOAA Fisheries, USFWS, ODFW).

- Prioritize projects that advance, or provide added benefit, to previous stream enhancement projects.
- Prioritize projects that can address multiple limiting factors over projects that address a single limiting factor, where applicable.
- Implement process-based restoration actions that create and maintain habitat. For instance, beaver habitat enhancement may be used in certain reaches to promote the creation of deep pool and off-channel habitat for juvenile salmon.
- Consider project feasibility: site accessibility, construction cost, area of habitat gained/cost, level of risk.
- Select projects based on the best available scientific information, including watershed-level modeling, in conjunction with habitat and fish distribution data from ODFW and other sources to assess potential project benefits. Areas designated as critical habitat with high-intrinsic potential scores will be prioritized.
- Prioritize projects that occur in the permit area. However, ODF will consider projects that occur outside the permit area. ODF contribution to projects outside the permit area will likely either be monetary contributions out of the Conservation Fund or be in the form of large wood donations for instream habitat enhancement projects. Projects that are located on ownerships outside the permit area will:
    - Directly benefit one of the covered species within a watershed (Hydrologic Unit Code [HUC] 10) that also includes a portion of the permit area.
    - Be done in partnership with other organizations or agencies. If partner agencies implement projects using ODF Conservation Fund monies, they are responsible for meeting any monitoring and reporting requirements in the HCP. Those items should be considered when determining funding arrangements with ODF.
    - Require the landowner(s) or manager(s) on whose ownership the project takes place to adhere to management standards in and around the project area that will ensure the project meets its objectives.

ODF will continue to support the implementation of the Strategic Action Plans (SAPs) for the Oregon Coast coho independent populations. ODF involvement will include providing sites for restoration work, access, and materials (e.g., wood). ODF's continued involvement in the SAPs will benefit Oregon Coast coho as projects will be designed to address their limiting factors. ODF will actively communicate with SAP owners (watershed councils) to ensure that when possible, ODF is contributing to specific actions identified in the SAPs. These actions will occur primarily in the permit area. Actions that occur outside the permit area but are done to benefit the covered species in the permit area may also occur and will be counted toward ODF's conservation actions goal. As needed, ODF will obtain input from ODFW for Implementation Plans and Annual Operations Plans and identify potential stream enhancement opportunities that could be incorporated into timber harvest and other management activities to benefit the covered species.

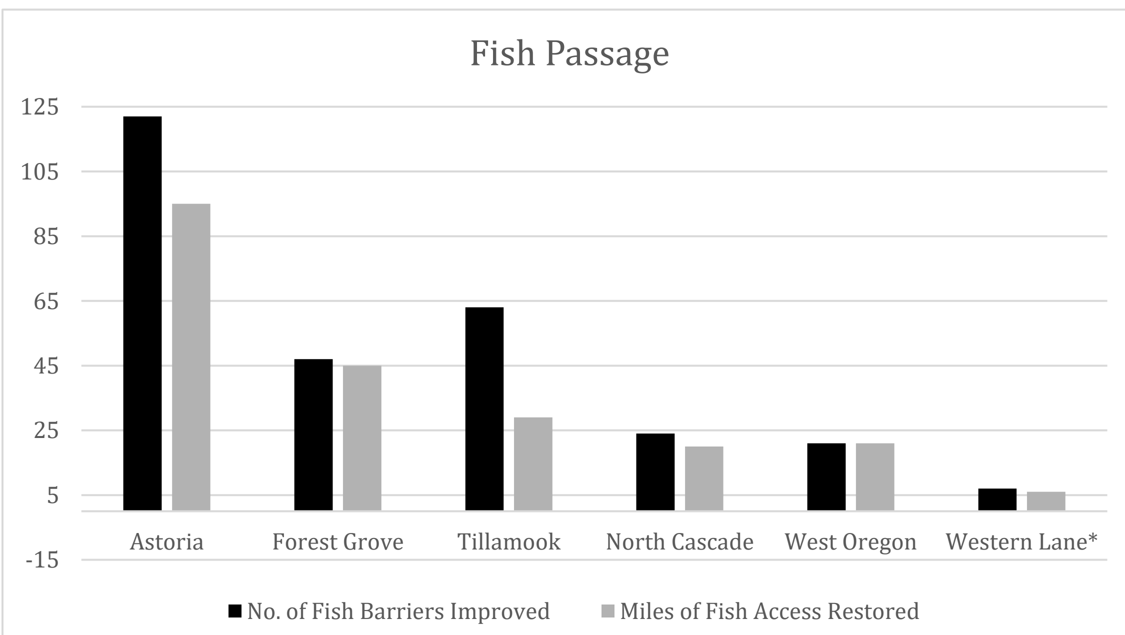
4.7.4 Conservation Action 4: Remove or Modify Artificial Fish-Passage Barriers

As shown in Table 4-2, Conservation Action 4 is intended to support the following biological objective.

- 1.4 Fish Passage

One of the biggest sources of salmon decline in the Pacific Northwest is the presence of a large number of artificial barriers, such as small dams, culverts, dikes, or levees that reduce or block access of salmon to large portions of their historical habitat (O'Hanley and Tomberlin 2005). Maintaining or improving fish passage through structures, such as culverts and other artificial barriers in streams, is critical to maintaining habitat connectivity (Roni et al. 2002). Reconnecting stream habitat that has been closed to salmonids is an important component when addressing impaired salmon stocks (O'Hanley and Tomberlin 2005). While fish passage is not identified as a primary limiting factor for the evolutionary significant unit/independent populations of covered salmonids, removing or improving fish-passage barriers in the permit area will benefit the covered species by increasing access to previously unavailable or underutilized habitat.

ODF has actively worked to replace blocked or undersized culverts to improve fish passage. Over the course of 23 years (1995 to 2018) ODF has implemented 284 fish-passage improvement projects to improve or open up access to 216 miles of stream. Most of this work has occurred in the Astoria District (Figure 4-16). Projects typically involved eliminating culvert jumps and placing new culverts so they will hold gravel and simulate a natural streambed.



Source: OWEB 2020
*Western Lane totals represent data reported to Oregon Watershed Enhancement Board as Western Lane District, Coos District, and Grants Pass Unit, since all these lands are now managed out of the Western Lane District. Projects on Common School land in the Elliott State Forest are not reported in this graph.

Figure 4-16. Number of Fish-Passage Projects Implemented from 1995 to 2018 in the Permit Area, by Forest District, and Miles of Fish Access Restored

In the permit area, there are currently at least 169 impassable fish barriers and 93 partial barriers, with the majority occurring in the northwest portion of the permit area (ODFW 2019; Table 4-7). Fish barriers will be reviewed during the Implementation Planning (IP) process, which occurs every 10-years as part of ODF's regular forest management planning process identified and evaluated for removal or improvement. ODF will prioritize improvements that will meet NOAA Fisheries' basin-wide objectives and have the greatest benefit for the covered species (fish and torrent salamanders). Following the prioritization process described by Roni et al. (2002), the review will identify culverts and other artificial blockages along with specific information on habitat quality and quantity and fish presence and absence above and below each blockage. This will allow for a prioritized list of culvert upgrades and end-of-life culvert replacements based on a cost-benefit analysis within each IP cycle. All new and replacement stream crossings in fish-bearing streams will be designed to meet NOAA Fisheries (2011 or most recent) passage criteria to maintain upstream and downstream passage for the covered fish species.

Table 4-7. Known Fish-Passage Barriers in the Permit Area by Independent Population

Population	Blocked	Partially Blocked	Unknown Anadromous	Total
Columbia River Chum – Coastal	14	9	18	41
Big Creek[a]	5	3	10	18
Claskanie River	7	5	8	20
Youngs Bay	2	1	0	3
Oregon Coast Coho	**124**	**83**	**51**	**258**
North Coast	**109**	**64**	**66**	**206**
Necanicum	0	1	0	1
Nehalem	63	30	16	109
Nestucca	2	10	2	14
Tillamook Bay[b]	44	23	15	82
Mid-Coast	**9**	**8**	**10**	**27**
Siletz	0	2	1	3
Siuslaw	2	4	6	12
Yaquina[c]	7	2	3	12
Mid-South Coast	**3**	**1**	**5**	**9**
Coos	3	1	5	9
Lakes	0	0	1	1
Tenmile	0	0	1	1
Umpqua	**3**	**10**	**2**	**15**
Lower Umpqua	1	4	0	5
Middle Umpqua	1	1	0	2
South Umpqua	1	5	2	8
Upper Willamette River Chinook	**14**	**0**	**0**	**14**
Molalla River	3	0	0	3
North Santiam River	11	0	0	11

Population	Blocked	Partially Blocked	Unknown Anadromous	Total
Upper Willamette River Steelhead	**16**	**1**	**3**	**20**
West Side Tributaries	16	1	3	20
SONCC Coho – Rogue	**1**	**0**	**0**	**1**
Illinois	1	0	0	1
Total	**169**	**93**	**72**	**334**

Source: ODFW 2019
Priority Barriers
[a] Gnat Creek Concrete Intake – Unknown Anadromous
[b] Tuffy Weir – blocked
[c] Unnamed Culvert – partial blocked

The following conditions identified in the inventory will be considered a priority for repair.

- Culvert outlet drops in fish-bearing streams where covered species are present and would benefit from improved fish passage.
- Nonembedded culvert with gradients above 0.5% slope.
- Structures such as old log fills.
- High washout potential due to an undersized structure and/or long steady grades below a stream crossing.
- Scour, oversteepening, or other erosion around culvert inlets and outlets.
- Structural deterioration of culverts.

From 1995 to 2018 ODF replaced an average of 12 culverts a year, with the number replaced being much lower in recent years because the most significant barriers (i.e., blocking the most habitat) had been completed. Recently, fewer and more complex and costly replacements have been completed. ODF commits to repairing or replacing at least 50% of the identified culverts that do not currently meet fish-passage requirements to provide passage for covered fish species over the course of the 70-year permit term. This equates to improving 167 culverts identified to date by ODFW (Table 4-7) as either complete barriers, a partial blockage, or unknown.

As shown in Table 4-7 (see table notes), there are currently three ODFW high-priority culverts in the permit area, one each in the Forest Grove, Astoria, and West Oregon Districts, were identified during the 2019 prioritization and will be reviewed by ODF for improvement as soon as feasible. These three barriers in the permit area are part of a larger group of barriers identified that represent the highest-priority fish barriers for fish passage in Oregon (ODFW 2019). These areas represent locations where culvert improvements would result in the greatest habitat gains for the covered species. These barriers will be corrected when they occur in a harvest unit. However, there is the likelihood that priority barriers will not overlap with proposed harvest units in the IP (10-year plan). ODFW updates the fish-passage priority list every 5 years. At each update, ODF will determine if additional priority barriers have been identified by ODFW's high-priority culvert inventory in the permit area that require additional review by ODF during the IP and Annual Operation Planning (AOP) processes. ODF will correct at least three ODFW priority barriers (as part of the 167 total barriers that will be upgraded) over the course of the permit term. If these upgrades do not overlap a harvest unit, Conservation Fund dollars will be used and work will be counted as mitigation to maximize benefit to the covered species in the permit area.

Some fish barrier removals or upgrades to state and federal standards will occur as part of routine haul road upgrades associated with planned harvest activities. A subset of barrier removals or upgrades will occur as targeted conservation actions outside of the harvest program. ODF's regional partners may be interested in addressing fish barriers in locations that are not planned to be harvested and therefore would not likely be candidates for passage upgrades as part of routine road upgrades or maintenance. In those instances, ODF may use Conservation Fund dollars to address fish passage issues as part of a standalone stream enhancement project. See Section 9.2.2.2 for a description of how Conservation Fund dollars may be used in those instances.

4.7.5 Conservation Action 5: Standards for Road Improvement and Vacating

As shown in Table 4-2, Conservation Action 5 is intended to support the following biological objectives.

- 1.3 Water Quality and Quantity
- 1.4 Fish Passage

As described in Chapter 2, many of the historic logging roads that remain in the permit area were not built to current design standards and can be improved. In other cases, historic roads were located in unsuitable areas and, therefore, cannot or should not be maintained because they are unstable, unsafe, or subject to chronic erosion. Where operationally or economically feasible these unsuitable roads will be vacated, closed, and stabilized to benefit the covered species. Requirements for road improvement and road vacating in the permit area are described in this conservation action as landscape enhancements. Conservation Action 11 describes ODF's maintenance of existing and usable roads to ensure their continued stability in order to minimize erosion into aquatic systems.

4.7.5.1 Road Drainage Repair Projects

Roads will be repaired or improved at sites that have been determined to be high risk for the covered species due to accelerated erosion and sediment loading, changes in channel morphology, or runoff characteristics of watersheds, all of which cause secondary changes in channel morphology and affect fish habitat (Furniss et al. 1991). Objectives associated with road improvements and associated best management practices are aimed at disconnecting the road system hydrologically from stream channels. Identification and prioritization of large hydrologic disconnection projects will be done as part of each IP, and more opportunistic or immediate needs (e.g., unanticipated culvert failure) will be addressed through the AOP process. To determine what road segments pose a risk to the covered species, ODF will use the best available data (i.e., historic inventories and watershed assessments) as a starting point to review the conditions of the road system in the permit area and conduct field inspections to identify potential erosion and landslide hazards in proposed harvest areas. Methods for identifying potential landslide areas include initial inspection of high-resolution topographic data (i.e., LiDAR), aerial photographs and, where necessary, field survey by a geotechnical specialist to identify sites with a high likelihood of failure and delivery to a stream (Roni et al. 2002). This process will identify existing roads that should be reconstructed or considered for removal, based on factors identified below, to reduce the potential for failure or contributing sediment to the stream channel:

Sidecast Failures/Slope Stability

- Steep slopes.
- Nearby slope failures.
- High cut slopes, i.e., over 15 feet high.
- Sidecast over 2 feet deep on steep slopes.
- Fills supported by trees and/or organic debris.
- Arc-shaped cracks in the fill or other evidence of fill movement.

Water Quality/Sediment Delivery[15]

- Direct delivery of sediment in runoff water from roads to streams.
- Ditch downcutting.
- Inadequate depth and/or poor-quality road surfacing.
- Damaged, collapsing, and/or inadequate drainage relief structures. Relief culvert shall be placed in the best location possible to allow filtering of sediment from the road ditches or upslope areas.

Eroding Soil on Cut-and-Fill Slopes

- Buried culverts and ditches.
- Fill erosion at culvert outlet.

Current/Planned Uses of Road

- Unsafe conditions are present, i.e., width, alignment, visibility, etc.
- Volume of traffic exceeds road design.
- Road surfacing will not accommodate current/planned uses.

Several factors will affect the final priority ranking of road projects, including the need and timing of the planned uses of the road; costs and biological benefits of the project; amount and type of environmental damage that is occurring or could occur; likelihood that damage will occur; and the risk of impacts to human life/safety or private property. Factors such as the availability of funds, equipment, staff capacity, the time of the year, and potential impacts on covered species will affect the scheduling of road improvement projects.

Projects may include the following items.

- Re-aligning the horizontal and/or vertical alignment of the road.

[15] Hydrologically disconnecting the road system from the stream.

- Upgrading stream crossings and culverts to meet NOAA Fisheries (2011 or most recent) fish-passage criteria (Conservation Action 4: Remove or Modify Artificial Fish-Passage Barriers).
- Installing additional cross-drainage structures.
- Reshaping the roadbed and/or ditch line for improved surface drainage.
- Upgrading the road surface by adding new rock.
- Removing and/or stabilizing fill slopes that exhibit instability.
- Relocating sections of roads away from sensitive areas, such as streams or springs.
- Repairing washouts, fill or cut slope failures, and severe damage to road surfacing.

The design of road repair projects will follow the general guidelines for road design and construction described previously and in Appendix H, *Forest Roads Manual*. However, because of the nature of some road projects, additional engineering and design work may be needed before construction begins.

4.7.5.2 Road Vacating

Some roads may need to be improved or vacated due to their proximity to a fish-bearing stream, high erosion potential, or landslide hazards that could affect the covered species when these issues cannot be addressed with road projects. The purpose of vacating roads is to disconnect the road system hydrologically from the stream channels. Vacated forest roads will be left in a condition where road-related damage to the waters of the State is unlikely. When a road is to be vacated and taken off the active road network, erosion prevention work will be performed so that continued maintenance is not necessary. Vacated roads will have sidecast material, stream crossings, culverts, cross drains and fills removed; unstable road and landing fills excavated; ditch and road surfaces treated to disperse runoff and prevent surface erosion; and exposed soils revegetated. Segments of a road that have near-natural levels of risk for sediment delivery can be left intact and receive minimal road drainage improvements.

Over the course of 23 years (1995 to 2018) ODF closed or vacated 138 miles of road in the permit area, primarily to reduce sediment transport to the aquatic system. Where feasible, alternate routes were established in ridgetop locations, and some roads were no longer needed for forest-management activities. The majority of this activity occurred in the Astoria District (Table 4-8).

Table 4-8. Miles of Roads Closed and Vacated (1995–2018)

District	Miles of Roads Vacated
Astoria	68
Forest Grove	8
Tillamook	31
North Cascade	14
West Oregon	4
Western Lane[a]	13
Total	**138**

[a] Western Lane totals represent data reported to the Oregon Watershed Enhancement Board as Western Lane District, Coos District, and Grants Pass Unit, because all these lands are now managed out of the Western Lane District.

During the permit term, ODF will review roads during the IP and AOP processes to identify sections that will be improved, vacated, closed, and/or gated in across the permit area to benefit the covered species.

4.7.6 Conservation Action 6: Establish Habitat Conservation Areas

As shown in Table 4-2, Conservation Action 6 is intended to support the following biological objectives.

- 4.1 Existing Oregon Slender Salamander Habitat
- 5.1 Existing Northern Spotted Owl Habitat
- 6.1 Existing Marbled Murrelet Nesting Habitat
- 6.2 Marbled Murrelet Nesting Habitat Enhancement
- 7.1 Occupied Red Tree Vole Habitat
- 7.2 Red Tree Vole Habitat Enhancement
- 8.1 Existing Coastal Marten Habitat

The designation, preservation, and long-term enhancement of HCAs throughout the permit area is the primary conservation action intended to conserve, maintain, and enhance habitat for the terrestrial covered species. As described below, ODF will immediately designate upon permit issuance approximately 275,000 acres of HCAs in 262 units to support the persistence of northern spotted owl, marbled murrelet, red tree vole, Oregon slender salamander, and coastal marten. These HCAs (and the portion of RCAs within them) represent 43% of the permit area that will be conserved, maintained, and enhanced to provide habitat for covered species throughout the permit term (Appendix F).

Ownership patterns also played a major factor in determining the location and extent of HCAs, including designating large HCAs where other public lands are lacking and ODF is the majority public land owner. Such areas occur primarily in the northern portion of the Coast Range Ecoregion. Of nine HCAs greater than 5,000 acres, eight are in the Clatsop and Tillamook State Forests (Coast Range Ecoregion), and one is in the Santiam State Forest (West Cascades Ecoregion). HCAs between 1,000 and 5,000 acres occur throughout the permit area, but are located predominantly on the north coast (22 of 30). Smaller HCAs are found throughout the permit area, but predominate on lands outside the north coast, where ODF managed lands are smaller and more scattered. These smaller HCAs are designated to protect and enhance known species occurrence, or provide connectivity between federal lands within smaller patchwork ownership patterns.

The overall purpose of HCAs includes the following.

- Conserve, maintain, and enhance existing habitat for terrestrial covered species in the permit area over the permit term.
- Improve lower quality and develop new habitat in HCAs, where necessary and where such treatments can be implemented effectively and efficiently, including expanding and connecting existing habitat to improve landscape-level habitat function.

- Limit management activities in HCAs to those necessary and prudent to improve habitat quantity and quality over the permit term.

Forests within HCAs will be managed to maintain and develop late-seral structure stands as they relate to specific habitat needs for individual covered species. As described under Conservation Action 7: Manage Habitat Conservation Areas, HCA standards will direct land-management activities in HCAs to improve long-term habitat values for covered species in HCAs.

4.7.6.1 HCA Design Criteria

ODF designed HCAs to avoid, minimize, and mitigate for the impacts of take of terrestrial covered species to the maximum extent practicable while maintaining an economically viable harvest program (Appendix F).

The primary design criteria for HCAs are to conserve, maintain, and enhance habitat in and adjacent to existing occupied habitat, as well as to increase overall habitat values for covered species at the landscape level. Over the course of the permit term, the HCAs will result in interconnected blocks of covered species habitat to help meet the goals and objectives stated in this HCP, including supporting the persistence of covered species under changing circumstances related to climate change.

The permit area contains patches of habitat suitable for covered species interspersed within a matrix of less suitable habitat or areas that are unsuitable. HCAs were designed to provide both local and landscape contiguity, and as a result contain both suitable habitat and non-habitat areas. Suitable habitat within HCAs will be managed only as needed to maintain or accelerate development of mature habitat conditions. Lower quality habitat and non-habitat will be allowed to develop naturally into habitat or managed to accelerate development of suitable habitat to expand and connect existing habitats (Conservation Action 7: Manage Habitat Conservation Areas).

HCA design criteria includes maintaining known habitat areas for protection of northern spotted owl and marbled murrelet nest sites. HCA boundaries provide buffering to known occupied species habitat, to avoid creating hard edges (e.g., within 100 meters of marbled murrelet nesting habitat). ODF will use both passive management and targeted silvicultural activities to increase the quality and quantity of covered species habitat over time in the HCAs. Improvement of covered species habitat in HCAs will balance habitat removed from covered activities outside of HCAs over the course of the permit term.

HCAs were established by considering the following criteria and available data.

- **Occupied habitat:** Areas where covered species are known to currently exist, including nesting locations and occurrence data for northern spotted owl, marbled murrelet and, where available, red tree vole.
- **Historically occupied habitat:** Areas where covered species have been documented in the past 30 years and where habitat remains, but where status is currently unoccupied or unknown. Historic sites with documented occupancy or occurrence over multiple years were identified as a priority for conservation.
- **Suitable habitat:** Areas that contain habitat suitable for covered species as defined by the habitat distribution models in Chapter 2 but that are currently unsurveyed or unoccupied.

- **Future habitat adjacent to suitable habitat:** Areas that do not currently contain suitable habitat but are adjacent to or close to areas with suitable habitat, and that can become suitable habitat efficiently and effectively, either passively or through active management. Over time, this will increase late-seral habitat amount, patch size, and connectivity, creating larger and better-connected blocks of suitable habitat than exist today.
- **Patch size:** Areas that already contain larger blocks of suitable habitat, as well as occupied habitat that is fragmented but that could be consolidated through long-term habitat development in areas between habitat patches.
- **Edge:** HCAs were designed to minimize the edge-to-area ratio to reduce "edge effects" on covered species, particularly marbled murrelets. This includes both patch HCA shape configuration and the inclusion of unsuitable habitat adjacent to designated occupied habitat.
- **Proximity**: Areas that are in proximity of other HCAs and suitable habitat managed by federal entities.
- **Adjacency**: Areas where the permit area is adjacent to covered species occurrences and habitat located on federal lands.
- **Geographic representativeness:** Areas that could serve to create an HCA network that is distributed across the permit area—rather than concentrated in a few areas—to maintain habitat availability across the full range of each covered species in the permit area (thus protecting the genetic diversity within subpopulations of covered species).

4.7.6.2 HCA Designations

The HCP designates 262 HCAs, totaling approximately 275,000 acres, or 43% of the permit area (including portions of RCAs occurring in HCAs). Designated HCAs include blocks of habitat in the northern portion of the Oregon Coast Ecoregion, an area where state lands are believed to be essential in maintaining and expanding the current distribution of both northern spotted owls and marbled murrelets (USFWS 2011, 1997).

Table 4-9 summarizes the acres of habitat in the permit area and the percentage of acres included in HCAs for the covered species. Additional habitat to be created over the term of the HCP is described under Conservation Action 7: Manage Habitat Conservation Areas.

4.7.6.3 Modifying HCA Boundaries

HCA boundaries were selected using a desktop exercise and were based on species occurrences and modeled habitat, as described above. During implementation it may be necessary to modify the boundaries of HCAs to better align with existing operational boundaries or to generally optimize how HCAs protect species occurrences or habitat. Adjustments to the boundaries of HCAs will only occur in situations where there is no net loss in acres for covered species habitat inside of the HCA in question. If an HCA boundary shift causes a reduction in habitat acres for covered species inside the HCA, it will not be allowed. All HCA boundary adjustments will be disclosed in annual reports, including the rationale for the adjustments.

Table 4-9. Acres of Covered Species Habitat in Habitat Conservation Areas

Species	Habitat in HCAs at the Beginning of Permit Term	% of HCAs that are Habitat at the Beginning of Permit Term[f]	Habitat Commitment in HCAs at End of Permit Term[g]
Northern spotted owl[a]	88,000[e]	32%	134,000
Marbled murrelet[b]	63,000	23%	142,000
Red tree vole[b]	53,000	19%	117,000
Oregon slender[c] salamander	16,000	6%	19,000[c]
Coastal marten[d]	27,000	10%	27,000

[a] Acres include modeled nesting, roosting, and foraging habitat

[b] Acres include modeled suitable and highly suitable habitat.

[c] Acres include the extent of Oregon slender salamander range in the permit area. In addition to the 19,000 acres that will be managed as Oregon slender salamander habitat in HCAs, retention standards described in Conservation Action 8: Conservation Actions Outside Habitat Conservation Areas and Riparian Conservation Areas, will ensure that Oregon slender salamander can persist in areas that are subject to harvest within the species range.

[d] Any portion of the permit area from northern Lane County south to the California border, west of I-5 is considered habitat. So the amount of habitat will not change dramatically during the permit term unless new lands are acquired by ODF. Within that landscape the HCAs are fixed, meaning that the amount of land inside HCAs will not change during the permit term. All of the 27,000 acres of coastal marten habitat are expected to be improved during the permit term, and habitat quality is expected to be higher at the end of the permit term than it is at the beginning.

[e] 28 out of 31 active northern spotted owl activity centers are inside of HCAs

[f] HCAs comprise approximately 275,000 acres. Species distribution does not cover the entire extent of HCAs so the percentage is not indicative of habitat quality. For example, Oregon slender salamander only occurs in the North Cascades, which comprises less than 15% of the permit area.

[g] Commitments to conserve, maintain, and enhance acres of covered species habitat are based on the assumption that at least 50% of nesting and roosting habitat and 80% of foraging habitat modeled to grow within HCAs over the 70-year permit term can be achieved.

4.7.7 Conservation Action 7: Manage Habitat Conservation Areas

As shown in Table 4-2, Conservation Action 7 is intended to support the following biological objectives for increasing long-term habitat for terrestrial species.

- 5.1 Existing Northern Spotted Owl Habitat
- 5.3 Northern Spotted Owl Habitat Enhancement
- 6.2 Marbled Murrelet Nesting Habitat Enhancement
- 7.2 Red Tree Vole Habitat Enhancement
- 8.2 Coastal Marten Habitat

The overarching management objective for HCAs is to increase the quality and quantity of habitat for terrestrial covered species. Therefore, the only management actions that will occur in HCAs are those that will contribute toward achieving that objective, or at least do not preclude that the objective will be achieved (e.g., recreation activities conducted consistent with the HCP and ITP).

Stand management activities in HCAs will be implemented in order to improve habitat for covered species. Typically this will include a variety of density management prescriptions in young healthy conifer forests to ensure that late-seral structure develops more quickly. In some cases, such as stands that are dominated by hardwoods or infested with Swiss needle cast it will be more efficient to conduct regeneration harvests and replant a species mix that will develop into covered species habitat in a shorter time frame. Management activities in HCAs will incorporate principles and techniques of ecological forestry (Franklin et al. 2018). Silvicultural prescriptions such as variable-density thinning and variable retention harvest will be primary tools for advancing stand structure and habitat development.

The pace and scale of these activities is described below along with a description of the types of stand management that will occur in HCAs. As the intention for management activities in HCAs is to improve covered species habitat it follows that stands that are already high quality habitat will require little to no management. Stands that provide lower quality habitat or no habitat will be managed more frequently, in order to increase the quality and quantity of habitat during the permit term. The majority of stand management that occurs in HCAs will be in locations that currently provide limited habitat value for covered species. Further, many of the stands in HCAs will be managed passively, allowing habitat to develop without intervention. This section provides a discussion of which management activities can occur in species habitat and the relative frequency of those activities.

During HCP implementation all management activities in HCAs will be disclosed in IPs and AOPs. Management activities slated for the upcoming year will be disclosed in the AOP and HCP annual report of the preceding year. The effectiveness of management activities will be reviewed during the 5-year midpoint check-in and during the 10-year comprehensive review. Changes to management activities in response to the results of habitat monitoring will be outlined in each subsequent IP.

4.7.7.1 Management of Existing Habitat in Habitat Conservation Areas

Stands in HCAs that already contain suitable habitat for covered species are expected to require minimal management to maintain those habitat conditions. Therefore, management of existing habitat in HCAs will be limited to treatments that will clearly enhance habitat in the near-term by creating specific habitat components such as snags or small stand gaps (0.5 to 2 acres) to increase stand heterogeneity. Insects, disease and fire are natural components of forest ecosystems, and treatments to address these risks may entail short-term degradation of late seral stands that are already functioning as habitat for covered species. For instance, the removal of ladder fuels can reduce canopy layering, or the removal of insect infested trees can result in less future snag and large wood recruitment. As a result, habitat within HCAs will generally not be managed. Instead, treatments to reduce fire, insect and disease risk will occur in stands adjacent to late seral stands, rather than within late seral stands. Fire risks may increase over time due to climate change (Oregon Climate Change Research Institute 2017), so actions to reduce fire risks to late seral habitat may also increase over time, but this should be partially ameliorated by treatments in other stands and the ingrowth of additional late seral habitat within HCAs over the permit term.

Application of conservation actions will be based on site-specific conditions, as informed by forest inventory data and baseline surveys. Specific treatments will also follow measures to minimize displacement or disturbance to covered species, as outlined in Conservation Action 10: Operational Restrictions to Minimize Effects on Covered Species.

4.7.7.2 Management to Accelerate Development of Habitat in Habitat Conservation Areas

Managing stands in HCAs that are lacking habitat characteristics for covered species will help promote development of them as the forest grows. These important characteristics include large trees and snags, multistoried and multi-species canopies, and large woody material. The primary purpose of these management actions is to selectively and strategically improve and accelerate development of such habitat characteristics for terrestrial covered species that rely on late-seral forests.

There is broad professional consensus that thinning and other silvicultural treatments can accelerate the development of late-seral forest characteristics, including habitat suitable for northern spotted owls (Kuehne et al. 2015, Dodson et al. 2012, Andrews 2005). The Revised Recovery Plan for Northern Spotted Owl (USFWS 2011) notes that thinning can be effective in accelerating development of northern spotted owl habitat, particularly in stands 50 years or older that contain uniform, densely stocked stands that are not likely to achieve habitat complexity for many decades without intervention. Newton et al. (2015) found that variable density thinning within such stands (50 to 55 years old) allowed development of some larger trees by the age of 65, as well as increasing overall structural and tree species diversity. While thinning may have short-term adverse effects on habitat quality (USFWS 2011), Newton et al. (2015) reported that crown cover increased rapidly during the 15 years following thinning. In addition, these younger stands typically have lower habitat suitability, so short-term effects of thinning are less impactful to covered species. ODF will manage varying types of partial cutting (i.e., variable density thinning, variable retention harvest, patch cuts) to increase vertical and horizontal spatial heterogeneity, overall tree size, structural complexity, compositional diversity, and understory development (Table 4-10). As a stand becomes older, the intensity of silviculture applied becomes generally less intensive, to balance potential short-term adverse effects with long-term habitat development (Chapter 3; Table 4-12).

In addition to increased habitat quality over time for northern spotted owl (Objective 5.3), these types of management activities will also serve to achieve biological objectives for marbled murrelets (Objective 6.2) and red tree voles (Objective 7.2; Table 4-10). Application of management activities to accelerate development of suitable and highly suitable habitat will be based on site-specific conditions, as informed by forest inventory data and baseline surveys, and occur early in the HCP permit term, in order to realize the benefits to these species prior to the end of the permit term. Specific treatments will also follow measures to minimize disturbance to covered species, as outlined under Conservation Action 10: Operational Restrictions to Minimize Effects on Covered Species.

4.7.7.3 Pace and Scale of Stand Management Activity in HCAs

The HCAs are intended to provide protection for existing covered species habitat and be the focus of habitat improvement over time. At approximately 275,000 acres (43% of the permit area) this is a sizeable commitment to terrestrial species habitat that is designed to offset the impacts of habitat loss outside of HCAs over the permit term. While management in HCAs for habitat improvement is an important element of the overall conservation strategy, careful planning and consideration of how to minimize effects from management actions on covered species is equally essential. This section describes the pace and scale of management activities in the three management categories: (1) healthy conifer stands, (2) Swiss needle cast stands, and (3) hardwood-dominant stands. By limiting the pace and scale of acres managed in HCAs temporal effects on species habitat can be minimized. Additional restrictions on where stand management activities can occur, relative to existing species habitat, are shown in Table 4-11. No stand management activities will occur inside RCAs, even within HCAs. Reforestation and young stand management practices in HCAs are described in Chapter 3.

Healthy Conifer Stands

There are approximately 180,000 acres of healthy conifer stands inside of HCAs. At least 70,000 acres are potential candidates for management. Many of these stands have a high original planting density intended for timber production, and will persist as simple, closed canopy stands without a reduction in density and overall uniformity. To improve covered species habitat, these stands would receive thinning and patch cuts that will increase growth of dominant trees and allow for the initiation (or re-initiation) of understory tree and shrub species that will increase both vertical and horizontal heterogeneity, as well as species diversity, within the stand. A summary of silviculture prescriptions that will be used and the expected biological outcomes from those activities is provided in Table 4-10.

To assist in meeting the biological goals and objectives for the terrestrial covered species ODF plans to actively manage up to 45,000 acres (16% of HCAs) of healthy conifer stands during the first 30 years of the permit term. Focusing management early in the permit term will allow time before the end of the permit term for stands to respond to management and better habitat to develop. On average, the 45,000 acres will be spread evenly over the 30 years. To minimize effects on covered terrestrial species, management actions will follow the operational restrictions described in Conservation Action 10. Though the acres of healthy conifer stands treated within HCAs will vary year to year, acres sold in any one year will likely average 1,500 acres for the entire permit area and will not exceed 2,500 acres in any year or 7,500 acres across a 5-year period. Further, the 7,500 treated acres in each 5-year period will be distributed among multiple HCAs.

Swiss Needle Cast Stands

There are approximately 46,000 acres in HCAs that are moderately to severely infected Swiss needle cast stands[16] (17% of HCAs). Of those, approximately 20,000 acres provide opportunities for management because they are on accessible terrain or in accessible locations. The focus of management in a subset of these stands within HCAs will be to reset stands that are stunted, due to Swiss needle cast, and will likely not become high quality habitat for covered species over the course of the permit term. By harvesting those stands early in the permit term, including regeneration

[16] The severity of Swiss needle cast damage can be assessed by several methods: aerial survey, ground-based foliage retention assessments, and growth assessment. Aerial detection surveys describe discoloration of Douglas-fir foliage in April and May as moderate (yellow) or severe (yellow-brown and sparse), and provide a very coarse qualitative estimate of where disease is severe enough to cause tree damage. Foliage (needle) retention is measured by examining individual tree branches in spring or early summer before budbreak and estimating the number of annual foliage complements present on the tree; it is the most reliable and widely used method of estimating tree volume growth loss due to Swiss needle cast (Shaw et al. 2014, Maguire et al. 2002, Maguire et al. 2011). Tree volume loss from Swiss needle cast ranges from approximately 50% with a foliage retention of 1 or less to no loss when foliage retention is 3.5 or greater. In terms of foliage retention, disease severity is considered low when retention is 2.6–3.5 years; medium = 1.6–2.5 years; and high = <1.5 years (Filip et.al. 2000). Crown-length to sapwood-area ratio (CL:SA) is a measure of crown sparseness and Swiss needle cast severity. It requires several tree measurements and increment coring to measure sapwood radius; it offers no advantages over foliage retention (except perhaps in large trees) and is seldom used.

harvests that remove significant portions of stands, ODF will be able to replant the stands with a species mix that will grow into more suitable habitat during the permit term. Swiss needle cast regeneration prescriptions will include the retention of other conifer and hardwood species that are unaffected by the disease. A summary of stand management techniques that will be used and the expected biological outcomes from those activities is provided in Table 4-10.

To assist in meeting the biological goals and objectives for the terrestrial covered species ODF plans to manage up to 15,000 acres (6% of HCAs) of Swiss needle cast infected stands in HCAs during the first 30 years of the permit term. On average, the 15,000 acres will be spread evenly over the 30 years. In order to minimize effects on covered terrestrial species management actions will follow the operational restrictions described in Conservation Action 10. Though the acres of Swiss needle cast stands treated within HCAs will vary year to year, the acres sold in any one year will likely average 500 acres for the entire permit area and will not exceed 1,000 acres in any year or 5,000 acres across a 5-year period. Further, the 5,000 treated acres in each 5-year period will be distributed among multiple HCAs.

Conifer Restoration in Hardwood-Dominant Stands

There are roughly 50,000 acres of hardwood-dominant stands inside of HCAs, primarily red alder (18% of HCAs). Hardwood-dominant stands include those that have >50% hardwood species. Hardwood species have value for covered species and other wildlife; however, large expanses of red alder dominant stands with little conifer component are unlikely to develop into suitable or highly suitable habitat for marbled murrelets or red tree voles and are unlikely to support nesting northern spotted owls over the permit term. Therefore, there will be a focus on managing a portion of hardwood-dominant stands (primarily red alder) in the first 30 years of the permit term in order to reforest those stands with conifer species that will grow into higher quality habitat for covered species over time. In addition to the reforested conifer component, existing conifers will be retained where operationally feasible, and some hardwoods will also be retained in these stands during harvest. A summary of stand management techniques that will be used and the expected biological outcomes from those activities is provided in Table 4-10.

To assist in meeting the biological goals and objectives for the terrestrial covered species ODF plans to utilize stand management practices up to 15,000 acres (6% of HCAs) of hardwood-dominant stands in HCAs during the first 30 years of the permit term. Focusing management early in the permit term will allow time before the end of the permit term for stands to respond to management and better habitat to develop. On average, the 15,000 acres will be spread evenly over the 30 years. In order to minimize effects on covered terrestrial species, management actions will follow the operational restrictions described in Conservation Action 10. Though the acres of hardwood-dominant stands treated within HCAs will vary year to year, the acres sold in any one year will likely average 500 acres for the entire permit area and will not exceed 1,000 acres in any year or 5,000 acres across a 5-year period. Further, the 5,000 treated acres in each 5-year period will be distributed among multiple HCAs. The remaining 35,000 acres of hardwood-dominated stands in HCAs that are not proposed for management will provide some foraging habitat diversity, and allow for comparative analyses in an adaptive management framework to assess the efficacy of treatments intended to promote habitat.

Managing In Covered Species Habitat

Stand management activities in HCAs will frequently occur in covered species habitat. HCAs were designed to conserve the highest quality existing covered species habitat and nearly all known occupied parts of the permit area; however, there are many areas of lower quality habitat in HCAs, given the size of HCAs and the disturbance and management history of the permit area. Over time HCAs will become better habitat for terrestrial species as more acres of lower quality habitat grow into higher quality habitat. It is imperative to manage carefully in HCAs so short-term harm to covered species can be minimized in favor of long-term benefits.

Table 4-11 outlines what types of management activities can occur in various types of covered species habitat. The table is organized by species and linked to the species habitat models described in Chapter 2. Habitat suitability indices are used as a guide for the frequency and type of management activities. In some cases no management is proposed, particularly in occupied habitat. Table 4-11 is meant as an initial guide for management in HCAs, but stands will be evaluated in the field for suitability prior to management, especially in the initial years of the HCP. As time progresses and species habitat is better understood through improved modeling, forest inventory and field assessments, management activities will be adapted to maximize habitat gains while minimizing short-term negative effects.

As described above, management will be more frequent in stands with lower habitat suitability and less frequent in stands with higher habitat suitability. The frequency of management in each type and quality of covered species habitat is described using a percentage of total management expected to occur in a typical year (see above). The frequency of management in covered species habitat in HCAs is as follows:

- Rare = <5% of total managed acres in HCAs occurs in this habitat type.
- Infrequent = <25% of total managed acres in HCAs occurs in this habitat type.
- Frequent = >75% of total managed acres in HCAs occurs in this habitat type.

The frequency and type of management expected in each covered species habitat category is shown in Table 4-11. As a blanket rule, management activities in northern spotted owl nesting and roosting habitat or marbled murrelet and red tree vole highly suitable habitat will not reduce habitat quality. Management in these habitat types will be rare and precise (e.g., single tree removals), so the risk of reducing habitat quality is low.

Table 4-10. Summary of Expected Biological Outcomes from Planned Silvicultural Prescriptions

Stand Type	Silvicultural Prescriptions	Expected Biological Outcomes
Healthy Conifer	• ***Light Thinning*** – Retain at least 40% of basal area (BA) (e.g., 140 sq. ft.) and 50% of canopy cover; more commonly 35–45% stand diversity index (SDI).	To improve tree growth and development of limb structure, and maintain a well-stocked stand of healthy, wind-firm trees. Maintenance and improvement of stands that buffer known occupied habitat, or suitable habitat of unknown occupancy. Increase overall mature forest connectivity among suitable patches. Intended to improve buffer function and murrelet habitat development while minimizing edge effects and disturbance.
	• ***Moderate Thinning*** – Thin to 25–35% SDI.	To maintain growth and enhance limb and crown structure of the dominant cohort and foster natural recruitment of minor tree and understory species. Improve trajectories for understory development, compositional diversity, and canopy layering. Development of higher quality suitable habitat and mature forest connectivity.
	• ***Heavy Thinning*** – >80 sq. ft. BA but <25% SDI; >15 trees per acre (TPA)	Applied to dense stands with poor vigor and diversity (e.g., offsite seed Douglas-fir plantations), particularly when a legacy component is present that can be retained. Heavily thinned areas can be underplanted with minor, shade-tolerant species to promote complex patches of early seral stage forest, including a dominant cohort of emergent trees with complex limb and crown structure, a well-developed mid-story of co-dominant and subdominant species, and a diverse, patchy understory. Planting will generally not include dense monoculture stands of Douglas-fir. Positions stand for further habitat development for one or more covered species.
	• ***Variable Density Thinning*** –	Combines light, moderate, and heavy thinning within a stand at scales that mimic spatial heterogeneity in late-seral forests resulting from small-scale disturbances and unmanaged stand development. Variable-density thinning can be combined with patch cuts (e.g., in root-rot pockets) and underplanting to improve spatial heterogeneity, compositional diversity, understory development, canopy layering, and structural complexity of dominant and subdominant cohorts. Applied at 0.25- to 5.0-acre scale, patch cuts <15% of unit.
	• ***Single Tree Removal*** – Typically removes 15% BA from an intermediate or subdominant cohort. Rarely, used to address forest health or hazard issues. Some trees may be marked as a specific premium, or specialty product, and go to market.	Entails removal of very few trees per acre and is intended to improve tree growth and layering, increasing spatial heterogeneity. In many instances, felled trees are left as downed wood, or simply topped for snag creation.

Stand Type	Silvicultural Prescriptions	Expected Biological Outcomes
Swiss Needle Cast Stands	• ***Retention Harvest*** – At least 10–15 TPA (borders on heavy thin) are retained, prioritizing any larger, healthy Doug-fir to 30–45 sq. ft. BA and all other conifers and hardwoods to approximately 80 sq. ft. total BA.	Regeneration harvest with higher levels of retention is used to treat moderate to severe Swiss needle cast infestations while retaining existing habitat elements. Retention levels are variable across a harvest unit, with individual trees scattered and clumped in random or non-random configurations depending on circumstances. Subsequent stands are underplanted with SNC-tolerant seed and minor species to promote complex patches of early seral stage forest. Results in a stand that is positioned for future habitat treatments to grow into habitat for covered species in an accelerated timeframe. Treatments are intended to improve spatial heterogeneity, compositional diversity, understory development, canopy layering, and structural complexity of dominant and subdominant cohorts relative to untreated stands with similar conditions.
	• ***Modified Clearcut*** – Generally occurs where trees are larger (older). 5–10 TPA are retained, prioritizing Doug-fir >18 inches (or >24 inches) and all other conifers and hardwoods, generally to <40 sq. ft. total BA.	Removes majority of Swiss needle cast component while retaining largest trees available, and tree species that are resistant to Swiss needle cast. Replanting with a mix of conifer tree species to promote complex patches of early seral stage forest. Results in a stand that is positioned for future habitat treatments to grow into habitat for covered species in an accelerated timeframe. Treatments are intended to improve spatial heterogeneity, compositional diversity, understory development, canopy layering, and structural complexity of dominant and subdominant cohorts relative to untreated stands with similar conditions.

Stand Type	Silvicultural Prescriptions	Expected Biological Outcomes
Conifer Restoration in Hardwood-dominant Stands	• ***Retention Harvest*** – Red alder is the primary hardwood species targeted for removal and at least 10–45 TPA are retained (borders on heavy thin), prioritizing any larger, conifers (e.g., hemlock >16 inches or Doug-fir >24 inches) and hardwoods to a range of 30–120 sq. ft. total BA. Retention levels contingent on species composition, tree size, and density.	Regeneration harvest with higher levels of retention is used to treat moderate to hardwood-dominant stands while retaining existing habitat elements. Retention levels are variable across a harvest unit, with individual trees scattered and clumped in random or non-random configurations depending on circumstances. Subsequent stands are underplanted with a diversity of species to promote complex patches of early seral stage forest. Results in a stand that is positioned for future habitat treatments to grow into habitat for covered species in an accelerated timeframe. Treatments are intended to improve spatial heterogeneity, compositional diversity, understory development, canopy layering, and structural complexity of dominant and subdominant cohorts relative to untreated stands with similar conditions.
	• ***Modified Clearcut*** – Generally occurs where trees are larger (older). 5–10 TPA are retained, prioritizing the largest conifers >18 inches (or >24 inches) and hardwoods, generally to <40 sq. ft. total BA.	Removes majority of the hardwood component (primarily red alder) while retaining largest conifer trees available, as well as some hardwoods, replanting with a mix of conifer tree species to promote complex patches of early seral stage forest. Remaining hardwood component provides diversity. Results in a stand that is positioned for future habitat treatments to grow into habitat for covered species in an accelerated timeframe. Treatments are intended to improve spatial heterogeneity, compositional diversity, understory development, canopy layering, and structural complexity of dominant and subdominant cohorts relative to untreated stands with similar conditions.
Young Stand Management	• ***Site Preparation, Reforestation, Manual Release, Precommercial Thinning*** – Applies to retention harvests and modified clearcuts, and may apply to patch cuts and heavy thins.	Plantings will occur at lower densities and incorporate greater proportions of minor species (western red cedar, Sitka spruce, western white pine, hemlock, true firs). Natural regeneration will be allowed to occur in some small patch cuts, and root-rot tolerant species will be planted where patch cuts are used to address infestations. If needed, alternative management plans will be filed where restocking conditions fail to meet FPA standards. Intensity of manual release operations will be reduced to allow for some hardwood retention and development. These treatments are intended to promote complex early seral stand conditions that have greater potential to develop into high quality habitat for the covered terrestrial species than more intensive production-oriented treatments and prescriptions.

Table 4-11. Summary of Management Type and Frequency in Select Covered Species Habitat in HCAs

Species	Habitat Type	HSI[a]	Habitat Characteristics (mean)	Frequency[b]	Rationale for Management	Likely Silvicultural Activities	Expected Biological Outcomes
Northern Spotted Owl	Core Area 250 acres around active activity center	Best Available	Include best available habitat and areas of known use	Never	Preserve integrity of potential nesting and immediate post-fledging area, or core use area for resident singles and non-nesting pairs	None	Maintain integrity of core area, minimize disruption of breeding activities
	Within 0.7 mile of Active Activity Centers	0.6–1.0	Age: >93 Height: >142 TPA 30: >13 DDI: >6.1	Never	Maintain minimum of 50% (500 acres) in foraging or better habitat to support persistence	None	Support persistence of active sites
	Nesting/Roosting	0.7–1.0 0.6–0.69	Age: >113 Height: >151 TPA 30: >17 DDI: >6.8	Rare	Address limiting factors to improve quality, e.g., decadence features, simple structure	Single Tree Treatments, e.g., snag or downed wood creation	Accelerate development of structural habitat features of interest, enhance understory development and diversity to support prey
			Age: >93 Height: >142 TPA 30: >13 DDI: >6.1	Rare	Address limiting factors to improve quality, e.g., decadence features, simple structure, homogeneous landscape	Group Selection or Single Tree Treatment	Accelerate development of structural habitat features of interest, promote understory and midstory development and diversity, enhance spatial heterogeneity

Species	Habitat Type	HSI[a]	Habitat Characteristics (mean)	Frequency[b]	Rationale for Management	Likely Silvicultural Activities	Expected Biological Outcomes
	Foraging	0.4–0.59	Age: >66 Height: >119 TPA 30: >3 DDI: >5.6	Infrequent	Address dense, homogeneous stands with little canopy diversity, poor limb development, and suppressed understory cover to increase quantity and quality of nesting/roosting habitat Large limb development benefits to other covered species (platform quality, red tree vole habitat complexity)	Variable Density Thinning; Moderate Thinning	Accelerate development of dominant and midstory trees (canopy complexity), promote understory development and diversity, enhance structural complexity and spatial heterogeneity

Species	Habitat Type	HSI[a]	Habitat Characteristics (mean)	Frequency[b]	Rationale for Management	Likely Silvicultural Activities	Expected Biological Outcomes
	Dispersal	0.3–0.39	Age: >51 Height: >103 TPA 30: >5 DDI: >0.4	Common	Address dense, homogeneous stands with little canopy diversity, poor limb development, and suppressed understory cover to increase quantity and quality of nesting/roosting and foraging habitat Large limb development benefits to other covered species (platform quality, red tree vole habitat complexity)	Variable Density Thinning; Heavy or Moderate Thinning	Accelerate development of dominant and midstory trees (canopy complexity), promote understory development and diversity, enhance structural complexity and spatial heterogeneity, provide for potential future habitat pathways

Species	Habitat Type	HSI[a]	Habitat Characteristics (mean)	Frequency[b]	Rationale for Management	Likely Silvicultural Activities	Expected Biological Outcomes
	Not Habitat	<0.29	Age: <51 Height: <103 TPA 30: <5 DDI: <0.4	Common	Address dense, homogeneous stands with little canopy diversity, poor limb development, and suppressed understory cover to increase quantity and quality of nesting/roosting and foraging habitat Large limb development benefits to other covered species (platform quality, red tree vole habitat complexity)	Retention Harvest; Modified Clearcut[c]; Variable Density Thinning; Heavy, Moderate, and Light Thinning	Accelerate development of dominant and midstory trees (canopy complexity), promote understory development and diversity, enhance structural complexity and spatial heterogeneity, provide for potential future habitat pathways in non-habitat
Marbled Murrelet	Designated Occupied Habitat Includes known occupied survey areas AND areas of high-quality habitat, even in the absence of survey results	Delineated based on occupied and highly suitable habitat with known or expected occupancy	Age: >108 Height: >153 TPA 30: >16 for unsurveyed areas designated as occupied. N/A for areas designated as occupied based on survey data	Never	Maintain and protect known occupied and other highly suitable habitat	None	Maintain integrity of known breeding areas and other likely nesting habitat, minimize disruption of breeding activities

Species	Habitat Type	HSI[a]	Habitat Characteristics (mean)	Frequency[b]	Rationale for Management	Likely Silvicultural Activities	Expected Biological Outcomes
	100 meter non-habitat buffer around designated occupied habitat	< 0.29	Age: <75 Height: <130 TPA 30: <6	Rare	Manage for continuous forest structure and cover, reduce edge effects, promote interior habitat.	Light Thinning	Increased tree growth improves buffer function and cover to suitable nest trees in designated occupied habitat while minimizing short-term risks of increased predation, windthrow, or microclimatic changes that affect habitat quality
	Highly Suitable	0.6–1.0	Age: >108 Height: >153 TPA 30: >16	Rare	Large limb development benefits to other covered species (platform quality, spotted owl access to prey)	Single Tree Removal	Quality of nest substrates, enhanced, canopy complexity enhanced over time
	Suitable	0.3–0.59	Age: >75 Height: >130 TPA 30: >6	Infrequent	Large limb development, benefits to other covered species (platform quality, spotted owl access to prey)	Group Selection or Single Tree Removal; Variable Density Thinning; Moderate Thinning	Quality of nest substrates, enhanced, canopy complexity enhanced over time

Species	Habitat Type	HSI[a]	Habitat Characteristics (mean)	Frequency[b]	Rationale for Management	Likely Silvicultural Activities	Expected Biological Outcomes
	Not Habitat	<0.29	Age: <75 Height: <130 TPA 30: <6	Common	Address dense, homogeneous stands with little canopy diversity and limited limb development to increase quantity and enhance quality of suitable habitat	Retention Harvest; Modified Clearcut[c]; Variable Density Thinning; Heavy, Moderate, and Light Thinning	Accelerate development of dominant and midstory trees with complex limb and crown structure to improve amount and quality of suitable nesting platforms and associated cover, provide for potential future habitat pathways in non-habitat
Red Tree Vole	≥10 acres around known nest trees with connectivity among buffered areas, larger skips incorporated in larger thinning projects.	>0.4	Age: >74 DDI: >5.6 TPA >30	Never	Buffer and maintain known occupied nest trees in addition to protected habitat for northern spotted owl and marbled murrelet	None	Protect nest tree and groups of trees around nest locations and maintain connectivity among known nest trees or other occupied habitat.
	Highly Suitable	0.8–1.0	Age: >113 DDI: >6.9 TPA >30	Rare	Benefits to other covered species (platform quality, spotted owl access to prey)	Single Tree Removal	Increased spatial heterogeneity, enhanced midstory and understory development, species diversity and structural complexity

Species	Habitat Type	HSI[a]	Habitat Characteristics (mean)	Frequency[b]	Rationale for Management	Likely Silvicultural Activities	Expected Biological Outcomes
		0.6–0.79	Age: >86 DDI: >6.2 TPA >30	Infrequent	Benefits to other covered species (platform quality, spotted owl access to prey)	Group Selection or Single Tree Removal	Increased spatial heterogeneity, enhanced midstory and understory development, species diversity and structural complexity
	Suitable	0.4–0.59	Age: >74 DDI: >5.6 Large TPA >30	Infrequent	Improve long term quality while minimizing short-term impacts	Variable Density Thinning; Moderate Thinning	Increased spatial heterogeneity, enhanced midstory and understory development, species diversity and structural complexity
	Not Habitat	<0.39	Age: <74 DDI: <5.6 TPA >30	Common	Address dense, homogeneous stands with little canopy diversity and limited limb development to increase quantity and enhance quality of suitable habitat	Retention Harvest; Modified Clearcut[c]; Variable Density Thinning; Heavy, Moderate, and Light Thinning	Promote a dominant cohort of emergent trees with complex limb and crown structure, a well-developed mid-story of co-dominant and subdominant species, and a diverse, patchy understory. Increase amount, quality, and connectivity of habitat.

[a] Habitat Suitability Index (HSI) and related rules regarding management only apply within the range of a given covered species.
[b] Rare = <5% of management will occur in habitat type; Infrequent = <25% of management will occur in habitat type; Frequent = >75% of management in HCAs will occur in habitat type.
[c] Retention harvests are limited to Swiss needle cast and hardwood-dominant stands.

4.7.8 Conservation Action 8: Conservation Actions Outside Habitat Conservation Areas and Riparian Conservation Areas

As shown in Table 4-2, Conservation Action 8 is intended to support the following objectives.

- 4.1 Existing Oregon Slender Salamander Habitat
- 5.1 Existing Northern Spotted Owl Habitat
- 5.2 Northern Spotted Owl Dispersal Habitat

Under the conservation strategy, approximately 325,000 acres (51%) of the permit area will be outside of HCAs or RCAs. This conservation action describes the approach ODF will take to manage this important component of the landscape to avoid and minimize adverse effects on covered species from the activities covered under this HCP.

In implementing this conservation action, ODF will commit to standards that improve landscape-level forest structure through multiple measures, including using a leave tree retention strategy that emphasizes leaving the oldest, largest trees, especially those with large branches or other structural characteristics desirable for the covered species, during regeneration harvest. Where these trees persist until the next harvest, they would again be emphasized for retention, as the oldest, largest trees. The standards are intended to create long-term, landscape-level habitat values for covered species, including foraging habitat and connectivity between designated HCAs (Conservation Action 6: Establish Habitat Conservation Areas). This strategy, in conjunction with habitat-centric silvicultural activities and passive management in HCAs, will allow overall forest conditions that function to the benefit of the covered species.

An important aspect of the strategy is that habitat values provided for covered species outside of HCAs and RCAs will be dynamic, with habitat values that are gained in one area over time being eventually lost through harvest. However, some of these same values will be replaced elsewhere in the permit area as legacy structure increases over time. Using this approach, when combined with management of HCAs, habitat values at the landscape level will be improved over the permit term. Eventually, HCAs and RCAs will provide the majority of mid- to late-seral forest, balanced by early- and mid-seral forests that contain important legacy structures outside of HCAs and RCAs.

4.7.8.1 Landscape-Level Management Standards

ODF is able to be more flexible in how lands outside of HCAs and RCAs are managed with take authorization under the HCP and permits. Harvest rotations can coincide with habitat development, with certainty that stands can still be harvested at the appropriate time. Individual harvest timing decisions can be responsive to market conditions, and there will be less risk to harvest activities being constrained if habitat for threatened or endangered species develops prior to harvest. This in turn provides more habitat for a longer period of time for covered species, even if that habitat is eventually harvested. In all, the landscape as a whole will provide higher quality habitat for covered species with the combination of the HCAs, RCAs, and management regime outside of HCAs and RCAs that also provides additional habitat development.

Outside of HCAs and RCAs most stands will be managed for timber production, with a predicted focus on growing stands that generate a product mix of predominately large and medium sawtimber. This does not preclude some stands being managed or harvested on shorter rotations; however, the overall landscape strategy for the matrix outside of HCAs (and RCAs) is not short-rotation, intensive timber production. At any given point in the permit term, most stands in the matrix will be less than 60 years old, and the vast majority will be less than 90 years old. Some stands will remain infeasible to harvest due to physical constraints that prevent logging and thus may grow into older age classes. RCAs outside HCAs (approximately 42,000 acres) will be allowed to develop mature forest conditions and are well distributed throughout the permit area. Leave tree strategies are intended to retain and promote large live trees in harvest units. Thus, some habitat features may improve over time (e.g., abundance of large snags) at stand and landscape scales. Taken together, many of the forest stands outside of HCAs will continue to provide some function as habitat or in support of habitat function at the forest level.

Maintain a Minimum Amount of Northern Spotted Owl Dispersal Habitat on the Landscape

One of the primary management standards will be the commitment to maintain northern spotted owl dispersal habitat across the permit area outside of HCAs. This HCP defines dispersal habitat the same as the criteria for dispersal habitat in the 2011 recovery plan (USFWS 2011): Stands of trees averaging 11 inches in diameter at breast height (DBH) or greater and at least 40% canopy closure (Appendix C). There was an attempt to determine which habitat qualifies as dispersal habitat, using the habitat suitability models described in Chapter 2 and Appendix E. However, those models were developed specifically to identify nesting, roosting and foraging habitat, so the parameters do not translate perfectly to habitat characteristics that typically define dispersal habitat. Nonetheless, to meet Objective 5.2, ODF will maintain a minimum 40% of the permit area outside HCAs in conditions that meet the definition of dispersal habitat for northern spotted owl.

This target for northern spotted owl dispersal habitat outside of HCAs is supported by recent studies. For example, Davis et al. (2016) found that a threshold of at least 40% dispersal habitat across the landscape accounted for 90% of documented northern spotted owl movements reported by Forsman et al. (2002). The overall percentage and spatial arrangement of dispersal habitat will vary, based largely on habitat conditions and known habitat-management strategies on lands adjacent to the permit area (e.g., amount of state forest ownership and ownership/species occupancy patterns in surrounding matrix). The measurement of 40% will be calculated as described in Table 4-12, and will be tracked on a 10-year basis using updated Implementation Plan level modeling and field assessments of habitat quality.

Dispersal habitat as defined represents the minimum standard that must be met in the matrix outside of HCAs. ODF does not intend to manage the entirety of the matrix down to that minimum standard. Outside of HCAs and RCAs most stands will be managed for timber production, with a predicted focus on growing stands that generate a product mix that includes large and medium sawtimber. This does not preclude some stands being managed or harvested on shorter rotations; however, the overall landscape strategy for the matrix outside of HCAs (and RCAs) is not short-rotation, intensive timber production. While at any given point in the permit term, most stands in these areas will be less than 60 years old, and the vast majority will be less than 90 years old, many will still exceed the minimum definition of dispersal habitat and some may provide nesting, roosting, or foraging habitat. Some stands that are currently infeasible to harvest due to physical constraints that prevent logging and thus may grow into older age classes. RCAs outside HCAs (approximately

42,000 acres) will be allowed to develop mature forest conditions and are well distributed throughout the permit area. A few hundred acres of small, scattered habitat patches are either current old-growth or otherwise unavailable for harvest due to other existing constraints (e.g., scenic, social, geotechnical, access-related) and will further contribute to habitat for the covered species outside of HCAs. Leave tree strategies detailed below will provide potential nesting, roosting, and denning opportunities for covered species outside of HCAs and ensure that habitat features important to northern spotted owl prey are present in areas managed primarily for timber production.

4.7.8.2 Stand-Level Management Standards

Retain Forest Legacy Features

Management standards are intended to retain and improve the existing structures in managed stands over time. These structures consist primarily of existing old-growth, large trees and snags (both scattered and grouped), and downed wood. Management standards have been designed to provide land managers with flexibility in developing site-specific plans. Table 4-12 summarizes the management standards that will be applied throughout the term of the HCP on lands outside HCAs. Sale planners and administrators and ODF biologists will work closely, especially early in the permit term, to increase alignment and develop further operational guidance and related contract language to ensure standards are met during harvest operations outside HCAs.

Table 4-12. Timber Stand Management Standards Outside of HCAs

Category	Management Standards
Maximum size of regeneration harvest allowed	• *Per FPA*: 120 acres
Minimum distance between adjacent regeneration harvest units	• *Per FPA*: No type 3 harvest[a] (i.e., clearcuts) within 300 feet of the perimeter of a prior harvest unit if the combined acreage of the harvest would exceed 120 acres in size, unless the prior harvest unit has been reforested as required by all applicable regulations and: ○ At least the minimum tree stocking required by rule is established per acre; and either ○ The resultant stand of trees has attained an average height of at least 4 feet; or ○ At least 48 months have elapsed since the stand was created and it is "free to grow" as defined by the FPA.
Spotted owl dispersal habitat maintenance	• At least 40% of the permit area outside of HCAs will be in a condition that meets the definition of northern spotted owl dispersal habitat across the permit area at all times. This metric will be calculated within each of the following geographies: ○ North Coast – Astoria, Tillamook, and Forest Grove Districts ○ Rest of permit area – North Cascade and Western Oregon Districts, and Southern Oregon State Forests • Dispersal habitat is defined as stands with at least 40% canopy cover and an average DBH of 11 inches or greater. • RCAs outside of HCAs can count towards meeting this standard.
Leave tree retention	• Leave all old-growth trees, patches, and stands as defined by the Forest Ecosystem Management Assessment Team (≥175 years old; USDA Forest Service et al. 1993). Old-growth trees will be identified in the field pre-harvest by ODF biologists and foresters using standard forest mensuration tools and techniques to ensure no old-growth is harvested. • Two trees per acre will be retained within any forest stand harvested using regeneration harvest techniques. Trees selected for retention will be outside of RCAs[b] and will be assessed during each final harvest so that selected trees will not be removed in subsequent rotations and will contribute to long-term recruitment of large diameter snags and downed wood. The following applies when determining which trees will be retained to meet the two trees per acre standard: ○ All existing retained (not limited to two trees per acre). o Known nest trees and groups of trees around nest trees for covered species or dens for coastal marten. o Old-growth trees as defined above. ○ If additional trees are needed to meet the two trees per acre standard once nest trees and old growth trees are retained, trees with one or more of the following characteristics will be emphasized in retention:

Category	Management Standards
	○ Larger diameter trees in the stand. ○ Trees from the oldest cohort of the stand. ○ Platform-bearing trees in marbled murrelet range. ○ Trees with other key habitat features (e.g., large branches, broken or forked tops, cavities). ○ Less common conifer species (cedar, Sitka, western white pine, true firs, Pacific yew). ○ Retain an upland hardwood component where present.
Snag retention	• All existing snags will be retained during harvest activities. • Where retention would constitute a safety hazard or result in a violation of state or federal law, individual trees or snags may be removed. Safety hazards can be reduced by grouping leave trees in patches around high value snags. • Manage to provide an average of two hard snags per acre, at least 15 inches in diameter, within each regeneration harvest unit. ○ Hard snags include those in decay classes 1 and 2 (Thomas et al. 1979). ○ Where fewer than 2 hard snags per acre exist in a planned harvest unit, additional leave tree retention will be used to supplement snag levels following the guidelines for leave trees above. ○ Snag creation prescriptions may also be used to supplement existing hard snags. Larger diameter trees (>24-inch-diameter at breast height) will be prioritized for snag creation.
Downed wood retention	• During harvest activities, retain existing down logs and avoid damage to large-diameter, well-decayed logs. • During regeneration harvest, retain at least an average of 600 to 900 cubic feet of hard conifer logs (decay class 1 and 2) per acre in each harvest unit outside RCAs, including at least an average of two logs per acre greater than 20 inches in diameter (at the largest end), where available. • Where this is not available, consider additional green tree or snag retention for future downed wood recruitment.

[a] Harvest Type 1 is heavy thinning. Harvest Type 2 consists of clearcuts with some residual seedlings, saplings, and poles retained. Harvest Type 3 consists of clearcuts with few residual trees left.

[b] Trees outside of RCA buffer widths listed in Table 4-3 and Table 4-4 may be counted towards the two upland trees per acre standard. This includes trees primarily retained to address inner gorges, unstable slopes, and other geomorphic features.

4.7.9 Conservation Action 9: Strategic Terrestrial Species Conservation Actions

The conservation strategy will result in an increase in habitat for all of the terrestrial covered species, but other factors may remain that limit the ability of covered species to take advantage of the new habitat and for populations to increase. The Conservation Fund, described in Chapter 9, *Cost and Funding*, will provide funding on an annual basis to address these limiting factors. The priorities for how the Conservation Fund is used will change during the permit term but ODF will work with USFWS and ODFW along with species experts and other state and federal partners to identify where and how Conservation Fund monies are spent. Expenditures will be tracked and reported annually. Use of the funds will generally fall into four categories:

1. Address known stressors on species productivity and survival (e.g., barred owl on northern spotted owl).
2. Research on covered species response to management actions in HCAs.
3. Implement activities to augment species populations (e.g., northern spotted owl reintroduction, red tree vole translocation).
4. Gain a better understanding of species ecology or habitat use that could influence how management actions are used in HCAs (e.g., coastal marten).

Some of specific uses of the Conservation Fund for terrestrial species are known, while others will emerge during the permit term. For example, the extent of use of additional funds for barred owl removal efforts is not known at this time due to multiple factors.

4.7.9.1 Barred Owl Management

Regardless of the amount and type of habitat that is in the permit area, competition with barred owls continues to stress northern spotted owl populations (Spies et al. 2018). Competition with established populations of barred owls is a prominent and complex threat to the long-term persistence of the northern spotted owl (USFWS 2011; Lesmeister et al. 2018; Weikel 2019). Studies indicate that barred owls have a strong negative impact on northern spotted owls and have resulted in lower northern spotted owl occupancy, reduced survival, lower reproductive rate, lower detection, and even limited hybridization between the two species (Lesmeister et al. 2018; Long and Wolfe 2019). Barred owls appear to co-occupy and outnumber spotted owls throughout much of the entire range of the threatened subspecies (Yackulic et al. 2012; Dugger et al. [2016], as cited by Lesmeister et al. [2018]).]), and the majority of the permit area. In the *Revised Recovery Plan for the Northern Spotted Owl* (USFWS 2011), USFWS acknowledges the need for aggressive strategies to address the threat from barred owls on spotted owls.

An analysis conducted by Wiens (2021) found that barred owl removal increased survival of individual spotted owls. In some cases, nonterritorial spotted owls were found to regain territories after the barred owl occupants had been removed. However, Wiens (2021) cautioned that low reproductive rates continue to be a major barrier to northern spotted owl recovery and that, therefore, in addition to increased survival, northern spotted owl reproduction rates will also need to increase so that new individuals are available to fill territory vacancies once barred owl occupants are removed. Also, habitat is currently limited or of low quality in many places where barred owls occur, so not all areas released from barred owl competition will be immediately available to northern spotted owls or adequate to increase reproduction rates with concomitant increases in the amount and quality of habitat.

ODF plans to use funds from the Conservation Fund to establish and implement a regional barred owl management program (see Section 9.2.2.3). The program will focus on barred owl management in the permit area but will be coordinated with USFWS and other regional partners—including ODFW, BLM, and USFS—and non-federal landowners, which may conduct barred owl management programs of their own across private, state, and federal lands. Barred owl management may include a suite of activities, up to and including removal of barred owls. ODF's barred owl management program will be aligned with the USFWS barred owl management strategy and will evolve over time as more information is collected on the efficacy of various techniques. ODF will dedicate approximately $250,000/year for at least the first 20 years of the permit term, at which point the program will be evaluated and a determination about whether to fund the program into the future would be discussed with the USFWS.

If barred owl management is found to be impractical or ineffective at reducing negative effects from barred owls on northern spotted owl populations, then ODF will shift budget from barred owl management to other terrestrial management activities through coordination with the USFWS, consistent with the adaptive management program described in Chapter 6, *Monitoring and Adaptive Management*.

4.7.9.2 Covered Species Reintroduction

At some point in the future, as conservation actions are successful in producing additional habitat for, or removing threats to, covered species, there may be interest in reintroducing or translocating covered species onto Oregon forests, or creating a captive breeding program. One example is the reintroduction of spotted owls where barred owl control measures have been successful, but this could apply to other covered species as well. The HCAs would be possible locations for those releases, and ODF could partner with other organizations and agencies to create such a program.

4.7.9.3 Conservation Action Effectiveness Research

Conservation funds could also be used to strategically address research questions needed to more effectively execute the conservation strategy over time for covered species such as red tree voles, Oregon slender salamanders, and coastal marten and for which targeted research could improve conservation delivery.

4.7.10 Conservation Action 10: Operational Restrictions to Minimize Effects on Covered Species

The following operational restrictions will be followed to prevent disturbance from covered activities that may interfere with behaviors of covered species. Operational restrictions described in this conservation action may apply inside or outside of HCAs or both, as noted in each section below. Outside of HCAs restrictions will apply to nest and den sites that are known to ODF; however, ODF will not be engaged in an operations-based survey program, and sites unknown to ODF may be subject to disturbance. Within HCAs restrictions will be applied to known sites and designated occupied habitat for marbled murrelets (which includes highly suitable habitat of unknown occupancy). Unknown species sites within HCAs may have some impact, but management standards detailed in Conservation Action 7: Manage Habitat Conservation Areas and monitoring programs for covered species (see Chapter 6) are expected to minimize this.

4.7.10.1 Operational Restrictions for Northern Spotted Owls

Seasonal Restrictions Inside HCAs

To minimize adverse effects on nesting northern spotted owls in HCAs, covered activities that may disturb or disrupt normal spotted owl behavioral patterns will not occur within distances expected to result in take during the critical breeding period (between March 1 and September 30) inside of HCAs. Activities will be restricted around all resident status sites (pair and single) within the specified distances from a nest tree or activity center given below until it is determined through surveys that no spotted owls are present, that there is no active nest, or that any nesting attempt has failed, or until July 7, whichever is sooner (Table 4-13). For active nests and fledglings, restrictions will extend to September 30. Methods for determining nesting status follow USFWS-approved protocols (e.g., USFWS 2012).

Beyond minimizing effects from activities by utilizing seasonal distance restrictions, as described in Table 4-13, ODF will also maintain at least 500 acres of nesting, roosting, or foraging habitat within 0.7 mile of active activity centers to provide adequate habitat and continue to support nesting northern spotted owls. In order to meet the 500-acre minimum standard inside the 0.7-mile activity center the highest quality habitat will be retained (nesting and roosting will be prioritized over foraging habitat). This will generally happen by default as the management activities allowed in nesting and roosting habitat within 0.7 mile of a nest location are minimal, as described in Conservation Action 7. Restrictions within HCAs do not apply to areas outside of HCAs. Restrictions outside of HCAs are discussed below and other actions are detailed in Conservation Action 8: Conservation Action 8: Conservation Actions Outside Habitat Conservation Areas and Riparian Conservation Areas.

Table 4-13. Seasonal Distance Restrictions for Active Northern Spotted Owl Nest Sites in HCAs during the Nesting Season[a,b]

Covered Activity	Where Not Allowed during Early Nesting Season (March 1– September 30)[c]
Light maintenance (e.g., road brushing and grading, clearing of downed trees, and felling of hazard trees) at campgrounds, trails, administrative facilities, and roads	No restrictions, as activities would occur only at sites with existing high levels of human activity
Chainsaws/tree felling (excludes light maintenance as described above)	≤65 yards
Cable yarding and heavy equipment operation for felling, logging, and loading	≤ 65 yards
Heavy equipment for road/trail construction, road/trail repairs, bridge construction, culvert replacements, etc.	≤65 yards
Pile-driving, rock-crushing, and screening equipment	≤120 yards
Blasting (road or trail construction)[d]	≤0.25 mile
Blasting (quarry development)[d]	≤0.25 mile
Helicopter: Type I (Chinook 47)	≤265 yards
Helicopter: Type II (Boeing Vertol 107, Sikorsky S-64)	≤150 yards

Covered Activity	Where Not Allowed during Early Nesting Season (March 1– September 30)[c]
Helicopter: Type III (K-MAX, Bell 206 L4, Hughes 500)	≤110 yards
Small fixed-wing aircraft (Cessna 185, etc.)	≤110 yards
Tree climbing	≤25 yards
Burning (prescribed fires, pile burning)	≤0.25 mile

Source: USFWS 2013

[a] Active sites are based on nest tree locations or designated activity centers if the nest site is not known. Restrictions only apply to actively nesting pairs and associated nest sites or other activity centers.

[b] These restrictions apply unless ODF is under a fire, search and rescue, or other public emergency in the vicinity of the active site.

[c] As measured from the edge of the active nest site or activity center to the limit of the activity performed, unless ODF determines that young are not present, based on USFWS-approved survey methods, at which point distance restrictions may be lifted as noted above.

[d] Disruption distances associated with blasting may be reduced if a site-specific evaluation by the area biologist finds that topographic or other features provide adequate acoustic shadowing.

ODF may deviate from these restrictions only in situations where either (1) applying these restrictions would compromise the safety of ODF staff, contractors, or members of the public; or (2) applying a more limited restriction is clearly justified based on site conditions, such as topographic features that provide sound insulation. Deviations from these restrictions are expected to be rare and will be applied by ODF only after a site-specific review by the wildlife biologist, documentation of recommendations, and approval by ODF's HCP administrator. The wildlife biologist will consider site-specific, topographic features and the location of the likely nesting habitat when considering any deviations from these restrictions. Any deviations will be documented as part of monitoring reporting requirements, as described in Chapter 6. Examples include such considerations as late nesting attempts, establishment of nonbreeding status, local topography, and acoustic shadow. Once ODF determines that there is no nesting activity or that young are not present, covered activities can proceed without restriction, consistent with the HCP and permits.

Seasonal Restrictions Outside HCAs

To minimize adverse effects on northern spotted owls nesting outside HCAs, covered activities that may disturb or disrupt normal spotted owl behavioral patterns will not occur within distances of known northern spotted owl nests during the critical breeding period (between March 1 and September 30). Activities that modify suitable habitat will be restricted within ¼ mile of an activity center with an active nest or where there is evidence of active nesting (e.g., juveniles) but the nest has not been located, during the period from March 1 through September 30, or until it is determined that the pair is not nesting, or has failed, whichever is sooner.

Other activities will be restricted from a nest tree or activity center to the specified distances in Table 4-13, until it is determined through surveys that there is no pair present, the pair present is not nesting, any nesting attempt has failed, or until July 7, whichever is sooner. For active nests and fledglings, restrictions will extend to September 30. These restrictions distances apply to areas outside HCAs and extend inside HCAs where and when applicable.

After the expiration of seasonal restrictions, nest trees outside of HCAs will be retained in any subsequent harvest following Conservation Action 8 and the associated standards in Table 4-12.

4.7.10.2 Operational Restrictions for Marbled Murrelets

Seasonal Restrictions Inside HCAs

To avoid disturbance to nesting marbled murrelet adults and chicks, ODF will apply seasonal restrictions for activities that may occur in or near designated occupied habitat during the murrelet nesting season (April 1 to September 15) (Table 4-14). Site-specific topographic features will be considered when seasonal restrictions are applied. ODF will, at a minimum, avoid disturbance in the “disruption” thresholds identified by USFWS (2013) for marbled murrelet nest sites. Restriction distances from designated occupied habitat in HCAs do not extend beyond HCA boundaries.

Table 4-14. Seasonal Restriction Distances for Marbled Murrelet Designated Occupied Habitat[a]

Covered Activity	Where not Allowed during the Critical Nesting Period (April 1–August 5)	Where not Allowed for the Remainder of the Nesting Period (August 6–September 15) with Daily Timing Restrictions[b]
Rock crushing	≤ 180 yards	≤ 180 yards
Blasting (road or trail construction)[c]	≤ 0.25 mile	≤ 0.25 mile
Blasting (quarry development)[c]	≤ 1 mile	≤ 1 mile
Helicopter: Type I (Chinook47d)	≤ 0.25 mile or ≤ 800 feet above ground level (AGL)	≤ 0.25 mile or ≤ 800 feet AGL
Helicopter: Type II & III (Boeing Vertol 107, Sikorsky S-64; K-MAX, Bell 206 L4, Hughes 500)	≤ 120 yards or ≤ 800 feet AGL	≤ 120 yards or ≤ 800 feet AGL
Light maintenance (e.g., road brushing and grading, clearing of downed trees, and felling of hazard trees) at campgrounds, trails, administrative facilities, and roads	No restrictions[d]	No restrictions
Log hauling	No restrictions	No restrictions
Chainsaws (excludes light maintenance as described above)	≤ 100 yards	No restrictions
Cable yarding and heavy equipment operation for felling, logging, and loading	≤ 100 yards	No restrictions
Heavy equipment for construction, repairs, bridge construction, culvert replacements, etc.	≤ 100 yards	No restrictions

Source: USFWS

[a] These restrictions apply unless ODF is under a fire, search and rescue, or other public emergency in the vicinity of the designated occupied habitat. Distances are measured from the edge of designated occupied habitat and do not extend outside HCAs.

[b] The first work restriction stops two hours after sunrise, and the work restriction starts again 2 hours before sunset.

[c] Disruption distances associated with blasting may be reduced if a site-specific evaluation by the area biologist finds that topographic or other features provide adequate acoustic shadowing.

[d] Disturbances with no likely adverse effects and associated no restrictions needed are based conclusions presented in USFWS 2013.

ODF may deviate from these restrictions only in situations where either (1) applying these restrictions would compromise the safety of ODF staff, contractors, or members of the public; or (2) applying a more limited restriction is clearly justified based on site conditions. Deviations from these restrictions are expected to be rare and will be applied by ODF only after a site-specific review by the wildlife biologist, documentation of recommendations, and approval by ODF's HCP administrator. The wildlife biologist will consider site-specific, topographic features and the location of the likely nesting habitat when considering any deviations from these restrictions. Any deviations will be documented as part of monitoring reporting requirements, as described in Chapter 6.

Tailhold and Guyline Anchors

In cable logging operations, anchors are used to secure logging equipment (e.g., yarder towers, skyline cables) to intermediate lift trees or tail trees. Tailhold anchors are used to secure the ends of skyline cables directly onto a stump or tree via a broad notch. The skyline sometimes extends out past the unit to the furthest point that supports enough lift for the particular corridor being yarded. Depending on the design of the cable system, skylines may extend 1/4 mile or more from the tower. Guyline anchors are used to stabilize yarding towers. Typically, several guyline anchors (2–9) extend radially 50–150 feet from the equipment and are attached to sound stumps or live trees by creating a broad notch.

The use of tailholds and guyline anchors are not seasonally restricted; however the use of heavy equipment or chainsaws to install these features are prohibited within a designated occupied habitat and 100-m buffer from April 1 through August 5. From August 6 through September 15, activities are allowed with daily timing restrictions. Daily timing restrictions prohibit the use of heavy machinery and chainsaws within 2 hours of sunrise and 2 hours of sunset. From September 16 to March 31, activities are unrestricted. If tailholds are installed on trees or stumps during April 1 through August 5, non-mechanized methods such as an ax will be used when notching the tree or stump and follow the guidelines as discussed in #6, below.

Specific criteria will be required for all tailholds and guylines within designated occupied habitat to protect trees that contain suitable nesting platforms and associated cover trees from damage. Suitable nesting platforms include relatively flat structures ≥ 4 inches wide and 33 feet high in the live crown of a coniferous tree. Platforms can be created by a wide bare branch, epiphytes or duff covering a branch, mistletoe, witches' brooms, other deformities, or structures such as squirrels' nests. Cover trees are adjacent to potential nesting trees and provide vertical and horizontal cover to potential nesting platforms. Conifer trees (e.g., Douglas-fir, Sitka spruce, western hemlock, western red cedar) are considered potential nesting trees whereas cover trees can include both conifer and hardwood trees (e.g., red alder, big leaf maple). The protection criteria are as follows:

1. Existing sound stumps will be favored as a first choice for tailholds and guyline anchors where it is safe to do so.
2. If no suitable guyline or tailhold trees exist, operational equipment such as a Yoder, which does not require guylines, or a bulldozer, which may serve as a tailhold, may be used provided no designated occupied habitat is removed or destroyed when using such equipment and appropriate disturbance timing restrictions are applied.
3. If the preferred alternatives (#1 and 2) are not available or feasible, the following trees in designated occupied habitat will **not** be selected for guylines or tailhold anchors:

   a. Trees with potential nest platforms **or** immediately surrounding trees that provide cover to potential nest platforms;

   b. The largest trees in areas where the number of large trees is limited; and

   c. Less common conifer species (cedar, Sitka, western white pine, true firs, Pacific yew).

4. Guylines or skylines will not be placed where they have the potential to damage platforms or platform trees when the cable is lifted or lowered.
5. No trees will be felled within the designated occupied habitat. Felling may occur within the 330-foot buffer but may not include, or damage, platform or cover trees.
6. To protect trees used as tailhold and guyline anchors, it is preferred that plates, nylon straps or other ODF-approved devices be utilized to prevent damage to trees. If this is not feasible, notching of the trees to prevent cable slippage will be limited to less than 1/3 the circumference of the tree.
7. An ODF Area Biologist or a designee familiar with murrelet habitat and biology will inspect and approve all trees before each is used. Lead time of at least two weeks for all reviews or meetings with ODF representatives is required. No trees that are considered platform trees or surrounding trees that provide cover to platform trees, as determined by an ODF Area Biologist or designee will be damaged or harvested.
8. Relevant protection measures are detailed in sale contracts and logging plan maps. The ODF Contract Sale Administrator will ensure the purchasers and affiliated subcontractors are aware of and adhere to these measures before and during operations. For complex projects, supplemental maps may be provided that clearly identify designated occupied habitat boundaries or boundaries may be physically marked by hand in the field.
9. During contract inspections, if any deviations from required protection measures are identified, operations in the affected area will be halted until appropriate additional measures are taken to ensure compliance. Additional measures may include alternate placement of equipment, utilizing alternative equipment, adjusting the prescription or project boundary, delaying or canceling the operation, or fining the operator or purchaser.

Aquatic Restoration Projects

Trees that do not have the structure or characteristics utilized by marbled murrelets can be felled inside designated occupied habitat for aquatic restoration projects on stream segments within or adjacent to that designated occupied habitat. Aquatic restoration projects will not fall, push, or pull trees that have the structure or characteristics utilized by marbled murrelets located inside designated occupied habitat. Where conflicts exist with in-water work periods, felling or tipping of these trees may occur between August 6 and September 15, from 2 hours after sunrise until 2 hours before sunset.

- The following trees will **<u>not</u>** be selected for removal during aquatic restoration projects:
  - Known nest trees;
  - Trees with existing nest platforms and immediately surrounding trees that provide cover to potential nest platforms; And
  - The largest trees in areas where the number of large trees is limited.

- Trees may be felled or pushed/pulled directly into a stream or floodplain.
- Trees may be felled and subsequently repositioned by cable, ground-based equipment, horses, or helicopters.

Wildlife biologists with experience in murrelet habitat will assist the aquatic biologist in the selection of trees for removal when inside designated occupied marbled murrelet habitat. A wildlife biologist with experience in murrelet habitat will approve the selected trees. The implementation of projects within designated occupied marbled murrelet habitat will be scheduled outside of April 1–July 15. This allows for tree installation in-stream during the in-water work window that will minimize effects on covered fish species, while also minimizing effects on marbled murrelet nesting behavior.

Trash Management

Within designated occupied marbled murrelet habitat and associated buffers, trash management and removal applies to all planned management activities. These activities will be focused in high-use areas such as campgrounds, parking lots, and trailheads. Contracts and permits related to the activities addressed in this guidance document (e.g., timber sale, harvest of special forest products) will include trash management measures to minimize or eliminate potential impacts on nesting murrelets. Wildlife-proof trash disposal bins will be made available or signage, contracts, and permits will clearly state that trash is to be removed from the management activity site at the end of each day and wildlife is not to be fed.

Seasonal Restrictions Outside of HCAs

To avoid disturbance to nesting marbled murrelet adults and chicks, ODF will apply seasonal restrictions to known active nests outside of HCAs during the murrelet nesting season (April 1 to September 15). Distances follow Table 4-14 but will extend from known active nest trees outside of HCAs. Restrictions apply to all ODF-managed lands within the specified distances. If the nest tree is within a planned or sold sale, harvest will be delayed through the nesting season. Post-nesting season, nest trees outside of HCAs will be retained in any subsequent harvest following Conservation Action 8 and the associated standards in Table 4-14.

4.7.10.3 Red Tree Vole Nest Trees

Stand management activities are unlikely to occur in HCAs in older stands that provide suitable red tree vole habitat (e.g., in stands that also provide habitat for spotted owls and murrelets). In younger HCA stands where management would have clear long-term benefits to the covered species, but short-term impacts on red tree vole occupancy, a 10-acre block of contiguous habitat will be maintained around red tree vole nest tree(s) during management activities, with additional consideration of connectivity among retained patches. If nest trees are identified outside HCAs they will be retained as part the leave tree strategy, described in Table 4-12

4.7.10.4 Coastal Marten Den Locations

ODF will protect confirmed denning females and their young by limiting or preventing access and disturbance near occupied sites, including preventing the destruction of the denning structure itself (i.e., a tree, snag, log, or other structure). Denning activities are most likely to occur between March

15 and August 15, and females may remain at a particular den site for days or weeks before moving to a new site. Specifically, ODF will not conduct or authorize any of the covered activities within 0.25 mile of a known occupied den site, because those activities could result in disturbance or harm to denning martens, except where these activities may be necessary to remove an immediate threat to public safety.

Once the occupancy of a denning marten is confirmed, the occupied den site will be protected with a 0.25-mile radius buffer that excludes timber operations during the marten denning season (March 15–August 15) until either the marten denning season has ended, or it has been determined that the den site is unoccupied. ODF will implement protection measures within 24 hours of notification that an occupied den site has been confirmed.

Confirmed den structures will be retained on the landscape, and tree retention will be incorporated around the den structure during and post timber harvest operations. Inside HCAs, harvest will be avoided in stands with known dens. Outside of HCAs, the standard for tree retention around a natal den structure will be a no-less-than 100-foot radius no-harvest retention area, centered on the den.

In cases where a female marten chooses to establish a den site within 0.25 mile of an active road, road use that is under ODF control can continue provided the volume of traffic and potential disturbance remains at or below the level that existed in the 2 weeks before the den was detected. Considerations should be made to use alternate routes away from occupied dens when possible, and, where alternate roads do not exist, caution should be taken to avoid marten road mortality (e.g., reduced speed limits to <15 miles per hour).

In cases where a female marten chooses to establish a den site within 0.25 mile of an active harvest operation, yarding and hauling of felled timber may continue as long as the footprint of the habitat modification component of the activity does not move any closer to the denning marten. Tailholds and guyline anchors for timber yarding are permitted within the 0.25-mile marten den site buffer provided that they are not located within 500 feet of the occupied marten den site.

In cases where a female marten chooses to establish a den site within 0.25 mile of covered activities that do not result in habitat modification or disturbance (e.g., silvicultural surveys), those activities may continue as long as the footprint of those activities does not move any closer to the denning marten. Activities that do not pose disturbance (e.g., surveys for other wildlife species) will not be restricted, but time spent within 500 feet of a den site should be minimized or avoided entirely.

ODF will provide protection of denning female or other known martens (e.g., known radio-collared individuals) by prohibiting ODF nuisance animal control trapping activities on enrolled lands within 2.5 miles of known occupied dens or locations. Upon notification of a denning female or other known marten, ODF will, as soon as logistically feasible, make every effort to ensure all authorized agent nuisance traps are tripped and not reset. Nuisance animal trapping and control activities within 2.5 miles of the den site will cease until September 30 or until ODF is informed that the denning female has moved the den site or tracked individual has left the area.

4.7.10.5 Fuels Reduction

Fuels reduction efforts will be infrequent in HCAs and limited to site-specific circumstances where the integrity of the HCA is at risk from a high probability catastrophic fire event. Fuels reduction efforts will be focused outside of HCAs (e.g., removal of ladder fuels at harvest unit scales). Specific fuels reduction activities will be separate from general management on the landscape outside of HCAs and RCAs, as the fire return interval over the most of the permit area, coupled with the level of active management, has generally resulted in fire-resilient forest, outside of extreme weather events (e.g., 2020 Labor Day fires). There may be increased focus on fuels reductions with HCAs in the future, as circumstances change, forests age, and fire frequency and severity increase. Fuels reduction efforts in HCAs will focus on mitigating wildfire risk while minimizing effects on habitat suitability. For instance, some stands may be managed to be large, mature, single-story stands with reduced risk of carrying fire into larger blocks of habitat. While layering and snag components may be reduced in these areas, they will not be eliminated. Fuel breaks consisting of extensive clearing of suitable habitat will not be employed inside HCAs, but may be employed external to the perimeters of HCAs to influence fire behavior and improve defensible space.

4.7.10.6 Water Drafting

All water development, maintenance, and abandonment would be performed in accordance with restrictions placed by the Oregon FPA (OAR 629) and other applicable statutes regarding water quality protections. Water drafting will only occur in free-flowing streams or human-created ponds and impoundments that are disconnected from streams at the time of drafting. Drafting locations will be screened using the NorWeST climate data to prioritize the use of stream reaches that have limited projected risk of mean August temperature increases. If current stream temperature data is available for the stream in question that information will be used instead of modeling.

For ponds and impoundments that are not connected at the time of drafting, there will be no limit on the amount of drafting (i.e., the impoundment may be depleted). When water is drafted directly out of the stream for covered activities the stream must be deep enough that the drafting pipe can be fully submerged and the water level cannot be reduced such that the drafting pipe becomes exposed. Generally a 2- to 3-inch pipe is used when drafting. In addition, there would not be more than a 10% reduction in stream depth during the period of drawdown. If a reduction in stream depth approaches 10%, drafting will cease until volume recovers back to pre-drafting levels. When drafting from a human-created connected pond or impoundment that is hydrologically connected to the stream at the time of drafting, there would not be more than a 10% reduction in the depth of the connected stream during the period of drawdown, and it would not become disconnected as a result of the drawdown, potentially stranding fish. Drafting will not occur in locations where a temporary dam is needed to create a pool to allow drafting. Any intake used for water drafting will be screened according to NMFS Juvenile Fish Screen Criteria for Pump Intake for salmonid fry. This will also be protective of other covered species (e.g. torrent salamanders).

To protect against the introduction of aquatic invasive species, any portion of the pipe or pump that will be in the water will be disinfected between uses, unless the uses are from the same drafting location, at a different drafting location in the same stream, or occurs at least 48 hours after that last drafting event.

4.7.11 Conservation Action 11: Road and Trail Construction and Management Measures

As shown in Table 4-2, Conservation Action 11 is intended to support the following biological objectives.

- 1.1 Wood Recruitment

- 1.3 Water Quality and Quantity
- 1.4 Fish Passage

Forest roads can reduce or degrade wildlife habitat through habitat removal, fragmentation, and disturbance associated with road use as well as increase mortality due to vehicle-animal interactions. Forest roads that are not designed, built, and maintained according to best management practices can have particularly high potential to adversely affect fish habitat. Roads and trails can degrade salmon habitats through increased delivery of fine sediment, greater landslide frequency, and changes in stream hydrology (Furniss et al. 1991, Boston 2016). In addition, stream-crossing structures such as culverts can impede the transport and delivery of sediment and woody material to downstream reaches (Roni et al. 2002). Roads and trails in the permit area will be managed to keep as much forest land in a natural, productive condition as possible while also limiting impacts on the covered species by minimizing the removal of key habitat components, preventing water quality problems, minimizing disruption of natural streams, providing fish passage where roads and trails cross fish-bearing streams, and minimizing exacerbation of natural mass-wasting processes.

Surface erosion and delivery of sediment to streams can be substantially reduced through best management practices for road design and maintenance (Roni et al. 2002). Stream processes that can be restored through road design and improvement techniques are shown in Table 4-15 and will be considered when designing new roads and improving existing road systems in the permit area to benefit the covered salmonids.

Table 4-15. Processes Restored by Various Road Improvement Techniques

Road Improvement Technique	Hydrology	Sediment Delivery: Fine (sand and smaller particles)	Sediment Delivery: Coarse (gravel and larger particles)	Conservation Action
Removal of active roads or legacy roads	X	X	X	Conservation Action 5
Culvert or stream crossing upgrades (repair unstable crossings)		X	X	Conservation Action 4
Sidecast removal or reduction		X	X	Conservation Action 11
Reduce road drainage to stream[a]	X	X		Conservation Action 11
Increase surface material thickness or hardness with crushed rock or paving		X		Conservation Action 11
Traffic reduction (unpaved roads)		X		Conservation Action 11

Source: Roni et al. 2002

[a] Drainage reduced through increased crossings and by diverting water onto forest floor.

An existing geographic information system (GIS) overlay of the road network in the permit area will be maintained and updated, as needed, and will be used for planning purposes to limit impacts on the covered species. Development of new roads, and improvements to existing roads, will be in accordance with the standards laid out in the *Forest Roads Manual* (ODF 2000, or most current version, see Appendix H) and NOAA Fisheries Fish Passage Design (2011).

4.7.11.1 Road/Trail Design to Minimize Impacts on Covered Species

Construction of road networks can lead to accelerated erosion rates in a watershed (Furniss et al. 1991). ODF planning and district staff will solicit input from geotechnical specialists in designing roads/trails and harvest units. This input is based on interpretive geology and the use of soil and rock mechanics in slope stability analysis. It provides a rationale for risk assessment and mitigation in forest land management decisions. The use of geotechnical analysis in management decisions makes it possible to minimize the number or magnitude of management activity-induced soil movements and protect the aquatic covered species.

The most common causes of road-related mass movements are related to inappropriate placement and construction of road fills, inadequate road maintenance, insufficient culvert sizes, very steep hill gradients, placement or sidecast of excess materials, poor road location, removal of slope support by undercutting, and alteration of slope draining by interception and concentration of surface and subsurface water (Wolf 1982 as cited in Furniss et al. 1991). Many of these problems with forest road construction can be traced back to poor road design. With careful siting of roads and appropriate planning to minimize the length of roadbed needed to support timber operations and recreational access, the impacts of road construction and maintenance can be minimized.

ODF has identified the following road design measures from the *Forest Roads Manual* (ODF 2000, or most current version) and Roni et al. (2002) that will be implemented to minimize potential impacts on the covered aquatic species. The intent of these road design measures, which will also be applied to trail development, is to hydrologically disconnect the road and trail system from streams.

- Temporary and permanent roads, trails, and landings will be located on stable locations, e.g., ridge tops, stable benches, or flats, and gentle to moderate side slopes, and utilize full-bench construction on steep slopes.
- Roads or trails at risk of failure or that are contributing sediment to streams will be improved or vacated, consistent with valid existing rights, or improved to eliminate or minimize sediment delivery.
- Roads and trails will be located away from streams, wetlands, unstable areas, and sensitive resource sites, including sensitive habitats. Buffers of undisturbed land will be maintained between roads and streams. Removal of old growth trees, or trees with structures known to be important to the covered species (e.g., potential murrelet nesting platforms) will be avoided, where feasible.
- Road development within the RCA will only occur when other alternatives are not operationally/economically feasible.
- Where crossings of fish-bearing streams occur, bridges and culverts will be designed to meet NOAA Fisheries (2011 or most recent, Appendix K) and ODFW fish-passage laws (Oregon Revised Statute 509.580 through 910 and in OAR 635, Division 412).
- New roads and trails will use the minimum design standards practical with respect to road width, radius, and gradient. This will minimize road or trail width and the resultant cut-and-fill slopes, minimizing effects on the covered aquatic species from new road or trail construction.

- Road and trail designs will provide for proper drainage of surface water so as not to introduce runoff into streams. These measures could include the use of grade breaks, out-sloping, in-sloping, ditching, road/trail dips, water bars, and relief culverts.
- Ditches and cross-drain discharges will be directed onto the forest floor away from streams to limit runoff and fine sediment delivery into the stream.
- Cross drains will not discharge onto unstable slopes, and full-bench construction (no sidecast fill) will be used on steep slopes to avoid sidecast failure.
- Aligned rock fill will be installed over culverts where needed to reduce the risk of erosion and failure, in case culverts become plugged or overtopped.
- The road/trail runoff to the stream channel will be disconnected by outsloping the road/trail approach. If outsloping is not possible, runoff control, erosion control, and sediment-containment measures will be used. These may include using additional cross drain culverts, ditch lining, and catchment basins. Ditch flow conveyance to the stream will be prevented or reduced through cross-drain placement above the stream crossing at a distance that allows for adequate overland filtering and absorption.
- Underdrain structures will be installed when roads/trails cross or expose springs, seeps, or wet areas rather than allowing intercepted water to flow downgradient in ditchlines.
- Surface drainage structures (e.g., broad based dips, leadoff ditches) will be armored to maintain functionality in areas of erosive and low strength soils. Armoring will be applied along sections where evidence of gullying of the grade, ditches, or outfalls is occurring.
- New rock quarries will not be located in RCAs.

In addition, as with all covered activities, specific nesting sites for marbled murrelet or northern spotted owl will be protected as described in Conservation Actions 6: Establish Habitat Conservation Areas, 7: Manage Habitat Conservation Areas, and 10: Seasonal Operational Restrictions.

4.7.11.2 Road/Trail Construction and Maintenance to Minimize Impacts on Covered Species

Once forest roads/trails are designed to minimize impacts on the covered species, ODF will build and maintain the roads/trails using techniques that will also minimize impacts on covered species. Soil erosion and stream sedimentation may occur during and following road/trail construction or maintenance. Proper construction practices will reduce erosion and stream sedimentation impacts on the covered species.

The following guidelines will be followed during road/trail construction and maintenance, additional details are provided in Appendix H: *Forest Roads Manual*:

- Roads within or adjacent to RCAs that cannot be hydrologically disconnected (or connection mitigated), or are otherwise unsuitable for wintertime haul, will be closed to logging trucks during wintertime wet weather as specified at the ODF district level. This includes all native surfaced roads (dirt).
- Commercial road use will be suspended where turbid runoff is likely to reach waters of the State.

- Road construction will occur in HCAs to allow for habitat enhancement projects, provide efficient access to other areas of the forest outside of HCAs, allow for access required for adjacent landowners, and improve the overall efficiency of the transportation network to reduce impacts from roads more broadly. Transportation planning for HCAs will be done in conjunction with the wildlife biologist to minimize impacts on known species occurrence and suitable habitat. Road construction within HCAs will be conducted with additional considerations consistent with Conservation Action 10: Operational Restrictions to Minimize Effects on Covered Species, to protect covered terrestrial species occupied areas and highly suitable habitat. Project scope and scale will be considered by the wildlife biologist to determine the best application of seasonal restrictions (e.g., allowing for more acute disturbance in 1 year, versus lower level chronic disturbance extended projects over multiple years).
- In-water construction for roads and trails (e.g., stream crossings) will follow the established Oregon Guidelines for Timing of In-Water Work to Protect Fish and Wildlife (ODFW 2008) to minimize impacts on the covered species and their habitat. If work needs to occur outside of the established work window ODF will obtain appropriate approvals from ODFW.
- Storage and staging areas for road/trail construction, harvest activities, HCP management and restoration projects will be sited outside of RCAs and ERZs where the staging area or materials stored could cause erosion or contamination of waters of the United States (80 FR 37053). Staging areas will be constructed in a manner that is hydrologically disconnected from the aquatic environment. Storage of materials with no potential to deliver contaminants, such as culverts for stream crossings, logs for aquatic enhancement activities, and bales of mulch for erosion control, may be stored within RCAs and ERZs.
- Road improvement and construction activities will be conducted during the dry season April 1 through October 31. Outside of this period, ODF may allow construction through a written waiver during prolonged periods of dry weather. If rainy weather[17] occurs, construction will be suspended. Soils that are saturated with water, that would become muddy when disturbed, and that have the potential to reach waters of the State, will be allowed to drain before construction resumes. If rainy weather occurs, erosion and sediment control measures will be implemented and reinforced to ensure no sediment has potential to reach streams.
- To reduce surface erosion, vegetation removal, soil disturbance, and clearing and grubbing will be limited to the minimum needed to construct the road or trail.
- Excess road or trail excavation materials will be disposed of at a stable site that will not contribute to sedimentation or otherwise degrade covered species habitat.
- Roads or trails with high erosion potential will be rocked.[18] The hardest crushed rock available in the immediate area will be used when rocking a road or trail with the potential to deliver sediment to streams to reduce road/trail surface erosion and generation of sediment into adjacent waterbodies.
- All road or trail drainage structures (ditches, out-sloping, culverts, water bars, dips, etc.) will be in place as soon as possible during construction of the road or trail, and before the rainy season.

---

[17] When 2 inches of rain is expected in a 24-hour period.

[18] Increased thickness of surfacing material has been found to reduce surface erosion by approximately 80%.

- On roads or trails areas of bare soil, which could deliver sediment to waters of the state, will have effective drainage established or will be mulched and/or seeded before the start of the rainy season to reduce surface erosion. These areas include, but are not limited to, unsurfaced road grades, cut slopes, fill slopes, waste areas, borrow areas, and rock pits.
- Construction of roads and trails near waterbodies will use best management practices to prevent or minimize potential of sediment delivery to water.
- When a road construction project is partially completed at the start of the rainy period (mid-October), the project will be left in a condition that will minimize erosion and the sedimentation of streams during the rainy period. Drainage measures will be installed on uncompleted subgrades, such as surface smoothing, out-sloping, water-barring, and dip installation. Mulching and/or grass seeding will be done on all cut slopes, unarmored fill slopes, and on any other areas of bare soil where erosion and sedimentation could affect water quality. Silt fences and/or straw dams will be used near streams to prevent sedimentation. The road will be barricaded to prevent unauthorized use. Routine inspection will occur to ensure there is no failure in the performance of prevention and correction measures throughout the rainy season.
- The road or trail surface will be drained effectively by using crowning, insloping or outsloping, grade reversals (rolling dips), and waterbars or a combination of these methods. Concentrated discharge onto fill slopes will be avoided unless the fill slopes are stable and erosion proofed.
- Native seed and certified weed-free mulch will be applied to cut-and-fill slopes, ditchlines, and waste disposal sites with the potential for sediment delivery to wetlands, Riparian Reserves, floodplains and Waters of the State upon completion of construction and as early as possible to increase germination and growth. If necessary, sites will be reseeded to accomplish erosion control. Seed species will be selected that are fast growing, have adequate ability to provide ample groundcover and soil-binding properties. Mulch will be applied to will stay in place and at site-specific rates to prevent erosion.
- Prior to the wet season, effective road surface drainage maintenance will be performed on logging roads that were used for harvest during the season and observed to need maintenance. Ditch lines will be cleared in sections where there is lowered capacity or where the lines are obstructed by dry ravel, sediment wedges, small failures, or fluvial sediment deposition. Accumulated sediment and blockages will be removed at cross-drain inlets and outlets. Natural-surface and aggregate roads will be graded where the surface is uneven from surface erosion or vehicle rutting has the potential to deliver sediment to the water of the State. Crowning, outsloping or insloping will be restored for the road type for effective runoff. Outlets will be removed or provided for through berms on the road shoulder.
- Cleaned ditch lines and bare soils that drain directly to wetlands, floodplains, and waters of the State will be seeded with native species and mulched with weed-free mulch.
- Undercutting of cut-slopes will be avoided when cleaning ditch lines on roads or trails.

4.7.12 Conservation Action 12: Restrictions on Recreational Facilities

As shown in Table 4-2, Conservation Action 12 is intended to support the following objectives.

- 1.1 Wood Recruitment
- 1.3 Water Quality and Quantity
- 4.1 Existing Oregon Slender Salamander Habitat
- 5.1 Existing Northern Spotted Owl Habitat
- 6.1 Existing Marbled Murrelet Nesting Habitat
- 7.1 Occupied Red Tree Vole Habitat
- 8.1 Existing Coastal Marten Habitat

Existing recreation facilities are expected to expand, and new ones are expected to be developed, over the course of the permit term, with most new facilities being developed in the North Coast ecoregion. The maintenance and expansion of existing facilities will follow the measures and timing restrictions described in Conservation Action 2: Riparian Equipment Restriction Zones, and Conservation Action 10: Operational Restriction to Minimize Effects on Covered Species.

Development of new facilities in RCAs will be limited to boat ramps and trail segments. Over the 70-year permit term up to 421 miles of new ODF designated trails will be developed in the permit area. Of that, up to 55 miles will occur in RCAs, with approximately 58% of those miles (32) being sited in the ERZ to facilitate stream crossings (Table 4-16). All affiliated infrastructure, such as parking and campsites, will be sited outside of the RCA. In instances where work needs to occur closer to, or in water, the measures outlined in Conservation Action 3: Stream Enhancement, will be followed to limit impacts to the aquatic system and covered species.

Development of new trails in HCAs will not exceed 172 miles over the course of the permit term (Table 4-16). Specific nesting sites for marbled murrelet or northern spotted owl will be protected as described in Conservation Actions 6: Establish Habitat Conservation Areas, 7: Manage Habitat Conservation Areas, and 10: Seasonal Operational Restrictions.

Table 4-16. Planned Trail Miles, by Location

Planned Trail miles in Permit Area		Planned Trail Miles in RCAs		Planned Trail Miles in ERZs (35-foot buffer of streams)		Planned Trail Miles in HCAs	
Motorized	143	Motorized	10 (7%)	Motorized	9 (7%)	Motorized	29 (20%)
Non-motorized	277	Non-motorized	44 (16%)	Non-motorized	22 (8%)	Non-motorized	143 (59%)
Grand Total	421	Grand Total	55 (13%)	Grand Total	32 (8%)	Grand Total	172 (41%)

Development of new recreation facilities in HCAs and RCAs is expected to include all development types described in Section 3.8, *Recreation Infrastructure and Maintenance*. The development of new shooting lanes inside HCAs and RCAs is prohibited; however, existing shooting lanes within HCAs may be maintained and improved for safety reasons. All other facility development will follow Conservation Action 10.

In addition to the measures outlined in Conservation Action 11: Road and Trail Construction and Management Measures, the following practices will be followed for trail design and maintenance:

- Motorized trail development within the RCA will be limited to stream crossings.
- Development of motorized trails within the RCA to cross streams will only occur when other alternatives are not operationally feasible.
- Construction of trails will be suspended when soils become saturated with water that would become muddy when disturbed, and that would have the potential to reach waters of the State. Soils will be allowed to drain before construction resumes. Erosion and sediment control measures will be implemented and reinforced to ensure no sediment has potential to reach streams.
- When a trail construction project is partially completed at the start of the rainy period (mid-October), the project will be left in a condition that will minimize erosion and the sedimentation of streams during the rainy period. Drainage measures will be installed on uncompleted subgrades, such as surface smoothing, out-sloping, water-barring, and dip installation. Erosion and sediment control measures will be implemented and reinforced to ensure no sediment has potential to reach streams. The trail will be barricaded to prevent unauthorized use. Routine inspection will occur to ensure there is no failure in the performance of prevention and correction measures throughout the rainy season.
- Prior to the wet season, effective trail surface drainage maintenance will be performed as needed on designated trails that were used and observed to have the potential to deliver sediment and are in need of maintenance.

Chapter 5
Effects Analysis and Level of Take

5.1 Introduction

This chapter presents the analysis of effects of the covered activities on each covered species and their habitat in the permit area. Section 5.2 describes the approach and methods used for the effects analysis. Sections 5.3 through 5.10 describe the effects of the covered activities on each of the covered species. Discussions of effects are grouped according to covered species with similar types of effects. For example, the first section (5.3) discusses all effects on covered salmon, while Section 5.4 discusses effects on two covered salamanders with similar resource needs. Discussions of effects for terrestrial species are presented individually for each species.

The effects analysis for each covered species includes an assessment of sources and types of take, the amount of projected take, the impacts of the taking of individuals on population levels, the beneficial and net effects of the conservation strategy, and effects on designated critical habitat (for those that have designated critical habitat). The intention is to present all effects that may result from covered activities on covered species, though only a subset will likely result in take. An analysis of those that may result in take and those that likely will not is included for each species.

This chapter also summarizes the expected cumulative effects, as defined under Section 7 of the federal Endangered Species Act (ESA), of non-federal projects other than Western Oregon State Forest Habitat Conservation Plan (HCP) in or near the plan area, on each covered species and their critical habitat.

5.1.1 Regulatory Context

This effects analysis includes mandatory elements of an HCP and information necessary for the U.S. Fish and Wildlife Service (USFWS) and National Oceanic and Atmospheric Administration (NOAA) Fisheries to make their findings for issuance of their permits. Sections of the ESA relevant to this effects analysis are as follows.

- Section 10(a)(2)(A)(i) requires, among other requirements, that an HCP specify the impacts on covered species that will likely result from the taking.
- Section 10(a)(2)(B)(ii) and (iv) state that the USFWS and NOAA Fisheries may only issue an incidental take permit if, among other requirements, the applicant will minimize and mitigate the impact of the taking to the maximum extent practicable, and the taking will not appreciably reduce the likelihood of the survival and recovery of the species in the wild.

The USFWS and NOAA Fisheries will need to consult independently to comply with Section 7 of the ESA prior to issuance of permits. As a component of this internal consultation, the USFWS and NOAA Fisheries must prepare a written biological opinion describing how the agency's action will affect all listed species and their designated critical habitat. The *Habitat Conservation Planning and Incidental Take Permit Processing Handbook* (HCP Handbook) (USFWS and NOAA Fisheries 2016) recommends that an HCP include the information necessary for the USFWS and NOAA Fisheries to complete the internal consultation process under Section 7 of ESA, including a defined action area and associated effects at the local, recovery unit, and range-wide scales. Section 7 also requires a determination as to whether the federal action (issuance of an incidental take permit) is likely to destroy or adversely modify designated critical habitat.

5.2 Approach and Methods

5.2.1 Determining and Defining Effects

The definition of *effects* used in this HCP follows the 2019 ESA rule revisions (USFWS and NOAA Fisheries 2019), which simplified the formal definition of "effects of the action" by combining the categories of direct effects, indirect effects, and effects of interrelated and interdependent actions. The HCP considers effects without further classifying as whether the effects are considered direct or indirect or resulting from interrelated or interdependent actions. Per 50 Code of Federal Regulations (CFR) 402, as revised, effects are considered if they would meet the following two-pronged test.

- If they would not occur but for the proposed action (i.e., implementation of activities described in Chapter 3, *Covered Activities*).
- If they are reasonably certain to occur.

The effects analysis assumes that all proposed conservation actions defined in Chapter 4, *Conservation Strategy*, will be implemented as described (i.e., effects considered and identified are those that would still occur even with conservation actions, including avoidance and minimization measures, in place).

5.2.2 Sources and Types of Effects

The term effect refers to a change that is the result of a covered activity. This analysis focuses on effects that change the condition of a covered species or its habitat. Effects can be either adverse or beneficial. The verb *affect* is used to mean "to have an effect on."

Effects were determined following an "effects pathway" model described in the HCP Handbook, by which project activities are subdivided into their individual components that, in total, make up all the activities that may be needed to complete the covered activity. Note that the model is not a computer model, but rather a way of systematically thinking through cause and effects. The model follows the chain of causation to effects, starting with the covered activities and associated components and stressors to resource needs of the species that is affected. The model then considers the behavioral and physical responses of individuals to those stressors and associated biological effects (e.g., reduced reproduction or survival). Next, the model considers how the biological effects on individuals would translate into population-level effects on numbers and distribution.

Effects considered here are those effects that are reasonably likely to occur after proposed avoidance and minimization measures are in place, including the level of take projected to occur over the duration of the permit. The effects analysis considers implementation of the conservation strategy as part of the beneficial and net effects evaluation conducted for each covered species.

The effects analysis relies on the following.

- Application of the best available information regarding known effects of covered activities (Chapter 3) on covered species.
- The distribution and extent of covered species and their habitats (Chapter 2, *Environmental Setting;* Appendix C, *Species Accounts*).
- The natural history, essential behaviors, and resource requirements of covered species (Appendix C).

The approach to analyzing effects was programmatic. As described in Chapter 3, the covered activities will occur over a wide geographic area and over a 70-year permit duration. As a result, this effects analysis provides estimates of acres of habitat where terrestrial covered species habitat function will be reduced by covered activities and describes how covered activities may result in loss of ecological processes that influence the quality of covered fish and aquatic salamander habitat. Beneficial and net effects for each species were evaluated to describe the extent to which loss of habitat function will be offset by the conservation actions described in Chapter 4.

Adverse effects include any effects of the covered activities that adversely affect covered species or their habitat. For covered species, adverse effects may reduce the number, range, reproductive success, or survival of the covered species. Adverse effects may also affect species behavior in ways that negatively affect reproduction or survival. Adverse effects on covered species' habitat are effects that reduce the ability of the habitat to sustain the species, as a result of either reducing the quantity or quality of the habitat; this is also referred to as loss of habitat function.

Effects may also be considered beneficial, insignificant, or discountable. Beneficial effects have positive effects without any adverse effects on the species or habitat. Insignificant effects relate to the size of the impact and include those effects that are undetectable, not measurable, or cannot be evaluated. Discountable effects are those extremely unlikely to occur (USFWS and NOAA Fisheries 1998).

5.2.3 Methods and Metrics for Calculating Take

The Oregon Department of Forestry (ODF) has determined that proposed covered activities are reasonably certain to result in take of one or more of the covered species and, therefore, is applying for incidental take permits. ESA defines *take* as: to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or to attempt to engage in any such conduct. 16 United States Code (U.S.C.) 1542(b).

ODF is seeking an incidental take permit for covered activities that may harm covered species. *Harm* in the definition of take in the ESA means an act that kills or injures wildlife. Such an act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavior patterns, including breeding, feeding, or sheltering (50 CFR 17.3).

According to the HCP Handbook, the HCP must identify the impacts likely to result from the proposed incidental take. It must include defined units to quantify impacts in terms of taking a number of affected individual animals or acceptable habitat surrogate units within the permit area. These same units are used on the incidental take permit to specify the authorized levels of incidental take.

The covered fish species take is estimated based on the proportion of each evolutionarily significant unit's (ESU) distribution within the permit area and the acres of projected harvest levels within the watersheds that overlap with each ESU.

For the covered terrestrial species, take is estimated based on the expected loss, modification, and future growth of habitat, as determined by applying habitat models to the outcomes of forest management activity modeling. The unit of take is the acres of modeled habitat values that would be modified by covered activities over the duration of the permit. A habitat-based approach is a common practice of the USFWS in biological opinions and in the development of HCPs (USFWS 2019). ODF is using habitat models to account for habitat quality and the relative probability of occupancy for, and associated take of, covered terrestrial species.

A habitat-based approach to evaluating the effects of the proposed action on terrestrial covered species is appropriate due to: (1) forest habitat removal and growth being the primary means of effects under ODF's control, (2) the difficulty and costs of locating occupied sites, (3) the variation in the number of individuals present at any given time, and (4) the difficulty of monitoring the actual number of individuals taken during implementation. Habitat is closely associated with reproduction, population numbers, and distribution of the terrestrial species covered under this HCP, and habitat can be effectively and efficiently monitored. For these reasons, quantifying effects on modeled habitat offers the most reasonable and meaningful measure of assessing, permitting, and monitoring anticipated take of terrestrial covered species for this HCP and for the associated incidental take permit.

It is important to note that projected habitat levels presented in this chapter are not HCP commitments, but rather are projections ODF is using to estimate the level of take and to determine appropriate avoidance, minimization, and mitigation measures needed to offset that projected level of take. Habitat projections will also be used as part of monitoring to determine if habitat is developing as expected and, if not, to determine appropriate adaptive management actions (see Chapter 6, *Monitoring and Adaptive Management*). The commitments in this HCP take into account management that includes both the covered activities outside of Habitat Conservation Areas (HCAs) and conservation actions including designating and managing HCAs, as described under Conservation Action 6: Establish Habitat Conservation Areas, and Conservation Action 7: Manage Habitat Conservation Areas. In addition, the habitat acres presented in this chapter are the model outputs and do not represent precise predictions. Habitat estimates are based on many modeling assumptions and some variation is to be expected. The reported numbers represent the modeling outputs based on the best available science and information. The habitat commitments in the biological goals and objectives of this HCP are derived from these outputs, taking into account uncertainty associated with habitat models, growth and yield projections, and forest activity modeling.

For northern spotted owl and marbled murrelet, effects are further documented in terms of the number of known active northern spotted owl territories or areas occupied by marbled murrelet that may be adversely affected under the terms and conditions of the HCP.

5.2.4 Determining Impacts of Take

The *Impacts of the Taking* section for each covered species is based on guidance provided in the HCP Handbook. The impact of the take section considers effects with minimization measures in place, but prior to any compensatory mitigation. Compensatory mitigation, such as the offsetting benefits of cumulative habitat gains over time, is considered as part of the beneficial and net effects analysis. While authorized take relates to individuals of a covered species, the impact of taking considers the population-level impact that is commensurate with the species distribution and permit area. Per the HCP Handbook, determining impacts of take consists of defining the context and intensity of take identified.

Context is the setting in which the impact of the take analysis occurs as well as the location within or proximity to listed species. It may also include the probability that take is likely to occur, based on what is currently known about the species in question. *Intensity* is the severity or magnitude of the impact on the species, and is defined in this HCP as the percent of the ESU impacted for aquatic covered species and the quantity and degree to which habitat would be affected for both terrestrial and aquatic covered species.

5.2.5 Determining Beneficial and Net Effects

The conservation actions defined in Chapter 4 outline the measures ODF will undertake to minimize effects on covered species and fully offset the impacts of taking. Minimization measures are already considered as part of the effects determination and in predicting and calculating take. Mitigation measures have not been considered in the effects analysis because take occurs whether or not it is compensated for by mitigation. Mitigation proposed as part of conservation actions includes creating additional habitat to compensate for habitat lost or habitat with reduced function during the permit term. Therefore, for each species for which an increase in habitat quality or quantity is proposed, the "net" effect on habitat has been quantified. The timing of when such benefits would occur is described in relation to the timing of effects intended to be mitigated.

In some cases, the process of improving habitat quality may result in short-term adverse effects (e.g., thinning). Such short-term adverse effects are considered under the *Impacts of the Taking…* sections.

5.2.6 Determining Effects on Critical Habitat

The *Effects on Critical Habitat* section for each species provides an analysis of the effects on critical habitat, if it has been formally designated by USFWS or NOAA Fisheries for the covered species (critical habitat may be designated only for listed species). This analysis is not a requirement for an HCP, but is intended to assist the USFWS and NOAA Fisheries in their mandatory evaluation of whether the federal action of issuing a Section 10(a)(1)(B) permit may destroy or adversely modify designated critical habitat. The USFWS and NOAA Fisheries document this analysis in their Section 7 Biological Opinions to conclude their intra-service consultation. The critical habitat analysis in this HCP is provided to support the analysis in the USFWS and NOAA Fisheries Biological Opinions.

Effects on salmon and steelhead critical habitat are evaluated by assessing effects of HCP implementation on physical and biological features of freshwater spawning and rearing sites in stream reaches within designated critical habitat.

Critical habitat has been designated in the permit area for ESA-listed Oregon Coast coho, Southern Oregon-Northern California Coast coho, Lower Columbia River coho, and Upper Willamette River steelhead (Chapter 2). Critical habitat has not been designated in the permit area for Oregon coast and Southern Oregon-California Coastal spring-run chinook salmon. All covered fish species overlap in distribution; thus, the effects on Oregon Coast coho, Southern Oregon-Northern California Coast coho, and Lower Columbia River coho salmon critical habitat is likely to be the same for Oregon coast and Southern Oregon-California Coastal spring-run chinook salmon habitat, should it be designated during the permit term. Critical habitat has not been designated for the Columbia torrent salamander or Cascade torrent salamander, so effects on critical habitat for these species are not discussed further.

Effects on critical habitat of terrestrial species are evaluated by determining and quantifying the area (in acres) of effects on lands within designated critical habitat units, including the current condition of the lands as highly suitable, suitable, marginal, or non-habitat. Terrestrial covered species with designated critical habitat in the permit area are northern spotted owl and marbled murrelet. Critical habitat has not been designated for Oregon slender salamander, red tree vole, or coastal marten.

5.2.7 Determining Cumulative Effects

Per the HCP Handbook cumulative effects are “those effects of future *state or private* activities, not involving federal activities, which are reasonably certain to occur within the action area.” Following this definition, cumulative impacts are limited to reasonably foreseeable future state or private actions not subject to federal jurisdiction or permit or funding of any kind. Future federal actions are not considered because they require separate consultation pursuant to Section 7 of the ESA. Past and present actions are not considered as part of cumulative effects because the cumulative analysis in HCPs is focused only on future effects.

5.3 Effects Analysis for Covered Salmon Evolutionary Significant Units

This section describes the effects of the covered activity on the eight ESUs of listed salmon and steelhead covered by this HCP. Many of the effects of the covered activities are the same or similar across all or most of the listed salmonid ESUs covered by this HCP. In cases where effects are similar or the same, the listed salmon and steelhead ESUs covered by this HCP are referred to as the covered salmon species. The known range of Oregon Coast coho and spring-run chinook, Lower Columbia River coho, and Columbia River chum have the greatest overlap with the permit area (Appendix C). Upper Willamette River steelhead, Upper Willamette River chinook, and Southern Oregon/Northern California Coast coho and spring-run chinook have limited distribution in the permit area (Appendix C). Lower Columbia River chinook fish distribution does not overlap the permit area, but waters from the permit area empty into streams within their distribution (Appendix C).

This section presents the analysis of effects of the covered activities on covered salmonid species and their habitat in the permit area. Effects of the action refer to the permanent or temporary direct and indirect effects of an action on a species or its habitat. The conservation actions (Chapter 4) in the HCP are expected to protect salmon, steelhead, and their habitat within the permit area. The likelihood of direct injury to, or death of, any salmonid from forestry activities, road management, or other operational activities is expected to be low under the HCP. Effects on the covered species, by independent population, are described below.

This section also presents the cumulative effects of projects other than HCP covered activities in or near the permit area and effects on covered species’ critical habitat.

5.3.1 Sources and Types of Effects

The covered activities described in Chapter 3 could result in the following categories of stressors on the covered salmonid species, each of which is described in more detail below.

- **Reduce large wood recruitment**. Reduction in availability of large wood for instream complexity.
- **Reduce water quality and quantity**. Reduction in function or quality of habitat because of covered activities.
- **Impede fish passage**. Reduction in access to suitable habitat due to barriers (e.g., undersized culverts, large jump heights)
- **Cause direct mortality**. Injury or mortality of individuals because of handling or crushing by equipment, humans, or felled trees.

The stressors listed above are categorized in this manner to facilitate a meaningful assessment of the effect's pathways for the covered salmonid species. The sections below describe the effects pathways associated with each of the stressors that result from the covered activities.

Vulnerability of the covered salmon to take by the described activities is dependent on the life-stage of the salmon, their residency time in the system, their location in the system, and the timing of activities. These factors are considered below in the summary of stressors.

5.3.1.1 Large Wood Recruitment

A common issue in fish-bearing streams in western Oregon is a lack of instream wood. Reduced instream wood is the result of removal of trees from within the riparian zone around streams and rivers for timber as well as the long-standing practice of clearing debris and logjams from river channels (Bryant 1983). Large living and dead wood in the riparian zone provides important habitat for the covered salmon and steelhead. Large riparian trees that die and fall into and near streams, such as within floodplains and wetlands, regulate sediment and flow routing, influence stream channel complexity and stability, increase pool volume and area, and provide refugia and cover for fish (Bisson et al. 1987, Gregory et al. 1987, Hicks et al. 1991, Ralph et al. 1994, Bilby and Bisson 1998). The loss of wood is a primary limiting factor for salmonid production in almost all watersheds west of the Cascade Mountains (Appendix E, *Effects Analysis*).

Harvest in riparian areas adjacent to streams eliminates or reduces the amount of wood available for delivery to streams. Reductions in riparian forests that provide large wood for recruitment would reduce instream habitat (e.g., habitat and channel complexity, cover) used by the covered salmon and steelhead in the permit area for spawning, rearing, and migration. The effects of the HCP on large wood recruitment are expected to be minor due to the implementation of Conservation Action 1: Establish Riparian Conservation Areas, and Conservation Action 2: Riparian Equipment Restriction Zones.

Implementation of this conservation action will retain most of the available wood volume in the RCAs during the 70-year permit term (TerrainWorks 2020), which will be available for recruitment into streams that support covered salmon and steelhead. Most of the wood recruited from the RCAs will come from streamside sources (i.e., riparian conservation areas adjacent to fish-bearing streams [88%]), while the remainder (12%) comes from debris flows in the upper watersheds (TerrainWorks 2020).

Wood delivery to Type F waters and ecologically important Type N waters from potentially unstable slopes can result from shallow landslides/debris flows as well as from deep-seated landslide processes. Because the HCP will retain a 35-foot buffer on any Type N stream with the potential to deliver wood to Type F waters and a 500-foot-long, 50-foot-wide process protection buffer at the confluence of high energy and potential debris-flow streams and fish-bearing streams, wood recruitment from these areas is expected to remain at or near background levels. In addition, areas with potentially unstable slopes that have the potential to deliver to a fish stream, buffers will be expanded out to up to 170 feet (horizontal distance) to more fully encompass nearby potentially unstable slopes known as inner gorges and aquatic adjacent unstable areas, as described in Chapter 4 and Appendix I, *Potentially Unstable Slope Evaluation*. This is particularly true for areas in the northern part of the permit area where high landslide frequencies make mass wasting an important debris delivery mechanism.

Within the Riparian Conservation Areas (RCAs), thinning and other silvicultural practices will not be employed. Minor reductions in the amount of wood available for recruitment within the RCAs will be associated with new road construction in the RCA, where no upland alternative is viable. The construction of a new road will require vegetation removal that will persist until the road is vacated and trees can regrow. Acres of riparian habitat that will be protected under Conservation Action 1: Establish Riparian Conservation Areas are shown in Table 5-1; this represents the area under the HCP that will be maintained as a source of wood for the covered species. These acres are further split out by ESU in Section 5.3.2, *Impacts of the Taking on Salmon and Steelhead*. Over the course of the permit term stand age distribution in the permit area will trend toward older forests (Figure 5-1). A diversity of riparian age classes, with a presence of mature trees, will help supply organic material (leaves, woody debris, and macroinvertebrates) and serve as an ongoing source of large woody material to provide instream structure that benefits the covered salmon and steelhead.

Table 5-1. Acres of Riparian Conservation Areas Created Under the Habitat Conservation Plan

	North Coast	South Coast	Willamette Valley	Total
Acres of Habitat in RCAs	65,300	4,400	7,600	77,300
Percent of Total Acres	84%	6%	10%	100%

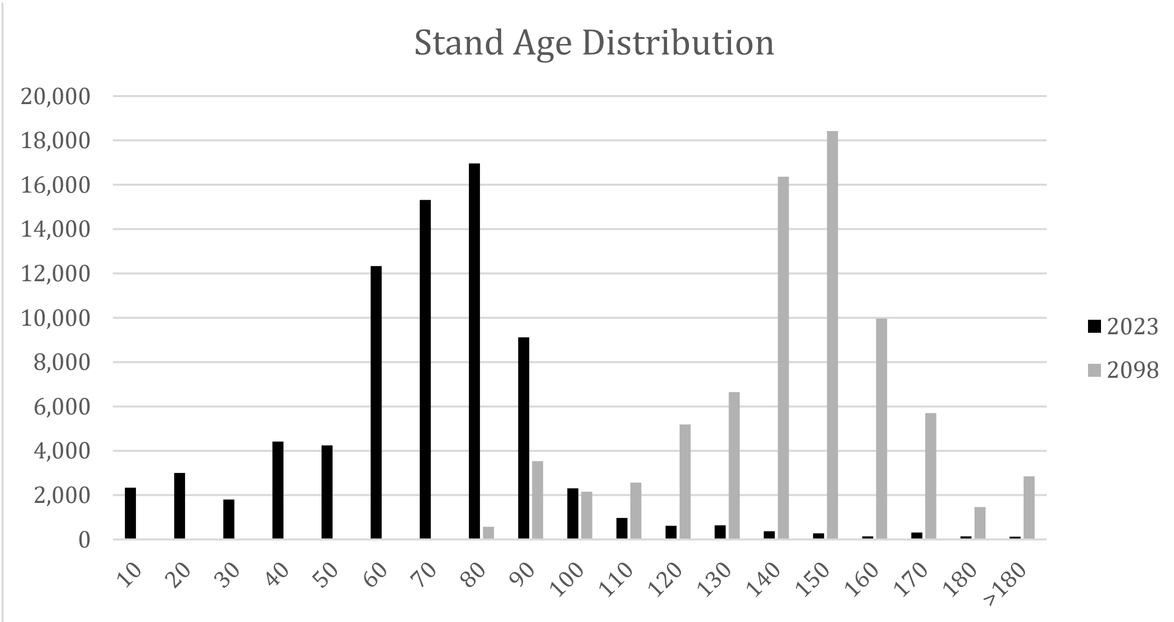


Figure 5-1. Stand Age Distribution in RCAs at the Start (2023) and End (2093) of the Permit Term

Potential for Take to Occur

Implementation of Conservation Action 1: Establish Riparian Conservation Areas, and Conservation Action 2: Riparian Equipment Restriction Zones will retain enough riparian forest to allow large wood to be recruited into fish-bearing streams within the permit area, including streams with high debris flow potential that are not fish bearing. The construction of new roads, cable corridors, and quarries will result in minor reductions in the amount of wood available for recruitment at some locations in the permit area. This action will be governed by Conservation Action 11: Road and Trail Construction and Management Measures, which limits new road construction in RCAs to occur when no other viable alternative is available. This minor reduction in available large wood and the habitat alterations associated with removal of wood for roads, cable corridors, and quarries will be unlikely to result in take. In addition, the implementation of conservation actions in the RCAs will result in the development of larger trees over time, leading to higher quality wood recruitment that will deliver instream structure into the aquatic system throughout the permit term.

5.3.1.2 Water Quality and Quantity

Riparian areas maintain ecological processes, such as regulating stream temperature and streamflow, cycling nutrients, providing organic matter, filtering chemicals and other pollutants, trapping and redistributing sediments, stabilizing stream channels and banks, absorbing and detaining floodwaters, maintaining fish habitats, and supporting the food web for a variety of biota (Buffler 2005). The reduction of functional riparian forests can degrade water quality and quantity, while protection and expansion of existing riparian forests can improve conditions.

The effects of timber harvest and its associated activities can impact the covered species at both a local and watershed scale. Implementation of the HCP will include protection of existing functional riparian systems and restoration of degraded systems to address potential water quality issues. An assessment of the function and quality of habitat, related to water quality and quantity parameters, as a result of covered activities is presented below. Further analysis of impacts, by ESU, is provided in Appendix E.

Water Temperature

Fish are ectothermic ("cold blooded") animals, and the environmental conditions of the stream control their body temperature. Because water temperature affects the body temperature of fish, it can regulate activity and physiological processes (Thompson and Larsen 2004). Stream temperature directly influences aquatic organisms' physiology, metabolic rates, susceptibility to disease and nonnative competitors, and life history behaviors and influence aspects of important processes of habitat for fish and aquatic species such as nutrient cycling and productivity (Allen 1995). Interactions between external drivers of stream temperature such as air temperature, solar radiation, and wind speed and the internal structure of the stream system such as the channel, riparian zone, hyporheic exchanges, and alluvial aquifers drive stream temperature regimes (Poole and Berman 2001).

Harvest activities adjacent to fish-bearing streams can increase summer stream temperatures through reduction of shade that results in increased solar radiation reaching the water's surface. This can also occur on small, non-fish-bearing streams that flow into fish-bearing streams, particularly in stream reaches immediately above fish-bearing streams. These temperature increases, if not managed, can extend downstream into fish-bearing waters and affect the covered salmon and steelhead.

During the summer months, many of the streams that salmon juveniles inhabit are already close to harmful or lethal temperatures. With the expectation of rising stream temperatures due to global climate change, increases in infection rates of juvenile salmon by parasites and competition by warm water species may become an increasingly important stressor both for freshwater and marine survival (NOAA Fisheries 2016). Effects of rising temperature on the covered species could include physiological stress and reduced growth, disruption of life cycle timing, and increased predation and disease that would potentially reduce survival and reproductive success (NOAA Fisheries 2016).

Potential effects on water temperature from harvest activities in the permit area are minimized by maintaining RCAs adjacent to the aquatic zone (see Chapter 4 for full RCA description). Stream shading and instream temperature protection will be maintained by retaining vegetation in riparian areas during adjacent harvest activities. As shown in Figure 5-1 vegetation in the riparian buffers will continue to grow over the course of the permit term, increasing the total amount of riparian shade and over time evolving into multi-layered riparian stands capable of providing adequate shade under a wide variety of provided conditions.

RCA widths vary by stream type. All fish-bearing streams and large and medium non-fish-bearing perennial streams have a 120-foot buffer (horizontal distance). The U.S. Environmental Protection Agency (EPA) (2013) indicates that a 120-foot no-cut buffer is adequate to prevent riparian shade loss that would cause stream temperatures to increase.

RCAs adjacent to small non-fish-bearing perennial and seasonal streams will be narrower than RCAs adjacent to fish-bearing and medium and large non-fish-bearing streams. Small perennial non-fish-bearing streams will have Process Protection Zones (PPZ) that extend 120 feet (horizontal distance) from the aquatic zone for the first 500 feet upstream of the end of fish use to protect stream temperatures in water within that 500 feet. It also allows for some temperature recovery from narrower upstream buffers as water flows from a small non-fish perennial stream into a fish-bearing stream. Upstream of the 500-foot PPZ, the buffer will be 35 feet (horizontal distance) from the aquatic zone.

The 120-foot RCA (horizontal distance) within the 500-foot PPZ at the intersection of fish and small perennial non-fish streams will help ameliorate stream temperature increases. The PPZ buffer will not entirely dissipate accumulated heat from the harvested area; however, it will allow stream temperatures to return to near the pre-harvest temperature regime prior to reaching a fish-bearing stream and prevent additional heat accumulation within 500 feet of the fish-bearing stream.[1] The PPZ was identified based on a literature review process with the HCP Scoping Team.[2] A list of sources reviewed by the Scoping Team to assess how forestry activities and riparian management strategies affect downstream temperatures in the proposed PPZ is provided in Appendix E and summarized below.

While the 120-foot-wide by 500-foot-long PPZ is not expected to completely offset the effects of harvest on small non-fish stream temperature, it would result in substantial reduction of water temperature changes prior to entering fish-bearing streams. Bladon et al. (2018) found that while maximum daily stream temperatures were elevated in small, non-fish-bearing headwaters after harvest there was no statistically significant measurable downstream warming related to upstream harvest activities on small headwaters streams.

Numerous upstream-downstream longitudinal studies examined temperature recovery downstream of single harvest units. Davis et al. (2015), in an analysis of sites from ODF's RipStream study, found that the temperature change 300 meters (984 feet) downstream of harvest units on small and medium fish-bearing streams was approximately 56% of the change at the harvest unit, on average (range of 1% to 82% of harvest unit change). However, this behavior was highly site-dependent (streams with lower gradients and/or greater surface area showed lower remaining temperature change magnitudes at 300 meters, demonstrating heat loss dependence on groundwater, transit time, and surface area). Arismendi and Groom (2019), in another RipStream analysis, also showed a tendency for downstream sites to converge towards the pre-harvest equilibrium, the tendency generally strengthened with time, and post-harvest temperature regimes with wide buffers returned to behavior that was statistically similar to their pre-harvest characteristics while sites with narrow buffers often did not. Roon et al. (2021) found that, in streams with measurable temperature increases after riparian thinning (approximately 50% removal of canopy cover), six of eight warmed study reaches continued to have measurable stream temperature increases 150–200 meters (320–656 feet) downstream of the thinned reach. Several other studies examining the extent of stream temperature recovery towards pre-harvest conditions downstream of harvest units show incomplete downstream mitigation of single harvest unit temperature increases that were due to narrow stream buffers (Keith et al. 1998: 0.5° of 5.0 degrees Celsius [°C] of the temperature increase remaining after 73 meters [240 feet] and 0.5° of 6.0°C temperature increase remaining after 46 meters [151 feet]; MacDonald et al. 1998: 2° of 3.0°C increase remaining after 500 meters [1,640 feet]; Rutherford et al. 2004: 0.77 to 7.18°C increase reduced by 0.35 to 2.51°C, over distances of 153 to 892 meters [502 to 2,926 feet]; Wilkerson et al. 2006 [unbuffered streams]: 1.8° of 2.8°C of increase remaining and 1.3° of 2.5°C increase remaining

[1] Fish-bearing streams are often higher in gradient than the use of listed species, creating additional shaded buffers above critical habitat to provide further cooling of the stream.
[2] The Scoping Team is composed of representatives from ODF, Oregon Department of State Lands, Oregon Department of Environmental Quality, Oregon Department of Fish and Wildlife, USFWS, and NOAA Fisheries.

after 100 meters [328 feet]; and Zwieniecki and Newton 1999: study mean across sites was 0.4° of 1.09°C increase remaining after 150 meters [492 feet]).

Unlike the small non-fish-bearing streams observed by Bladon et al. (2018), some of the above studies were primarily on fish-bearing streams. Non-fish-bearing headwater streams often have very high groundwater inputs, low flow volumes relative to fish-bearing streams, and substantial post-harvest flow increases so heat loss and dilution may be a greater factor in return to equilibrium than in fish-bearing streams (e.g., Moore et al. 2003, Story et al. 2003, Kibler et al. 2013). Heated water from harvested sites around non-fish-bearing headwaters can rapidly decrease in temperature and move towards pre-harvest equilibrium upon flowing through fully forested stream reaches in the absence of subsequent harvest units, depending on site conditions such as gradient and cold-water inputs. With other harvest units present, measurable cumulative heating is probable unless harvest site best management practices (BMPs) prevent substantial riparian shade loss. Cole and Newton (2013) showed cumulative temperature increases through multiple harvest units with private forest-type buffers (0 to 50 feet[3]), even when separated by uncut reaches, on three of four study streams. The 120-foot-wide buffers in the PPZ will likely prevent additional harvest-related heating within the 500 feet directly upstream of fish-bearing reaches.

While temperature recovery may not be total through the 500-foot PPZ, the relative total flow contribution of non-fish streams in a harvest unit to the receiving fish-bearing stream is critical. For example, a net temperature increase of 0.5°C in a non-fish stream will be undetectable (≤0.2°C) in a fish stream if it provides 40% or less of the total fish-bearing stream's flow, while an increase of 1.5°C must comprise no more than 13% of the total fish-bearing stream's flow. This includes an average increase of 1°C for a 35-foot buffer, which falls within the range of responses in the longitudinal studies described above. With attenuation to 0.75°C at 500 feet (see Appendix E), temperature increases in a fish stream may be undetectable if the non-fish streams' contributions in a particular harvest area are no more than 27% of the combined total flow of the receiving fish-bearing stream. Based on Bladon et al. (2018), that non-fish stream contribution could be as high as 67%. Considering the range of temperature recovery responses in the literature, the semi-conservative nature of heat pollution, and the dependence on site-specific characteristics, the 500-foot PPZ provides a reasonable degree of certainty that measurable temperature impacts on fish-bearing reaches in the permit area will be avoided.

Conservation Action 11: Road and Trail Construction and Management Measures, will limit new road construction and stream crossings within RCAs and provides BMPs for roads that need to be constructed in the RCA due to no other viable alternative, and existing road improvement and vacating projects. Right-of-way clearing for road building can permanently remove an average width of 45 feet of vegetation (see Appendix H, *Forest Roads Manual*, for details) within the new road's right-of-way that would reduce stream shading due to a reduction in tree density. Management direction will limit new road construction such that roads will infrequently[4] occur in RCAs, which limits temperature effects on adjacent streams. However, some circumstances will require new road construction in the RCAs for harvest in areas outside the RCAs to occur. Due to the limited amount of roads that are expected to be constructed in the RCAs and the implementation of Conservation Action 11: Road and Trail Construction and Management Measures, impacts on stream shading and

[3] Both sun sided partial and two-sided

[4] Activity intersects RCAs a few times annually, but is generally not be present on every State Forests district, every year, See Conservation Action 2.

temperature are expected to be localized and minor and will decrease with downstream flow and shading provided by the RCAs.

Culvert replacement, installation, and removal will frequently[5] occur in RCAs; however, in locations where stream crossings are required, small amounts of overstory vegetation may need to be removed in addition to the right of way. This additional removal is typically in situations where a culvert is being replaced with a larger one that is more capable of fish passage, which can require slightly more area to sink into the stream channel. Because culvert work will be distributed in space and time throughout the permit area, effects associated with small decreases in shading will be localized and minor. Further, some of this vegetation will regrow over time and provide stream shading.

Road maintenance and vacating activities could require brushing, removal of hazard trees, culvert cleaning, road resurfacing (e.g., rocking), and drainage improvements. These actions could require that trees and brush be removed; however, vegetation removed would be primarily from the understory, which does not affect shading. The removal of hazard trees could impact overstory vegetation that provides stream shade; however, this would occur infrequently[6] and would not affect enough overstory vegetation in one location to cause more than a minor localized impact.

The implementation of Conservation Action 1: Establish Riparian Conservation Areas, Conservation Action 2: Riparian Equipment Restriction Zones, and Conservation Action 11: Road and Trail Construction and Management Measures, will keep stream shade reduction to a minimum and protect water temperature. Covered salmon and steelhead are likely to experience minor, localized increases in water temperature associated with harvest near lower order streams that have narrower stream buffers and new road construction. Streams, and associated covered species, that are most at risk from minor increases in stream temperatures are those that are 303(d) listed for temperature. These effects are discussed by ESU below in Section 5.3.2.

Fine Sediment

Forestry activities, if not managed properly, can increase the input of fine sediment into the aquatic system, which degrades spawning areas, reduces pool refuge habitat, decreases winter refuge areas for juveniles, abrades gills, and impedes feeding visibility. Lakel et al. (2010) found that streamside management zones (buffers) between 25 and 100 feet are effective in trapping sediment before it can enter streams. Conservation Action 1: Establish Riparian Conservation Areas, reduces sedimentation by maintaining a buffer of 120 feet in all perennial fish-bearing streams and a buffer of 35 to 120 feet on all perennial streams, and 35 to 50 feet on seasonal streams that are potential debris flow tracks (PDFT) or high energy (HE). Other seasonal non-fish-bearing streams (i.e., not PDFT or HE) will maintain a 35-foot equipment restriction zone with restrictions on ground disturbance (no more than 30% vegetative disturbance of the Seasonal Equipment Restriction Zone),and limiting ground-based equipment operation to what is necessary to implement conservation actions and those actions required for felling and removal of trees. There are 88.6 miles of existing roads in the RCAs. Of that, 7 miles of road are within 35 feet of a waterbody, the remaining 81.6 miles occur between 35 and 120 feet of a waterbody. Based on Lakel et al. (2010)

[5] Will occur multiple times annually. Amount of activity varies by district, dependent on habitat and forest health goals. See Conservation Action 2.

[6] Activity intersects RCAs a few times annually, but is generally not be present in every State Forest District, every year. See Conservation Action 2.

and Rashin et al. (2007) these RCAs will be enough to minimize sediment inputs to the aquatic system from road and harvest activities.

Upslope routing of sediment from harvest units to seasonal non-fish channels will be reduced both by Conservation Action 2: Riparian Equipment Restriction Zones, and the general downed wood retention requirements of Conservation Action 8: Conservation Actions Outside Habitat Conservation Areas and Riparian Conservation Areas.

Any work that needs to occur within the RCA, such as road system management activities, will follow Conservation Action 2: Riparian Equipment Restriction Zone, and maintain a 35-foot equipment restriction zone from the outer edge of the aquatic zone for all streams. This zone applies to both sides of the stream. Construction of new roads in the RCAs will be minimized by following Conservation Action 11: Road and Trail Construction and Management Measures, which provides measures to minimize potential impacts on the covered species. Measures such as following the *Oregon Guidelines for Timing of In-Water Work to Protect Fish and Wildlife* (ODFW 2008) will ensure the covered salmon and steelhead are not directly affected by construction activities. Management direction such as siting requirements, proper drainage, and erosion control measures will limit inputs of sediment to the aquatic system over the course of the permit term.

Ongoing use and maintenance of logging roads in the permit area will be a continual potential source of sedimentation. Similarly, an increase in the volume of truck traffic during timber harvest activities could increase the delivery of fine sediment to adjacent streams. However, as stated above, Conservation Action 1: Establish Riparian Conservation Areas, and Conservation Action 11: Road and Trail Construction and Management Measures, will limit inputs of sediment to the aquatic system. These actions will ensure that an adequate buffer exists between the road and stream to minimize sedimentation. They will also require that maintenance activities would occur in a manner that will not likely result in harm of the covered salmon and steelhead, that roads that cannot be hydrologically disconnected and/or mitigated will be closed during wet weather, and that commercial road use will be suspended in areas where turbid runoff is likely to reach waters of the State.

Culvert replacement, installation, and removal has the potential to temporarily increase downstream sedimentation. To limit the effect this will have on the covered species all in-water work, including culvert replacement, installation, and removal would occur during the Oregon Department of Fish and Wildlife (ODFW) in-water work window. This will limit the potential for the covered salmon and steelhead to be affected by any sediment plumes that may be associated with this work.

New logging roads and recreational trails allow easy public access to areas that were previously less accessible. Increased human activity in and around streams could affect stream bank stability (Kaufmann et al. 2009). Up to 55 new miles of non-motorized trails could be developed in RCAs over the course of the permit term, with up to 32 miles occurring in ERZs to facilitate stream crossings. This equates to new trails adjacent to 0.7% of the stream miles in the permit area. Recreational activities involving horseback riding, off-highway vehicles, mountain bikes, and foot traffic can compact soil and cause the loss of vegetative structure in riparian areas, which could increase erosion and sedimentation in adjacent waterbodies (USFS n.d.). The indirect effects of increased access could result in increased deposition of fine sediment on the stream bed. While the specific activities of recreational users are not covered under this HCP, ODF does institute closures of unsurfaced roads and recreation infrastructure (e.g., boat ramps and trails) that have the potential to deliver sediment to the waters of the State. The maintenance and/or construction of new boat ramps or trail segments may occur in RCAs. Implementation of Conservation Action 11: Road and Trail Construction and Management Measures and Conservation Action 12: Restrictions on Recreational Facilities, will ensure activities are performed in a manner that limits sediment input and effects on the covered salmon and steelhead.

Rock quarries provide rock and gravel for road construction and management activities across the permit area. Rock quarry activities can generate sediment when pits are excavated, and the material is crushed, piled, and hauled. Sediment is most likely to enter streams from quarries within a distance of 150 feet. Quarries outside of riparian areas may transport sediment via road ditches if the ditches are connected to streams.

Implementation of Conservation Action 1: Establish Riparian Conservation Areas, and Conservation Action 11: Road and Trail Construction and Management Measures, will limit work on steep slopes in the permit area. Regulating timber harvesting and road and landing construction on steep, potentially unstable slopes will limit sediment input by avoiding management activities that have the potential to increase the probability of slope failures and mass-wasting events. Should those slopes fail and reach the stream network, retained trees will provide large wood to the stream, reduce the likely travel distance of resulting debris flows, and inhibit the movement of fine sediment farther downstream while sorting and retaining coarse sediment. Habitat restoration activities implemented under Conservation Action 3: Stream Enhancement, could result in harm to covered species. Stream restoration projects within the permit area may include placement of logs or whole trees in streams to create pools and to retain spawning gravels, replacement or removal of stream crossing structures (i.e. culverts) that block fish passage, relocation or redesign of improperly located roads, stabilization of sediment sources (i.e., cut bank improvement of road drainage systems), road closure, and/or road decommissioning. These activities may temporarily affect covered fish species through scouring and erosion but will ultimately be beneficial, and will follow BMPs to reduce short-term impacts.

Within aquatic ecosystems, important functions of large wood include the storage, sorting, and modulation of the downstream movement of sediment. The presence of large wood in upstream reaches promotes sediment storage, which reduces fine sediment that degrades and entombs salmon redds; while in spawning areas it helps reduce bed mobility, which also helps to keep redds intact and minimize their loss through the movement of the spawning substrate during high flows (NOAA Fisheries 2016). As described in Section 5.3.1.1, *Large Wood Recruitment*, implementation of Conservation Action 1: Establish Riparian Conservation Areas, will ensure that nearly all available wood volume in the permit area will remain in RCAs (TerrainWorks 2020), which will be available for recruitment into streams that support to covered salmon and steelhead. This wood will be available throughout the permit area and provide upstream sediment storage opportunities that will sort fine sediment and limit redd entombment.

The implementation of Conservation Action 1: Establish Riparian Conservation Areas, and Conservation Action 11: Road and Trail Construction and Management Measures, would limit effects on the covered salmon and steelhead in the permit area to minor, localized increases in sedimentation associated with new road construction, existing road and culvert maintenance, road use, and habitat restoration activities. While implementation of these conservation actions will minimize management-related erosion and sedimentation, complete elimination of management and public recreation related inputs is not possible.

Chemical Contaminants

If not sited properly forest roads can direct and increase the runoff of soils into waterbodies, increasing sedimentation and exposure to potential chemical spills (Gucinski et al. 2001). Stormwater runoff from impervious surfaces delivers a wide variety of pollutants to aquatic ecosystems, such as metals (e.g., copper and zinc), petroleum-related compounds (polynuclear aromatic hydrocarbons), along with the sediment washed off the road surface (Driscoll et al. 1990, Buckler and Granato 1999, Colman et al. 2001, Kayhanian et al. 2003). Pesticides and metals can be toxic to fish at high concentrations and have been shown in the laboratory to affect fish behavior even at very low concentrations. Accidental introduction of contaminants associated with timber harvest activities (e.g., fuel spills from timber harvest equipment) could result in mortality or inhibit normal behaviors of covered species that encounter these contaminants. The introduction of contaminants associated with maintenance-related activities would have similar effects.

The implementation of Conservation Action 11: Road and Trail Construction and Management Measures, reduces the potential that activities associated with road construction and use in the RCAs would result in the runoff of contaminants into the adjacent stream. All new roads in or adjacent to RCAs will be hydrologically disconnected if possible. Roads that cannot be disconnected, or are unsuitable for wintertime haul, will be closed to logging trucks during wet weather. Staging and storage areas associated with construction activities in the RCAs would be at least 150 feet away from any waterbody or wetland to minimize leaks and spills that could enter waters of the State.

Water Quantity

Forests influence water yield through the interception of precipitation and transpiration by trees. Increased coarse sediment inputs to streams following logging can also increase the effect of low flows by shallowing and widening stream channels (Hicks et al. 1991). Conservation Action 1: Establish Riparian Conservation Areas, and Conservation Action 2: Riparian Equipment Restriction Zones, address this potential effect on water quantity from harvest activities in the permit area by maintaining RCAs adjacent to the aquatic zone, which includes the stream channel(s) and associated aquatic habitat features (beaver ponds, stream-associated wetlands, side channels, and the channel migration zone). This riparian vegetation will provide bank stability and prevent the shallowing and widening of a stream that can occur in its absence.

Upland timber harvest can affect streamflow. When a forest is harvested, water that is normally transpired by trees becomes available for streamflow. Post-harvest peak streamflows after fall and spring storms generally increase; however, flows associated with large mid-winter events are generally unaffected as soils are already saturated regardless of cover type (Brown n.d.). Peak flows following storms with return intervals of 6 years or more are generally insensitive to canopy removal-related flow increases. Peak flow events from more common return interval storms (e.g., those with a 2-year or smaller return interval) generally do increase in magnitude if sufficient tree cover removal occurs (e.g., 20–40%; Grant et al. 2008). This increase in streamflow associated with regenerating stand conditions with low live tree retention generally lasts approximately 5–10 years.

Once forests are 10+ years old and regrowing rapidly, they transpire more than three times the amount of water as mature forests (Moore et al. 2004). This increased transpiration can further exacerbate summer low flows, reducing available habitat for covered salmon and steelhead. In an analysis of 60 years of daily stream flow records from eight paired-basin experiments, Perry and Jones (2016) found that average daily streamflow in basins with 34- to 43-year-old Douglas-fir plantations was 50% lower than reference basins of 150- to 500-year-old mixed species forests, with the greatest deficit occurring in August and September. Thinning of young replanted forests did not alleviate this effect. Thinning of mature stands by up to 50% "shelterwood" conditions, or the use of patch cuts of 3 acres or less, resulted in lower initial summer flow increases that did not persist. Earlier onset of low flows could reduce available habitat and alter the timing and rate of smolts' migration to the ocean for covered salmon and steelhead (Spies et al. 2018.)

The creation of RCAs under Conservation Action 1: Establish Riparian Conservation Areas, and equipment restriction zones (ERZs) under Conservation Action 2: Riparian Equipment Restriction Zones, will reduce runoff associated with storm events, which will limit delivery of sediments to the stream as well as mass soil movement (Bathurst and Iroumé 2014, Grant and Wolff 1991). Upslope routing of sediment from harvest units to seasonal channels will be reduced both by Conservation Action 2: Equipment Restriction Zones, and the general downed wood retention requirements of Conservation Action 8: Conservation Actions Outside Habitat Conservation Areas and Riparian Conservation Areas. Seasonal potential debris flow tracts and high energy streams will have RCAs that extend 50 feet (horizontal distance) from the aquatic zone for the first 500 feet upstream of the end of fish use to capture material moving into fish-bearing streams. These areas are the most likely to deliver wood and sediment to fish-bearing streams that would affect the covered salmon and steelhead. Debris flows that occur in the permit area would be a short-term scouring event. In the short term these events could directly destroy redds or kill fish; however, they also introduce and redistribute spawning gravels and wood that provide habitat for the covered species.

Peak stream flows can be exacerbated by road-related runoff. Construction of new roads in the RCAs will be minimized to the extent possible. Any work that needs to occur within the RCA, such as road system management activities, will follow Conservation Action 2: Riparian Equipment Restriction Zone, and maintain a 35-foot equipment restriction zone from the other edge of the aquatic zone for all streams. This zone applies to both sides of the stream. Construction of new roads in the RCAs will be minimized by following Conservation Action 11: Road and Trail Construction and Management Measures, which provides measures to minimize potential impacts on the covered species. Measures such as following *Oregon Guidelines for Timing of In-Water Work to Protect Fish and Wildlife* (ODFW 2008) will ensure the covered salmon and steelhead are not directly affected by construction activities. In addition, roads located near a fish-bearing stream that have a high erosion potential, or landslide hazards that could affect the covered species will be evaluated for vacating. Roads that are vacated will follow the measures described in Conservation Action 5: Standards for Road Improvement and Vacating, which will fully disconnect the road from the stream, resulting in a decrease in peak flows. The implementation of these conservation actions will partially ameliorate the effects of road runoff and associated changes in peak streamflow.

The creation of RCAs under Conservation Action 1: Establish Riparian Conservation Areas, and HCAs will provide a buffer of mature trees that will protect summer low flows across the permit area. This will be most beneficial in areas drained by young volcanic rocks with deep, slow groundwater systems, such as the High Cascades, that may be particularly vulnerable to declines in summer streamflow. Areas with shallow subsurface aquifers and limited potential to store water are less sensitive to changes in low flows. Limiting the proportion of each ESU in recently harvested condition will moderate changes to low and peak flows; see *Impacts of the Taking…* sections below by ESU for harvest area proportion estimates and additional discussion. ODF maintains water developments such as small water catchments, basins, and impoundments, which provide a water source for firefighting or for filling water trucks that may be on standby during prescribed burning or wildland fires. These water developments are located at creeks and rivers, and springs. Up to 35 new water drafting sites could be built and operational during the 70-year permit term. The primary method used to extract water would be portable pumps. The use of multiple pumps in a small area has the potential to deplete streamflow, which could affect the covered salmon and steelhead depending on timing. Most fire response occurs in the summer months, during low flow, but is complete by the fall when the salmon and steelhead are returning to spawn. Therefore, reduction in streamflow is not likely to affect migration and spawning, but it could impact salmon rearing in the freshwater system.

Most water quantity effects would be minimized under Conservation Action 1: Establish Riparian Conservation Areas, Conservation Action 11: Road and Trail Construction and Management Measures, and Conservation Action 5: Standards for Road Improvement and Vacating. Salmon and steelhead are likely to experience minor, localized decrease in water quantity associated with fire-related water drafting. Similarly, salmon and steelhead would also experience localized increases in water quantity associated with storm events. These storm events can cause debris flows that enter fish-bearing streams.

5.3.1.3 Fish Passage

Stream crossings such as bridges or culverts can be migration barriers that affect the covered salmon and steelhead. Migration barriers limit or prohibit access to upstream habitat, limiting spawning and rearing locations within the species range. Stream crossings that are replaced, installed, or removed under this HCP will be compliant with Conservation Action 4: Remove or Modify Artificial Fish-Passage Barriers, that requires new and replacement culverts meet NOAA Fisheries (2014) and ODFW (2015) passage criteria to ensure culverts are designed to maintain hydraulic conditions, including hydrology, velocities, and slopes that pass juvenile and adult fish. Culvert replacements and upgrades will occur at those areas identified to be a passage barrier or that are at the end of their life and due for an upgrade.

Culvert replacement would create a temporary fish barrier during construction as well as decrease shading and increase sedimentation. Measures are taken to offset potential impacts, articulated in the *Oregon Guidelines for Timing of In-Water Work to Protect Fish and Wildlife* (ODFW 2008) or will obtain appropriate approvals from ODFW if it needs to occur outside appropriate windows. Effects of instream work are described in Section 5.3.1.2, *Water Quality and Quantity,* as are the effects associated with vegetation removal and increased sedimentation.

The removal or modification of artificial barriers in the permit area will increase fish passage to upstream areas that could be used by salmon and steelhead for spawning and rearing. The access to additional previously inaccessible habitat will increase the carrying capacity of the system, potentially increasing populations of covered fish.

5.3.1.4 Direct Mortality

Direct mortality of the covered salmon and steelhead could occur if they make contact with equipment, personnel, or chemicals, or are present during dewatering associated with the covered activities. In-water activities such as culvert maintenance and installation, stream crossing construction, and stream enhancement projects have the potential to affect the covered fish species. As described in Conservation Action 11: Road and Trail Construction and Management Measures, in-water work will follow the established *Oregon Guidelines for Timing of In-Water Work to Protect Fish* *and Wildlife* (ODFW 2008) or will obtain appropriate approvals from ODFW if it needs to occur outside appropriate windows. The ODFW work windows will minimize impacts on the covered species and their habitat by having work occur during times that avoid the vulnerable life stages of fish, including migration, spawning, and rearing.

5.3.2 Impacts of the Taking on Salmon and Steelhead

The sections below provide ESU-specific assessments of implementation of the HCP. Take resulting from habitat loss and other adverse effects, described above, is not expected to result in an adverse impact on the species' long-term persistence in the permit area for the following reasons:

- Timber harvest activities will occur outside the RCAs. Implementation of the HCP will protect and enhance approximately 77,300 acres of forest in RCAs along 5,405 river and stream miles.
- Road decommissioning and culvert replacement activities that will occur under the HCP will reduce road-related sedimentation across the permit area and remove existing barriers to improve instream habitat conditions and make additional upstream habitat accessible for the covered salmon.
- Stream enhancement projects that will occur under the HCP will focus on restoring natural processes to create habitats that improve overall conditions for the covered species and other aquatic organisms in the permit area, allowing for immediate improvements to instream complexity, while the adjacent riparian forests are developing to provide long-term benefits.

While individual actions can affect the covered species, BMPs and conservation actions identified in Chapters 3 and 4, respectively, will minimize those effects on minor, localized changes that will be spread out across the permit area. To assess the overall impact of timber harvest on the covered salmon and steelhead, timber harvest modeling was used to predict the pace, scale, and amount of harvest over the course of the permit term. The results of this modeling exercise were used to determine if clearcut conditions would occur in any watersheds/ESUs over the course of the permit term at proportions that could result in watershed-wide effects.

As described in Section 5.3.1, the RCAs will minimize most of the effects associated with harvest activities to the covered salmon and steelhead. However, harvest outside of the RCAs can contribute to changes in watershed processes.[7] If more than 19–25% of a watershed is clearcut at any given time, elevated peak flows become measurable; however, these effects diminish as the watershed becomes larger (Grant et al. 2008, Stednick 1996). Increases in peak flow associated with storm events can cause geomorphic effects with effects being amplified in rain-on-snow watersheds (Grant et al. 2008). Flows that are large enough to alter channel morphology, bank erosion, or habitat structure have the highest likelihood of affecting fish (Grant et al. 2008).

Detailed results of the watershed analysis, by Hydrologic Unit Code (HUC) 10, are presented in Appendix E. The below section focuses on identifying HUC 10 watersheds, by ESU, or group of ESUs, that could experience elevated peak flows associated with timber harvest (stands <10 years old) in the permit area. The analysis focuses on the proportion of land within ODF ownership that would exhibit clearcut conditions; however, in some instances the analysis is expanded to the larger HUC 10 for context. If an average of 20% of timber in the permit area of the HUC would be <10 years old

[7] Annual water and sediment yield, low flows, peak flows, and water quality metrics (e.g., temperature, chemical composition).

over the course of the permit term, then effects on fish could occur. Outside the permit area it is assumed that watersheds that are primarily privately owned will have younger stands, while federally owned watersheds are likely to have older aged forests.

5.3.2.1 Oregon Coast Coho and Spring-run Chinook

The Oregon Coast coho ESU is made up of 27 independent and dependent populations, 13 of which have no stream miles in the permit area, and 14 populations that could be affected by harvest in their watershed (Appendix E). The majority of these independent populations have less than 5% of their stream miles in the permit area while the Nehalem and Tillamook Bay have 49 and 28%, respectively of their stream miles in the permit area. The remaining 13 populations do not overlap the permit area, will not be affected by covered activities, and are therefore not further discussed. Effects on the 14 populations where harvest would occur in the permit area are discussed below. Given the high proportion of the Nehalem and Tillamook Bay populations in the permit area, impacts those populations are also further discussed in their own sections. Effects on Oregon Coast spring-run chinook are expected to be the same as those described for Oregon Coast coho and are not described separately.

The Oregon Coast ESU is composed of 4,227,104 acres; the permit area encompasses 639,489 acres within this ESU and overlaps 43 HUC 10s (Appendix E). Rivers in the ESU flow from the mountains of the Coast Range, except for the Umpqua River, which extends east through the Coast Range to drain the Cascade Mountains (NOAA Fisheries 2016). Rivers and streams in this ESU are fed by both rainfall and snowmelt, though most systems are rain-dominated.

An assessment of clearcut conditions at 5-year intervals, by HUC 10, is provided in Appendix G. Average percent of HUC 10 watersheds in clearcut and young forest conditions (0–10 years) in the permit area ranges from 0% in the Clark Branch South Umpqua River, Olalla Creek – Lookinglass Creek, and Umpqua River – Sawyers Rapids to 15% in Beaver Creek, Nestucca River, and Trask River. The distribution of clearcuts in the permit area, across the permit term are not projected to exceed 20% of the total forest cover; therefore, upland harvest in the permit area is not likely to affect overall watershed process for any of the HUC 10s in the Oregon Coast Coho ESU.

Nehalem Independent Population

The Nehalem Independent Population of Oregon Coast coho (HUC 17100202) is composed of 464,777 acres; the permit area encompasses 209,569 acres within this subbasin that overlap six HUC 10s (Appendix E). Rivers and streams in the Nehalem subbasin are primarily fed by rainfall.

An assessment of clearcut conditions at 5 year intervals, by HUC 10, is provided in Appendix E. Average percent of HUC 10 watersheds in clearcut and young forest conditions (0–10 years) in the permit area ranges from 6% in the Salmonberry River to 16% in the Upper Nehalem River. The distribution of clearcuts in the permit area, over the permit term, will not exceed 20% of the total forest cover for any HUC 10 in range of the Nehalem Independent Population at any point during the permit term. This, in conjunction with the large overall size of the subbasin, indicates that upland harvest is not likely to affect overall watershed process in the Nehalem subbasin. Furthermore, watersheds located in the rain-dominated zone, such as the Nehalem, are less sensitive to changes in peak flows (Grant et al. 2008).

Tillamook Bay Independent Population

The Tillamook Bay Independent Population of Oregon Coast coho is composed of 342,363 acres; the permit area encompasses 214,980 acres within this subbasin that overlaps six HUC 10s (Appendix E). Rivers and streams in the Tillamook Bay watershed are primarily fed by rainfall.

An assessment of clearcut conditions at 5 year intervals, by HUC 10, is provided in Appendix E. Average percent of HUC 10 watersheds in clearcut and young forest conditions (0–10 years) in the permit area ranges from 5% in the Kilchis River and Tillamook River HUCs to 15% in the Trask River HUC. The distribution of clearcuts in the permit area, across the permit term, will not exceed 20% of the total forest cover for any HUC 10 in range of the Tillamook Bay Independent Population. This, in conjunction with the large overall size of the subbasin, indicates that upland harvest is not likely to affect overall watershed process in the Nehalem subbasin. Furthermore, watersheds located in the rain-dominated zone, such as Tillamook Bay, are less sensitive to changes in peak flows (Grant et al. 2008).

5.3.2.2 Lower Columbia River Coho, Chinook, and Columbia River Chum

Lower Columbia River coho, chinook, and Columbia River chum ESUs have minor overlap with the permit area (Chapter 2 and Appendix C). Their ESUs are composed of 325,599 acres, with 43,639 acres that overlap five HUC 10s in the permit area. The permit area is in the Coast Range ecological zone where rivers and streams are primarily fed by rainfall.

An assessment of clearcut conditions at 5-year intervals, by HUC 10, is provided in Appendix E. Average percent of HUC 10 watersheds in clearcut and young forest conditions (0–10 years) in the permit area ranges from 0% in the Salmon River HUC to 19% in the Big Creek HUC. The distribution of clearcuts in the permit area, across the permit term, will not exceed 20% of the total forest cover; therefore, upland harvest in the permit area is not likely to affect overall watershed process for any of the HUC 10s within the range of Lower Columbia River coho, Lower Columbia River chinook, and Columbia River chum.

5.3.2.3 Upper Willamette River Spring Chinook and Winter Steelhead

Upper Willamette River spring chinook and Winter Steelhead ESUs have minor overlap with the permit area (Chapter 2 and Appendix C). Their ESU boundaries are not identical, so total ESU and permit area acreages are not included here. Rivers and streams in the Willamette River basin are fed by rainfall and snowmelt.

An assessment of clearcut conditions at 5-year intervals, by HUC 10, is provided in Appendix E. Average percent of HUC 10 watersheds in clearcut and young forest conditions (0–10 years) in the permit area ranges from 0% in the Quartzville Creek – Green Peter Lake HUC to 21% in the Rickreall Creek – Willamette River HUC. While Rickreall Creek exceeds the 20% threshold, watershed effects are not expected as the permit area accounts for less than 1% of the overall acreage within this HUC. Therefore, upland harvest in the permit area is not likely to affect overall watershed process for any of the HUC 10s within the range of Upper Willamette River spring chinook and winter steelhead.

5.3.2.4 Southern Oregon/Northern California Coasts Coho and Spring-run Chinook

The Southern Oregon/Northern California Coasts coho and spring-run chinook ESU has minor overlap with the permit area (Chapter 2 and Appendix C). Their ESU is composed of 606,716 acres, with 9,295 acres that overlap 20 HUC 10s in the permit area. Rivers and streams in these watersheds are primarily fed by rainfall.

An assessment of clearcut conditions at 5-year intervals, by HUC 10, is provided in Appendix E. Average percent of HUC 10 watersheds in clearcut and young forest conditions (0–10 years) in the permit area is expected to exceed 20% of the permit area in the following HUCs: Josephine Creek – Illinois River, West Fork Illinois, Hellgate Canyon – Rogue River, and Shady Cove – Rogue River HUCs; however, the permit area represents a small portion of the overall watershed for each of these. Therefore, while clearcuts in the permit area for these HUCs will exceed a 20% average of the total forest cover over the course of the permit term, the clearcut acreage in the permit area represents a small portion of the overall HUC 10 (Appendix E). Consequently, upland harvest in the permit area is not likely to affect overall watershed process for any of the HUC 10s within the range of the Southern Oregon/Northern California Coast coho.

5.3.2.5 Climate Change

Climate change is described in Section 2.3.1.3, *Climate and Climate Change,* and is expected to result in warmer, drier summers, reduced snowpack, lower summer flows, higher summer stream temperatures, and increased winter floods. These changes could affect the covered salmon and steelhead by reducing available summer rearing habitat, increasing potential scour and egg loss in spawning habitat, increasing thermal stress, and increasing predation and disease risk. Climate change will cause the covered salmon and steelhead to be exposed to more intense winter peak flows and more severe summer low flow periods.

Higher winter stream flows increase the risk that winter peak flows and floods could damage spawning redds and wash away incubating eggs. Earlier peak stream flows could also flush some young salmon and steelhead from rivers to estuaries before they are physically mature, increasing stress and the risk of predation. Lower stream flows and warmer water temperatures during summer will degrade summer rearing conditions, in part by increasing the prevalence and virulence of fish diseases and parasites (USGCRP 2009). Other adverse effects are likely to include altered migration patterns, accelerated embryo development, premature emergence of fry, variation in quality and quantity of tributary rearing habitat, metabolic stress when food resources are limited, and increased competition and predation risk from warm-water, nonnative species (ISAB 2007).

Climate change effects to summer low flows may be compounded by changes in forest vegetation conditions over the course of the permit term. Climate change is expected to alter tree growth and mortality due to increasing CO2, changes in water availability, and disturbances such as drought, fire, insects, and pathogens with the magnitude of effect varying by geography and species (Spies et al. 2018). Thinning prescriptions to prevent invasive species (Chapter 3) will be used across the permit area. These measures, which will be used to support the development of harvestable stands, also serve to increases tree resilience to future vulnerabilities associated with drought and disturbance (Spies 2018).

Halofsky et al. (2017) shows that primary adaptation strategies for fisheries and aquatic habitat should focus on storing more water on the landscape, increasing resilience to disturbance, maintaining and restoring riparian and wetland vegetation complexity, and maintaining and restoring natural thermal conditions in streams. Conservation Action 1: Establish Riparian Conservation Areas, and promoting the colonization of beaver under Conservation Action 3: Stream Enhancement, will increase water storage across the permit area and provide deep pool refugia. Furthermore, Conservation Action 5: Standards for Road Improvement and Vacating, will limit the amount of new road construction in the riparian area as well as reduce the number of existing roads that contribute to chronic erosion and sedimentation of adjacent waterbodies. As described in Chapter 4, the RCAs are adequate to ameliorate instream warming, and harvest within each HUC 10 is not expected to exceed the 20% threshold that would result in watershed effects over the course of the permit term.

Implementation of the conservation actions will help offset climate change effects such as flow alterations and increases in instream temperatures and sedimentation in the permit area.

5.3.3 Beneficial and Net Effects on Salmon and Steelhead

This section describes how implementation of the conservation actions will achieve the biological goals and objectives to benefit the covered salmon and steelhead. The conservation actions described in Chapter 4 are expected to minimize effects on covered species and fully offset the impact of the taking by maintaining and improving the natural processes necessary for salmon spawning and rearing habitat in the permit area. The HCP is expected to have both short- and long-term benefits to the covered salmon and steelhead by:

- Establishing a protective riparian strategy through RCAs adjacent to fish- and non-fish-bearing streams to protect riparian forests during and following harvest activities and contribute to the long-term development of large wood to benefit instream habitat over time.
- Promoting the development of older forests within RCAs and upland areas within HCAs to improve instream habitat quality.
- Limiting the construction of new roads in RCAs and having BMPs in place for road management activities will limit runoff and sediment inputs.
- Implementing stream enhancement and restoration projects to benefit habitat for the covered salmon at key locations.

The HCP covers approximately 5,405 river miles in the permit area that are within the range of the covered salmon species distribution. Limiting factors for each ESU are presented in Chapter 2 and Appendix C. While limiting factors vary across ESU and independent population, the main factors limiting the listed salmon and steelhead in the permit area that ODF has the ability to affect are physical habitat quality and quantity and water quality associated with land management. Recovery plans have been developed for the covered salmon species with a goal of improving the viability of the species to the point that they meet the delisting criteria and no longer require ESA protection.

The implementation of Conservation Action 1: Establish Riparian Conservation Areas, and Conservation Action 2: Riparian Equipment Restriction Zones, will protect 77,300 acres of riparian forests from harvest in the permit area. These RCAs minimize impacts on stream habitat by maintaining necessary connections between terrestrial and aquatic forest conditions and providing a buffer around streams. Streams with riparian buffers have intact vegetative cover (shading) and are not likely to have increased stream temperatures, large diurnal temperature fluctuations (Macdonald et al. 2003, Johnson and Jones 2000), or warming effects on adjacent downstream reaches. Riparian buffers provide a physical barrier that keeps logging debris (slash) from adjacent activity from reaching the stream and provides shading over the stream that maintains ambient stream temperatures (Jackson et al. 2001, Richardson et al. 2010). They also function as a filter to absorb increased nutrients and sediments following harvest from exposed or disturbed soils (Richardson et al. 2010).

Riparian buffers and other tree reserves are highly susceptible to windthrow due to increased edge-effect (Hassen et al. 2005). In years following harvest, tree fall into or adjacent to the stream is common and will impact salmonid habitat by altering stream-channel dynamics. Windthrow following harvest and the presence of a riparian buffer provide a source of large wood recruitment to streams (Hairston-Strang and Adams 1998). Large wood within streams provides collection points for spawning gravel, facilitates pool formation, and creates habitat cover (quality rearing habitat). Tree fall from the buffer creates a low risk of direct take and indirect harm of fish, through the potential crushing or disturbance of redds, creation of severe logjams that are potential barriers to upstream movement, and potential temporary increase of fines.

Although there is a potential for streams to warm because of silvicultural activities, the likelihood is very small when harvest takes place outside of riparian areas. This is especially applicable to small streams because temperature increases in headwater streams are unlikely to produce substantial changes in the temperatures of larger streams into which they flow unless the total inflow of heated tributaries constitutes a significant proportion of the total flow in the receiving stream (Kibler et al. 2013, Moore et al. 2005 as cited in Reeves et al. 2016). Silvicultural actions are not permitted within the RCAs and will, therefore, not contribute to stream warming.

Over the course of the permit term the distribution of the forest stand age over time in the RCAs will continue to develop into older forests as they will not be harvested. In addition, 36,561 acres of RCAs overlap with HCAs. Thinning will not occur in these RCAs, but will be used in the adjacent HCAs to promote development of late seral forest conditions, which will benefit the covered salmon and steelhead. As trees get older and bigger, they will continue to stabilize streamside soils, provide shade, and be available for recruitment as large woody debris, all of which will benefit the covered fish species.

Riparian areas experiencing moderate annual climate conditions can have higher humidity and can act as a buffer against fire and as a refuge for fire-sensitive species (Halofsky and Hibbs 2008). Some studies have found fire typically occurs less frequently in riparian areas (Russell and McBride 2001, Dwire et al. 2016). The creation of RCAs in the permit area will provide resilience against climate change.

A review of Oregon forest roads after the 1996 storm (Skaugset and Wemple 1998) indicates that most of the road-related erosion in the permit area is associated with roads that were constructed during or before the 1960s. And of those roads, most erosion incidents were associated with mid-slope locations, not roads that were located on the ridge or valley bottom. Existing roads that are contributing to sedimentation will be inventoried and addressed under Conservation Action 5: Standards for Road Improvement and Vacating.

Road decommissioning can ameliorate the effect of increases in peak flows to the streams caused by new road construction by disconnecting runoff from previous roads to streams. Road decommissioning will include blocking the road, out-sloping and adding waterbars for drainage control, ripping and subsoiling the roadbed, removing culverts and re-establishing natural drainage, and replanting the roadbed. Roads that receive full decommissioning (ripping and subsoiling) will have the most beneficial effect of reducing runoff to streams. The fully decommissioned roads will provide a long-term benefit of decreasing peak flows to streams by disconnecting these roads from the stream.

Construction of new roads in the RCAs will be minimized to the extent possible. When roads need to be constructed in an RCA, they will follow Conservation Action 11: Road and Trail Construction and Management Measures, which will ensure all new roads are hydrologically disconnected to the maximum extent possible and avoid sensitive environments (e.g., streamside, midslope, steep slopes) to the extent feasible. Conservation actions will also ensure management direction is in place to limit the use of roads with the potential to deliver sediment to the streams during the wet season. Overall, the combination of all road-related conservation measures will result in a reduction in road-related sediment input to the aquatic system over the course of the permit term.

Implementation of Conservation Action 4: Remove or Modify Artificial Fish-Passage Barriers, and Conservation Action 11: Road and Trail Construction and Management Measures, will result in an increase in stream miles accessible to the covered salmon and steelhead by improving and removing existing barriers and ensuring all new stream crossings meet NOAA Fisheries and ODFW regulations. ODF will replace at least 167 (50%) culverts identified by ODFW that do not currently meet fish passage criteria expanding the upstream extent of the covered salmon and steelhead over the course of the permit term.

Habitat restoration activities implemented under Conservation Action 3: Stream Enhancement, will protect and improve watershed processes for covered salmon and steelhead. Stream enhancement projects will be focused in the permit area and will provide direct benefit to covered salmon and steelhead through the implementation of actions that address the covered species' limiting factors and promote the restoration of natural processes. However, projects may also be implemented outside the permit area if it is determined they are high priority and would benefit the covered species. The implementation of stream enhancement projects will immediately benefit the covered species while the adjacent riparian forests are developing to provide long-term benefits.

Beaver management, to benefit the covered species, will also occur under Conservation Action 3: Stream Enhancement. The promotion of beaver habitat and the presence of beavers in the permit area can naturally increase stream complexity and provide high quality rearing habitat. In addition, if natural disturbances occur in riparian areas in locations where beaver could occur and improve fish and aquatic habitat, reforestation methods that promote beaver colonization will be utilized. Ecosystem alterations made by beavers that would benefit the covered species include: reconnected and expanded floodplains, greater hyporheic exchange, higher summer baseflows, expanded wetlands, improved water quality, increased habitat complexity, and increased prey base (Pollock et al. 2015).

Full implementation of the ODF HCP will result in a net increase in quality of available habitat for the covered salmon species. With full implementation of the HCP, 5,405 river miles and 77,300 acres of riparian habitat will be managed towards an improved habitat condition and will minimize effects from covered activities occurring outside of RCAs. Long-term benefits in the permit area associated with implementation of the conservation actions include: improved habitat, increased channel complexity, increased fish passage to spawning and rearing habitat, improved water quality conditions, and improved functioning of riparian forest, which would address limiting factors for the covered species, and improve conditions for the covered species in the permit area over the course of the 70-year permit term.

5.3.3.1 Benefits of Monitoring and Adaptive Management Program

The monitoring program described in Chapter 6 includes ODF's commitment to document trends in habitat conditions across the permit area to verify that the biological goals and objectives are met. The results of the monitoring program will provide documentation that the intended benefits to the covered salmon and steelhead habitat are being realized. Should monitoring results indicate that biological objectives are not being realized, ODF will implement the adaptive management process described to rectify deficiencies, see Chapter 6.

5.3.3.2 Net Effects

The conservation strategy includes maintaining riparian conservation areas, which will not be harvested and will develop into older forests over the permit duration. The RCAs will provide long-term protection and enhancement of the covered salmon and steelhead habitat that will offset timber harvest and other covered activities carried out within the permit area.

Minor, localized take associated with the covered activities will be offset through the implementation of stream enhancement projects. These projects will restore natural processes and create habitat that will improve the overall conditions for the covered species in the permit area.

5.3.4 Effects on Critical Habitat

Within the permit area designated critical habitat occurs for Oregon Coast coho, Lower Columbia River coho, Lower Columbia River chinook, Upper Willamette River spring chinook, Upper Willamette River winter steelhead, and Southern Oregon/Northern California Coasts coho (Table 5). There is no designated critical habitat for Oregon Coast spring-run chinook, Columbia River chum, and spring-run chinook in the permit area.

Under the HCP, all stream miles designated as critical habitat within the permit area will be protected by RCAs. The RCAs will promote the development of function riparian forests with large trees that will provide shade, contribute to instream habitat, and improve water quality and quantity. Existing roads in the RCAs will be assessed to identify locations that contribute sediment to the aquatic system and need to be hydrologically disconnected or moved. In addition, development of new roads in the RCAs will be limited to areas where no other option is economically or operationally feasible. New and replacement road design and construction within the RCA will follow Conservation Actions 1 and 2, which include specifications for stream crossings and road buffers to minimize sedimentation. The commitment to reduce sedimentation from existing roads and limit future road development will limit potential sediment inputs to critical habitat. The commitment to improve fish passage will increase available spawning and rearing habitat within the permit area. As riparian conditions are developing in the RCAs, stream enhancement projects will focus on restoring natural processes to create habitats that improve overall conditions for the covered species and other aquatic organisms in the permit area, allowing for immediate improvements to instream complexity.

While the covered activities could have minor, localized effects on critical habitat, implementation of the conservation actions identified in Chapter 4, and described above, are expected to protect the physical and biological features that support the life history requirements of for Oregon Coast coho, Lower Columbia River chinook, Lower Columbia River chinook, Upper Willamette River spring chinook, Upper Willamette River winter steelhead, and Southern Oregon/Northern California Coasts coho in the permit area and would be unlikely to destroy or adversely modify critical habitat.

Table 5-2. Miles of Critical Habitat by ESU in the Permit Area

ESU	Total Miles of Designated Critical Habitat	Miles of Critical Habitat in Permit Area	Percent
Oregon Coast coho	6,568	435	7
Nehalem Independent Population	514	192	37
Tillamook Bay Independent Population	375	189	50
Lower Columbia River coho	3,281	25	<1
Lower Columbia River chinook	1,314	5	<1
Columbia River chum	712	0	0
Upper Willamette River spring chinook	1,472	3	<1
Upper Willamette River winter steelhead	1,285	14	1
Southern Oregon/Northern California Coasts coho[a]	1,649	2.2	<1

[a] GIS dataset does not currently exist for Southern Oregon-Northern California Coast coho critical habitat. These numbers are based on steelhead distribution (as described in Appendix C) and is confined to Southern Oregon; stream miles in Northern California are not included.

5.3.5 Cumulative Effects on Salmon and Steelhead

Cumulative effects, as defined in this HCP, are the combined effects of future state, local, or private (i.e., non-federal) actions that are reasonably certain to occur in the action area, considered collectively with the effects of this HCP.

ODF is not aware of any future state or local actions that may contribute to cumulative effects that are reasonably certain to occur. The Department of State Lands (DSL) is currently preparing an HCP for the Elliott State Forest. As an HCP, it is required to fully offset the impacts of take and is unlikely to adversely affect the Oregon Coast coho population or distribution or otherwise contribute to cumulative effects. In addition, because the Elliott State Forest HCP is in development and not yet final, it is not considered a cumulative effect in this HCP (per the regulatory definition of cumulative effects, 50 CFR 02.02).

Port Blakely is pursuing an HCP and ITP for forest lands in Clackamas County, Oregon, some of which occur in the same ESUs as the covered fish species discussed above. However, that HCP is not complete, nor is it available to the public, so any cumulative effects that may occur from it would be speculative. ODF is not aware of any other non-federal landowner that is seeking an incidental take permit through Section 10 of the ESA. Therefore, actions on other non-federal lands are not anticipated to contribute to cumulative effects, because those landowners are required to avoid take under Section 9 of the ESA. Other state, local, or private future actions that are reasonably certain to occur may include road construction, recreational development plans (e.g., mountain bike trail networks), and linear rights-of-way construction (e.g., transmission lines, pipelines). But ODF is not aware of any specific projects reasonably certain to occur within the covered fish ESUs.

5.4 Effects Analysis for Eulachon

This section describes the effects of the covered activities on eulachon. Eulachon may only occur in a limited portion of the permit area. The permit area does contain a small number of tidally influenced streams along the Columbia River, where eulachon may exist now or at some point during the permit term (Appendix C).

5.4.1 Sources and Types of Take

Sources and types of take would be the same as those described for salmon and steelhead in Section 5.3. Eulachon occur primarily in the mainstem Columbia River and alcoves in the mouths of its tributaries. These mainstem rivers are outside the permit area and eulachon are unlikely to migrate upstream into the streams that occur in the permit area.

5.4.2 Impacts of the Taking on Eulachon

Direct effects on this species would be unlikely. However, they could be affected by changes in water quality and quantity of tributaries of the Columbia River. As described in Section 5.3, these changes would be minor due to implementation of the conservation actions (Chapter 4) and BMPs (Chapter 3).

5.4.3 Beneficial and Net Effects

The implementation of conservation actions to benefit the covered salmon and steelhead would benefit eulachon by providing adequate shade in the permit area to maintain/cool water temperatures that are likely to ameliorate the impact of climate change in tributaries to the Columbia River.

5.4.4 Effects on Critical Habitat

Critical habitat has not been designated for eulachon within the permit area; therefore, none will be affected.

5.4.5 Cumulative Effects on Eulachon

Eulachon are likely to have minimal occurrence in the permit area. With implementation of the HCP, streams that feed into eulachon habitat will be protected to offset effects associated with timber harvest and protect against climate change. This ever-improving condition of streams and covered species habitat in the permit area will therefore minimize effects on eulachon and fully offset the impact of the taking.

5.5 Effects Analysis for Columbia and Cascade Torrent Salamanders

This section describes the effects of the covered activity on Columbia torrent salamander and Cascade torrent salamander.

Within the permit area there are approximately 677 stream miles of potential habitat (perennial non-fish-bearing streams) for Columbia torrent salamander within their range. Known occurrences of Columbia torrent salamander in the permit area are clustered in Clatsop County, south of the Clatsop State Forest and in Tillamook, Washington, and Yamhill Counties (Appendix C).

The permit area includes approximately 76 stream miles of suitable habitat (perennial non-fish-bearing streams) for Cascade torrent salamander. Known occurrences of Cascade torrent salamander in the permit area, based on ODF and Global Biodiversity Information Facility (GBIF) data are clustered in Linn County, in the Santiam State Forest. Additional occurrences in the vicinity of the permit area have been recorded in Marion, Clackamas, and Lane Counties (Appendix C).

5.5.1 Sources and Types of Take

The covered activities described in Chapter 3 could result in the following categories of stressors on the covered torrent salamander species, each of which is described in more detail below.

- **Reduced water quality and quantity:** Reduction in function or quality of habitat as a result of covered activities.
- **Habitat loss and fragmentation:** Reduction in habitat resulting in habitat fragmentation from covered activities.
- **Direct mortality:** Injury or mortality of individuals resulting from handling or crushing by equipment, humans, or felled trees.

The stressors listed above are categorized in this manner to facilitate a meaningful assessment of the effect's pathways for the covered torrent salamander species. The following sections describe the effects pathways associated from each of the stressors that result from the covered activities.

5.5.1.1 Water Quality and Quantity

Water Temperature

Because torrent salamanders are closely associated with streams and have specific requirements for clear, cold, well-shaded streams (Stebbins 1951), activities that alter these stream conditions degrade the species' habitat. Activities in riparian areas that remove canopy cover, such as timber harvest, timber management, and fire management, may result in increased water temperatures and decreased dissolved oxygen (Thomas et al. 1993, Blaustein et al. 1995). Torrent salamanders are highly sensitive to temperature changes (Dunham et al. 2007).

Expected temperature effects on torrent salamanders from implementation of the HCP would be the same as described under Water Temperature in Section 5.3.1.2. Torrent salamanders are specialized for life in cold water and are less likely to be found in streams greater than 16° C (Howell and Maggiulli 2011). Their intolerance to warm temperatures may be attributed to their highly reduced lungs and reliance on cutaneous respiration, which makes them vulnerable to desiccation (Howell and Maggiulli 2011) and more reliant on cold, well-aerated environments. Potential effects on water temperature from harvest activities in the permit area are addressed by maintaining RCAs adjacent to the aquatic zone (see Chapter 4 for full RCA description). Torrents occur in perennial Type N streams; these streams will maintain at least a 35-foot vegetated buffer for the entire length. Seasonal "other" streams will not be buffered; however, leave tree groups will be maintained around the junction of seasonal streams and perennial streams during timber harvest where torrent salamanders are most likely to occur. While these measures will maintain cover and shade in torrent habitat, the buffers may not be wide enough to completely shade some channels. Bladon et al. (2018) indicates that streams with a 35-foot buffer could warm by approximately 1°C. Surveys will be used to identify where torrents occur within the permit area, and stream temperatures will be monitored in reaches where harvest activities have the potential to affect the species. While localized increases in water temperature could result in alteration of torrent habitat that could result in take, implementation of species and temperature monitoring, as well as adaptive management practices, will limit impacts.

The implementation of Conservation Action 1: Establish Riparian Conservation Areas, Conservation Action 2: Riparian Equipment Restriction Zones, and Conservation Action 11: Road and Trail Construction and Management Measures, will keep stream shade reduction to a minimum and protect water temperature. Torrent salamanders are likely to experience minor, localized increases in water temperature associated with harvest in smaller order streams that have smaller stream buffers and new road construction. Streams, and associated covered species, that are most at risk from minor increases in stream temperatures are those that are 303(d) listed for temperature.

Suspended Sediment

Torrent salamanders are found in shallow, fast flowing streams with gravel and cobble present. Sedimentation associated with forest management activities degrade habitats used by torrent salamanders. Expected effects associated with sedimentation from implementation of the HCP would be similar to those described under *Fine Sediment* in Section 5.3.1.2.

The implementation of Conservation Action 1: Establish Riparian Conservation Areas, and Conservation Action 11: Road and Trail Construction and Management Measures, would limit effects on torrent salamanders in the permit area to minor, localized increases in sedimentation associated with new road construction, existing road and culvert maintenance, road use, and habitat restoration activities. While implementation of these conservation actions will minimize management-related erosion and sedimentation, complete elimination of management-related inputs is not possible.

5.5.1.2 Habitat Loss and Fragmentation

One of the main threats to torrent salamanders is loss of habitat. Loss of habitat may also contribute to habitat fragmentation. Fragmentation of habitats may lead to the further isolation of populations and restriction of gene flow, which makes populations more vulnerable to local extirpations. These factors are compounded by the relatively long time it takes these salamanders to reach sexual maturity (approximately 4.5 years), and the low number of eggs produced per female and the tendency for females to produce only one clutch per year (Blaustein et al. 1995, Howell and Maggiulli 2011).

Temporary habitat loss may result from the development and use of temporary access roads that cross streams. These areas, however, would be restored to pre-disturbance conditions when covered activities are complete. Roads, trails, and culverts crossing streams may also pose barriers to amphibian movements (Howell and Maggiulli 2011). Perched culverts are problematic for torrent salamander movement due to the loss of substrate continuity, increased water velocity at the downstream outflow pipe, significant drops at the outflow pipe, and lack of instream structures (e.g., quiet pool) (Howell and Maggiulli 2011). Because torrent salamanders are highly associated with the stream channel and adjacent moist ground, the salamanders will not likely move upland to navigate around the barriers that roads and culverts may present. Although it is not known to what degree, roads and trails that cross streams may also fragment habitat for Columbia and Cascade torrent salamanders (Howell and Maggiulli 2011). An inability to disperse puts populations at risk because it limits gene flow and the ability to recolonize after disturbance (Jackson 2003).

The implementation of Conservation Action 1: Establish Riparian Conservation Areas, Conservation Action 2: Riparian Equipment Restriction Zone, Conservation Action 4: Remove or Modify Artificial Fish-Passage Barriers, Conservation Action 11: Road and Trail Construction and Management Measures, and Conservation Action 12: Restrictions on Recreational Facilities would minimize effects on torrent salamanders in the permit area to minor, localized areas of habitat loss associated with new culvert installation, and road-related stream crossings.

5.5.1.3 Direct Mortality

Timber harvest or forest management activities that take place in or immediately adjacent to suitable streams and disturb stream surfaces could result in direct injury or mortality of individual salamanders and their eggs. Equipment and vehicles used to conduct covered activities could also crush salamanders resulting in direct injury or mortality. The implementation of Conservation Action 1: Establish Riparian Conservation Areas, and Conservation Action 2: Riparian Equipment Restriction Zones, limits work in RCAs. Conservation Action 11: Road and Trail Construction and Management Measures, will reduce the risk of mortality by developing roads away from streams and implementing buffers of undisturbed land between roads and streams. While implementation of these conservation actions will minimize the potential for direct mortality, complete elimination of direct mortality cannot be assured as it may occur when temporary stream crossings or culverts are constructed. These effects would be localized and temporary. The potential for mortality to occur will be better understood following presence/absence surveys in suitable streams, as described in Chapter 6.

5.5.1.4 Other Stressors

Diseases in torrent salamanders are currently unknown (Howell and Maggiulli 2011); however, Jancovich et al. (1997) suggest that *Ambystoma tigrinum* Virus has been implicated in a series of mass salamander mortalities in the United States and that the disease is being spread via anthropogenic means. Although more common in frogs, salamanders have been documented with chytridiomycosis and mortalities have occurred (Scheele et al. 2019). Increased human presence in suitable Columbia and Cascade torrent salamander habitat could increase the potential for introduction of disease.

The construction of additional roads in the permit area over the course of the permit term will provide additional public access. Implementation of Conservation Action 11: Road and Trail Construction and Management Measures, will limit construction of new roads inside the RCAs, and Conservation Action 5: Standards for Road Improvement and Vacating, will result in identification and vacating of existing roads inside RCAs. Overall, road miles inside RCAs, and associated public access, are not expected to increase significantly over the course of the permit term.

5.5.2 Impacts of the Taking on Columbia and Cascade Torrent Salamanders

The permit area supports an estimated 677 miles of Columbia torrent salamander habitat and 76 miles of Cascade torrent salamander habitat. Under the HCP, take through direct mortality and habitat modification will be minimized through the establishment of RCAs and ERZs (Conservation Action 1: Establish Riparian Conservation Areas, and Conservation Action 2: Riparian Equipment Restriction Zones). With implementation of the HCP, suitable habitat for Columbia and Cascade torrent salamanders in the permit area will be conserved in RCAs.

However, some disturbance in riparian areas that support torrent salamanders will still occur. Based on historic road construction/reconstruction data it is estimated that an average of 17 perennial Type N stream crossings per year will be constructed in the range of the Columbia torrent salamander. Within the range of the Cascade torrent salamander an average of 11 perennial Type N stream crossings are expected to be constructed per year. In general new road construction will be concentrated outside of HCAs, where most harvest will be occurring, though new roads will be built inside HCAs to facilitate management and to provide access to harvest units outside HCAs. Direct mortality of torrents could occur if they make contact with equipment, personnel, or chemicals, or are present during dewatering associated with the covered activities as described above. In-water activities such as culvert maintenance and installation, stream crossing construction, and stream enhancement projects have the potential to crush torrent salamanders or temporarily displace them.

A total of 285 miles (42%) of Columbia torrent habitat and 28 miles (37%) of Cascade torrent habitat is located inside of HCAs, areas that will be subject to less harvest over time and therefore likely fewer new roads. Further, the occurrence of these activities in the RCA and ERZ would be infrequent.[8]. When they do occur the implementation of the conservation actions (Chapter 4) will limit the potential for injury or mortality of the torrent salamanders resulting directly from the covered activities.

Table 5-3. Miles of Perennial Non-Fish-Bearing Streams and Associated RCA Widths in the Range of the Torrent Salamanders in the Permit Area

	Perennial Non-Fish-Bearing			
Species	**Large**	**Medium**	**Small**	**Total**
Columbia Torrent Salamander	4[a]	106[a]	567[b]	677
Cascade Torrent Salamander	2[a]	15[a]	59[b]	76

[a] 120-foot RCA
[b] 35- to- 120-foot RCA

5.5.3 Beneficial and Net Effects on Columbia and Cascade Torrent Salamanders

The HCP will have positive effects on torrent salamanders by: (1) increasing the overall amount and quality of late-successional coniferous forest habitat near streams; (2) maintaining canopy cover directly adjacent to streams; (3) protecting and improving water quality and instream habitat; and

[8] See Conservation Action 2.

(4) providing protection of talus fields (including all permanently wet talus) located within inner gorge areas up to 170 feet from the stream, all of which are important habitat components for this species. Minimal negative effects are expected because the riparian buffers to be implemented under the HCP will maintain stream temperatures and minimize impacts of timber harvesting on Columbia and Cascade torrent species.

When combined with upland forest management measures intended to promote development of mature and late-seral forest in the HCAs, the riparian protection measures will minimize the effects of timber harvesting on the microclimate of small streams. Mature forest cover is beneficial to torrent salamanders because it contributes to the cool, moist microclimate required by adults. Riparian management measures and stream enhancement projects will protect and promote shade, bank stability, instream habitat, and water quality in the watershed(s). These stream functions are critical to the fully aquatic larval of torrent salamanders, which require cold, clear, oxygen-rich water. Road construction and maintenance measures, including road closures to the public, road abandonment, roadside vegetation, erosion control, culvert improvements, stream-crossing improvements, and road construction improvements on steep and unstable soils will protect existing water quality and stream habitat and improve continuity of riparian forests. Species-specific measures designed to protect salmon and steelhead will benefit Columbia and Cascade torrent salamanders by providing permanent protection of riparian forests used by the species.

5.5.4 Effects on Critical Habitat

Critical habitat has not been designated for Columbia torrent salamander and Cascade torrent salamander.

5.5.5 Cumulative Effects on Columbia and Cascade Torrent Salamanders

With implementation of the HCP, all of the suitable habitat for Columbia and Cascade torrent salamanders in the permit area will be conserved in RCAs. All lands in the conservation area that support torrent salamanders will be monitored and adaptively managed to maintain the habitat value and function for the species. Full implementation of the HCP will protect the riparian areas used by the torrent salamanders and minimize effects in locations where new roads need to cross torrent salamander habitat. As RCAs grow older and taller they will continue to moderate changes in stream temperatures. Improvements in stream structure will create better habitat conditions for torrent salamanders over time. The HCP will minimize effects on Columbia and Cascade torrent salamanders in the permit area.

5.6 Effects Analysis for Oregon Slender Salamander

5.6.1 Sources and Types of Take

Covered activities that include disturbing or removing large woody debris used by Oregon slender salamander—including timber harvest, thinning, release treatments, road work, quarry work, and recreation development and maintenance—are projected to result in the following two types of incidental take of Oregon slender salamander.

- Harm due to direct injury or mortality, such as inadvertently crushing individuals during harvest operations.
- Harm due to habitat modification to the extent that Oregon slender salamander have reduced survival or reproductive success in areas that are harvested and the species persists. Habitat modification may also lead to mortality over time if adequate levels of large woody debris are not maintained or individuals are exposed to warmer, drier conditions post-harvest.

The following sections describe the criteria and thresholds for determining when such take will occur, the effects pathways leading to take, and the specific covered activities expected to result in take, as well as those covered activities not expected to result in take.

5.6.1.1 Criteria and Thresholds for Determining Take

Habitat must be occupied by Oregon slender salamanders to expose individuals to the effects of habitat modification. Habitat modification could occur within stands with documented occupancy or that are within the range of the species within the permit area, as these are places that Oregon slender salamander are most likely to be present. Therefore, to quantify the level of incidental take of Oregon slender salamanders, the HCP uses the acres of habitat that will be harvested or otherwise disturbed under the HCP within the range of Oregon slender salamander.

Table 5-4 summarizes the general sources of habitat modification and the associated thresholds used in this HCP to determine the level of take presented in Section 5.7.2, *Quantity and Timing of Take*. The effects pathways leading to such take are described in the next subsection. For this assessment, *modification* is considered altered habitat structure or composition so that habitat values move from highly suitable or suitable to marginal or non-habitat.

Table 5-4. Criteria and Threshold for Determining Take on Oregon Slender Salamander

Covered Activities Assumed to Result in Take of Oregon Slender Salamander	Covered Activities With Beneficial, Insignificant, or Discountable Effects
• Covered activities that modify a stand (e.g., regeneration harvest or thinning) in areas where OSS occurs • Covered activities or other disturbance (including use of heavy equipment) in areas where OSS occurs.	• Covered activities that modify stands in areas where OSS does not occur; particularly those that do not require use of heavy equipment.

5.6.1.2 Effects Pathways

As stated, modification of occupied habitat will be the primary stressor acting on Oregon slender salamanders over the permit duration. The effects pathways leading to harm due to direct injury or mortality include all covered activities that will involve tree felling and yarding and associated heavy equipment operation and other physical disturbance that could remove or break apart large downed wood and associated bark plates and moss mats or directly crush individual Oregon slender salamanders. The effects pathway includes reduced forest structure, particularly the reduction of large downed logs required by the species (Clayton and Olson 2009). Loss of these forest structures and overstory may result in the following stressors to resources.

- Reduce availability of large downed wood and associated habitat, including habitat refuges and microclimates.

- Reduce future recruitment of large downed wood and associated habitat.
- Remove bark plates and moss mats on downed logs required by Oregon slender salamander.
- Reduce available foraging habitat and associated prey.
- Expose downed wood habitat to sunlight and associated heating and drying (desiccation) (Garcia et al. 2020).
- Fragment habitat and consequently isolate individuals and small groups due to limited dispersal capabilities (Clayton and Olson 2009).

Individual Oregon slender salamanders have limited mobility and dispersal capability, and are thus generally incapable of moving away from stressors to find new habitat. The physical response to such stressors and associated behavioral responses will be reduced physical fitness due to increased energy expenditure (e.g., stress, thermoregulation, metabolism, movement) and reduced energy capture (prey). These energy costs can result in an energy deficit that translates into biological effects, including reduced physical fitness, reproduction, and survival of individual Oregon slender salamander. Harm will occur when energy deficits result in reduced reproductive success or direct mortality of adults through starvation, exposure/desiccation (heat/cold/rain), disease, or predation. Harm may also occur if habitat is fragmented, preventing movement and associated foraging and reproductive success.

The effects pathway ends with the consideration of the biological effects on individuals within the context of regional and range-wide distribution and populations, which is discussed in Section 5.6.3, *Impacts of the Taking on Oregon Slender Salamander*. Figure 5-2 summarizes the general effects pathways identified for potential harm to Oregon slender salamander due to habitat modification.

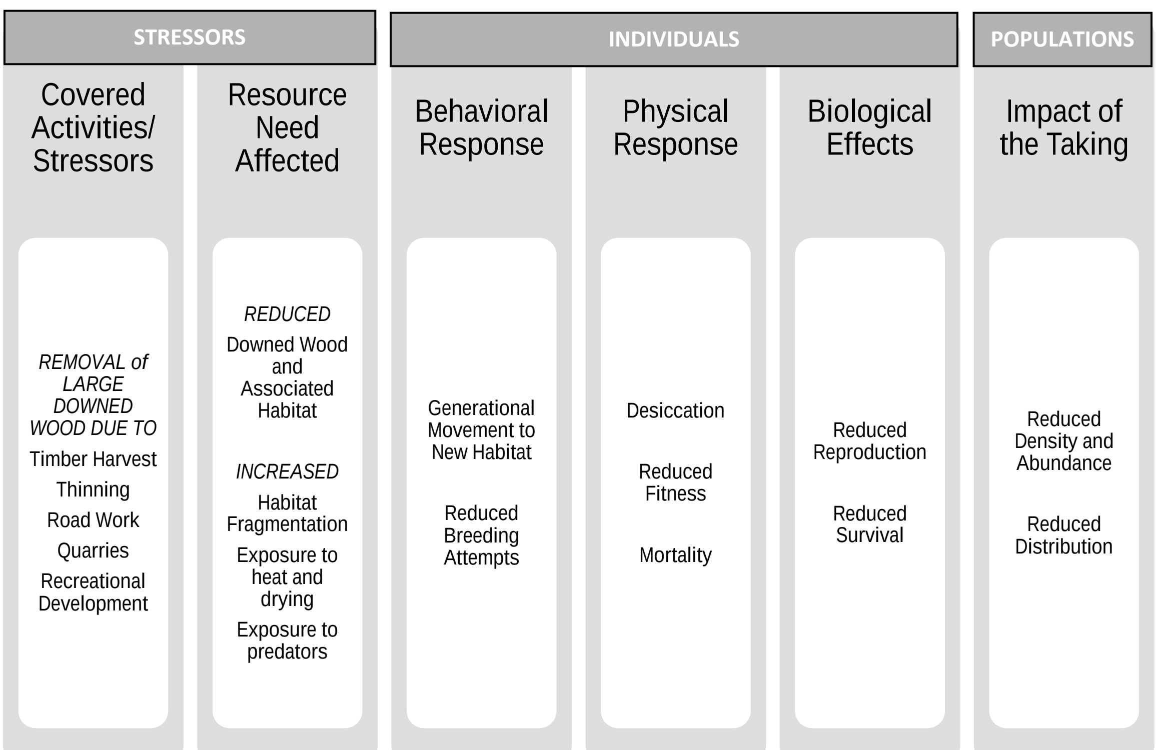


Figure 5-2. Effects Pathways for Impacts of Take of Oregon Slender Salamander via Habitat Modification

5.6.1.3 Covered Activities that May Result in Take

Any covered activity that will physically disturb moss and litter layers and downed wood where Oregon slender salamanders are present may rise to the level of take either through direct injury and mortality or through habitat modification and associated loss of resources needed by Oregon slender salamanders for breeding, feeding, and shelter. These activities include timber harvest (regeneration and thinning), treatments, road construction, quarry work, and recreation development and maintenance (e.g., at campgrounds, trails, trailheads).

Timber harvest, including regeneration harvest and thinning, is the primary activity that is expected to rise to the level of take. Table 5-5 lists covered activities and associated types of take expected to occur over the duration of the permit. Details regarding the effects pathways are provided in the previous subsection.

Table 5-5. Sources and Types of Take of Oregon Slender Salamander Expected Under the Terms of the HCP

Covered Activity	Type of Take
Regeneration Harvest	Regeneration harvests and associated temporary roads, landings, yarding operations, and use of heavy equipment within suitable and highly suitable habitat is the primary source of take expected for Oregon slender salamander. Take will primarily be due to risk of direct mortality or exposure of individuals that are not directly killed. Habitat suitability may be reduced through disturbance of downed wood.
Slash piling	Mechanical piling of smaller slash after regeneration harvest could result in the disturbance of some larger pieces of downed wood. Subsequent burning of piles may result in the loss of some large downed wood and direct mortality.
Thinning	As with regeneration harvest, thinning within occupied habitat could result in direct mortality, exposure, or reduced habitat suitability.
Road Management	Removal of hazard trees along roads has the potential to reduce habitat values for Oregon slender salamander by reducing source of future wood recruitment.
Other Covered Activities that Disturb Large Downed Wood	Development of new roads, quarries, and recreation infrastructure and maintenance (e.g., campgrounds, trails, trailheads) within Oregon slender salamander habitat has the potential to result in take due to direct mortality or habitat loss.
Controlled Burning	Cole et al. (1997) found that other salamander species were able to persist following controlled burns and hypothesized that refugia in large downed wood may protect individuals from harm during burns. However, individual Oregon slender salamanders may be injured or killed during controlled burns conducted within occupied habitat.

5.6.1.4 When Covered Activities Are Not Expected to Cause Take

Covered activities that do not disturb large woody debris within known occupied or modeled suitable habitat are unlikely to cause adverse effects that rise to the level of take, particularly activities that do not include use of heavy equipment that could crush downed wood that is supporting Oregon slender salamanders. Table 5-6 lists the covered activities not expected to result in take of Oregon slender salamander.

Table 5-6. Covered Activities Not Expected to Result in Take of Oregon Slender Salamander

Covered Activity	Rationale for Determining that Mortality or Habitat Modification Would Not Result in Take
All Covered Activities Conducted Outside of Oregon Slender Salamander Range and Habitat	Covered activities that do not modify Oregon slender salamander habitat would not result in take.
Animal Damage Control	Control of mountain beaver (*Aplodontia rufa*) will not adversely affect Oregon slender salamanders because large woody debris would not be disturbed.
Precommercial Thinning and Pruning	Thinning and pruning of young stands does not involve extensive disturbance of large, downed wood and is not likely to adversely affect Oregon slender salamanders or their habitat.
Unmanned Aircraft Systems	No effect pathways identified.
Road System Management Activities	
Existing Road System	Existing roads add to habitat fragmentation effects, which may block movements. However, the presence of existing roads is not expected to rise to the level of take because they are considered part of the environmental baseline.
Road Use	Road use, including administrative, haul traffic, and recreational/public vehicle use, could conceivably result in direct injury or death of Oregon slender salamander, but due to the limited movements of this species (Clayton and Olson 2009), the risk is expected to be discountable.
Road Maintenance	Work within the road prism would not be likely to affect Oregon slender salamander habitat.
Road Decommissioning	Road decommissioning would not disturb large downed wood or otherwise adversely affect Oregon slender salamander.
Drainage Structure Construction and Maintenance	Drainage work would not adversely affect Oregon slender salamander habitat.
Minor Forest-Product Harvest	Harvest of forest greens would not affect habitat. Firewood collection could remove woody debris from forest stands.
Water Drafting and Storage (fire management)	This activity is not likely to adversely affect Oregon slender salamander habitat.
Conservation Strategy Implementation Activities:	
Aquatic Habitat Restoration	Aquatic habitat restoration may result in minor habitat modification, such as select tree tipping, but such effects are not likely to rise to the level of take because of the avoidance and minimization measures described in Chapter 4.
Barred Owl Management	This activity is not likely to adversely affect Oregon slender salamander habitat.
Monitoring Activities	This activity is not likely to adversely affect Oregon slender salamander habitat. Any research activities that might utilize destructive sampling techniques would be permitted separately.

5.6.2 Quantity and Timing of Take

Quantifying take of Oregon slender salamander based on habitat is complicated by the lack of data regarding a key habitat variable—downed wood—across the range of Oregon slender salamander within the permit area, as well as by uncertainty regarding the habitat requirements and effects of timber harvest on the species (Garcia et al. 2020) and altered conditions due to fires in 2020. While Oregon slender salamanders are abundant in older stands with abundant well-decayed large downed wood, they are also common in younger stands (e.g., <60 years old) where previous disturbance (harvest, fire) has occurred (Garcia et al. 2020). Because of this, and based on known occurrence and distribution of this species as present throughout the permit area in the vicinity of the Santiam State Forest, ODF assumes the species is present in all stands within the range of the Oregon slender salamander and that any harvest in such stands has the potential to take individuals. ODF took the approach of considering any timber harvest within the range of the species as habitat modification that could result in take over the 70-year permit term.

Approximately 45% (21,400 acres) of the species' range within the permit area will be located within HCAs. Habitat modification within HCAs will be limited to thinning in select stands and some conifer restoration projects. This management will follow the criteria and processes outlined under Conservation Action 7: Manage Habitat Conservation Areas. Therefore, ODF expects take to be limited within HCAs. Thinning in HCAs would occur earlier in permit term. Most stands in HCAs would be managed passively and allowed to mature over time.

The remaining 55% (26,100 acres) of the species' range within the permit area is outside of HCAs. Harvest outside of HCAs will occur consistent with Conservation Action 8: Conservation Actions Outside Habitat Conservation Areas and Riparian Conservation Areas, and Conservation Action 10: Operational Restrictions to Minimize Effects on Covered Species. While various operational restrictions beyond the scope of this HCP will prevent the harvest of all 26,100 acres during the permit term, it is assumed that most areas outside of HCAs could be harvested at least once during the permit term, and harvest is expected to occur consistently over time. Without a habitat model linked to a timber harvest model it is not possible to determine the precise effect of harvest on Oregon slender salamander habitat. Harvest activities will occur every year on the North Cascade District, inside the range of Oregon slender salamander. This will result in an average of 400 acres of harvest per year outside of HCAs. Some areas may be harvested more than once, depending on stand age at the beginning of HCP implementation. In all cases it is assumed that stands may be thinned once or twice before a final harvest is completed.

Table 5-7summarizes the amount of thinning or regeneration harvest that may be conducted within the range of Oregon slender salamander in the permit area over the 70-year permit term. Section 5.6.4 details the beneficial and net effects projected for the HCP.

Table 5-7. Oregon Slender Salamander Habitat Subject to Harvest or Thinning Under the HCP Over the Permit Duration[a]

Location	Habitat Thinned	Habitat Harvested	Total
Within HCAs	3,600[b]	--	**4,800**
Outside of HCAs	16,000	17,500	**33,500[c]**
Total	**19,600**	**19,700**	**39,300**

[a] Assumes presence in all areas within the range of Oregon slender salamander within the range of the permit area. Numbers have been rounded to nearest 100 acres.

[b] HCAs within the range of Oregon slender salamander equate to 8% of all HCAs. Therefore, it is assumed that 8% of the 45,000 acres of young stand management (thinning) will occur in healthy conifer stands in these HCAs. That equates to 3,600 acres of thinning in the first 30 years of implementation (on average 120 acres per year).

[c] Note that some stands may be thinned more than once so the total acres available for harvest outside HCAs (26,100 acres) is different than total acres reported here.

5.6.3 Impacts of the Taking on Oregon Slender Salamander

Take resulting from habitat loss and other adverse effects, such as direct mortality from vehicles operating off-road in harvest units, described in Section 5.6.2, *Quantity and Timing of Take*, will occur within the following contexts and levels of intensity.

- Approximately 45% (21,400 acres) of the range of Oregon slender salamander within the permit area will be located within HCAs, where habitat conditions will improve over time (described under *Beneficial and Net Effects* below). Approximately 17% of HCAs will be harvested or thinned, meaning that approximately 3,600 acres in HCAs will be subject to harvest or management. That will occur in the first 30 years of the permit term resulting in, on average, 120 acres/year. No regeneration harvest will occur in HCAs in Oregon slender salamander habitat.
- Approximately 55% (26,100 acres) of the range of Oregon slender salamander habitat in the permit area is outside HCAs and RCAs, and therefore subject to harvest.

Oregon slender salamanders are known to persist in harvested areas if sufficient legacy downed wood and associated habitat is retained (Garcia et al. 2020), as will occur under the HCP (Conservation Action 8: Conservation Actions Outside Habitat Conservation Areas and Riparian Conservation Areas), so it is difficult to predict the total intensity of effect. Some individuals will likely perish, due to newly inhospitable habitat conditions, but others will persist in the stands post-harvest. The impact of the taking from habitat modification is therefore not likely to eliminate Oregon slender salamanders from even those stands that are harvested. Long-term monitoring of some harvested stands, as described in Chapter 6, will increase understanding of how the species is affected by harvest-related activities and will guide retention of downed wood standard over time, thereby further minimizing effects in the future through adaptive management.

As described in the following section, Oregon slender salamander habitat is projected to increase over the 70-year permit duration in terms of quantity and quality, resulting in net, long-term benefits to abundance and distribution in portions of the permit area within the range of the species.

5.6.4 Beneficial and Net Effects on Oregon Slender Salamander

Under the HCP, Oregon slender salamander populations will benefit from (1) protection of occupied habitat within HCAs (Conservation Action 6: Establish Habitat Conservation Areas), (2) a net increase in the quantity and quality of habitat over the permit term, both inside and outside HCAs (Conservation Action 7: Manage Habitat Conservation Areas), and (3) retention of legacy structure, including downed wood, in harvested stands (Conservation Action 8: Conservation Actions Outside Habitat Conservation Areas and Riparian Conservation Areas).

While 26,100 acres (55%) of the permit area within the range of Oregon slender salamander and outside of HCAs may be subject to harvest, green tree and downed wood retention in those harvest units will retain some in-unit habitat for the species. As a result, harvest of those acres will not be a complete loss of habitat or habitat value. Take will only occur in portions of harvested habitat where covered activities result in a loss of habitat value. Post-harvest monitoring of Oregon slender salamander will reveal a better understanding of the species' response to timber harvest and the efficacy of Conservation Actions 8 and 10, allowing for better estimates of potential effects as the implementation of the HCP progresses. Knowing that the species will persist in harvested units at some level, coupled with the retention standards implemented during harvest, combined with designation and management of HCAs, will result in a net benefit for this species over the permit term.

Most notably, under Conservation Action 6 ODF includes 21,400 acres (45% of the permit area total) of Oregon slender salamander habitat in HCAs and manages that habitat for mature forest conditions and processes. This will result in the recruitment of abundant large downed wood, increasing habitat quantity (amount of wood) and quality (size of wood, size of habitat patches, and connectivity) over time. The average stand age at the beginning of the permit term inside HCAs is 70–90 years (Figure 5-3). At the end of the permit term the average stand age inside HCAs is 140–160 years (Figure 5-4). This increase in older, larger trees inside HCAs will result in the recruitment of higher quality downed wood in Oregon slender salamander habitat. Additionally, ODF will supplement downed wood as part of harvest plans or habitat improvement within HCAs, which will provide immediate recruitment. Silvicultural prescriptions in HCAs will enhance large tree development while minimizing impacts on existing downed wood, enhancing large wood recruitment and quality over the permit term relative to unmanaged conditions.

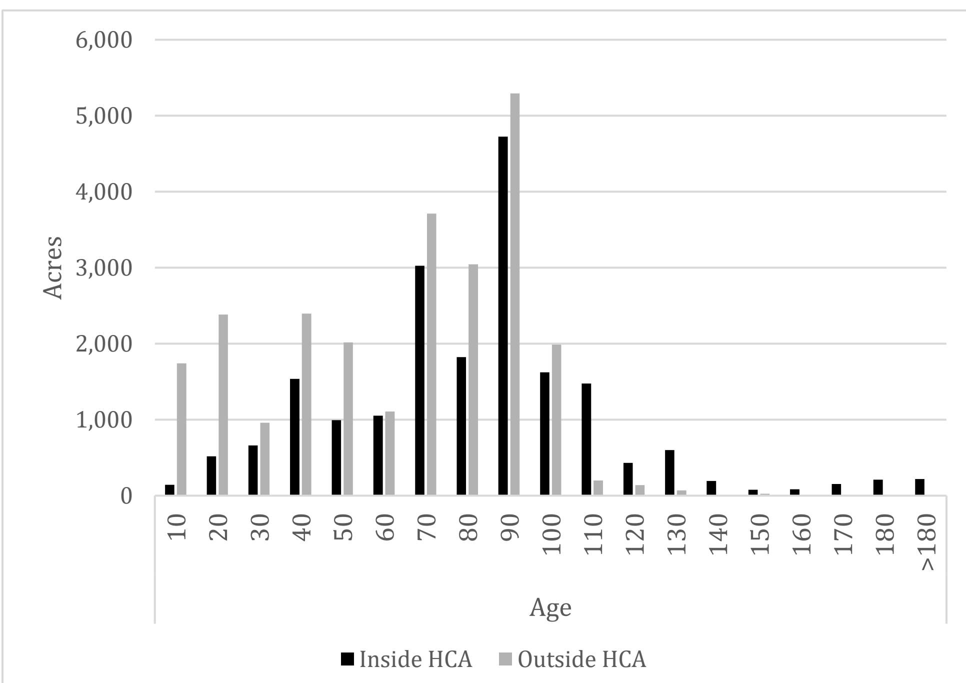


Figure 5-3. Stand Age Distribution in Oregon Slender Salamander Habitat in 2023 (beginning of permit term)

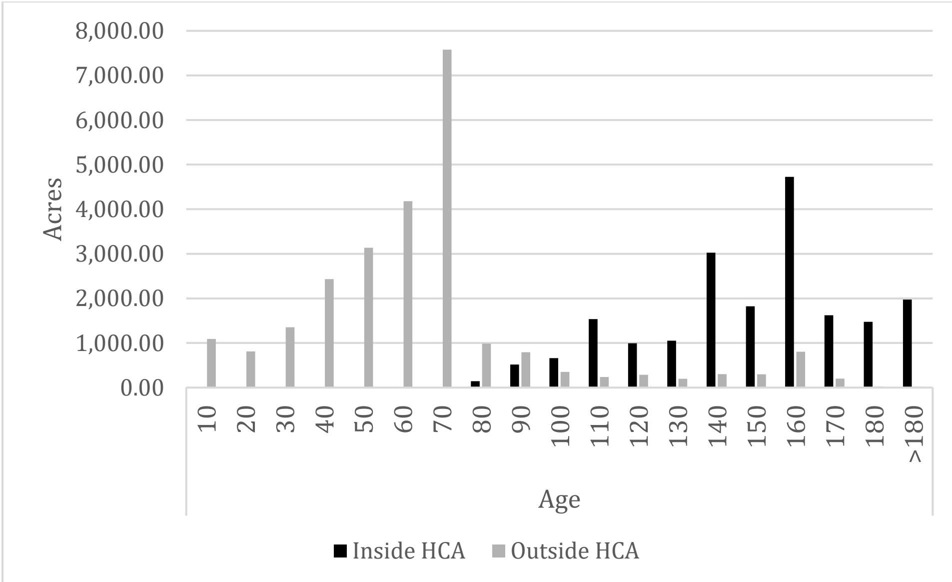


Figure 5-4. Stand Age Distribution in Oregon Slender Salamander Habitat in 2093 (in of permit term)

Outside of HCAs ODF's retention standards will allow Oregon slender salamander to persist in harvest units, even following harvest (Figure 5-3 and Figure 5-4). In addition, retention of legacy structure on the landscape will speed recruitment of more large downed wood in the future. This will occur as described in Conservation Action 8. This will minimize take and improve habitat conditions. Retaining snags and emphasizing the need to select from the larger trees in the stand to determine which trees to retain as upland leave will ensure larger trees are present through subsequent rotations, and long-term recruitment will occur in the stand over time.

As described in Chapter 6, baseline monitoring under the HCP will provide a better understanding of Oregon slender salamander distribution, abundance, and habitat use within the permit area, including effects of timber harvest, silvicultural practices, and fire.

5.6.5 Effects on Critical Habitat

Critical habitat has not been designated for Oregon slender salamander.

5.6.6 Cumulative Effects on Oregon Slender Salamander

Cumulative effects, as defined in this HCP, are the combined effects of future state, local, or private actions that are reasonably certain to occur in the action area, considered collectively with the effects of this HCP.

Most effects on Oregon slender salamander populations and distribution from impacts on other non-federal lands have likely already occurred due to relatively long histories of intensive commercial forest management coupled with lower retention standards for large downed woody debris. Therefore, actions on private lands are not anticipated to contribute to cumulative effects.

Other state, local, or private future actions that are reasonably certain to occur may include road construction, recreational infrastructure development and maintenance (e.g., mountain bike trail networks), and linear rights-of-way construction (e.g., transmission lines, pipelines). ODF is not aware of any specific projects reasonably certain to occur within the range of the Oregon slender salamander.

5.7 Effects Analysis for Northern Spotted Owl

5.7.1 Sources and Types of Take

All covered activities that involve tree removal within modeled northern spotted owl nesting, roosting, or foraging habitat have the potential to result in four types of incidental take of northern spotted owls.

- Harm in the form of direct injury or mortality from activities such as inadvertently destroying a nest with young or eggs.
- Harm due to behavioral or physical responses to noise and disturbance, such as unintentionally flushing an owl from a nest and exposing the young or eggs to predation or rain.
- Harm due to habitat modification to the extent that owls become more susceptible to predation, abandon established territories, or have reduced reproductive success due to reduced foraging efficiency (i.e., lack of forage or expansion of home range).
- Harm due to habitat modification that reduces the resilience of spotted owls to barred owl competition.

The conservation strategy described in Chapter 4 is designed to minimize or avoid these potential sources and types of take. Harm due to direct injury or mortality and disturbance of actively nesting pairs will be avoided during the nesting season through Conservation Action 10: Operational Restrictions to Minimize Effects on Covered Species. Harm due to modification of suitable or highly suitable habitat from timber harvest and other silvicultural activities – including disturbance (e.g., roads, cable corridors) will be the primary sources and type of take of northern spotted owls that ODF anticipates over the permit duration. The HCP minimizes and mitigates for such habitat modification through designated HCAs (Conservation Action 6: Establish Habitat Conservation Areas) and associated management and conservation measures (Conservation Action 7: Manage Habitat Conservation Areas).

Inside of HCAs, harvest activities will occur where there are opportunities to increase the quality and quantity of habitat for covered species over the duration of the permit, following the criteria and decision processes outlined in Chapter 4 under Conservation Action 7) and shown in Appendix H. This includes regeneration harvest in non-habitat or heavy thinning of stands of non-habitat that are unlikely to grow into nesting, roosting, or foraging habitat within the permit duration without silvicultural intervention. Stands requiring this management will be treated during the first 30 years of the permit term so they are put on a trajectory to develop into habitat. In those instances, short-term effects on northern spotted owl habitat are expected to be minimal, given that operations are in habitat with dispersal-only habitat or areas that are non-habitat. Less intensive thinning or variable density thinning may be used in dispersal-only habitat or areas of non-habitat to accelerate the development of understory and mid-story canopy, or promote horizontal diversity necessary for nesting, roosting, or foraging habitat. These treatments may have short-term negative effects, primarily through the removal of some forest canopy cover and reduction in prey availability

(Lesmeister et al. 2018); however, thinning efforts will be conducted only at a limited scale, and effects will be offset by the creation of better habitat in less time than would occur with natural growth. In addition, as outlined in Conservation Action 7, any management activities in nesting or roosting habitat cannot reduce habitat quality, even over the short-term, to a point where the stand no longer functions as nesting or roosting habitat. Reforestation and young stand management practices in HCAs are described in Chapter 3.

Outside of HCAs and RCAs, habitat will be subject to harvest, although dispersal habitat will be maintained, as specified under Conservation Action 8. The potential for habitat loss to result in take of northern spotted owl will be higher where owls are currently resident; lower in locations where owls were once known to be resident, but have not been documented recently; and lowest in locations where owl activity has never been documented.

The following sections describe the criteria and thresholds for determining when take will occur, the effects pathways leading to take, and the specific covered activities expected to result in take, as well as those not expected to result in take.

5.7.1.1 Criteria and Thresholds for Determining Take

To quantify the level of incidental take of northern spotted owls, the HCP uses the acres of nesting, roosting, and foraging habitat that will be harvested under the HCP. Not all modification of habitat will result in take. The likelihood that effects of habitat modification from timber harvest on northern spotted owls would rise to the level of take depends on (1) existing conditions of the stand to be modified and (2) proposed harvest specifications. Habitat must be occupied by northern spotted owls in order for individuals (or pairs or young) to be exposed to the effects of habitat modification. In addition, the habitat modification must be sufficiently severe as to interfere with essential behaviors to the extent that individuals are actually harmed.

Habitat modification within stands that are modeled as nesting, roosting, and/or foraging habitat are most likely to result in take. Therefore, the HCP uses modification of such modeled habitat as the primary metric of take for northern spotted owls.

Table 5-8 summarizes the general sources of habitat modification and the associated thresholds used in this HCP to determine the level of take presented in Section 5.7.2, *Quantity and Timing of Take*. The effects pathways leading to such take are described in the next subsection.

Table 5-8. Criteria and Threshold for Determining Take of Northern Spotted Owl

Covered Activities Assumed to Take Northern Spotted Owl	Harvest Activities With Beneficial, Insignificant, or Discountable Effects
• Covered activities that modify[a] a stand (e.g., regeneration harvest or thinning) with a known nest tree or site (i.e., young found but no nest tree identified) regardless of modeled habitat status of that stand. • Covered activities that modify modeled *nesting/roosting or foraging* habitat as defined by the species habitat model for this HCP.[b]	• Covered activities (e.g., regeneration harvest or thinning) in stands modeled as *dispersal-only not habitat*.

[a] *Modification* is considered altered habitat structure or composition so that habitat values move from nesting, roosting, or foraging habitat to non-habitat. Modification of dispersal-only habitat is not assumed to result in take, provided a minimum of 40% of each subgeographic area is at least 40% dispersal habitat outside HCAs, as described in Conservation Action 8: Conservation Actions Outside Habitat Conservation Areas and Riparian Conservation Areas.

[b] The potential for habitat loss to result in take of northern spotted owl will be higher where owls are currently resident; lower in locations where owls were once known to be resident, but have not been documented recently; and lowest in locations where owl activity has never been documented.

5.7.1.2 Effects Pathways

As described in Section 5.7.1, *Sources and Types of Take*, modification of occupied habitat through tree removal will be the primary stressor acting on northern spotted owls over the permit duration. Habitat modification may result in take only if the habitat is occupied and if remaining habitat is not sufficient to support the individual owls or owls that were once occupying the habitat that was modified by covered activities.

The effects pathway leading to take begins with reduced forest structure, including reduced tree density, canopy cover, canopy layers, and large trees, snags, and downed logs. Loss of these forest structures may result in the following stressors to resources.

- Eliminate large trees and associated canopy cover required for nesting.
- Eliminate perches, canopy cover, and multiple canopy layers required for roosting and foraging.
- Reduce available prey that is associated with high levels of forest structure.
- Increase the presence of competitors and predators that are able to use habitats modified by timber harvest, including great horned owls, barred owls, and corvids.
- Fragment habitat so that habitat patches become inaccessible or require additional effort and predation risk to access.
- Create habitat that reduces the resilience of spotted owls to barred owl competition.

The behavioral response of individual owls (or pairs) to such stressors may include the following. All of these would reduce overall fitness for the species.

- **Avoidance**. Individual northern spotted owls will not nest in clear cuts and heavily thinned stands that result in low or reduced canopy cover and fewer large trees and associated buffer habitat. Owls may also avoid roosting or foraging in modified habitat due to reduced perches, canopy protection, lack of prey, or exposure to predators and competitors, including barred owls. Owls may also avoid habitat patches that become isolated due to habitat modification.

- **Shift nesting area or do not nest**. If suitable alternative habitat is available, established pairs may shift nest sites to new areas if a nesting site is lost or if barred owls occupy nesting areas due to habitat modification. If habitat is not available, owls may not nest for 1 or more years until a suitable nesting area is found.
- **Abandoned nesting attempts**. Established spotted owl pairs may have lower nest success due to reduced prey capture or due to exposure to predators near nesting areas or due to disturbance. Owls may also not attempt to nest if adequate prey is not available.
- **Shift foraging areas or use smaller areas**. Northern spotted owls may expand foraging areas to make up for loss habitat (Meiman et al. 2003), potentially using areas with lower suitability and prey base. Owls may also simply confine use to remaining habitat, resulting in a reduced home range and associated reduced prey base.
- **Territory abandonment**. At some point, loss of habitat may be sufficient to cause northern spotted owls to abandon established territories due to lack of habitat or to displacement by barred owls and the subsequent inability of new individuals to recolonize, or displaced individuals to find, new territories. Abandonment of a territory and search for replacement territory may or may not result in pairs splitting up. In either case, abandoning a territory to search for a new one would place tremendous stress on individuals, including increased energy expenditures (movement) and decreased energy acquisition (feeding).

All of these stressors and associated behavioral responses may result in an ultimate physical response of reduced physical fitness due to increased energy expenditure (e.g., stress, increased time spent moving or hunting) and reduced energy capture (prey). These energy costs can result in an energy deficit that translates into biological effects, including reduced physical fitness, reproduction, and survival of individual northern spotted owls. Harm would occur when energy deficits result in reduced nesting successes or mortality of adults through starvation, exposure (heat/cold/rain), disease, or predation.

The effects pathway ends with the consideration of the biological effects on individuals within the context of regional and range-wide distribution and populations, which is discussed in Section 5.7.3, *Impacts of the Taking on Northern Spotted Owl*.

Figure 5-5 summarizes the general effects pathways identified for potential harm to northern spotted owls due to habitat modification.

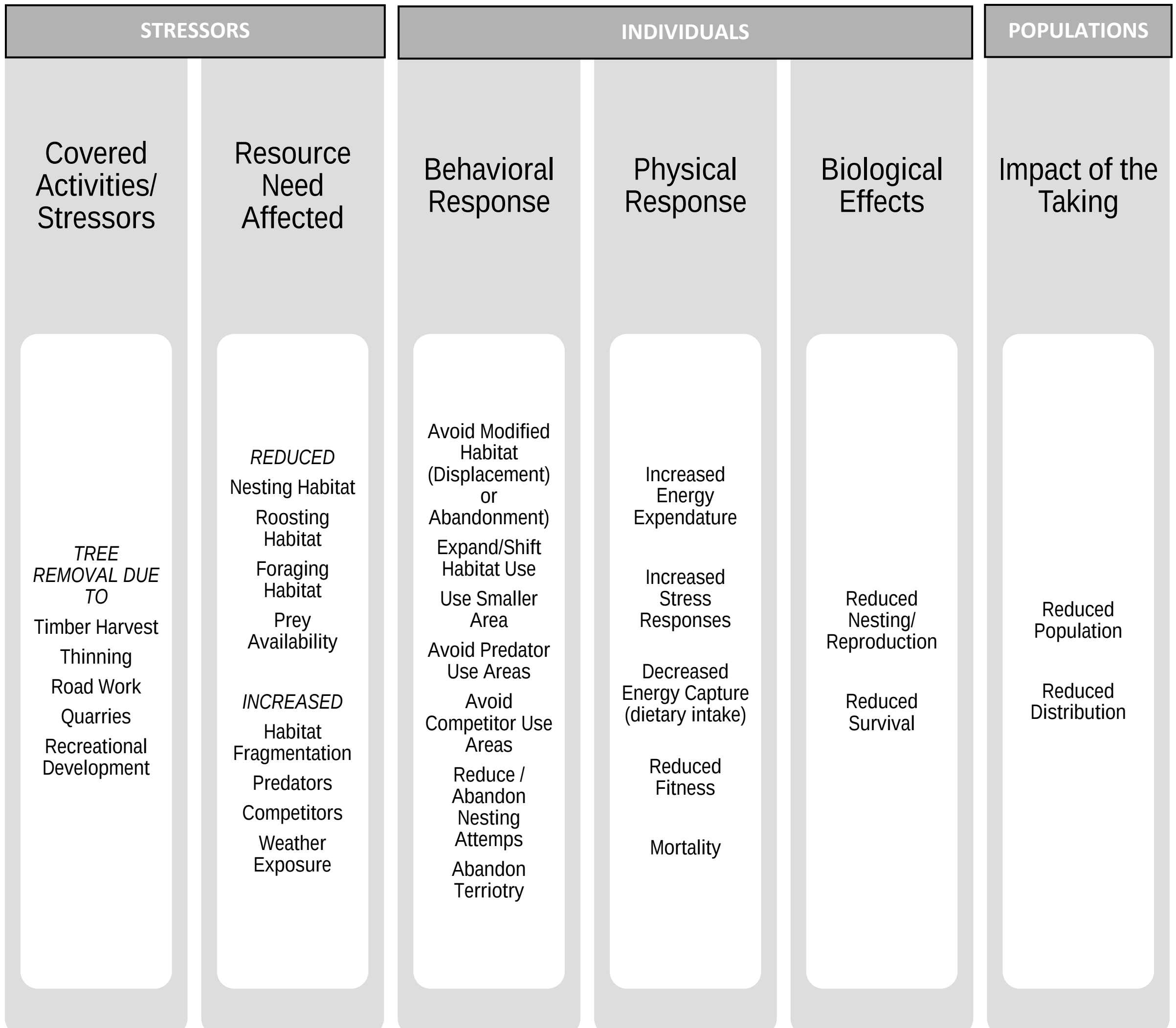


Figure 5-5. Effects Pathways for Impacts of Take of Northern Spotted Owl via Habitat Modification

5.7.1.3 Covered Activities that May Cause Take

Based on the thresholds and effects pathways described previously, several covered activities will result in take via habitat modification when conducted within northern spotted owl habitat, including regeneration harvest, thinning, landings, road construction, quarry work, and recreation infrastructure development and maintenance (e.g., campgrounds, trails, trailheads). Table 5-9 lists covered activities and associated types of take expected to occur over the duration of the permit.

Table 5-9. Sources and Types of Take of Northern Spotted Owl Expected From Covered Activities

Covered Activity	Type of Take
Regeneration Harvest	Removal of nesting, roosting, or foraging habitat currently occupied by northern spotted owls can kill or injure individuals by significantly impairing essential behavioral patterns, including nesting, roosting, and foraging. Behavioral response may include shifting habitat use or abandonment of the territory, leading to reduced prey capture, reproductive success, and survival. Habitat modification can also increase exposure to predation and competition from barred and great horned owls and other species.
Thinning	As with regeneration harvest, thinning could remove a sufficient number and type of trees to reduce habitat quality for northern spotted owls, resulting in potential reduced reproductive success or site abandonment.
Other Covered Activities that Involve Tree Removal	Development of new roads, quarries, or recreation infrastructure as well as maintenance (e.g., campgrounds, trails, trailheads) within active northern spotted owl nest sites[a] has the potential to result in take due to habitat modification, including potential reduced prey capture and associated reproductive success and increased exposure to predators.

[a] "Active sites" are locations assumed to be occupied by northern spotted owl(s), based on historic survey data. Locations are centered on nest tree locations or designated activity center if nest site is not known.

Most habitat modification is expected to occur outside of HCAs and RCAs. Some timber harvest activities inside of HCAs may also result in short-term modification of a few areas of non-habitat or dispersal-only habitat, including regeneration harvest and thinning where needed to improve long-term habitat conditions. However, silvicultural prescriptions inside of HCAs will only be carried out if such harvest would result in higher habitat quality later in the permit term than was present prior to the prescription. All timber harvest practices are allowed inside of HCAs, but they will be consistent with the practices outlined in Conservation Action 7: Manage Habitat Conservation Areas. As previously mentioned, take from direct destruction of active nest sites will be avoided through limits on management activities near nest sites (Conservation Action 7) and seasonal timing restrictions (Conservation Action 10: Operational Restrictions to Minimize Effects on Covered Species).

Take via habitat modification may occur throughout the duration of the incidental take permit. Take in the early years of the permit will occur within existing habitat, while take in later years may include habitat that is currently not suitable but that has developed into habitat over time. The amount and timing of take anticipated to occur through habitat modification over the permit duration is described in Section 5.7.2, *Quantity and Timing of Take*.

5.7.1.4 When Covered Activities Are Not Expected to Result in Take

Covered activities conducted outside of nesting, roosting, and foraging habitat are not expected to cause take because northern spotted owls are not expected to occupy non-habitat areas. The potential for covered activities to result in take of northern spotted owls differs among the three major conservation designations defined in Chapter 4 (i.e., inside HCAs and RCAs, and outside of HCAs and RCAs). As previously described, most take will occur outside of HCAs and RCAs.

Within HCAs, ecological forestry-based thinning treatments in selected stands, and variable-retention harvest of some hardwood-dominated and Swiss needle cast stands will be conducted to improve forest conditions for covered species (Conservation Action 7). Some of this will occur within foraging habitat. As described in Conservation Action 7, management in nesting, roosting, or foraging habitat within HCAs will be limited in pace and scale. Management will be focused primarily on younger stands where greater habitat gains are expected. Any management that does occur in nesting, roosting, or foraging habitat within HCAs will not reduce the habitat quality of the stand, as specified in Conservation Action 7.

Barred owl management will be implemented consistent with Conservation Action 9: Strategic Terrestrial Species Conservation Actions. Other covered activities similarly will not result in sufficient habitat modification to result in take. Table 5-10 lists the covered activities that are not expected to rise to the level of take of northern spotted owls.

Table 5-10. Covered Activities Not Expected to Result in Take of Northern Spotted Owl

Covered Activity	Rationale for Determining that Covered Activity Would Not Result in Take
All Covered Activities Conducted Outside of Nesting, Roosting, and Foraging Habitat	Covered activities that do not modify nesting, roosting, and foraging habitat would not result in take.
Site Preparation, Tree Planting, and Release Treatments	Reforestation and young stand management activities will take place outside of nesting, roosting, and foraging habitat and are not likely to adversely affect northern spotted owls.
Animal Damage Control	Mountain beavers represent only a small and very seasonal proportion of northern spotted owl diets (Forsman 2004), and control activities will occur only in reforestation areas that are non-habitat for northern spotted owl foraging with the exception of edge habitat.
Precommercial and Commercial Thinning	Precommercial thinning will be conducted in young forest stands and will not occur within northern spotted owl nesting, roosting, or foraging habitat. Light to heavy commercial thinning could occur within dispersal habitat. However, a minimum of 40% of the landscape will be maintained as dispersal habitat (Conservation Action 8: Conservation Actions Outside Habitat Conservation Areas and Riparian Conservation Areas), an amount that has been determined to be sufficient to maintain connectivity for northern spotted owl dispersal (Davis et al. 2016).
Unmanned Aircraft Systems and Helicopter Use	Nest site disturbance from drones and helicopters would be avoided through seasonal operational restrictions (Conservation Action 10: Operational Restrictions to Minimize Effects on Covered Species).
Existing Road System	Existing roads add to habitat fragmentation effects, encourage use by predators such as great horned owls, and provide access that may encourage people to enter habitat areas. However, the presence of existing roads is not expected to rise to the level of take because they are considered part of the environmental baseline and current nest sites have been established in the presence of the road system.
Road Management	Removal of hazard trees along roads has the potential to reduce habitat values for northern spotted owl. However, the effects are likely to be discountable in relation to the intensity and location of habitat modification (small amount next to roads) to the large home range size of northern spotted owls.

Covered Activity	Rationale for Determining that Covered Activity Would Not Result in Take
Road Use	Road use has not been reported in the literature as a source of take of northern spotted owls (Lesmeister et al. 2018). Most road use in the permit area is an existing use and considered part of the environmental baseline, and road density will be reduced in some areas under the HCP as part of the aquatic conservation strategy.
Road Maintenance	Work within the road prism is not likely to adversely affect northern spotted owl habitat.
Road Decommissioning	Road decommissioning would not adversely affect northern spotted owl habitat and may provide long-term benefits.
Drainage Structure Construction and Maintenance	Drainage work would take place within the existing road prism (footprint) and will not adversely affect northern spotted owl habitat.
Minor Forest-Product Harvest	Harvest of forest greens would not adversely affect owl habitat. Permitted firewood collection could remove woody debris from recent harvest units. Firewood permits issued will be limited to landings and roadsides and within 100 feet of the road.
Controlled Burning	The likelihood of smoke harming spotted owls is low. No direct mortality or displacement of spotted owls due to smoke has been reported in the literature, even in cases where thick smoke covered several spotted owl site-centers for a week (USFWS 2011). Existing fire management protocols are expected to adequately reduce the chance of fire spreading into habitat to be negligible.
Water Drafting and Storage (fire management)	This activity will not require large tree removal or otherwise adversely affect northern spotted owl habitat.
Aquatic Habitat Restoration	Aquatic habitat restoration may result in minor habitat modification, such as select tree tipping or removal, but such effects are not likely to rise to the level of take because of the avoidance and minimization measures described in Chapter 4. Implementation of Conservation Action 9: Strategic Terrestrial Species Conservation Actions, further reduces this potential in locations where restoration activities occur near species habitat.
Barred Owl Management	The HCP includes ODF's commitments to support barred owl removal and those activities will be conducted in a manner that avoids take of northern spotted owl.
Monitoring Activities	Monitoring is generally not expected to result in take. If any monitoring activity is determined to likely result in take (e.g., banding activities during the breeding season), then ODF will obtain necessary clearance with the USFWS (or the research organization will, if a different entity).

5.7.2 Quantity and Timing of Take

5.7.2.1 Habitat Modification/Loss

Modeling data (as described in Appendix E) projects that approximately 147,000 acres of northern spotted owl nesting, roosting, and/or foraging habitat will be harvested or thinned within the permit area over the duration of the permit. In addition, modeling projects 134,000 acres of dispersal-only habitat (habitat rated between 0.3 and 0.4 that is suitable only for dispersal) will be harvested or thinned. Table 5-11 provides a more specific breakdown of projected harvest and thinning by habitat types. Not all of this habitat will be suitable at the outset of the permit. Some stands will grow into habitat over time. The habitat model used to project future harvests accounted for expected growth and harvest of habitat throughout the 70-year permit term.

Habitat modification will occur both inside and outside of HCAs. Within HCAs, habitat will only be modified in situations where short-term silvicultural activities will result in long-term increases in habitat quality. Conservation Action 7: Manage Habitat Conservation Areas, specifies how and where those activities will occur and limits the amount, proximity, and timing of activity in active sites. These areas include hardwood- dominant stands (primarily red alder), infected with Swiss needle cast, or otherwise determined to require regeneration to provide long-term habitat value. In addition, seasonal restrictions (Conservation Action 10: Operational Restrictions to Minimize Effects on Covered Species) will avoid disturbance of any active nest sites. There is a commitment in Conservation Action 7 that any management that occurs in nesting or roosting habitat will not result in a reduction value that is less than nesting and roosting. Outside of HCAs, northern spotted owl nesting, roosting, and foraging habitat will be harvested or thinned for commercial timber production. Table 5-11 summarizes habitat that would be modified through thinning or lost through regeneration harvest over the 70-year permit duration.

Table 5-11. Northern Spotted Owl Habitat Projected to Be Harvested or Thinned Under the HCP Over the Permit Duration (acres)

	Habitat Thinned[a]			Habitat Harvested[b]			
Location	**Nesting-Roosting**	**Foraging**	**Dispersal Only**	**Nesting-Roosting**	**Foraging**	**Dispersal Only**	**Total**
Within HCAs	2,000	4,200	6,600	--	--	--	**12,800**
Outside of HCAs	1,200	2,300	20,800	35,200	111,500	107,000	**278,000**
Total	**3,200**	**6,500**	**27,400**	**35,200**	**111,500**	**107,000**	**290,800**

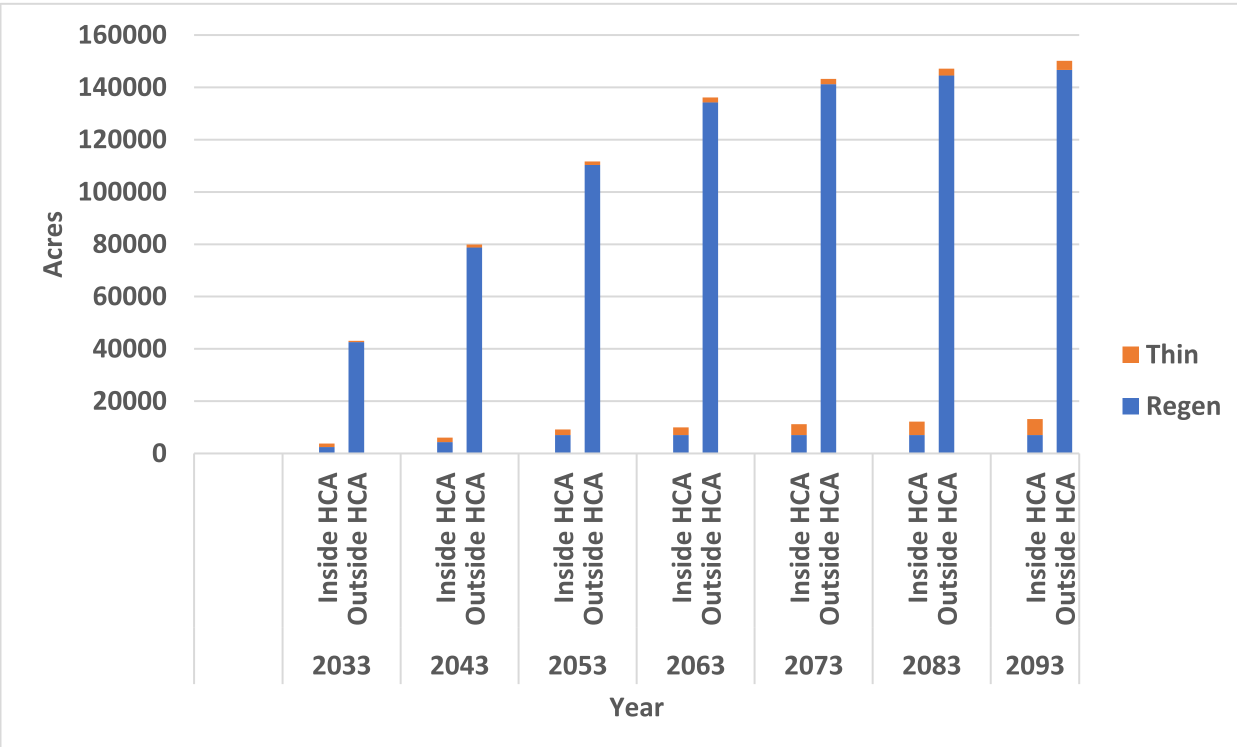
[a] Habitat thinned inside HCAs will be completed consistent with Conservation Action 7: Manage Habitat Conservation Areas.

[b] Approximately 21,500 acres of stands were projected to be harvested within HCAs over the permit term. Those stands consisted entirely of Swiss needle cast or red alder stands that were deemed non-habitat for modeling purposes.

While harvest of northern spotted owl habitat will occur over the entire 70-year permit term, approximately half of projected habitat modification will occur within the first 20 years of plan implementation and approximately 90% will occur within the first 40 years. This is not due to targeting habitat early in the permit term, but rather due to the current stand age distribution. During the first 40 years of the permit term, some areas outside HCAs that are not currently habitat will grow into habitat prior to harvest. Take authorization afforded by the HCP and associated ITPs will authorize that habitat modification. As the permit term progresses, past year 40, acres of habitat modified are fewer, not because less harvest is occurring, but because the age and structure of the forest outside of HCAs will have stabilized by then. As stand age stabilizes due to harvest intervals, fewer acres outside HCAs will be developing into nesting, roosting, and foraging habitat. However, inside HCAs, nearly all of the acres will either develop into nesting, roosting, and foraging habitat, or will be on a trajectory to do so at some point in the future.

1 Cumulative harvest means that the total harvest of previous periods is added to show the running total of amount of habitat harvested for each period. The 2093 period shows total cumulative harvest over the permit term.

Figure 5-6 illustrates the cumulative level of spotted owl nesting, roosting, and foraging habitat projected to be modified over the permit term (i.e., running total of acres harvested over permit duration). Note that dispersal habitat is not included in the figure.



[1] Cumulative harvest means that the total harvest of previous periods is added to show the running total of amount of habitat harvested for each period. The 2093 period shows total cumulative harvest over the permit term.

Figure 5-6. Cumulative[1] Northern Spotted Owl Nesting, Roosting, and Foraging Habitat Projected to Be Harvested or Thinned Under the HCP Over the Permit Duration (in acres).

5.7.2.2 Northern Spotted Owl Active Sites

Northern Spotted Owl Active Sites Located within Permit Area

Loss of northern spotted owl active sites[9] and in some cases associated nest trees due to covered activities is expected to be rare over the duration of the permit. Of the 31 known active northern spotted owl active sites in the permit area, all but three are included in HCAs. Management activities in HCAs will only be implemented to increase habitat quality for northern spotted owls over the permit term, so loss of activity centers due to habitat loss inside HCAs is not expected.

It is expected that the three activity centers outside of HCAs would be degraded over time from harvest activities, likely due to a reduction in habitat quality within them. Two of the three activity

[9] "Active sites" are locations assumed to be occupied by northern spotted owl(s), based on historic survey data. Locations are centered on nest tree locations or designated activity center if nest site is not known.

centers have a portion of the site inside an HCA. Those activity centers consist of two active pair sites and one resident single site. None of the three sites have had recent northern spotted owl activity. Owls were last seen at one site in 2014, at another in 2015, and at the third in 2016. Any harvest that would occur would be done consistent with Conservation Action 10: Operational Restrictions to Minimize Effects on Covered Species.

Table 5-12 summarizes existing northern spotted owl active sites, and their distribution across HCAs and RCAs.

Table 5-12. Active Northern Spotted Owl Sites Within the Permit Area

	Confirmed Pair	Pair-Status-Unknown[a]	Resident Single	Total
Inside HCA (conserved)	18	4	6	28
Outside HCA (available for harvest)	2	0	1	3
Total	20	4	7	31
Maximum Amount and % Taken by Covered Activities	2 (10.0%)	0 (0%)	1 (14.3%)	3 (9.7%)

[a] Active sites for which surveys indicate a suspected pair that was not confirmed based on the survey protocol criteria.

Northern Spotted Owl Activity Centers Located on Adjacent Lands

There are 142 active northern spotted owl sites with activity centers located outside of the permit area but within the provincial radius[10] of permit area lands. Using the provincial radius, “owl circles” that overlap the permit area include 119 sites with confirmed pairs, 5 sites with unconfirmed pairs, and 18 sites with resident single owls. As shown in Table 5-13, most (121) of these adjacent activity centers are located on federal lands (Bureau of Land Management [BLM] and U.S. Forest Service [USFS]). Twelve adjacent activity centers are located on state lands within the Elliott State Forest, and nine are located on private forest lands. Activity centers located on federal lands are already managed to protect spotted owls under the Northwest Forest Plan and associated land management plans (USDA and USDI 1994; BLM 2016a, 2016b). Activity centers on the Elliott State Forest are being evaluated as part of an HCP effort being led by Oregon Department of State Lands. The general ownership and distribution of activity centers located on adjacent lands within the provincial radius of the permit area is as follows:

- **Coast Range ecoregion:** most (26 sites) activity centers are located on the BLM Eugene District and 12 are located on the Elliot State Forest.
- **Klamath ecoregion:** 57 adjacent sites are located primarily on BLM lands within checkerboard ownership with private forest lands on the BLM Medford and Roseburg Districts and on the Rouge River-Siskiyou National Forest.

[10] Activity centers are the location of a nest or day-time roost sites of a resident spotted owl or pair of spotted owls. The “provincial radius” of a circle centered on the activity center represents the approximate home range for an owl in a given geographic location. Based on guidance from the USFWS, ODF uses the following provincial radii: Klamath Province (Southwest Unit), 1.3 miles; Oregon Cascades (North Cascade District), 1.2 miles; Oregon Coast Ranges (all other Districts), 1.5 miles. Using the provincial radius, a circle is drawn around each activity center, creating an “owl circle” in which habitat effects may occur.

- **West Cascades ecoregion:** most (11) of the 15 adjacent sites are located on the Willamette National Forest.

Table 5-13. Adjacent Active Northern Spotted Owl Activity Centers Within the Provincial Radius of the Permit Area

Ecoregion and Ownership	Active Pair	Pair Status Unknown	Resident Single	Total
Coast Range				
BLM Eugene District	21	1	4	26
Elliott State Forest	10		2	12
Other Private	8		1	9
Siuslaw NF	6		2	8
BLM Roseburg District	4		1	5
Total	**49**	**1**	**10**	**60**
Klamath				
BLM Medford District	28	1	1	30
Rogue River-Siskiyou NF	11			11
BLM Roseburg District	9		1	10
Klamath NF	1		1	2
Umpqua NF	2			2
Private	1	1		2
Total	**52**	**2**	**3**	**57**
West Cascades				
Willamette NF	9		2	11
BLM Medford District	1			1
BLM Salem District	1	1	1	3
Total	**11**	**1**	**3**	**15**
Permit Area Total	**119**	**5**	**18**	**142**

As described in Chapter 4, ODF considered adjacent northern spotted owl activity centers when selecting areas to include within HCAs (Conservation Action 6: Establish Habitat Conservation Areas), so that most of the existing nesting, roosting, and foraging habitat located on permit lands near activity centers will be protected within HCAs. Specifically, as detailed in Table 5-14, habitat to be conserved within HCAs or RCAs in permit area that is also within the provincial radius of owl circles centered on adjacent lands include:

- 99.5% of habitat rated as 0.8 or better[11] (considered nesting and roosting habitat),
- 92% of habitat rated between 0.6 and 0.8 (also considered nesting and roosting habitat), and
- 61% of habitat rated between 0.4 and 0.6 (considered foraging habitat only).

[11] Multi-factor habitat models rated habitat with a score ranging from 0 to 1, with 1 being the highest quality: <0.3 = Not Habitat; 0.3 - 0.4 = Dispersal-only Habitat; 0.4 - 0.6 = Foraging/Dispersal Habitat; 0.6 – 1.0 = Nesting/Roosting/Foraging/Dispersal Habitat. See Appendix D for more details on habitat models.

Table 5-14. Habitat Conditions in the Permit Area Within the Provincial Radius of Northern Spotted Owl Activity Centers Located on Adjacent Lands

Ecoregion – HCA Location	Number of Adjacent Sites	Habitat Suitability Rating[a]					
		0.8–1.0		0.6–0.8		0.4–0.6	
		Acres	%	Acres	%	Acres	%
Coast Range	**70**						
Inside HCA		450	99.5	2,689	95	7,631	66
Outside HCA		2	0.5	129	5	3,929	34
Klamath	**57**						
Inside HCA		96	100	632	78	1,426	36
Outside HCA			0	180	22	2,545	64
West Cascades	**15**						
Inside HCA		86	99	119	100	1,068	93
Outside HCA		1	1		0	83	7
Total	**142**						
Inside HCA		632	99.5	3,439	92	10,125	61
Outside HCA		3	0.5	308	8	6,556	39

[a] Multi-factor habitat models rated habitat with a score ranging from 0 to 1, with 1 being the highest quality: <0.3 = Not Habitat; 0.3–0.4 = Dispersal-only Habitat; 0.4–0.6 = Foraging/Dispersal Habitat; 0.6–1.0 = Nesting/Roosting/Foraging/Dispersal Habitat. See Appendix C for more details on habitat models.

While the majority of habitat near adjacent sites will be protected within HCAS, as detailed in Table 5-15, the HCP will allow harvest of 100 acres or more within the provincial radius of 10 activity centers within the Coast Ecoregion and 10 activity centers within the Klamath Ecoregion.

Table 5-15. Active Northern Spotted Owl Activity Centers Located on Adjacent Lands, With Projected Habitat Effects Greater than 100 Acres Within the Permit Area Under the HCP

Ownership of Activity Center	Site ID	Activity Center Name	% Other Ownership			% of Activity Center Circle Within Permit Area	Acres Within HCA	Acres of Suitable Habitat Outside of HCA[a]		
			BLM	USFS	Private			0.6–0.8	0.4–0.6	Total
Coast Ecoregion										
BLM Eugene District	4680	Upper Greenleaf	54	13	--	34	598	--	502	502
	2546	Knapp Creek	42	--	13	45	1,419	--	459	459
	4088	Mcvey Creek	34	--	16	50	1,436	--	453	453
Private	4474	Upper Mcvey	10	--	43	47	861	--	445	445
BLM Eugene District	2549	Jackass Creek	48	--	40	12	--	--	430	430
	3914	Liebre Creek	42	--	14	45	1,559	--	378	378
	2548	Pataha Creek	48	--	28	24	559	125	222	346
	4688	Iron Mountain	47	--	44	9	--	--	318	318
Private	11002	January Creek East	34	--	62	4	--	--	187	187
BLM Eugene District	2313	Lower Greenleaf	50	--	42	8	91	--	109	109
Klamath Ecoregion										
BLM Medford District	2365	Althouse Ditch	48	--	35	17	--	41	372	413
	4039	Golconda	27	36	22	15	--	11	389	400
	2634	Blind Sam	34	18	32	16	--	41	357	398
BLM Roseburg District	2195	North Lawson	24	--	66	10	4	--	214	214

Ownership of Activity Center	Site ID	Activity Center Name	% Other Ownership			% of Activity Center Circle Within Permit Area	Acres Within HCA	Acres of Suitable Habitat Outside of HCA[a]		
			BLM	USFS	Private			0.6–0.8	0.4–0.6	Total
BLM Medford District	2069	Kelseys Demise	86	--	0	14	--	--	190	190
	1947	# 7 Gulch	22	41	31	7	--	41	118	159
	2015	Bull Run	61	--	27	11	--	37	93	130
	3280	KCNA	79	--	6	15	--	--	129	129
	2361	Anderson Lookout	41	--	47	12	--	--	127	127
	2624	Wolf Creek	32	--	45	23	434	--	119	119

[a] This habitat would be subject to harvest under the HCP. Habitat ratings for northern spotted owl are described in Appendix C. Ratings were defined as 0.6–1.0 = Nesting/Roosting/Foraging Habitat; 0.4–0.6 = Foraging Habitat; 0.3–0.4 = Dispersal-only Habitat; <0.3 = Not Habitat. No habitat greater than 0.8 rating would be affected within owl circles centered on adjacent lands. Dispersal habitat not included in table.

5.7.3 Impacts of the Taking on Northern Spotted Owls

5.7.3.1 Context, Intensity, and Duration of Impacts

Take resulting from habitat loss and other adverse effects, described Section 5.7.2, *Quantity and Timing of Take*, would take place within the following contexts and levels of intensity:

- Approximately 28% of existing nesting-roosting habitat and 48% of existing foraging habitat will be located outside of HCAs and other protected areas (such as RCAs) and subject to harvest.
- Approximately 10% (2 pairs out of 20) of active sites with activity centers[12] with confirmed pairs within the permit area will be located outside of HCAs and other protected areas and subject to loss to harvest over the permit term.
- The two active pair activity centers that will be lost to harvest have not had documented nesting or young, or observations of adults, in the most recent 6 years of completed protocol surveys.
- Dispersal habitat outside of HCAs will not fall below the thresholds established under Conservation Action 8: Conservation Actions Outside Habitat Conservation Areas and Riparian Conservation Areas (40% within each subgeographic area).

Harvest of nesting, roosting, and foraging habitat within the two active pair territories outside the HCAs will occur during the permit term. If owls are occupying this habitat at the time it is modified by covered activities, then during or following harvest, the owls may relocate to other areas or may die due to inadequate food, exposure, or predation (see 5.7.1, *Sources and Types of Take*). Seasonal operating restrictions will apply to management activities affecting these two activity centers, as defined in Conservation Action 10: Operational Restrictions to Minimize Effects on Covered Species.

Removal of northern spotted owl habitat outside of HCAs and RCAs will also likely result in localized reductions in habitat available for non-territorial individuals seeking to establish new territories. However, the HCAs established under Conservation Action 6: Establish Habitat Conservation Areas, as well as RCAs established under Conservation Action 1: Establish Riparian Conservation Areas, will support foraging and dispersal habitat. Also, any active nest sites encountered outside of HCAs will be protected during breeding season to allow for successful fledging, as specified under Conservation Action 10. Retention standards for legacy structures (Conservation Action 8), especially the prioritization of large green trees intended to persist through multiple harvests, will enhance dispersal conditions outside HCAs by providing roosting structure within younger stands. Leave patches (versus scattered individual leave trees) may also provide enhanced sheltering and foraging opportunities.

Once northern spotted owl nesting and roosting habitat is harvested outside of HCAs, those stands are likely to be harvested again before developing back into habitat, so the effects are considered to be permanent. Some habitat that is harvested early in the permit term may develop into foraging habitat by the end of the permit term, but there is no commitment in the HCP to maintain nesting, roosting, or foraging habitat outside HCAs. Management in HCAs will be used to promote

[12] Existing activity centers are defined as those activity centers that have been confirmed at one point and have had ≤6 consecutive years of surveys with no observations. Activity centers that have not been surveyed consistently during the last 6 years were assumed to have their same status as of their most recent survey history.

development of nesting, roosting, and foraging habitat as described in Conservation Action 7: Manage Habitat Conservation Areas.

Habitat gains that are projected to outpace habitat losses under the HCP and associated impacts are discussed in Section 5.7.4, *Beneficial and Net Effects on Northern Spotted Owl*.

5.7.3.2 Effects on Critical Habitat

The permit area includes 169,058 acres of designated critical habitat for northern spotted owl (USFWS 2012a, 2021), broken out by Unit as follows:

- Unit 1, North Oregon Coast, 126,060 acres (73% of total northern spotted owl designated critical habitat in permit area)
- Unit 2, Oregon Coast, 30,498 acres (18%)
- Unit 9, Klamath West, 10,049 acres (6%)
- Unit 10, Klamath East, 2,451 acres (2%)

Effects in critical habitat are the same as those described previously in this section. When harvest occurs habitat could become less hospitable. If individuals are present, they could be displaced. The degree to which critical habitat could be modified from covered activities relates to the type and quality of habitat of the critical habitat when the covered activity occurs. Not all critical habitat supports northern spotted owl and habitat quality is variable. The stated justification for designating areas that are currently not suitable habitat as critical habitat was the need for increased and enhanced habitat and habitat connectivity to support dispersal, population growth, and buffering from competition with the barred owl (USFWS 2012a, 2021).

Approximately one fourth of the land designated as critical habitat within the permit area does not currently contain northern spotted owl habitat as modeled in this HCP. Approximately 22% of the designated critical habitat meets the definition of dispersal habitat, 42% meets the definition of foraging habitat, 10% meets the definition of nesting and roosting habitat, and 25% is not habitat.

Of the critical habitat that is currently modeled as suitable, HCAs will include:

- 75% of designated critical habitat that meets the definition of nesting and roosting habitat.
- 51% of designated critical habitat that meets the definition of foraging habitat.

In general, critical habitat that is located in HCAs is expected to increase in habitat value during the permit term. Management activities in HCAs will be tailored to that purpose. There may be some short-term effects to critical habitat in locations where management activities occur for Swiss needle cast or to convert stands of hardwood to conifer, but over the permit term any critical habitat inside HCAs will be of higher quality than at the start of the permit term. Outside of HCAs critical habitat may be modified, particularly in locations where critical habitat is designated in nesting, roosting, or foraging habitat.

Table 5-16 summarizes the acres of critical habitat inside and outside of HCAs, by habitat type, according to models developed for this HCP. Key summary points include:

- A total of 17,627 acres of critical habitat meets the HCP model criteria of nesting and roosting habitat, and 75% of those acres are located within HCAs. The 25% outside HCAs could be subject to harvest.

- Of the 71,089 acres of foraging habitat that is also critical habitat, 51% is in HCAs and will likely grow into nesting and roosting habitat during the permit term. The other 49% could be subject to harvest.
- The remainder of critical habitat is either dispersal habitat or does not currently meet minimum criteria for habitat. Habitat loss due to covered activities modification is not expected in dispersal-only habitat or areas that are not habitat.

Table 5-16. Northern Spotted Owl Critical Habitat and Modeled Existing Habitat Suitability Within the Permit Area (acres)

	Breakout by Habitat Suitability[a]								
Critical Habitat Unit	Dispersal	%[b]	Foraging	%	Nesting/ Roosting	%	Non-Habitat	%	Total
1. North Oregon Coast Ranges	28,760	23	52,510	42	11,630	9	33,159	26	126,060
Critical Habitat within HCAs	15,646	24	28,230	43	7,882	12	13,365	21	65,122
Critical Habitat outside of HCAs	13,115	22	24,280	40	3,748	6	19,795	32	60,937
2. Oregon Coast Ranges	4,779	16	14,045	46	5,185	17	6,489	21	30,498
Critical Habitat within HCAs	1,800	12	6,307	43	4,728	32	1,999	13	14,834
Critical Habitat outside of HCAs	2,979	19	7,738	49	457	3	4,490	29	15,664
9. Klamath West	3,594	36	3,814	38	756	8	1,884	19	10,049
Critical Habitat within HCAs	1,683	37	1,375	30	583	13	936	20	4,577
Critical Habitat outside of HCAs	1,912	35	2,439	45	172	3	949	17	5,472
10. Klamath East	891	36	720	29	56	2	783	32	2,451
Critical Habitat within HCAs	412	60	169	25		0	102	15	683
Critical Habitat outside of HCAs	480	27	551	31	56	3	681	38	1,768
Totals	38,026	22	71,089	42	17,627	10	42,316	25	169,058
Critical Habitat within HCAs	19,541	51	36,080	51	13,193	75	16,402	39	85,216
Critical Habitat outside of HCAs	18,485	49	35,008	49	4,433	25	25,914	61	83,841

[a] Habitat ratings are described in Appendix C. Ratings scored from 0 to 1, with <0.3 = Not Habitat; 0.3–0.4 = Dispersal-only Habitat; 0.4–0.6 = Foraging and Dispersal Habitat; 0.6–1.0 = Nesting/Roosting/Foraging/Dispersal Habitat.

[b] Percent of total, by row.

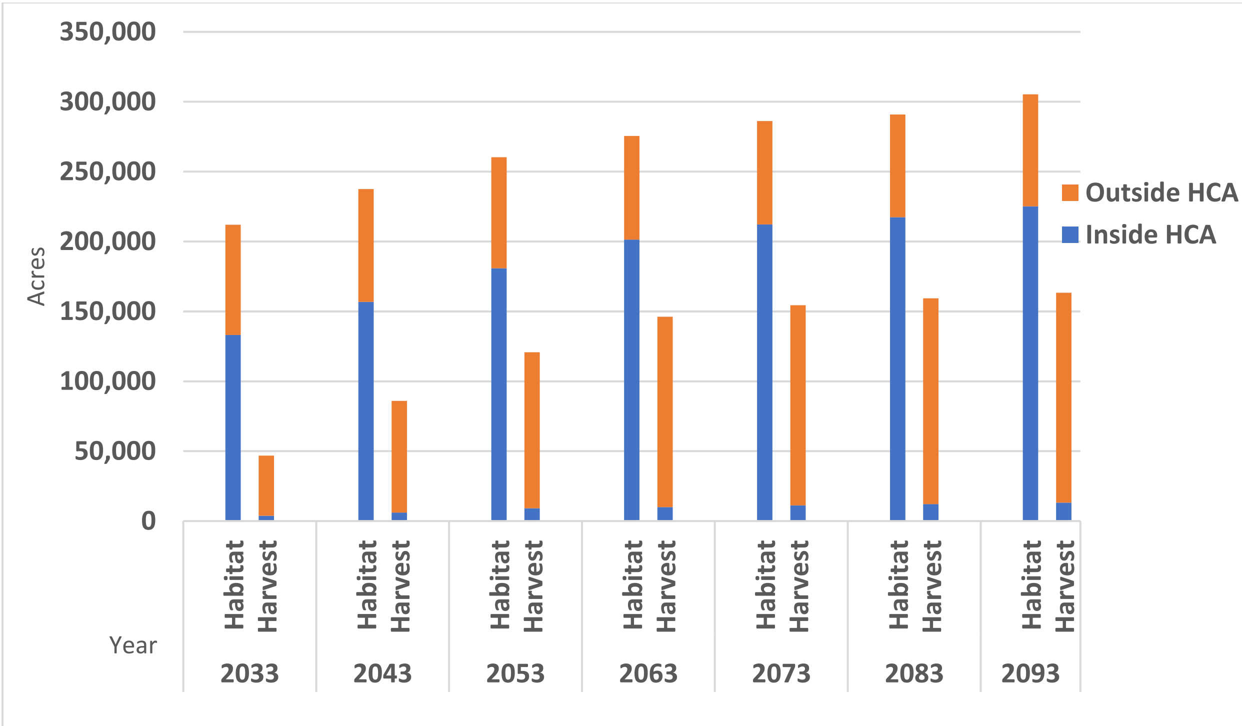
5.7.4 Beneficial and Net Effects on Northern Spotted Owl

The impact of the level of take just described will occur within the context of a landscape that is recovering from a history of large-scale disturbances – including fire and timber harvest – that have left relatively little high quality northern spotted owl habitat within the permit area (see Chapter 2). In addition, the impact will occur within the context of ongoing competition with and displacement by barred owls. Within this context, the unmitigated loss of any habitat currently occupied by northern spotted owls is significant at the local population level, as the landscape carrying capacity has already been lowered.

A key consideration regarding the impact of the taking – and the associated mitigation needed to offset that taking – is the net habitat gain and loss over time, as projected by modeling under the HCP. Based on the modeling conducted for this HCP, habitat gains within HCAs will outpace total losses in every 10-year period of the 70-year permit term, as habitat loss has been minimized through HCAs and as habitat increases within HCAs over time. Under the HCP, northern spotted owl populations will benefit from (1) protection of most existing occupied habitat within HCAs (Conservation Action 6*:* Establish Habitat Conservation Areas) and (2) an increased amount and quality of habitat over the permit duration (Conservation Actions 6 and 7). Specific benefits and net projected outcomes are described below.

5.7.4.1 Potential Benefits of Habitat Conservation Areas

The conservation strategy (Conservation Actions 6: Establish Habitat Conservation Areas and 7: Manage Habitat Conservation Areas) is projected to result in 225,167 acres of nesting, roosting, and foraging habitat within HCAs at the end of the permit term, a gain of 102,392 acres within HCAs over the 70-year permit term. Both habitat quantity and quality within HCAs is projected to increase through passive management and some active management. An additional 80,140 acres of nesting, roosting, and foraging habitat is projected to be present outside of HCAs at the end of the permit term, although these acres are projected based on ODF's forest growth and timber harvest modeling and do not represent an ODF commitment to provide habitat for northern spotted owls beyond that provided in HCAs. Figure 5-7 shows the modeled projections of cumulative habitat harvested and total habitat present over the duration of the permit, by decade. Figure 5-8 shows the change in habitat quality within the permit area during the permit term.



[1] Projected habitat levels show habitat and cumulative harvest starting at the year indicated (e.g., 2033 = first decade). Harvest is shown as cumulative over the permit term (i.e., a running total accumulating over the permit duration). Habitat projections presented in this chapter are not HCP commitments, but rather are modeled projections ODF is using to estimate the level of take and to determine appropriate avoidance, minimization, and mitigation measures needed to offset that projected level of take. As described in Chapter 4, commitments to conserve, maintain, and enhance acres of covered species habitat were estimated based the assumption that, within the permit term, 50% of nesting and roosting habitat and 80% of foraging habitat, projected to grow in over 70 years by habitat models, could be achieved in HCAs.

Figure 5-7. Northern Spotted Owl Habitat Harvested and Estimated Habitat In Growth, by Decade[1]

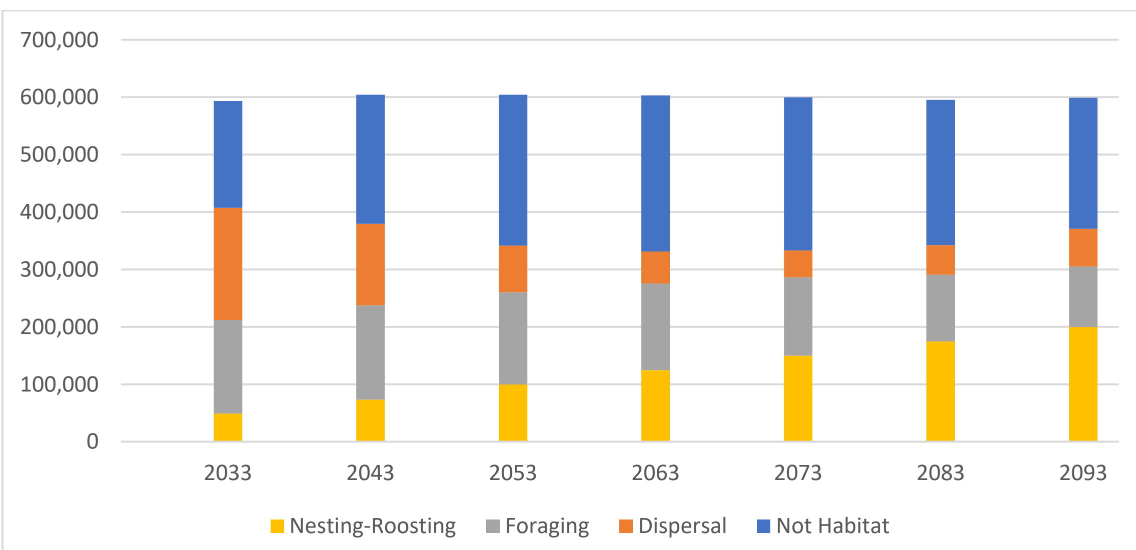


Figure 5-8. Change in Northern Spotted Owl Habitat Quality over Permit Duration, by Decade

Habitat development will be accelerated in some stands in HCAs as described under Conservation Action 7 (see Chapter 4, Table 4-8). This conservation action is consistent with Recovery Action 6 of the *Revised Northern Spotted Owl Recovery Plan* (USFWS 2011), which states “in moist forests managed for spotted owl habitat, land managers should implement silvicultural techniques in plantations, overstocked stands and modified younger stands to accelerate the development of structural complexity and biological diversity that will benefit spotted owl recovery.”

As noted in Chapter 4, the conservation approach was developed in the context of a forested landscape that has been modified from historical conditions, particularly in the northwest portion of the permit area (i.e., the Tillamook and Clatsop State Forests). As a result, many forest stands are now dominated by densely spaced, young conifer and mixed deciduous forest (for a detailed description of current conditions and their history, see Chapter 2). Less than 20,000 acres of the permit area contains highly suitable habitat for northern spotted owl. However, due in part to investments made by ODF since the mid-1990s to improve forest conditions, and in part due to natural growth within stands through passive management, much of this habitat is capable of becoming habitat suitable for northern spotted owl at some point during the permit term.

The conservation strategy has been developed to anticipate this increase of habitat over time and to proactively develop an HCP that includes a significant portion of these areas to be allowed or encouraged through active management to become suitable habitat for northern spotted owls, and to maintain this habitat. This is consistent with Recovery Action 32 in the *Revised Northern Spotted Owl Recovery Plan* (USFWS 2011). The benefits of developing additional habitat within HCAs is that, rather than operating on a “no-take” basis, which conserves only the minimum habitat that is necessary to avoid take of currently “active” (occupied), the HCP will proactively designate and manage habitat that is currently not suitable in order to create more suitable habitat on the landscape over time.

The extent and location of HCAs is anticipated to ensure the persistence of northern spotted owls throughout the permit area, including within the north coast areas, which USFWS has identified as a priority for maintaining the viability of the Oregon Coast Recovery Unit (USFWS 2011).

In addition, under Conservation Action 9: Strategic Terrestrial Species Conservation Actions, ODF will establish a conservation fund to fund and implement in cooperation with USFWS barred owl research and management activities within the permit area. The benefits of barred owl removal are still being evaluated, but, based on initial research (Wiens 2019), control of barred owls, if implemented, could enhance survival and site tenacity within the permit area over the duration of the permit, and thus further offset the projected impacts of take under this HCP.

5.7.4.2 Benefits of Monitoring and Adaptive Management Program

The monitoring program described in Chapter 6 includes ODF’s commitment to document progress toward maintenance and enhancement of existing nesting, roosting, and foraging habitat over the permit term. The monitoring program also includes efforts to confirm occupation status of habitat over time and responses of northern spotted owls to forest management and barred owl removal. Monitoring will provide documentation to the USFWS and interested stakeholders that the intended benefits to northern spotted owls are being realized. Should monitoring results indicate that biological objectives are not being realized, then ODF will use the adaptive management process described in Chapter 6 to implement changes to improve progress toward the biological objectives.

5.7.4.3 Net Effects

USFWS and others have consistently stated the need to conserve and restore large areas of contiguous, high-quality habitat across the range of the northern spotted owl to prevent further population declines and to allow for the recovery of the species (Lesmeister et al. 2018, Dugger et al. 2011, Forsman et al. 2011, USFWS 2011). The conservation strategy includes focusing management for species habitat improvement in contiguous areas of suitable habitat and associated active northern spotted owl nesting territories within HCAs. Designated HCAs will provide long-term protection and enhancement of northern spotted owl habitat in exchange for allowable harvest in other habitat areas outside of HCAs to maintain important economic values from ODF lands within the permit area.

As previously described, the HCP is projected to result in a net increase in suitable habitat for northern spotted owls within the permit area over the permit duration, from the 219,500 acres of nesting, roosting and/or foraging habitat (modeled as ≥0.4) distributed across the permit area at the start of the permit (year 2023) to 225,000 acres located within HCAs at the end of the permit term (2092). An additional 80,000 acres of habitat are projected to be present outside of HCAs at the end of the permit term. Based on the timing of projected harvest under the HCP, a net increase in habitat will occur within each 10-year modeling period over the permit term so that growth of northern spotted owl habitat will more than offset habitat lost through harvest and thinning throughout the permit term. Table 5-17 summarizes the net habitat outcomes under the HCP at the projected to be present at the end of the 70-year permit.

Table 5-17. Net Northern Spotted Owl Modeled Habitat Projections from Start to End of Permit Term[a]

	Inside HCA			Outside HCA			Total		
	Foraging	Nesting/ Roosting	Total	Foraging	Nesting/ Roosting	Total	Foraging	Nesting/ Roosting	Total
Start	92,000	30,500	122,500	85,000	12,000	97,000	177,000	42,500	219,500
End	63,500	161,500	225,000	42,000	38,000	80,000	105,500	199,500	305,000
Change	-28,500[b]	+131,000	+102,500	-43,000	+26,000	-17,000	-71,500	+157,000	+85,500

[a] Habitat ratings are described in Appendix C. Ratings scored from 0 to 1, with <0.3 = Not Habitat; 0.3–0.4 = Dispersal-only Habitat; 0.4–0.6 = Foraging and Dispersal Habitat; 0.6–1.0 = Nesting/Roosting/Foraging/Dispersal Habitat. While habitat is projected to develop outside of HCAs and likely will, ODF is not committing to maintain habitat for northern spotted owls outside of HCAs other than dispersal habitat (see Conservation Action 10: Operational Restrictions to Minimize Effects on Covered Species, for a description of dispersal habitat commitments).

[b] Note that much of the foraging habitat decreases can be attributed to foraging habitat developing into nesting and roosting habitat.

The amount of habitat conserved and additional habitat to be developed over time is expected to fully offset the amount of authorized take and maintain and enhance northern spotted owl reproduction, numbers, and distribution within the permit area over the duration of the permit.

5.7.5 Cumulative Effects on Northern Spotted Owl

ODF is not aware of any future state or local actions that may contribute to cumulative effects that are reasonably certain to occur. On state lands, DSL is currently preparing an HCP for the Elliott State Forest. As an HCP, it is required to fully offset the impacts of take and is unlikely to adversely affect northern spotted owl populations or distribution or otherwise contribute to cumulative effects. In addition, because the Elliott State Forest HCP is not considered a cumulative effect in this

HCP because it is not yet complete (per the regulatory definition of cumulative effects, 50 CFR 402.02).

On industrial private lands, most effects on spotted owl populations and distribution have likely already occurred throughout Western Oregon due to a long history of intensive commercial forestry. Some private lands are managed under HCPs for areas where habitat and owls remain (see Chapter 2 for other HCPs in the vicinity of the permit area). The USFWS identified no private lands in Oregon as critical habitat for northern spotted owl (USFWS 2012a, 2021). Actions on private lands that would likely result in take of northern spotted owl would require an incidental take permit under Section 10 of the ESA. Therefore, actions on private lands are not anticipated to contribute to cumulative effects.

Other state, local, or private future actions that are reasonably certain to occur include road construction, recreational infrastructure and maintenance (e.g., trailhead parking lots, mountain bike trail networks), and linear rights-of-way construction (e.g., transmission lines, pipelines). But ODF is not aware of any specific projects reasonably certain to occur within the Oregon Coast Recovery Unit for northern spotted owl that may significantly contribute to cumulative effects. Effects of such actions would be addressed through ESA review and authorizations (under Section 7 or Section 10).

5.8 Effects Analysis for Marbled Murrelet

5.8.1 Sources and Types of Take

All covered activities that involve tree removal—including timber harvest, thinning, road work, quarries, and recreational infrastructure development and maintenance—have the potential to result in four types of incidental take of marbled murrelet.

- Harm due to direct injury or mortality, such as inadvertently destroying a nest with eggs or young.
- Harm due to disturbance from noise and activities, such as missed feedings of young due to adult murrelets avoiding the nesting areas.
- Harm due to habitat modification to the extent that murrelets have reduced reproductive success due to predation or abandonment of the nesting site, including from edge effects due to harvests adjacent to nesting habitat that degrade microclimate, increase nest depredation, or result in increased windthrow.
- Harm due to habitat modification to the extent that murrelets stop nesting within a previously used tree or stand.

Harm due to disturbance near known active nest stands during the nesting season and harm due to direct injury or mortality will be avoided through seasonal operational restrictions during the nesting season (Conservation Action 10: Operational Restrictions to Minimize Effects on Covered Species). The following sections describe the criteria and thresholds for determining when take will occur, the effects pathways leading to take, and the specific covered activities expected to result in take, as well as those not expected to result in take.

5.8.1.1 Criteria and Thresholds for Determining Take

To quantify the level of incidental take of marbled murrelets, the HCP uses the acres of suitable and highly suitable habitat that will be harvested or otherwise disturbed under the HCP due to covered activities. Harm due to habitat modification from timber harvest is the primary source and type of take of marbled murrelets ODF anticipates occurring over the permit duration. While take through habitat modification has been minimized through designated HCAs (Conservation Action 6: Establish Habitat Conservation Areas), habitat outside of HCAs and RCAs will be subject to harvest under the HCP.

Table 5-18 summarizes the general sources and thresholds used in this HCP to determine when covered activities have the potential to rise to the level of take of marbled murrelets. Note that all of these types of take may not occur. Projected level and type of take is described in Section 5.8.2 below. The effects pathways leading to such take are described in the next subsection.

Table 5-18. Criteria and Threshold for Determining Take of Marbled Murrelets

Covered Activities Assumed to Take Marbled Murrelet	Covered Activities With Beneficial, Insignificant, or Discountable Effects
• Covered activities that modify[a] a stand (e.g., regeneration harvest or thinning) of occupied habitat,[b] regardless of habitat modeling designation. • Covered activities that modify a stand modeled as *suitable* or *highly suitable* within the range of species.[c] • Covered activities that modify habitat immediately adjacent[c] to a stand with designated occupied habitat or modeled as *suitable* or *highly suitable* within the range of the species.	• Covered activities within stands modeled as *marginal* or *non-habitat* in all districts within the range of marbled murrelets[c] unless there are observations indicative of occupancy. • Activities in 100-meter (328-foot) buffers to designated occupied habitat where those activities do not result in an increase of edge to, or otherwise degrade the habitat quality of the adjacent habitat. (Conservation Action 7: Manage Habitat Conservation Areas) • Also minor activities and aquatic restoration in designated occupied habitat and buffers as described in Conservation Action 10: Operational Restrictions to Minimize Effects on Covered Species

[a] *Modification* is considered altered habitat structure or composition so that habitat values move from highly suitable or suitable to marginal or non-habitat.

[b] Designated occupied habitat is defined as any area with known nests or with observations of murrelets indicating nesting, as defined by the USFWS-approved marbled murrelet nesting survey protocol (Evans Mack et al. 2003).

[c] Immediately adjacent means within 100 meters (328 feet) of the stand edge.

[d] Effects on marbled murrelet are most likely to occur in modeled habitat in Astoria, Tillamook, Western Oregon, Western Lane, and Coos Districts and less likely to occur in Forest Grove based on species range and past survey history. No effects are expected in North Cascade or Southwest.

5.8.1.2 Effects Pathways

The effects pathway leading to take begins with reduced forest structure, including large trees and associated nesting platforms and reduced tree density, canopy cover, and canopy layers. Loss of these forest structures may result in the following stressors to resources.

- Eliminate trees with platforms that are required for nesting (Nelson and Wilson 2002), either through direct harvest or subsequent windthrow events along harvest edges.

- Create “hard edges” (recent clearcuts) near nest trees or stands, increasing exposure to nest predators (Malt and Lank 2007) and reducing microclimate conditions needed to support nesting platforms (van Rooyen et al. 2011). Microclimate effects on moss can occur within 150 feet of hard edges, possibly further in areas with greater wind exposure (Raphael et al. 2018).

Cutting down active nest trees or stands during the nesting season will be avoided through the conservation measures described in Chapter 4 (Conservation Action 10: Operational Restrictions to Minimize Effects on Covered Species). Therefore, effects of modified nesting habitat will not be realized until murrelets return to nest. The behavioral response of individual marbled murrelets (or pairs) to such stressors may include the following.

- **Continued use.** In situations where nest trees are retained but edge habitat is created near the nest location, then birds returning to nest may still use the tree, but the eggs and young could be lost due to increased predation risks created by the modified habitat.
- **Abandonment of nest site**. Adults returning to stands that have been significantly modified by timber harvest or other covered activities may seek a new nest location or may forego nesting for the year. If seeking a new nest location, the pair would likely expend considerable energy and may acquire less energy due to less time spent foraging. The pair or individuals may or may not find a suitable replacement nest location. In addition, loss of a nest site could affect pair bonds. In any case, the likely biological effect is assumed to be lost reproductive success for at least 1 year.

The effects pathway ends with the consideration of the biological effects on individuals within the context of regional and range-wide distribution and populations. Because available nesting habitat and associated reproduction levels is considered a limiting factor in current population numbers (Raphael et al. 2018), loss of nest locations or increased predation risk could reduce local population levels through reduced nesting and production of young. Such population-level effects are discussed under Section 5.8.3, *Impacts of the Taking on Marbled Murrelet*.

Figure 5-9. summarizes the potential effects pathways from covered activities, on individual murrelets, through to population-level effects.

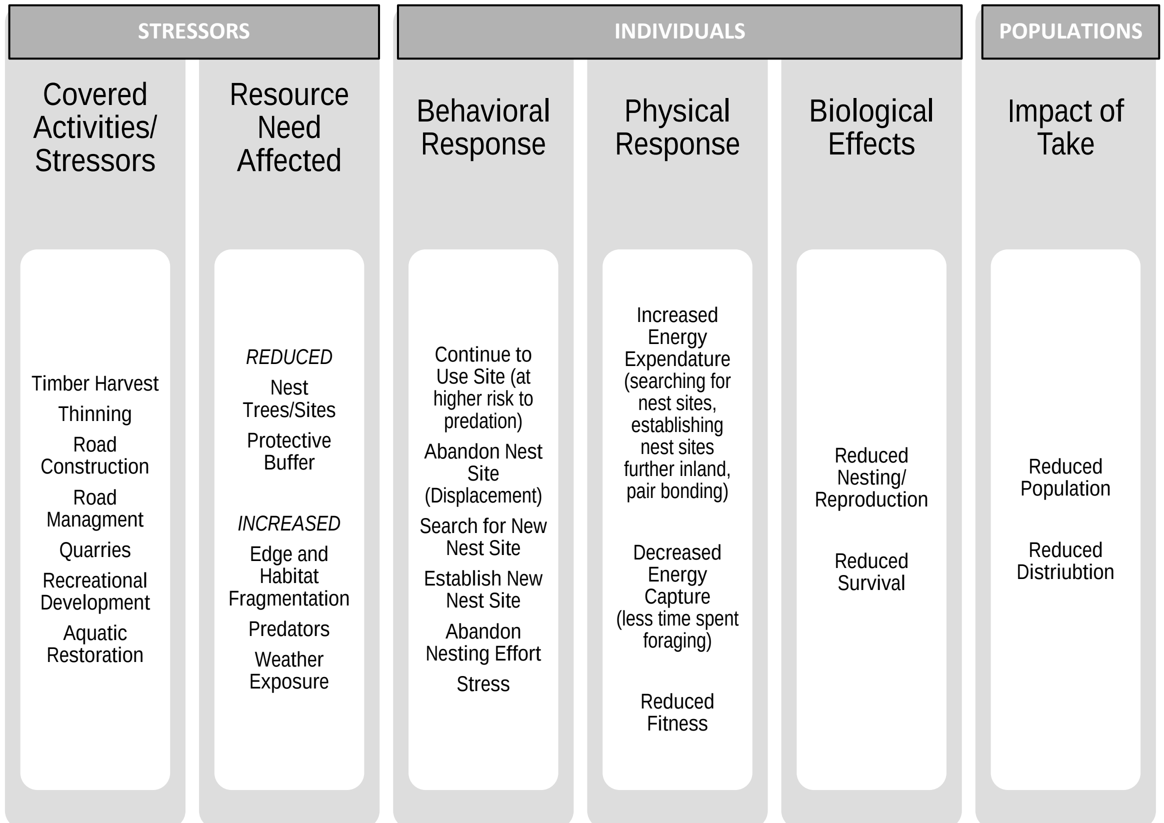


Figure 5-9. Effects Pathways for Impacts of Take of Marbled Murrelets via Habitat Modification from Covered Activities

5.8.1.3 Covered Activities that May Result in Take

Harm via timber harvest and associated modification of habitat outside HCAs will be the primary source and type of take of marbled murrelets. These effects will be minimized through implementation of Conservation Action 8: Conservation Actions Outside Habitat Conservation Areas and Riparian Conservation Areas, and Conservation Action 10: Operational Restrictions to Minimize Effects on Covered Species. There could also be instances where harvest occurs outside HCAs in stands that have supported nesting marbled murrelets and the occupancy was yet undiscovered. These effects will be minimized following the implementation of Conservation Action 10. Other covered activities may also include tree removal that could modify marbled murrelet habitat if conducted in such habitat, including new road construction, landings, and development of new quarries and recreation infrastructure and maintenance (e.g., campgrounds, trails, trailheads). Even in instances where these activities do not result in habitat loss, they may result in habitat degradation through the creation of more habitat edge and less interior habitat. This in turn results in an increased risk of blowdown and microclimatic effects, including increased use by corvids. Similarly, establishment of recreation infrastructure has the added potential for take by attracting corvid populations (ravens, jays, and crows), which may in turn increase predation risks to marbled murrelets nesting near such areas (Malt and Lank 2007, Walker and Marzluff 2015, Raphael et al. 2018).

These effects would be minimized because when management activities occur in HCAs they will follow the provisions described in Conservation Action 7: Manage Habitat Conservation Areas. Silvicultural prescriptions inside of HCAs will only be carried out if the harvest action will result in higher habitat quality over the duration of the permit. These areas include hardwood-dominated stands comprised primarily of red alder with little or no conifer component, or those infected with Swiss needle cast that have limited potential to provide habitat value during the permit term. These managed stands will achieve a higher level of suitability than the non-habitat or marginally suitable habitat stand they replaced.

Take via habitat modification may occur throughout the duration of the incidental take permit. As with northern spotted owl, take in the early years of the permit will occur within existing suitable habitat outside of HCAs, while take in later years may include habitat that is currently not suitable but that has developed over time. The amount and timing of take anticipated to occur through habitat modification over the permit duration is described in Section 5.8.2.

Not all habitat modification will result in take. As with other covered terrestrial species, the likelihood that effects of habitat modification from timber harvest on marbled murrelets will rise to the level of take depends on (1) existing conditions of the stand to be modified and (2) proposed harvest specifications. Habitat must be used at some point in time by nesting marbled murrelets in order for nesting murrelets to be exposed to the effects of habitat modification, although it may not occur every year (i.e., annual variation of actual nesting in occupied habitat). In addition, the habitat modification must be sufficiently severe as to interfere with nesting to the extent that individuals or their eggs or young are actually harmed. Habitat modification will be most likely to result in take within stands that are modeled as suitable or highly suitable, as these are places that are most likely to support marbled murrelet nesting. Table 5 summarizes covered activities and associated type of take expected to occur under the permit terms and conditions.

Table 5-19. Sources and Types of Take of Marbled Murrelet Expected Under the Habitat Conservation Plan

Covered Activity	Type of Take
Regeneration Harvest	Removal of habitat within or adjacent to occupied stands has the potential to increase predation and reduce nest site productivity. Removal of habitat that is near, or that includes, the nest tree would likely cause marbled murrelets to abandon the nesting area and seek replacement habitat elsewhere. Finding replacement habitat may place a high energy demand on displaced individuals and reduce the likelihood of successful nesting for at least 1 year or longer, depending on available replacement habitat.
Thinning	As with regeneration harvest, thinning could remove a sufficient number and type of trees to reduce habitat values and increase predation risk for nesting marbled murrelets, with the potential for reduced reproductive success or nest abandonment.
Road Construction and Maintenance	New road construction within designated occupied habitat, suitable habitat, or highly suitable habitat has the potential to remove habitat, including nest trees, and increase habitat edge, which in turn increases predation risks on eggs or young and reduces overall reproductive success or causes nest abandonment. New road construction will be avoided where possible in designated occupied habitat, suitable habitat, or highly suitable habitat within HCAs. Where road construction does take place, trees with platform branches capable of hosting murrelet nests will not be removed.

Covered Activity	Type of Take
Other Covered Activities Outside of HCAs and RCAs	Development of new quarries and recreation infrastructure as well as maintenance (e.g., campgrounds, trails, trailheads) within designated occupied habitat, suitable habitat, and highly suitable habitat has the potential to result in take due to habitat modification, including potential reduced reproductive success or nest abandonment. In addition, recreational infrastructure development and maintenance has the potential to increase predator populations due to attractants such as trash, and may increase predation of marbled murrelet nests or young.

5.8.1.4 When Covered Activities Are Not Expected Cause Take

Covered activities conducted more than 100 meters (328 feet) from designated occupied habitat and suitable or highly suitable habitat are not expected to cause take because most significant physical and biological effects on murrelet nesting stands (e.g., windthrow, loss of moss for nesting substrate, reduced canopy cover, increased predation) are believed to occur within this distance (USFWS 2019). Within HCAs, thinning and hardwood release treatments to improve forest conditions will not be conducted within a specified distance of occupied nesting areas during the nesting season, though light thinnings may still occur Conservation Action 7. In some cases placement of tailholds, guylines, or other harvest infrastructure will need to occur in designated occupied habitat. Those activities are not expected to result in take because they will following the provisions in Conservation Action 10. Similarly, within RCAs, aquatic habitat restoration projects could result in disturbance or minor habitat modifications, including tree removal, but such effects are not likely to rise to the level of take because of the small amount of habitat affected and the provisions outlined in Conservation Action 10. Other covered activities will either not be conducted within RCAs or will be conducted only when such activities will not result in take as determined by an ODF biologist.

Table 5-20 lists covered activities that are not expected to rise to the level of take of marbled murrelets.

Table 5-20. Covered Activities Not Expected to Result in Take of Marbled Murrelet

Covered Activity	Rationale for Determining that Covered Activity Will Not Result in Take
All Covered Activities Conducted Outside of Suitable and Highly Suitable Habitat	Activities that do not modify suitable or highly suitable habitat would not result in take.
Helicopter Use	Helicopters used for aerial yarding would follow avoidance measures defined under Conservation Action 10: Operational Restrictions to Minimize Effects on Covered Species.
Site Preparation, Tree Planting, and Release Treatments	Reforestation and young stand management activities will take place outside of suitable habitat and are not likely to adversely affect marbled murrelets.
Animal Damage Control	Animal damage control treatments will occur primarily in reforestation areas that are non-habitat for marbled murrelet. Treatments that include an area surrounding the reforestation area may intersect habitat for marbled murrelet, but are not expected to result in take.

Covered Activity	Rationale for Determining that Covered Activity Will Not Result in Take
Precommercial Thinning and Pruning	Precommercial thinning will be conducted in young forest stands and will not occur within suitable marbled murrelet habitat.
Unmanned Aircraft Systems (UAS)	Nest disturbance from drones will be avoided through seasonal operational restrictions (Conservation Action 10).
Existing Road System	The presence of existing roads is not expected to rise to the level of take because they are considered part of the environmental baseline and current nest locations have been established in the presence of the road system.
Road Management	Removal of hazard trees along roads has the potential to reduce habitat values for marbled murrelets. However, minimization and avoidance measures will protect nest locations.
Road Use	Marbled murrelets rarely fly at ground level and are not expected to be at risk of collisions with vehicles.
Road Maintenance	Work within the road prism rarely intersects marbled murrelet nesting habitat.
Road Decommissioning	Road decommissioning will not adversely affect murrelet habitat and may improve habitat conditions over time by reducing hard edge effects and reducing human use.
Drainage Structure Construction and Maintenance	Drainage work will not adversely affect marbled murrelet nesting habitat
Minor Forest-Product Harvest	Harvest of forest greens will not alter habitat conditions or expose murrelets to significant exposure from harvesters.
Controlled Burning	The likelihood of smoke harming marbled murrelets is low, as burns are rarely conducted within the breeding season when murrelets are present. They are only conducted when wind speeds are low and consistent. Existing fire management protocols are expected to adequately mitigate the chance of fire spreading into suitable habitat or smoke drifting into suitable habitat during the nesting season.
Water Drafting and Storage (fire management)	This activity is not likely to adversely affect nesting marbled murrelets or their eggs or young.
Aquatic Habitat Restoration	Aquatic habitat restoration may result in minor habitat modification, such as select tree tipping or removal, but such effects are not likely to rise to the level of take because of the avoidance and minimization measures described in Chapter 4. Implementation of Conservation Action 9: Strategic Terrestrial Species Conservation Actions, further reduces this potential in locations where restoration activities are occurring near species habitat.
Barred Owl Management	The HCP includes ODF's commitments to support barred owl removal and those activities will be conducted in a manner that avoids take of marbled murrelets.
Monitoring Activities	Monitoring is generally not expected to result in take. If any monitoring activity is determined to likely result in take, then ODF will obtain necessary clearance with the USFWS (or the research organization will, if a different entity).

5.8.2 Quantity and Timing of Take

5.8.2.1 Suitable and Highly Suitable Habitat Modification/Loss

Based on timber harvest and forest growth modeling, harvest or thinning activities will occur in 110,241 acres of suitable or highly suitable marbled murrelet habitat over the 70-year permit duration. Not all of this habitat is suitable at the outset of the permit. Some stands will grow into habitat as time progresses and the forest develops characteristics indicative of suitable or highly suitable habitat, including trees containing platforms (large branches or deformities) used for nesting, which is the most important characteristic of their nesting habitat (USFWS 2011). Habitat modification will occur inside and outside of HCAs.

Modification of marbled murrelet habitat within HCAs will only be done in situations where those short-term silvicultural actions will result in long-term increases in habitat quality. Management activities in HCAs will be conducted consistent with the provision in Conservation Action 7, including no management in designated occupied habitat. Management in highly suitable habitat will be rare and limited to single tree removals or precise management actions, avoiding any platform-bearing trees. In suitable habitat, management will be infrequent and limited to thinning.

Outside of HCAs, suitable and highly suitable habitat could be harvested or thinned for timber production. The habitat modification would be authorized by the HCP and associated ITPs. Table 5-21 summarizes the suitable and highly suitable habitat that will be modified through thinning or lost through regeneration harvest over the 70-year permit duration.

Effects on marbled murrelet are most likely to occur in modeled habitat in Astoria, Tillamook, Western Oregon, Western Lane, and Coos Districts and less likely to occur in Forest Grove based on species range and past survey history. No effects are expected in North Cascade or Southwest Oregon State Forests.

Table 5-21. Marbled Murrelet Habitat Projected to Be Harvested or Thinned Under the HCP Over the Permit Duration

	Habitat Thinned[a]		Habitat Harvested[b]		
Location	**Suitable**	**Highly Suitable**	**Suitable**	**Highly Suitable**	**Total**
Within HCAs	4,479	--	--	--	4,479
Outside of HCAs	380	--	101,736	388	102,504
Total	4,859	--	101,736	388	106,983

[a] Habitat thinned inside HCAs will be completed consistent with Conservation Action 7: Manage Habitat Conservation Areas.
[b] Approximately 3,300 acres of stands were projected to be harvested within HCAs over the permit term. Those stands consisted entirely of Swiss needle cast or red alder stands that were deemed non-habitat for modeling purposes.

While harvest of marbled murrelet habitat will occur over the entire 70-year permit term, approximately 50% of projected habitat modification (55,066 acres) will occur within the first 20 years of plan implementation, and approximately 90% (98,593 acres) will occur within the first 40 years. This is not due to targeting habitat early in the permit term, but rather due to the current stand age distribution. During the first 40 years of the permit term some areas outside HCAs that are not currently habitat will grow into habitat prior to harvest. Take authorization afforded by the HCP and associated ITPs will authorize that habitat modification. As the permit term progresses, past year 40, acres of habitat modified are fewer, not because less harvest is occurring, but because the age and structure of the forest outside of HCAs will have stabilized by then.

Figure 5-10 illustrates the cumulative level of marbled murrelet nesting habitat projected to be modified over the permit term.

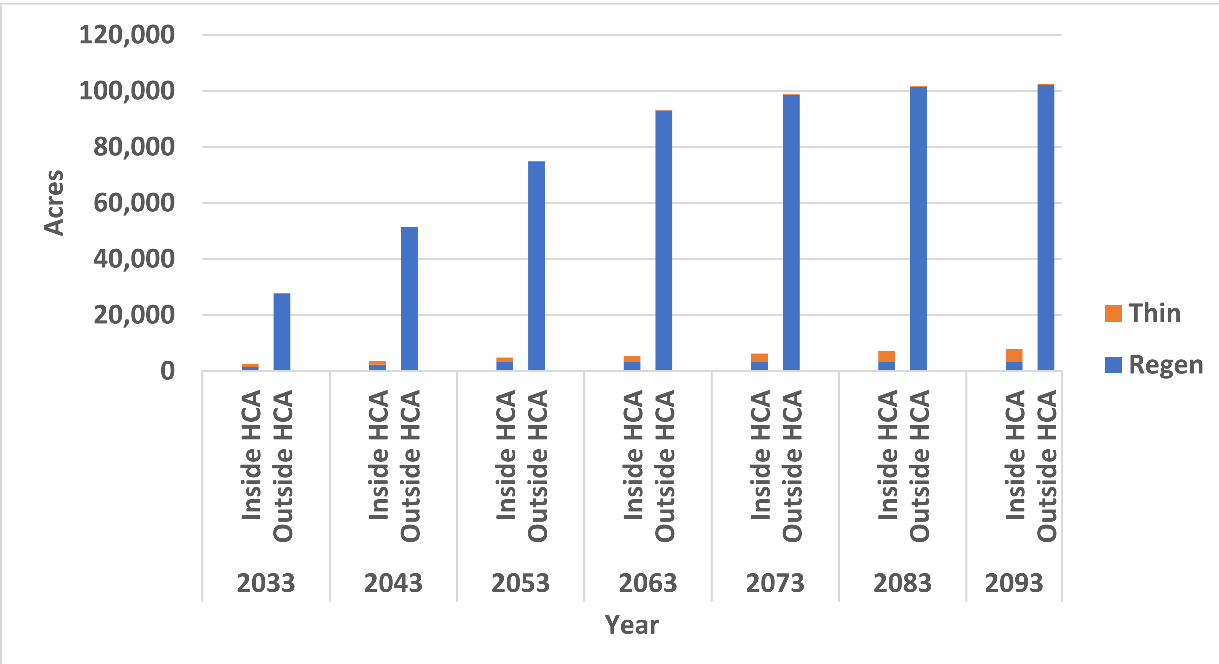


Figure 5-10. Cumulative Marbled Murrelet Suitable and Highly Suitable Habitat Projected to Be Harvested or Thinned Under the HCP Over the Permit Duration (in acres)

5.8.2.2 Marbled Murrelet Nesting Sites

Loss of nesting habitat is expected to be rare over the duration of the permit, because the majority of confirmed occupied sites are located within HCAs. Of the 363 survey detections indicating marbled murrelet occupancy in the permit area, all but 4 are included in HCAs (note that 3 of the 4 detections are from one survey location). By definition management activities in HCA will only be implemented to increase habitat quantity for marbled murrelet over the permit term, so loss of nest trees inside HCAs is not expected. It is expected that occupied stands outside of HCAs could be lost over time, likely due to a reduction in habitat quality in the stand. However, under Conservation Action 10: Operational Restrictions to Minimize Effects on Covered Species, leave tree commitments will retain platform trees and associated cover trees and harvest of potential nesting habitat will be avoided during the nesting season as long as nesting persists. Additionally, ODF has surveyed the vast majority of highly suitable marbled murrelet habitat on the permit area over the last 30 years and estimates potential loss of less than 400 acres of highly suitable habitat of unknown occupancy over the 70-year permit term. Harvest of low quality habitat of unknown occupancy status is where most habitat modification will occur and therefore the primary source of potential take outside of HCAs.

Table 5-22 summarizes the results of marbled murrelet surveys that have been conducted over the permit area over many years (see Appendix C).

Table 5-22. Marbled Murrelet Survey Results Within the Permit Area, Including Those Inside and Outside HCAs

Location	Significant[a]	% in HCA	Presence – Visual[b]	% in HCA	Presence – Audio[c]	% in HCA	Total
Inside HCA	359	99	248	84	620	87	1,227
Outside HCA	4		47		96		147
Total[d]	**363**		**295**		**716**		**1,374**

[a] "Significant" observations are assumed active nesting sites.
[b] "Presence – Visual" indicates the possibility of nesting, but birds observed may be traveling to other stands.
[c] "Presence – Audio" indicates the possibility that the surveyed stand is occupied, but calls are frequently heard far away from nesting areas, so not a strong indicator of nesting. See Evans Mack (2003) for details on survey protocol and result classification.
[d] In many cases there are multiple observations at a single survey area and sometimes in multiple years.

5.8.3 Impacts of the Taking on Marbled Murrelet

5.8.3.1 Context, Intensity, and Duration of Impacts

Take resulting from habitat loss and other adverse effects, described in Section 5.8.2, will occur within the following contexts and levels of intensity.

- Approximately 17% of existing habitat is located outside of HCAs and will be subject to harvest (approximately 19% of existing habitat rated as suitable and 3% of existing habitat rated as highly suitable). These areas include a mix of previously surveyed (with presence only or presumed absence) and unsurveyed habitat.
- One occupied marbled murrelet site (<1% of all known occupied locations) within the permit area will also be located outside of HCAs and subject to harvest, though any harvest that occurs will follow Conservation Action 10 to avoid harvest during the nesting season.

Once suitable marbled murrelet nesting habitat is harvested outside of HCAs, it is likely to be harvested again before developing back into habitat, so the effects are considered to be permanent. And if stands are not subsequently harvested, they will be unlikely to develop into habitat by the end of the permit term. However, leave tree commitments under Conservation Action 10 may result in patches of suitable nesting habitat developing over time outside of HCAs. In addition, some modification due to thinning will be temporary. All modifications within HCAs will be temporary and will be implemented consistent with the provisions in Conservation Action 7.

Habitat gains that are projected to outpace habitat losses under the HCP and associated impacts are discussed in Section 5.8.4, *Beneficial and Net Effects on Marbled Murrelet*.

5.8.3.2 Effects on Critical Habitat

USFWS has designated critical habitat for marbled murrelet on approximately 1.5 million acres in Oregon (USFWS 2016), of which 163,160 acres (11%) are within the permit area. Critical habitat has been designated by unit and subunit. Of the total marbled murrelet critical habitat designated within the permit area, 82% (133,808 acres) is within Unit OR-01, and 16% (25,607 acres) is within Unit

OR-03, both of which are located in the north Oregon Coast area. Approximately 2% (3,400 acres) is within Unit OR-02, also located in the north Oregon Coast area and less than 1% is located within in OR-04 (213 acres) and OR-07 (33 acres), located in the central and southern Oregon Coast areas, respectively.

While ODF considered marbled murrelet designated critical habitat when delineating HCAs, the two do not completely overlap. This is because ODF used actual species occurrence, existing suitable habitat, and connectivity as primary drivers for HCA delineation. In addition, approximately 63% of the land designated as critical habitat within the permit area does not currently support marbled murrelet nesting habitat as modeled in this HCP. Approximately 32% of the designated critical habitat currently meets the definition of suitable habitat, and only 6% meets the definition of highly suitable.

Of the critical habitat that is currently modeled as suitable, HCAs will include:

- 88% of designated critical habitat that meets the definition of highly suitable
- 67% of designated critical habitat that meets the definition of suitable habitat

In general, critical habitat that is located in HCAs is expected to increase in habitat value during the permit term. Management activities in HCAs will be tailored to that purpose. There may be some short-term effects to critical habitat in locations where management activities occur, but over the permit term any critical habitat inside HCAs will be higher quality than at the start of the permit term. Outside of HCAs critical habitat may be modified, particularly in locations where critical habitat is designated in suitable or highly suitable habitat. Table 5-23 summarizes the acres of critical habitat inside and outside of HCAs by habitat type, according to models developed for this HCP. A total of 10,130 acres of critical habitat meets the HCP model criteria of highly suitable habitat and 88% of those acres are inside HCAs. The 12% outside HCAs could be subject to harvest if not within the RCAs. Of the 49,477 acres of suitable habitat that is also critical habitat, 67% is in HCAs and will likely grow into highly suitable habitat during the permit term. The other 33% could be subject to harvest if outside of RCAs. The remainder of critical habitat does not currently meet minimum criteria for habitat as modeled by this HCP.

Table 5-23. Marbled Murrelet Critical Habitat and Modeled Existing Habitat Suitability (acres)

	Breakout by Habitat Suitability[a]						
Critical Habitat Unit	**Highly Suitable**	**%[b]**	**Suitable**	**%**	**Non-Habitat**	**%**	**Total**
OR-01	6,902	5	43,359	32	83,547	62	133,808
Critical Habitat within HCAs	6,233	7	29,876	35	49,671	58	85,780
Critical Habitat outside of HCAs	669	1	13,483	28	33,876	71	48,028
OR-02	129	4	722	21	2,550	75	3,400
Critical Habitat within HCAs	129	4	720	21	2,511	75	3,360
Critical Habitat outside of HCAs	--	0	2	5	38	95	40
OR-03	3,050	12	5,324	21	17,233	67	25,607
Critical Habitat within HCAs	2,584	25	3,025	29	4,846	46	10,455
Critical Habitat outside of HCAs	466	3	2,299	15	12,387	82	15,152

Critical Habitat Unit	Breakout by Habitat Suitability[a] Highly Suitable	%[b]	Suitable	%	Non-Habitat	%	Total
OR-04	46	21	66	31	101	47	213
Critical Habitat within HCAs	46	41	35	31	32	29	112
Critical Habitat outside of HCAs	0	0	32	32	69	68	101
OR-07	3	10	6	17	24	73	33
Critical Habitat within HCAs	3	10	6	17	24	73	33
Critical Habitat outside of HCAs	--	--	--	--	--	--	--
Total	10,130	6	49,477	30	103,454	63	163,061
Critical Habitat within HCA	8,866	88	32,942	67	54,573	53	96,381
Critical Habitat outside of HCA	1,135	11	15,816	32	46,370	45	63,321

[a] Habitat ratings are described in Appendix C. Ratings scored from 0 to 1, with <0.3 = Not Habitat; 0.3–0.79 = suitable; and 0.8–1.0 = highly suitable

[b] Percent of total (far right column)

5.8.4 Beneficial and Net Effects on Marbled Murrelet

Under the HCP, marbled murrelet populations will benefit from (1) protection of most existing designated occupied habitat within HCAs (Conservation Action 6*:* Establish Habitat Conservation Areas) and (2) an increased amount and quality of nesting habitat over the permit duration (Conservation Action 6 and Conservation Action 7: Manage Habitat Conservation Areas).

5.8.4.1 Potential Benefits of Habitat Conservation Areas

The conservation strategy (particularly Conservation Actions 6 and 7) is projected to result in 196,325 acres of marbled murrelet nesting habitat within HCAs at the end of the permit term, with increases in habitat quantity and quality through passive management and some active management. This represents a net projected gain of 115,420 acres of habitat within HCAs. Models also project an additional 68,400 acres of suitable marbled murrelet nesting habitat developing outside of HCAs at the end of the permit term, although these acres are projected based on forest growth and timber harvest modeling and do not represent an ODF commitment to provide habitat for marbled murrelets beyond that provided in HCAs (see Chapter 4 for specific commitments). Acres outside of HCAs will also be subject to harvest. In addition to a net increase in acreage, the conservation strategy is projected to improve habitat conditions through increased patch size and decreased exposure of existing and future nesting sites to edge effects.

Figure 5-11 shows the projected cumulative habitat harvested and total habitat projected to be present over the duration of the permit, by decade. Figure 5-12 shows the projected habitat conditions within the permit area over the 70-year permit duration.

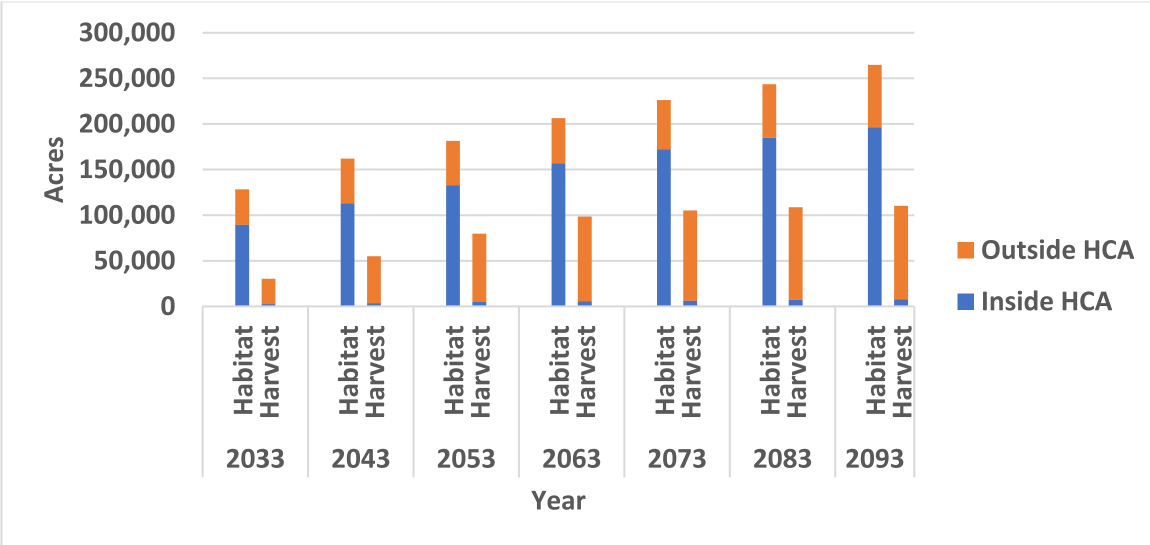


Figure 5-11. Marbled Murrelet Habitat Harvested and Estimated Habitat In Growth Over the Permit Duration, by Decade

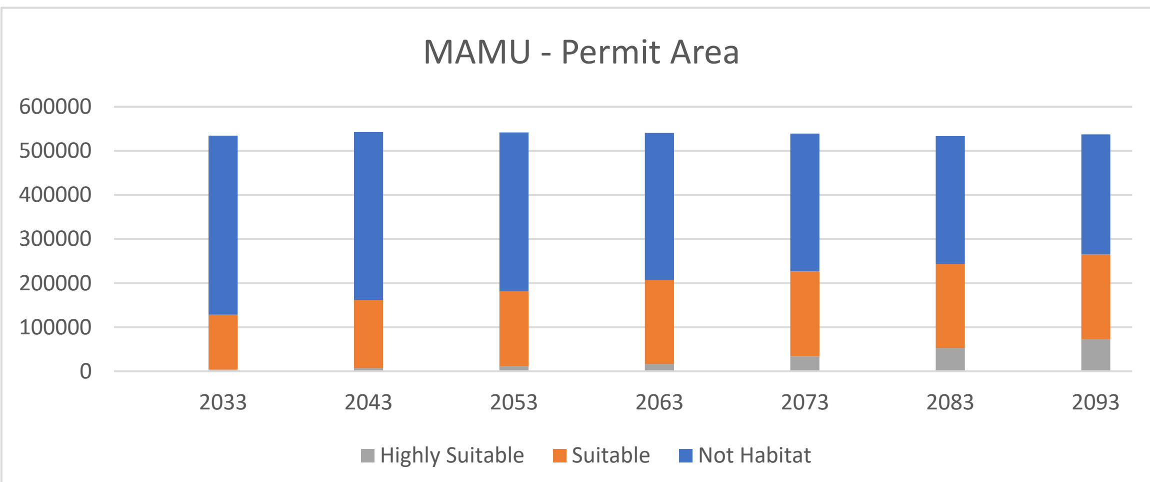


Figure 5-12. Change in Marbled Murrelet Habitat Quality Over Permit Duration, by Decade

5.8.4.2 Benefits of Monitoring and Adaptive Management Program

The monitoring program described in Chapter 6 includes ODF's commitment to document progress toward maintenance and enhancement of existing marbled murrelet habitat over the permit term. This will include reporting of acres of habitat as well as known occupied habitat over the permit area at permit issuance.

The monitoring program also includes efforts to confirm occupation status of habitat over time using a combination of bioacoustics monitoring with field verification. Monitoring surveys will be conducted in designated occupied habitat, suitable habitat, and highly suitable habitat inside and outside HCAs. Monitoring will also be focused in areas inside HCAs where habitat quality is increasing to determine species response to management activities allowing for more informed management decisions as the permit term progresses. Should monitoring results indicate that biological objectives are not being realized, then ODF will implement the adaptive management process described in Chapter 6 to rectify deficiencies.

5.8.4.3 Net Effects

As stated in Chapter 4 the conservation approach was developed in the context of a forested landscape that has been modified from historical conditions, particularly in the northwest portion of the permit area (i.e., the Tillamook and Clatsop State Forests). As a result, many forest stands are now dominated by densely spaced, young conifer and mixed deciduous forest (for additional details regarding current forest conditions, see Chapter 2), and the permit area currently contains relatively little highly suitable habitat for marbled murrelets. However, many existing forest stands are within a sufficiently mature level of development that it is capable of becoming habitat suitable for marbled murrelet nesting over the 70-year permit duration.

The conservation strategy has been developed to anticipate this increase of habitat over time and to include a significant portion of these areas to be allowed to become suitable habitat for marbled murrelets through establishment of HCAs and a moderate level of active management to maintain and enhance habitat over the permit duration.

As previously shown in Figure 5-11 and as detailed in Table 5-24, the HCP is projected to result in a net increase in suitable habitat for marbled murrelets over the permit duration, thereby fully offsetting habitat modification that is projected to occur under the terms and conditions of the HCP.

Table 5-24. Net Marbled Murrelet Modeled Habitat Projections From Start to End of Permit Term[a]

	Inside HCA			Outside HCA			Total		
	Suitable	Highly Suitable	Total	Suitable	Highly Suitable	Total	Suitable	Highly Suitable	Total
Start Habitat	78,585	2,320	80,905	52,073	73	52,146	130,658	2,393	133,051
End Habitat	133,704	62,621	196,325	58,455	9,945	68,400	192,159	72,567	264,725
Change	+55,119	+60,301	+115,420	+6,382	+9,872	+16,254	+61,500	+70,174	+131,674

[a] Habitat ratings are described in Appendix C. Ratings scored from 0 to 1, with <0.3 = Not habitat; 0.3–0.8 = Suitable, and 0.8–1.0 = Highly Suitable

Areas within designated HCAs will provide long-term protection and enhancement of marbled murrelet habitat in exchange for allowable harvest in other habitat areas outside of HCAs to maintain important economic values from ODF lands within the permit area. The amount of habitat conserved and additional habitat to be developed over time is expected to maintain and enhance marbled murrelet reproduction, numbers, and distribution within the permit area over the duration of the permit.

5.8.5 Cumulative Effects on Marbled Murrelet

Cumulative effects, as defined in this HCP, are the combined effects of future state, local, or private actions that are reasonably certain to occur in the action area, considered collectively with the effects of this HCP.

There are no future state or local land management actions that may contribute to cumulative effects that are reasonably certain to occur. On state lands, DSL is currently preparing an HCP for the Elliott State Forest that includes incidental take of marbled murrelets and northern spotted owls. As an HCP, it is required to fully offset the impacts of take and is unlikely to adversely affect marbled murrelet populations or distribution or otherwise contribute to cumulative effects. In addition, because the Elliott State Forest HCP is not yet complete, it is not considered a cumulative effect in this HCP (per the regulatory definition of cumulative effects, 50 CFR 402.02).

Effects on marbled murrelet populations and distribution from impacts on private lands have likely already generally occurred throughout western Oregon, and actions on private lands in the future will be subject to take avoidance under the federal ESA. Therefore, actions on private lands are not anticipated to contribute to cumulative effects.

Other state, local, or private future actions that are reasonably certain to occur may include road construction, recreational infrastructure development and maintenance (e.g., mountain bike trail networks), and linear rights-of-way construction (e.g., transmission lines, pipelines). ODF is not aware of any specific projects reasonably certain to occur within the Oregon Coast Recovery Unit for marbled murrelet.

5.9 Effects Analysis for Coastal Marten

5.9.1 Sources and Types of Take

All covered activities that involve tree removal or reduction in understory cover—including timber harvest, thinning, road work, quarry work, and recreational infrastructure development and maintenance—have the potential to result in two types of incidental take of coastal marten.

- Harm due to direct injury or mortality via roadkill or destroying a den with young during harvest operations.
- Harm due to habitat modification to the extent that individual coastal martens have reduced survival or reproductive success.

Because coastal marten are believed to be absent from approximately 90% of the permit area (see Appendix C), covered activities will have limited effects on behaviors, habitat use, or survival of individuals over the permit duration. Coastal marten covered area includes all ODF managed lands from the northern boundary of Lane County south to the California border and west of Interstate 5 (49,987 acres). Distribution therein is not well understood. There are extant populations in dunes areas of far western Lane and Coos Counties but none were documented inland during recent survey efforts. South of the Coquille River the inland population is better defined but there is still limited data. This HCP takes a conservative approach to assessing effects on coastal marten by generally defining the coastal marten covered area, where the species has the potential to occur. For more details see Chapter 2.

This HCP assumes that any timber harvest in this area will have adverse effects on potentially suitable habitat. This is due to limited information about how coastal martens respond to harvest and the relative density of coastal martens in suitable habitat. So, this is a conservative estimate of the amount of take that will actually occur.

5.9.1.1 Criteria and Thresholds for Determining Take

Habitat must be occupied by coastal marten to expose individuals to the effects of habitat modification. In practice this means covered activities occurring in an established home range or in areas otherwise important to dispersing individuals. Therefore, habitat modification within stands that are most likely to support coastal marten at some time over the duration of the permit has the highest potential to affect the species. The HCP uses modification of habitat inside the coastal marten covered area as a primary metric of take for coastal marten.

Table 5-25 summarizes the general sources of habitat modification and the associated thresholds used in this HCP to determine the level of take presented in Section 5.7.2, *Quantity and Timing of Take*.

Table 5-25. Criteria and Threshold for Determining Take to Coastal Marten

Covered Activities Assumed to Take Coastal Marten	Covered Activities With Beneficial, Insignificant, or Discountable Effects
• Covered activities that modify[a] a stand (e.g., regeneration harvest or thinning) with known presence, particularly a known den location, or in an known home range. • Covered activities that modify a stand in habitat in the coastal marten covered area inside or outside of HCAs.	• Habitat management activities inside of HCAs in the coastal marten covered area will have a beneficial effect on coastal marten. • Covered activities on parcels outside the coastal marten covered area will have insignificant or discountable effects.

[a] Modification is considered altered habitat structure or composition so that habitat values move from suitable to non-habitat.

5.9.1.2 Effects Pathways

The effects pathways leading to harm due to direct injury or mortality include all covered activities that will physically disturb denning habitat, including harvesting, yarding, clearing, and grading associated with timber harvest.

The effects pathway of harm due to habitat modification begins with covered activities that reduce forest structure, particularly large trees, snags, downed logs, and a dense understory of shrubs (Slauson et al. 2019a, 2019b). Regeneration harvest is assumed to have adverse effects on potentially suitable habitat. Thinning that removes important habitat features (denning structures, understory shrub cover) may have adverse effects on suitable habitat, though these effects would be shorter term if reduced canopy cover in turn promotes increased understory development while retaining potential denning structures. Acres of effect are estimated based on policy-level harvest modeling. Harvest that removes or disturbs active maternal den sites is assumed to result in “take” of individual marten. In the HCP, loss of habitat is used as a surrogate, assuming that if suitable habitat exists in a stand and it is harvested, there is the potential for den sites to be impacted.

Based on the USFWS Coastal Marten Species Status Assessment (USFWS 2018) and on the most recent habitat modeling study for coastal marten (Slauson et al. 2019b), loss of these forest structures and canopy cover may result in the following stressors to resources required by coastal marten.

- Reduce volume of large downed wood, snags, live trees with suitable cavities, and associated resting, denning, and foraging habitat.
- Reduce future recruitment of large downed wood and associated habitat.
- Reduce shrub layers and associated foraging habitat and cover from predators.
- Reduce prey densities due to loss of cover and food required by prey species (e.g., berries, truffles, seeds).
- Increase exposure to predators that use more general habitat requirements, particularly bobcat.
- Increase exposure to competitors, including bobcat, gray fox, raccoon, and western spotted skunk.
- Fragment habitat and consequently remove landscape-level habitat requirements and isolate individuals or local populations.

The behavioral response of individual coastal marten to such stressors may include avoiding disturbed areas and using a smaller area, expanding foraging into new adjacent areas, or abandoning an existing territory altogether. Using a smaller area would reduce prey intake. Expanding use or moving to a new area would expose individuals to increased predation risks and lack of food. The ultimate physical response to all these behavioral responses would likely include reduced physical fitness due to increased energy expenditure (e.g., stress, increased time spent hunting and moving) and reduced energy capture (prey). These energy costs can result in an energy deficit that translates into biological effects, including reduced reproduction and survival. Harm would occur when energy deficits result in reduced reproductive success or direct mortality of adults through starvation, exposure (heat/cold/rain), disease, or predation. Harm may also occur if habitat is fragmented, preventing movement and associated foraging and reproductive success.

The effects pathway ends with the consideration of the biological effects on individuals within the context of regional and range-wide distribution and populations, which is discussed in Section 5.9.3, *Impacts of the Taking on Coastal Marten*.

Figure 5-13 summarizes the general effects pathways identified for potential harm to coastal marten due to habitat modification.

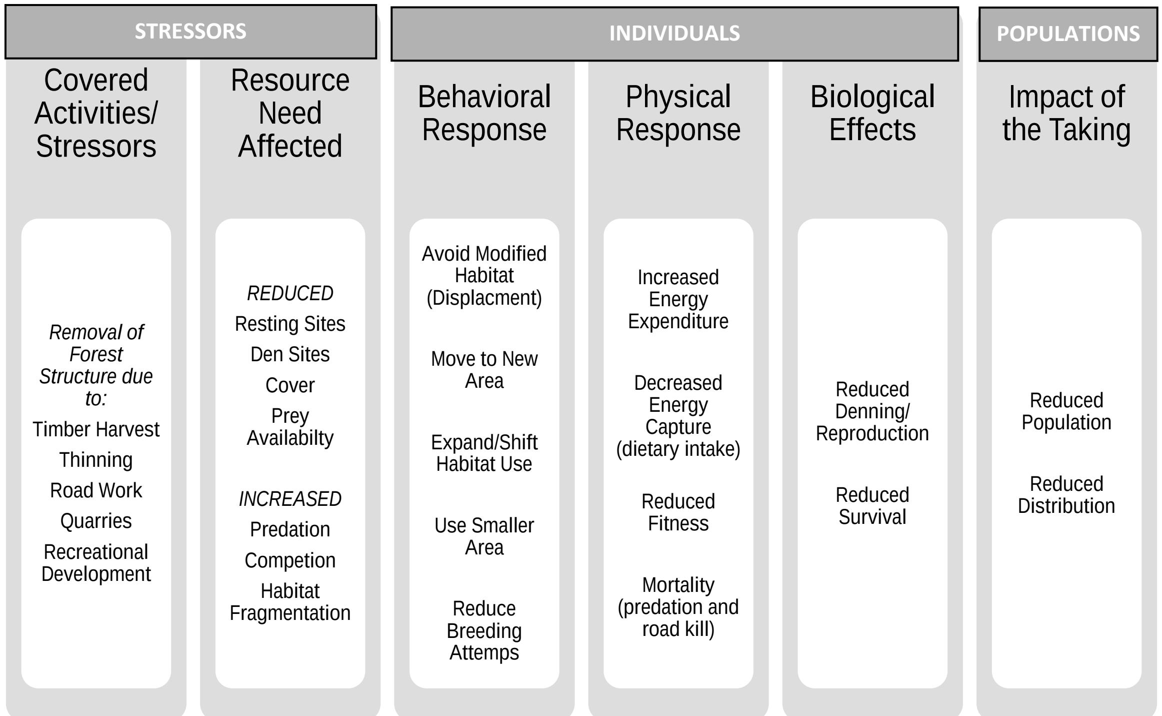


Figure 5-13. Effects Pathways for Impacts of Take of Coastal Marten via Habitat Modification

5.9.1.3 Covered Activities that May Result in Take

Any covered activity that will physically disturb habitats where coastal marten are present may rise to the level of take either through direct injury and mortality or through habitat modification and associated loss of resources needed by coastal marten for breeding, feeding, and shelter. Timber harvest, including regeneration harvest, and thinning, is the primary activity that is expected to rise to the level of take. Table 5-26 lists covered activities and associated types of take expected to occur over the duration of the permit. Details regarding the effects pathways are provided in the previous subsection.

Table 5-26. Sources and Types of Take of Coastal Marten Expected Under the Terms of the HCP

Covered Activity	Type of Take
Regeneration Harvest	Regeneration harvests and associated temporary roads, landings, yarding operations, and use of heavy equipment within suitable habitat is the primary source of take expected for coastal marten.
Thinning	As with regeneration harvest, thinning within occupied habitat could result in take via habitat modification if it results in the removal of understory cover.
Road Construction and Maintenance	New road construction within occupied or suitable habitat will reduce available habitat and could be a source of mortality.
Other Covered Activities Outside of HCAs and RCAs	Development of new quarries and recreation infrastructure as well as maintenance (e.g., campgrounds, trails, trailheads) within occupied or suitable coastal marten habitat is expected to result in take due to direct mortality or habitat modification.

5.9.1.4 When Covered Activities Are Not Expected to Cause Take

Covered activities that do not disturb suitable habitat are unlikely to cause adverse effects that rise to the level of take. Table 5-27 lists covered activities not expected to modify suitable habitat and result in take of coastal marten over the duration of the permit.

Table 5-27. Covered Activities Not Expected to Result in Take of Coastal Marten

Covered Activity	Rationale for Determining that Covered Activity Would Not Result in Take
All Covered Activities Conducted Outside of Suitable Habitat	Covered activities that do not modify suitable habitat would not result in take.
Site Preparation, Tree Planting, and Release Treatments	Reforestation and young stand management activities will take place outside of suitable habitat and are not likely to adversely affect coastal marten.
Animal Damage Control	Control of mountain beaver could reduce prey availability, but overall effect is not expected to rise to the level of take due to the infrequency of the activity. Mountain beaver control will not modify coastal marten habitat.
Precommercial Thinning and Pruning	Precommercial thinning will take place in young stands, so such effects would not be expected to rise to the level of take.
Unmanned Aircraft Systems	No effect pathways identified.
Existing Road System	Existing roads add to habitat fragmentation effects that may block movements. However, the presence of existing roads is not expected to rise to the level of take because they are considered part of the environmental baseline.
Road Maintenance	Work within the road prism would not be likely to affect coastal marten habitat.
Road Decommissioning	Road decommissioning would not adversely affect coastal marten habitat.
Drainage Structure Construction and Maintenance	Drainage work would not adversely affect coastal marten habitat.
Minor Forest-Product Harvest	Harvest of forest greens or firewood gathering would not occur at sufficient levels within suitable habitat to modify habitat suitability for coastal marten.
Water Drafting and Storage (fire management)	This activity is not likely to adversely affect coastal marten habitat.
Aquatic Habitat Restoration	Aquatic habitat restoration may result in minor habitat modification, such as select tree tipping or removal, but such effects are not likely to rise to the level of take because of the avoidance and minimization measures described in Chapter 4.
Barred Owl Management	Barred owl management would have no effect on coastal marten habitat. Prey base may increase in some areas.
Monitoring Activities	Monitoring is not likely to adversely affect coastal marten habitat or otherwise harm individuals. If needed, a scientific collectors permit would be obtained prior to work commencing.

5.9.2 Quantity and Timing of Take

Based on the boundaries of the coastal marten covered area and timber harvest and forest growth modeling expected to occur within that range, approximately 23,000 acres of the roughly 50,000 acres of suitable coastal marten habitat could be subjected to harvest outside of HCAs or RCAs over the duration of the permit. The remaining 27,000 acres is located inside HCAs or RCAs. While 27,000 acres of suitable habitat are inside HCAs, only roughly 30% of HCAs will be subject to management or harvest during the permit term, resulting in approximately 9,000 acres of harvest or thinning in HCAs over the permit term, or 500 acres/year. Not all of this habitat will be suitable at the outset of the permit (Table 5-28). Some stands will grow into habitat as time progresses and the forest develops characteristics indicative of suitable habitat, including denning structures, closed canopy condition, and robust understory cover of fruit- and mast-producing species. Habitat modification will occur inside and outside of HCAs, thought the majority of harvest will occur outside HCAs and any management activities inside HCAs will be implemented with coastal marten habitat needs as a priority. Inside of HCAs, habitat modification will only be done in situations where those short-term silvicultural actions will result in long-term increases in habitat quality while minimizing impacts to existing habitat features.

Table 5-28. Coastal Marten Habitat Potentially Subject to Harvest or Thinning in Suitable Habitat Under the HCP Over the Permit Duration (acres)

Location	Suitable Habitat	Potentially Subject to Harvest or Management
Within HCAs or RCAs	27,000	9,000 [a,b]
Outside of HCAs or RCAs	23,000	23,000[c]
Total	**50,000**	**32,000[c]**

[a] While 27,000 acres of suitable habitat are inside HCAs, only roughly 30% of HCAs will be subject to management or harvest during the permit term.

[b] Suitable habitat will be subject to thinning and rarely regeneration harvest inside HCAs. Any management or harvest will be completed consistent with the provision in Conservation Action 7: Manage Habitat Conservation Areas.

[c] Not all acres shown are likely to be harvested. Some are inoperable or otherwise not economically viable.

Harvest is expected to occur consistently over the course of the permit term. Without a habitat model linked to a timber harvest model it is not possible to determine exactly when harvest is likely to occur in the coastal marten covered area. ODF would harvest in southern Oregon State Forests, inside the coastal marten covered area every year. With the estimate of 32,000 acres harvested during the permit term, a simple assumption would be that approximately 500 acres would be harvested a year on average.

5.9.3 Impacts of the Taking on Coastal Marten

Take resulting from this habitat loss and other adverse effects, described above, will occur within the following contexts and levels of intensity:

- All areas within the range of coastal marten are considered potentially suitable habitat, with approximately 50,000 acres (8%) of the permit area defining the marten covered area.
- Approximately 54% (27,000 acres) of potentially suitable habitat within the permit area will be conserved within HCAs and RCAs.

With over 50% of current coastal marten habitat located inside HCAs or RCAs, the conservation strategy provides a habitat stronghold for the species within southwestern Oregon. Management inside HCAs will be completed with coastal marten habitat development as a priority. Outside of HCAs harvest activities will modify forest structure but largely leave intact many of the forest attributes that coastal marten rely upon, including a dense understory cover, downed wood, and snags. Any harvest activities that occur will be completed consistent with Conservation Action 8: Conservation Actions Outside Habitat Conservation Areas and Riparian Conservation Areas, which dictates retention standards for downed wood and snags. Direct effects on coastal marten den sites will be minimized by identifying those locations during monitoring, described in Chapter 6, and implementing restrictions on covered activities in locations where coastal marten dens are known, through implementation of Conservation Action 10: Operational Restrictions to Minimize Effects on Covered Species.

5.9.4 Beneficial and Net Effects on Coastal Marten

5.9.4.1 Potential Benefits of Habitat Conservation Areas

Over the course of the permit term the 54% of coastal marten habitat in the marten covered area will improve in habitat quantity and quality through passive management and some active management. The average stand age at the beginning of the permit term inside HCAs is 70–90 years (Figure 5-14). At the end of the permit term the average stand age inside HCAs is 130–150 years old (Figure 5-15). This general increase in mature forest condition will increase the habitat quantity and quality for coastal marten. Effects associated with the 46% of suitable habitat outside HCAs and RCAs, which is subject to harvest activities, will be minimized through the implementation of the monitoring program (see Chapter 6), implementation of restrictions around den site, and through implementation of retention standards outlined in Conservation Action 8.

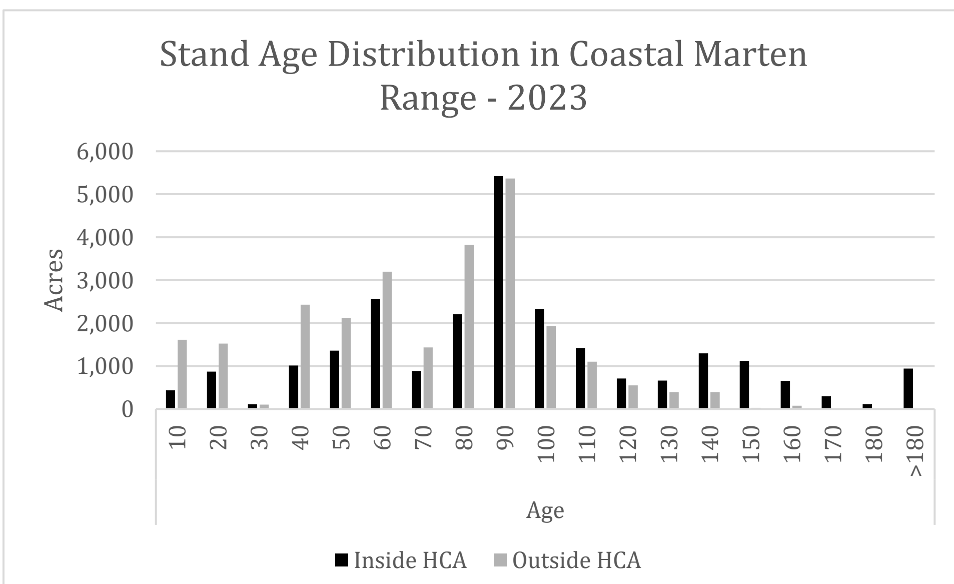


Figure 5-14. Stand Age Distribution Within Coastal Marten Range in 2023 (beginning of permit term)

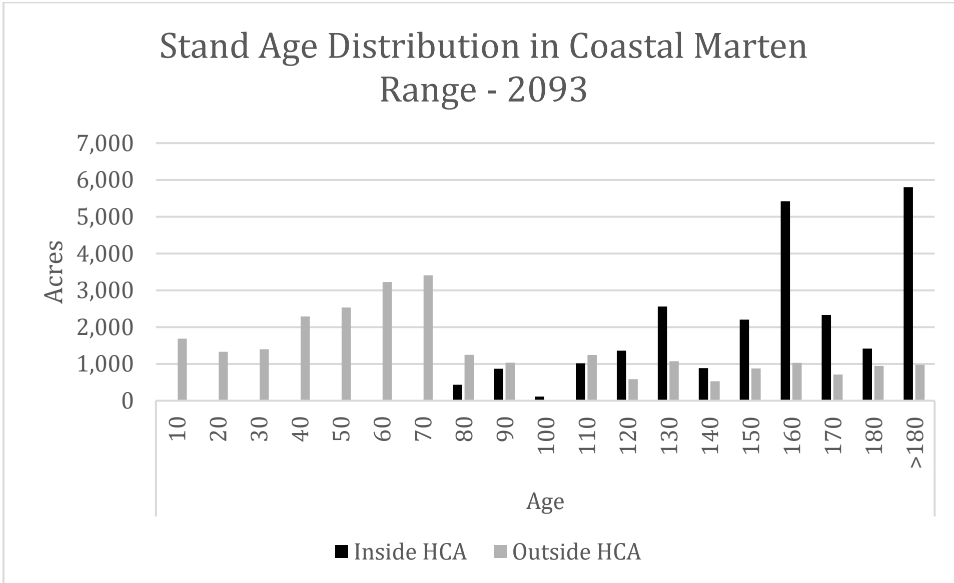


Figure 5-15. Stand Age Distribution Within Coastal Marten Range in 2093 (end of permit term)

5.9.4.2 Benefits of Monitoring and Adaptive Management

The monitoring program described in Chapter 6 includes ODF's commitment to provide technical support and financial assistance to coastal marten research and monitoring efforts in Oregon. The program will benefit coastal marten populations in Oregon in the following ways.

- Expand current understanding of the distribution and interactions of existing marten populations.
- Protect known breeding marten and their offspring (including protecting occupied den sites, minimizing activities that may disturb the marten using those den sites, and prohibiting trapping within 2.5 miles of known den site).
- Improve current understanding of marten response to vegetation management activities.
- Aid in acquiring more accurate estimates of marten densities.
- Examine carnivore populations in and between occupied areas.
- Facilitate future translocation and monitoring of marten in portions of the permit area where they no longer exist.
- Facilitate the cooperation and collaboration among land managers and federal and state wildlife agencies in furthering marten conservation in western Oregon.

ODF will also participate in the Oregon Forest Carnivore Working Group and related USFWS-led Marten Stakeholder Meetings and seek opportunities to collaborate in research and monitoring efforts related to marten to provide information needed by forest managers and conservation biologists to determine effective strategies and techniques for coastal marten conservation.

Also, as described in Chapter 6, adaptive management will allow for mutually agreed-upon changes to conservation commitments in response to changing conditions or new information, where those changes will avoid or minimize effects and provide a conservation benefit for marten. Adaptive management changes will occur in response to biological information indicating that the conservation commitments are ineffective at meeting the stated goals of the HCP. Examples include if best available scientific data reveal that: (1) protection measures for denning female marten may be inadequate to minimize or avoid take; or (2) retention strategies for trees, snags, and downed wood are inadequate or could be improved with modifications or additions (e.g., slash piles). Should the USFWS or other ODF cooperators desire to implement adaptive management research to determine the characteristics (location, aspect, size, structure, grouping) of slash piles used for denning by martens, ODF will cooperate in managing its planned timber harvests to leave unburned slash piles for monitoring and controlled research on active management of slash to create habitat elements useful to marten.

5.9.4.3 Net Effects

Implementation of the HCP is projected to result in a net increase in suitable habitat for coastal marten over the permit duration, thereby fully offsetting habitat modification that is projected to occur under the terms and conditions of the HCP. With 54% of the current coastal marten range inside HCAs or RCAs, the majority of coastal marten habitat in the permit area will develop into higher quality habitat through the permit term. These areas within designated HCAs will provide long-term protection and enhancement of coastal marten habitat as well as broad landscape connectivity and dispersal habitat in exchange for allowable harvest in other habitat areas outside of HCAs to maintain important economic values from ODF lands within the permit area. The amount of habitat conserved and additional habitat to be developed over time is expected to maintain and enhance coastal marten reproduction, numbers, and distribution within the permit area.

5.9.5 Cumulative Effects on Coastal Marten

Cumulative effects, as defined in this HCP, are the combined effects of future state, local, or private actions that are reasonably certain to occur in the action area, considered collectively with the effects of this HCP. There are no future state or local actions that may contribute to cumulative effects that are reasonably certain to occur. On state lands, DSL is currently preparing an HCP for the Elliott State Forest, but coastal marten are currently not proposed to be covered under that plan. Because the Elliott State Forest HCP is not yet complete, it is not considered a cumulative effect in this HCP (per the regulatory definition of cumulative effects, 50 CFR 402.02).

Effects on coastal marten populations and distribution from impacts on private lands have likely already occurred throughout the historic range of coastal marten. Therefore, actions on private lands are not anticipated to contribute to cumulative effects.

Other state, local, or private future actions that are reasonably certain to occur may include road construction, recreational infrastructure development and maintenance (e.g., mountain bike trail networks), and linear rights-of-way construction (e.g., transmission lines, pipelines). ODF is not aware of any specific projects reasonably certain to occur within the range of the coastal marten.

5.10 Effects Analysis for Red Tree Vole, North Oregon Coast Distinct Population Segment

5.10.1 Sources and Types of Take on Red Tree Vole

All covered activities that involve tree removal—including timber harvest, thinning, road work, quarry work, and recreational infrastructure development and maintenance—have the potential to result in the following types of incidental take of red tree vole.

- Harm due to direct injury or mortality, such as inadvertently killing individuals during harvest operations.
- Harm due to habitat modification to the extent that red tree voles have reduced survival or reproductive success.

The following sections describe the thresholds for determining when such take will occur, the effects pathways leading to take, and the specific covered activities expected to result in take, as well as those covered activities not expected to result in take.

5.10.1.1 Criteria and Thresholds for Determining Take

Habitat must be occupied by red tree voles to expose individuals to the effects of habitat modification. Therefore, habitat modification within known occupied stands or stands that are modeled as suitable or highly suitable are most likely to result in take, as these are places that are mostly likely to support red tree voles. Therefore, the HCP uses modification of suitable and highly suitable habitat as a primary metric of take for red tree voles.

Table 5-29 summarizes the general sources of habitat modification and the associated thresholds used in this HCP to determine the level of take presented in Section 5.7.2, *Quantity and Timing of Take*.

Table 5-29. Criteria and Thresholds for Determining Potentially Adverse Effects on Red Tree Voles

Covered Activities with Potential to Effect	Covered Activities With Beneficial, Insignificant, or Discountable Effects
• Covered activities that modify[a] a stand (e.g., regeneration harvest or thinning) with known presence • Covered activities that modify *suitable* or *highly suitable* habitat. • Covered activities within occupied stands, including younger forests.	• Covered activities in unoccupied stands modeled as *marginal* habitat or as *non-habitat*.

[a] Modification is considered altered habitat structure or composition so that habitat values move from highly suitable or suitable to marginal or non-habitat.

5.10.1.2 Effects Pathways

The effects pathways leading to harm due to direct injury or mortality include all covered activities that will involve felling trees occupied by red tree voles, including timber harvest, thinning, road work, quarry work, and recreational infrastructure development and maintenance.

Because red tree voles spend nearly their entire lives within tree canopies, individuals will not likely be able to flee tree felling operations and will fall with the tree, either being directly injured or killed or forced to flee and find new habitat. If surviving, individuals would be subject to stress, increased energy expenditure, decreased food intake, and risk of mortality due to predation and starvation. The cost of relocation may be reduced reproduction effort and success due to increased energy costs or potentially lower suitable habitat.

The effects pathway ends with the consideration of the biological effects on individuals within the context of regional and range-wide distribution and populations, which is discussed in Section 5.10.3, *Impacts of the Taking on Red Tree Vole*.

Figure 5-16 summarizes the general effects pathways identified for potential harm to red tree voles due to habitat modification.

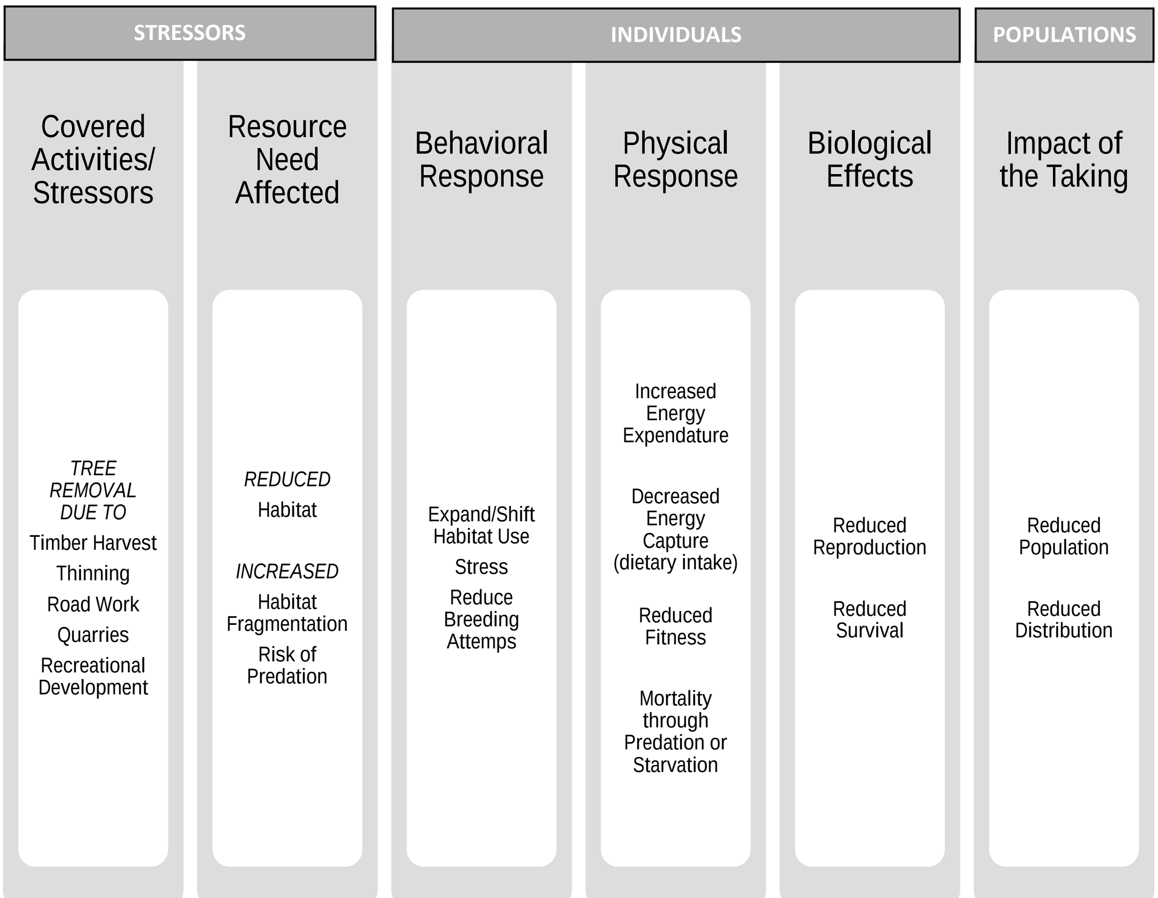


Figure 5-16. Effects Pathways for Impacts of Take of Red Tree Vole via Habitat Modification

5.10.1.3 Covered Activities that May Result in Take

Any covered activity that will remove trees where red tree voles are present may rise to the level of take either through direct injury and mortality or through habitat modification and associated loss of resources needed by red tree voles for breeding, feeding, and shelter. These activities include timber harvest (regeneration and thinning), road construction, quarry work, and recreation infrastructure development and maintenance (e.g., campgrounds, trails, trailheads).

Timber harvest, including regeneration harvest and thinning, is the primary activity that is expected to rise to the level of take. Table 5-30 lists covered activities and associated types of take expected to occur over the duration of the permit. Details regarding the effects pathways are provided in the previous subsection.

Table 5-30. Sources and Types of Take of Red Tree Vole Expected Under the Terms of the HCP

Covered Activity	Type of Take
Regeneration Harvest	Regeneration harvests and associated temporary roads, landings, yarding operations, and use of heavy equipment within suitable habitat is the primary source of take expected for red tree vole.
Thinning	As with regeneration harvest, thinning within occupied habitat could result in direct mortality or reduced habitat suitability.
Road Construction and Maintenance	New road construction within occupied suitable habitat will reduce habitat as well as fragment habitat and isolate individuals.
Road Management	Hazard tree removal and any other tree removal required for road maintenance can remove trees used by red tree vole.
Other Covered Activities Outside of HCAs and RCAs	Development of new quarries and recreation infrastructure as well as maintenance (e.g., campgrounds, trails, trailheads) within occupied red tree vole habitat is expected to result in take due to direct mortality or habitat modification.

Other covered activities outside of HCAs and RCAs including development of new quarries and recreation infrastructure as well as maintenance (e.g., campgrounds, trails, trailheads) within occupied red tree vole habitat has the potential to result in take due to direct mortality or habitat modification.

5.10.1.4 When Covered Activities Are Not Expected to Cause Take

Covered activities that do not remove trees within modeled suitable habitat are unlikely to cause adverse effects that rise to the level of take. Table 5-31 lists the covered activities not expected to result in take of red tree voles.

Table 5-31. Covered Activities Not Expected to Result in Take of Red Tree Voles

Covered Activity	Rationale for Determining that Covered Activity Would Not Result in Take
All Covered Activities Conducted Outside of Suitable and Highly Suitable or Activities in Unoccupied Habitat	Covered activities that do not modify suitable or highly suitable habitat or that are otherwise unoccupied by red tree voles would not result in take.
Site Preparation, Tree Planting, and Release Treatments	Reforestation and young stand management activities will take place outside of suitable habitat and are not likely to adversely affect red tree voles.
Animal Damage Control	Control of mountain beaver will not have any effect on red tree voles because habitat would not be disturbed.
Precommercial Thinning and Pruning	Precommercial thinning occurs in young stands (generally less than 30 years old). If these stands are not adjacent to suitable or highly suitable habitat take is not likely to occur.
Unmanned Aircraft Systems	Not effect pathways identified.

Covered Activity	Rationale for Determining that Covered Activity Would Not Result in Take
Existing Road System	Existing roads add to habitat fragmentation effects that may block movements. However, the presence of existing roads is not expected to rise to the level of take because they are considered part of the environmental baseline.
Road Use	Road use, including administrative, haul traffic, and recreational/public vehicle use, is not likely to affect red tree voles because they spend their entire lives within trees.
Road Maintenance	Work within the road prism would not be likely to affect red tree vole habitat.
Road Decommissioning	Road decommissioning would not adversely affect red tree vole habitat and may provide benefits at some point in the future.
Drainage Structure Construction and Maintenance	Drainage work would not adversely affect red tree vole habitat
Controlled Burning	Controlled burning will not take place within suitable red tree vole habitat.
Minor Forest-Product Harvest	Harvest of forest greens or firewood collection would have no effect on red tree vole habitat.
Water Drafting and Storage (fire management)	This activity is not likely to adversely affect red tree vole habitat.
Aquatic Habitat Restoration	Aquatic habitat restoration may result in minor habitat modification, such as select tree tipping or removal, but such effects are not likely to rise to the level of take because of the avoidance and minimization measures described in Chapter 4.
Barred Owl Management	Barred owl management would have no effect on red tree vole habitat. Predation levels may be reduced.
Monitoring Activities	Monitoring is generally not expected to result in take. If any monitoring activity is determined to likely result in take (e.g., tree climbing activities during the breeding season), then ODF will obtain necessary clearance with the USFWS (or the research organization will, if a different entity).

5.10.2 Quantity and Timing of Take

Based on timber harvest and forest growth modeling, approximately 85,900 acres of suitable and highly suitable red tree vole habitat will be harvested over the duration of the permit. As with the other terrestrial species, not all of this habitat will be suitable at the outset of the permit. Some stands will grow into habitat as time progresses and the forest develops characteristics indicative of suitable or highly suitable habitat. Habitat modification will occur inside and outside of HCAs.

Inside of HCAs, habitat modification will only be done in situations where those short-term silvicultural actions will result in long-term increases in habitat quality and will avoid known nest trees. Under those circumstances it is unlikely, but still possible, for there to be a loss or reduction in suitability of suitable or highly suitable habitat. No highly suitable habitat is anticipated to be regeneration harvested or thinned within HCAs (see Conservation Action 7: Manage Habitat Conservation Areas).

Outside of HCAs, suitable and highly suitable habitat will be harvested or thinned for commercial forestry production consistent with provisions in Conservation Action 10: Operational Restrictions to Minimize Effects on Covered Species. Table 5-32 summarizes the suitable and highly suitable habitat that will be modified through thinning or lost through regeneration harvest over the 70-year permit duration.

Table 5-32. Red Tree Vole Habit Projected to Be Harvested or Thinned Under the HCP Over the Permit Duration

	Habitat Thinned		Habitat Harvested		
Location	**Highly Suitable**	**Suitable**	**Highly Suitable**	**Suitable**	**Total**
Within HCAs	--	2,726[a]	--	--	**2,726**
Outside of HCAs	--	341	4,361	83,022	**87,724**
Total	**--**	**3,067**	**4,361**	**83,022**	**90,450**

[a] 45,000 acres of thinning in healthy conifer stands are proposed in HCAs over the permit term (Conservation Action 7). Much of that is likely to occur in young stands on the North Coast, within the range of red tree voles. Occupancy of young stands by red tree voles is not well understood, but these thinning activities could result in take. Habitat thinned inside HCAs will be completed consistent with Conservation Action 7.

[b] Approximately 2,900 acres of stands were projected to be harvested within HCAs over the permit term. Those stands consisted entirely of Swiss needle cast or red alder stands that were deemed non-habitat for modeling purposes.

While harvest of red tree vole habitat will occur over the entire 70-year permit term, about half of projected habitat modification (48,836 acres) will occur within the first 20 years of plan implementation and approximately 90% (84,848 acres) will occur within the first 40 years. This is not due to targeting habitat early in the permit term, but rather due to the current stand age distribution. As the permit term progresses, past year 40, acres of habitat modified are fewer, not because less harvest is occurring, but because the age and structure of the forest outside of HCAs will have stabilized by then and will no longer be developing into habitat.

Figure 5-17 illustrates the cumulative level of red tree vole habitat projected to be modified over the permit term.

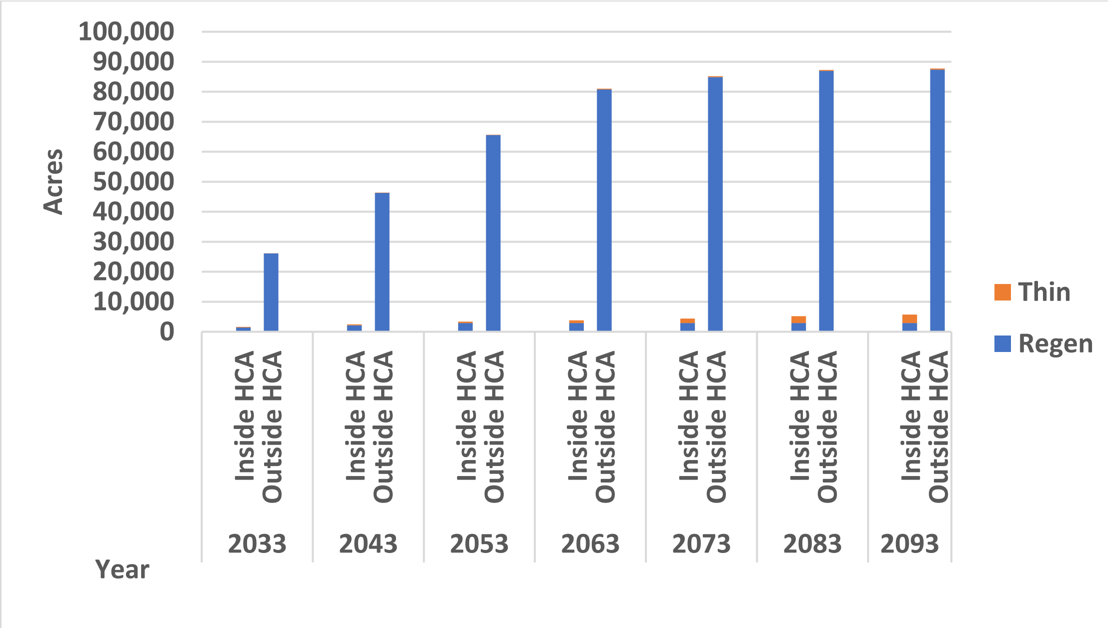


Figure 5-17. Cumulative Red Tree Vole Suitable and Highly Suitable Habitat Projected to Be Harvested or Thinned Under the HCP Over the Permit Duration (in acres)

5.10.3 Effects on Critical Habitat

No critical habitat has been designated for red tree vole.

5.10.4 Impacts of the Taking on Red Tree Vole

Take resulting from this habitat loss and other adverse effects, described above, will occur within the following contexts and levels of intensity.

- Approximately 40% of existing habitat is located outside of HCAs and will be subject to harvest.
- Habitats outside of HCAs that will be harvested are suitable habitat (rather than highly suitable) and are located in smaller and more fragmented habitat patches than habitat to be conserved in HCAs.
- Through implementation of the HCP monitoring program and restrictions on covered activities described in Conservation Action 10, take of active red tree vole nest trees will be minimized.

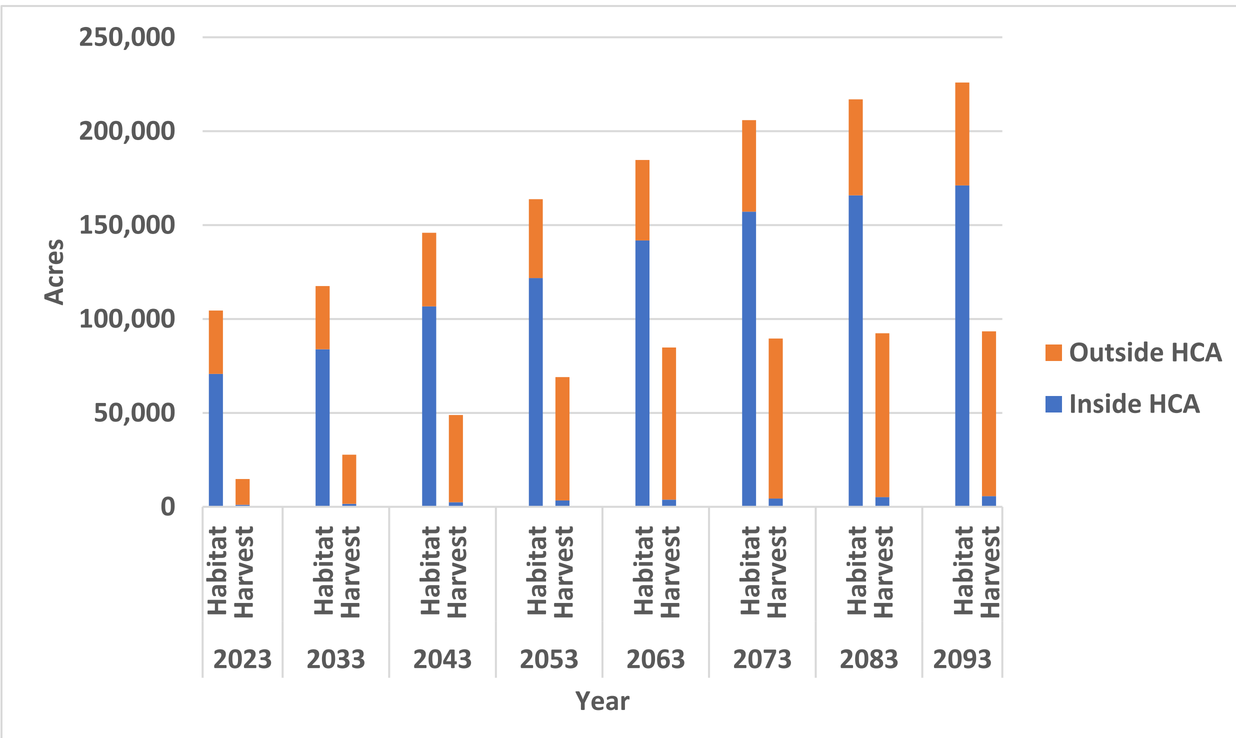
Once suitable red tree vole is harvested outside of HCAs, it is likely to be harvested again before developing back into high quality habitat, so the effects are considered to be permanent, although red tree voles will likely recolonize some younger stands. All modifications within HCAs will be temporary, although development of desired suitable habitat characteristics may not be achieved in all stands within HCAs by the end of the permit term.

Habitat gains that are projected to outpace habitat losses under the HCP and associated net impacts are discussed in the following section.

5.10.5 Beneficial and Net Effects on Red Tree Vole

As described previously, timber harvest models project that 85,900 acres of suitable red tree vole habitat will be harvested over the 70-year permit term and 3,067 acres will be modified through thinning. The conservation strategy (Conservation Action 6: Establish Habitat Conservation Areas and Conservation Action 7: Manage Habitat Conservation Areas) is projected to result in habitat development outpacing this loss, increasing over time to a total of 171,072 acres of suitable/highly suitable habitat projected for red tree vole within strategically located HCAs by the end of the permit term, an increase of 51,733 acres over the existing 119,339 acres of habitat distributed throughout the permit area. Models also project additional suitable habitat developing outside of HCAs by the end of the permit term. Shows projected habitat and cumulative harvest at each decade, Projected habitat levels presented in this chapter are not HCP commitments, but rather are projections ODF is using to estimate the level of take and to determine appropriate avoidance, minimization, and mitigation measures needed to offset that projected level of take.

Figure 5-18 shows the cumulative habitat harvested and habitat present over the duration of the permit, in 10-year increments. Figure 5-19 shows changes in habitat quality over time. Table 5-33 details the net habitat changes (habitat grown minus habitat harvested or thinned) projected to occur within the permit area over the 70-year permit term.



Shows projected habitat and cumulative harvest at each decade, Projected habitat levels presented in this chapter are not HCP commitments, but rather are projections ODF is using to estimate the level of take and to determine appropriate avoidance, minimization, and mitigation measures needed to offset that projected level of take.

Figure 5-18. Red Tree Vole Habitat Harvested and Estimated Habitat In Growth, by Decade

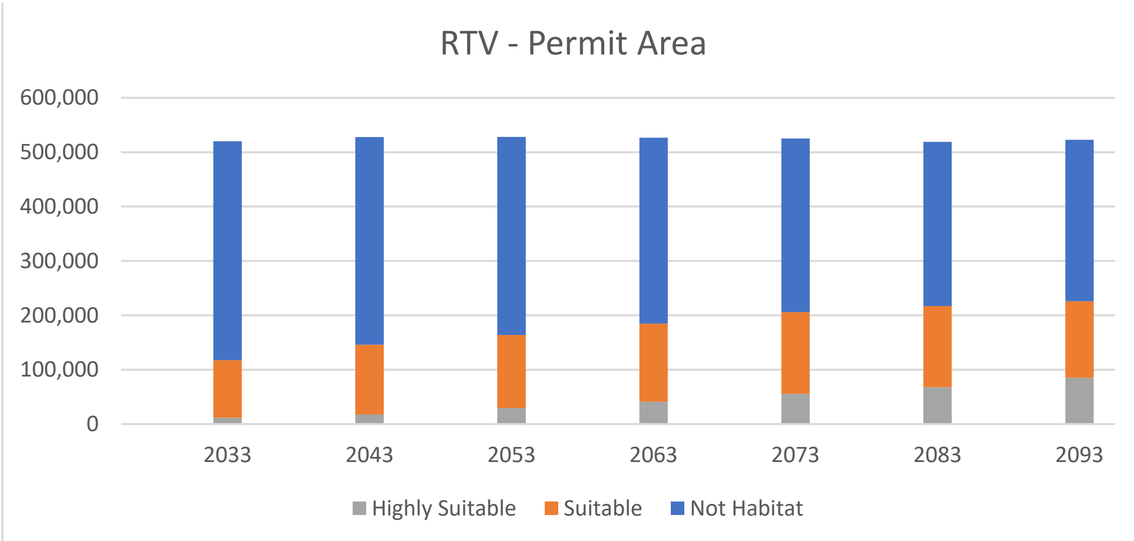


Figure 5-19. Change in Red Tree Vole Habitat Quality Over Permit Duration, by Decade

Table 5-33. Net Red Tree Vole Modeled Habitat Projections From Start to End of Permit Term[a]

	Inside HCA			Outside HCA			Total		
	Suitable	Highly Suitable	Total	Suitable	Highly Suitable	Total	Suitable	Highly Suitable	Total
Start Habitat	61,191	10,664	71,855	46,057	1,427	47,484	107,248	12,090	119,339
End Habitat	97,556	73,517	171,072	43,193	11,653	54,846	140,749	85,169	225,918
Change	+36,364	+62,853	+99,217	-2,864	+10,226	+7,362	+33,501	+73,079	+106,580

[a] Habitat ratings are described in Appendix C. Ratings for red tree vole scored from 0 to 1, with <0.4 = Not habitat; 0.4–0.8 = Suitable, and 0.8–1.0 = Highly Suitable. Note that red tree voles use of young stands are not captured in this modeling.

In addition to habitat gains, the HCP monitoring program described in Chapter 6 includes ODF's commitment to provide technical support and financial assistance to red tree vole research and monitoring efforts in Oregon. The program will benefit red tree vole populations in Oregon in the following ways.

- Expand current understanding of the distribution and habitat associations of red tree voles in western Oregon.
- Improve current understanding of red tree vole population response to vegetation management activities.
- Aid in acquiring more accurate estimates of red tree vole densities.
- Facilitate future translocation and monitoring of red tree voles in portions of the permit area where they no longer exist.

- Facilitate the cooperation and collaboration among land managers and federal and state wildlife agencies in furthering red tree vole conservation in western Oregon.

5.10.6 Cumulative Effects on Red Tree Vole

Effects on late-seral red tree vole habitat on private lands have likely already occurred throughout the range of the species, and actions in the future will similarly continue to suppress growth into late-seral habitat. Therefore, actions on private lands are not anticipated to contribute to cumulative effects in late-seral habitat for red tree vole. Red tree voles also use young stands and the extent to which this occurs and the role that young stands play in the life history of the species is not yet fully understood. Forest management on private lands that occur in younger stands do have the potential to result in effects on red tree vole throughout the range of the species.

Other state, local, or private future actions that are reasonably certain to occur may include road construction, recreational infrastructure development and maintenance (e.g., mountain bike trail networks), and linear rights-of-way construction (e.g., transmission lines, pipelines). But ODF is not aware of any specific projects reasonably certain to occur within the range of red tree vole in Oregon.

Chapter 6
Monitoring and Adaptive Management

6.1 Monitoring and Adaptive Management Program

This chapter describes the monitoring and adaptive management framework for the Western Oregon State Forests Habitat Conservation Plan (HCP). The framework includes guidelines and recommendations that will help the Oregon Department of Forestry (ODF) develop a detailed program during the initial years of implementation. The purposes of this framework and the final monitoring program are to ensure compliance with the HCP, to assess the response of covered species habitat condition to conservation actions, and to evaluate the effects of management actions such that the successful implementation of the conservation strategy described in Chapter 4, *Conservation Strategy*, including the biological goals and objectives, can be assessed.

Monitoring and adaptive management are integrated processes, and monitoring will inform changes in management actions to continually improve outcomes for covered species. An overview of the program, monitoring and management actions, and data and reporting requirements are found below.

It is beyond the scope of this HCP to develop a comprehensive program at this time. Rather, the goal of this chapter is to provide sufficient guidance to ensure that the program designed during implementation will meet Endangered Species Act (ESA) regulatory standards discussed in Section 6.2, *Regulatory Context*. It is also true that the monitoring program and priorities will change as the permit term progresses. ODF will be continually evaluating the monitoring program to ensure that the latest accepted techniques and technologies are used and that monitoring provides information necessary to determine whether they are in compliance and if the HCP is being effective at meeting the biological goals and objectives.

The monitoring framework provided in this chapter will be operationalized by ODF as part of each 10-year Implementation Planning cycle, during which ODF will assess monitoring priorities, using this framework as a guide. The adaptive management program is also generally aligned with these 10-year Implementation Planning cycles. Covered activities, conservation actions, and monitoring activities will be assessed during 10-year Comprehensive Reviews, to ensure that any adjustments that need to be made, for the subsequent decade, are integrated into the associated Implementation Plan.

6.2 Regulatory Context

An HCP must provide for the establishment of a monitoring program that generates information necessary to assess compliance and verify progress toward achieving the biological goals and objectives of the HCP (50 Code of Federal Regulations [CFR] 17.22(b)(2)(A-F), 50 CFR 17.32(b)(2)(i-iii), and 50 CFR 222.307(b)(5)). Adaptive management programs are generally recommended for large, programmatic plans and those with data gaps and scientific uncertainty that could affect how species are managed and monitored in the future. The *Habitat Conservation Planning and Incidental Take Permit Processing Handbook* (HCP Handbook) (USFWS and NOAA

Fisheries 2016) describes adaptive management as a method for addressing uncertainty in natural resource management and states that management must be linked to measurable biological goals and monitoring.

6.3 Types of Monitoring

Guidance for conservation planning defines monitoring as the "systematic and usually repetitive collection of information typically used to track the status of a variable or system" (Atkinson et al. 2004). ODF will monitor and report trends in quantity and quality of habitat for covered species over time within the permit area. ODF will conduct compliance monitoring to ensure adherence to HCP implementation and management standards, and effectiveness monitoring to determine if conservation actions are having the intended effect on habitat conditions for covered species in the permit area. Habitat metrics will be used to determine if ODF is meeting the biological goals and objectives of the HCP. For species with well-established habitat relationships, monitoring will focus primarily on habitat condition over time. For species whose range of habitat conditions, or response to changes in those conditions, is not well understood ODF will conduct species and habitat monitoring to better understand those relationships and more reliably report on progress towards the biological goals and objectives. A description of these monitoring types is provided below. Reporting requirements are described in Chapter 8, Section 8.6, *Reporting*.

6.3.1 Compliance Monitoring

Compliance monitoring (also known as implementation monitoring) tracks the status of HCP implementation and documents that the requirements of the HCP are being met. Compliance monitoring verifies that ODF is carrying out the terms of the HCP and ITPs. ODF will track compliance internally to ensure the HCP is working as planned and will provide the monitoring results to the U.S. Fish and Wildlife Service (USFWS) and National Oceanic and Atmospheric Administration (NOAA) Fisheries, who will verify the HCP remains in compliance. As defined by the HCP, compliance monitoring will occur yearly and track the following components:

- Design of a comprehensive monitoring and adaptive management strategy during first five years of implementation.
- Location, extent, and timing of loss of covered species habitats to ensure that habitat loss from covered activities is appropriately balanced with increases in the quantity and quality of habitat from growth and habitat enhancement activities.
- Habitat management, including the details of silvicultural activities used in Habitat Conservation Areas (HCAs).
- Restoration activities in upland and aquatic locations, including the type of project, and species expected to benefit.
- Implementation of Riparian Conservation Areas (RCAs) on timber sales.
- Implementation of conservation actions, including those that involve avoidance and minimization requirements.
- Reporting of management actions and monitoring activities (e.g., the extent and type of monitoring completed).

- Location, extent, and timing of implementation of conservation actions (e.g., barred owl management).
- Tracking expenditures from the Conservation Fund, in total, and split out by aquatic species expenditures and terrestrial species expenditures.

Reporting requirements related to compliance monitoring are described in Section 8.6.

6.3.2 Effectiveness Monitoring

Effectiveness monitoring assesses the biological success of the HCP and evaluates whether the effects of implementing the conservation strategy described in Chapter 4 is consistent with the assumptions and predictions made during its development (USFWS and NOAA Fisheries 2016). Effectiveness monitoring assesses whether implementation of the conservation strategy is achieving the HCP's biological goals and objectives. Effectiveness monitoring typically measures the effects of management actions on covered species, status and trends in resources (e.g., change in forest age or species habitat quality), and status and trends of stressors to the biological resources (e.g., changes in water temperature) (Atkinson et al. 2004).

To conduct effectiveness monitoring, it is necessary to first develop thresholds of success for management actions. These may include quantitative measures such as area of habitat suitable for covered species. Quantifying these conditions before and after management is the basis for judging success. In most cases, success will not be immediately apparent, and monitoring must be conducted over a sufficient period for results to manifest. The ultimate measure of success for the HCP is achievement of the biological objectives. Therefore, effectiveness monitoring should be designed to address each biological objective and allow ODF to determine whether progress is being made towards achieving those objectives. More specific, and shorter-term metrics can be included in monitoring plans that are developed during each 10-year Implementation Planning cycle.

6.4 Compliance Monitoring

6.4.1 Compliance Monitoring of Covered Activities

Contract administrative reporting is associated with all harvest units. During the course of the contract, and at the close of a contract, ODF staff monitors all activities performed by operators to ensure that they are complaint with the contract requirements, which reflect the Covered Activities and Conservation Measures of the HCP. Specific instances where Best Management Practices (BMPs) or Management Direction cannot be implemented will be described, along with actions taken to minimize effects from the departures. Data from the contract administration reports will be used by ODF during compliance monitoring and will be incorporated into the annual report. Below is a checklist of items that will be tracked for each type of covered activity. During implementation additional items may need to be tracked in order to report more accurately on compliance. This list is meant to be an example of the types of information that will need to be monitored and included in the annual report.

6.4.1.1 Recreation Facilities

The following items will be tracked for the development of recreation facilities and reported annually.

- Location and size of new recreation infrastructure, including buildings, campgrounds, boat ramps, or other non-trail facilities, including whether they are inside or outside of HCAs and RCAs.
- Locations of new and ongoing trash management sites.
- Miles of new trail constructed and vacated, by trail type, including whether they are inside or outside of HCAs and RCAs.
- Number of new stream crossings by trails, including location, stream type, and crossing type.
- Acres of species habitat lost to all recreational facilities.

6.4.1.2 Timber Harvest Activities

For harvest activities, the timber sale close-out process will be the primary tool used to demonstrate compliance with the HCP and permits. Following a timber harvest, during sale close-out, ODF will confirm items on the following checklist:

- Acres managed or harvested, harvest type, and location.
- Any activities that occurred in RCAs, consistent with exceptions described in Chapter 5, *Effects Analysis and Level of Take.*
- Acres in terrestrial species habitat, by harvest type or management prescription.
- Confirmation that stream crossings are consistent with provisions in Chapter 5. For new crossing or rehabilitated crossings, confirm stream type and type of crossing used.
- Confirmation that RCA restrictions (buffers, equipment, etc.) were implemented consistent with the HCP and permits.
- Confirmation that stand management activities in HCAs were implemented consistent with Conservation Action 7: Manage Habitat Conservation Areas.
- Confirmation that retention standards described in Conservation Action 8: Conservation Actions Outside Habitat Conservation Areas and Riparian Conservation Areas, were implemented.
- Confirmation that operations were implemented consistent with Conservation Action 10: Operational Restrictions to Minimize Effects on Covered Species.

6.4.1.3 Road Construction, Improvement, Maintenance, and Vacating Activities

Road related activities will be tracked in the annual report. Most of these items will also be tracked as part of timber sale administration and close out. Items to be reported include:

- New stream crossing features by type and location.
- Miles of road constructed, including location within or outside of RCAs and HCAs.
- Miles of road vacated, including location within or outside of RCAs and HCAs.

- Miles of road improved to eliminate or reduce hydrological connections to streams.
- Surface conditions of road segments with hydrologic connections to streams. Roads closed by ODF districts due to wet weather that could result in sediment delivery to Waters of the United States.[1]
- Acres disturbed in the Equipment Restriction Zone that experienced soil disturbing operations during road construction and harvest activities.
- Results of turbidity monitoring.
- Confirmation that road construction standards described in Conservation Action 11: Road and Trail Construction and Management Measures, were implemented.

6.4.2 Compliance Monitoring of Conservation Actions

6.4.2.1 Aquatic Conservation Actions

Monitoring the implementation of aquatic conservation actions will involve tracking both expenditures on aquatic conservation actions and the actions themselves. The Conservation Fund, described in Chapter 9, *Costs and Funding,* is expected to generate on average, $1 million per year. Implementation of the aquatic conservation strategy will, on average, require approximately $325,000 per year (Section 9.2.2.1). The amount will not be the same every year. Some years will be more while others will be less. The amount of the Conservation Fund that is spent on the aquatic conservation strategy will be tracked annually and evaluated to ensure that ODF has spent approximately half of the fund on aquatic enhancement projects by the end of the 10-year period. Leading up to the 10-year comprehensive review, if too much or too little has been spent on the aquatic strategy earlier in the decade, strategies and expenditures will be adjusted to ensure compliance by the end of the decade. In the event that a very large project cannot be accomplished within the 10-year period, aquatic conservation funds may be carried over to the subsequent 10-year period to accomplish the project. Information regarding the expecting timing of those future expenditures will be described in the annual report.

The average number of aquatic enhancement projects, including barrier removal projects,[2] expected each year are summarized in Conservation Action 3: Stream Enhancement, and Conservation Action 4: Remove or Modify Artificial Fish-Passage Barriers. The annual averages are estimates based on past projects and the expected level of funding under the HCP. The number of projects is not a requirement because in some years there may be one large project; in others there may be several small projects. As long as ODF is in compliance with the percentage of the Conservation Fund spent on aquatic projects in each decade, the number of projects does not matter, though the number of projects will be reported, along with the aquatic enhancement project information listed below. This information will be included in annual reports, for projects completed in the reporting year, and then summarized in 5-year midpoint reviews and 10-year comprehensive reviews.

---

[1] Timber harvest operators are required to check specific weather stations during the wet season. If >2 inches of rain is projected, they are required to self-regulate and shut down hauling. These closures will not be included in the annual report.

[2] Regular maintenance and replacement of barriers associated with timber sales would not utilize Conservation Fund monies. Conservation Fund monies will only be used on barrier projects that would not otherwise be undertaken in the permit area but would have a direct benefit to covered species.

Aquatic Enhancement Project Information Tracked

1. Project location (including Evolutionary Significant Unit (ESU) and independent population of each covered species overlapping location)
2. Project type (wood enhancement, side-channel reconnection, etc.)
3. ODF lead project or partner lead
4. Project expenditures (including any matching partner funds tracked separately)
5. Covered species that will benefit
6. Limiting factors that will be addressed
7. Non-covered species expected to benefit
8. If project is a barrier removal include the following:
    a. Type of barrier removed
    b. Description of improved passage (e.g. improved culvert, bridge, vacated for natural drainage)
    c. Miles of habitat now accessible to covered species

6.4.2.2 Terrestrial Conservation Actions

Monitoring the implementation of terrestrial conservation actions will also involve tracking both expenditures on terrestrial actions and the actions themselves. Implementation of the terrestrial conservation strategy will, on average, require approximately half of those annual funds, approximately $250,000/year for barred owl management and another $240,000/year for habitat enhancement activities in HCAs. This would be a combination of some management activities and some reforestation activities, following management. Not all acres treated will require active reforestation and where possible natural regeneration will be utilized. Additionally, some stands that are harvested will generate enough revenue to pay for reforestation activities. The funding is provided for those stands that would otherwise not be profitable to harvest, with the intent of improving them for covered species habitat.

Similar to the aquatic strategy, the amount will not be the same every year. Some years will be more while others will be less. The amount of the conservation fund that is spent on the terrestrial conservation strategy will be tracked annually and evaluated to ensure that ODF has spent approximately half of the conservation fund on terrestrial conservation actions by the end of the 10-year period. Leading up to the 5-year midpoint check-in, if too much or too little has been spent on the terrestrial strategy earlier in the decade, strategies and expenditures will need to be adjusted to ensure compliance by the end of the decade. In instances where funds are being saved in order to implement a large project, that will be disclosed as well, so it is clear that even if the funds have not been expended at the end of the decade, those funds are dedicated to a specific project in the future. In other cases, ODF may use funds outside of the HCP budget, from other budget categories, to complete a project sooner that would otherwise be possible using only conservation fund dollars. Those non-conservation fund dollars will be tracked so that future conservation fund dollars can be reallocated to “pay back” those budget categories, from which they were borrowed.

The acres of terrestrial species management activities that occur each year will be reported annually and then further summarized at the 5-year midpoint check-in and 10-year comprehensive review. Terrestrial habitat restoration information that will be collected and reported is listed below.

Terrestrial Habitat Restoration Information Tracked

1. Acres treated in the following three categories:
    a. Swiss needle cast restoration
    b. Hardwood to conifer restoration
    c. Healthy conifer management
2. Location of treatments
3. Rationale for treatment and expected biological outcomes from it
4. Covered species that will benefit
5. Non-covered species that will benefit
6. Any novel attributes to the management that will benefit covered species uniquely
7. Acres reforested, including location and expenditures
8. Young stand management activities, including location and expenditures

6.5 Effectiveness Monitoring

This section provides an overview of monitoring activities for all covered species, summarized into aquatic and terrestrial species. The purpose of effectiveness monitoring is to determine whether the conservation actions are "effectively" achieving the biological goals and objectives. As such they are primarily focused on monitoring changes in habitat quality and quantity over time, including long-term trends in ecosystem processes, though there are a few instances where species response to habitat changes are also monitored. A description of monitoring activities associated with each biological goal and objective is described below and included in tables centered around either biological objectives (aquatic) or covered species (terrestrial). In all cases there are compliance monitoring requirements and effectiveness monitoring requirements for each biological objective, although often the process for demonstrating compliance is the same across objectives. Methods and metrics for compliance are also provided in the tables in each section because often the compliance process is key to determining effectiveness.

6.5.1 Aquatic Habitat Monitoring

6.5.1.1 Aquatic Habitat Monitoring Methods

Monitoring is an essential component of the HCP to determine if the biological goals and objectives are being met. The aquatic monitoring program focuses on monitoring the status and trends of aquatic habitat quality and quantity in the permit area; it is not intended to be a measure of production (i.e., number of fish) of the covered salmon, steelhead, and eulachon in the permit area. The aquatic monitoring program will, in part, rely on a partnership between Oregon Department of Fish and Wildlife (ODFW) and ODF. However, if over the course of the permit term ODFW is no longer able to collect data in a manner that meets the HCP monitoring requirements, ODF will be responsible for ensuring their monitoring requirements are met.

Aquatic Inventories Project

ODFW has been monitoring instream habitat conditions of wadable streams across western Oregon for 20 years using the Aquatic Inventories Project (AIP) under the Oregon Plan for Salmon and Watersheds. Sites are chosen at random and visited on a temporal rotating panel. This sampling design enables a non-biased portrayal of the status and trends in habitat conditions. ODF will partner with ODFW, by providing land access and funding, to utilize the AIP to monitor trends in physical habitat attributes within the permit area over the course of the permit term. The AIP collects data on many habitat variables within the four variable classes (substrate, channel morphology, wood, riparian) following the methods outlined in *Methods for Stream Habitat and Snorkel Surveys* (ODFW 2019). For the purposes of this HCP the variables described below[3] and in Table 6-1 will be tracked over time to determine the trajectory of habitat trends in the permit area.

- Wood: volume, number of key pieces, and number of pieces
- Riparian: channel shade, density of conifers by size class
- Channel Morphology: active channel width, pool frequency
- Substrate: fine sediment in substrate

Funding provided by ODF to the AIP will allow for increased sampling on the permit area under the AIP that will allow for status and trends reporting specific to the HCP. Funding for additional AIP monitoring sites in the permit area will be provided as described in Chapter 9. ODFW and ODF will work together to set-up the monitoring program, including determining the monitoring focus and appropriate spatial and temporal sampling scale. Monitoring locations will be increased within the permit area to provide more robust monitoring coverage than is otherwise provided by the random sampling ODFW conducts. An initial 10-year effort to monitor key watersheds will be completed. The location of supplemental HCP monitoring sites will be determined based on previous monitoring done by ODFW in the permit area. The results of the initial 10-year effort will then be used to identify subsequent decadal restoration goals and monitoring needs.

As with the rest of the monitoring program, the results of monitoring completed each year will be reported in the annual report. That information will then be summarized in the 5-year midpoint check-ins and further summarized in the 10-year comprehensive reviews completed by ODF. Due to the extent of the permit area, it is infeasible to monitor habitat trends in all watersheds. Instead ODF will work with project partners[4] at the start of each 10-year cycle to identify key watersheds for focused effectiveness monitoring over the next decade. These areas will be selected based on their ability to provide a large amount of information that can help future management decisions or address data gaps. Monitoring changes in riparian and aquatic conditions will provide information for tracking status and trends based on implementation of the covered activities and natural disturbance. At the 5- and 10-year marks monitoring and restoration goals will be assessed to determine if they are being met and to ensure they are still adequate to meet the covered species needs, or if they should be recalibrated. Any changes to monitoring and/or restoration will be documented and rational, and the change will be provided in the annual reports, 5-year midpoint

[3] Data will be collected as described in ODFW 2019 or more current version.

[4] Oregon Department of Fish and Wildlife, NOAA Fisheries, Watershed Councils, and Tribes.

check-ins, and 10-year comprehensive reviews. It may be determined that some key watersheds should be monitored in successive 10-year periods for a longer term look at changes in habitat conditions over time.

Turbidity Monitoring

In addition to substrate monitoring that will occur under the AIP, ODF will install paired turbidity monitors upstream and downstream of selected road crossings to monitor for changes in in-stream turbidity following the construction of haul roads. Turbidity monitoring locations will occur at locations where AIP data is also being collected so substrate and turbidity data can be reported for the reach. Similar monitoring will also be used upstream and downstream of new, upgraded, or decommissioned stream crossings to determine the adequacy of the prescribed management actions and BMPs. In addition, post-harvest monitoring at select sites in in year 1, 5, and 10 will identify and record any road-related landslides/debris flows including: likely triggering event, track width, distance traversed, stream type at deposition zone, and volume of wood delivered. The AIP data will be used in conjunction with the road monitoring data to determine if changes in fine sediment inputs associated with road activities are occurring.

Water Temperature

The AIP monitoring program does not include temperature monitoring. However, ODFW is implementing a large-scale, long-term temperature monitoring program in Oregon. ODF will partner with ODFW to enroll key locations in the permit area into this program to track trends in water temperature. Thermistors will be placed in key watersheds where data will help address water quality questions. Once placed, thermistors will collect data year-round. ODFW will download data twice a year (spring and fall) and provide the information to ODF who will be responsible for analysis and reporting.

6.5.1.2 Aquatic Habitat Monitoring by Objective

This section provides an overview for covered fish and torrent salamander monitoring, collectively aquatic species monitoring. The biological goals and objectives for the covered fish are focused on habitat parameters, including the ecological processes that influence habitat condition. Monitoring these ecological processes and habitat variables, using the methods described in the previous section, allows ODF to determine whether progress is being made towards the biological objectives. Monitoring does not include covered species distribution or abundance surveys for covered fish. Habitat quality and quantity are being used as a surrogate for species distribution and abundance, with a long-term objective of habitat improvement within the permit area.

Monitoring for Columbia and Cascade torrent salamanders will focus on determining salamander presences in the permit area, as well as the effect that covered activities may have on the distribution and abundance of the species. Torrent salamander surveys that occur in the permit area will be summarized in annual reports, 5-year midpoint check-ins, and 10-year comprehensive reviews, as appropriate.

Objective 1.1: Wood Recruitment

The creation of RCAs adjacent to the aquatic zone will promote the development of mature riparian forests that can contribute to instream large wood. Large wood may also be placed in selected stream reaches through the implementation of stream enhancement projects. In addition to these measures that would increase large wood recruitment in streams in the permit area, equipment restriction zones will be retained adjacent to the aquatic zone and BMPs will be followed to minimize effects from road construction inside RCAs. Compliance and effectiveness monitoring is summarized by biological objective in Table 6-1. Methodologies used in monitoring are described under Section 6.5.1.1. Data will be reported on an annual basis and include a rolling 10-year trend analysis to show the trajectory of large wood recruitment in the permit area, summarized by covered fish population, and where necessary at the watershed scale.

Table 6-1. Wood Recruitment Compliance and Effectiveness Monitoring

Conservation Action	Compliance Monitoring		Effectiveness Monitoring		Methodology
	Monitoring Action	**Metrics**	**Monitoring Action**	**Metrics**	

CA1 – Establish Riparian Conservation Areas	ODF collects compliance information during sale close-out process, including number of exceptions and rationale for exceptions	Length of stream by type, and acres of RCA established :
		• Type F
		• Type N perennial, by size
		• Seasonal high-energy and potential debris flow tracks
		
		Inner gorge and potentially unstable slope features
		
		Annual report on timber sales that needed to observe exceptions to RCAs
			Trends in stream conditions (large woody debris) will be reported as a rolling average at a 10-year monitoring interval
			
			ODF monitors a subset of harvest units and roads where potentially unstable slopes were identified as having the potential to deliver to fish-bearing waters
				Large wood frequency and volume as tracked by AIP protocols
				• Volume
				• # Key pieces
				• # Pieces
				
				Number of potentially unstable slopes that have not experienced failure
				
				Number of potentially unstable slopes that experienced failure, measured for:
				• Likely triggering event
				• Track width
				• Distance traversed
				• Stream type at deposition zone
				• Wood delivered
				  ○ Volume
				  ○ # Key pieces
				  ○ # Pieces
					Oregon Department of Fish and Wildlife (ODFW) AIP 2019
					
					Contract administration reporting:
					• Adherence to RCA posted boundaries
					• RCA exceptions
					• Rationale and administrative approvals for exceptions
					
					Landslide monitoring protocol

Conservation Action	Compliance Monitoring		Effectiveness Monitoring		Methodology
	Monitoring Action	Metrics	Monitoring Action	Metrics	
CA3 – Stream Enhancement	Document annual enhancement projects completed by project type and stream length and/or pieces donated (concurrent with Objective 1.2) Track annual expenditures from Conservation Fund	Narrative in annual report Conservation Fund summary in annual report	Monitoring of projects over time, specific to the immediate post-implementation condition	Large wood change from original placement (decrease or increase from project implementation): • Volume • # Key pieces • # Pieces	ODFW AIP 2019 Other project-specific protocols for metrics

Objective 1.2: Stream Enhancement Projects

Targeted stream enhancement projects such as wood and boulder placement will be implemented in key areas of the permit area to provide rapid improvements to physical habitat utilized by the covered species. Project planning and design will consider basin, watershed, species action plans and assessments, local knowledge and expertise of current habitat conditions, intrinsic potential, stream processes, and the disturbance regime at the watershed and basin scale to identify areas best suited for enhancement (Appendix E). Based on project history, it is expected that over the course of the permit term ODF will complete approximately 440 instream improvement projects,[5] with an average of 60 projects being completed per decade. The overall number will depend on the size and scale of each project. Stream enhancement targets will be tied to and commensurate with the level of harvest expected in any one ESU during a 10-year implementation planning cycle. Monitoring of stream enhancement projects will be done under a project-specific monitoring plan and is not part of the general effectiveness monitoring that will use the AIP process. Results from project-specific effectiveness monitoring plans will be summarized and included in the HCP annual report. However, data collection will likely occur in the same manner, and results will be incorporated into trends analysis if appropriate. Compliance and effectiveness monitoring metrics that will be utilized to track compliance with identification and prioritization of stream enhancement projects and spending of the Conservation Fund on project implementation are described in Table 6-2.

[5] Projects are generally focused on increasing instream complexity and typically consist of at least five logs or trees per structure site with several sites per project. Other projects may include, but are not limited to, road decommissioning to reduce sedimentation, floodplain reconnection, and projects to promote the colonization of beaver.

Table 6-2. Stream Enhancement Projects Compliance and Effectiveness Monitoring

Conservation Action	Compliance Monitoring		Effectiveness Monitoring		Methodology
	Monitoring Action	Metrics	Monitoring Action	Metrics	
CA3: Stream Enhancement	Annual report will list stream enhancement projects, justification for project selection, and list potential projects for the upcoming year Document on a project basis any benefit on covered species habitat	Number and type of projects Narrative in annual report Conservation Fund summary in annual report	Trends in stream conditions (channel complexity); 10-year monitoring interval	1. Active channel width 2. Channel morphology 3. Pool frequency	ODFW AIP

Objective 1.3: Water Quality and Quantity

Protection of existing functional riparian systems and restoration of degraded systems will be implemented to protect water quality in the permit area. The creation of RCAs adjacent to the aquatic zone, including the addition of the processes protection zone, will promote the development of mature riparian forests to provide shade to maintain and/or improve stream temperatures. Inputs of fine sediments will be minimized and mitigated through the implementation of an Equipment Restriction Zone (ERZ), implementation of road construction and management BMPs, road improvement and vacating projects, and disconnection of hydrologically connected road systems. To ensure watershed effects associated with harvest are minimized, the annual report will include a rolling summary of acres harvested, by HUC 10, and the percentage of each HUC 10 that is in clearcut and young forest conditions (0–10 years). Compliance and effectiveness monitoring is summarized by biological objective in Table 6-3. Methodologies used to in monitoring are described under Section 6.5.1.1. Data will be reported on an annual basis and will include a rolling 10-year trend analysis to show the trajectory of water quality and quantity metrics in the permit area.

Table 6-3. Water Quality and Quantity Compliance and Effectiveness Monitoring

Conservation Action	Compliance Monitoring		Effectiveness Monitoring		Methodology
	Monitoring Action	**Metrics**	**Monitoring Action**	**Metrics**	
CA1: Establish Riparian Conservation Areas	ODF collects compliance information during sale close out process Operators disclose number and percent of streams in compliance with HCP and permits, and provide rationale for exceptions ODF tracks acres of harvest by watershed	Number and percent of sales that successfully implemented RCAs Annual report on timber sales that needed to observe exceptions to RCAs Report and summarize harvest by HUC 10 to ensure clearcut conditions (0–10 years) do not exceed 20% of any given watershed to retain water quantity	Summary of sales with exceptions provided in annual report Tracking of stand age distribution in RCAs by watershed Stream temperature monitoring using AIP protocol Substrate monitoring using AIP protocol	1. Channel shade on fish-bearing streams by watershed 2. Riparian conifer density by size class 3. Riparian hardwood density by size class 4. Stream temperature monitoring (maintain and/or increase stream shading on fish bearing streams to improve stream temperature) 5. Turbidity or fine sediment levels	Contract administration reporting ODFW AIP (2019)
CA2: – Riparian Equipment Restriction Zones	ODF collects compliance information during sale close out process Operators disclose number and percent of streams in compliance with HCP and permits, and provide rationale for exceptions	Number and percent of sales that successfully implemented ERZs Annual report on timber sales that needed to observe exceptions to ERZ	Substrate monitoring using AIP protocol	Substrate class and composition	Contract administration reporting ODFW AIP (2019)

Conservation Action	Compliance Monitoring		Effectiveness Monitoring		Methodology
	Monitoring Action	**Metrics**	**Monitoring Action**	**Metrics**	
CA5: Standards for Road Improvement and Vacating	Identify roads in the permit area that are high risk of sedimentation for improvement or vacating Baseline and every 10th year – use Forest Road Hazard Inventory (ODF 2009) or suitable surrogate, to review current conditions of road system in permit area; document roads most susceptible to degrading aquatic conditions in proposed harvest areas	Document annually any road improvements completed by road length and roads vacated by road length	Determine miles of road or road segments that are high risk "problem areas"	Miles of road or road segments	Forest Road Hazard Inventory (ODF 2009)
	Disconnect the road system hydrologically from stream channels	Document annually any road improvements completed by road length and roads vacated by road length	Determine miles of roads improved or vacated	Miles of roads improved Miles of roads vacated Sediment delivery at connection points for different flow events Persistence of fine sediment in riffles downstream of connection points	Before-After-Control-Impact (BACI) design for a subset of improved versus control sites

Conservation Action	Compliance Monitoring		Effectiveness Monitoring		Methodology
	Monitoring Action	Metrics	Monitoring Action	Metrics	
CA11: Road Construction and Management Measures	Document compliance with CA5 and CA11 Document miles of roads within RCAs that were constructed or underwent management activities annually Document miles of roads vacated from RCAs annually	Road miles in RCAs constructed/vacated annually	Determine miles of road or road segments that are high risk “problem areas”	Miles of road or road segments	Forest Road Hazard Inventory (ODF 2009)

Objective 1.4: Fish Passage

The removal or modification of artificial barriers in the permit area will increase fish access to upstream areas that could be used by covered fish for spawning and rearing and release gravels that have accumulated behind barriers to downstream spawning locations. Over the course of the permit term ODF will evaluate and improve as appropriate the 167 culverts identified to date by ODFW as either complete barriers, a partial blockage, or unknown, as well as additional culverts that may be located over the permit term. Most fish barrier removals or upgrades will occur as part of routine haul road upgrades associated with planned harvest activities. A subset of barrier removals or upgrades will occur as targeted conservation actions outside of the harvest program. Compliance and effectiveness monitoring metrics that will be utilized to measure progress toward meeting the barrier removal goal are described in Table 6-4.

Table 6-4. Fish Passage Compliance and Effectiveness Monitoring

Conservation Action	Compliance Monitoring		Effectiveness Monitoring		Methodology
	Monitoring Action	Metrics	Monitoring Action	Metrics	
CA4: Remove or Modify Artificial Fish-Passage Barriers	Conduct fish passage inventory every 5 years and prioritize and identify projects to repaired/replace during permit term	Number and percent of road/stream crossings in compliance with NOAA Fisheries (2011) fish passage criteria Barriers modified each year, separating barrier modification during timber sale from barrier modification through use of Conservation Fund or other monies	Document barriers removed or modified Document miles of fish-bearing stream made accessible above modified barriers	Miles of stream opened above barriers Narrative plus photos in annual report	Contract administration reporting
CA5: Standards for Road Improvement and Vacating	Demonstrate compliance with fish-passage criteria for new or improved roads Baseline and every 10th year – use Forest Road Hazard Inventory (ODF 2009) or suitable surrogate, to review current conditions of road system in permit area; document roads most susceptible to degrading aquatic conditions in proposed harvest areas	Number and percent of road/stream crossings in compliance with fish passage criteria	Document barriers removed or modified	Miles of stream opened above barriers Narrative plus photos in annual report	Forest Road Hazard Inventory (ODF 2009) Contract administration reporting
CA11: Road Construction and Management Measures	Demonstrate compliance with fish-passage criteria for new or improved roads	Number and type of road/stream crossings constructed Barriers modified each year, separating barrier modification during timber sale from barrier modification through use of Conservation Fund or other monies	Document miles of fish bearing stream retained as accessible above new road/ stream crossing	Narrative plus photos in annual report	Contract administration reporting

Objectives 2.1 and 3.1: Riparian Habitat within Species Range (Columbia and Cascade Torrent Salamanders)

Very little data currently exists about Columbia or Cascade torrent salamander within the permit area. Therefore, the primary goal of monitoring for these two species initially is to gain a better understanding of their distribution. During the first 10 years of implementation, baseline surveys will be completed in a subset of non-fish-bearing perennial streams within the range of the two species of torrent salamander. Survey techniques will include collection of environmental DNA (eDNA) to gain an understanding of watersheds where the species is present.

Once presence or absence is established using these broad-scale techniques, more focused surveys on density and abundance can be implemented in targeted locations. Surveys will be focused on pre- and post-road construction or rehabilitation of roads that cross streams where torrent salamanders were deemed present during the initial 10-year survey. In addition to salamander density and abundance, ODF will document pre- and post-road construction habitat conditions to determine the effects of the covered activity on both the species and its habitat. The post-construction survey effort will persist for up to 3 years following the project to allow time for generational changes in distribution.

Not every project will be monitored in this way. The intention is for this to be a sampling effort to better gauge the type of effect road projects have on the species over time and to confirm that culvert enhancement and stream enhancement projects are proving beneficial for the species. For the latter, pre- and post-stream restoration surveys will be conducted if they are to occur in locations where torrent salamanders were deemed present. If a stream enhancement project is expected to benefit torrent salamander through the creation of more or better habitat, follow up surveys will help determine whether the project had the expected benefits.

In other instances, where torrent salamanders are determined to be present during baseline surveys, follow up surveys will be conducted after timber harvest activities occur in adjacent stands, to test whether the RCAs established on non-fish-bearing streams are adequately protecting habitat for torrent salamanders. As harvest activities are determined, during the 10-year implementation planning process, torrent salamander surveys will be targeted in locations where harvest is expected. These surveys could be combined with those described above related to new road locations.

Compliance and effectiveness monitoring metrics are described in Table 6-5. As with other species, a review of torrent salamander monitoring priorities will be evaluated during each 10-year comprehensive review. ODF and other project partners including USFWS, NOAA Fisheries, and ODFW will determine how best to utilize monitoring funds during the next 10-year period including, but not limited to, focused surveys and/or additional broad-scale determinations of presence or absence in the permit area.

Table 6-5. Columbia and Cascade Torrent Salamander Compliance and Effectiveness Monitoring

Conservation Action	Compliance Monitoring		Effectiveness Monitoring		Methodology
	Monitoring Action	**Metrics**	**Monitoring Action**	**Metrics**	
Support the Persistence of Columbia Torrent Salamander in the Clatsop and Tillamook State Forests					
CA1: Establish Riparian Conservation Areas	ODF collects compliance information during sale close out process Operators disclose number and percent of streams in compliance with HCP and permits, and provide rationale for exceptions	Length of stream and acres of RCA established for Type N perennial streams Annual report on timber sales that needed to observe exceptions to RCAs	Track species presence pre- and post-harvest activities, including road construction in RCAs	Species presence	Contract administration reporting: • Adherence to RCA posted boundaries • RCA exceptions • Rationale and administrative approvals for exceptions Pre-and post-covered activity monitoring in locations where species is present using field data collection, including eDNA sampling

Conservation Action	Compliance Monitoring		Effectiveness Monitoring		Methodology
	Monitoring Action	**Metrics**	**Monitoring Action**	**Metrics**	
Support the Persistence of Cascade Torrent Salamander in the Santiam State Forest					
CA1: Establish Riparian Conservation Areas	ODF collects compliance information during sale close out process Operators disclose number and percent of streams in compliance with HCP and permits, and provide rationale for exceptions	Length of stream and acres of RCA established for Type N perennial streams Annual report on timber sales that needed to observe exceptions to RCAs	Track species presence pre- and post-harvest activities, including road construction in RCAs	Species presence	Contract administration reporting: • Adherence to RCA posted boundaries • RCA exceptions • Rationale and administrative approvals for exceptions Pre-and post-covered activity monitoring in locations where species is present using field data collection, including eDNA sampling

6.5.2 Terrestrial Species Monitoring

The aim of terrestrial species monitoring is two-fold. First, ODF wants to continue to monitor a subset of northern spotted owls and marbled murrelets to build upon 30 years of data collection and continue to better understand how these two species respond to the conservation actions described in the HCP. Second, ODF wants to gain a better understanding of the distribution of the lesser-studied covered species in order to more effectively implement conservation actions. Though success of the HCP is not tied to species numbers or population sizes (see Table 4-1, *Biological Goals and Objectives for the Western Oregon State Forests Habitat Conservation Plan*, in Chapter 4) it is helpful to know whether the conservation actions are benefiting the species and how populations are responding. The monitoring described for each species below is designed for that purpose.

6.5.2.1 Terrestrial Habitat Monitoring Methods

Terrestrial habitat monitoring will be a means by which to track progress towards the biological objectives for each terrestrial species. Species monitoring is how ODF will track the response of covered species to the conservation actions.

Changes in Habitat Quality

Habitat monitoring will be conducted annually, but the results will be summarized and reported at 5-year intervals. Quantity and quality of habitat lost to covered activities will be tracked with administration of those activities (e.g. timber sale close out). Habitat growth over time will be tracked using species habitat models based on forest inventory metrics. Forest inventory updates will include both current habitat conditions and 5-year projections of growth to estimate the quality and quantity of habitat. Sometimes new forest growth will be in response to management activities in HCAs; other times it will be from passive management. In both cases ODF will determine the quality of habitat for each of the covered terrestrial species by tracking changes in forest characteristics that support them. While landscape levels of habitat quality and quantity (both inside and outside of HCAs) will be summarized from habitat models based on ODF's forest inventory, individual stand exams will be used to increase understanding of habitat characteristics over time, which will in turn improve the species models. Active management in HCAs will also be coupled with field measurements and monitoring that will test the efficacy of terrestrial habitat enhancement projects.

Habitat modeling described in Chapter 2, *Environmental Setting,* was based on inventory data available at the time that is designed to be summarized at the level of the forest stand. Forest inventory methods and data and habitat modeling capabilities will continue to improve during the permit term, allowing habitat metrics to be summarized more precisely and at a wider variety of spatial scales (e.g., within stand habitat patches). Improved terrestrial species habitat modeling will occur using the new information. Regardless of changes in modeling methods, the acreage commitments in the biological goals and objectives will remain in place. If at some point new habitat modeling results in a need to modify those commitments, ODF will follow the processes described in Section 8.9, *Modifications to the HCP*.

As described in Section 8.6, *Reporting,* ODF will provide an update in the changes in habitat quality and quantity at each 5-year mid-point check-in and again at each 10-year comprehensive review. Not only are these timeframes appropriate to track changes in habitat, which are based on slow changing forest characteristics, but they also position ODF to make changes to the timber harvest program if needed, in response the updated habitat acreages. For example, the 10-year comprehensive review is intended to align with the 10-year implementation planning process that ODF undertakes to set specific harvest targets and to more precisely plan where and how harvest will occur. Tracking changes in habitat quality and quantity on 5- and 10-year cycles allows ODF to make adjustments to current implementation plans and incorporate information into the next 10-year implementation planning cycle appropriately. If habitat is not developing as fast as expected, the timber harvest program can be slowed, so as not to create an imbalance between acres of habitat grown versus acres of habitat harvested. Stand management activities can be tailored to locations where habitat can be developed more quickly, in order to make strides toward the biological objectives. If habitat is developing as planned the harvest would likely continue as planned, knowing that the HCP is in compliance.

Monitoring Managed Stands

ODF would be implementing stand management activities in HCAs, as described in Conservation Action 7: Manage Habitat Conservation Areas, in order to accelerate the growth and quality of habitat. These activities will mostly occur during the first 30 years of HCP implementation. A key element of the monitoring program will be to track long-term changes, after management has occurred, to determine if stand management activities had the desired effect. The return interval will vary over time. Initial monitoring will occur every few years to determine the response of retained vegetative components and the establishment of new ones. Return intervals will then become longer as initial vegetative response slows. While the habitat attributes collected may vary depending on the specific enhancement objective, tracking where management occurred, what type of management occurred, and the expected outcomes will be critical to later determining whether management activities were effective. As monitoring reveals whether biological outcomes are being met ODF will utilize adaptive management to adjust silvicultural practices in HCAs to minimize short-term habitat degradation and maximize long-term habitat creation.

6.5.2.2 Terrestrial Monitoring by Species Objective

Objective 4.1: Existing Oregon Slender Salamander Habitat, and Objective 4.2: Downed Wood

Very little data currently exists about Oregon slender salamander within the permit area, although information regarding habitat requirements is improving (Garcia et. al. 2020). Therefore, the primary goal of monitoring for Oregon slender salamander is to gain a better understanding of species distribution within the permit area and the relationship between habitat, timber harvest, and distribution and abundance.

Monitoring for Oregon slender salamander will include baseline surveys in a subset of stands to be conducted over the first 15 years of the permit term, including pre- and post-harvest surveys to document species response to harvest. Survey locations will focus on habitat within HCAs, although habitat outside HCAs will be included as part of timber harvest effects monitoring. Surveys to determine whether Oregon slender salamander persists in stands that are managed will be conducted in a subset of harvested stands outside HCAs and managed stands inside HCAs to determine whether downed wood retention standards are adequately supporting the species. Monitoring will include a sufficient number of sites and replication such that the results will have enough statistical power to meaningfully inform future management decisions.

ODF may work with partners to set up a more rigorous study designed to determine whether varying amounts of downed wood, decadence management, and recruitment processes benefits the species differently, particularly over a longer period of time. With the 2020 North Cascade fire event occurring largely in Oregon slender salamander habitat, much the species monitoring will also include an evaluation of the role fire plays in habitat quality.

Survey methods will be based on currently accepted protocols, which at this time follow Garcia et al. (2020). Long-term efforts will included a mix of repeat sample plots and new plots, with efforts to minimize cumulative effects in all (per Otto et al. 2013a, Kroll et al. 2015). Data collection will include coarse woody debris inventories based on length, width, and decay classes (e.g., following Maser and Trappe 1984).

ODF forest inventory methods will utilize a densified plot network in cooperation with the Forest Inventory and Analysis (FIA) group of the U.S. Forest Service (USFS) Pacific Northwest Research Station, which will include data on downed wood. This will allow ODF to establish a baseline for downed wood on the permit area within the range of the Oregon slender salamander at the outset of the permit term from which overall trends can be monitored over time.

Compliance and effectiveness monitoring metrics are described in Table 6-6. A review of Oregon slender salamander monitoring priorities will be evaluated during each 10-year comprehensive review. ODF and other project partners, including USFWS and ODFW, will determine how best to utilize monitoring funds during the next 10-year period including, but not limited to, focused surveys and/or additional broad-scale determinations of presence or absence in the permit area.

Table 6-6. Oregon Slender Salamander Compliance and Effectiveness Monitoring

Conservation Action	Compliance Monitoring		Effectiveness Monitoring		Methodology
	Monitoring Action	Metrics	Monitoring Action	Metrics	
Biological Objective 4.1: Existing Oregon Slender Salamander Habitat					
CA6: Establish Habitat Conservation Areas	Document establishment of HCAs	Conserve 16,000 acres of habitat on the Santiam State Forest	Annual reporting on acres and type of harvest in HCAs through sale close out reports	Document acres of suitable and highly suitable habitat in the permit area at 5-year intervals over the permit term	• Acres of habitat by suitability category • Difference from baseline acreage and change since last reporting period • Over time linkage between previous harvest actions and relative changes in habitat quality to inform future management actions
Biological Objective 4.2: Downed Wood					
CA7: Manage Habitat Conservation Areas	Variable density thinning in stands identified as potentially benefitting from this treatment	Document annually management actions that occur in HCAs, using the timber sale contract administration close out process	Annual reporting on acres and type of harvest in HCAs Annual reporting on downed wood retention from the timber sale contract administration close out process	Determine trends of downed wood in HCAs over time Survey selected management actions pre- and post-activity to determine differences in quantity of downed wood by decay class Species distribution surveys and species persistence monitoring in select stands following management activities	• Trend monitoring through densified FIA plot network • Pre- and post-activity sampling of selected activities to determine: ○ Cubic feet of downed wood pre- and post-harvest, by diameter and decay class ○ Measured decay classes, snags, and number of green trees following regeneration harvest ○ Species presence in managed stands

Conservation Action	Compliance Monitoring		Effectiveness Monitoring		Methodology
	Monitoring Action	**Metrics**	**Monitoring Action**	**Metrics**	
CA8: Conservation Actions Outside Habitat Conservation Areas and Riparian Conservation Areas	Retain legacy structures (e.g., downed wood, snags, green trees)	Document compliance with Management Standards outside HCAs and RCAs, using the timber sale contract administration close out process	Report exceptions when standards were not able to be implemented and justification Annual reporting on downed wood retention from the timber sale contract administration close out process	Survey selected management actions pre- and post-activity to determine differences in quantity of downed wood by decay class Species persistence monitoring in select stands following harvest activities	• Trend monitoring through densified FIA plot network • Pre- and post-activity sampling of selected activities to determine: ○ Cubic feet of downed wood pre- and post-harvest, by diameter and decay class ○ Measured decay classes, snags, and number of green trees following regeneration harvest ○ Species presence in managed stands

Objective 5.1: Existing Northern Spotted Owl Habitat, Objective 5.2: Northern Spotted Owl Dispersal Habitat, and Objective 5.3: Northern Spotted Owl Habitat Enhancement

The monitoring goal for northern spotted owl is to retain understanding of site status in active sites and to document presence and trends in nesting, roosting, and foraging habitat both inside and outside HCAs. In addition, monitoring will include confirmation that northern spotted owl dispersal habitat meets the minimum requirements described in Conservation Action 8: Conservation Actions Outside Habitat Conservation Areas and Riparian Conservation Areas. Additional monitoring will be completed to track recolonization, survival, and productivity in response to barred owl removal and to stand management activities in HCAs. Compliance and effectiveness monitoring metrics for northern spotted owl are described in Table 6-7.

A subset of active sites within the permit area will be monitored each nesting season. The purpose of monitoring is to ascertain how northern spotted owls are responding to management in HCAs as well as other management actions, such as barred owl management. Monitoring will be prioritized in locations where habitat quality is improving and northern spotted owls are expected to colonize or recolonize an area. Within that, special priority will be given to areas where barred owl management is occurring in order to determine whether barred owl removal is resulting in an increase in northern spotted owl use. Surveys will cycle through locations with active or historical northern spotted owl use, over generally a 15- to 20-year period. Monitoring will begin no later than year 10 following permit issuance. Surveys of those sites will be conducted for 2 years and then a new set of sites will be monitored for the next 2-year period. Surveys will continue to rotate though the subsets of sites every 2 years over of the permit term. Within each survey rotation, survey sites will focus on nesting and roosting habitat over foraging and dispersal habitat; locations with historical northern spotted owl use, over those with no historical use; areas within HCAs over those outside of HCAs; and areas where stand management activities are expected in the subsequent 10-year Implementation Plan over those where it is not expected. In addition, monitoring will focus on HCAs that are large enough to support owls, including dispersal. Monitoring will include a sufficient number of sites and replication that the results will have enough statistical power to meaningfully inform future management decisions.

Monitoring methods will include a combination of bioacoustics monitoring and ground-based call surveys. Passive acoustic monitoring uses autonomous recording units (ARUs) that have been shown to be effective in detecting both northern spotted owls and barred owls (Duchac et al. 2020). Detections made through ARUs may be followed up with field surveys to confirm nesting, depending on the specific monitoring objectives for the detection site. Field surveys may also be conducted to supplement acoustic monitoring for demographic data.

For activity centers centered on lands outside the permit area, ODF will rely on monitoring conducted by the landowner (e.g., BLM, USFS) if such data are available. Where survey data are not available, ODF may seek permission to conduct surveys of sites with activity centers centered on adjacent lands but within 0.7 mile of the permit area if occupancy status must be known to inform ODF harvest plans.

Table 6-7. Northern Spotted Owl Compliance and Effectiveness Monitoring

Conservation Action	Compliance Monitoring		Effectiveness Monitoring		Methodology
	Monitoring Action	Metrics	Monitoring Action	Metrics	
Biological Objective 5.1: Existing Northern Spotted Owl Habitat					
CA6: Establish Habitat Conservation Areas	Document establishment of HCAs	Establish HCAs that include 15,000 acres of existing nesting and roosting habitat, 73,000 acres of foraging habitat	Annual reporting on acres and type of silvicultural activity in HCAs, by habitat suitability categories for the covered species, using the timber sale contract administration process	Document acres of nesting, roosting, and foraging habitat in the permit area at 5-year intervals over the permit term Track status of active sites (and inactive sites in barred owl management areas) using a combination of ground-based audio or call surveys and bio-acoustic monitoring Document occupation status of previously inactive or unoccupied nesting, roosting, and foraging habitat through a combination of field based and acoustic monitoring	• Acres of habitat by suitability category, as modeled from inventory metrics, using densified FIA plot network, LiDAR, and stand exams • Difference from baseline acreage and change since last reporting period • Monitoring of a subset of management activities and relative changes in habitat quality compared to anticipated modeled outcomes and passive approaches in similar stands • Activity Site Monitoring – combination of ground-based audio or call surveys and bioacoustic monitoring around activity centers to estimate occupancy by active pairs and resident singles and inactive (historic) sites in barred owl management areas • Habitat Validation Monitoring – survey of existing habitat and ingrowth of nesting, roosting, and foraging habitat inside of HCAs for presence using a combination of field surveys and bioacoustics monitoring

Conservation Action	Compliance Monitoring		Effectiveness Monitoring		Methodology
	Monitoring Action	Metrics	Monitoring Action	Metrics	
CA7: Manage Habitat Conservation Areas	Document silvicultural treatments in HCAs to develop nesting, roosting, and foraging habitat	Increase the quantity of nesting and roosting habitat by 69,000 acres, for a total of 84,000 acres by the end of the permit term, while maintaining 50,000 acres of foraging habitat. Total nesting, roosting, and foraging habitat at the end of the permit term shall be 134,000 acres	Annual reporting on acres and type of silvicultural activity in HCAs, by habitat suitability categories for the covered species, using the timber sale contract administration process	Document acres of nesting, roosting, and foraging habitat in the permit area at 5-year intervals over the permit term and over time link relative changes in habitat quality to silvicultural treatments	Same metrics as Conservation Action 6
CA9: Strategic Terrestrial Species Conservation Actions	Fund strategic conservation actions out of the Conservation Fund, including, but not limited to barred owl management	Document annual contributions to and expenditures from the Conservation Fund	Narrative in annual report, including potential acres subject to strategic actions	Determine effectiveness of strategic actions	Changes in NSO populations over time in response to strategic actions

Conservation Action	Compliance Monitoring		Effectiveness Monitoring		
	Monitoring Action	Metrics	Monitoring Action	Metrics	Methodology
CA10: Operational Restrictions to Minimize Effects on Terrestrial Species	Prohibit covered activities within distances expected to affect NSO nest sites during critical breeding period (March 1–July 15) and other minimization measures (see Conservation Action 10)	Document annually compliance with restrictions and any deviations from restrictions through sale close out process	Deviations require: 1. Site-specific review by area biologist 2. Documentation of recommendations 3. Approval by ODF's HCP manager	--	--
Biological Objective 5.2: Northern Spotted Owl Dispersal Habitat					
CA8: Conservation Actions Outside Habitat Conservation Areas and Riparian Conservation Areas	Maintain a minimum of 40% dispersal habitat at the subgeographic level	Document percentage of dispersal habitat at landscape level outside of RCAs and HCAs over permit area at 5-year intervals	Acres and percentage of dispersal habitat outside of HCAs and RCAs every 5 years	Determine whether base requirement (at least 40%) is being met at 5-year intervals and track changes over time	Acres of habitat type by suitability category and percentage of each subgeographic area that meets the dispersal habitat characteristics.
Biological Objective 5.3: Northern Spotted Owl Habitat Enhancement					
CA7: Manage Habitat Conservation Areas	Same actions stated for Objective 5.1				

Objective 6.1: Existing Marbled Murrelet Nesting Habitat, and Objective 6.2: Marbled Murrelet Nesting Habitat Enhancement

The monitoring goal for marbled murrelet is to track occupied status in designated occupied habitat and to document use of suitable and highly suitable habitat inside and outside HCAs, in stands that have not been previously surveyed. Monitoring will also be used to document marbled murrelet responses to stand management activities in HCAs. Compliance and effectiveness monitoring metrics are described in Table 6-8. Monitoring is expected to be conducted primarily through passive acoustic sampling, as described by Borker et al. (2015). Standard field survey protocols will also be conducted to verify acoustical surveys and where they are determined to be preferable to acoustical methods. Monitoring will be prioritized in stands that are developing into habitat for marbled murrelets, either due to active management or passive management. Monitoring will include a sufficient number of sites and replication that the results will have enough statistical power to meaningfully inform future management decisions.

Monitoring of a subset of suitable and highly suitable habitat distributed across the permit area will be conducted over the first 15–20 years of implementation. Monitoring will begin no later than year 10 following permit issuance. Highly suitable habitat will be surveyed more frequently (e.g., 4 or 6 out of 10 years) and suitable habitat is surveyed less frequently. Monitoring locations will also prioritize areas with historical marbled murrelet observations over those with no historical use; areas within HCAs over those outside of HCAs; and areas where stand management activities are expected in the subsequent 10-year Implementation Plan over those where it is not expected.

Table 6-8. Marbled Murrelet Compliance and Effectiveness Monitoring

Conservation Action	Compliance Monitoring		Effectiveness Monitoring		Methodology
	Monitoring Action	**Metrics**	**Monitoring Action**	**Metrics**	
Biological Objective 6.1: Existing Marbled Murrelet Nesting Habitat					
CA6: Establish Habitat Conservation Areas	Document establishment and maintenance of HCAs	Establish HCAs that include 62,000 acres of suitable habitat and 1,000 acres of highly suitable habitat, including occupied habitat	Annual reporting on acres and type of silvicultural activity in HCAs, by habitat suitability categories for the covered species, using the timber sale contract administration process	Document acres of suitable or highly suitable habitat in the permit area at 5-year intervals over the permit term and over time link relative changes in habitat quality to silvicultural treatments Complete survey of suitable and highly suitable habitat by year 20 using field based and acoustic monitoring. Conduct follow up surveys in designated occupied habitat and newly suitable habitat	1. Acres of habitat by suitability category, as modeled from inventory metrics, using densified FIA plot network, LiDAR, and stand exams 2. Difference from baseline acreage and change since last reporting period 3. Monitoring of a subset of management activities and relative changes in habitat quality compared to anticipated modeled outcomes 4. Average and range of habitat patch size and interior to perimeter ratio 5. Habitat Validation Monitoring – beginning in year 20 implement a monitoring effort designed to assess nesting activity in the permit area; the effort would be focused on locations with habitat inside of HCAs that have not been surveyed in the past but where occupancy is expected due to adjacency to other occupied areas, or locations where habitat quality has improved to suitable under the HCP, focusing especially on stands that are known to have platform trees Species presence and establishment or refinement of designated occupied habitat.

Conservation Action	Compliance Monitoring		Effectiveness Monitoring		
	Monitoring Action	Metrics	Monitoring Action	Metrics	Methodology
CA7: Manage Habitat Conservation Areas	Document silvicultural activities used to improve habitat over time	Increase the amount of habitat by at least 45,000 acres of suitable habitat and 34,000 acres of highly suitable habitat. This amounts to a total of 107,000 acres of suitable habitat and 35,000 acres of highly suitable habitat conserved by the end of the permit term.	Annual reporting on acres and type of silvicultural activity in HCAs, by habitat suitability categories for the covered species, using the timber sale contract administration process	Document acres of suitable or highly suitable habitat in the permit area at 5-year intervals over the permit term and over time link relative changes in habitat quality to silvicultural treatments Complete survey of suitable and highly suitable habitat by year 20 using field based and acoustic monitoring Conduct follow up surveys in designated occupied habitat and newly suitable habitat	Same metrics as Conservation Action 6.
CA8: Conservation Actions Outside Habitat Conservation Areas and Riparian Conservation Areas	Retain legacy structures (e.g., green trees)	Document compliance with Management Standards outside HCAs and RCAs, using the timber sale contract administration close out process	Report exceptions when standards were not able to be implemented and justification Annual reporting on green tree retention from the timber sale contract administration close out process	Confirm compliance with retention standards and protection of nest trees or platform trees as part leave tree strategy.	1. Trend monitoring through densified FIA plot network 2. Pre- and post-activity sampling of selected activities to determine compliance with leave tree strategy. 3. Species presence in managed stands

Conservation Action	Compliance Monitoring		Effectiveness Monitoring		Methodology
	Monitoring Action	Metrics	Monitoring Action	Metrics	
Biological Objective 6.2: Marbled Murrelet Habitat Enhancement					
CA7: Manage Habitat Conservation Areas	Document silvicultural activities used to improve habitat over time	Use silvicultural treatments in HCAs to develop 45,000 acres of suitable and 30,000 acres of highly suitable habitat. This amounts to a total of 107,000 acres of suitable habitat and 35,000 acres of highly suitable habitat conserved by the end of the permit term.	Annual reporting on acres and type of silvicultural activity in HCAs, by habitat suitability categories for the covered species, using the timber sale contract administration process	Document acres of suitable or highly suitable habitat in the permit area at 5-year intervals over the permit term and over time link relative changes in habitat quality to silvicultural treatments Complete survey of suitable and highly suitable habitat by year 20 using field based and acoustic monitoring Conduct follow up surveys in designated occupied habitat and newly suitable habitat	Same metrics as Objective 6.1
CA10: Operational Restrictions to Minimize Effects on Terrestrial Species	Prohibit covered activities within distances expected to affect nesting marbled murrelet (see Conservation Action 10)	Document annually compliance with restrictions and any deviations from restrictions through sale close out process	Deviations require: 1. Site-specific review by area biologist 2. Documentation of recommendations 3. Approval by ODF's HCP manager	--	--

Objective 7.1: Occupied Red Tree Vole Habitat, and Objective 7.2: Red Tree Vole Habitat Enhancement

Because current knowledge of this species presence is limited within the permit area, the primary goal of monitoring for red tree vole in the short term is to gain a better understanding of species presence, with particular emphasis on distribution and abundance within HCAs. Other monitoring goals include gaining a better understanding of species use of young stands and the role that management in HCAs may play in providing young stand habitat. In addition, monitoring may include post-harvest surveys to gain a better understanding of how management activities and conservation actions influence the presence and abundance of red tree voles within the permit area. Potential changes in harvest activities in red tree vole habitat could then be modified, through adaptive management, to further minimize effects on the species. Compliance and effectiveness monitoring metrics are described in Table 6-9.

To establish baseline conditions, ODF will conduct and complete surveys of a subset of suitable and highly suitable habitat within HCAs on the north coast within 15 years of permit issuance. Surveys will begin no later than year 10 following permit issuance. Surveys will start within suitable and highly suitable habitat in proximity to known subpopulations and occupied stands and expand into adjacent habitat of lower quality to gain a better understanding of habitat use. Sampling will include selectively surveying young stands for occupancy, either adjacent to known occupied stands or adjacent to suitable or highly suitable habitat. Monitoring sites will be selected primarily within HCAs and in suitable stands outside, but adjacent to HCAs where harvest is expected, to gain information on how adjacent harvest and associated conservation actions affect species persistence. Stands within the Tillamook and Clatsop State Forests, where isolated subpopulations have been identified but few occurrences have been documented, will be prioritized for monitoring over stands in Western Lane and West Oregon, where the species is more common. Thus, surveys will begin near known occurrences on the Tillamook and Clatsop State Forests.

Monitoring methods will be based on the best available techniques at the time monitoring occurs. At the beginning of HCP, monitoring protocols will generally follow those described in Forsman et al. (2016), which include visually searching for arboreal nests and climbing trees to determine if nests were built by tree voles.

Table 6-9. Red Tree Vole Compliance and Effectiveness Monitoring

	Compliance Monitoring		Effectiveness Monitoring		
Conservation Action	**Monitoring Action**	**Metrics**	**Monitoring Action**	**Metrics**	**Methodology**
Biological Objective 7.1: Occupied Red Tree Vole Habitat					
CA6: Establish Habitat Conservation Areas	Document establishment and maintenance of HCAs	Establish HCAs that include 48,000 acres of suitable and 5,000 acres of highly suitable red tree vole habitat, including areas known to be occupied from previous surveys	Annual reporting on acres and type of silvicultural activity in HCAs, by habitat suitability categories for the covered species, using the timber sale contract administration process	Document acres of suitable or highly suitable habitat in the permit area at 5-year intervals over the permit term and over time link relative changes in habitat quality to silvicultural treatments Complete monitoring of suitable and highly suitable habitat in HCAs by year 20 Conduct targeted follow up monitoring to evaluate species response to management	1. Acres of habitat by suitability category, as modeled from inventory metrics, using densified FIA plot network, LiDAR, and stand exams 2. Difference from baseline acreage and change since last reporting period 3. Monitoring of a subset of management activities and relative changes in habitat quality compared to anticipated modeled outcomes 4. Habitat Validation Monitoring – beginning in year 20 implement a monitoring effort designed to assess nesting activity in the permit area; the effort would be focused on locations with habitat inside of HCAs that have not been surveyed in the past but where occupancy is expected due to adjacency to other occupied areas, or locations where habitat quality has improved to suitable under the HCP. 5. Species presence or presence of nest trees.

	Compliance Monitoring		Effectiveness Monitoring		
Conservation Action	**Monitoring Action**	**Metrics**	**Monitoring Action**	**Metrics**	**Methodology**
CA7: Manage Habitat Conservation Areas	Document use of silvicultural activities used to improve habitat over time	Increase the amount of suitable habitat by 30,000 acres and highly suitable habitat by 34,000 acres, for a total of 78,000 acres of suitable habitat and 39,000 acres of highly suitable habitat by the end of the permit term.	Annual reporting on acres and type of silvicultural activity in HCAs, by habitat suitability categories for the covered species, using the timber sale contract administration process	Document acres of suitable or highly suitable habitat in the permit area at 5-year intervals over the permit term and over time link relative changes in habitat quality to silvicultural treatments Conduct targeted follow up monitoring to evaluate species response to management	Same metrics as CA6.
CA8: Conservation Actions Outside Habitat Conservation Areas and Riparian	Retain legacy structures (e.g., green trees)	Document compliance with Management Standards outside HCAs and RCAs, using the timber sale contract administration close out process	Report exceptions when standards were not able to be implemented and justification Annual reporting on green tree retention from the timber sale contract administration close out process	Confirm compliance with retention standards and protection of nest trees or platform trees as part leave tree strategy.	1. Trend monitoring through densified FIA plot network 2. Pre- and post-activity sampling of selected activities to determine compliance with leave tree strategy. 3. Species presence in managed stands
Biological Objective 7.2: Red Tree Vole Habitat Enhancement					
Same conservation actions, monitoring actions, and metrics as Objective 7.1					

Objective 8.1: Existing Coastal Marten Habitat, and Objective 8.2: Coastal Marten Habitat Enhancement

Initially the monitoring goal for coastal marten is to gain a better understanding of species distribution and habitat use patterns in permit area. Once a better understanding of species distribution and habitat use in the permit area is established, monitoring will focus on evaluating changes in habitat quality for coastal marten following management activities, and eventually species response to changes in habitat quality. Compliance and effectiveness monitoring metrics are described in Table 6-10. Within 15 years of permit issuance, ODF will conduct a multi-species carnivore survey, focused on marten habitat, that covers the range of coastal marten in the permit area. Surveys may include capture and tagging to monitor movements of individuals. As individuals are found, follow up habitat association monitoring will be conducted to determine denning, resting, and foraging features and understory vegetation associations.

Following completion of carnivore surveys, ODF will identify focus areas within which to continue marten monitoring efforts. These areas will prioritize stands in HCAs as well as stands outside of HCAs where management is planned to promote understory growth. Follow up monitoring will be conducted to determine whether management treatments achieved wanted understory species and cover and how coastal marten respond to those changes.

Monitoring methods will follow currently accepted techniques and tools, including non-disturbing camera, track traps, and wildlife detection dogs for presence/absence and relative abundance monitoring and live trapping for tagging and telemetry studies. Vegetation surveys may be conducted at camera stations to quantify habitat conditions, including variables used in habitat models for coastal marten.

Table 6-10. Coastal Marten Compliance and Effectiveness Monitoring

Conservation Action	Compliance Monitoring		Effectiveness Monitoring		Methodology
	Monitoring Action	Metrics	Monitoring Action	Metrics	
Biological Objective 8.1: Existing Coastal Marten Habitat					
CA6: Establish Habitat Conservation Areas	Document establishment and maintenance of HCAs	Establish HCAs that include 27,000 acres of suitable coastal marten habitat, including areas known to be occupied from previous surveys	Annual reporting on acres and type of silvicultural activity in HCAs, by habitat suitability categories for the covered species, using the timber sale contract administration process	Document acres of suitable habitat in the permit area at 5-year intervals over the permit term and over time link relative changes in habitat quality to silvicultural treatments Complete survey of species distribution in first 15 years. Conduct targeted follow up monitoring to evaluate species response to management, located den sites, and potentially collar females	1. Acres of habitat by suitability category, as modeled from inventory metrics, using densified FIA plot network, LiDAR, and stand exams 2. Difference from baseline acreage and change since last reporting period 3. Monitoring of a subset of management activities and relative changes in habitat quality compared to anticipated modeled outcomes 4. Habitat Validation Monitoring – field-based habitat surveys on a rolling basis, in a subset of stands thought to be suitable, in order to confirm microhabitat features necessary for likely species occupancy; surveys in suitable habitat can begin immediately; over time an association of habitat characteristics and LiDAR-based inventory information can be used to better predict habitat quality within the range of the species 5. Species presence; number of dens located

Conservation Action	Compliance Monitoring		Effectiveness Monitoring		Methodology
	Monitoring Action	Metrics	Monitoring Action	Metrics	
CA7: Manage Habitat Conservation Areas	Use silvicultural treatments in HCAs to improve species habitat quality over time	Increase in habitat quality over time in the 27,000 acres in HCAs	Annual reporting on acres and type of silvicultural activity in HCAs, by habitat suitability categories for the covered species, using the timber sale contract administration process	Document acres of suitable habitat in the permit area at 5-year intervals over the permit term and over time link relative changes in habitat quality to silvicultural treatments Complete survey of species distribution in first 15 years. Conduct targeted follow up monitoring to evaluate species response to management, located den sites, and potentially collar females	Same as CA6
Biological Objective 8.2: Coastal Marten Habitat Enhancement					
Same conservation actions, monitoring actions, and metrics as Objective 8.1					

6.6 Adaptive Management

6.6.1 Overview of Adaptive Management Strategy for the HCP

This section describes how ODF will use adaptive management to respond to monitoring results and new information. Chapter 7, *Assurances*, describes how ODF will respond to changed and unforeseen circumstances, including new species listings, climate change, fire, wind events, invasive species, and disease. An overarching goal of the adaptive management program is to optimize implementation of the HCP and all other ODF programs that are related to or support the implementation of the HCP. ODF is striving for efficiency and effectiveness on all fronts and all programs, including how HCP implementation will adhere to that objective.

For the purposes of this HCP, adaptive management is a decision-making process used to examine alternative strategies (e.g., conservation actions) to meet the biological goals and objectives, and, if necessary, adjust future management actions based on new information (U.S. Fish and Wildlife Service and National Marine Fisheries Service 2016). Adaptive management is based on a flexible approach whereby actions can be adjusted as uncertainties become better understood or as assumptions change. Monitoring and learning from the outcomes of past actions is the foundation of adaptive management (Williams et al. 2007).

The conservation strategy of this HCP is based on the best scientific information currently available, and it is expected that the conservation actions will effectively achieve the biological goals and objectives as stated in Chapter 4. However, there are varying degrees of uncertainty associated with the management techniques and conditions within the plan area. Future improvements in forest inventory methods and increased accuracy or precision of important metrics, or improvements in species habitat models, may result in different estimations of current and projected habitat trends. Results of effectiveness monitoring may indicate that some management techniques are more or less effective than anticipated, resulting in an increase or decrease in their use, or modifications in how they are implemented. Evolving science on the habitat requirements, life histories, and distributions of covered species may inform changes to the pattern of implementation of strategies on the landscape. Monitoring strategies themselves may change, as they are improved to better quantify or describe specific habitat metrics.

To address these uncertainties, the monitoring and adaptive management program allows ODF to learn from experience and reevaluate and revise the type, extent, and location of conservation actions when necessary to meet the biological goals and objectives of the HCP.

6.6.2 Adaptive Management Process

The adaptive management process will follow the conceptual model provided in the HCP Handbook (USFWS and NOAA Fisheries 2016). The model includes a series of steps for identifying problems and their sources, designing and implementing responses to problems, and evaluating the effectiveness of the responses, resulting in a cycle of continuous learning and improvement (Figure 6-1).

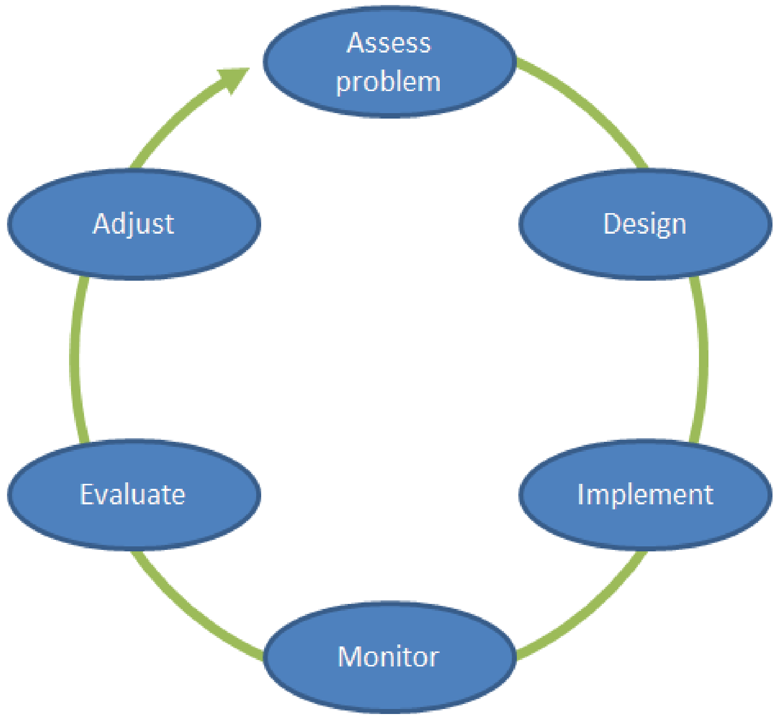


Figure 6-1. Adaptive Management Concept Model

The monitoring program will be ***designed*** and ***implemented*** as described earlier in this chapter. Monitoring results will be evaluated as described below and adjusted as necessary, following collection and assessment of results.

1. **Monitor**
    a. The monitoring and reporting program will be implemented at the district and plan-wide levels as described in Sections 6.1, *Monitoring and Adaptive Management Program*.
    b. Monitoring teams, ODF staff, and forest management contractors will assess and identify deficiencies, lessons learned, new information, new techniques, or other opportunities for improvement; and compile and report such information and associated recommendations to the appropriate district staff to forward to the HCP administrator.
    c. Monitoring results and associated lessons learned will be compiled and documented in annual reports.
    d. There will be annual reports, 5-year midpoint check-ins, and 10-year comprehensive reviews. It is expected that most potential adjustments to specific management techniques will occur during 10-year comprehensive reviews.
2. **Evaluate**
    a. The HCP administrator will evaluate this information to identify current and projected levels of accomplishment in achieving biological goals and objectives and where an adaptive management response may be appropriate. This includes the identification of areas of both under- and over-accomplishment.
    b. The administrator will facilitate discussions among ODF staff, the Services, and state agencies to fully understand the trends identified and evaluate options for adjustments or

corrective actions. ODF will then select an adaptive management response from among those alternatives that are within the scope of the conservation actions detailed in Chapter 4.

3. **Adjust**

   a. The corrective or adaptive management response will be defined and adjustments made at the appropriate planning level, including adjustments to budgets, operations plans, implementation plans, and policies (see Section 6.3.3, *Range of Adaptive Management Adjustments*).

   b. As stated above, monitoring results will be tracked, as will any modifications to management practices or alternative strategies selected for implementation in response to monitoring results.

ODF will also coordinate and share the results of monitoring and the effectiveness of adaptive management responses with USFWS, NOAA Fisheries, Oregon Department of Fish and Wildlife, Department of State Lands, Department of Environmental Quality, county partners, stakeholder groups, and the public.

6.6.3 Range of Adaptive Management Adjustments

Before the USFWS and NOAA Fisheries can issue a permit under the HCP, there must be a clear understanding and agreement between them and ODF as to the range of adjustments to the management actions that might be required as a result of any adaptive management provisions (USFWS and NOAA Fisheries 2016). The HCP Handbook further states that changes to the conservation program should be planned to minimize the need for amending the permit.

Toward these ends, adaptive management under the HCP is not expected to require changes to biological goals and objectives of the HCP. Rather, the range of adaptive management adjustments is expected to fall within operational level planning, including adjustments to annual budgets, project-specific operation plans, 10-year implementation plans, and operation policies, as described below.

- **Budgets** are prepared both biennially and annually and have a major effect on the type and extent of management activities conducted in any given year. The HCP administrator will consider results of monitoring, recommended adaptive management adjustments and needs, as well as new information and available funding opportunities and constraints when developing annual budgets and work plans and adjust budgets accordingly.
- **Implementation Plans** are developed to detail how management strategies that are outlined in the HCP, Forest Management Plan, or operational policies will be implemented at the management unit level (e.g., geographic area). Implementation plans describe forest management activities for a predetermined period—typically 10 years—and will be revised either at the end of the period or sooner if circumstances warrant. ODF decisions regarding implementation plans will be informed through 10-year comprehensive reviews of HCP implementation and monitoring, supplemented by annual or other periodic reporting within the implementation period. Adaptive management changes to implementation plans will include changing the type and extent of planned management activities, including specific HCP conservation activities that will be implemented in each district. The HCP administrator will weigh the monitoring and scientific information, HCP biological goals and objectives, and successes and challenges of past conservation actions when considering the approval of

proposed habitat management activities within HCAs and enhancement activities in RCAs, and related adaptive management adjustments to implementation plans. For example, if HCP implementation is at risk of falling behind stay ahead requirements, an increase in conservation actions may be required in the next IP.

- **Operation policies** are written and revised on an as-needed basis, and typically include a policy statement, goals, responsibilities, and standards that provide direction to ODF forest planners in developing implementation and operation plans. In response to HCP monitoring results, ODF may revise existing policies or develop new policies, particularly where major deficiencies are identified through monitoring or when significant new science or management techniques become available.

Figure 6-2 summarizes the range of planning levels under which adaptive management will be applied as needed to respond to deficiencies identified through monitoring or to respond to new information and management techniques.

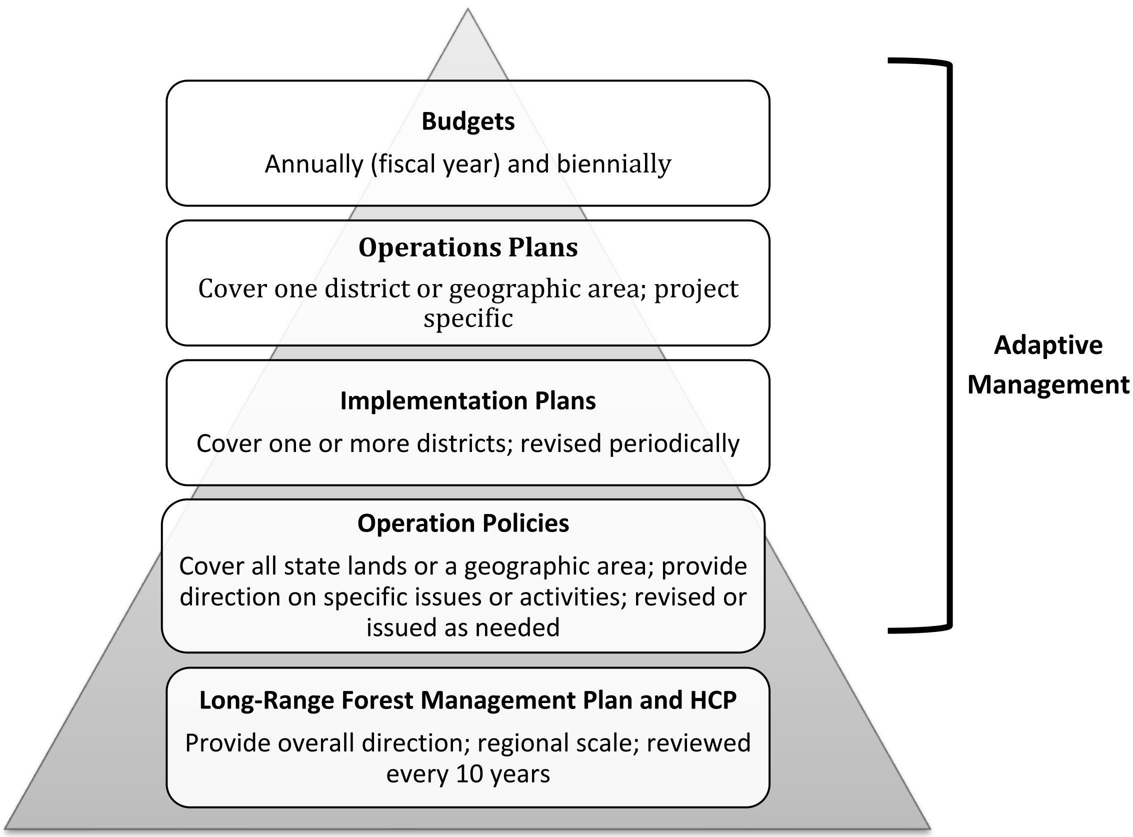


Figure 6-2. Range of Adaptive Management Adjustments Within State Forest Management Planning Levels

It is important to note that the range of adaptive management responses at all planning levels falls within the range of covered activities described in Chapter 3. Adaptive management adjustments will involve modifications to the way covered activities are implemented, including the number, extent, and location of covered activities as well as project-specific designs and specifications.

Any adaptive management adjustments made during implementation of the HCP will be documented in the annual reports ODF will prepare and submit to USFWS and NOAA Fisheries for the duration of the permit. Annual reports will also include details on compliance, impacts, conservation actions, and monitoring activities and results. In addition to documenting changes through adaptive management in annual reports, ODF will complete a 5-year midpoint check-in and a 10-year comprehensive review, at which time the entire monitoring program will be assessed along with the efficacy of conservation actions and modifications will be implemented accordingly.

6.6.4 Adaptive Management Triggers

Adaptive management responses will be triggered when monitoring or other information indicates either of the following.

- Existing practices are under- or over-achieving the biological goals and objectives.
- Alternative practices are available that can achieve biological goals and objectives more efficiently and effectively.

Triggers will vary with the level of planning at which adaptive management is being considered, with major adjustments being made at the policy and implementation planning levels and more minor adjustments being made at the operations plan and budget level (Table 6-11). Triggers may also change based on the frequency of new monitoring results, due to the frequency with which data are collected or available (e.g., degree of annual variation in baseline conditions or timescale of the response variable). For instance, species responsiveness or detectability may vary considerably year to year, or habitat response to silvicultural activities may take many years.

Table 6-11. Adaptive Management Triggers at Different Planning Levels

Planning Level	Potential Trigger	Adaptive Management Response Example
Budgets	The conservation fund is not generating sufficient funding to implement conservation actions as described in the HCP or additional actions are needed to respond to monitoring results.	Reevaluate and reallocate budgets and identify opportunities for additional funding sources and partnerships.
Implementation Plans	Deficiencies identified through monitoring	Add corrective actions to implementation plan. Adjust type, number, extent, and location of planned operations.
Operation Policies	Major deficiencies identified through monitoring or based on significant new science or management techniques	Revise existing policy or create new policy

The specific type of adaptive management triggers and associated responses will also vary on the specific monitoring metric indicating potential deficiencies. Table 6-12 provides examples of the range of conservation actions expected to be potential areas for adaptive management and associated metrics, triggers, and adaptive management responses. All adaptive management responses will begin with a determination of the underlying causes of deficiencies/triggers identified. Note that while the examples in Table 6-12 focus on deficiencies, the same rationale can be applied where desired outcomes are overachieved, resulting in allowance for increased management flexibility.

Table 6-12. Potential Triggers for Adaptive Management

Aquatic Actions	Potential Trigger	Adaptive Management Response Example
Wood Recruitment in Streams	Trend in large wood frequency/volume in streams is not increasing in watersheds where wood is a limiting factor for covered fish species.	Revise implementation plans during the subsequent 10-year planning cycle to incorporate additional wood enhancement.
Stream Temperature	Temperature increases are detected in perennial streams within or above fish-bearing stream despite implementation of riparian conservation areas.	Consider targeted riparian conservation strategy adjustments in locations where temperature increases are detected and similar stream segments in the permit area. Potentially revise implementation plans during the subsequent 10-year planning cycle to modify amount of harvest in an affected watershed.
Stream Enhancement	Stream enhancement projects are not being completed or are not achieving expected results. Biological return on investments not realized.	Identify and capture additional opportunities to fund and implement stream enhancement. Increase number of stream enhancement projects identified in implementation plans. Apply lessons learned to selection and design of operations plans to improve efficiency and effectiveness of stream enhancement projects.
Road Improvement and Vacating	Sediment and flow impacts from roads identified within a catchment.	Identify opportunities for road improvement to treat problem areas, through adjustments to budgets and operations and implementation plans.
Fish Passage	Passage enhancement projects do not achieve intended results. Return on investments not realized.	Rectify specific projects as practicable. Apply lessons learned to selection and design of operations plans to improve efficiency and effectiveness of fish passage improvement projects.
Terrestrial Actions	**Potential Trigger**	**Adaptive Management Response Example**
HCA Habitat for Covered Species	Trends in habitat development are below 5-year projections for one or more covered species.	Increase number and extent of enhancement treatments at the implementation plan level, where and when appropriate. Reevaluate and revise management prescriptions defined in operation and implementation plans and operation policies.
		Reevaluate and revise operations plans and implementation plans accordingly.
HCA Management	Results of habitat treatments (e.g., thinning) do not seem to be achieving intended trend in habitat improvement. Return on investments not realized (i.e., cost/benefit).	Adjust enhancement treatments through operations and implementation plans. Revise or adjust enhancement treatment prescriptions to improve efficiency and effectiveness.

Aquatic Actions	Potential Trigger	Adaptive Management Response Example
Riparian Buffers	Over time, debris flow studies show that riparian buffers are insufficient at capture debris, when slides occur.	Reconsider buffering strategy on specific stream types or in specific locations, to address debris flow issues on future sales and roads.
Leave Trees and Downed Wood	Leave trees or downed wood are not persisting on the landscape as intended.	Apply lessons learned to selection and design of future operations plans. Adjust leave tree and downed wood prescriptions.

Additional triggers may be identified as part of routine annual reporting, 5-year midpoint check-ins, or as part of the 10-year HCP comprehensive reviews. New triggers may also be added in response to new science or emerging issues that influence biological outcomes in the permit area. New triggers can be added at any time during implementation and will be set so that they provide a warning of trends in the wrong direction in enough time to make adjustments.

6.6.5 Adaptive Management and Climate Change

The HCP addresses the anticipated effects of climate change in several ways. As described in Chapter 4, measures to increase resiliency of habitats and species have been incorporated into the conservation strategy, including providing adequate habitat to sustain the persistence of covered species within the permit area in the face of potential habitat losses due to fire, wind, drought, insects, and disease. In addition, the distribution of proposed conservation actions occur throughout the planning area, across elevation gradients and diverse forest types, providing a network of areas that would continue to meet biological goals and objectives even if portions of some areas are adversely affected by climate change.

And as described in Chapter 7, climate change is also considered in anticipation of potential changed and unforeseen circumstances, and the HCP includes assurances that changed circumstances due to climate change will be addressed through the triggers and associated remedial measures identified in Chapter 7.

In terms of adaptive management, climate change effects may be detected through monitoring results that will in turn trigger adaptive management responses, following the adaptive management process previously described. This includes effects that may act as stressors for the covered species, as well as those that present risks to the maintenance and enhancement of the quantity and quality of habitat. As such, ODF will use adaptive management to respond to climate change effects at the operational level, including adjustments made to budgets, operations plans, implementation plans, and policies. Due to the broad scope and effects of climate change on covered species, ODF anticipates that adaptive management for climate change will be informed through ongoing discussions and coordination at a state and federal level with other major forest land owners in western Oregon, including private industrial forest land owners, federal land managers (the Bureau of Land Management and U.S. Forest Service), and tribal governments and natural resource agencies.

Chapter 7
Assurances

7.1 Introduction

This chapter discusses the rights and responsibilities of the Permittee (Oregon Department of Forestry [ODF]), U.S. Fish and Wildlife Service (USFWS), and National Oceanic and Atmospheric Administration (NOAA) Fisheries regarding changed and unforeseen circumstances that may occur over the permit term. The No Surprises Regulation limits the scope of a Permittee's requirement to provide additional mitigation under the Endangered Species Act (ESA).

7.2 Federal No Surprises

The federal No Surprises Regulation was established on March 25, 1998. It provides assurances to Section 10 permit holders that no additional mitigation in the form of money, water, or land, or restrictions of land or water will be required should unforeseen circumstances arise once the permit is in place. The No Surprises Regulation states that if a Permittee is fully implementing an HCP that has been approved by USFWS and/or NOAA Fisheries, no additional commitment of resources or limitations on land uses, beyond that already specified in the plan, will be required unless the plan is amended.

ODF requests regulatory assurances (No Surprises) for all covered species in the HCP. In accordance with No Surprises, ODF will be responsible for implementing and funding measures in response to any changed circumstances, as described in this chapter. ODF will not be obligated to address unforeseen circumstances but will work with the USFWS and NOAA Fisheries to address them within the funding and other constraints of the HCP should they occur.

ODF understands that No Surprises assurances are contingent on the full implementation of the HCP and permits. ODF also understand that USFWS or NOAA Fisheries may suspend or revoke the federal permit, in whole or in part, in accordance with federal regulations (50 Code of Federal Regulations [CFR] Sections 13.27, 13.28, and 222.306 and other applicable laws and regulations) in force at the time of such suspension. See Section 8.10, *Permit Suspension or Revocation,* for details related to this process.

7.3 Changed and Unforeseen Circumstances

7.3.1 Changed Circumstances

Changed circumstances are defined in the federal No Surprises Regulation.[1] With respect to HCPs, Congress recognizes that "circumstances and information may change over time and that the

[1] 63 *Federal Register* 35 (1998) (amending 50 CFR 17.22(b)(5), and 222.307(g)).

original plan might need to be revised" (H.R. Rep. No. 97-835, 97th Congress). Section 10 regulations[2] describe changed and unforeseen circumstances and specify procedures for addressing changed circumstances that may arise during the permit term. Changed circumstances describe what changes can be anticipated over the permit term and thus bind the Permittees' commitments to address those changed circumstances, as described above.

7.3.2 Unforeseen Circumstances

Unforeseen circumstances are defined by federal regulation as "changes in circumstances affecting a species or geographic area covered by a conservation plan that could not reasonably have been anticipated by plan developers and the USFWS or NOAA Fisheries at the time of the conservation plan's negotiation and development, and that result in a substantial and adverse change in the status of the covered species." By definition, any circumstance not described in this HCP or as a changed circumstance in this chapter is considered an unforeseen circumstance. ODF is not obligated to respond to an unforeseen circumstance but may do so voluntarily.

7.3.3 Changed Circumstances Addressed by this HCP

Under ESA Section 10, an HCP is required to identify anticipated and possible changed circumstances that could arise during its implementation. Identifying strategies and protocols for addressing such anticipated changes allows for appropriate program adjustments. ODF will maintain sufficient financial reserves to fund any remedial actions that may occur throughout the permit term as described in Section 9.2.4, *Remedial Measures for Changed Circumstances*.

Climate change poses the most uncertainty and risk to state forests. Warmer, drier summers with more extreme heat events, and more extreme precipitation events in winter are expected in Western Oregon (Spies et al. 2018). Climate change will likely be a driver for many of the changed circumstances described below, increasing the potential for these events to occur. For example, weather pattern changes may affect forest productivity and health and biodiversity in unforeseen ways, as well as have large but variable effects on species and ecosystems, including increased frequency and severity of drought, fire, invasive species outbreaks, or other disturbances. These more frequent and intense disturbances may quickly change habitat conditions for covered species in the plan area.

Climate change resulting from increased concentrations of atmospheric carbon dioxide is expected to result in warmer temperatures and changed precipitation regimes during this century. Climate change is expected to diminish tree health and improve conditions for some highly damaging pathogens (Kliejeunas et al. 2009). The effects of climate change also are generally expected to predispose forests to more and larger wildfires and additional outbreaks of insects and disease; reduce growth and survival; and ultimately change forest structure and composition at the landscape scale. Species ranges are expected to shift northward and upward in elevation.

Additionally, if streams and rivers across the northwest U.S. warm this century, that will have biological implications for both the quality and quantity of habitats available to species of regional importance like salmonids. Ongoing temperature increases will profoundly influence the ecology of salmonids, in particular. Climate change is projected to alter the flow regimes of streams and rivers, with consequences for physical processes and aquatic organisms (Spies et al. 2018). The volume of

---

[2] 50 CFR 17.22(b)(2), 17.32(b)(2), and 222.307.

available habitat is shrinking as summer stream discharges across the region continue multi-decadal declines that have also been partially linked to climate change (Isaak et al. 2012). Warm water predatory fish, such as bass, will likely impact the survival and recovery of salmonids.

Because of the variability of climate change and because it is so interconnected to fire, storm/wind events, and invasive species, thresholds discussed below for setting changed circumstances take into account any potential implications of climate change.

7.3.3.1 New Species Listings

Over the course of the permit term (70 years), USFWS or NOAA Fisheries could list species that are not covered under the HCP as threatened or endangered. ODF will know when a noncovered species associated with habitat in the permit area has been proposed for listing, becomes a candidate for listing, or is emergency-listed because it is a publicly noticed process. During the annual reporting process ODF will review and consider any pending listing decisions that may influence the status of species that occur in the permit area.

Changed Circumstance

This changed circumstance will be triggered when ODF receives public notification that a noncovered species associated with habitat in the permit area has been proposed for listing, becomes a candidate for listing, or is emergency-listed.

Response

Following such public notification, ODF will take the following measures.

1. **Determine the potential species to occur in the permit area.** Once a species is listed ODF will evaluate and determine the potential distribution of the species on ODF managed lands and the necessary coordination with USFWS and/or NOAA Fisheries.
2. **Coordinate with USFWS and/or NOAA Fisheries and implement Agency-provided avoidance measures.** If ODF determines that the newly listed species may be present in the permit area, they will initiate coordination as soon as this is determined. Through technical assistance with the USFWS or NOAA Fisheries, the potential effects of covered activities on the newly listed species will be evaluated, including an assessment of the presence of suitable habitat in the permit area. If ODF and USFWS or NOAA Fisheries determine that the newly listed species occurs or could occur in the permit area, ODF will identify and implement any necessary measures provided by USFWS (in Habitat Conservation Areas [HCAs]) or NOAA Fisheries (in Riparian Conservation Areas [RCAs]) to avoid take of the species. ODF will implement the interim take avoidance guidelines for the species until the permit amendment is finalized, or an alternate permit is issued to ensure compliance with the ESA. Permit amendments to include additional covered species require amendment to the HCP and the appropriate permit. Such an amendment would require USFWS or NOAA Fisheries to re-initiate Section 7 consultation and conduct a National Environmental Policy Act (NEPA) analysis prior to their decision of whether to approve or deny the amendment.
3. **Apply for permit amendment or alternative take coverage**. If ODF proceeds with activities that have the potential to cause take of the newly listed species, they can only begin those activities after the HCP permit is amended or take authorization is granted through a separate permitting process.

7.3.3.2 Temporary Change in Species Habitat Quality From Natural Events

Some natural events can cause significant temporary changes in terrestrial species habitat quality. Natural events that occur in a forested landscape in western Oregon, including the permit area, include:

- Fire
- Storms (e.g., ice, wind, snow)
- Invasive species and disease

The following sections summarize how these natural events have affected forests within the permit area historically. That information provides context for the thresholds defined for this HCP and used to determine what would be considered a changed circumstance versus an unforeseen circumstance. The proposed responses to these changed circumstances are described after the summary of these natural events.

Fire

State forests have a legacy of repeated, large-scale wildfires. Wildfires can be natural or human caused events. The effects on state forest lands are the same, no matter the initiation cause. Before fire suppression techniques were introduced to the area, the dominant disturbance to forests was fire. Low-intensity fires were historically frequent in dry interior Oregon forests, and were key to maintaining wildfire resilience, forest structure, and ecosystem health. However, wildfires were typically much less frequent, but much more intense in western Oregon and coastal forests. Forest fires have burned hundreds of thousands of acres in western Oregon over the past century. In August 1933, a wildfire burned approximately 240,000 acres of mostly old growth forest in Tillamook State Forest. Fires again burned the Tillamook area in 1939, 1945, and 1951. Some areas burned three or four times. By the end of 1945, 355,000 acres had burned. Over the last 20 years, 1,160 acres have burned in the Southwest District.

From 1960–2019 there were 1,208 fires that burned 2,775 acres of ODF managed land in the permit area (Table 7-1). Fires were generally infrequent and small. In 2020, the Labor Day Fires event burned over 24,000 acres of ODF management lands, primarily in the Santiam State Forest. Similar to the Tillamook Burn, this was a rare, wind-driven event that left a mosaic of burn severity on the landscape. This event was viewed as an anomaly compared to other years, and is therefore not included in the summary of fire history below.

Table 7-1. Fire History on ODF Managed Lands by District (1960–2019)

District	# of Fires	Acres Burned	Average Acres Burned per Fire
Northwest Oregon	628	1,176	2
West Oregon & North Cascades	124	439	4
Western Lane & Southwest	456	1,160	3
Total	1,208	2,775	2

Storm Events

Storm events (e.g., ice storms, severe wind, heavy snow) can lead to under-productive forest conditions and susceptibility to insects and disease. These stands often require immediate action to restore resilient and productive forest conditions.

Northwest Oregon experiences periodic severe windstorms. The Columbus Day storm on October 12, 1962, blew down an estimated 17 billion board feet of timber in western Oregon and Washington. As is typical of most disturbances, windstorms interact with other events in many ways. After the Columbus Day storm in 1962, Douglas-fir bark beetles killed an additional 2.6 billion board feet of timber by 1965.

The Great Northwest Gale occurred over 3 days in December 2007 and was the most impactful storm event to hit western Oregon since the Columbus Day storm.

In addition to those named storms, there have been eight other major storm/wind events since the Columbus Day storm in 1962: in 1981, 1993, 1995, 1996, 2006, 2007, 2015 (2), and 2016.

Invasive Plant Species and Disease

Nonnative species and diseases currently occur in the plan area, including invasive weeds, insects, and pathogens. Scotch broom and Himalayan blackberry, the state's costliest weeds at nearly $80 million annually due to lost timber revenue and direct control measures, are prevalent through most of the region. Other invasive species like laminated root rot, caused by the fungal pathogen *Phellinus weirii,* and spruce aphid and balsam woody adelgid have caused severe tree mortality within the plan area.

There are also nonnative species and diseases that exist in areas outside the plan area that have the potential to spread into the plan area and adversely affect the covered species. Emerald ash borer has caused extensive damage to ash trees across the United States. If it invades Oregon, it would cause local extinction of ash trees within 10–20 years, likely causing changes in stream temperatures and associated changes in plant animal communities in riparian areas below 2,000-foot elevation. Sudden oak death, caused by the nonnative pathogen *Phytophthora ramorum*, is currently present in Oregon, but is confined to Curry County. Future spread to other counties would impact forest viability. European and Asian Gypsy moth, while not established in Oregon, have the potential to have long-lasting negative impacts on state forests if they were to establish. Increasing popularity of recreational activities in state forests increases the likelihood of new invasive species being introduced, which, in turn, could affect long-term forest health.

A disease or invasive species that spreads throughout the plan area within the permit term is a foreseeable event. If a disease or nonnative species spreads beyond the thresholds identified below, however, it will be considered an unforeseen circumstance.

Changed Circumstance

Any of the natural events described above will be considered a changed circumstance if up to 50% of any one HCA is impacted in 1 calendar year or up to 5,000 acres of HCAs collectively are impacted in 1 calendar year from any combination of these events. These thresholds account for functionality of individual HCAs and HCAs at a landscape scale, and more than account for the average acreage of disturbance events on ODF-managed lands over the past 60 years, even when inducing the Labor Day fires. If more than 50% of any one HCA or more than 5,000 acres of HCAs collectively are affected by any combination of these events in 1 calendar year, that will be considered an unforeseen circumstance.

No changed circumstances are defined for RCAs. RCA buffers will be maintained throughout the permit term, and there will be no salvage logging in HCAs or RCAs. Felling of hazard trees or removal of downed trees may be conducted where necessary for public safety, or to protect infrastructure. Where RCAs have been affected by wildfire, an assessment will be performed to determine post-fire conditions, including natural regeneration of riparian areas, instream habitat and water quality, and soil condition. ODF may determine, based on findings of the assessment and monitoring results, that select sites would benefit from active restoration to improve regeneration of riparian vegetation, in-stream habitat, and/or water quality. Sites identified for active restoration would be prioritized based on the following criteria: (1) presence of HCP covered species, (2) burn severity, (3) soil or water quality conditions, and (4) degree of natural regeneration.

Response

ODF will implement remedial measures to address the temporary loss of species habitat due to natural events following the steps listed below. The steps are aimed at determining whether the changed circumstance from natural events would potentially undermine ODF's ability to successfully implement the conservation strategy as described in Chapter 4.

Step 1: Quantify habitat loss from the natural event for each of the affected covered terrestrial species, based on modeled habitat.

Step 2: Determine whether ODF is still meeting the Stay-Ahead provision (as described in Chapter 8, *Implementation*) for each covered species despite the habitat loss incurred by the natural event, using modeled habitat. If the Stay-Ahead provision is still being met for a given covered species no further response is needed. If the Stay-Ahead provision is not being met for one or more species, move to Step 3.

Step 3: Examine current Implementation Plans to assess potential harvest within the range of the covered species that is now not meeting the Stay-Ahead provision and adjust harvest in proximity to the disturbance event where feasible, with the aim of providing temporary refuge for the species. Identify potential harvest activities whose deferment may provide suitable habitat refugia of a similar size to the acres affected by the natural disturbance. Activities identified for deferment will be observed until the Stay-Ahead provision for all covered species can again be met, or until the end of the Implementation Plan cycle, whichever comes first. If, despite deferments, the Stay-Ahead provision cannot be met by the end of the Implementation Plan cycle, the 10-year Comprehensive Review will identify necessary actions to meet the Stay-Ahead requirement during the next Implementation Plan. In no event shall deferments associated with any specific disturbance event exceed 20 years. Potential deferments will not result in reductions to Implementation Plan harvest volume or acres in total, it is only meant to shift harvest priorities to locations that will allow the portion of the permit area affected by the natural event to recover for a period of time, before harvest there resumes.

1. Priorities for locations to temporarily defer harvest are (in order of priority):Harvest in HCAs within the range of the covered species not meeting the Stay-Ahead requirement, that is not part of an operation currently under contract.

2. Harvest outside HCAs but within the same subgeographic area[3] where the natural disturbance occurred, that is not part of an operation currently under contract or planned within the current Annual Operations Plan.
3. Harvest outside HCAs in different subgeographic area than where the natural disturbance occurred, but still within the range of the covered species not meeting the Stay-Ahead requirements, that is not part of an operation currently under contract or planned within the current Annual Operations Plan.

7.3.3.3 Aquatic Invasive Plants, Nonnative Fish and Disease/Parasites

Nonnative aquatic plant species, disease, and warm water predatory fishes may currently occur in portions of the plan area as well as outside the plan area. Aquatic invasive plant species like Knotweeds (*Polygonum* spp.) can inundate streamside habitat in open areas, where it displaces native vegetation and can increase streambank erosion (OSU 2013).

Introduction and/or expansion of nonnative fish, such as the brook trout (*Salvelinus fontinalis*),compete with the covered species for cold water spawning and rearing habitat. As stream temperatures increase, the range of nonnative warm water predators, such as smallmouth bass that predate upon juvenile salmon and steelhead, expands. Rising stream temperatures also increase the susceptibility of the covered salmon and steelhead to disease and parasitic loads due to increased disease virulence and fish crowding at low flows (Crozier 2016).

The spread of aquatic invasive species can affect native species. Under the HCP ODF will be managing the RCAs in the permit area in accordance with the biological goals and objectives to ensure the riparian and aquatic habitat is maintained (e.g., riparian forests, shading, no harvest) to benefit the covered species. If an invasive aquatic plant(s) were to expand its range within the permit area, to the point at which it becomes a limiting factor for habitat quality for covered species, ODF will work with the Department of Agriculture to identify measures necessary to eradicate the plant. Similarly, if expansions of nonnative fish (warm or cold water) into the permit area begin to outcompete the covered salmon and steelhead, to a point where it becomes a limiting factor for covered species populations in the permit area, ODF will coordinate with the Oregon Department of Fish and Wildlife (ODFW) on what measures, if any, should be taken to address the species expansion.

Changed Circumstance

Under the HCP, changed circumstances are only considered for aquatic invasive plants, for which ODF will fund remedial measures:

- Spread of aquatic invasive plants species within an RCA that affects up to 25% of stream miles within any given hydrologic unit code (HUC) 10 independent population of salmon or steelhead within a 3-year time period. Any new invasion that expands beyond 25% within a 3-year time period will be considered unforeseen.

[3] The permit area is divided into three subgeographic areas: North Coast, Willamette Valley, and South Coast.

Response

ODF will address changed circumstances using manual, mechanical, cultural, and biological treatments to manage new occurrences of invasive plant infestations within the permit area.

For unforeseen circumstances ODF may still coordinate a response with ODFW and other state and federal agencies, but it would not be required by the HCP.

7.3.3.4 Stream Temperature Changes

Climate change is projected to raise temperatures and alter the flow regimes of streams and rivers within the plan area, which will have consequences for physical processes and aquatic organisms, including covered fish species and their habitats. Water temperature plays a critical role for fish and other aquatic organisms in rivers and streams because their biological processes are directly controlled by ambient water temperatures (Neuheimer and Taggart 2007, Buisson et al. 2008, Pörtner and Farrell 2008, Durance and Ormerod 2009). As climate change continues to impact normal weather patterns in the Pacific Northwest, the effects of climate change increasingly manifest through changes in air temperature (Barnett et al. 2008, Walsh et al., 2014), seasonal patterns of snow accumulation and stream runoff (Luce et al. 2013, Mote et al. 2005, Stewart et al. 2005), and increasing wildfires (Littell et al. 2016, Westerling et al. 2006). All of these changes, increases in air temperature, changes in seasonal rain and snow patterns and run-off, and wildfires also impact stream temperature and flow.

Changed Circumstance

While water temperature varies over time based on location, time of day, and season, stream temperatures across the Pacific Northwest averaged 58°F (14.2°C) from 1993–2011 (Isaak et al. 2018). Based on climate change model scenarios water temperature in streams and rivers can be expected to increase on average by 2°F and 3.5°F (0.73°C and 1.4°C) by 2040 and 2080, respectively (Isaak et al. 2017).

Based on this modeled climate scenario, average annual water temperatures rising more than 3.5°F (1.4°C) during the Permit Term would be considered unforeseen.

Response

In response to potential changes in water temperature and flow from climate change, ODF will take preventative measures for streams and rivers in the RCAs. These measures may include, but are not limited to, the following.

- Maintain stream buffers to keep rivers and streams shaded by maximizing shade from vegetation.
- Expand stream buffers in key locations on fish bearing streams or in perennial non-fish bearing streams upstream of covered fish presence to further minimize risk of temperature rise should the HCP monitoring program establish that stream temperatures are rising despite use of stream buffers thought to be adequate.
- Reconnect streams to floodplains and protect seeps, springs, and wetlands to facilitate flow.

- Increase the potential of large wood production to the streams through the buffers within the RCAs. Increased bed load will lead to cooler ground water temperature reducing stream temperatures.
- Actively place large wood structures instream to provide habitat for covered species.
- Manage RCAs to increase beaver habitat and presence where possible.

Chapter 8
Implementation

8.1 Overview

This chapter describes how the Western Oregon State Forest Habitat Conservation Plan (HCP) will be implemented, including the roles and responsibilities of participating state and federal agencies, data tracking and reporting, coordination during implementation, and plan modifications.

8.2 Implementation Roles and Responsibilities

8.2.1 Oregon Department of Forestry

The Oregon Department of Forestry (ODF) will oversee HCP implementation, including staffing internal positions, hiring consultants, reporting, monitoring, and maintaining all program records. ODF staff includes biologists, foresters, administrators, and other natural resource specialists who will carry out planning, monitoring, adaptive management, and as-needed coordination with and reporting to the U.S. Fish and Wildlife Service (USFWS) and National Oceanic and Atmospheric Administration (NOAA) Fisheries (collectively, the Services), including annual reporting. To implement the HCP, ODF will assign HCP implementation responsibilities to staff within the State Forests Division. Table 9-1 in Chapter 9, Cost and Funding, summarizes assumptions about staff time and time allocation across the HCP program.

8.2.1.1 HCP Administrator

ODF will assign HCP implementation responsibilities to the Resource Support Unit Manager within the State Forests Policy and Technical Support Team, who will serve as the HCP Administrator. The HCP Administrator will serve as a point of contact for HCP-related issues between ODF, USFWS, NOAA Fisheries, and the Oregon Department of Fish and Wildlife (ODFW). The HCP Administrator is expected to report to the Deputy Chief of Policy and Technical Support, and will also provide support for and oversee the following tasks.

- Develop and maintain annual budgets and work plans for HCP implementation. Annual budgets will be incorporated as specific line items into the State Forests Division's fiscal budgeting process and Fiscal Year Operating Plan.
- Coordinate communication and decision-making within ODF on HCP implementation and between ODF, USFWS, NOAA Fisheries, and ODFW, as needed.
- Coordinate compliance and effectiveness monitoring activities.
- Maintain effectiveness and compliance monitoring and survey data reports and archives, including monitoring results, and produce an annual report.
- Coordinate the development of policies needed to communicate HCP expectations and requirements to staff.

- Coordinate updates to existing policies, guidelines, and business practices to align with HCP requirements, as needed.
- Ensure adequate training for ODF staff on HCP implementation, including all compliance requirements.
- Answer internal HCP-related questions.
- Coordinate the conservation funding and priority of projects.

8.2.1.2 Data Analyst

The State Forests Division Information Management Specialist will serve as the lead Data Analyst for the HCP and will develop a geographic information system (GIS) and other database systems to collect, store, and use spatial data necessary for HCP implementation. Compliance and effectiveness monitoring will be tracked in part through the GIS database system. In addition, the status and trends of covered species habitat across the plan area will be tracked through this system, combined with timber stand inventory data.

8.2.1.3 Staff and Field Biologists

The Staff Biologist and Staff Aquatic and Riparian Specialist, within the State Forests Resource Support Unit of the Policy and Technical Support Team, will serve as the lead biologists for the terrestrial and aquatic HCP strategies, respectively. They will provide policy direction and technical assistance for implementing HCP conservation actions within the permit area, help guide key monitoring and adaptive management, and assist in the selection and prioritization of projects that will receive conservation funds.

Two lead field biologists will be primarily responsible for implementation of HCP conservation actions as part of ODF's regular planning cycles and providing direct technical assistance to field foresters. These positions are within the Planning Unit of the State Forests Planning and Coordination Team, but will work closely with the lead biologists to ensure consistency in application of conservation actions.

8.2.1.4 Other Specialists

Other specialists will collaborate with the positions listed above to implement the HCP conservation actions. While many specialists will be needed to support HCP implementation, collectively their time will comprise one full-time position, as shown in Table 9-1. These positions include the following.

- State Forests Engineer (Resource Support Unit): Consults with field Roads Specialists to minimize road effects in Habitat Conservation Areas (HCAs) and Riparian Conservation Areas (RCAs), consults on best management practices in road design and fish passage structures, and helps prioritize and implement restoration activities related to vacating of roads.
- State Forests Geotechnical Specialist (Planning and Coordination Team): Evaluates potential landslide initiation areas or other features that may affect RCAs, and buffers features to ensure RCA strategies for potentially unstable slopes function as intended.

- State Forests Adaptive Management Specialist and Monitoring Specialist (Resource Support Unit): Plans, coordinates, and implements monitoring and adaptive management activities for the HCP, and suggests improvements to conservation actions to more efficiently and effectively achieve the Biological Goals and Objectives.
- State Forests Forest Analyst (Resource Support Unit): Conducts modeling and analysis of habitat suitability, using metrics derived from forest inventory data.

8.2.2 Oregon Board of Forestry

Once the NEPA process and federal permit decisions are complete, the Board of Forestry will determine whether to accept the permit as issued. During implementation, ODF and the HCP Administrator will provide the Board of Forestry with periodic updates on the status of HCP implementation and progress towards achieving the biological goals and objectives of the HCP.

The Board of Forestry is also responsible for approving Forest Management Plans (FMPs) that guide the operations of ODF. All FMPs will be aligned with the requirements of the HCP and therefore consistent with the HCP. FMPs cannot alter the requirements of the HCP without an HCP modification as described in Section 8.9, *Modifications to the HCP*.

8.2.3 Oregon Land Board and Department of State Lands

As described in Chapter 1, *Introduction*, the HCP permit area includes 25,826 acres of Common School Forest Lands (CSFL) outside of the Elliott State Forest that are managed by ODF. The Oregon Land Board oversees these lands through the Department of State Lands (DSL). The DSL Real Estate Asset Management Plan directs DSL to manage forestland "in accordance with plans adopted by the Land Board in cooperation with the Board of Forestry." As described above, in conjunction with this HCP, ODF will be adopting a new FMP consistent with the HCP. Therefore, the State Land Board needs to adopt the new FMP so that ODF can manage these lands consistent with the FMP and this HCP.

8.2.4 U.S. Fish and Wildlife Service and NOAA Fisheries

USFWS and NOAA Fisheries will be responsible for assessing and ensuring that ODF implementation of the HCP is consistent with the provisions and outcomes that informed the federal agencies' issuance of the incidental take permit. The following summarizes the activities that the federal agencies may perform in support of HCP implementation:

- Receive annual, 5-year, and 10-year reports submitted by ODF.
- Meet annually with ODF.
- Determine if ODF is properly implementing the HCP in compliance with the HCP and any additional terms and conditions of each permit, based on the annual report and other information provided by ODF.
- Respond to requests by ODF for HCP amendments (see Section 8.9).
- Work with ODF to address unforeseen circumstances and possible voluntary remedial measures to address them, as described in Chapter 7, *Assurances*.

- Enforce the provisions of the incidental take permits, as needed.

8.2.5 Oregon Department of Fish and Wildlife

ODFW will play a key role in the implementation of the aquatic monitoring program (see Chapter 6, *Monitoring and Adaptive Management*) with funding support from ODF. ODFW will also serve as technical advisors to ODF during HCP implementation, advising on implementation of conservation actions, the monitoring program, and application of the adaptive management program to inform changes in either. Costs associated with implementation of the aquatic monitoring program are summarized in Table 9-3.

8.3 Technical Assistance

During HCP implementation, ODF may seek technical assistance from USFWS, NOAA Fisheries, or ODFW in order to most effectively comply with the HCP and permits and implement the conservation strategy. Technical assistance will be most valuable in situations not clearly defined by the HCP or permits, where ODF needs assistance determining how to proceed with a particular action while remaining in compliance. For situations that are not clearly articulated in the HCP or permits, or as new situations arise, ODF will work with USFWS, NOAA Fisheries, and ODFW to develop and implement practical solutions in a manner that is consistent with the intent of the HCP and permits, and that allow for logistically feasible actions on the ground. If it is determined during technical assistance that there needs to be a clarification to the HCP or a modification to the permit, up to and including an amendment, the process described in Section 8.9 will be followed.

8.4 Data Tracking

Proper data management, tracking, analysis, and reporting are critical to HCP implementation, including the monitoring and adaptive management program. Data on monitoring methods, results, and analysis must be managed, stored, and made available to staff, decision makers, USFWS and NOAA Fisheries, and others, as appropriate. ODF will maintain the following data to support HCP implementation.

- The location, extent, and timing of loss and gains of species habitat.
- The location, extent, and timing of implementation of all conservation actions.
- The results of all HCP monitoring, including status and trends monitoring, described in Chapter 6, including changes in species habitat quality and quantity and trends in aquatic inventory variables over time.

The comprehensive data repository for tracking will be operational within 12 months of permit issuance. These reports and other data will be stored and archived electronically whenever possible. When electronic archiving is not available or feasible, ODF will retain hard copy records, which, along with electronic records, will be available for inspection by USFWS and NOAA Fisheries, as requested.

8.5 Stay-Ahead Provision

The Endangered Species Act (ESA) requires that HCPs minimize and mitigate the impacts of the taking to the maximum extent practicable (ESA Section 10(a)(2)(B)(ii)). In order to make findings that the proposed impacts are mitigated to the maximum extent practicable, USFWS and NOAA Fisheries will consider temporal losses (if any) resulting from a delay between the time of impact relative to the time of mitigation. The Stay-Ahead provision will minimize or eliminate the risk of any temporal losses associated with the impacts from covered activities. The Stay-Ahead provision will be tracked by ODF on a continual basis and will be reported to USFWS and NOAA Fisheries annually and during the 5-year check-in and 10-year comprehensive reviews. The primary means by which Stay-Ahead will be documented is through modeling and monitoring of terrestrial and aquatic habitat changes.

The underlying assumption in the terrestrial conservation strategy is that terrestrial habitat quality will improve over time, as the forest grows, and that more acres of habitat and, more importantly, more acres of higher quality habitat will grow than will be lost to covered activities. The designation of HCAs and RCAs at the outset of the program will immediately provide conservation benefits to covered species. By maintaining these boundaries through the permit term ODF provides certainty that habitat within the HCAs and RCAs will continually improve in quality and that the total acres of conservation areas will not be reduced. Graphs in Chapter 5, *Effects Analysis and Level of Take,* show the balance of acres expected on the landscape during the permit term. These graphs demonstrate that there will always be more acres of habitat grown than lost to harvest across the permit area in any 10-year implementation period. The Stay-Ahead provision for the HCP requires that ODF replace modeled or assumed habitat for the covered terrestrial species lost to harvest with at least as much habitat of equivalent or better quality (as defined by the same models) grown over time within HCAs. There is no Stay-Ahead provision or requirement for RCAs for the reasons described below.

Temporal effects in the aquatic environment are expected to be minimal due to the specific design of the RCAs to retain ecological processes needed to support covered species and the commitment to further enhance stream conditions through restoration activities. The underlying assumption in the aquatic conservation strategy is that there will be continual improvement in aquatic habitat quality for covered species through the combination of those factors: riparian conservation areas and stream enhancement activities. This is due to no harvest activities in RCAs, resulting in the continual growth of riparian habitat over time. If natural disturbances occur in RCAs there can be no similar adjustment to or reduction in harvest activities because no harvest activities will be occurring. RCAs will naturally regenerate and, depending on the severity of the fire, some riparian restoration work will be completed to expedite the recovery of those locations.

The monitoring program will measure the improvement of both terrestrial and aquatic habitat and determine whether mitigation is staying ahead of effects. The Stay-Ahead provision will ensure that the growth of terrestrial habitat in the HCAs stays ahead of habitat lost to covered activities outside of HCAs and due to management activities inside of HCAs. The Stay-Ahead provision will ensure that natural riparian habitat development and implementation of restoration projects in the RCAs stays ahead of habitat lost to covered activities (e.g., new roads through RCAs). Documenting that covered aquatic species habitat quality is improving through the monitoring of aquatic habitat trends will ensure that there is no decrease in aquatic habitat quality due to covered activities.

Adjustments to how the Stay-Ahead provision is measured in response to landscape-scale events such as fire, storms, and pests are described in the next section.

8.5.1 Adjustments to Stay Ahead

The permit area is a forested landscape subject to natural events, as described in Chapter 2, *Environmental Setting,* and Chapter 7. Fires, storms, and insect outbreaks, routinely change the landscape and along with it the habitat quality for covered species. These natural events are part of the cycle in forest succession. It is conceivable that the HCAs or RCAs will be affected by one or more of these natural phenomena during the permit term. While the biological objectives outline the ultimate habitat quality commitments for the HCP, it cannot be assumed that progress towards those commitments will be linear, due to these stochastic events. The potential for that to occur in the future is described in Chapter 7 in the context of historical examples of how natural events have already changed the permit area.

When these natural events occur ODF will respond as described in Chapter 7. In HCAs and RCAs the response will include an assessment of damage to covered species habitat and the potential for regeneration of healthy forests following the event. In some cases restoration activities, such as reforestation, will occur to speed the recovery of species habitat, but in many cases natural succession will be allowed to proceed. When these natural disturbances occur in HCAs or RCAs, ODF will adjust how the Stay-Ahead requirement is measured on those acres because, depending on the type and severity of the natural event, habitat quality will likely be reduced for covered species. In many cases, the Stay-Ahead measurement will exclude areas subject to the extreme disturbance. In others, however, ODF may decide to retain the area in the Stay-Ahead calculation if it will continue to provide habitat for covered species. These determinations will be species-specific. An area that is disturbed may no longer provide habitat for one covered species, but may still provide habitat for another. Many factors, including the variation in severity of disturbance will influence those determinations.

Those acres affected by the natural disturbance will continue to be reported in 5-year and 10-year reports, but they will be reported as naturally disturbed acres or HCA or RCA habitat rehabilitation areas. Overall, there will be a new baseline set that will acknowledge the acres of terrestrial species habitat lost or RCAs lost to a particular disturbance. An assessment will be completed to determine whether the loss of habitat quality from disturbed acres caused ODF to drop below the Stay-Ahead threshold for any of the covered terrestrial species. Adjustments will be made in subsequent 10-year implementation plans to ensure that eventually the Stay-Ahead requirement is met and ultimately that the biological objectives are met. For disturbances in RCAs a new baseline of riparian forest stand age and aquatic habitat quality will be set. From that point forward the requirement to manage toward continual improvement in habitat quality will still be enforced, only now with a new baseline.

8.6 Reporting

Reporting will occur on three timescales during implementation: (1) annual reports, (2) 5-year check-ins, and (3) 10-year comprehensive reviews. The timing of reports serve multiple purposes, including some annual accounting of compliance with the HCP and permits and longer term, 5- and 10-year reviews of implementation of conservation actions. The 10-year comprehensive reviews are specifically designed to inform the 10-year implementation planning process, which guides forest management planning for the State Forests Division.

8.6.1 Annual Reporting

ODF will prepare and submit an annual report for the duration of the permit term detailing, among other things, compliance, habitat loss, conservation actions, and monitoring activities. The annual reports will summarize the previous state fiscal year's implementation activities (July1–June 30) and be provided to USFWS and the NOAA Fisheries by November 15 of each year. Annual reports will require synthesis of data and reporting on important trends. A due date of November 15 will allow time for the data to be assembled, analyzed, and presented in a clear and concise format. If ODF requires more time to prepare and submit the annual report, ODF may request from USFWS and NOAA Fisheries a 30-day extension of this deadline. In addition to submitting to USFWS and NOAA Fisheries, annual reports will be made available to the public and posted on the ODF website. An annual meeting reviewing the above submitted information and addressing any other issues will be held with USFWS, NOAA Fisheries, and ODFW between November 15 and January 31. The annual meeting will be at least 30 days following submittal of annual report.

The goals of the annual reports are to demonstrate to Board of Forestry, USFWS, NOAA Fisheries, and the public that the HCP is being implemented properly. If any implementation problems have occurred, they will be disclosed with a description of corrective measures planned or measures that have been taken to address the problems. The reports will also identify past and expected future changes to the management and monitoring program, through adaptive management, and remedial actions needed to address changed circumstances.

The minimum required content of the annual reports is as follows.

- Description of covered activities implemented during the reporting year as well as cumulative total (i.e., from the start of the permit term). Examples include:
    - Acres of timber harvested.
    - Acres of management activities by silvicultural prescription used in HCAs, by species' habitat suitability class.
    - Roads constructed and vacated in RCAs and HCAs.
    - Road management activities aimed at reducing erosion and sedimentation.
    - Barriers to fish passage upgraded or removed.
    - Recreational facilities constructed in RCAs and HCAs.
- Documentation and justification of any instances where deviations/exceptions from standard practices occurred in RCAs or HCAs (Chapter 4, *Conservation Strategy*).
- Documentation of any known instances of direct mortality of covered species (reported within 24 hours and then summarized in annual reports).
- Progress toward achieving the biological goals and objectives by implementation of conservation actions (including avoidance, minimization, and mitigation).
- Summary of communication with Federal agencies that occurred over the year.

- Status of the stay-ahead provision (as described in Section 8.5).
- An accounting of conservation fund expenditures and balance.
- Description of any changes in HCP implementation resulting from the adaptive management process during the reporting year, as applicable. This description will include the information that triggered the change, the rationale for the planned responses, and the results of any applicable monitoring actions.
- Summary of surveys conducted through the monitoring program for the reporting year, including a description of surveys conducted, protocols used, and survey results.
- Discussion of possible changes to the monitoring and research program based on interpretation of monitoring results and research findings, if applicable.
- Documentation of any changed circumstances described in Chapter 7 that were triggered during the reporting year, if applicable. If any such circumstances were triggered, the report shall also include any responses implemented (i.e., remedial measures) and resulting monitoring.
- If changed circumstances were triggered in prior years, document on-going responses to those past changed circumstances in the current reporting year, and the on-going results of remedial measures.
- Any administrative changes or amendments proposed or implemented during the reporting year (see Section 8.8).

8.6.2 5-Year Mid-Point Check-ins

ODF operates on 10-year implementation planning cycles that guide forest management activities at the district level. Halfway through any given implementation plan cycle (i.e., at Year 5 of each 10-year implementation cycle) there will be a mid-point check in on HCP implementation. The following will be summarized during the mid-point check ins.

- Amount and general location of modeled habitat for covered terrestrial species lost to covered activities, and amount and general location of modeled terrestrial habitat gained through management actions and natural succession.
- Amount and general location of aquatic covered species habitat and riparian area lost to covered activities in the RCAs and amount and general location of aquatic covered species habitat and riparian area gained through management actions and mitigation.
- A summary of expenditures from the conservation fund, including an accounting of the proportion of funds expended on aquatic and terrestrial species conservation actions.
- An explanation of how expenditures from the conservation fund are addressing the limiting factors for covered species and offsetting the impacts of habitat loss that may have occurred from covered activities.
- Acres of timber harvest.

8.6.3 10-Year Comprehensive Reviews

In order to inform the implementation planning process, and to make adjustments accordingly in order to continue to comply with the HCP and permits, ODF will undertake 10-year comprehensive reviews. These reviews will include information from the annual reports in the intervening 10 years and the summary provided in the 5-year mid-point check-in, and will examine whether any program-level or systemic changes need to occur to adjust the level or location of habitat loss, the type of management activities, or the type or location of conservation actions that are being implemented. For example, if different choices need to be made regarding how habitat is managed inside of HCAs or where conservation fund dollars are spent for aquatic enhancement projects, the need for those decisions could emerge during the 10-year review, and changes that result could be codified in implementation plans or other State Forests Division operational policy changes as described in Chapter 6. Information generated during the 10-year comprehensive review process will be informed by ODF staff along with USFWS, NOAA Fisheries, and ODFW.

8.7 Timber Sale Contracts

Several conservation measures will be implemented wholly or in part by timber operators contracted to ODF through a formal timber sale bidding process. This implementation will occur through execution of project work (e.g., culvert replacement and other road work), tree felling that occurs as part of harvest or habitat enhancement silvicultural prescriptions, adherence to disturbance standards, and all other activities necessary to carry out covered activities in a manner that complies with conservation actions. After ITP issuance by USFWS and NOAA Fisheries, ODF will modify all future bid specifications and contracts for timber sales to conform to the requirements of the HCP. These future timber sale specifications and contracts will require all timber operators to implement the appropriate avoidance, minimization, and mitigation measures described in Chapter 4.

Timber contracts are typically awarded for 3 years with the expectation that a timber operator will harvest at some point during the 3-year contract period. Timber sale contracts awarded prior to HCP implementation (i.e., prior to ITP issuance by USFWS and NOAA Fisheries) may therefore be implemented either prior to or just after HCP implementation begins. Beginning July 1, 2021, ODF will modify their timber harvest bid specifications and contracts to allow timber operators who harvest after HCP permit issuance (expected in 2022) to harvest either (1) under requirements pre-HCP to avoid take of listed species or (2) under the new requirements of the HCP, as applicable to each timber sale. If a timber operator chooses to harvest consistent with the requirements of the HCP, it will be the responsibility of the timber operator to comply with the HCP and permits, with assistance from and approval by ODF.

ODF retains the responsibility for ensuring that all covered activities are carried out in compliance with the HCP. ODF contracts contain provisions to ensure contractors and operators adhere to federal and state law, including this HCP. ODF maintains control over operations by suspending work, charging increased rates for timber harvest, and termination of the contract, if the operator cannot come into compliance. ODF will report operator violations during annual reports, along with any punitive and remedial actions taken. ODF will also retain the right and ability to field-verify implementation of any timber sale to ensure its compliance with the HCP and any additional terms and conditions of the ITPs.

8.8 Decision Making in Implementation

As described in this chapter, ODF is responsible for day-to-day implementation of this HCP. ODF will be making almost all decisions related to HCP implementation within the authority provided to them by USFWS and NOAA Fisheries through the ITPs.[1] ODF will coordinate regularly with USFWS and NOAA Fisheries on HCP implementation to ensure that any issues that arise are addressed quickly and with the input of USFWS and NOAA Fisheries. In rare instances, ODF may need to deviate from the HCP requirements for practical reasons that cannot be predicted over the 70-year timeframe. In those instances, ODF, USFWS, and NOAA Fisheries will confer to discuss and reach agreement on those deviations. In those rare instances where an agreement cannot be reached, a formal *dispute resolution process* is available, as described below.

8.9 Changes to Permit Area

As described in Chapter 1, *Introduction*, the permit area consists of the lands that ODF operates on at the time of permit issuance. A plan area has been designated around the permit area to account for and accommodate future changes in ODF managed lands through acquisitions and exchanges. As the permit area will comprise the lands ODF is operating on, it may change over time. When lands are removed or added to the permit area ODF will demonstrate that the level of take authorized by the ITP and the mitigation provided by the conservation strategy for each covered species, as described in Chapter 4, remain intact. In instances where both of those requirements are not upheld an amendment would be necessary. In situations where both are upheld, an amendment would not be necessary. ODF will report all instances of land acquisition and exchange, the resulting change in the permit area, and the validation that the level of take is within the authorized limit and the mitigation continues to fully offset the impact of the taking, in the annual report.

8.10 Modifications to the HCP

The HCP and associated ITP may be modified in accordance with the ESA, USFWS and NOAA Fisheries implementing regulations, and the provisions outlined in this section. HCP or permit modifications are expected to be rare. Modifications to the HCP or ITPs may be requested by either ODF, USFWS, or NOAA Fisheries. USFWS or NOAA Fisheries also may amend their permit at any time for just cause, and upon a written finding of necessity, during the permit term in accordance with 50 Code of Federal Regulations (CFR) Section 13.23(b) and the No Surprises assurances described in Chapter 7. HCP modifications are considered either an administrative change or an amendment, as described below.

8.10.1 Administrative Changes

Administrative changes are minor internal changes or corrections to the HCP that may be made by ODF, at their own initiative, or approved by ODF in response to a written request submitted by

[1] Some decisions will be the responsibility of USFWS or NOAA Fisheries, such as whether to approve or deny a request for an HCP amendment (e.g., see Section 8.8.2, *Amendments*).

USFWS or NOAA Fisheries. Requests from USFWS or NOAA Fisheries will include an explanation of the reason for the change as well as any supporting documentation.

Administrative changes to the HCP should be consistent with the scope of the analysis in the HCP and the original National Environmental Policy Act (NEPA) document. Administrative changes will address small errors, omissions, or language that may be too general or too specific for practical application. Administrative changes can be suggested by ODF or the USFWS and NOAA Fisheries. Minor administrative changes made by ODF will not require pre-approval from the Services, but ODF will report minor administrative changes in the annual report. More substantial administrative changes will require and approval by USFWS and NOAA Fisheries through a written exchange.

Examples of administrative changes to the HCP are as follows, with responsibilities noted in parentheses.

Minor administrative changes (exempt from approval by the Services):

- Corrections of typographical, grammatical, and similar editing errors that do not change the intended meaning or obligations.
- Corrections of any minor errors in maps or exhibits.
- Corrections of any maps, tables, or appendices in the HCP to reflect approved amendments (Section 8.9.2) to the HCP or incidental take permit.
- Changes to maps and calculations in the extent of ODF managed lands that are inside of the plan area and where the new extent of ODF managed lands allows for the full implementation of the conservation strategy as described in the HCP and ITPs. These changes could include land transfers, land sales, or land purchases consistent with the plan area boundary described in Chapter 1.

Administrative changes that require written approval from the Services:

- Minor adjustments to conservation actions in order to more effectively and efficiently implement the action as long as that change is consistent with its intent and with the same or improved likelihood of achievement of biological objectives.
- Clarifications of implementation where the HCP was vague or internally inconsistent.

8.10.2 Amendments

Changes to the HCP or ITPs that do not qualify for an administrative change can be accomplished through an amendment requested by ODF. Once an amendment is requested by ODF, USFWS and NOAA Fisheries will decide the level of review needed to satisfy ESA, NEPA, and other regulatory requirements. HCP amendments require written approval by USFWS and NOAA Fisheries.

Depending on their scope and effects, amendments to the HCP can be approved by USFWS and NOAA Fisheries through an exchange of formal correspondence, addendum to the HCP, revision to the HCP, or a formal permit amendment. Substantial changes would likely require a formal amendment to the HCP and relevant permit, which may include a *Federal Register* notice and review to ensure NEPA compliance for the amendment. Examples of changes that would require an amendment include, but are not limited to, the following actions.

- Addition or deletion of covered species.
- Change in the allowable take limit for existing covered activities or the addition of new covered activities.
- Modifications of any important action or component of the conservation strategy under the HCP that may affect levels of authorized take, effects of the covered activities, or the nature or scope of the conservation strategy.
- Changes in the extent of ODF managed lands that would remove lands from the permit area that were deemed essential for the full implementation of the conservation strategy, as described in the HCP. The amendment would include a revision to the conservation strategy, and possibly the authorized level of take, that is practicable considering the new extent of ODF managed lands.
- Changes in the extent of ODF managed lands to add any lands outside of the plan area or changes in the permit area that result in an increase in the level of take, beyond what was authorized, or changes in the conservation strategy that no longer fully offset the impacts of take on one or more covered species.

8.11 Permit Transfer

In the event of a sale or transfer of ownership of the state forest lands during the permit term, the new owner(s) will submit to the Services written documentation providing assurances pursuant to 50 CFR 13.25 (b)(2) that the new owner(s) will provide sufficient funding for the HCP and will implement the relevant terms and conditions of the ITP, including any outstanding minimization and mitigation. The new owner(s) will commit to all remaining requirements regarding the take authorization and mitigation obligations of this HCP unless otherwise specified in writing and agreed to in advance by USFWS and NOAA Fisheries.

8.12 Permit Suspension or Revocation

The USFWS and NOAA Fisheries have the ability under federal law to suspend or revoke all or a portion of the permits if ODF is out of compliance with the HCP or ITPs. USFWS and NOAA Fisheries each have the ability to suspend or revoke all or a portion of the Section 10(a)(1)(B) permit it issues if continuation of covered activities would appreciably reduce the likelihood of the survival and recovery of a covered species in the wild (50 CFR 17.22(b)(8), 17.32(b)(8)) or if ODF does not comply with the conditions of their permits (50 CFR 13.27, 13.28).

If the Permit is revoked, ODF will have to fulfill all outstanding mitigation requirements for any take impacts that occurred prior to the revocation, including land management actions and restoration/enhancement actions. For example, if ODF had removed more modeled habitat for covered species than they had created through management to that point, they would need to continue to manage HCAs or RCAs consistent with the HCP and ITPs until that deficiency was reduced and the habitat loss was offset.

Chapter 9
Costs and Funding

9.1 Introduction

The Endangered Species Act (ESA) requires that habitat conservation plans specify, "the funding that will be available to implement" conservation actions that minimize and mitigate impacts on covered species (16 United States Code [U.S.C.] 1539(a)(2)(A)). The ESA also requires the U.S. Fish and Wildlife Service (USFWS) and the National Atmospheric and Oceanic Administration (NOAA) Fisheries to find that the applicant will ensure that adequate funding is available to implement the Western Oregon State Forest Habitat Conservation Plan (HCP). This chapter outlines the estimated costs to implement the HCP over the proposed 70-year permit term and provides assurances that the Oregon Department of Forestry (ODF) will pay for those costs.

9.2 Implementation Costs

As described in Chapter 8, *Plan Implementation*, ODF staff will oversee implementation of the HCP. Staff includes administrators, data analysts and natural resource specialists who will carry out the conservation strategy, monitoring, adaptive management, and coordination with USFWS and NOAA Fisheries. The cost to implement the HCP is divided into five categories, summarized in the following subsections. All estimated costs are expressed in 2021 dollars.

- Plan Administration and Staffing
- Conservation Strategy
- Monitoring
- Adaptive Management
- Remedial Measures for Changed Circumstances

All costs were estimated based on cost estimates provided by ODF staff for the same or similar actions conducted currently. In cases where actual ODF cost data was unavailable (e.g., HCP costs that are new), costs were estimated based on similar actions conducted by other entities in the state, or with data from comparable HCPs in other states.

It is important to note that these cost estimates are planning-level estimates only for the purpose of demonstrating assured funding for the HCP. ODF will prepare an annual budget to implement the HCP that may differ from these cost estimates (either more or less). These cost estimates are not requirements of funds ODF must spend, but rather reasonable estimates of total HCP costs over the entire permit term.

The implementation costs outlined in this section are expressed in 2021 dollars. These costs are not adjusted for inflation because funding is expected to increase at the same rate as costs are expected to increase due to inflation. All revenue sources that fund ODF operations, including HCP implementation, are reevaluated each year and adjusted for inflation, as necessary. This is discussed further in Section 9.4, *Implementation Funding*.

9.2.1 Plan Administration and Staffing

Program administration involves ongoing or yearly costs associated with staff time for coordination, agency meetings, activity tracking, and reporting. The HCP administrator, staffed by ODF, will be responsible for oversight of all administration including contract management and leading coordination efforts with USFWS and NOAA Fisheries. A data analyst will maintain and update a database(s) of spatial data necessary for tracking covered activities and conservation actions. The HCP conservation program will be overseen by the State Forests Resource Support Unit and two staff biologists (terrestrial and aquatic), and will be implemented by two full-time field biologists. Other specialists will be involved in HCP implementation as needed. See Section 8.2, *Implementation Roles and Responsibilities*, for more details on the roles and duties of these positions and Table 9-1 for a summary of estimated time commitments by each position.

The costs of the unit manager, staff biologists, and other specialists are split between several cost categories to recognize their roles in HCP implementation (Table 9-1). It is expected that the actual staffing needs of the HCP program will vary seasonally and from year-to-year. For example, staffing costs during the first several years of HCP implementation are expected to be greater than costs at other times because of the need to establish new procedures and new data tracking systems, and when coordination with state and federal partners may be more extensive. This cost estimate therefore represents a long-term average of staffing needs and costs used only for the purposes of the HCP cost estimate. ODF will provide staff and staff time necessary at all times to properly implement the HCP.

Table 9-1. HCP Staffing Assumptions

Labor Category	FTEs	Years Needed	Cost Category
HCP Administrator	0.5	70	Plan Administration (100%)
Data Analyst	0.3	70	Plan Administration (100%)
Staff Biologist	0.75	70	Conservation Strategy (67%) Monitoring (33%)
Staff Aquatic and Riparian Specialist	0.75	70	Conservation Strategy (67%) Monitoring (33%)
Field Biologist	2.5	70	Conservation Strategy (20%) Monitoring (80%)
State Forest Engineer	0.25	70	Monitoring (100%)
Geotechnical Specialist	0.25	70	Conservation Strategy (100%)
Recreation Specialist	0.75	70	Monitoring (100%)
Monitoring and Adaptive Management Specialist	1.0	70	Monitoring (100%)
State Forest Analyst	0.25	70	Monitoring (100%)
Total	**7.3**		

FTE = full-time employee

Table 9-2. Estimated ODF Staff Time and Costs During Permit Term (2021 dollars)

Labor Category	FTEs	Monthly Salary + OPE (FY 2021)	Average Annual Cost Today	Total Cost Over 70 Years
HCP Administrator	0.5	$15,307	$91,842	$6,428,940
Data Analyst	0.3	$11,265	$40,554	$2,838,780
Staff Biologist	0.75	$10,997	$98,973	$6,928,110
Staff Aquatic and Riparian Specialist	0.75	$10,997	$98,973	$6,928,110
Field Biologist	2.5	$9,531	$285,930	$20,015,100
State Forest Engineer	0.25	$16,132	$48,396	$3,387,720
State Forest Geotechnical Specialist	0.25	$13,970	$41,910	$2,933,700
State Forests Recreation Specialist	0.75	$9,531	$85,779	$6,004,530
Monitoring and Adaptive Management Specialist	1.0	$9,531	$114,372	$8,006,040
State Forest Analyst	0.25	$12,690	$38,070	$2,664,900
Total	**7.3**	**--**	**$944,799**	**$66,135,930**

OPE = Other Payroll Expense; FY = fiscal year

9.2.2 Conservation Strategy

As stated in Chapter 4, *Conservation Strategy*, the conservation program implements the biological goals and objectives and fulfills the HCP requirement to avoid, minimize, and mitigate impacts of the taking to the maximum extent practicable. Costs associated with the conservation strategy include the following conservation measures:

1. Aquatic restoration activities (e.g., in-stream wood enhancement projects, fish barrier removals and replacements).
2. Upland restoration activities (e.g., treatment of stands with Swiss needle cast; converting stands to higher quality covered species habitat).
3. Strategic terrestrial conservation strategies.

HCP staff will implement the conservation strategy by overseeing each of the conservation measures, including designing and implementing mitigation actions, as well as overseeing implementation of avoidance and minimization measures. ODF staff expected to support the conservation strategy are listed in Table 9-1.

Within each category, the levels of annual funding necessary to implement conservation actions under the Conservation Fund are estimated based on historical patterns of likely future needs (see Section 9.4.1.3 for information on the Conservation Fund). These estimates are included merely to demonstrate that the average annual amount of funding of $1 million will more than adequately cover the costs of implementation of conservation actions. The annual estimates shown for each category are neither a maximum nor a minimum that will be spent each year, but an average. Year-to-year spending on conservation activities will vary based on the type of projects being implemented and their complexity that year. Levels of conservation spending will also be relative to the level of effect on covered species from covered activities. By linking the Conservation Fund to harvest volume there will inherently be more funding available in years of higher harvest, when there is potentially more adverse effects on covered species habitat. Additionally, the full cost of conservation actions may not be borne by the Conservation Fund specifically, but in some instances will be supported as part of the project work associated with specific harvest operations.

9.2.2.1 Aquatic Restoration Activities

Section 4.7.3, *Conservation Action 3: Stream Enhancement,* describes stream enhancement activities that ODF will carry out during the permit term. These activities generally fall into three categories: (1) wood enhancement projects, (2) stream restoration projects, and (3) fish barrier removal and replacement projects. ODF has implemented similar projects over the course of 23 years (1995–2018)—over 1,100 projects, with an average of 8 projects per year. During that time annual costs of aquatic restoration projects varied between $28,000 and $900,000, with an average annual cost of $310,000/year. These ODF costs were combined with funding from other agencies and grant sources to implement the restoration projects. Under the HCP, the assumption is that the level and type of restoration activities will be similar to what has been done in the past, with a slight increase to account for additional reporting needed under the HCP. It is estimated that ODF will spend, on average, at least $325,000 annually during the permit term on aquatic restoration activities, and a total of $22,750,000 over the permit term.

9.2.2.2 Targeted Fish Barrier Removal or Upgrades

Some fish barrier removals or upgrades to state and federal standards will occur as part of routine haul road upgrades associated with planned harvest activities. These are described in Conservation Action 4: Remove or Modify Artificial Fish-Passage Barriers, in Chapter 4, *Conservation Strategy*. A subset of barrier removals or upgrades will occur as targeted conservation actions outside of the harvest program. ODF's regional partners may be interested in addressing fish barriers in locations that are not planned to be harvested and therefore would not likely be candidates for passage upgrades as part of routine road upgrades or maintenance. In those instances ODF may use Conservation Fund dollars to address fish passage issues as part of a standalone stream enhancement project.

Conservation fund dollars will not be spent on barrier upgrades associated with the timber harvest program, unless the funding is being used to enhance an otherwise adequate upgrade to a more ecologically beneficial infrastructure upgrade. For example, if installation of a properly sized culvert would meet state and federal fish passage requirements, and improve fish passage, but a bottomless culvert or bridge would be a better ecological solution for covered species, Conservation Fund dollars could be used to pay for the difference between the adequate culvert and the upgraded solution.

9.2.2.3 Upland Restoration Activities

ODF will be investing in upland restoration activities that will benefit covered species inside of HCAs. These activities will primarily include harvest of stands that have marginal habitat suitability or are not currently suitable and that are unlikely to develop into better habitat during the permit term. Typically this occurs when a stand is stunted (e.g., infected by Swiss needle cast) or otherwise not suitable for covered species (e.g., hardwood-dominated stands).

Conservation Fund dollars will not be spent to subsidize or otherwise pay for harvest of these stands. In instances where stand initiation costs are prohibitive, the Conservation Fund may be utilized to pay for reforestation and young stand management activities needed to establish diverse early seral forests that will grow into covered species habitat over time. ODF will manage 600 acres of stands like this annually (on average) during the permit term at an average reforestation cost of $400/acre, resulting in an annual average reforestation cost of $240,000/year. These activities are largely expected to occur during the first 30 years of the permit term. Reforestation of covered species habitat in HCAs will cost approximately $7,200,000 over that time period.

9.2.2.4 Contribution to Strategic Terrestrial Species Conservation Action

Section 4.7.9, *Conservation Action 9: Strategic Terrestrial Species Conservation Actions*, outlines ODF's commitment to contributing funds to address strategic conservation actions for terrestrial covered species. At any point during the permit term priorities for strategies that are most important may change, but the intention is to use the Conservation Fund to address key issues or constraints that were limiting the effectiveness of the remainder of the conservation strategy described in the HCP. The conservation strategy will result in an increase in habitat for all of the terrestrial covered species, but if there are other factors that limit the ability of covered species to take advantage of the new habitat, this fund could be used to address those limiting factors.

For example, regardless of the amount and type of habitat that is in the permit area barred owls continue to stress northern spotted owl populations. One potential use of the fund would be to establish and/or support regional barred owl management projects/programs. ODF could work in concert with regional partners, including the Oregon Department of Fish and Wildlife (ODFW), USFWS, Bureau of Land Management (BLM), and U.S. Forest Service (USFS) to conduct barred owl management activities across private, state, and federal lands. Additionally, at some point in the future, provided barred owl management can be successful, there may be interest in reintroducing northern spotted owls onto Oregon forests or creating a captive breeding program to boost owl numbers in western Oregon, similar to ongoing efforts in British Columbia. The HCAs would be possible locations for those releases, and ODF could partner with other organizations and agencies to create such a program. Finally, one of the limiting factors for red tree vole, Oregon slender salamander, and coastal marten is a lack of understanding of population stressors and in some cases a basic understand of how species use habitat on state lands and what conservation actions are likely to be most successful. Conservation funds could be used to strategically address research questions needed to more effectively execute the conservation strategy over time for these species.

ODF's contribution to strategic terrestrial species conservation actions will be an average annual contribution of approximately $250,000 on average. This money will most likely be spent during the first 20 years of HCP implementation in order to increase the effectiveness of the terrestrial conservation strategies generally. However, the timing of the expenditure of these dollars will be dependent on the need and opportunities presented by regional partners. Specifically, barred owl management may require increased spending in certain years, or multiple efforts over the permit term, to ensure adequate removal to achieve spotted owl conservation objectives. The activities discussed above are just examples of the type of programs or projects that could be implemented; others will likely be identified during implementation. These activities are not defined in more detail in the HCP because the need and efficacy of them is not known at this time, but ODF will continue to explore these activities in collaboration with USFWS, NOAA Fisheries, BLM, USFS, and ODFW during HCP implementation.

9.2.3 Monitoring and Adaptive Management

9.2.3.1 Monitoring Actions

The HCP monitoring program is described in Chapter 6, *Monitoring and Adaptive Management*. Monitoring the outcomes of conservation measures is the foundation of the HCP's conservation program and adaptive management approach, and can help advance scientific understanding to better achieve the HCP's biological goals and objectives. The monitoring actions will result in the costs shown in Table 9-3. These costs include both staff costs and material costs associated with the monitoring program.

Table 9-3. Estimated Costs of Monitoring Actions Annually and During the Permit Term

	Estimated Annual Cost	Total for 70-year Permit Term
Aquatic Monitoring Program[a]	$404,488[a]	$28,134,160
Terrestrial Monitoring	$1,500,000[b]	$105,000,000
Road Program Compliance Monitoring	$48,396	$3,387,720
Aquatic Restoration Monitoring	Included in costs estimates for restoration projects	--
Upland Restoration Monitoring	Included in costs allocated to Conservation Fund	
Barred Owl Management Effectiveness Monitoring	Included in costs for barred owl management program	--
Total Cost of Monitoring Program	**$1,952,884**	**$136,521,880**
Estimated Cost of Adaptive Management (10% of total)	$195,288	$13,652,188

[a] Includes $204,488/year of ODF staff time and a contribution to the ODFW Aquatic Inventory Program includes monitoring for stream temperature, sediment, large woody debris, and key habitat features (e.g., pools).

[b] Includes $242,559/year of ODF staff time and material costs associated with monitoring, including external contracts that may be needed to complete the monitoring program.

9.2.3.2 Adaptive Management

Chapter 6 describes the processes for addressing the specific uncertainties associated with the conservation strategy, and the adaptive management measures and potential responses associated with those measures. The costs are shown in Table 9-3. Costs for adaptive management are included as a 10% contingency on all monitoring actions. This funding will be accessed if the monitoring program demonstrates a need to change conservation actions to better address covered species needs. This would be funded out of the State Forest Reserve Fund (Section 9.4.1.2, *Reserve Fund Balance*).

9.2.4 Remedial Measures for Changed Circumstances

Section 7.3, *Changed and Unforeseen Circumstances,* describes the actions and remedial measures associated with anticipated and possible circumstances that could change during implementation and that may affect the status of the covered species. Remedial measures may also be necessary if foreseeable changes occur that may alter the assumptions or information upon which the HCP is based (see Chapter 7, *Assurances*, for a description of changed circumstances). The cost of remedial measures is calculated as 5% of the cost of the conservation strategy. This cost is included as a contingency in the total cost estimate. This funding will be accessed if changed circumstances do occur and need to be addressed. This would be funded out of the State Forest Reserve Fund (Section 9.4.1.2).

9.3 Total HCP Program Costs

Table 9-4 summarizes all costs for the HCP program over a 70-year permit term. Details for each cost category can be found in Section 9.2, *Implementation Costs*.

Table 9-4. Total Costs for the Western Oregon State Forest HCP

Cost Category	Average Annual Cost	Cost Over 70-Year Permit Term
HCP Administration	$132,396	$9,267,720
Conservation Strategy	$1,231,060[a]	$86,174,200
Monitoring	$1,952,884[b]	$136,521,880
Adaptive Management	$195,288[c]	$13,652,188
Remedial Measures	$61,553[d]	$4,308,710
Total	**$3,573,181**	**$249,924,698**

[a] Costs consist of $1,000,000/year for the Conservation Fund and $231,060/year for staff to oversee and implement the conservation strategy.
[b] Costs are outlined in Table 9-3.
[c] Costs are estimated to be 10% of monitoring costs over the permit term.
[d] Costs are estimated to be 5% of the cost of the conservation strategy over the permit term.

9.4 Implementation Funding

This HCP will be implemented by the State Forests Division of ODF. The State Forests Division is responsible for the management of all state forestlands, including those owned by the Board of Forestry. The State Forests Division of ODF also manages the Common School Forest Lands owned by the Department of State Lands and covered by this HCP (see Sections 1.2.1, *Plan Area,* and 1.2.2, *Permit Area,* for details).

The State Forests Division of ODF is unique within ODF and other state agencies in that almost 100% of its revenue comes from timber sales on state forestlands. In some years, the State Forests Division obtains small amounts of state General Fund money for supplemental capital expenditures such as land acquisition or debt service on past acquisitions. The State Forests Division also supplements its own funds with limited federal matching grants for special projects such as riparian and stream restoration.

Despite this unique external funding source the State Forests Division must still request an annual budget and get it approved by the Legislature and signed by the Governor. Budgeting for state forests is accomplished by a biennial budget process. Biennial budgets are prepared every 2 years for a 2-year period and submitted to the Oregon Legislature through the Governor's Office for legislative approval. ODF prepares a balanced budget to ensure expected revenue covers anticipated expenses. Biennial budgets provide spending authorization for the State Forests Division to spend money over the 2-year period on Forest Management Plan (FMP) implementation, of which HCP implementation is a part.

On Board of Forestry Lands, current state law[1] mandates that 63.75% of the gross revenues is returned to the county and local taxing districts where the revenue was generated. The remaining 36.25% is used by the State Forests Division for state forestland management to implement all aspects of Greatest Permanent Value, which will include almost all HCP implementation. The next section describes the sources and history of timber sales and other revenue to the State Forest Division.

9.4.1 Revenue to State Forest Division

Timber sales are, by far, the largest revenue source to the State Forests Division and are expected to remain so for the foreseeable future (Table 9-5). More details on timber sale revenue are provided in Section 9.4.1.1.

The State Forests Division occasionally receives a small amount of funding from the State General Fund for one-time capital expenditures such as land transfers or acquisitions. Federal funds to the State Forests Division are provided in the form of competitive grant awards, including for stream restoration projects (see section below for more details). Recreational fee revenues are currently only 1% of the revenue to the State Forests Division but are expected to increase as facilities are upgraded or added and as the population grows. Alternative revenue sources continue to be examined but are currently not considered viable for planning purposes. Therefore, only current revenue sources are considered available to support HCP implementation. Each of these revenue sources is discussed further below.

Table 9-5. Revenue Sources to the State Forest Division

	Biennial Budget for State Forest Division (2 years)[a]		
Revenue Source	**2015–2017 Biennial Actual Revenue**	**2017–2019 Biennial Actual Revenue**	**2019–2021 Approved Budget**
State General Fund	$ 0	$ 0	$200,000 (<1%)
Federal Funds	$3,041,880 (4%)	$ 734,629 (1%)	$909,381 (<1%)
Recreational Fees	$1,221,747 (1%)	$1,329,978 (2%)	$1,591,857 (1%)
Timber Sales	$80,792,866 (95%)	$84,725,888 (98%)	$106,513,000 (98%)
TOTAL	**$85,056,493 (100%)**	**$86,790,495 (100%)**	**$109,214,238 (100%)**

[a] Source: ODF

9.4.1.1 Timber Sale Revenue

Since 1949 ODF has been harvesting timber and selling timber through timber sale contracts. The Board of Forestry Land base has continued to increase since 1949. The State Forests Division's mission has not changed and continues to provide a full range of economic, environmental, and social benefits. A summary of timber sale revenue to the State Forests Division from 2000–2019 is shown in Table 9-6. Revenue generated is largely due to a combination of changes in timber prices

[1] Oregon Revised Statute 530.110.

and differences in harvest volume. The variations in timber prices from 2000–2019 are shown in Table 9-7.

Timber sales are sold annually to the highest bidder. Bids reflect current market conditions. ODF's operating costs are adjusted to ensure a target fund balance. Annual operating costs are adjusted to align with expected revenue whenever possible. For example, in severe market downturns ODF strives to reduce expenditures to minimize deficit spending out of the operational reserve and investment account. The FMP includes levels of implementation that allows for budget fluctuations though all market conditions.

Table 9-6. Timber Sale Revenue to the State Forest Division (2000–2019)

Fiscal Year	Timber Revenue	Fiscal Year	Timber Revenue
2019	$53,819,957	2009	$24,217,089
2018	$47,174,928	2008	$29,319,099
2017	$34,914,595	2007	$33,000,415
2016	$34,748,095	2006	$33,761,492
2015	$31,958,423	2005	$27,985,988
2014	$27,679,219	2004	$27,400,765
2013	$26,976,098	2003	$26,314,199
2012	$21,409,368	2002	$25,053,874
2011	$21,787,543	2001	$24,159,544
2010	$24,467,207	2000	$27,177,101

Oregon state forests timber management practices focus on the production of high-quality sawlogs. This product is in demand by the lumber manufacturing industry that is well established in the Pacific Northwest. As with all commodities, prices can fluctuate greatly from year to year, but over time continue to gain value in line with inflation (Table 9-7).

Table 9-7. Revenue Sources to the State Forest Division (2000–2019)

Fiscal Year	Average Timber Sale Sold Stumpage Price/MBF (BOFL only)
2019	$419
2018	$536
2017	$397
2016	$382
2015	$366
2014	$391
2013	$336
2012	$309
2011	$315
2010	$257
2009	$211
2008	$250
2007	$348

Fiscal Year	Average Timber Sale Sold Stumpage Price/MBF (BOFL only)
2006	$365
2005	$361
2004	$277
2003	$284
2002	$306
2001	$308
2000	$347

MBF = 1,000 board feet; BOFL = Board of Forestry Lands

9.4.1.2 Reserve Fund Balance

ODF maintains a reserve fund balance to maintain operations, including HCP implementation, regardless of revenue generated from harvest and market conditions. ODF's reserve fund balance is currently almost $50 million. The target fund balance is 6–12 months of operating funds, and is based on current operating budget. Figure 9-1 shows the change in ODF's reserve fund balance from 2000–2020.

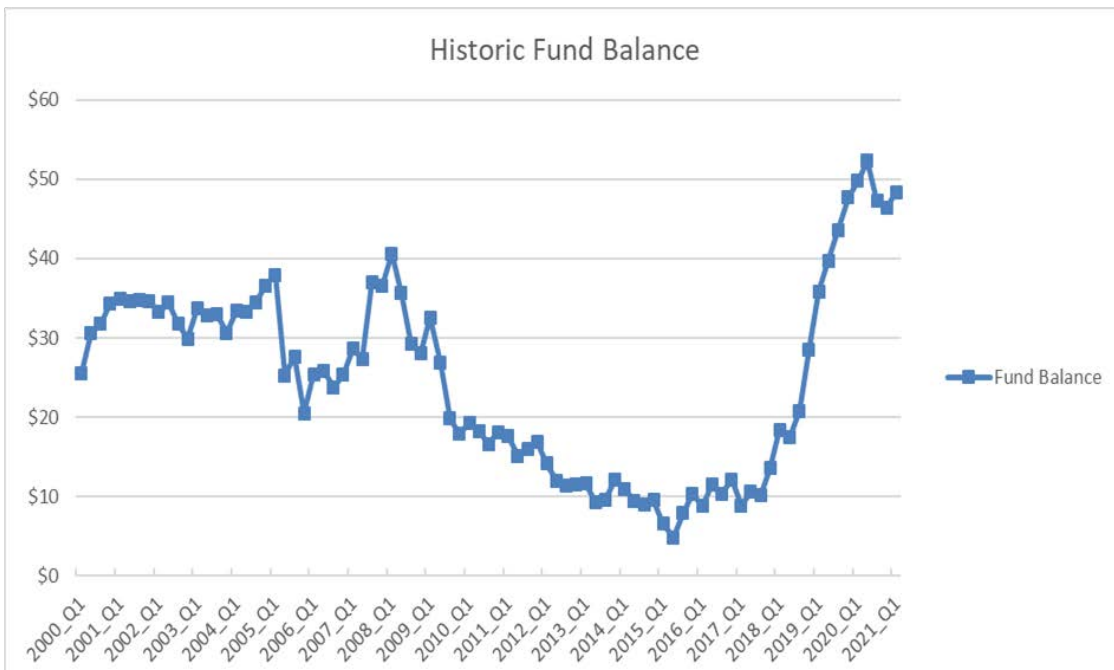


Figure 9-1. State Forest Division Reserve Fund Balance (2000–2020)

9.4.1.3 HCP Conservation Fund

Several conservation actions will be funded by ODF wholly or in part through an "HCP Conservation Fund" that will be established and maintained by a fixed proportion: $5 per 1,000 board feet (MBF) of all timber sold will be allocated to the HCP Conservation Fund. Effectively this serves as a fixed earmark within ODF's budget to complete conservation actions for the HCP. This amount will be adjusted with each implementation plan to account for inflation, based on the consumer price index. It will be managed to address both upland terrestrial species activities and riparian and aquatic activities. ODF will report expenditures from the Conservation Fund annually, and the balance of projected needs (upland versus aquatic) will be determined during the 10-year Comprehensive Reviews, for the next 10 year implementation cycle. This HCP Conservation Fund will be used to ensure implementation of the following conservation actions:

- Conservation Action 3: Stream Enhancement
- Conservation Action 4: Remove or Modify Artificial Fish-Passage Barriers
- Conservation Action 7: Manage Habitat Conservation Areas
- Conservation Action 9: Strategic Terrestrial Species Conservation Actions

Implementation of restoration projects and strategic terrestrial species conservation actions will vary over time. Funding these conservation actions through a dedicated HCP Conservation Fund will help to ensure that these projects can be implemented when their planning and any necessary site-specific permitting is complete. This approach also insulates these projects from fluctuations in timber harvest revenue as a result of stumpage price fluctuations or other decisions by ODF regarding the pace of timber sales. Funds will be expended from the HCP Conservation Fund consistent with the requirements of these conservation actions described in Chapter 4.

9.4.2 Funding Assurances

As a state governmental agency with budgets approved biennially by the Legislature, ODF and the State Forests Division cannot guarantee the expenditure of state funds, which are not yet authorized by the Legislature, for the requirements set forth in the HCP over its entire permit term. However, as a commitment of this HCP, ODF will incorporate in its biennial budget request to the Legislature a budget sufficient to fulfill its obligations under this HCP, including all expected costs associated with the administration of the HCP, implementation of the conservation program, monitoring, reporting, adaptive management, changed circumstances, and contingency costs. Each biennial budget request will be adjusted for inflation of capital and operational costs, including salaries and benefits.

ODF will provide to USFWS and NOAA Fisheries evidence (1) of its biennial budget requests to the Legislature and (2) that the Legislature has authorized sufficient funding to implement this HCP for the 2-year period. In addition, HCP commitments will be reflected in the dedication of staff resources through ODF's annual budget, adjusted for inflation, and documented in the HCP annual report. ODF recognizes that failure to annually ensure adequate funding to implement the HCP may be grounds for suspension or partial suspension of the incidental take permits until adequate funding is restored (see Section 8.10, *Permit Suspension or Revocation*, regarding this process).

ODF is confident that it can successfully fund HCP implementation, despite expected fluctuations in the timber market and consequently timber sale revenue. ODF and the HCP itself have safeguards in place to ensure flexibility in HCP implementation and adequacy of funding for HCP implementation:

- Several of the key conservation actions have little or no direct cost associated with them because they involve land designations that forgo timber harvest to conserve, enhance, and restore suitable or occupied habitat for the covered species. Conservation Action 1: Establish Riparian Conservation Area, Conservation Action 5: Standards for Road Improvement and Vacating, and Conservation Action 6: Establish Habitat Conservation Areas are three examples.

- Several conservation actions will occur, in part, in conjunction with timber sales because of the operational efficiency that provides. For example, downed wood to supply Conservation Action 3: Stream Enhancement projects may come from nearby timber harvest activities. Similarly, Conservation Action 4: Remove or Modify Artificial Fish-Passage Barriers could occur with timber harvest activities to ensure operational and cost efficiencies of using heavy equipment in the field. These conservation actions will therefore occur more often (or be more robust) when timber sales increase and would occur less often (or be less robust) when timber sales decrease. Fluctuations in timber sales may or may not be in response to timber markets, as explained below.

- Timber sales by ODF do not necessarily track the timber market. In years of depressed timber prices (stumpage price), for example, ODF maintains the level of timber sales necessary in order to maintain a target fund balance and continue to provide critical revenue to local communities and to protect timber jobs that rely on harvest in state forests. In years of high timber prices ODF may increase the level of timber sales, which increases revenue to the ODF operational reserve fund and provides additional benefits to local communities. Conservation actions tied to the amount and location of timber sales (Conservation Actions 3, 4, 7, and 9) therefore may occur somewhat independently from timber market prices.

- Several conservation measures are designed so that they are insulated against fluctuations in the timber market and in timber harvest revenue. The HCP Conservation Fund, described above, will be used when conservation projects are ready to be implemented. Funding for the following project types will come from the HCP Conservation Fund:

    - Stream enhancement projects (Conservation Action 3)

    - Targeted fish-passage barrier removal or enhancement projects (subset of removals described in Conservation Action 4)

    - Upland restoration projects (Conservation Action 7)

    - Strategic terrestrial species conservation actions (Conservation Action 9)

- It is ODF's policy to maintain to maintain at least 6 months to 1 year or more of reserve operating funds for management of state forest lands. The exact amount of operating funds is determined by market conditions and expenses. For the last 20 years, ODF has maintained a reserve fund of between $4.5 million and $52.3 million, with an average of $24.6 million. Many of the conservation actions are accomplished along with the implementation of management activities and would still be accomplished at a rate consummate with management activity levels under variable economic conditions. While extended economic downturns could adversely impact operating funds, ODF will prioritize maintaining compliance with the HCP.

- Within its biennial authorization, ODF has the ability to adjust fiscal budgets in response to changing conditions. This HCP will become an essential part of ODF's core business function for management of state forests, and, as such, HCP functions will be prioritized during economic downturns or other situations where budgets may be reduced. The Conservation Fund will continue to be earmarked at the same rate, conservation actions will continue to be implemented, and required monitoring and adaptive management functions will be maintained. If budgets are reduced to the extent that key monitoring provisions cannot be maintained as described, ODF will work with the Services to adjust monitoring plans to create efficiencies while still capturing critical information for compliance and effectiveness.

Chapter 10
Alternatives to Take

10.1 Introduction

The ESA requires that applicants for an ITP specify what alternative actions to the take of federally listed species were considered and why those alternatives were not selected. The *Habitat Conservation Planning and Incidental Take Permit Processing Handbook* (U.S. Fish and Wildlife Service and National Marine Fisheries Service 2016) identifies two alternatives commonly used in HCPs.

- Any specific alternative that would reduce take below levels anticipated for the proposed project.
- An alternative that would avoid take and, therefore, not require a permit from USFWS or NMFS.

The preferred and proposed approach is described in all of the previous chapters of this HCP. This proposed approach represents ODF's best attempt to minimize take of the covered species while allowing ODF to conduct on-going and planned forest management activities. In accordance with the ESA, this chapter discusses alternatives that were considered but not selected and the reasons those alternatives were not selected for inclusion in the HCP.

Note that the alternatives described in this chapter are different than the alternatives described in the Environmental Impact Statement (EIS) that accompanies this HCP. The EIS alternatives serve a broader purpose than the alternatives here, which are narrowly focused on alternatives that may eliminate or reduce take of one or more of the covered species. To distinguish the alternatives here from the EIS alternatives, alternatives in the HCP are called *alternatives to take*.

10.2 Description of Alternatives to Take

Three alternatives to take were considered but not selected for analysis in the Western Oregon State Forest HCP: no take, reduced covered activities, and reduced covered species. These alternatives to take and the rationale for their elimination are discussed below. ODF considered an increased timber harvest alternative but this alternative was found to increase the likely level of take[1] of one or more covered species. In the alternatives, and the HCP itself, take is primary the result of habitat loss or modification that impairs essential behavioral patterns for fish or wildlife. Because this alternative would not reduce take on any covered species it is not considered further.

ODF also considered an increased conservation alternative that expanded the amount and extent of HCAs to increase protection for northern spotted owl, marbled murrelet, and other associated terrestrial covered species such as red tree vole. The HCAs in the proposed HCP include 98% of all known occurrences of northern spotted owl and 61% of nesting, roosting, and foraging habitat, along with 99% of all known occurrences of marbled murrelet and 68% of suitable and highly

[1] From Section 3(18) of the Federal Endangered Species Act: "The term 'take' means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct."

suitable habitat in the permit area. Therefore, larger or more HCAs would have only incremental benefits to those species, reducing take but also reducing available acreage for timber harvest. This increased conservation alternative was rejected because it does not balance the need for species conservation with ODF's mission to harvest timber. ODF also considered an increased conservation alternative that reduced or eliminated forest management activities within HCAs. This alternative was also rejected because forest management within HCAs is essential to accelerate the development of additional suitable habitat for the covered species. Furthermore, forest management actions within HCAs are designed to avoid or minimize take of the covered species within HCAs. Therefore, such an alternative that eliminates forest management within HCAs would not reduce take of the covered species.

10.2.1 No Take Alternative

Under the no take alternative, ODF would not engage in forest management activities that result in the take of any of the covered species, thereby removing the need for ITPs from USFWS or NMFS. This alternative was not selected because ODF must continue to adhere to their mandates and mission to manage forests to benefit a variety of organisms, provide economic benefits to citizens, maintain ecosystem services, and provide recreational opportunities for residents in Oregon. ODF's mission statement is described below.

> "*To serve the people of Oregon by protecting, managing, and promoting stewardship of Oregon's forests to enhance environmental, economic, and community sustainability*."

While ODF's mission statement is aligned with the need to protect habitat for covered species, it also requires the integrated use of the forest for community (e.g. recreation and aesthetics) and economic (e.g. timber harvest) sustainability, which often competes or conflicts with using forests to maximize benefits for covered species. In addition, activities that provide long term benefits to covered species habitat may have direct, short-term impacts on individual covered species. Chapter 3, *Covered Activities*, identifies the forest management activities that are necessary for ODF to fulfill its mission statement.

ODF has been managing state forests using a take avoidance strategy since the northern spotted owl was listed in 1990. This strategy requires ODF to conduct intensive and expensive field surveys prior to every timber sale planned in areas that support federally listed species. If listed species or their suitable habitat is found, timber sales must be redesigned, postponed, or abandoned to avoid taking the species. While ODF has used this strategy successfully for many years, it is becoming increasingly impractical as the number of listed species increases. Species expected to be listed in the future are also increasingly difficult to survey and detect, making take avoidance even more challenging and costly. Based on all of these factors, managing state forests using a full take avoidance strategy to comply with the ESA is expected to be increasingly difficult, unpredictable, and costly to ODF. ODF believes that this HCP and the take authorization it will provide is essential to ensure to the agency can successfully implement its mission. Therefore, the no take alternative was rejected as impracticable.

10.2.2 Reduced Covered Activities

Under the reduced covered activities alternative, select covered activities would not be included in the HCP. The activities considered for exclusion from the HCP were road construction and recreational infrastructure construction and maintenance. Use of roads and recreational facilities in the Western Oregon State Forest HCP supports forest management and public use purposes. Road construction and maintenance requires the removal or modification of habitat through tree removal and stream crossings. Development and maintenance of recreational infrastructure requires similar activities at a smaller scale on the landscape. While the elimination of these select activities could reduce or delay implementation of some remaining covered activities under HCP, the majority would continue to occur without significant limitations.

Road and recreational infrastructure construction and maintenance have the potential to affect covered species habitat and individuals in a manner similar to timber harvest. While eliminating road and recreational infrastructure construction and maintenance from the HCP would reduce take of covered species, this alternative was not selected because road and recreational infrastructure construction and maintenance are necessary to the forest management practices covered under the Western Oregon State Forest HCP and to the implementation of ODFs mission. ODF does not expect that in the future, it will be able to fully avoid take of the covered species from road construction/maintenance or recreational infrastructure construction/maintenance. Also, covering these activities will provide ODF with the necessary flexibility in its operations to optimize their designs to minimize all environmental effects (as opposed to prioritizing take avoidance of listed species).

Covering these activities under this HCP will lead to a more comprehensive, large-scale conservation strategy that will provide greater conservation benefit to covered species.

10.2.3 Reduced Habitat Loss from Timber Harvest

This alternative would include a reduction in timber harvest that results in loss of covered species habitat. A reduction in timber harvest activities would reduce incidental take of covered species, at least in locations where species habitat exists on the landscape. This alternative would result in a net reduction in timber volume and harvest revenue from the forest and, in turn, would likely result in the inability to meet the economic needs of the Oregon Department of Forestry. Beyond the economic infeasibility of this alternative, it would also limit the type and amount of habitat management that could be completed in HCAs. This would likely reduce the long-term habitat value provided under the HCP, because without management of some locations (i.e., even-aged Douglas-fir plantations in HCAs), habitat quality is expected to be less, in the future, than it would be if management were to occur. Therefore, while there may be less habitat modification there would also be less habitat developed over time, and all the while economic needs would likely not be met. Therefore, this alternative was rejected.

10.2.4 Reduced Covered Species

The reduced number of covered species take alternative would reduce the number of species covered by the HCP to those that are currently listed as threatened or endangered under the ESA. Under this alternative to take, the HCP would not cover species that are not currently protected under the ESA but are expected to become listed during the HCP permit term. Eliminating non-listed species from the HCP would result in of the HCP covering 11 species (instead of 17): Oregon coast coho, Lower Columbia River coho, Upper Willamette River spring Chinook, Upper Willamette River winter steelhead, Columbia River chum, Southern Oregon/Northern California Coast coho, Lower Columbia River Chinook, eulachon, northern spotted owl, marbled murrelet, and coastal marten. Under this alternative to take, the HCP would not include the following six species: Oregon Coast

Spring Chinook, Southern Oregon Northern California Coast spring Chinook, red tree vole, Oregon slender salamander, Columbia torrent salamander, and Cascade torrent salamander.

The Reduced Number of Covered Species Take Alternative would result in the same level of take for the 11 species covered by this alternative. However, for those species not covered under this alternative (i.e., the nonlisted species), take is likely to increase because take of these species is not prohibited until they become listed. As a result, ODF would not include measures to avoid or minimize effects on these species in the HCP and, therefore, take of these species would likely increase. Once a non-listed species is listed, ODF would have to avoid take of the species or amend this HCP to add it.

This alternative may provide some benefits to ODF in the short term because narrowing the list of covered species would reduce ODF's obligations to implement avoidance, minimization, mitigation, and conservation measures for these non-listed species, thereby reducing costs. However, covering fewer species would result in a biologically inferior program relative to the proposed HCP, and may require additional compliance (if species become listed) during the permit term.

The Reduced Number of Covered Species Take Alternative was rejected because it would result in less protection of, and less mitigation for, rare and sensitive species. Also, one or more of these rare and sensitive species might be listed in the future; if this were to happen, ODF would not be authorized for take and any project affecting a newly listed species would be required to go through a separate permit process or take would need to be avoided entirely. In addition, this alternative could result in fewer long-term efficiencies as non-listed species become listed over the permit term.

Chapter 11
References

Albright, W.L., and D.L. Peterson. 2013. Tree Growth and Climate in the Pacific Northwest, North America: A Broad-Scale Analysis of Changing Growth Environments. *Journal of Biogeography* 40:2119–2133.

Allen, J.D. 1995. *Stream Ecology: Structure and Function of Running Waters*. Chapman & Hall, New York.

Andrews, L.S., J.P. Perkins, J.A. Thrailkill, N.J. Poage, and J.C. Tappeiner, II. 2005. Silvicultural Approaches to Develop Northern Spotted Owl Nesting Sites, Central Coast Ranges, Oregon. *Western Journal of Applied Forestry* 20:13–27.

Arismendi, I., and J.D. Groom. 2019. A Novel Approach for Examining Downstream Thermal Responses of Streams to Contemporary Forestry. *Science of the Total Environment* 651:736–748.

Armstrong, J. B., and D. E. Schindler. 2013. Going with the Flow: Spatial Distributions of Juvenile Coho Salmon Track an Annually Shifting Mosaic of Water Temperature. *Ecosystems* 16(8):142–144.

Atkinson, A. J., P. C. Trenham, R. N. Fisher, S. A. Hathaway, B. S. Johnson, S. G. Torres, and Y. C. Moore. 2004. *Designing Monitoring Programs in an Adaptive Management Context for Regional Multiple Species Conservation Plans*. US Geological Survey, California Department of Fish and Game, and U.S. Fish and Wildlife Service.

Barnett T.P., D.W. Pierce, H.G. Hidalgo, C. Bonfils, B.D. Santer, T. Das, G. Bala, A.W. Wood, T. Nozawa, A.A. Mirin, D.R. Cayan, and M.D. Dettinger. 2008. Human Induced Changes in the Hydrology of the Western United States. *Science* 319:1080–1083.

Bathurst, J. C., and A. Iroumé. 2014. Quantitative Generalizations for Catchment Sediment Yield Following Forest Logging. *Water Resour. Res*. 50:8383–8402.

Becker, B.H., M.Z. Peery, and S. R. Beissinger. 2007. Ocean Climate and Prey Availability Affect the Trophic Level and Reproductive Success of the Marbled Murrelet, an Endangered Seabird. *Mar Ecol Prog Ser.* 329:267–279.

Beechie, T.J., G. Pess, G., P. Kennard, R. Bilby, and S. Bolton. 2000. Modeling Recovery Rates and Pathways for Woody Debris Recruitment in Northwestern Washington Streams. *North American Journal of Fisheries Management* 20:436–452.

Beechie, T, G. Pess, S. Morley, L. Butler, P. Downs, A. Maltby, P. Skidmore, S. Clayton, C. Muhlfeld, and K. Hanson. 2012. Watershed Assessments and Identification of Restoration Needs. In P. Roni and T. Beechie (eds.), *Stream and Watershed Restoration: A Guide to Restoring Riverine Processes and Habitats.* Wiley-Blackwell.

Beschta, R.L., J.R. Boyle, C.C. Chambers, W.P. Gibson, S. V. Gregory, J. Grizzel, J.C. Hagar, J. L. Li, W. C. McComb, T. W. Parzybok, M. L. Reiter, G. H. Taylor, and J. E. Warila. 1995. *Cumulative Effects of Forest Practices in Oregon: Literature and Synthesis.* Report prepared for the Oregon Department of Forestry, Salem, OR, by Oregon State University, Corvallis, OR.

Betts, M.G., J. M. Northrup, J.A. Bailey Guerrero, LJ. Adrean, S.K. Nelson, J.L. Fisher, B.D. Gerber, M.S. Garcia-Heras, Z. Yang, D.D. Roby, and J.W. Rivers. 2020. Squeezed by a Habitat Split: Warm Ocean Conditions and Old-Forest Loss Interact to Reduce Long-Term Occupancy of a Threatened Seabird. *Conservation Letters* 13: e12745.

Bilby, R.E., and P.A. Bisson. 1998. Function and Distribution of Large Woody Debris. Pages 324–326 in R. J. Naiman and R. Bibly (eds.), *River Ecology and Management: Lessons from the Pacific Coastal Ecoregion.* Springer-Verlag, New York.

Bisson, P.A., R.E. Bilby, M.D. Bryant, C.A. Dolloff, G.B. Grette, R.A. House, M.L. Murphy, K.V. Koski, and J.R. Sedell. 1987. Large Woody Debris in Forested Streams in the Pacific Northwest: Past, Present, and Future. Pages 143–190 in E.O. Salo and T.W. Cundy (eds.), *Streamside Management: Forestry and Fishery Interactions*. University of Washington, Institute of Forest Resources, Seattle. Contribution 57.

Bladon, K.D., C. Segura, N.A. Cook, S. Bywater-Reyes, and M. Reiter. 2018. A Multicatchment Analysis of Headwater and Downstream Temperature Effects from Contemporary Forest Harvesting. *Hydrol. Process.* 32:293–304.

Blaustein, Andrew P., Joseph J. Beatty, Deanna H. Olson, and Robert M. Storm. 1995. *The Biology of Amphibians and Reptiles in Old-Growth Forests in the Pacific Northwest.* Gen. Tech. Rep. PNW-GTR-337. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 98 p.

BLM (Bureau of Land Management). 2016a. *Northwestern & Coastal Oregon. Record of Decision and Resource Management Plan*. Oregon State Office. Portland, OR.

———. 2016b. *Southwestern Oregon Record of Decision and Resource Management Plan*. Oregon State Office. Portland, OR.

———. 2019. Unpublished Oregon Slender Salamander Survey Data. Provided to Oregon Department of Forestry, June 28, 2019.

Boguski, D, D H. Goodman, and M. Docker. 2011. Validity of Lampetra pacifica (*Petromyzontiformes: Petromyzontidae*), a Brook Lamprey Described from the lower Columbia River Basin. *Zootaxa* 3091(3091):42–50.

Borker, A.L., P. Halbert, M.W. McKown, B.R. Tershy, and D.A. Croll, D.A., 2015. A Comparison of Automated and Traditional Monitoring Techniques for Marbled Murrelets Using Passive Acoustic Sensors. *Wildl. Soc. Bull.* 39:813–818.

Boston, K. 2016. The Potential Effects of Forest Roads on the Environment and Mitigating Their Impacts. *Current Forestry Reports* 2:215–222.

Bottom, D. L., K. K. Jones, C. A. Simenstad, and C. L. Smith. 2009. Reconnecting Social and Ecological Resilience in Salmon Ecosystems. *Ecology and Society* 14(1):5.

Brown, G. W. No Date. *The Impact of Timber Harvest on Soil and Water Resources*. School of Forestry, Oregon State University.

Bryant, M.D. 1983. The Role and Management of Woody Debris in West Coast Salmonid Nursery Stream. *North American Journal of Fishery Management* 3(3):322–330.

Bryant, M. D., T. Gomi, and J.J. Piccolo. 2007. Structures Linking Physical and Biological Processes in Headwater Streams of the Maybeso Watershed, Southeast Alaska. *Forest Sciences* 53(2):371–383.

Buckler, D.R., and G.E. Granato. 1999. *Assessing Biological Effects from Highway-Runoff Constituents.* U.S. Geological Survey Open File Report 99-240, Northborough, Massachusetts. 45 p.

Buffler, Susan. 2005. *Synthesis of Design Guidelines and Experimental Data for Water Quality Function in Agriculture Landscapes in the Intermountain West*. Thesis. 60pp.

Buisson L., G. Blanc, and G. Grenouillet. 2008. Modelling Stream Fish Species Distribution in a River Network: The Relative Effects of Temperature Versus Physical Factors. *Ecol Freshw Fish* 17:244–257.

Burnett K. M., G. H. Reeves, D. J. Miller, S. Clarke, K. Vance-Borland, and K. Christiansen. 2007. Distribution of Salmon-Habitat Potential Relative to Landscape Characteristics and Implications for Conservation. *Ecological Applications* 14(1):66–80.

Bury, R. B. 1988. Habitat Relationships and Ecological Importance of Amphibians and Reptiles. In K.J. Raedeke (ed.), *Streamside Management: Riparian Wildlife and Forestry Interactions*. Contrib. 59, Inst. For. Resour., Univ. of Washington, Seattle.

Camaclang, A.E., M. Maron, T.G. Martin, and H.P. Possingham. 2015. Current Practices in the Identification of Critical Habitat for Threatened Species. *Conservation Biology* 29:482–492.

Carey, A. B. 2007. *Aiming for Healthy Forests: Active, Intentional Management for Multiple Values*. General Technical Report PNW-GTR-721. USDA Forest Service, Pacific Northwest Research Station, Portland, OR

Castro, J., M. Pollock, C. Jordan, G. Lewallen, and K. Woodruff. 2015. *The Beaver Restoration Handbook: Working with Beaver to Restore Streams, Wetlands, and Floodplains.* USFWS, Portland OR. 189p.

Clayton, D.R., and D.H. Olson. 2009. *Conservation Assessment for the Oregon Slender Salamander*. Version 2.0. January 2009. U.S.D.A. Forest Service Region 6 and U.S.D.I. Bureau of Land Management.

Cole, E., and M. Newton. 2013. Influence of Streamside Buffers on Stream Temperature Response Following Clear-Cut Harvesting in Western Oregon. *Can. J. Forest Res*. 43:993–1005.

Cole, E.C., W.C. McComb, M. Newton, C.L. Chambers, and J. P. Leeming. 1997. Response of Amphibians to Clearcutting, Burning, and Glyphosate Application in the Oregon Coast Range. *The Journal of Wildlife Management* 61(3).

Colman, J.A., K.C. Rice, and T.C. Willoughby. 2001. *Methodology and Significance of Studies of Atmospheric Deposition in Highway Runoff*. U.S. Geological Survey Open-File Report 01-259, Northborough, Massachusetts, 63 p.

Corn, P.S., and R.B. Bury. 1989. Logging in Western Oregon: Responses of Headwater Habitats and Stream Amphibians. *Forest Ecology and Management* 29:39–57.

CRITFC (Columbia River Inter-Tribal Fish Commission). 2011. *Tribal Pacific Lamprey Restoration Plan for the Columbia River Basin. Nez Perce, Umatilla, Yakama, and Warm Springs Tribes.*

December 19. Available: https://www.critfc.org/fish-and-watersheds/columbia-river-fish-species/lamprey/lamprey-plan/.

Crozier, L. 2016. *Impacts of Climate Change on Salmon of the Pacific Northwest. A Review of the Scientific Literature Published in 2015*.

Cummer, M.R., D.E. Green, and E.M. O'Neill. 2005. Aquatic Chytrid Pathogen Detected in Terrestrial Plethodontid Salamander. *Herpetological Review* 36:248–249.

Davis, L.J., M. Reiter, and J.D. Groom. 2015. Modelling Temperature Change Downstream of Forest Harvest Using Newton's Law of Cooling. *Hydrological Processes* 30:959–971.

Davis, R.J., B. Hollen, J. Hobson, J.E. Gower, and D. Keenum. 2016. *Status and Trends of Northern Spotted Owl Habitats. Northwest Forest Plan. The First 20 Years (1994–2013).* Pacific Northwest Research Station. General Technical Report. PNW-GTR-929. Portland, OR.

Dodson, E. K., A. Ares, and K.J. Puettmann. 2012. Early Responses to Thinning Treatments Designed to Accelerate Late Successional Forest Structure in Young Coniferous Stands of Western Oregon, USA. *Canadian Journal of Forest Research* 42(2):345–355. DOI: 10.1139/x11-188.

Driscoll, E.D., P.E. Shelley, and E.W. Strecher. 1990. *Pollutant Loadings and Impacts from Highway Runoff, Volume III: Analytical Investigation and Research Report*. FHWD-RD- 88-0088. Federal Highway Administration, Office of Engineering and Highway Operations Research and Development, McLean, Virginia.

Duchac, L.S., D.B. Lesmeister, K.M. Dugger, Z.J. Ruff, and R.J. Davis. 2020. Passive Acoustic Monitoring Effectively Detects Northern Spotted Owls and Barred Owls Over a Range of Forest Conditions. *The Condor* 122:1–22.

Dugger, K. M., R.G. Anthony, and L.S. Andrews. 2011. Transient Dynamics of Invasive Competition: Barred Owls, Spotted Owls, Habitat, and the Demons of Competition Present. *Ecological Applications* 21(7).

Dugger, K.M., E.D. Forsman, A.B. Franklin, R.J. Davis, G.C. White, C.J. Schwarz, K.P. Burnham, J.D. Nichols, J.E. Hines, C.B. Yackulic, P.F. Doherty Jr., L.L. Bailey, D.A. Clark, S.H. Ackers, L.S. Andrews, B. Augustine, B.L. Biswell, J.A. Blakesley, P.C. Carlson, M.J. Clement, L.V. Diller, E.M. Glenn, A. Green, S.A. Gremel, D.R. Herter, J.M. Higley, J. Hobson, R.B. Horn, K.P. Huyvaert, C. McCafferty, T.L. McDonald, K. McDonnell, G.S. Olson, J.A. Reid, J. Rockweit, V. Ruiz, J. Saenz, and S.G. Sovern. 2016. The Effects of Habitat, Climate and Barred Owls on the Long-Term Population Demographics of Northern Spotted Owls. *Condor*. 118: 57–116. doi:10.1650/CONDOR-15-24.1.

Dunham, J.B., A.E. Rosenberger, C.H. Luce, and B.E. Rieman. 2007. Influences of Wildfire and Channel Reorganization on Spatial and Temporal Variation in Stream Temperature and the Distribution of Fish and Amphibians. *Ecosystems* 10:335–346.

Durance, I. and S. Ormerod. 2009. Trends in Water Quality and Discharge Confound Long-Term Warming Effects on River Macroinvertebrates. *Freshw Ecol* 54:388–405.

Dwire, K.A., K.E. Meyer, G. Riegel, and T. Burton, T. 2016. *Riparian Fuel Treatments in the Western USA; Challenges and Considerations.* Gen. Tech. Rep. RMRS-GTR-352; Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 156 p.

ECONorthwest and ICF. 2018. *Oregon Department of Forestry Habitat Conservation Plan A Business Cases Analysis.* Prepared for Oregon Department of Forestry. 12 p.

EPA (United States Environmental Protection Agency). 2013. *Potential Modeling Approach to Evaluate the Effects of Thinning Activities on Stream Shade*. EPA Comment to BLM 11/19/2013. Portland, OR.

Evans Mack, D., W.P. Ritchie, S.K. Nelson, E. Kuo-Harrison, P. Harrison, and T.E. Hamer. 2003. *Methods for Surveying Marbled Murrelets in Forests: A Revised Protocol for Land Management and Research.* Pacific Seabird Group unpublished document. Available: http://www.pacificseabirdgroup.org.

Falxa, G.A., and M.G. Raphael. 2016. *Status and Trend of Marbled Murrelet Populations and Nesting Habitat. Northwest Forest Plan. The First 20 Years (1994–2013).* Pacific Northwest Research Station. General Technical Report. PNW-GTR-929. Portland, OR.

Federal Geographic Data Committee. 2013. *Classification of Wetlands and Deepwater Habitats of the United States.* FGDC-STD-004-2013. Second Edition. Wetlands Subcommittee, Federal Geographic Data Committee and U.S. Fish and Wildlife Service, Washington, DC.

Filip, G., A.K.K. Kavanagh, G. Johnson, R. Johnson, and D. Maguire. 2000. *Silviculture and Swiss Needle Cast: Research and Recommendations.* Research Contribution 30, Forest Research Laboratory, College of Forestry, Oregon State Univ., Corvallis, OR.

Forsman, E.D., I.A. Otto, S.G. Sovern, M. Taylor, D.W. Hays, H. Allen, S.L. Roberts, and D.E. Seaman. 2001. Spatial and Temporal Variation in Diets of Spotted Owls in Washington. *Journal of Raptor Research* 35:141–150.

Forsman, E.D., R.G. Anthony, J.A. Reid, P J. Loschl, S.G. Sovern, M. Taylor, B.L. Biswell, A. Ellingson, E.C. Meslow, G.S. Miller, K.A. Swindle, J.A. Thrailkill, F.F. Wagner, and D.E. Seaman. 2002. *Natal and Breeding Dispersal of Northern Spotted Owls.* Wildlife Monographs:1–35.

Forsman, E.D., R. G. Anthony, E.C. Meslow, and C.J. Zabel. 2004. Diets and Foraging Behavior of Northern Spotted Owls in Oregon. *Journal of Raptor Research* 38 (3).

Forsman, E.D., R.G. Anthony, K.M. Dugger, E.M. Glenn, A.B. Franklin, G.C. White, C.J. Schwarz, K.P. Burnham, D.R. Anderson, J.D. Nichols, J.E. Hines, J.B. Lint, R.J. Davis, S.H. Ackers, L.S. Andrews, B.L. Biswell, P.C. Carlson, L.V. Diller, S.A. Gremel, D.R. Herter, J.M. Higley, R.B. Horn, J.A. Reid, J. Rockweit, J. Schaberl, T.J. Snetsinger, and S.G. Sovern. 2011. *Population Demography of Northern Spotted Owls: 1985–2008.* Studies in Avian Biology. Cooper Ornithological Society.

Forsman, E.D., J.K. Swingle, R.J. Davis, B.L. Biswell, and L.S. Andrews. 2016. *Tree Voles: An Evaluation of Their Distribution and Habitat Relationships Based on Recent and Historical Studies, Habitat Models, and Vegetation Change*. Gen. Tech. Rep. PNW-GTR-948. Portland, OR: US Department of Agriculture, Forest Service, Pacific Northwest Research Station. 119 p., 948.

Franklin, J.E., and C.T. Dyrness. 1988. *Natural Vegetation of Oregon and Washington*. Corvallis, OR, USA: Oregon State University Press. 427 p.

Franklin, J.F., K.N. Johnson, and D.L. Johnson. 2018. *Ecological Forest Management.* Long Grove, IL: Waveland Press.

Furniss, M.J., T.D. Roelofs, and C.S. Yee. 1991. Influences of Forest and Rangeland Management on Salmonid Fishes and Their Habitats. *American Fisheries Society Special Publications* 19:297–232.

Garcia, T.S., J. Johnson, J. Jones, and A.J. Kroll. 2020. Experimental Evidence Indicates Variable Responses to Forest Disturbance and Thermal Refugia by Two Plethodontid Salamanders. *Forest Ecology and Management* 464.

GBIF (Global Biodiversity Information Facility). 2019. GBIF Occurrence Download. *Rhyacotriton kezeri*. Available: https://www.gbif.org/species/2431179.

Gilbert, F.F., and R. Allwine.1991. Terrestrial Amphibian Communities in the Oregon Coast Range. Pages 318–324 in L.F. Ruggiero, K.B. Aubry, A.B. Carey, and M.H. Huff (eds.), *Wildlife and Vegetation of Unmanaged Douglas-Fir Forests.* U.S. Forest Service General Technical Report PNW-285, Portland, OR.

Gomi, T., R.D. Moore, and M.A. Hassan. 2005. Suspended Sediment Dynamics in Small Forest Streams of the Pacific Northwest. *J. Am. Water Resour. Assoc*. 41:877–898.

Good, D.A., and D.B. Wake. 1992. Geographic Variation and Speciation in the Torrent Salamanders of the Genus Rhyacotriton (*Caudata: Rhyacotritonidae*). *University of California Publications in Zoology* 126:1–91.

Grant, G.E., and A.L. Wolff. 1991. *Long-Term Patterns of Sediment Transport after Timber Harvest, Western Cascade Mountains, Oregon, USA, in Sediment and Stream Water Quality in a Changing Environment.* Proceedings of the Vienna IAHS Symposium, IAHS Publ. 203, edited by D. E. Walling and N. Peters, pages 31–40. Int. Assoc. of Hydrol. Sci. Publ., Oxford, U.K.

Grant, G.E., S.L. Lewis., F.J. Swanson, J.H. Cissel, and J.J. Mcdonnell. 2008. *Effects of Forest Practices on Peak Flows and Consequent Channel Response: A State-of-Science Report for Western Oregon and Washington*. DIANE Publishing.

Green Diamond Resource Company. 2018. *Green Diamond Forest Habitat Conservation Plan.* June. Public Draft.

Gregory, S.V., G.A. Lamberti, D.C. Erman, K.V. Koski, M.L. Murphy, and J.R. Sedell. 1987. Influence of Forest Practices on Aquatic Production. Pages 233–255 in E.O. Salo and T.W. Cundy (eds.), *Streamside Management: Forestry and Fishery Interactions*. University of Washington, Institute of Forest Resources Contribution 57, Seattle.

Griffith, G. 2010. *Level III North American Terrestrial Ecoregions: United States Descriptions*. May 11, 2010 Version. Available: https://www.epa.gov/eco-research/ ecoregions-north-america.

Groom, J.D., L. Dent, L.J. Madsen, and J. Fleuret, 2011. Response of Western Oregon (USA) Stream Temperatures to Contemporary Forest Management. *Forest Ecology and Management* 262:1618–1629.

Gucinski, H.,M.J. Furniss, R.R. Ziemer, and M.H. Brooks. 2001. *Forest Roads: A Synthesis of Scientific Information.* General Technical Report PNW-GTR-509. U.S. Forest Service. Portland, OR.

Hairston-Strang, A.B., and P.W. Adams. 1998. Potential Large Woody Debris Sources in Riparian Buffers after Harvesting in Oregon, U.S.A. *Forest Ecology and Managemen*t 113(1-2):66–77.

Halofsky, J.E., and D.E. Hibbs. 2008. Determinants of Riparian Fire Severity in Two Oregon Fires, USA. *Canadian Journal of Forest Research* 38:1959–1973.

Halofsky, J.E., D.L. Peterson, and J.J. Ho. 2017. *Climate Change Vulnerability and Adaptation in South Central Oregon*. USDA. 439 p.

Hammerson, G. 2004. *Rhyacotriton olympicus*. The IUCN Red List of Threatened Species 2004:e.T59437A11941548.

Hassan, M. A., M. Church, T. E. Lisle, F. Brardinoni, F., L. Benda, and G.E. Grant. 2005. Sediment Transport and Channel Morphology of Small, Forested Streams 1. *Journal of the American Water Resources Association* 41(4):853–876.

Hicks B.J., R.L. Beschta, and R.D. Harr. 1991. Long-Term Changes in Streamflow Following Logging in Western Oregon and Associated Fisheries Implications. *Water Resources Bulletin* 27(2):217–226.

Howell, B.L., and N.M. Maggiulli. 2011. *Conservation Assessment for the Cascade Torrent Salamander* (Rhyacotrition cascadae). Version 1. February 2011. USDA Forest Service Region 6 and USDI Bureau of Land Management Interagency Special Status and Sensitive Species Program. Available: https://www.fs.fed.us/r6/sfpnw/issssp/species-index/fauna-amphibians.shtml. Accessed: May 2, 2019.

Huff, M.H., M.G. Raphael, S.L. Miller, S.K. Nelson, and J. Baldwin. 2006. *Northwest Forest Plan—The First 10 Years (1994–2003): Status and Trends of Populations and Nesting Habitat for the Marbled Murrelet.* Gen. Tech. Rep. PNW-GTR-650. U.S. Forest Service, Pacific Northwest Research Station, Portland, OR

ICF International. 2012. *Santa Clara Valley Habitat Plan*. Santa Clara County, California. Prepared for County of Santa Clara, City of San Jose, City of Morgan Hill, City of Gilroy, Santa Clara Valley Water District, and Santa Clara Valley Transportation Authority.

ICF. 2018. *Western Placer County Habitat Conservation Plan and Natural Community Conservation Plan.*

Isaak, D., S. Wollrab, D. Horan, and G. Chandler. 2012. Climate Change Effects on Stream and River Temperatures Across the Northwest U.S. from 1980–2009 and Implications for Salmonid Fishes. *Climatic Change* 113:499–524.

Isaak, D., S. Wenger, E. Peterson, J. Ver Hoef, D. Nagel, C. Luce, S. Hostetler, J. Dunham, B. Roper, S. Wollrab, G. Chandler, D. Horan, and S. Parkes-Payne. 2017. The NorWeST Summer Stream Temperature Model and Scenarios for the Western U.S.: A Crowd-Sourced Database and New Geospatial Tools Foster a User Community and Predict Broad Climate Warming of Rivers and Streams. *Water Resources Research* 53:9181–9205. Available: https://doi.org/10.1002/2017WR020969.

Isaak, D.J., C. Luce, D. Horan, G. Chandler, S. Wollrab, and D. Nagel. 2018. Global Warming of Salmon and Trout Rivers in the Northwestern U.S.: Road to Ruin or Path Through Purgatory? *Transactions of the American Fisheries Society* 147. DOI:10.1002/tafs.10059.

ISAB (Independent Science Advisory Board). 2007. *Climate Change Impacts on Columbia River Basin Fish and Wildlife.* ISAB Climate Change Report ISAB 2007-2. Portland, OR: Northwest Power and Conservation Council. 136 p

Jackson, C.R., C.A. Sturm, and J.M. Ward. 2001. Timber Harvest Impacts on Small Headwater Stream Channels in the Coast Range of Washington. *Journal of the American Water Resources Association* 37(6):1533–1549.

Jackson, S.D. 2003. Ecological Considerations in the Design of River and Stream Crossings. Pages 20–29 in C. L. Irwin, P. Garrett, and K. P. McDermott (eds.), *Proceedings of the International Conference on Ecology and Transportation.* North Carolina State University, Center for Transportation and the Environment, Raleigh, NC.

Jancovich, J.K., E.W. Davidson, J.F. Morado, B.L. Jacobs, and J.P. Collins. 1997. Isolation of a Lethal Virus from the Endangered Tiger Salamander, *Ambystoma tigrinum stebbinsi Lowe*. *Diseases of Aquatic Organisms* 31:161–167.

Johnson, S.L., and J.A. Jones. 2000. Stream Temperature Responses to Forest Harvest and Debris Flows in Western Cascades, Oregon. *Canadian Journal of Fisheries and Aquatic Sciences* 57:30–39.

Jones, K.K., K. Anlauf-Dunn, P.S. Jacobsen, M. Strickland, L. Tennant, and S.E. Tippery. 2014. Effectiveness of Instream Wood Treatments to Restore Stream Complexity and Winter Rearing Habitat for Juvenile Coho Salmon. *Transactions of the American Fisheries Society* 143:334–345.

Kauffman, P.R., D.P. Larsen, and J. Faustini. 2009. Bed Stability and Sedimentation Associated with Human Disturbances in Pacific Northwest Streams. *Journal of the American Water Resources Association* 45(2):434–459.

Kayhanian, M., A. Singh, C. Suverkropp, and S. Borroum. 2003. The Impact of Annual Average Daily Traffic on Highway Runoff Pollutant Concentrations. *Journal of Environmental Engineering* 129(11):975–990.

Keith, R.M., T.C. Bjornn, W.R. Meehan, N.J. Hetrick, and M.A. Brusven. 1998. Response of Juvenile Salmonids to Riparian and Instream Cover Modifications in Small Streams Flowing Through Second-Growth Forests of Southeast Alaska. *Transactions of the American Fisheries Society* 127:889–907.

Kibler, K.M., A. Skaugset, L.M. Ganio, and M.M. Huso. 2003. Effect of Contemporary Forest Harvesting Practices on Headwater Stream Temperatures: Initial Response of the Hinkle Creek Catchment, Pacific Northwest, USA. *For. Ecol. Manag.* 310:680–691.

Kliejeunas, J.T, B.W. Geils, J.M. Glaeser, E.M. Goheen, P. Hennon, M. Kim, H. Kope, J. Stone, R. Sturrock, and S.J. Frankel. 2009. *Review of Literature on Climate Change in Western North America*. Gen. Tech. Rep. PSW-GTR-225. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest research Station. 54 p.

Kroll, A.J., T. Garcia, J. Jones, K. Dugger, K.B. Murden, J. Johnson, S. Peterman, B. Brintz, and M. Rochelle. 2015. Evaluating Multi-Level Models to Test Occupancy State Responses of Plethodontid Salamanders. *PLoS ONE* 10, e0142903.

Kuehne, C., A. R. Weiskittel, S. Fraver, and K.J. Puettmann. 2015. Effects of Thinning-Induced Changes in Structural Heterogeneity on Growth, Ingrowth, and Mortality in Secondary Coastal Douglas-Fir Forests. *Can. J. For. Res.* 45:1448–1461.

Kuletz, K.J. 2005. *Foraging Behavior and Productivity of a Non-Colonial Seabird, The Marbled Murrelet, Relative To Prey And Habitat.* University of Victoria, Victoria, Canada.

Lakel, W.A., W.M. Aust, M.C. Bolding, C.A. Dolloff, P. Keyser, and R. Feldt. 2010. Sediment Trapping by Streamside Management Zones of Various Widths after Forest Harvest and Site Preparation. *For. Sci.* 56(6):541–551.

Lesmeister, D.B., R.J. Davis, P.H. Singleton, and J.D. Wiens. 2018. Northern Spotted Owl Habitat and Populations: Status and Threats. Chapter 4, pages 374–624 in T.A. Spies, P.A. Stine, R. Gravenmier, J.W. Long, and M.J. Reilly (tech. coords.), *Volume 2—Synthesis Of Science To Inform Land Management Within the Northwest Forest Plan Area*. Gen. Tech. Rep. PNW-GTR-966. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Lindenmayer, D., and J. Franklin. 2002. *Conserving Forest Biodiversity: A Comprehensive Multiscaled Approach*. Island Press.

Linnell, M.A., R.J. Davis, D.B. Lesmeister, and J.K. Swingle. 2017. Conservation and Relative Habitat Suitability for an Arboreal Mammal Associated with Old Forest. *Forest Ecology and Management* 402:1–11.

Littell, J.S., D.L. Peterson, K.L. Riley, Y. Liu, and C.H. Luce. 2016. A Review of the Relationships Between Drought and Forest Fire in the United States. *Global Change Biology* 22:2353–2369. Available: https://doi.org/10.1111/gcb.13275.

Long, L.L., and J.D. Wolfe. 2019. Review of the Effects of Barred Owls on Spotted Owls. J*. Wildl. Manag*. 83:1281–1296.

Luce, C.H., J.T. Abatzoglou, and Z.A. Holden. 2013. The Missing Mountain Water: Slower Westerlies Decrease Orographic Enhancement in the Pacific Northwest USA. *Science* 342(6164):1360–1364, doi:10.1126/science.1242335.

Macdonald, J.S., J.C. Scrivener, D.A. Patterson, and A. Dixon-Warren. 1998. Temperatures in Aquatic Habitats: The Impacts of Forest Harvesting and the Biological Consequences to Sockeye Salmon Incubation Habitats in the Interior of B.C. Pages 267–282 in M.K. Brewin and D.M.A. Monita (tech. coord.), *Forest–Fish Conference: Land Management Practices Affecting Aquatic Ecosystems. Proceedings of the Forest-Fish Conference, 1–4 May 1996, Calgary, Alberta.* Can. For. Serv. North. For. Res. Cent. Inf. Rep. Nor-X356.

Macdonald, J.S., E.A. MacIsaac, and H.E. Herunter. 2003. The Effect of Variable-Retention Riparian Buffer Zones on Water Temperatures in Small Headwater Streams in Sub-Boreal Forest Ecosystems of British Columbia. *Canadian Journal of Forest Research* 33(8):1371–1382.

Magby, J., J. Firman, T. Haren, D. Cone, N. Palazzotto, J. Clark, M. Buren, J. Butteris, L Dent, T. Williams, T. Calhoun, M. Meleason, M. Totey, and R. Lefebvre. 2018. *Western Oregon State Forest Resource Assessment*. Oregon Department of Forestry. Salem, OR.

Maguire, D. A., A. Kanaskie, W. Voelker, R. Johnson, and G. Johnson, 2002. *Growth of Young Douglas-Fir Plantations Across a gradient in Swiss Needle Cast Severity. Western Journal of Applied Forestry* 17:86–95.

Maguire, D.A., D.B. Mainwaring, and A. Kanaskie. 2011. Ten-Year Growth and Mortality in Young Douglas-Fir Stands Experiencing A Range in Swiss Needle Cast Severity*. Can. J. For. Res.* 41:2064–2076.

Malt, J., and D. Lank. 2007. *Temporal Dynamics of edge Effects on Nest Predation Risk for the Marbled Murrelet.* Biological Conservation 140.

Marks-Fife, C.A. 2016. *Estimation of Population Age Structure, Detection Probability, and Density of Red Tree Voles in Oregon*. MS thesis. Oregon State University. Corvallis, OR.

Martin, K.J. and B. McComb 2002. Small Mammal Habitat Associations at Patch and Landscape Scales in Oregon. *Forest Science* 48(2).

Maser, C., and J. M. Trappe. (Tech. Eds.). 1984. The *Seen and Unseen World of the Fallen Tree*. USDA For. Sew. Gen. Tech. Rep. PW- 164. 56 p.

McFarland, W. 1983. A *Description of Aquifer Units in Western Oregon*. U.S. Geological Survey Open-File Report 82-165. Portland, OR.

McIver, W. 2019. Ma*rbled Murrelet Effectiveness Monitoring, Northwest Forest Plan. 2018 Summary Report.* Northwest Forest Plan Interagency Regional Monitoring Program. April 2019.

Meiman, S., R. Anthony, E. Glenn, T. Bayless, A. Ellingson, M.C. Hansen, and C. Smith. 2003. Effects of Commercial Thinning on Home-Range and Habitat-Use Patterns of a Male Northern Spotted Owl: A Case Study. *Wildlife Society Bulletin* 31(4).

Montana Department of Natural Resources and Conservation (MDNRC). 2010. *Forested State Trust Lands. Habitat Conservation Plan Final EIS*. Appendix A. Habitat Conservation Plan. Montana Department of Natural Resources and Conservation and US Fish and Wildlife Service.

Montgomery, D.R., T.B. Abbe, J.M. Buffington, N.P. Peterson, K.M. Schmidt, and J.D. Stock. 1996. Distribution of Bedrock and Alluvial Channels in Forested Mountain Drainage Basins. *Nature* 381:587–589.

Moore, R.D., and J.S. Richardson, 2003. Progress Towards Understanding the Structure, Function, and Ecological Significance of Small Stream Channels and Their Riparian Zones. *Canadian Journal of Forest Research* 33:1349–1351.

Moriarty K.M., C.W. Epps, and W.J. Zielinski 2016. Forest Thinning for Fuel Reduction Changes Movement Patterns and Habitat Use by Pacific Marten*. The Journal of Wildlife Management* 80:621–633

Moriarty, K.M., J. Verschuyl, A.J. Kroll, R. Davis, J. Chapman, and B. Hollen. 2019. Describing Vegetation Characteristics Used by two Rare Forest-Dwelling Species: Will Established Reserves Provide for Coastal Marten in Oregon? *PLoS ONE* 14(1):e0210865.

Mote, P.W., A.F. Hamlet, M.P. Clark, and D.P. Lettenmaier. 2005. Declining Mountain Snowpack in Western North America. *Bull. Am. Meteorol. Soc.* 86(1):39–49, doi:10.1175/BAMS-86-1-39.

Mote, P.W., S. Li, D.P. Lettenmaier, M. Xiao, and R. Engel. 2018. Dramatic Declines in Snowpack in the Western US. *Climate and Atmospheric Science,* Volume 1, Article 2.

Nelson, S.K., and A.K. Wilson. 2002. *Marbled Murrelet Habitat Characteristics on State Lands in Western Oregon*. Corvallis, OR, Oregon Cooperative Fish and Wildlife Research Unit, Oregon State University, Department of Fisheries and Wildlife, 151 pp.

Neuheimer, A.B., and C.T. Taggart. 2007. The Growing Degree-Day and Fish Size-at-Age: The Overlooked Metric. *Can J Fish Aquat Sci* 64:375–385.

Newton, M. and L. Cole., 2015. Overstory Development in Douglas-Fir-Dominant Forests Thinned to Enhance Late-Seral Features*. Forest Science* 61:809–816.

Nickelson, T.E., J.D. Rodgers, S.L Johnson, and M.F. Solazzi. 1992. Seasonal Changes in Habitat Use by Juvenile Coho Salmon (*Oncorhynchus kisutch*) in Oregon Coastal Streams. *Canadian Journal of Fisheries and Aquatic Sciences* 49(4):783–789.

Nijhuis, M.J., and R.H. Kaplan. 1998. Movement Patterns and Life History Characteristics in a Population of the Cascade Torrent Salamander (*Rhyacotriton cascadae*) in the Columbia River Gorge, Oregon. *Journal of Herpetology* 32:310–304.

NOAA Fisheries (National Oceanic and Atmospheric Administration Fisheries). 2013. *ESA Recovery Plan for Lower Columbia River Coho Salmon, Lower Columbia River Chinook Salmon, Columbia River Chum Salmon, and Lower Columbia River Steelhead.* National Marine Fisheries Service, Northwest Region. June

———. 2014a. *Final Recovery Plan for the Southern Oregon/Northern California Coast Evolutionarily Significant Unit of Coho Salmon.*

———. 2014b. *Fish-Habitat Relationships and the Effectiveness of Habitat Restoration*. Prepared by Roni, P., G.R. Pess, T.J. Beechie, and K.M. Hanson. NOAA Technical Memorandum NMFS-NWFSC-127.

———. 2014c. *Anadromous Salmonid Passage Facility Design*. NOAA Fisheries, Northwest Region. Portland, Oregon.

———. 2016. *Effects of Thinning on Large Wood Production and Recruitment from Riparian Reserves in the Context of Proposed Western Oregon Plan Revisions for BLM Lands.* 66 p.

Nussbaum, R.A., and C.K. Tait. 1977. Aspects of the Life History and Ecology of the Olympic Salamander, *Rhyacotriton olympicus* (Gaige). *American Midland Naturalist* 98:176–199.

Nussbaum, R.A., E.D. Brodie Jr., and R.M. Storm. 1983. *Amphibians and Reptiles of the Pacific Northwest*. University Press of Idaho, Moscow, Idaho.

O'Hanley J.R., and D. Tomberlin. 2005. Optimizing the Removal of Small Fish Passage Barriers. *Environmental Modeling and Assessment* (2005) 10:85–98.

ODF (Oregon Department of Forestry). 1996. *Flood Study and Landslide Inventory*.

———. 2000a. *Forest Road Hazard Inventory.*

———. 2000b. *State Forests Program, Forest Engineering Roads Manual.*

———. 2009. *Road Hazards Inventory.* Salem, Oregon.

———. 2010a. *Northwest Oregon State Forests Management Plan*. Revised April 2010. 581 pp.

———. 2010b. *Southwest Oregon State Forests Management Plan*. Revised April 2010. 581 pp.

———. 2017a. *Northern Spotted Owl Operational Policies*. Oregon Department of Forestry Policy Document. November 2017. Salem, OR.

———. 2017b. *Slope Stability and Landslides in the Context of Harvest*. 5 pp.

———. 2019. *Marbled Murrelet Technical Report Final*. April 24, 2019. Report developed by Jennifer Weikel, Wildlife Biologist Private Forest Program, Oregon Department of Forestry. Salem, OR.

———. 2019a. *Draft Astoria District, 2020 Annual Operations Plan.*

———. 2019b. *Draft Forest Grove District, 2020 Annual Operations Plan.*

———. 2019c. *Draft Klamath Lake District, 2020 Annual Operations Plan.*

———. 2019d. *Draft North Cascade District, 2020 Annual Operations Plan.*

———. 2019e. *Draft Tillamook District, 2020 Annual Operations Plan.*

———. 2019f. *Draft Western Lane District, 2020 Annual Operations Plan.*

———. 2019g. *Draft West Oregon District, 2020 Annual Operations Plan.*

———. 2019h. *Western Oregon State Forests Management Plan*. Draft Plan. December 2019. Salem, OR.

ODFW (Oregon Department of Fish and Wildlife). 2008. *Oregon Guidelines for Timing of In-Water Work to Protect Fish and Wildlife*. Available: https://www.dfw.state.or.us/lands/inwater/Oregon_Guidelines_for_Timing_of_%20InWater_Work2008.pdf.

———. 2009. *Guidance on Beavers*. https://www.dfw.state.or.us/wildlife/living_with/docs/beaver.pdf

———. 2013. *Fish Passage Priority List. Fish Screening and Passage Program*. February 1. 65 pp.

———. 2016. *Oregon Conservation Strategy*. Salem, OR.

———. 2019a. *Instream Habitat Trends*. Completed for the Oregon Department of Forestry. May 2019.

———. 2019b. *Oregon Fish Passage Barriers*. Available: https://nrimp.dfw.state.or.us/nrimp/default.aspx?pn=fishbarrierdata#:~:text=Oregon%20Fish%20Passage%20Barriers,that%20is%20stewarded%20by%20ODFW.

ODFW and NOAA (Oregon Department of Fish and Wildlife and National Oceanic and Atmospheric Administration). 2011. *Upper Willamette River Conservation and Recovery Plan for Chinook Salmon and Steelhead. Final.* August 5, 2011.

Olson, D. and C. Rugger. 2007. Preliminary Study of the Effects of Headwater Riparian Reserves with Upslope Thinning on Stream Habitats and Amphibians in Western Oregon. *Journal of Forest Science* 53:331–342.

Olson, G.S., E.M. Glenn, R. G. Anthony, E.D. Forsman, J.A. Reid, P.J. Loschl, and W.J. Ripple. 2004. Modeling Demographic Performance of Northern Spotted Owls Relative to Forest Habita tin Oregon*. Journal of Wildlife Management* 68(4).

Olson, G.S., R.G. Anthony, E.D. Forsman, S.H. Ackers, P.J. Loschl, J.A. Reid, K.M. Dugger, E M. Glenn, and W.J. Ripple. 2005. Modeling of Site Occupancy Dynamics for Northern Spotted Owls, With Emphasis on the Effects of Barred Owls. *Journal of Wildlife Management* 69:918–932

Oregon Climate Change Research Institute. 2017. *The Third Oregon Climate Assessment Report.* January. Oregon Climate Change Research Institute, College of Earth, Ocean and Atmospheric Sciences, Oregon State University, Corvallis, OR.

Oregon Department of Environmental Quality. 2013. *Oregon Basin and Subbasins List.* Available: https://www.oregon.gov/deq/wq/tmdls/Pages/TMDLS-Basin-List.aspx. Accessed: September 2019.

———. 2020. *Willamette Basin Water Quality / Total Maximum Daily Loads.* Available: https://www.oregon.gov/deq/wq/tmdls/Pages/TMDLs-Willamette-Basin.aspx. Accessed: September 4, 2020.

Oregon Department of State Lands. 2020. *Exploring an Elliot State Research Forest.* Available: https://www.oregon.gov/dsl/land/pages/elliott.aspx. Accessed: December 23, 2020.

OSU (Oregon State University). 2013. *Invasive Weeds in Forest Lands Knotweeds* Polygonum *spp. Extension Services*. 3 pp.

Otto, C.R.V., Kroll, A.J., McKenny, H.C., 2013. Amphibian Response to Downed Wood Retention in Managed Forests: A Prospectus for Future Biomass Harvest in North America*. For. Ecol. Manage.* 304:275–285.

OWEB (Oregon Watershed Enhancement Board). 2020. *Stream and Watershed Restoration Summary*.

Pacific States Marine Fisheries Commission. 2019. Home Page. Available: https://www.psmfc.org/. Accessed: September 2019.

Pollock, M.M., G.R. Pess, T.J. Beechie, and D.R. Montgomery. 2004. The Importance of Beaver Ponds to Coho Salmon Production in the Stillaguamish River Basin, Washington, USA. *North American Journal of Fisheries Mgt.* 24(3):749–760.

Poole, G.C., and C.H. Berman. 2001. An Ecological Perspective on Instream Temperature: Natural Heat Dynamics and Mechanisms of Human-Caused Thermal Degradation. *Environ. Management* 27:787–802.

Pörtner H. and A. Farrell. 2008. Physiology and Climate Change. *Science* 322:690–692.

Price, A.L., J.S. Mowdy, J.K Swingle, and E.D. Forsman. 2015. Distribution and Abundance of Tree Voles in the Northern Coast Ranges of Oregon. *Northwestern Naturalist* 96(1):37–49.

Ralph, S.C., G.C. Poole, L.L. Conquest, and R.J. Naiman. 1994. Stream Channel Morphology and Woody Debris in Logged and Unlogged Basins of Western Washington. *Canadian Journal of Fisheries and Aquatic Sciences* 51(1):37–51.

Raphael, M.G., G.A. Falxa, and A.E. Burger. 2018. Marbled Murrelet. Chapter 5 in T.A. Spies, P.A. Stine, R. Gravenmier, J.W. Long, and J.W. Reilly (eds.), *Synthesis of Science to Inform Land Management in the Northwest Forest Permit Area.* General Technical Report PNW-GTR-966. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Rashin, E.B., C.J. Clishe, A.T., Loch, and J.M. Bell. 2007. Effectiveness of Timber Harvest Practices for Controlling Sediment Related Water Quality Impacts. *JAWRA* 42(5):1307–1327.

Reeves, G.H., K.M. Burnett, and E.V. McGarry. 2003. Sources of Large Wood in the Main Stem of a Fourth-Order Watershed in Coastal Oregon. *Can. J. For. Res.* 33:1363–1370.

Reeves, G.H., B.R. Pickard, and K.N. Johnson. 2016. *An Initial Evaluation of Potential Options for Managing Riparian Reserves of the Aquatic Conservation Strategy of the Northwest Forest Plan.* United States Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Reilly, M.J, T.A. Spies, J. Littell, R. Butz, and J.B. Kim. 2018. Climate, Disturbance, and Vulnerability to Vegetation Change in the Northwest Forest Plan Area. Chapter 2 in *Synthesis of Science to Inform Land Management Within the Northwest Forest Plan Area*. USDA Forest Service PNW Research Station, Portland, Oregon.

Relyea, R.A. 2005. The Lethal Impacts of Roundup and Predatory Stress on Six Species of North American Tadpoles. *Archives of Environmental Contamination and Toxicolog*y 48:351–357.

Richardson, J.S., E. Taylor, D. Schluter, M. Pearson, and T. Hatfield. 2010. Do Riparian Zones Qualify as Critical Habitat for Endangered Freshwater Fishes? *Canadian Journal of Fisheries and Aquatic Sciences* 67(7):1197–1204.

Robison, E.G., K.A. Mills, J. Paul, L. Dent, and A. Skaugset. 1999. *Oregon Department of Forestry Storm Impacts and Landslides of 1996: Final Report Oregon Department of Forestry Forest Practices Monitoring Program.* Salem, OR.

Roni, P.l., T.J. Beechie, R.E. Bilby, F.E. Leonetti, M.M. Pollock, and G.R. Pess. 2002, A Review of Stream Restoration Techniques and Hierarchical Strategy for Prioritizing Restoration in Pacific Northwest Watersheds. *North American Journal of Fisheries Management* 22:1–20.

Roon D.A., J.B. Dunham, and J.D. Groom. 2021. Shade, Light, and Stream Temperature Responses to Riparian Thinning in Second-Growth Redwood Forests of Northern California. *PLoS ONE* 16(2): e0246822. https://doi.org/10.1371/journal. pone.0246822

Rosenberg, D.K., R.J. Davis, K.J. Van Norman, J.R. Dunk, E.D. Forsman, and R.D. Huff. 2016. Patterns of Red Tree Vole Distribution and Habitat Suitability: Implications for Surveys and Conservation Planning. *Ecosphere* 7(12):e01630. 10.1002/ecs2.1630.

Rosenfeld, J.S., and L. Huato. 2003. Relationship Between Large Woody Debris Characteristics and Pool Formation in Small Coastal British Columbia Streams. *North American Journal of Fisheries Managemen*t 23:928–938.

Rundio, D.E., and D.H. Olson. 2007. Influence of Headwater Site Conditions and Riparian Buffers on Terrestrial Salamander Response to Forest Thinning. *For. Sci*. 53:320–330.

Russell, K.R., T.J. Mabee, and M.B. Cole. 2004. Distribution and Habitat of Columbia Torrent Salamanders at Multiple Spatial Scales in Managed Forests of Northwestern Oregon. *Journal of Wildlife Management* 68:403–415.

Russell, W.H., and J.R. McBride. 2001. The Relative Importance of Fire and Watercourse Proximity in Determining stand Composition in Mixed Conifer Riparian Forests. *For. Ecol. Manage*. 150, 259–265.

Rutherford J.C, J.C. Marsh, P.M. Davies, and S.E. Bunn. 2004. Effects of Patchy Shade on Stream Water Temperature: How Quickly Do Small Streams Heat and Cool? *Mar. Freshw. Res.* 55:737–748. Crossref, Google Scholar.

Scheele, B.C., F. Pasmans, L.F. Skerratt, L. Berger, A. Martel, W. Beukema, A.A. Acevedo, P.A. Burrowes, T. Carvalho, A. Catenazzi, I. De la Riva, M.C. Fisher, S.V. Flechas, C.N. Foster, P. Frías-Álvarez, T.W. J. Garner, B. Gratwicke, J.M. Guayasamin, M. Hirschfeld, J.E. Kolby, T.A. Kosch, E. La Marca, D.B. Lindenmayer, K.R. Lips, A.V. Longo, R. Maneyro, C.A. McDonald, J. Mendelson, P. Palacios-Rodriguez, G. Parra-Olea, C.L. Richards-Zawacki, M.-O. Rödel, S.M. Rovito, C. Soto-Azat, L.F. Toledo, J. Voyles, C. Weldon, S.M. Whitfield, M. Wilkinson, K.R. Zamudio, and S. Canessa. 2019. Amphibian Fungal Panzootic Causes Catastrophic and Ongoing Loss of Biodiversity. *Science* 363:1459.

Shaw, D.C., T. Woolley, and A. Kanaskie. 2014. Vertical Foliage Retention in Douglas-Fir Across Environmental Gradients of the Western Oregon Coast Range Influenced by Swiss Needle Cast*.* *Northwest Science* 88:23–32.

Siegel, J., and L. Crozier. 2019*. Impacts of Climate Change on Salmon of the Pacific Northwest. Fish Ecology Division*. Northwest Fisheries Science Center. NOAA Fisheries. Seattle WA.

Skaugset, A., and B. Wemple. 1998. *The Response of Forest Roads on Steep, Landslide-Prone Terrain in Western Oregon to the February 1996 Storm*.

Slauson, Keith M., Gregory A. Schmidt, William J. Zielinski, Phillip J. Detrich, Richard L. Callas, James Thrailkill, Brenda Devlin-Craig, Desiree A. Early, Keith A. Hamm, Kristin N. Schmidt, Amber Transou, and Christopher J. West. 2019a. *A Conservation Assessment and Strategy for the Humboldt Marten in California and Oregon*. Gen. Tech. Rep. PSW-GTR-260. Arcata, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station.

Slauson, Keith, William Zielinski, Thomas Kirk, and David Laplante. 2019b. A Landscape Habitat Suitability Model for Humboldt Marten in Coastal California and Coastal Oregon. *Northwest Science* 93(1):30–51.

Sovern, S. G., D. B. Lesmeister, K. M. Dugger, M. S. Pruett, R. J. Davis, and J. M. Jenkins. 2019. Activity Center Selection by Northern Spotted Owls. *Journal of Wildlife Management* 83:714–727.

Spies T., M. Pollock, G. Reeves, and T. Beechie. 2013. *Effects of Riparian Thinning on Wood Recruitment: A Scientific Synthesis*. Science Review Team Wood Recruitment Subgroup, USDA Forest Service, PNW Research Station, Portland, OR.

Spies, T.A., P.A. Stine, R. Gravenmier, J.W. Long, M.J. Reilly, and R. Mazza. 2018. *Synthesis of Science to Inform Land Management in the Northwest Forest Permit Area*. General Technical Report PNW-GTR-970. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

State of Oregon. 1997. *Oregon Plan for Salmon and* Watersheds (consisting of the Oregon Coastal Salmon Restoration Initiative, March 10, 1997 and as amended with the Steelhead Supplement, December 1997). Salem: Governor's Natural Resources Office, State of Oregon.

Stebbins, R.C. 1951. *Amphibians of Western North America.* Berkeley, CA: University of California Press. 537 p.

Stednick, J.D. 1996. Monitoring the Effects of Timber Harvest on Annual Water Yield. *Journal of Hydrology* 176:79–95.

Steele, C.A., E.D. Brodie, Jr., and J.G. Maccracken. 2003. Relationships Between Abundance of Cascade Torrent Salamanders and Forest Age. *Journal of Wildlife Management* 67(2):447–453.

Stewart, I., D. Cayan, and M. Dettinger. 2005. Changes Toward Earlier Streamflow Timing Across Western North America. *J. Clim.* 18(8):1136–1155, doi:10.1175/JCLI3321.1.

Story A., R.D. Moore, and J.S. Macdonald. 2003. Stream Temperatures in Two Shaded Reaches Below Cutblocks and Logging Roads: Downstream Cooling Linked to Subsurface Hydrology. *Can. J. For. Res.* 33(8):1383–1396.

StreamNet. 2019. StreamNet Database (Version 98.3) Portland, OR. Available: https://www.streamnet.org/. Accessed: September 2019.

Suzuki N., and W. McComb. 1998. Habitat Classification Models for Beaver (*Castor canadensis*) in the Streams of the Central Oregon Coast Range. *Northwest Science* 72(2):102–110.

Terrainworks. 2020. *NetMap and Wood Recruitment Modeling for the Western Oregon State Forest Habitat Conservation Plan*.

Thomas, Jack W., Ralph G. Anderson, Chris Maser, and Evelyn L. Bull. 1979. Snags. Pages 60−77 in *Wildlife Habitats in Managed Forests the Blue Mountains of Oregon and Washington*. USDA Forest Service. Ag. Hand. No. 553, 512 p.

Thomas, J.W., E.D. Forsman, J.B. Lint, E.C. Meslow, B.R. Noon, and J. Verner. 1990. *A Conservation Strategy for the Northern Spotted Owl: Report of the Interagency Scientific Committee to Address the Conservation of the Northern Spotted Owl* (USDA: Forest Service, USDI: Bureau of Land Management, Fish and Wildlife Service, and National Park Service). 1990-791-17l/20026. U.S. Government Printing Office. Washington, D.C.

Thomas, J.W., M.G. Raphael, R.G. Anthony, E.D. Forsman, A.G. Gunderson, R.S. Holthausen, B.G. Marcot, G.H. Reeves, J.R. Sedell, and D.M. Solis. 1993. *Viability Assessments and Management Considerations for Species Associated with Late-Successional and Old-Growth Forests of the Pacific Northwest*. The Report of the Scientific Analysis Team, U.S. Department of Agriculture. 530 p. March.

Thompson and Service. 2008. *Science Findings: A Landslide Is a Landslide Is a Landslide…or Is it? Defining Landslide Potential Across Large Landscapes*.

Thompson, L. C., and R. Larsen. 2004. *Fish Habitat in Freshwater Stream*. Farm Water Quality Planning FWQP; Reference Sheet 10.3, Publication 8112. University of California, California.

Thompson, M.S., S.J. Brooks, C.C. Sayer, G. Woodward, J.C. Axmacher, D.M. Perkins, and C Gray. 2018. Large Woody Debris "Rewilding" Rapidly Restores Biodiversity in Riverine Food Webs. *J Appl Ecol*. 55:895–904.

Thurman, L.L., D.H. Olson, B.F. Penaluna, and T.S. Garcia. 2019. *Fiscal Year 2019: Interim Report of Torrent Salamander Occurrence Surveys*.

Ubechu, B.O., and O.C. Okeke. 2017. Landslide: Causes, Effects and Control. *International Journal of Current Multidisciplinary Studies* 3(3):647–663.

U.S. Army Corp of Engineers. 2017. *Willamette Basin Review Feasibility Study. DRAFT Integrated Feasibility Report and Environmental Assessment*. November. 2017.

USDA and USDI (U.S. Department of Agriculture and U.S. Department of Interior). 1994. *Record of Decision for Amendments to Forest Service and Bureau of Land Management Planning Documents in the Range of the Northern Spotted Owl*. Portland, OR.

USFS (U.S. Forest Service). No Date. *How Recreation Impacts Affect Key Characteristics of Riparian Ecosystems.* Available: https://www.fs.fed.us/t-d/pubs/pdf/riparian_restoration/lo_res/04231201LChap3.pdf.

USFWS (U.S. Fish and Wildlife Service). 1990. 50 CFR Part 17. Endangered and Threatened Wildlife and Plants; Determination of Threatened/ Status for the Northern Spotted Owl; Final Rule. *Federal Register* Vol. 55, No. 123 I Tuesday, June 26, 1990 / Rules and Regulations. Department of the Interior. Fish and Wildlife Service.

———. 1997. *Recovery Plan for the Threatened Marbled Murrelet (*Brachyramphus marmoratus*) in Washington, Oregon, and California*. Portland, OR.

———. 2011. *Revised Recovery Plan for the Northern Spotted Owl (*Strix occidentalis caurina*).* U.S. Fish and Wildlife Service, Portland, OR, USA.

———. 2012a. *Endangered and Threatened Wildlife and Plants; Designation of Critical Habitat for the Northern Spotted Owl*. 50 CFR Part 17. Federal Register / Vol. 77, No. 233 / Tuesday, December 4, 2012.

———. 2012b. *Protocol for Surveying Proposed Management Activities that May Impact Northern Spotted Owls*. February 2, 2011. Revised January 9, 2012.

———. 2013a. *Experimental Removal of Barred Owls to benefit Threatened Northern Spotted Owls: Final EIS*. U.S. Fish and Wildlife Service, Portland, Oregon, USA.

———. 2013b. *Programmatic Biological Opinion for Aquatic Restoration Activities in the States of Oregon, Washington, and Portions of California, Idaho, and Nevada*. (ABRO II) FWS reference: 01EOFW00-2013-F-0090. Portland, OR.

———. 2015. *Coastal Oregon and Northern Coastal California Populations of the Pacific Marten Species Report*. April 2015.

———. 2016. *Endangered and Threatened Wildlife and Plants; Determination of Critical Habitat for the Marbled Murrelet*. 50 CFR Part 17. *Federal Register* / Vol. 81, No. 150 / Thursday, August 4, 2016.

———. 2018. *Species Status Assessment for the Coastal Marten*. Version 2.0. July 2018. U.S. Fish and Wildlife Service. Region 8. Arcata, CA.

———. 2019a. *Washington State Department of Natural Resources Marbled Murrelet Long-term Conservation Strategy Amendment to the 1997 Habitat Conservation Plan.* Endangered Species Act - Section 7 Consultation. Biological Opinion. Reference: 0IEWFW00-2019-F-1650. x-reference: 1-3-96-FW-594. U.S. Fish and Wildlife Service Washington Fish and Wildlife Office. Lacey, Washington.

———. 2019b. *Species Status Assessment for the Coastal Marten*. Version 2.0. July 2018. U.S. Fish and Wildlife Service. Region 8. Arcata, CA.

———. 2020. *Barred Owl Study Update*. U.S. Fish and Wildlife Service, Oregon Fish and Wildlife Office, Portland, OR. Available: https://www.fws.gov/oregonfwo/articles.cfm?id=149489616. Accessed: September 1, 2020.

———. 2021. *Endangered and Threatened Wildlife and Plants; Revised Designation of Critical Habitat for the Northern Spotted Owl*. 50 CFR Part 17. *Federal Register* / Vol. 86, No. 10 / Friday, January 15, 2021.

USFWS and NOAA (U.S. Fish and Wildlife Service and National Oceanic and Atmospheric Administration) Fisheries. 1998. *Endangered Species Consultation Handbook: Procedures for Conducting Consultation and Conference Activities under Section 7 of the Endangered Species Act.* Washington DC.

———. 2016. *Habitat Conservation Planning and Incidental Take Permit Processing Handbook*. December 21, 2016.

———. 2019. Final Rule. Endangered and Threatened Wildlife and Plants; Regulations for Interagency Cooperation. A Rule by the Fish and Wildlife Service and the National Oceanic and Atmospheric Administration on 08/27/2019. *Federal Register* Vol. 84, No. 166 / Tuesday, August 27, 2019 / Rules and Regulations.

USFWS and ODFW (U.S. Fish and Wildlife Service and Oregon Department of Fish and Wildlife). 2019. *Species Status Assessment. North Oregon Coast Population of the Red Tree Vole.* Version 1.0. Portland, OR.

USGCRP (U.S. Global Change Research Program). 2009. *Global Climate Change Impacts in the United States*. Cambridge University Press, New York.

Van Rooyen, J.C., J.M. Malt, and D.B. Lank. 2011. Relating Microclimate to Epiphyte Availability: Edge Effects on Nesting Habitat Availability for the Marbled Murrelet. *Northwest Science* 85(4):549–561.

Vesely, D.G., and W.C. McComb. 2002. Salamander Abundance and Amphibian Species Richness in Riparian Buffer Strips in the Oregon Coast Range. *Forest Science* 48:291–297.

Vesely, D., C. Corkran, and J. Hagar. 1999. *Habitat-Election by Oregon Slender Salamanders (*Batrachoseps wrighti*) in the Western Oregon Cascades.* Final Report prepared for the Oregon Department of Fish and Wildlife under Contract 63506138.

Walker, L.E., and J.M. Marzluff. 2015. Recreation Changes the Use of a Wild Landscape by Corvids. *The Condor* 117(2):262–283.

Walsh, J., and Coauthors. 2014. Our Changing Climate. Climate Change Impacts in the United States: The Third National Climate Assessment. Pages 19–67 in J. M. Melillo, T. C. Richmond, and G. W. Yohe (eds.), *U.S. Global Change Research Program Report*. Available: https://doi.org/10.7930/J0KW5CXT.

WDNR (Washington State Department of Natural Resources). 1997. *Habitat Conservation Plan for State Trust Lands.* Olympia, WA.

Weikel, J. 2019. *Marbled Murrelet Technical Report Final*. April 24, 2019. Report developed by Jennifer Weikel, Wildlife Biologist Private Forest Program, Oregon Department of Forestry. Salem, OR.

Welsh, H.H., Jr., and A.J. Lind. 1996. Habitat Correlates of the Southern Torrent Salamander, *Rhyacotriton variegatus* (Caudata: Rhyacotritonidae), in Northwestern California. *Journal of Herpetology* 30(3):385–398.

Westerling, A., H. Hidalgo, D. Cayan, and T. Swetnam. 2006. Warming and Earlier Spring Increase Western US Forest Wildfire Activity. *Science* 313(5789):940–943. doi:10.1126/science.1128834.

Wiens, J.D., K.M. Dugger, D.B. Lesmeister, K.E. Dilione, and D.C. Simon. 2019. *Effects of Barred Owl Removal on Population Demography of Northern Spotted Owls in Washington and Oregon, 2015–18*. U.S. Geological Survey Open-File Report 2019-1074.

Wigington, P.J., Jr., J.L. Ebersole, M.E. Colvin, S.G. Leibowitz, B. Miller, B. Hansen, H.R. Lavigne, D. White, J.P. Baker, M.R. Church, J.R. Brooks, M.A. Cairns, and J.E. Compton. 2006. Coho Salmon Dependence on Intermittent Streams. *Front Ecol Environ*. 4(10):513–518.

Wilkerson, E., Hagan, J.M., Siegel, D., and Whitman, A.A. 2006. The Effectiveness of Different Buffer Width for Protecting Headwater Stream Temperature in Maine. *For. Sci.* 52(3): 221–231.

Williams, B.K., R.C. Szaro, and C.D. Shapiro. 2007. *Adaptive Management: The U.S. Department of the Interior Technical Guide*. Adaptive Management Working Group, U.S. Department of the Interior, Washington, DC.

Wing, M.G., and A. Skaugset. 2002. Relationships of Channel Characteristics, Land Ownership, and Land Use Patterns to Large Woody Debris in Western Oregon Streams. *Canadian Journal of Fisheries and Aquatic Sciences* 59(5):796–807.

Wooster, J., and S. Hilton. 2004. *Large Woody Debris Volumes and Accumulation Rates in Cleaned Streams in Redwood Forests in Southern Humboldt County, California*. Research Note PSW-RN-426. U.S. Forest Service, Pacific Southwest Research Station, Arcata, CA

Yackulic, C.B., J. Reid, J.D. Nichols, J.E. Hines, R.J. Davis, and E. Forsman. 2012. Neighborhood and Habitat Effects on Vital Rates: Expansion of the Barred Owl in the Oregon Coast Ranges. *Ecology* 93:1953–1966.

Zwieniecki, M.A., and M. Newton. 1999. Influence of Streamside Cover and Stream Features on Temperature Trends in Forested Streams of Western Oregon. *Western Journal of Applied Forestry* 14(2):106–113.

FEBRUARY 2022

WESTERN OREGON STATE FORESTS HABITAT CONSERVATION PLAN

APPENDICES

OREGON
DEPARTMENT OF FORESTRY

Appendix A
Glossary

abiotic The non-living components of the planet not currently part of living organisms, such as soils, rocks, water, air, light, and nutrients.

active channel width The average width of the stream channel at the normal high water level. The normal high water level is the stage reached during average annual high flow. This high water level mark often corresponds with the edge of streamside terraces; a change in vegetation, soil, or litter characteristics; or the uppermost scour limit (bankfull stage) of a channel.

active nest tree A tree or snag in which a nest is tended during the breeding season by a pair of northern spotted owls.

activity center The nest tree, or the location best describing the focal point of the activity of a northern spotted owl or pair of northern spotted owls when the nest location is not known.

adaptive kernel A method for determining home range. In the adaptive kernel method, local adjustments are applied to the width of individual kernels. Observations in areas of high density get less smoothing (tighter fit), and observations in areas of low density get more smoothing (looser fit).

adaptive management Adaptive management is a system of making, implementing, and evaluating decisions, which recognizes that ecosystems and society are always changing. It is a systematic and rigorous approach to learning from actions, improving management, and accommodating change.

advanced structure stand Stands with advanced structure are more developed than intermediate structure stands in the understory reinitiation stage. Tree crowns show significant layering from the tallest trees to the forest floor. Advanced structure stands that are highly diverse may develop structural characteristics typically linked with older forests or old growth.

aggregate Sand and pebbles added to cement to make concrete, or that are used in road construction.

alluvial Soil, debris, and other materials that have been deposited by currents of water.

ambient Surrounding.

anadromous fish Species of fish (e.g., salmon) that hatch and rear for a portion of their life history in fresh water rivers and streams, then mature in the ocean, and then migrate back into freshwater rivers and streams to spawn.

anchor habitat	An existing key habitat area for a specific species; these blocks of habitat are left in place on the landscape as "anchors".
annosum	A root disease in trees caused by *Heterobasidion annosum*.
aquatic	In or on the water; aquatic habitats are in streams or other bodies of water, as contrasted with riparian habitats, which are near water.
aquatic zone	The area that includes the stream channel(s) and associated aquatic habitat features. This zone includes beaver ponds, stream-associated wetlands, side channels, and the channel migration zone.
aquifer	A sand, gravel, or rock formation that is capable of storing or transporting water below the surface of the ground.
archaeological and historical resources	Districts, sites, buildings, structures, and artifacts that possess material evidence of human life and culture of the prehistoric and historic past.
archaeological object	An object that is at least 75 years old; is part of the physical record of an indigenous or other culture found in the state or waters of the state; and is material remains of past human life or activity that are of archaeological significance, including, but not limited to, monuments, symbols, tools, facilities, technological by-products, and dietary by-products (Oregon Revised Statutes [ORS] 358.905).

archaeological site	A geographic locality in Oregon, including but not limited to, submerged and submersible lands and the bed of the sea within the state's jurisdiction, that contains archaeological objects and the contextual associations of the archaeological objects with each other, or with biotic or geological remains or deposits (ORS 358.905). Specific types of sites, as defined in Oregon law, are: **pre-historic archaeological site—**Created and/or used by humans indigenous to the area before Euro-American inhabitance. **historic archaeological site**—Created and/or used by humans since the time of Euro-American inhabitance; usually belowground and/or aboveground diminishing remains. **historic site**—Created and/or used by humans since the time of Euro-American inhabitance; usually aboveground structurally intact remains. **site of archaeological significance—**Any archaeological site on, or eligible for inclusion on, the National Register of Historic Places as determined in writing by the State Historic Preservation Officer, or any archaeological site that has been determined significant in writing by an Indian tribe (ORS 358.905).
average annual high flow period	High flows generally occur between November and March, with some variability in timing year to year. Average high flows are typically represented with a 2.5-year return interval.
average high water level	The stage reached during the average annual high flow period. This level often corresponds with the edge of streamside terraces, marked changes in vegetation, changes in soil or litter characteristics, or the bankfull stage of a channel.
basal area	The area of the cross-section of a tree stem near the base, generally at breast height (4.5 feet above ground) and including the bark. The basal area per acre is the total basal area of all trees on that acre.
Best management practices (BMP)	Oregon Forest Practices Act rules adopted by the Board of Forestry to minimize the impact of forest operations on water quality. These rules ensure that, to the maximum extent practicable, forest operations meet the water quality standards established by the Environmental Quality Commission. The rules focus on reducing nonpoint source discharges of pollutants resulting from forest operations.
biodiversity *or* biological diversity	The genetic variation and the variety of microbial, plant, and animal life.

biotic	Any living aspect of the planet.
board foot	The amount of wood equivalent to a piece of wood one foot wide by one foot high by one inch thick.
Board of Forestry (BOF)	The Oregon Board of Forestry (BOF) is a seven-member board appointed by the Governor and confirmed by the state Senate. At least one member must reside in each of the state's three administrative regions (east, south, and northwest). No more than three members may receive any significant portion of their income from the forest products industry. The BOF supervises all matters of forest policy within Oregon; appoints the State Forester; adopts rules regulating forest practices; and provides general supervision of the State Forester's management of the Oregon Department of Forestry (ODF).
Board of Forestry Lands (BOFL)	Board of Forestry Lands were acquired by the BOF under ORS 530.010 to 530.040. Most were transferred from counties to the BOF in exchange for a portion of future revenue from the lands. Some lands were acquired by direct purchase.
bog	A wetland that is characterized by the formation of peat soils and that supports specialized plant communities. A bog is a hydrologically closed system without flowing water. It is usually saturated, relatively acidic, and dominated by ground mosses, especially sphagnum. Bogs are distinguished from other wetlands by the dominance of mosses and the presence of extensive peat deposits.
burial	Any natural or prepared physical location, whether originally below, on, or above the surface of the earth, into which, as a part of a death rite or death ceremony of a culture, human remains were deposited (ORS 358.905).
buffer habitat	Stands surrounding occupied stands that do not have the characteristics of suitable habitat, but that buffer the occupied stand from wind and other environmental factors as well as from other potential deleterious effects of edge, such as increased predation.
candidate species	Species being considered by the Secretary of the Interior for listing as an endangered or a threatened species, but not yet the subject of a proposed rule.
certification	Approval by Land Conservation and Development Commission of a state agency program found to be consistent with the Statewide Planning Goals.

channel migration zone (CMZ)	An area adjacent to an unconfined stream channel where channel migration is likely to occur during high-flow events. The presence of side channels or oxbows, stream-associated wetlands, and low terraces are indicators of these zones. The extent of these areas will be determined through site inspections using professional judgment.
chlorosis	Yellowing of normally green plant tissue due to destruction or limited production of chlorophyll; often a symptom of mineral deficiencies, disease (such as Swiss needle cast), feeding by sucking insects, root or stem girdling, or serious light deficiencies.
Class I areas	National park lands and some wilderness areas are designated as federal mandatory Class I areas under the Clean Air Act.
Class I-III	The Clean Air Act divides clean air into three classes; Class I allows for minimal degradation of air quality, while Class III allows a relatively greater degree of degradation.
Clean Air Act	Federal law passed in 1970, and amended several times since. The authority to implement the act is delegated to the states. The Clean Air Act is implemented, in part, through a permit system.
clearcut	Traditionally, a silvicultural system in which the entire stand of trees is cleared from an area at one time. Clearcutting and planting (if needed) results in the establishment of a new even-aged stand of trees. In the Elliott State Forest, a modified clearcutting system is used, in which live trees, snags, and downed wood remain on the unit after harvest.
closed single canopy (CSC)	This stand type occurs when new trees, shrubs, and herbs no longer appear in the stand, and some existing ones begin to die from shading and competition, in a process called stem exclusion.
coarse filter – fine filter	For the Elliott State Forest, an operational approach to managing for biological diversity is the “coarse filter – fine filter” concept proposed by. The coarse-filter component is based on the premise that maintaining a range of seral stages, stand structures, and sizes, across a variety of ecosystems and landscapes, will meet the needs of most organisms. Fine-filter management superimposes specific management actions for individual species or habitats that require special consideration, such as species with unique or limited distributions.
co-dominant	Trees with crowns that form a general level of crown stratum and are not physically restricted from above, but are more or less crowded by other trees from the sides.

cohort	A group of trees regenerating after a single disturbance. The age range within a cohort may be as narrow as one year or as wide as several decades, depending on how long trees continue invading after a disturbance.
colluvial	Soil, debris, and other materials that have been moved downslope by gravity and biological activity.
Common School Forest Lands	Common School trust lands that have been listed by the State Land Board for the primary use of timber production. See "Common School trust lands."
Common School Fund	A permanent fund or account managed to provide revenues to the common schools. The State Land Board (Governor, Secretary of State, and Treasurer) is the trustee of the Common School Fund (CSF).
Common School Trust Lands	State lands owned by the State Land Board; the primary goal in managing these lands is the generation of the greatest amount of income for the Common School Fund over the long-term, consistent with sound techniques of land management. Common School trust lands that have been listed by the State Land Board for the primary use of timber production are called Common School Forest Lands. Other Common School trust lands are designated as rangelands or for other uses.
commonly used road	A road that receives frequent traffic during the marbled murrelet breeding season, including but not limited to, a mainline road and roads connecting mainline roads. Roads not commonly used may include, but are not limited to, spur roads and blocked or decommissioned roads.
composition	The different species of plants and animals that live in an ecosystem. The dynamic attributes of a forest ecosystem are composition, function, and structure. Composition is the proportion of various species. Function is the processes taking place in the system. Structure includes kinds and distribution of stand components such as trees, snags and logs of various sizes and shapes.
concept	An abstract or generic idea generalized from particular instances.
confirmed occupancy	Occupied behaviors observed on more than one visit.

conifer stand These stands occupy most of the Elliott State Forest. The ODF classifies as conifer stands those in which conifer species compose 30 percent or more of the tree canopy. Although conifers are the principal species with economic value in these stands, the stands may also include substantial amounts of other vegetation types such as hardwoods, brush, grass, and ferns, which contribute to a diverse forest ecosystem. These types are either intermixed with the conifers or are in clumps too small to map and inventory separately.

connectivity A measure of how well different areas (patches) of a landscape are connected by linkages, such as habitat patches or corridors. At a landscape level, the connectivity of ecosystem functions and processes is of equal importance to the connectivity of habitats.

conservation area Designated land where conservation strategies are applied for the purpose of attaining specific conservation objectives; this may include cultural or biological aspects. In the Elliott State Forest, conservation areas include habitats utilized by northern spotted owls and marbled murrelets, riparian management areas, rare or unique habitats, and areas requiring special protection for visual or other resource values. Management within conservation areas is aimed at maintaining desired conditions.

core area An area of contiguous suitable habitat surrounding a nest site or activity center.

core use area Areas of concentrated use within the home range identified by calculating an average observation density of all locations for an individual northern spotted owl and determining the contour where the observation density is greater than average. This contour does not have a connotation of statistical significance, but it delimits an area of concentrated use. The advantage to this approach is that it avoids arbitrary selection of contours, and each core area is based only on the density of locations for that particular northern spotted owl.

corridor Areas of habitat that connect separate but similar habitat patches, within the landscape mosaic. For example, an area of mature timber, such as a riparian buffer, may connect larger patches of mature timber.

critical habitat	The specific areas within the general geographic area occupied by a federally listed species in which physical and biological features occur that the U.S. Fish and Wildlife Service (USFWS) has determined to be essential to the conservation of the species. Critical habitat is designated by USFWS pursuant to the federal Endangered Species Act (ESA). Not all of the area encompassed by critical habitat contains the necessary habitat characteristics to support a particular species.
culmination of mean annual increment	Mean annual increment is the total increment of growth of a stand divided by the age of the stand. The culmination age is the age at which the mean annual increment reaches its maximum. If maximization of wood volume is the objective for the stand, this age is generally used as the rotation age. Periodic thinning enhances growth and extends the culmination age.
danger tree	A standing tree, alive or dead, that resents a hazard to personnel due to deterioration or physical damage to the root system, trunk (stem), or limbs, and the degree and direction of lean.
debris slide	Rapid landslide occurring on a slope. The material moved may include soil, wood, and vegetation. The slide may or may not reach a stream channel. See also “landslide.”
debris torrent	Rapid movement of a large quantity of materials, including wood and sediment, down a stream channel. This generally occurs in smaller streams during storms or floods, and scours the stream bed.
decadence	Process of decay, or condition of being in a decayed state, particularly as related to trees or stands of trees. Typified by the presence of pathogens causing various forms of rot, and often used to refer to the presence of snags and downed wood. A process influential in multiple aspects of ecosystem development from providing cavities for wildlife, to creating gaps in the canopy, to altering forest floor climate and structure.
demographic study	A study of population dynamics; the quantitative analysis of population structure and trends in size, growth rate, and distribution.
density	The number or size of a population (trees, species, etc.) in relation to a unit of space. In silviculture, stand density is measured as the amount of tree biomass per unit area of land. This can be measured as the number of trees, basal area, wood volume, or foliage cover. Also see “stand density” and “stand density index.”

desired future condition (DFC)	An explicit description of the physical and biological characteristics of the Elliott State Forest in the future, as described in the forest vision.
detection	Sighting or hearing of one or more birds acting in a similar manner, i.e., a single bird or flock.
diameter breast height	The diameter of a tree, measured 4.5 feet above the ground on the uphill side of the tree.
dissected	A landscape that has been cut into hills and valleys by the process of erosion.
disturbance	A force that causes significant change in an ecosystem's structure and/or composition. Disturbance can be caused by natural events such as fire, flood, wind, earthquake, and insect or disease outbreak, or by human activities. The disruption of marbled murrelet reproductive activities.
dominance	Trees with crowns that extend above the general level of crown cover of other trees of the same stratum and are not physically restricted from above, although possibly somewhat crowded by other trees on the sides.
downed wood	Fallen trees or pieces of trees on the forest floor or in the stream channel that provide many important functions such as mineral cycling, nutrient mobilization, maintenance of site productivity, natural forest regeneration (nurse logs), substrates for mycorrhizal formation, and diverse habitats for fish and wildlife species.
drainage basin	The large watersheds of major rivers. The Oregon Water Resources Department and the Oregon Department of Environmental Quality have delineated 18 major drainage basins in Oregon.
early structure stand	Following a disturbance, an early structure stand develops through the stand initiation process. In the early years of this stage, the site is occupied primarily by tree seedlings or saplings, herbs, grass, or shrubs. In later years, increasing crown closure shades the ground, and herbs, shrubs, and grasses begin to die out or lose vigor. At this point, the stand transitions from an early stand initiation stage to an intermediate stem exclusion stage, leading to an intermediate structure stand.
earthflow	Movement of material, both sediment and vegetation, down a slope. Earthflows are typically large, but move only a few centimeters each year. (See also "landslide.")

ecosystem	A complex system comprising populations of organisms considered together with their physical environment and the interacting processes between them (e.g., marsh, watershed, lake ecosystem). Ecosystems do not have boundaries fixed in time or space because the form and function of ecosystems change at various rates, depending on prevailing environmental factors.
ecosystem functions	The many and varied biotic and abiotic processes that make an ecosystem functional, changing, and interactive (e.g., biogeochemical processes, nutrient cycling, decomposition, regeneration, and succession).
ecosystem management	A management practice and philosophy aimed at selecting, maintaining, and/or enhancing the ecological integrity of an ecosystem to ensure continued ecosystem health while providing resources, products, or non-consumptive values for humans. The actions taken reflect the management goals and range from protection from human influence through to an increasing intensity of interventions to serve human needs.
edge	The point where two different plant communities (different vegetation types, successional stages, or conditions) meet. Edges may be created by a soil or topographical feature of the site, or where short-term effects are created by natural or human-caused disturbances.
endangered species	As defined by the ESA: Any species (including subspecies or qualifying population) that is in danger of extinction throughout all or a significant portion of its range.
ephemeral stream	Ephemeral streams occur in direct response to precipitation, running only during or shortly after periods of heavy rainfall or rapid snowmelt.
effectiveness monitoring	Used to determine if the design and execution of the prescribed management practices are achieving the Habitat Conservation Plan (HCP) conservation objectives. Every management decision is intended to achieve a given set of future conditions. Effectiveness monitoring can be used to compare existing conditions to both past and the desired future conditions to describe the overall progress or success of the management activities.

evolutionarily significant unit (ESU)	An evolutionarily significant unit (ESU) is a group of stocks or populations that: 1) are substantially reproductively isolated from other population units of the same species; and 2) represent an important component in the evolutionary legacy of the species. This term is used by the National Marine Fisheries Service (NMFS) as guidance for determining what constitutes a “distinct population segment” for the purposes of listing Pacific salmon species under the ESA. For example, the “Oregon Coast chinook ESU” is a delineation that encompasses all populations of chinook salmon from the Necanicum River on the northern Oregon coast, to Cape Blanco on the south coast.
extensive management	Extensive forest management is a term used for protection of the forest from fire and insects, and the reliance on natural regeneration for provision of the next forest.
federally listed species	Species, including subspecies and distinct vertebrate populations, of fish, wildlife, or plants, listed at 50 CFR 17.11 and 17.12 as either endangered or threatened.
fixed kernel	A method of determining home range. In the fixed kernel method, a single smoothing width is used on all the observations in the sample. The fixed kernel generally produces estimates of home-range size and contours with lower bias than the adaptive kernel in simulation studies.
Forest Land Management Classification System	Under OAR 629-035-055, state forest lands are classified according to the management that will be applied. The classification describes the management emphasis for the land as determined by Forest Management Plans and any applicable HCP. State forest lands are classified as General Stewardship, Focused Stewardship, or Special Stewardship. Focused and Special Stewardship classifications are used when a particular forest resource may need a more focused approach or priority in management compared to other resources.
formation	A group of strata, or layers, of the same sort of rock or mineral, or rock having common characteristics.
fractal	Irregular shapes and surfaces that cannot be represented by classical geometry. Fractal dimension is an index of the complexity of spatial patterns.

fragmentation	The relationship of the landscape matrix to other types of patches; as fragmentation increases, the matrix becomes geometrically more complex. Maximum landscape fragmentation occurs when no dominant patch exists. Fragmentation is also defined as the spatial arrangement of successional stages across the landscape as the result of disturbance, and is often used to refer specifically to the process of reducing the size and connectivity of late successional or old growth forests.
fry	For salmonids, young fish that have just emerged from the gravel and are actively feeding.
function	An activity or process that occurs in an ecosystem; some typical functions are plant growth, animal reproduction, and decay of dead plants.
geographic information system (GIS)	A system for management analysis and display of geographic knowledge that is represented using a series of information sets such as maps and globes, geographic data sets, processing and workflow models, data models, and meta data.
geotechnical	The study of soil stability in relation to engineering.
geothermal	Of or relating to the internal heat of the earth.
goals	A concise, broad statement of an organization's end or process that programs are designed to achieve. A goal is normally expressed as a broad, general statement of purpose, is usually not quantifiable, and is timeless in that it usually has no specific date by which it is to be completed.
groundwater	The subsurface water supply (below the water table) that saturates the pores and fractures of sand, gravel, and rock formations.
guidelines	A set of recommended or suggested methods or actions that should be followed in most circumstances to assist administrative and planning decisions, and their implementation in the field. They are provided as a broad framework of recommended actions to be taken, and thus provide some flexibility for decision-making.
guiding principles	The overall rules, goals, and responsibilities that guide the planning process for the northwest Oregon State Forests.
Habitat Conservation Plan	A comprehensive planning document that is a mandatory component of an Incidental Take Permit (ITP) application pursuant to section 10(a)(2)(A) of the ESA.

harass	"... an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, and sheltering." (50 CFR 17.3).
Harvest Unit	Delineated forest parcels that reflect potential logical harvest operation areas considering topography and access. A unit for clearcut and thinning choices.
hardwood stand	These stands are found on a minority of Elliott State Forest lands. The ODF classifies as hardwood stands those in which hardwood species comprise more than 70 percent of the tree canopy.
harm	An act "which actually kills or injures" listed wildlife; may include "significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering ..." (50 CFR 17.3).
headwall	The steep slope or rocky cliffs at the head of a valley.
high water line	The stage reached during the average annual high flow period. This level often corresponds with the edge of streamside terraces, marked changes in vegetation, or changes in soil or litter characteristics.
historic artifacts	Three-dimensional objects including furnishings, art objects, and items of personal property that have historic significance. "Historic artifacts" do not include paper, electronic media, or other media that are classified as public records (ORS 358.635).
historic property	Real property that is currently listed in the National Register of Historic Places, established and maintained under the National Historic Preservation Act of 1966, or approved for listing on an Oregon Register of Historic Places.
home range	The area within which an animal conducts its activities during a defined period of time (generally determined through radio-telemetry monitoring).
hydrological maturity	The degree to which hydrologic processes (e.g., interception, evapotranspiration, snow accumulation, snowmelt, infiltration, runoff) and outputs (e.g., water yield and peak discharge) in a particular forest stand approach those expected in an older forest stand under the same climatic and site conditions.
hydrology	The study of the properties, distribution, and effects of water on the landscape, under the surface, in the rocks, and in the atmosphere.

implementation monitoring	Used to determine if objectives, standards, and management practices specified in the HCP conservation strategies are being accomplished. Implementation monitoring is used to determine whether specified actions or criteria are being met.
Implementation Plan	An ODF plan that describes in more detail than the long-range Forest Management Plan how the management strategies will be applied. These plans are designed to describe forest management activities for a ten-year period, and are revised at least every ten years.
incidental take	Take of any federally listed wildlife species that is incidental to, but not the purpose of, otherwise lawful activities.
Incidental Take Permit	An Incidental Take Permit (ITP) is a federal exemption to take prohibition of Section 9 of the ESA; the ITP is issued by the USFWS pursuant to Section 10(a)(1)(B) of the ESA. An ITP is also referred to as a Section 10 Permit or Section 10(a)(1)(B) Permit.
induced landscape diversity	Aspects of the landscape that change as a result of disturbances such as fire, windstorms, human activities, and animals; for example, the successional stages of vegetation that occur after a wildfire.
inherent landscape diversity	Aspects of the landscape that are relatively permanent (changing only slowly over long periods of time) in any particular landscape, but that vary among landscapes. Examples are climate, soils, topography, and aspect (such as south-facing aspect).
inner gorge	An area next to a stream or river where the adjacent slope is significantly steeper than the gradient of the surrounding hillsides. In the absence of an on-site inspection and determination by a Department of Forestry geotechnical specialist or other qualified person, these areas are defined as having a slope gradient adjacent to the stream of 70 percent (35 degrees) or greater, and where the height of the slope break is at least 15 feet (measured vertically) above the elevation of the channel.
inner RMA zone	The next area away from the stream, adjacent to the stream bank zone.
integrated pest management	A systematic approach that uses a variety of techniques to reduce pest damage or unwanted vegetation to economically and socially tolerable levels. Integrated pest management techniques may include the use of natural predators and parasites, genetically resistant hosts, environmental modifications, and, when necessary and appropriate, chemical pesticides or herbicides.

integrated resource management	The management of two or more resources in the same general area and period of time (e.g., water, soil, timber, grazing, fish, wildlife, and forests). For the Elliott State Forest, integrated resource management means that the design and application of management practices must consider the effects and benefits of all of the forest resources in such a way that those effects and benefits lead to achieving the goals in the Forest Management Plan over time and across the landscape.
intensive management	Intensive forest management: A management concept promoting basic forest management in combination with juvenile-stand improvement and/or the use of artificial regeneration to ensure reasonably uniform stand establishment and stocking. Intensive silviculture: Any silvicultural practices designed to accelerate stand development and improve the stand value and final yields in stands that are well established.
interior habitat area	The portion of the older forest patch that remains effective when the negative effects of high contrast edge are removed.
intermediate structure stand	As early structure stands develop and transition into the stem exclusion stage, trees fully occupy the site and form a single, main canopy layer. The stem exclusion process begins when new trees, shrubs, and herbs no longer appear and existing ones begin to die, due to competition for light, nutrients, and moisture. Later, as more of the trees die, the understory reinitiation process begins, when enough light and nutrients become available so that herbs, shrubs, and young trees again appear in the understory.
intermittent stream	A stream with surface flow only part of the year. In the Forest Practices Act, defined as a stream that normally does not have summer surface flow after July 15.
jacks	Sexually mature male salmon that reached maturity earlier than usual for their species.
Land Conservation and Development Commission (LCDC)	A seven-person commission that sets the standards for Oregon's statewide planning program. Members are volunteers appointed by the Governor and confirmed by the State Senate.
Land Use Board of Appeals (LUBA)	Established in 1979 essentially as a state court that rules on matters involving land use. Appeals from LUBA go to the State Court of Appeals and finally to the Supreme Court.
landscape	An area of land containing a mosaic of habitat patches, often within which a particular "target" habitat patch is embedded. Also defined as a unit of land with separate plant communities or ecosystems forming ecological units with distinguishable structure, function, geomorphology, and disturbance regimes.

landslide	The dislodging and fall of a mass of earth and rock. There are many types of landslides, including debris slides, earthflows, rock block slides, slumps, slump blocks, and slump earthflows. The different types of landslides vary tremendously in how they occur, how far they move, what type of materials move, etc.
late successional habitat	A forest stand whose typical characteristics are a multi-layered, multi-species canopy dominated by large overstory trees; numerous large snags; and abundant large woody debris (such as fallen trees) on the ground. Other characteristics such as canopy closure may vary by the forest zone (lodgepole, ponderosa, mixed conifer, etc.).
layered (LYR)	This stand type occurs as the process of understory reinitiation progresses where openings in the canopy persist. Shrub and herb communities are more diverse and vigorous, and two or more distinct layers of tree canopy appear.
leave area	An area of standing timber retained among areas of logging activity to satisfy management objectives, such as seed source, wildlife habitat, or landscape management constraints.
legacy structures	Structural components within a forest stand that are retained during harvest operations, and that provide habitat diversity in the future stand. Examples of legacy structure include live trees, snags, and downed wood.
lieu lands	"Lieu lands" were offered by the federal government to the state to compensate for original land grants that had conflicting claims. The Elliott State Forest includes approximately 7,700 acres of lieu lands.
likely nesting habitat	Occupied marbled murrelet habitat that is considered to be the most likely location for nesting sites, based on information from surveys, aerial photos, stand information, and the judgment of biologists or others familiar with the area. Stand type breaks or topography may be used to delineate the boundaries of likely nesting habitat.
lithic scatter	A location where prehistoric stone tools were made, usually from obsidian. The tools and weapons were used locally or traded.
loading	The quantity of a substance entering a body of water.
management basin	An area used for forest planning. Management basins range from 5,000 to 8,000 acres. Their boundaries are based primarily on drainage and topographic patterns within the major drainage basins and watersheds, with some adjustments to follow roads or obvious topographic features.

management prescription	The management practices and intensity selected and scheduled for application on a specific area to attain predefined goals and objectives.
marbled murrelet management area	The area designated for the protection of marbled murrelets, according to ODF policy. (The acronym "MMMA" is sometimes pronounced "trima.")
matrix	The dominate landscape element in which patches are embedded.
mature forest condition	Desired mature forest condition consists of a stand dominated by large conifer trees, or where hardwood-dominated conditions are expected to be the natural plant community, a mature hardwood/shrub community. For conifer stands, this equates to a basal area of 220 square feet or more per acre, inclusive of all conifers over 11 inches diameter breast height. At a mature age (80 to 100 years or greater), this equals 40 to 45 conifer trees 32 inches in diameter breast height per acre.
minor tree species	For a given stand, tree species that occur as a relatively small component of the stand, such as western redcedar or alder in a stand consisting mostly of Douglas-fir trees.
monitoring	The measurement of environmental characteristics and conditions over an extended period of time to determine status or trends in some aspect of environmental quality. **implementation monitoring—**Asks the question, "Did we do what we said we would do?" **effectiveness monitoring—**Asks the question, "Are the management practices producing the desired results?" **validation monitoring—**Asks the question, "Are the planning assumptions valid, or are there better ways to meet planning goals and objectives?"
morphology	Form and structure.
National Environmental Policy Act (NEPA)	The National Environmental Policy Act (NEPA) was signed into law in 1969. NEPA requires all federal agencies to consider and analyze all significant environmental impacts of any action proposed by those agencies; to inform and involve the public in the agency's decision-making process; and to consider the environmental impacts in the agency's decision-making process.
native	Indigenous to Oregon and not introduced.
natural ecosystem	An ecosystem that is minimally influenced by humans and that is, in the larger sense, diverse, resilient, and sustainable.

near-stream riparian	Areas directly adjacent to the stream. Large wood is delivered by the tree falling directly into the stream from the adjacent streambank or hillslope.
nest stand	A stand with an active nest or a recent nest site as determined from a fecal ring or eggshell fragment, or discovery of a chick or eggshell fragment on the forest floor.
nonpoint source	Entry of a pollutant into a body of water from widespread or diffuse sources, with no identifiable point of entry. The source is not a distinct, identifiable source such as a discharge pipe. Erosion is one example of a nonpoint source.
non-salmonid fish	Any fish species outside the family *Salmonidae*. A salmonid may be resident or anadromous; examples are Pacific lamprey and sculpins.
non-silviculturally capable	Areas that are rocky, swampy, covered by water, or for various other reasons have little to no commercial value for timber production. The Elliott State Forest has a few parcels of rocky or swampy lands scattered throughout the forest. Most are less than 5 acres, although a few are as large as 20 acres.
northern spotted owl circle	An area defined by the provincial radius circle around a northern spotted owl activity center.
northern spotted owl site	A territory occupied by northern spotted owls.
Northwest Oregon state forests	Includes all state forest lands within the Permit Area.
not commonly used road	Roads not commonly used may include, but are not limited to, spur roads and blocked or decommissioned roads.
nutrient cycling	Circulation or exchange of elements, such as nitrogen and carbon dioxide, between living and nonliving portions of the environment.
objective	A clear and specific statement of results to be achieved within a stated time period. An objective is measurable and implies precise time-phased steps to be taken and resources to be used, which, together, represent the basis for defining and controlling the work to be done.
occupied stand	A stand of potential habitat where marbled murrelets have been observed exhibiting behaviors that have been observed in stands with evidence of nesting, such as subcanopy behaviors or circling.
occupied habitat	Suitable habitat that has been surveyed and determined to be occupied by marbled murrelets.

occupied sites	Sites determined to be occupied by marbled murrelets based on the observation of subcanopy behaviors during protocol surveys, or the observation of nest trees, eggshell fragments, or other evidence of marbled murrelet reproductive activities.
old growth	A forest stand whose typical characteristics are a patchy, multi-layered, multi-species canopy dominated by large overstory trees, some with broken tops and decaying wood; numerous large snags; and abundant large woody debris (such as fallen trees) on the ground. In western Oregon, old-growth characteristics begin to appear in unmanaged forests at 175 to 250 years of age. (See "late successional habitat.")
older forest structure (OFS)	This stand type occurs when forest stands attain structural characteristics such as numerous large trees, multi-layered canopy, substantial number of large, down logs, and large snags. It is not the same as old growth, although some of its structures are similar to old growth.
open road/active use	This category includes any road open for travel with a motorized vehicle. It includes permanent roads and also temporary roads that are currently in use or will be used in the near future. These roads are usually available for use at any time of the year. Use may be continuous or intermittent. Roads in this category require active maintenance and have a full maintenance obligation under the Forest Practices Act.
orographic	A process in which air masses are lifted up by mountains or similar obstructions, leading to higher amounts of precipitation on the windward side of the mountain.
outer RMA zone	The portion of the riparian management area farthest away from the stream.
Ownership, Site, Cover, Use, and Recommendations	The old inventory system developed by the ODF, that includes 1:12,000 scale maps and overlays, data files by type and various sorts, and data summaries. The system is now being replaced by the Stand Level Inventory.
OSCUR	This acronym refers to the Department of Forestry's current computerized forest inventory system. The acronym's letters stand for Ownership, Site, Cover, Use, and Recommendations. It includes 1:12,000 scale maps and overlays, data files by type and various sorts, and data summaries. OSCUR was developed by the Department of Forestry.

owl circle	The area defined for the purpose of identifying the home range of a northern spotted owl pair or resident single northern spotted owl; the circle size varies by physiographic province. In the Oregon Coast Range, the radius of an owl circle is 1.5 miles, encompassing the area of 4,766 acres. Guidelines established by the USFWS (later rescinded) required protecting 70 acres of northern spotted owl habitat immediately around a northern spotted owl activity center, 500 acres within 0.7 miles, and 1,906 acres within 1.5 miles.
owl site	A territory occupied by northern spotted owls.
particulate	Small particles in smoke produced by burning wood and other forest debris. Two kinds of particulate are controlled under federal and/or state requirements: total suspended particulates and PM_{10} (particulate matter less than 10 microns in diameter).
patch	The landscape patch is an environmental unit between which "quality" differs, such as a habitat patch.
perennial stream	A stream with year-round surface flow. In the Oregon Forest Practices Act, a perennial stream is defined as a stream that normally has summer surface flow after July 15.
platform	A relatively flat surface at least 5 inches in diameter and at least 50 feet high in the live crown of a coniferous tree. A platform includes the limb and any deformities of, or epiphyte cover growing on, the limb. For instance, a four-inch-diameter limb with moss cover that increases the overall diameter to five inches is a platform.
platform tree	Any tree having a single platform capable of hosting a nest for a marbled murrelet.
point source	The release of a pollutant from a pipe or other distinct, identifiable point, directly into a body of water or into a water course leading to a body of water.
policy	A definite, stated method or course of action adopted and pursued by an entity that guides and determines present and future decisions and actions. A policy establishes a commitment by which an entity is held accountable.
pollutant	A substance of such character and existing in such quantities as to degrade an environmental resource (i.e., water, air, or soil) by impairing its usefulness (including its ability to support living organisms).

population	The organisms that constitute a particular group of a species, or that live in a particular habitat or area. A group of fish (e.g., Nehalem River fall chinook salmon) that spawn in a particular area at a particular time, and that do not interbreed to any substantial degree with any other group spawning in a different area, or in the same area at a different time are considered a population (OAR, Division 7, 635-07-501(38)).
potential murrelet habitat	Potential murrelet habitat is defined as: 1) mature (with or without an old-growth component) and old-growth coniferous forests; and 2) younger coniferous forests that have deformations or structures suitable for nesting. Potential habitat can be as far as 50 miles from the ocean.
potential habitat	Stands with the characteristics of occupied marbled murrelet habitat, but that have not been surveyed for the presence of this species.
prescribed burning	Controlled fire burning under specified conditions to accomplish planned objectives; also called slash burning, as a frequent objective is to reduce the amount of slash left after logging. Objectives may include site preparation for planting and reduction of fire hazards or pest problems.
presence	A stand of potential habitat where marbled murrelets have been detected at the stand, but subcanopy behaviors have not been documented.
properly functioning aquatic systems	The range of diverse aquatic and riparian conditions over time and space that emulate the habitat conditions that resulted from natural disturbance regimes under which native species evolved. There is no one condition that is properly functioning.
recruitment nesting habitat	Stands that do not exhibit the characteristics of occupied habitat, but that could be managed to develop such characteristics in the future.
redd	Location selected by a female salmon or trout for laying eggs; female digs a “nest” in the stream gravels with her tail.

Reforestation Organization Operations Tracking System	The Reforestation Organization Operations Tracking System (ROOTS) is the next step in the development of the State Forests Program Integrated Information System. ROOTS contains the following three main functions: 1) Stand Level Inventory (SLI): Tools for importing, updating, analyzing, viewing, and reporting on SLI information. 2) Silvicultural Treatment Records: Tools for managing. Analyzing, viewing, and reporting on information related to forest management activities such as harvesting, site preparation, planting, animal damage protection, vegetation management, interplanting, fertilization, and pruning. 3) Planning Units: Tools for making and recording a plan for future activities needed to achieve the desired future condition (DFC) for a specific geographic location.
refugia	Locations and habitats that support population of organisms that are limited to small fragments of their previous geographic range, and areas that remain unchanged while surrounding areas change markedly (the areas serve as a refuge for those species requiring specific habitats). The changes could be short term, such as wildfires or human activity, or much longer term, such as periods of glaciation.
regeneration	Regeneration refers to the process of renewal of a forest or stand of trees, or to the young trees in a stand.
regeneration harvest	The removal of trees to make regeneration possible or to assist in the development of the established regeneration (young trees). The most common type of regeneration harvest in the Elliott State Forest is a modified clearcut, leaving specified amounts of live trees, snags, and downed wood.
reserve	An area of land set aside to maintain it in a desired condition, e.g., as functional habitat for wildlife.
resident fish	Fish species that complete their entire life cycle in freshwater; non-anadromous fish. One example is a resident population of cutthroat trout.
residual live trees	Live trees that are retained to provide short-term habitat needs of wildlife species, to serve as a source of future snags and downed wood, and to provide legacy trees in future stands. This term also refers to live trees present in a stand that are legacies of a previous cohort of trees.
riparian area	Three-dimensional zone of direct influence and/or interaction between terrestrial and aquatic ecosystems. The boundaries of the riparian area extend outward from the stream bed or lakeshore.

riparian management area (RMA)	A riparian management area (RMA) is a protected area with site-specific boundaries established by the ODF; the width varies according to the stream classification or special protection needs. The purpose of the RMA is to protect the stream, aquatic resources, and riparian area. Aquatic resources include water quality, water temperature, fish, stream structure, and other resources.
rock block slide	Type of landslide in which the weakness and initial breaking is in the underlying rock, not the soil. (See also "landslide.")
rotation	Also called tree age rotation. The time needed from regeneration of a crop of trees through to harvestable timber, or the time period to reach other stand criteria (e.g., complex habitat function).
salmonid	Fish species belonging to the family *Salmonidae*; includes trout, salmon, and whitefish species.
salvage	Salvage cutting is the utilization of standing or down trees that are dead, dying, or deteriorating, for whatever reason, before the timber values are lost.
seasonal stream	A stream with surface flow only part of the year. In the Forest Practices Act, defined as a stream that normally does not have summer surface flow after July 15.
seral stages	Developmental stages that succeed each other as an ecosystem changes over time; specifically, the stages of ecological succession as a forest develops.
silviculture	The art, science, and practice of controlling the establishment, composition, health, quality, and growth of the vegetation of forest stands. Silviculture involves the manipulation, at the stand and landscape levels, of forest and woodland vegetation, and the control or production of stand structures such as snags and down logs to meet the needs and values of society and landowners.

site class

Site class is a measure of an area's relative capacity for producing timber or other vegetation. It is an index of the rate of tree height growth, with lower values indicating faster growing trees. The site index is expressed as the height of the tallest trees in a stand at an index age. In this document, an age of 50 years is used. The five site classes are defined below. Most of the Elliott State Forest is site class II or III.

Site class I 135 feet and up

Site class II 115 to 134 feet

Site class III 95 to 114 feet

Site class IV 75 to 94 feet

Site class V below 75 feet

site index

A measure of forest productivity, expressed as the height of the tallest trees in a stand at an index age. In this document, an age of 50 years is used. (See "site class.")

site status

The occupancy status of a surveyed area, as defined by the survey protocol.

Pair Status—Established by any of the following:

A male and female are heard and/or observed (either initially or through their movement) in proximity (less than one-quarter mile apart) to each other on the same visit; or

A male takes a mouse to a female; or

A female is detected (seen) on a nest; or

One or both adults are observed with young.

Resident Single Status—Established by:

The presence or response of a single northern spotted owl within the same general area on three or more occasions within a breeding season; or

Multiple responses over several years (e.g., two responses in year 1 and one response in year 2, from the same general area).

The presence or response of two birds of the opposite sex where pair status cannot be determined and where at least one member meets the other resident single requirements. (Note: This is considered "two birds, pair status unknown" in the survey protocol. This is lumped with the resident single category because management options are the same as for resident singles.)

slope stability	The degree to which a slope resists the downward pull of gravity. The more resistant, the more stable.
slump	A type of landslide; involves a failure in the soil, tends to be spoon-shaped, and the base often oozes out. (See also "landslide.")
slump blocks, slump earthflows	Types of landslides. (See "landslide," "slump," and "earthflow.")
smolts	Juvenile salmon that are leaving freshwater and migrating to the ocean.
snag	A standing dead tree.
spatial forest modeling	Spatial forest modeling is the assignment of harvest activities to specific forest parcels, thereby controlling the size and juxtaposition of treatment areas. Examples of spatial control include the size of regeneration harvests, the shape and size of older forest patches, establishing and maintaining connectivity, scheduling of transportation, and coordination of upslope and riparian activities. Spatial forest modeling is contrasted with strata-based forest modeling where parcels with common characteristics are merged together into strata with harvest activities assigned to percentages of the strata. However, with strata-based modeling, it is not known which parcels in the strata are scheduled, and it is not possible to control the size and juxtaposition of treatments.
species	When referring to the federal ESA, species also means: "…any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature" [Section 3(15) of the ESA].
stand	A group of trees that forms contiguous potential marbled murrelet habitat with no gaps wider than 100 meters.
stand density	In silviculture, stand density is measured as the amount of tree biomass per unit area of land. This can be measured as the number of trees, basal area, wood volume, or foliage cover.
stand density index	A relative measure of stand density; converting a stand's current density into a density at a reference size. It is usually expressed in the equivalent number of trees that are 10 inches in diameter, e.g., 65 trees per acre that average 26 inches in diameter have the same stand density index as 300 trees per acre that average 10 inches in diameter.
stand initiation	This stand development process begins when a disturbance such as timber harvest, fire, or wind has killed or removed most or all of the larger trees, or when brush fields are cleared for planting.

Stand Level Inventory	The ODF's Stand Level Inventory acquires and updates state forest vegetation information at the specific site level (forest stand). This information is used for tactical and operational decision-making. The Stand Level Inventory includes vegetation sampling protocols, forest stand data arranged in a database, computer programs for managing and using the information, and documentation of inventory elements.
stand structure	For the purposes of this HCP, a series of three stand structures have been defined depicting the typical progression of stand development following a natural or human-caused disturbance. The stand initiation process is represented by the **early stand structure**. The stem exclusion and early understory reinitiation processes are represented by the **intermediate structure**. Structural complexity and larger tree size inherent to the advanced understory reinitiation process are characteristic of the **advanced stand structure**. Old growth stands are included in the advanced stand structure.
standard	A working principle that establishes the measure of performance extent, values, quantity, or quality for a given activity or item.
State Agency Coordination Program	Required under law for each state agency, to establish procedures to assure compliance with statewide land use goals and acknowledged city and county comprehensive plans and land use regulations.
State Historic Preservation Office	Oregon's State Historic Preservation Office was created in 1966 by federal statute. It administers the Statewide Plan for Historic Preservation and submits Oregon's nominations for the National Register of Historic Places.
State Land Board	The Oregon State Land Board is composed of the Governor, Secretary of State, and State Treasurer. It was established under the Oregon Constitution to manage Common School Trust Lands and serve as trustee of the CSF.
Statewide Planning Goals	Statewide Planning Goals are adopted by the Land Conservation and Development Commission to set standards for local land use planning. They have the force of law.

steep, unique, or visual lands	Areas almost exclusively associated with the steep, rocky slopes on either side of major rivers or streams, including the Umpqua River, Mill Creek, and the West Fork Millicoma River. These protected corridors vary from 1,000 to 4,000 feet in width. Slopes affected by public safety considerations fall within this category. Areas classified as non-silviculturally capable because they are rocky, swampy, or covered by water, or for various other reasons have little to no commercial value for timber production. Currently, the Elliott State Forest has a few parcels of rocky or swampy lands scattered throughout the forest. Most parcels are less than 5 acres, though a few are as large as 20 acres. Areas where scenic values are the primary values to be maintained, including areas buffering recreational areas, highway corridors, river corridors, lakeshores, and other scenic attractions.
stem exclusion process	The stem exclusion process begins when new trees, shrubs, and herbs no longer appear and existing ones begin to die, due to competition for light, nutrients, and moisture.
stock	For the purposes of fisheries management, a stock is an aggregation of fish populations that typically share common characteristics such as life histories, migration patterns, or habitats (OAR, Division 7, 635-07-501(51)). For example, "north-mid coast fall chinook salmon" can be defined as a stock. This stock includes a number of fall chinook "populations" from basins in this area such as the Siuslaw, Yaquina, and Tillamook Bay watersheds.
stocking	A measure of the adequacy of tree cover on an area. Unless otherwise specified, stocking includes trees of all ages.
strategy	A carefully considered plan or method, more encompassing and larger scale than tactics, for achieving an objective.
stream	To qualify as a stream, a water course must have a distinct channel that carries flowing surface water during some portion of the year, including associated beaver ponds, oxbows, side channels, and stream-associated wetlands if these features are connected to the stream by surface flow during any portion of the year. Ephemeral overland flow is not a stream, as this type of flow does not have a defined channel.
stream-associated wetland	A wetland that is immediately adjacent to a stream. This includes wetlands that are adjacent to beaver ponds, side channels, or oxbows that are hydrologically connected to the stream channel by surface flow at any time of the year.

stream bank zone	The land nearest to the stream, including the stream banks. Most riparian functions are supported to some extent by vegetation in this zone, which provides aquatic shade, delivers downed wood and organic inputs (leaves and tree litter) to the stream and riparian area, stabilizes the stream bank, contributes to floodplain functions, and influences sediment routing processes
stream classification	Under the ODF's Forest Practices Act, streams are classified in two categories based on their beneficial use. Type F — Fish-bearing stream Type N — Not a fish-bearing stream Streams are also classified by size and amount of flow. Large streams have an average annual flow greater than ten cubic feet per second (cfs); medium streams have an average annual flow of two to ten cfs; and small streams have an average annual flow less than two cfs. **perennial streams**—Year-round surface flow. In the Forest Practices Act, defined as a stream that normally has summer surface flow after July 15. **intermittent streams**—Surface flow only part of the year. In the Forest Practices Act, defined as a stream that normally does not have summer surface flow after July 15. Ephemeral streams may run only during or shortly after periods of heavy rainfall or rapid snowmelt.
stream reach	A section of stream that is geomorphically distinct, and that can be delineated from other adjacent sections based on channel gradient, form, or other physical parameters.
structure	The physical parts of an ecosystem that can be seen and touched; typical structures in a forest are tree sizes, standing dead trees (snags), and fallen dead trees.
structure based management	A silvicultural approach that produces and maintains an array of forest stand structures across the landscape. The existing forest is gradually moved toward a desired range of stand structures through active management, using sound silvicultural practices.
stumpage	The price charged for the right to harvest timber from publicly or privately owned forest land.
sub-canopy behavior	Behaviors occurring at or below the forest canopy, and strongly indicating that the site has some importance for breeding, including flying through the canopy, circling below canopy, and landing.

succession	A series of changes by which one group of organisms succeeds another group; a series of developmental stages in a plant community.
suitable habitat	Stands with the characteristics suitable for marbled murrelet nesting (including occupied habitat and potential habitat).
suppressed	Trees with crowns entirely below the general level of dominant and codominant trees and are physically restricted from immediately above.
sustainability	Sustainability is the ability of an ecosystem to maintain ecological processes and functions, biological diversity, and productivity over time. Sustainable forest management describes forest management regimes that maintain the productive and renewal capacities, as well as the genetic, species, and ecological diversity of forest ecosystems.
sustained yield	An ideal forest management objective at which point the volume of wood removed is equal to growth within the total forest. Sustained-yield management implies continuous production planned to achieve at the earliest practical time a balance between increment to the mature forest and its cutting. Achieving and maintaining in perpetuity a nearly equal annual or regular periodic output of the various renewable resources, without impairment of the productivity of the land.
take	"... to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct" with regard to federally listed endangered species of wildlife (Section 3(18) of the ESA). Federal regulations provide the same taking prohibitions for threatened wildlife species (50 CFR 17.31(a)).
tectonic	Resulting from changes in the earth's crust.
telemetry	The process of remotely monitoring an animal and its movements by radio transmissions from a device attached to the animal.
territory	The area that an animal defends, usually during breeding season, against intruders of its own species.

threatened and endangered species

Federal and state agencies make formal classifications of wildlife species, according to standards set by federal and state ESAs. The various classifications are defined below. Federal designations are made by the USFWS or NMFS. State of Oregon designations are made by the Oregon Department of Fish and Wildlife (ODFW).

Federal Classifications

candidate species—Those species for which the USFWS or NMFS has sufficient information on hand to support proposals to list as threatened or endangered.

endangered species—A species determined to be in danger of extinction throughout all or a significant portion of its range.

federally listed species—Species, including subspecies and distinct vertebrate populations, of fish, wildlife, or plants listed at 50 CFR 17.11 and 17.12 as either endangered or threatened.

proposed threatened or endangered species—Species proposed by the USFWS or NMFS for listing as threatened or endangered; not a final designation.

threatened species—Species likely to become endangered throughout all or a significant portion of their range within the foreseeable future.

State Classifications

endangered species—Any native wildlife species determined by the State Fish and Wildlife Commission to be in danger of extinction throughout any significant portion of its range within Oregon, or any native wildlife species listed as endangered by the federal ESA.

sensitive species—A watchlist, developed by the ODFW, of wildlife species that are likely to become threatened or endangered throughout all or a significant portion of their range in Oregon. Subdivided into four categories: critical, vulnerable, peripheral, and undetermined status.

threatened species—Any native wildlife species that the State Fish and Wildlife Commission determines is likely to become endangered within the foreseeable future throughout any significant portion of its range within Oregon.

Tillamook decline

A condition that has been observed in many Douglas-fir plantations in coastal northwest Oregon. Only Douglas-fir is affected; tree symptoms include chlorosis (yellowing), needle loss, and reduced growth (both height and diameter).

threshold phenomenon Pattern or trend in population growth (climate, etc.) that exhibits relatively long periods of slow change followed by sudden increase or decrease in response to a gradually changing environment.

triad approach An approach in which three land use types are distinguished that can coexist without compromising the goal of sustaining biological diversity. The land use types are: 1) intensive commodity production areas; 2) areas with little or no resource use by people except low-intensity recreation; and 3) areas in which modest resource use is allowed while ecological values are protected (maintenance of diversity and ecosystem function takes precedence over commodity production).

unclassified stand These stands are currently under contract for harvesting, or have already been harvested and will be planted soon.

understory (UDS) This stand type occurs after the stem exclusion process has created small openings in the canopy, when enough light and nutrients become available to allow herbs, shrubs, and new trees to grow again in the understory.

understory reinitiation The understory reinitiation process begins when enough light and nutrients become available to allow forest floor herbs, shrubs, and tree regeneration to again appear in the understory. The amount of brush and herbaceous species is minimal at the beginning, but increases to a substantial part of the stand by the end of the stage.

unsaturated zone The layer of soil or rock between the aquifer and the surface of the ground. In this layer, some water is suspended in the spaces between soil or rocks, but the zone is not completely saturated.

upslope Zero-order channels (zero-order channels are small unbranched draws), hollows, or hillslopes. Areas outside of the riparian area. Large wood is delivered by a landslide or landslide-debris flow combination that moves the wood into the stream channel from these areas.

upstream riparian Near-stream riparian sources that are upstream of the reach of concern. High water and/or a debris flow transport large wood to its current location after initially falling into the stream from the riparian area.

validation monitoring Used to determine whether data and assumptions for predicting outcomes and effects are correct. Validation monitoring seeks to verify the assumed linkages between cause and effect. Validation monitoring is long term and will be accomplished through formal research and effectiveness monitoring projects.

watershed	In general, a watershed is defined as an area within which all water that falls as rain or snow drains to the same stream or river. Watersheds can vary greatly in size, from that of a small stream to a larger waterbody.
watershed analysis	A process in which data are evaluated and interpreted in order to understand causal linkages between watershed-scale processes. This process informs the design and execution of management plans and activities.
water table	The top of the groundwater. The water table is generally subsurface; marshes and lakes form where the water table meets the land surface.
wetland	As defined in Oregon's Forest Practice Rules OAR 629-24-101 (77), wetlands are "those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions."
windthrow	Trees felled by high winds.

Appendix B
Stakeholder Engagement

KEARNS & WEST

Western Oregon State Forests Habitat Conservation Plan: Stakeholder and Public Engagement Report

January 20, 2022

CONTEXT AND INTRODUCTION

The purpose of the Western Oregon State Forests Habitat Conservation Plan (HCP) process is to develop potential options for reaching mutually agreeable conservation, forest management and financial outcomes through incidental take permits from the U.S. Fish and Wildlife Service (USFWS), and the National Marine Fisheries Service (NOAA Fisheries). In October of 2020, the Board of Forestry (BOF) gave direction to the State Forests Division to continue the development of the HCP. The Administrative Draft HCP entered the National Environmental Policy Act (NEPA) process in March 2021 and a Public Draft HCP will be shared with the public in March 2022. As ODF continues the HCP process, a key goal is to provide information and engage in dialogue with all Oregonians who want to weigh in on these important planning efforts.

Oregon Department of Forestry (ODF) staff, Oregon Consensus, Kearns & West, and ICF form the project team. Kearns & West leads facilitation of committees and stakeholder and public outreach, and Oregon Consensus is engaged in stakeholder coordination. ICF leads the technical and HCP development work. The project team developed and implemented a comprehensive stakeholder and public engagement process to ensure that interested parties had opportunities to provide meaningful input on the development of the HCP. Kearns & West developed a stakeholder engagement and communications plan that has guided the stakeholder and public involvement during the HCP development process.

The following report serves as a high-level summary of the stakeholder and public engagement efforts, including the stakeholder and public engagement approach, goals, and activities.

STAKEHOLDER ENGAGEMENT APPROACH AND GOALS

Public engagement is critical for an effective HCP process. ODF is working closely with sister agencies and partners to develop the HCP as part of the Scoping Team (ST), a technical level working group, and the Steering Committee (SC), a policy level working group. To supplement the ST and SC, Oregon Consensus and Kearns & West worked directly with stakeholders from a range of interests to design a public engagement process that is responsive to stakeholder feedback.

Early in the HCP development process, a comprehensive strategy for public engagement and communications was developed. The goals of the stakeholder engagement process include:

- Provide counties, stakeholders, and interested parties with opportunities to provide feedback at key points throughout the process.
- Engage counties as part of the Forest Trust Land Advisory Committee, and as part of the overall engagement effort.
- Keep interested parties informed at all major milestones through timely updates and information.
- Allow diverse interests to hear and learn from one another's perspectives.
- Provide clear expectations for how stakeholder and public input will be used and integrated into the Western Oregon State Forests HCP product.
- Build a common understanding on Western Oregon State Forests HCP development expected results of HCP implementation.

- Align engagement and outreach opportunities with related processes, such as the State Forest Management Plan (FMP) Revision.
- Keep stakeholders informed to promote relevant comments during the subsequent Western Oregon State Forests HCP NEPA Process.

The engagement strategy also outlined a structure and process for stakeholder input and review of HCP elements, and this structure was implemented throughout HCP development. Under the structure, the ST developed technical recommendations for the SC to consider when advising the ODF State Forests Division Chief. The SC provided overall guidance for the HCP process and provided direction and support to the ST.

After both the ST and SC reached alignment on key technical components and decision points for the HCP, the project team held large meetings open to the public to provide updates on the HCP process and present information on the development of the HCP. Follow-up meetings with stakeholder groups were then scheduled upon request to further discuss the information presented during the meetings open to the public and to dive deeper into the details of the HCP.

Key stakeholder and public engagement activities are outlined below and include details on the convening interviews, SC and ST meetings, meetings open to the public, stakeholder meetings, and county engagement.

CONVENING INTERVIEWS

SC and ST Convening Interviews

To kick-off the HCP stakeholder engagement process, Kearns & West conducted interviews with each entity in the ST and SC to learn about agency roles and responsibilities, interests, and issues, as well as to hear any ideas and suggestions on how to provide a productive and constructive process. The goal of the interviews was to gather information to help ensure the process strives for a mutually satisfactory and successful outcome to development of a potential Western Oregon HCP. At the conclusion of the interview process, Kearns & West developed process recommendations for any future HCP process.

Kearns & West conducted 15 interviews with individuals of the following entities: NOAA Fisheries, Oregon Department of Fish and Wildlife, Oregon Department of Environmental Quality, Oregon Department of State Lands, United States Fish and Wildlife Service, Oregon Department of Forestry, Oregon Department of Fish and Wildlife, and Oregon State University.

Stakeholder Convening Interviews

Kearns & West also interviewed key stakeholders to learn about their interests and concerns as it relates to the development of a Western Oregon HCP as well as to hear any ideas and suggestions for how to provide a productive public engagement process. The goal of the interviews was to gather information to help ensure an open and transparent process to keep stakeholders engaged in the development of a potential Western Oregon HCP. At the conclusion of the interview process, Kearns & West developed recommendations for future HCP public engagement processes.

Kearns & West conducted nine interviews with individual stakeholders and four small group interviews. Members of the following groups were invited to participate in the stakeholder interviews: Oregon Forests Conservation Coalition and Conservation Collaboration, Industry Adhoc, State Forests Advisory Committee, and the Forest Trust Land Advisory Committee. The invitation included over 80 stakeholders.

SC AND ST MEETINGS

ODF has continued to work with sister agencies and partners throughout the development of the HCP as part of the SC and ST. The SC consists of government agency representatives. Members voluntarily work together to provide advice on how ODF can achieve a mutually acceptable outcome that satisfies, to the greatest degree possible, the interests of all participants. The role of the SC is to provide overall guidance for the HCP process and to provide direction and support to the ST.

The HCP ST is comprised of terrestrial and aquatic biologists and technical specialists from state and federal agencies. Members provide the SC with technical information needed to evaluate potential policy options for ODF's consideration. The role of the ST is to provide technical expertise and to develop technical recommendations for the SC to consider when advising the Division Chief in the development of a potential HCP.

The SC and ST have met extensively throughout the project to develop the HCP and have been working collaboratively to develop the HCP since April 2018. By January 2022, the project team conducted 29 SC meetings and 55 ST meetings. The project team also conducted five joint SC and ST meetings to ensure there was agency alignment on the HCP. There were additional small group meetings with SC and ST members throughout the HCP development process to better understand agency interests, discuss specific technical topics, and seek alignment on key components of the HCP.

PUBLIC MEETINGS

The project team has conducted a total of ten Western Oregon HCP meetings open to the public. The meetings open to the public included updates on the HCP process, presentations, and question and answer/discussion periods which were followed by informal discussion periods with meeting participants to discuss topics of most interest to participants. The first three meetings were held in-person in Salem and offered a livestream option. The final seven meetings were held via webinar due to COVID-19 concerns and safety precautions. ODF notification methods to inform stakeholders and the public about the meetings included:

- Email distributions to interested parties
- Posts on ODF social media including Facebook and Twitter
- Meeting notice via FlashAlert to media in areas that would be potentially covered in the HCP (including Portland media)
- Posts on the ODF news site
- Posts on the Western Oregon HCP project webpage
- Posts on the State of Oregon Transparency website
- Letter from ODF to specifically invite county commissioners

The meetings open to the public have received strong participation and engagement. Attendance has ranged from approximately 15 to over 100 participants. The following is a list of the meetings open to the public and an overview of the number of attendees and the topics discussed.

- **March 21, 2019 Meeting Open to the Public**
    - Attendees: 24 individuals attended the public kick-off meeting and an additional 31

individuals participated in the livestream.
  - Meeting purpose:
    - To introduce the Western Oregon HCP Phase 2 process to a wide range of stakeholders.
    - Present Phase 2 scope of work and schedule.
    - Explain the process, including role of SC, ST, and stakeholder engagement.

- **June 12, 2019 Meeting Open to the Public**
  - Attendees: 26 individuals attended the meeting open to the public and an additional 21 individuals participated in the livestream.
  - Meeting purpose:
    - Provide updates on various elements of the HCP including: the permit and plan area, the covered species list, expected covered activities, existing conditions, and the data used in developing the HCP.
    - Present and discuss the proposed Mission, Vision and Goals that will help guide the direction and future of the HCP.
    - Present and discuss the overall HCP stakeholder engagement process.

- **October 15, 2019 Meeting Open to the Public**
  - Attendees: Seven individuals attended the meeting open to the public and an additional six people joined via livestream.
  - Meeting purpose:
    - Discuss the final draft of the Mission, Vision and Goals that will help guide the direction and future of the HCP.
    - Present and discuss the Western Oregon HCP conceptual Biological Goals and Objectives.
    - Share upcoming topics including: Conservation Actions, Impact Mechanisms, Effects Analysis, and Timber Modeling.

- **March 20, 2020 Meeting Open to the Public**
  - Attendees: Over 50 members of the public attended via webinar.
  - Meeting purpose:
    - Present the forest goals and objectives associated with the HCP.
    - Provide updates about the Western Oregon HCP's development and the status of conservation strategies, including:
      - A high-level overview of the methodology for habitat modeling and timber harvest modeling.
      - The conceptual framework of aquatic and terrestrial conservation strategies.

- **July 13, 2020 Meeting Open to the Public**
  - Attendees: Over 100 members of the public attended via webinar.
  - Meeting purpose:
    - Present the components of the aquatic and terrestrial conservation strategies.
    - Provide the results of the aquatic conservation strategy modeling and species habitat modeling.
    - Discuss policy-level forest management modeling.

- **September 16, 2020 Meeting Open to the Public**
    - Attendees: Over 100 members of the public attended via webinar.
    - Meeting purpose:
        - Provide updates on the development of the draft HCP.
        - Discuss the HCP Conservation Strategy.
        - Share the information that will be presented to the Board of Forestry in October to help the Board make a decision whether to move forward with an HCP.

- **May 6, 2021 Meeting Open to the Public**
    - Attendees: Over 70 members of the public attended via webinar.
    - Meeting purpose:
        - Hear updates on the Draft Western Oregon State Forests HCP.
        - Hear updates on the HCP NEPA process.

- **August 10, 2021 Meeting Open to the Public**
    - Attendees: Over 70 members of the public attended via webinar.
    - Meeting purpose:
        - Hear updates on the Draft Western Oregon State Forests Administrative Draft HCP.
        - Hear updates on the HCP NEPA process.

- **October 12, 2021 Meeting Open to the Public**
    - Attendees: 40 members of the public attended via webinar.
    - Meeting purpose:
        - Hear updates on the Draft Western Oregon State Forests Administrative Draft HCP.
        - Hear updates on the HCP NEPA process.

- **December 7, 2021 Meeting Open to the Public**
    - Attendees: Over 50 members of the public attended via webinar.
    - Meeting purpose:
        - Hear updates on the Draft Western Oregon State Forests Administrative Draft HCP.
        - Hear updates on the HCP NEPA process.

STAKEHOLDER MEETINGS

Following the meetings open to the public, the project team conducted stakeholder meetings with a cross-section of interests upon request from stakeholders. The purpose of these stakeholder meetings was to further discuss and provide additional details on the topics presented during the meetings open to the public as well as to have an open conversation with various interests to hear stakeholders' feedback, thoughts, concerns, and any additional information they would like the project team to consider during the development of the HCP. The project team conducted 17 stakeholder meetings and met with the following stakeholder groups: Conservation interests, industry representatives, recreation interests, and the State Forest Advisory Committee.

The following is a list of the focused stakeholder meetings and an overview of the number of attendees and the topics discussed.

Joint Stakeholder Meetings Representing Multiple Interests:

- April 8, 2020
    - Attendees: 21 stakeholders attended the meeting.
    - Meeting purpose:
        - Introduce the terrestrial species habitat modeling.
        - Introduce the riparian habitat modeling.
        - Introduce the timber harvest modeling.
- August 6, 2020
    - Attendees: 32 stakeholders attended the meeting.
    - Meeting purpose:
        - Present and discuss the conservation strategies and forest management approach including:
            - Overview of the approach to how Habitat Conservation Areas (HCAs) were designed and developed.
            - Management of the forest: Approach to management of forests on the landscape, both inside and outside of HCAs.
            - Policy-level forest management modeling update.
        - Next Steps: Expectations for information that will be available for the September 16 meeting open to the public.
        - Discussion on topics of most interest to participants.
- September 24, 2020
    - Attendees: 42 stakeholders attended the meeting.
    - Meeting purpose:
        - Further discuss topics presented during the September 16 meeting open to the public.
        - Discussion on topics of most interest to participants.
- December 3, 2020
    - Attendees: 32 stakeholders attended this meeting.
    - Meeting purpose:
        - Provide updates on the development of the HCP since the October 6 Board of Forestry meeting and share updates on the technical elements.
        - Discuss the processes, next steps, and timelines for the HCP, FMP, and NEPA.
        - Provide updates on the Santiam State Forest fire response and restoration efforts.
        - Discuss topics of most interests to participants.

Stakeholder Meetings with Conservation Interests:

- October 2, 2019
    - Attendees: Eight stakeholders attended the meeting.
    - Meeting purpose:
        - Discuss Western Oregon State Forests HCP Mission, Vision and Goals.
        - Present and discuss the conceptual Biological Goals and Objectives for species covered under the HCP.
        - Learn overall interests for the Western Oregon HCP.
        - Discuss future engagement with stakeholders.
- December 9, 2019

    - Attendees: 11 stakeholders attended the meeting.
    - Meeting purpose:
        - Overview of Western Oregon HCP current activities, including the terrestrial and riparian strategies.
        - Discussion on conservation groups' interest and inputs for the Western Oregon HCP.
- March 13, 2020
    - Attendees: Three stakeholders attended the meeting.
    - Meeting purpose:
        - Discuss the terrestrial species conservation strategy.
- January 21, 2021
    - Attendees: Eight stakeholders attended the meeting.
    - Meeting purpose:
        - Share updates on the development of the HCP.
        - Discuss and seek feedback on the draft HCP.
        - Discuss the HCP, FMP, and NEPA processes and timeline.
- June 24, 2021
    - Attendees: Two stakeholders attended the meeting.
    - Meeting purpose:
        - Share updates on the development of the HCP related to drinking water.
        - Discussion on the connection between drinking water and forest health.

Stakeholder Meetings with Industry Representatives:

- September 19, 2019
    - Attendees: Five stakeholders attended the meeting.
    - Meeting purpose:
        - Present the Western Oregon State Forests HCP Mission, Vision and Goals.
        - Present and discuss the conceptual Biological Goals and Objectives for species covered under the HCP.
        - Learn overall interests for the Western Oregon HCP.
        - Discuss future engagement with stakeholders.
- January 27, 2020
    - Attendees: Five stakeholders attended the meeting.
    - Meeting purpose:
        - Overview of Western Oregon HCP progress and products to date including:
            - HCP Timeline and Process
            - Biological Goals and Objectives
            - Terrestrial and Riparian Strategies
        - Discussion on industry groups' interest and inputs for the Western Oregon HCP.
- February 4, 2021
    - Attendees: Nine stakeholders attended the meeting.
    - Meeting purpose:
        - Share updates on the development of the HCP.
        - Discuss and seek feedback on the draft HCP.
        - Discuss the HCP, FMP, and NEPA processes and timeline.

Stakeholder Meetings with Recreation Interests:

- December 19, 2019
    - Attendees: Five stakeholders attended the meeting.
    - Meeting purpose:
        - Review Western Oregon HCP products to date.
        - Overview of Western Oregon HCP process.
        - Discuss interests of recreation groups for the Western Oregon HCP.
- February 3, 2021
    - Attendees: Six stakeholders attended the meeting.
    - Meeting purpose:
        - Share updates on the development of the HCP.
        - Discuss and seek feedback on the draft HCP.
        - Discuss the HCP, FMP, and NEPA processes and timeline.

State Forest Advisory Committee Meetings:

- October 25, 2019
    - ODF attended the October 25, 2020 State Forest Advisory Committee meeting and provided an update on the development of the HCP and sought feedback.
- December 9, 2019
    - Attendees: 11 State Forest Advisory Committee members attended the meeting.
    - Meeting purpose:
        - Provide updates on the Western Oregon HCP including:
            - Plan Area and Permit Area
            - Covered Species List
            - Covered Activities
            - Mission, Vision, and Goals
            - Biological Goals and Objectives
        - Discussion on State Forest Advisory Committee reflections and interests for the Western Oregon HCP.
        - Present next steps and future engagement.

Meetings with Individual Stakeholders:

ODF and the project team have also engaged in dozens of individual meetings and phone calls with individual stakeholders throughout the Phase 2 to check in on the development of the HCP and to understand their interests, concerns, feedback, and suggestions as it relates to the HCP.

COUNTY ENGAGEMENT

ODF and the project team engaged with the counties throughout Phase 2 of the process. ODF and the project team had several in-person meetings and phone calls with county representatives, members of the Forest Trust Land Advisory Committee, and members of the Association of Oregon Counties. ODF continues to engage with counties as the HCP moves forward into the NEPA process.

Appendix C
Species Accounts

Contents

C1 Oregon Coast Coho (*Oncorhynchus kisutch*)

The Oregon Coast coho salmon evolutionarily significant unit (ESU) is one of 19 ESUs and distinct population segments of salmon and steelhead in the Pacific Northwest listed as threatened or endangered under the federal Endangered Species Act (ESA). The Oregon Coast coho salmon ESU includes rivers and streams originating from the Oregon Coast range, except for the Umpqua River, which extends east through the Oregon Coast Range to originate from the Cascade Mountains.

Legal Status

State: Sensitive species

Federal: Threatened (NMFS 2008, final rule 2011)

Critical Habitat: Designated (NMFS 2008, reaffirmed 2011)

Recovery Planning: Recovery plan approved (NMFS 2016a)

Status Review: 5-year status review (NMFS 2016b)

Photo: Native Fish Society

Oregon Coast coho salmon are listed as a sensitive species under the Oregon State Sensitive Species List (OAR 635-100-0040) and are not listed under the Oregon Endangered Species Act (ORS 496.171 to 496.192, 498.026, and 564.100 to 564.135). Oregon developed the Oregon State Coast Coho Conservation Plan for the same populations as the federal listing to address the conservation concerns for the species. The Oregon Coast Coho Conservation Plan addresses legal requirements for conservation planning under Oregon's Native Fish Conservation Policy. The conservation plan was approved by the Oregon Fish and Wildlife Commission in March 2007.

Taxonomy

Coho salmon (*Oncorhynchus kisutch*) were first described by Walbaum in 1792. Coho are one of five recognized species of Pacific Salmon (*Oncorhynchus spp.*) that occur in North America.

Distribution

Coho salmon distribution is described for their entire range, the Oregon Coast ESU, and independent populations that intersect the HCP plan area and Oregon Department of Forestry (ODF) managed lands.

General

In North America, coho salmon originally ranged from Waddell and Scott creeks in Santa Cruz County, California, to Point Hope on the northwest corner of Alaska (Sandercock 1991). Botkin et al. (1995) estimated that coho salmon are no longer present (extirpated) from approximately 46% of their historic range in North America and 3.5% of their original range in Western Oregon and Northern California.

The Oregon Coast coho salmon ESU (Figure C1-1) includes the Pacific Ocean and the freshwater and estuarine habitat along the Oregon Coast from the Necanicum River on the north to the Sixes River on the south. Rivers in the ESU originate from the Oregon Coast Range, except for the Umpqua River, which extends east through the Oregon Coast Range to drain the Cascade Mountains.

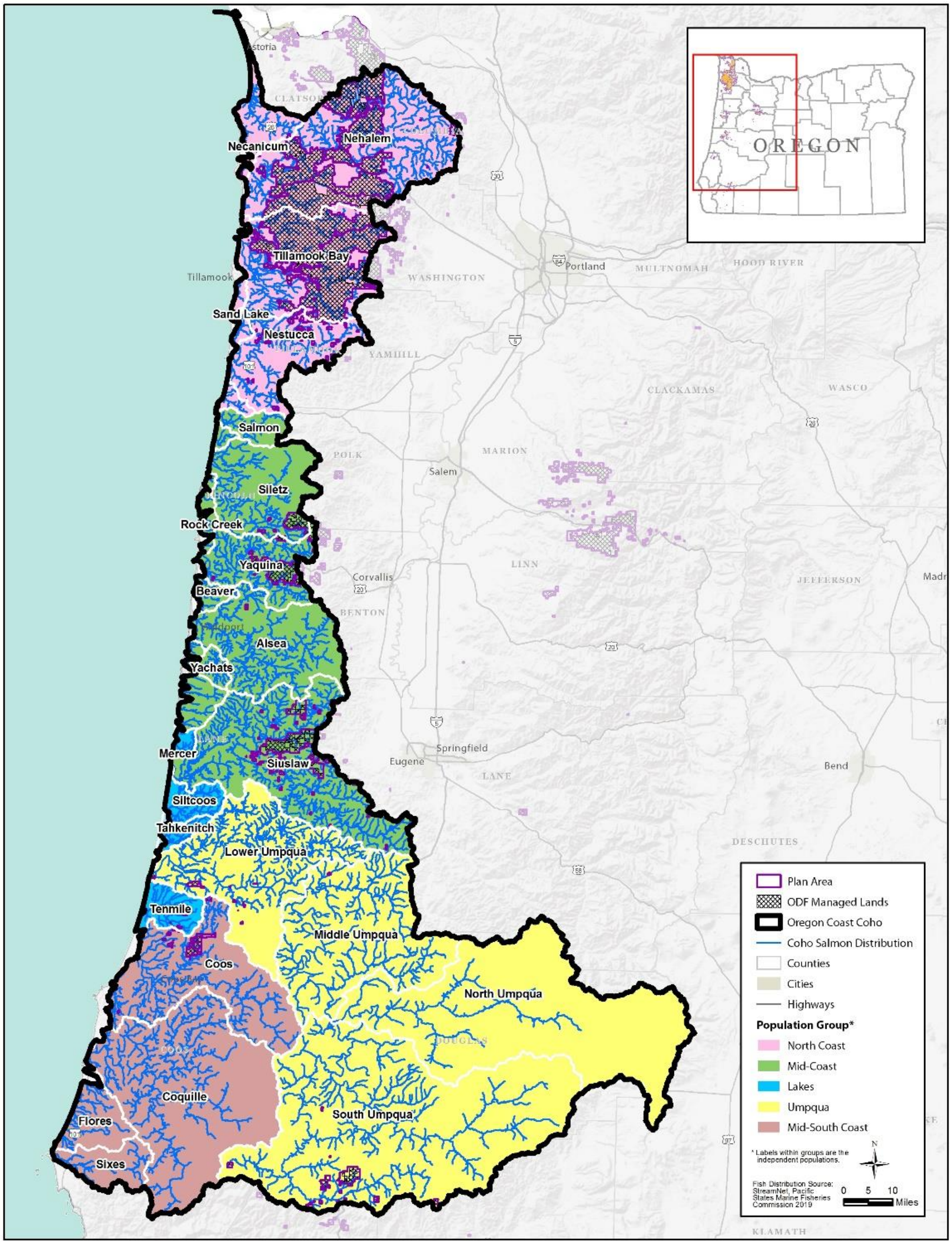
The Oregon Department of Fish and Wildlife (ODFW) identified three gene conservation groups (GCGs) within the ESU: (1) North/Mid Coast to Siuslaw River, (2) Umpqua River, and (3) Mid/South Coast to Cape Blanco/Sixes River (Kostow 1995). A fourth, lake population group was subsequently identified, and the northern GCG was divided into two areas based on geographic diversity within this population group. The result is five biogeographic strata across the ESU (Lawson et al. 2007).

Across the five strata a total of 56 historical populations were identified and were classified as either Dependent or Independent (Lawson et al. 2007). Independent populations are those that historically would have had a high likelihood of persisting in isolation from neighboring populations for 100 years. Across the five strata 21 independent populations were identified. Many of the identified dependent populations within the five biogeographic strata are in small coastal streams with limited freshwater habitat available for coho salmon spawning and rearing.

Historically adult coho salmon were widely distributed in streams across the ESU accessible to migrating adults and had favorable channel gradients for spawning. Burnett et al. (2007) reviewed several studies comparing reach gradient and juvenile coho salmon presence and no presence in streams greater than 7%.

The ESU recovery strategy calls for achieving sustainable independent populations within the ESU. NMFS set two recovery criteria for recovery of the Oregon Coast coho salmon ESU: (1) a majority of the independent populations in each stratum must be sustainable and (2) all five strata must be sustainable for the whole ESU to be sustainable (NMFS 2016a).

Figure C1-1. Oregon Coast Coho (*Oncorhynchus kisutch*) Biogeographic Strata and Independent Populations



Occurrences Within the Plan Area

Not all independent populations of coho salmon intersect or adjoin the plan area. However, across the entire ESU the following ten independent populations intersect portions of the plan area (Figure C1-1) (from north to south): (1) Necanicum, (2) Newhalem, (3) Tillamook Bay (includes Trask, Wilson, Tillamook, Miami, and Kilchis), (4) Nestucca, (5) Siletz, (6) Yaquina, (7) Siuslaw, (8) Tenmile, (9) South Umpqua, (10) Lower Umpqua, and (11) Coos.

Miles of streams with ODFW documented or assumed coho salmon presence within the plan area are summarized in Table C1-1. Stream miles are identified for independent populations by strata. The Newhalem and Tillamook Bay independent populations have the highest percentage of stream miles with coho salmon presence within the plan area.

Natural History

Oregon Coast Coho salmon typically have a 3-year life cycle. The typical freshwater period from the start of egg incubation to seaward migration is approximately 18 months. Adults return to fresh water and spawn between November and March after 18 months in the ocean. Each female deposits about 2,500 eggs into a redd formed in the stream. These eggs hatch in late winter, and alevins remain in the gravel until spring. In the spring the young coho salmon fry emerge from the gravel and begin to feed through spring, summer, and winter before migrating to sea the following spring.

Life History and Habitat Requirements

Coho salmon in North America inhabit small coastal streams as well as the largest rivers in western North America. Within larger river systems, coho salmon spawning is typically distributed in tributaries to the mainstem river. This pattern of spawning principally in smaller streams has given coho salmon a reputation of being primarily associated with small rivers and streams (Behnke 2002).

Sandercock (1991) described spawning distribution of coho salmon as follows:

> Their success as a species may be partly attributed to their utilization of a myriad of small coastal streams and to their aggressiveness and apparent determination to reach the small headwater creeks and tributaries of larger rivers to spawn. In many cases, they overcome difficult obstructions to reach areas inaccessible to other salmon and then share these locations with only migrant steelhead or perhaps resident cutthroat trout. These small headwater streams generally provide cool, clear, well-oxygenated water, with stable flows that are ideal for incubation and subsequent rearing.

Table C1-1. Miles of Coho Salmon Known or Presumed Coho Salmon Presence

Biogeographic Stratum and Population	Stream Miles with Known or Presumed Coho Salmon Presence		
	Total Stream Miles	Miles Within Plan Area	Percent of Total Within Plan Area
North Coast Stratum	**1,643**	**480**	**29%**
Necanicum River	100	1	1%
Nehalem River	769	242	31%
Tillamook River	0	0	0%
Tillamook Bay	461	233	51%
Nestucca River	256	4	2%
Sand Lake	57	0	0%
North Coast Dependents	0	0	0%
Mid Coast Stratum	**2,101**	**41**	**2%**
Salmon River	58	0	0%
Siletz River	284	7	3%
Yaquina River	280	0	0%
Beaver Creek	56	0.6	1%
Alsea River	424	0	0%
Siuslaw River	841	34	4%
Siuslaw River	63	0	0%
Rock Creek	44	0	0%
Yachats River	52	0	0%
Mid Coast Dependents	0	0	0%
Lakes Stratum	**262**	**0.8**	**0.3%**
Siltcoos Lake	97	0	0%
Mercer Lake	24	0	0%
Tahkenitch Lake	53	0	0%
Tenmile Lake	90	0.8	1%
Umpqua Stratum	**2,202**	**12**	**1%**
Lower Umpqua River	610	2	0.4%
Middle Umpqua River	559	0.3	0.1%
North Umpqua River	216	0	0%
South Umpqua River	816	9	1%
Mid South Coast Stratum	**1,273**	**14**	**1%**
Coos River	483	14	3%
Coquille River	598	0	0%
Floras Creek	120	0	0%
Sixes River	72	0	0%
Mid South Coast Dependents	0	0	0%

Source: Streamnet 2019.

Spawning

Females typically construct redds at the head of a riffle or in a pool tailout over substrate sized less than 15 centimeters (Sandercock 1991). Redds are located to maximize water circulation and oxygenation of the egg pocket.

Incubation

The factors most often associated with poor incubation survival of coho salmon are fine sediment and bed scour. Fine sediment can affect water circulation through the gravel and oxygenation of the egg pocket, affect the ability of fry to move within the substrate, and may cover the egg pocket, impacting the ability of fry to emerge from the gravel. Tagart (1984) reported poor egg survival to emergence of coho salmon when the percent fines (particles less than 0.85 millimeters) exceed 15%. Peterson et al. (1992) suggest a target percent fine sediment of less than 11% for good egg incubation survival.

Bedload movement and scour of the egg pocket can also reduce fry survival to emergence. Coho salmon egg pocket depths range from 12 to 25 centimeters (Devries 1997).

Freshwater Juvenile Residence

Throughout their freshwater residence juvenile coho salmon are strongly associated with slow water and areas with high channel complexity and physical cover (in-channel wood, vegetated banks, and side channels). Newly emergent coho salmon fry move quickly to low-velocity waters, usually along the stream's margins or into backwaters where velocities are minimal (Sandercock 1991; Nickelson et al. 1992). Nickelson et al. (1992) reported the highest fry densities in calm backwater pools in small streams on the Oregon Coast.

Coho salmon exhibit multiple life history patterns during freshwater residence. This movement of coho salmon fry following emergence and colonization of suitable rearing habitat may be a result of intraspecific competition (Chapman 1962), high flow (Hartman et al. 1982), or the lack of shallow, low-velocity habitat suitable for colonization (Au 1972). Fry movement may disperse fry long distances downstream into larger streams and lakes for summer rearing. Coho salmon that disperse to larger downstream streams and rivers may subsequently move into off-channel habitats to seek out calm, low-velocity water (Peterson and Reid 1984).

The fall movement of coho salmon fingerlings to downstream habitats is likely in response to the onset of fall rains and cooler temperatures and a need to seek more suitable low-velocity overwinter habitats, particularly floodplain channels, wetlands, and ponds. Coho fingerlings may be swept downstream by fall and winter rains if suitable low-velocity habitats are not present in their natal stream.

Reach geomorphic features (i.e., wide valley width and moderate to low gradients), increase intrinsic potential, consistent with juvenile coho salmon affinity for slow water habitats and floodplain habitats (Burnett et al. 2007). This affinity for slow water habitats also means coho salmon are susceptible to loss of complex in-channel habitat structure and disconnected floodplain habitats.

Some studies have found evidence for life history patterns for coho salmon that include the use of estuarine habitat or direct seaward migration by juveniles after only 6 months in freshwater. Koski (2009) reviewed several studies to better understand the role that these "nomadic" juveniles play in population resiliency, and suggests that estuarine habitats may have a significant role in the recovery of depressed coho salmon populations. Miller and Sadro (2003) reported spring movement of juveniles to downstream estuarine habitats for a coastal Oregon stream, where most fry resided through the summer and returned upstream to fresh water to overwinter. Roni et al. (2012) reported juvenile coho salmon leaving a Strait of Juan de Fuca stream (Washington) in the fall of their first year. They reported over 50% of the juveniles from a given brood year were fall migrants (migrated to saltwater between early October and end of December).

During the summer, juvenile coho salmon reside in a wide variety of stream types and sizes, including connected lakes where present (e.g., Tenmile Lake). The highest densities are found in natal streams, although a higher proportion of fry will move from higher gradient streams (Lestelle et al. 1993).

The affinity for calm, low-velocity habitats remains during summer rearing. Juvenile coho salmon are more closely associated with the shoreline or dense cover of woody debris than other salmonids. Juvenile coho salmon are most often found in pools (Nickelson et al. 1992), and densities in small Oregon coastal streams can be high, ranging from 0.31 juvenile fish per square meter to 0.68 juvenile fish per square meter (Jepsen and Rodgers 2004; Jepsen 2006). In addition to stream complexity affecting juvenile densities, density can be strongly affected by stream productivity (amount of food available) (Mason 1976; Ptolemy 1993; Ward et al. 2003). More productive streams tend to support higher densities of juvenile salmon.

The presence of wood in streams is loosely correlated to number of juvenile fish. Wood may have a more important role in pool formation and the quantity of pool habitat favorable for coho salmon and have less importance as cover in small streams (Lestelle 2007). However, high quantities of wood may be more important as cover in larger streams and rivers. Peters (1996) found that juvenile coho salmon rearing in the mainstem Clearwater River (Washington) was strongly associated with large wood. The study hypothesized that the attraction of wood during the summer in mainstem rivers is primarily because it provides refuge cover from predators rather than refuge from water velocity.

Lestelle (2007) summarized several studies on effects of water temperature on juvenile coho salmon. A study in the Mattole River (Northern California) reported coho were not found in streams that exceeded a maximum weekly temperature of 18°C (Welsh et al. 2001 in Lestelle 2007). Another study in the Sixes River (Southern Oregon) reported juvenile coho salmon to be absent or rare in stream segments where temperatures exceeded 21°C (Frissell 1992 in Lestelle 2007).

Juvenile coho salmon may seek sites of thermal refuge to avoid warm water temperatures. These sites may be at the confluence of cool-water tributaries entering a stream, springbrooks, and side channels, or at smaller scales of thermally stratified pools. At the reach scale and smaller, bedform topography may create vertical hydraulic gradients of exchange between the streambed and flowing channel (Torgersen et al. 2012) providing thermal variation longitudinally along the channel and across pool/riffle habitat units.

The quantity of summer rearing habitat can have a strong density-dependent effect on survival. Low late summer flows, few pools, and reduced food may reduce survival and limit population abundance. However, the effects of summer low flow on survival and freshwater smolt abundance may be less important than the quantity of overwinter habitat for coho salmon. Overwinter survival of juvenile fish is a major factor found to influence abundance in Oregon Coast streams. Limited overwinter habitat can create a population bottleneck during coho salmon freshwater residence.

Solazzi et al. (2000) reported a substantial increase in abundance of seaward migrating smolts following habitat modifications to increase the quantity of winter rearing habitat. They increased the amount of overwinter habitat through a combination of improvements of in-channel habitats and the creation of new off-channel habitats. They concluded critical elements to improving survival were increasing the quantity of slow-water habitat and the addition of large quantities of wood.

Ocean Life

Pacific salmon are anadromous fish; adults migrate from the ocean to spawn in freshwater lakes and streams where their offspring hatch and rear prior to migrating back to the ocean to forage until maturity. The physiological and behavioral changes required for the transition to saltwater results in a distinct smolt stage. Adult coho salmon begin migrating into coastal streams and rivers in the fall. Eggs hatch in the spring and fry grow rapidly to the parr stage by early summer or early fall. Parr then seek out areas protected from high flows and spend a second winter in freshwater before migrating to the ocean as smolts in March through June. Coho salmon, primarily male fish, mature and spawn after only several months in the ocean. About 20% of males mature at age 2 and return to freshwater as "jacks" in the same year they entered the ocean as adults. Although the production of jacks is a heritable trait in coho salmon, the proportion of jacks in a given coho salmon population is strongly influenced by environmental factors. The remainder of juveniles rear in the ocean for 18 months and return as 3-year-old adults in the fall. Habitat capacity for coho salmon on the Oregon Coast has significantly decreased from historical levels. During periods of poor ocean survival, high quality habitat is necessary to sustain coho populations. Disease and infection of juvenile coho salmon in the first few months of ocean residence is a key concern.

Ecological Relationships

Juvenile salmon migrate downstream through every riverine and estuarine corridor between their natal lake or stream and the ocean. On their journey, they develop behaviors such as predator avoidance, foraging, and competition that help ensure their survival. Salmon's complex life cycle gives rise to complex habitat needs, particularly during the freshwater phase. Juveniles compete for abundant food sources, including insects, crustaceans, and other small fish. They need places to hide from predators (mostly birds and bigger fish), such as under logs, root wads, and boulders in the stream, as well as beneath overhanging vegetation. Returning adults also require cool waters and places to rest and hide from predators.

Population Status and Trends

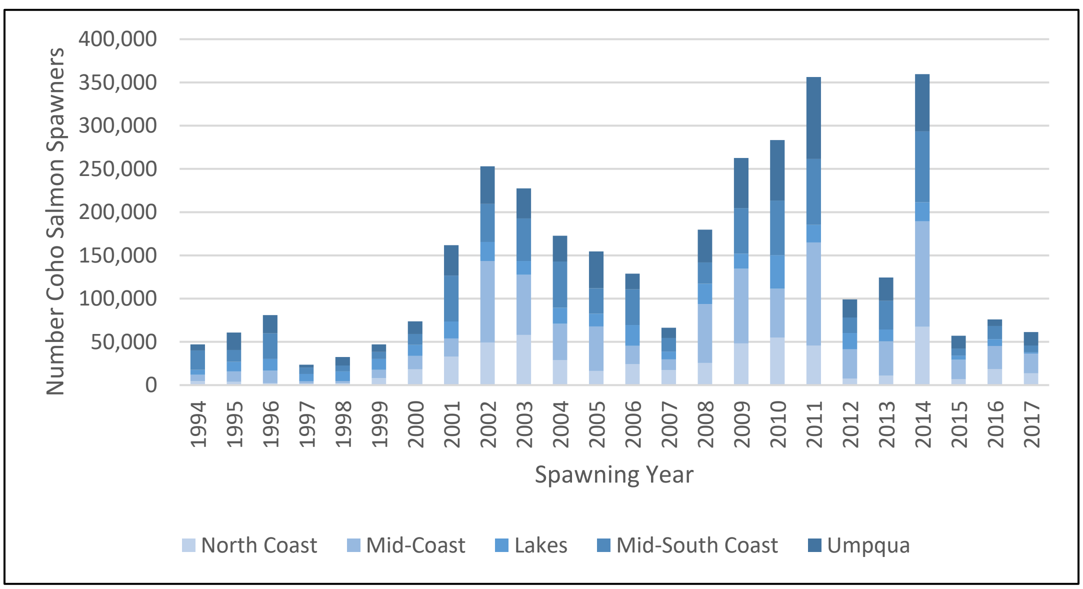
The Oregon Coast Coho Conservation Plan assumes a historical (pre-development) coho salmon adult return to the Oregon Coast coho salmon ESU in the range of 1 to 2 million fish during periods of favorable ocean conditions (ODFW 2007).

Since 1994, coho salmon spawner abundance in the Oregon Coast coho salmon ESU has ranged from 23,661 to 359,692 coho salmon (Figure C1-2). Abundance during the early period was low, averaging 52,240 fish from 1994 to 2000. Coho salmon spawner abundance increased considerably from 2001 to 2014, due mostly to improved marine survival, combined with substantially reduced harvest on returning adults (NMFS 2016b). From 2001 to 2017, the number of adult coho salmon averaged 177,920 fish. However, there has been a decline in abundance beginning in 2015; from 2015 to 2017 the number of coho salmon spawners across the ESU has been less than 100,000 fish.

The recent year decline is likely because of low ocean survival and possibly freshwater conditions during egg incubation and juvenile residence. However, many positive improvements to Oregon Coast coho salmon are described by ODFW, including positive long-term abundance trends and escapement. Increases in ESU scores for persistence and sustainability also clearly indicate the biological status of the ESU is improving, due in large part to management decisions (reduced harvest and hatchery releases) and favorable environmental variation such as high marine survival. Environmental conditions in both fresh and marine waters inhabited by Pacific Northwest salmon are also influenced by two ocean-basin scale drivers, the Pacific Decadal Oscillation (PDO) and the El Niño-Southern Oscillation (ENSO). Starting in late 2013, however, abnormally warm conditions in the Central Northeast Pacific Ocean known as the "warm blob" has also had a strong influence on both terrestrial and marine habitats (NMFS 2016b).

Coho salmon spawner abundance from 2013 to 2017 by stratum and independent population are summarized in Table C1-2. The averages and ranges during this period include the high abundance in 2014 (359,692 adults). The Mid Coast stratum comprising six independent populations was on average 34% of the total ESU abundance during this period. The most abundant population in this stratum was the Siuslaw River with an average of almost 16,000 adults. The Mid South Coast stratum comprising four independent populations was on average 22% of the total ESU abundance during this period. The most abundant population in this stratum was the Coquille River with an average of approximately 16,500 adults. As shown in Table C1-1 the plan area has the largest overlap with the North Coast stratum, specifically the Nehalem and Tillamook independent populations. These two populations comprise, on average, 13% of the total ESU abundance during this period (Table C1-2).

Figure C1-2. Trends Abundance Adult Spawning Coho Salmon



Source: ODFW 2019.

Table C1-2. Adult Coho Salmon Abundance

Biogeographic Stratum and Population	Coho Salmon Adult Abundance	
	Recent 5-year Average and Range (2013–2017)	Percent of Total ESU Abundance
Oregon Coast Coho ESU	**135,702 (57,125/359,692)**	
North Coast Stratum	**23,481 (6,740/67,370)**	**17%**
Necanicum River	1,767 (529/5,727)	1%
Nehalem River	10,246 (3,079/30,577)	8%
Tillamook River	7,173 (1,345/20,090)	5%
Nestucca River	3,050 (946/6,369)	2%
North Coast Dependents	1,245 (206/4,607)	<1%
Mid Coast Stratum	**46,739 (22,673/121,963)**	**34%**
Salmon River	1,336 (332/3,680)	1%
Siletz River	7,518 (2,216/19,496)	6%
Yaquina River	7,551 (2,400/25,582)	6%
Beaver Creek	2,435 (332/6,564)	2%
Alsea River	10,566 (4,288/25,733)	8%
Siuslaw River	15,927 (7,129/38,896)	12%
Mid Coast Dependents	1,406 (473/2,012)	1%
Lakes Stratum	**9,949 (1,302/22,010)**	**7%**
Siltcoos Lake	3,134 (715/7,178)	2%
Tahkenitch Lake	1,941 (269/3,691)	1%
Tenmile Lake	4,874 (318/11,141)	4%
Umpqua Stratum	**26,227 (7,494/66,272)**	**19%**
Lower Umpqua River	12,746 (3,725/36,942)	9%
Middle Umpqua River	4,681 (1,159/13,939)	3%
North Umpqua River	2,537 (1,148/3,979)	2%
South Umpqua River	6,263 (765/12,178)	5%
Mid South Coast Stratum	**29,309 (8,092/82,077)**	**22%**
Coos River	11,221 (2,689/38,880)	8%
Coquille River	16,558 (3,357/41,660)	12%
Floras Creek	1,236 (693/1,936)	1%
Sixes River	267 (69/567)	0%
Mid South Coast Dependents	27 (0/105)	<1%

Source: ODFW 2019.
Note: *italics* = populations occur in the plan area.

Threats

A federal recovery plan for the Oregon Coast coho salmon ESU was finalized in December 2016 (81 FR 90780). The plan provides guidance to improve the viability of the species to the point that it meets the delisting criteria and no longer requires ESA protection. The primary threat identified in the recovery plan is deteriorating freshwater habitat conditions and a concern that existing voluntary and regulatory mechanisms are inadequate to protect and recover Oregon Coast coho salmon (NMFS 2016a).

The Oregon State Coast Coho Conservation Plan (Oregon Coho Plan) was approved by the Oregon Fish and Wildlife Commission in 2007 prior to final listing under the ESA (ODFW 2007). The Oregon Coho Plan addresses the legal requirements for conservation planning under Oregon's Native Fish Conservation Policy. The Oregon Coho Plan is a strategic approach to recovery based on science, supported by stakeholders, built on existing efforts, and including new recovery actions. NMFS determined that the depressed status of the ESU is the result of habitat degradation, water diversions, harvest, and hatchery production (NMFS 2016a). NMFS concluded that the adverse effects of natural environmental variability from drought, floods, and poor ocean conditions have been exacerbated by the degradation of habitat by human activities. A subsequent status review by the Northwest Fisheries Science Center found that risks posed by hatcheries and fisheries have largely been remediated (NMFS 2016b). NMFS concluded in its 5-year status review that continued threats from habitat degradation and climate change remain factors affecting the ESU's long-term status and that the Oregon Coast coho salmon ESU should remain listed under the ESA as threatened. During the summer months, many of the streams coho salmon juveniles inhabit are already at close to lethal temperatures, and with the expectation of rising stream temperatures due to global climate change, increases in infection rates of juvenile coho salmon by parasites may become an increasingly important stressor both for freshwater and marine survival (NMFS 2016b).

NMFS-identified threats to coho salmon, by recovery stratum, are shown in Tables C1-3 and C1-4. The North Coast stratum has the most overlap with the plan area. Limiting factors in this stratum include a loss of stream complexity, including floodplain connectivity and large wood, and water quality (temperature, dissolved oxygen, pH, sediment, and contaminants).

Table C1-3. Limiting Factors for Oregon Coast Coho Salmon by Biogeographic Recovery Stratum

Stratum	Limiting Factors
North Coast	• Stream complexity • Water quality
Lakes	• Non-native fish species predation • Stream complexity • Water quality
Umpqua	• Stream complexity • Water quantity • Hatchery impacts
Mid-South Coast	• Hatchery impacts • Stream complexity (including spawning gravel) • Water quality

Source: NMFS 2016b.

Table C1-4. Description of Limiting Factors for Oregon Coast Coho Salmon

Limiting Factor	Description
Stream Complexity	• Loss of the physical habitat variety, including floodplain connectivity, supporting adult spawning, egg incubation, and juvenile rearing • Removal of beavers and in-stream large woody debris
Water Quality	• Elevated water temperature and pH • Diminished dissolved oxygen • Increased fine sediments and contaminants
Water Quantity	• Reduced instream flows from irrigation and population growth demands
Hatchery Impacts	• Interactions with hatchery-origin coho reduces wild coho abundance, productivity, and diversity
Non-native fish species predation	• Bass and other non-native predators preying on coho salmon

Source: NMFS 2016b.

Literature Cited

Au, D. W. K. 1972. *Population Dynamics of the Coho Salmon and its Response to Logging in Three Coastal Streams.* Ph.D. Thesis, Oregon State University, Corvallis, OR.

Botkin, D.B., K. Cummins, T. Dunne, H. Regier, M. Sobel, and L. Talbot. 1995. *Status and Future of Salmon of Western Oregon and Northern California: Findings and Options.* The Center for the Study of the Environment, P.O. Box 6945, Santa Barbara, CA 93160, Research Report 951002.

Burnette, K.M., G.H. Reeves, D. J. Miller, S. Clarke, K. Vance-Borland, and K. Christiansen. 2007. Distribution of Salmon-Habitat Potential Relative to Landscape Characteristics and Implication for Conservation. *Ecology Application* 17(1):66–80.

Chapman, D.W. 1962. Aggressive Behavior in Juvenile Coho Salmon as a Cause of Emigration*. Journal of the Fisheries Research Board of Canada* 19:1047–1080.

Devries, Paul. 1997. Riverine Salmonid Egg Burial Depths: A Review of Published Data and Implications for Scour Studies. *Canadian Journal of Fisheries and Aquatic Sciences* 54: 1685–1698.

Hartman, G.F., B.C. Anderson, and J.C. Scrivener. 1982. Seaward Movement of Coho Salmon (*Oncorhynchus kisutch*) Fry in Carnation Creek, an Unstable Coastal Stream in British Columbia. *Canadian Journal of Fisheries and Aquatic Sciences* 39:588–597.

Jepsen, D.B. 2006. *Abundance Monitoring of Juvenile Salmonids in Oregon Coastal Streams, 2004.* Monitoring Program Report Number OPSW-ODFW-2006-1, Oregon Department of Fish and Wildlife, Salem, OR.

Jepsen, D.B., and J.D. Rodgers. 2004. *Abundance Monitoring of Juvenile Salmonids in Oregon Coastal Streams, 2002-2003.* Monitoring Program Report Number OPSW-ODFW-2003-1, Oregon Department of Fish and Wildlife, Portland, OR.

Koski, K., 2009. The Fate of Coho Salmon Nomads: The Story of an Estuarine-Rearing Strategy Promoting Resilience. *Ecology & Society* 14(1).

Kostow, K. (editor). 1995. *Biennial Report of the Status of Wild Fish in Oregon*. Oregon Department of Fish and Wildlife, Fish Division. Portland.

Lawson, P.W., E.P. Bjorkstedt, M.W. Chilcote, C.W. Huntington, J.S. Mills, K.M.S. Moore, T.E. Nickelson, G.H. Reeves, H.A. Stout, T.C. Wainwright, and L.A. Weitkamp. 2007. *Identification of Historical Populations of Coho Salmon (*Oncorhynchus kisutch*) in the Oregon Coast Evolutionarily Significant Unit.* U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-79, 129 p.

Lestelle, Lawrence C. 2007. *Coho Salmon (*Oncorhynchus kisutch*) Life History Patterns in the Pacific Northwest and California.* Final report submitted to the U.S. Bureau of Reclamation, Klamath Area Office, Klamath Falls, OR.

Lestelle, L.C., G.R. Blair, S.A. Chitwood. 1993. Approaches to Supplementing Coho Salmon in the Queets River, Washington. Pages 104-119 in L. Berg and P.W. Delaney (eds.), *Proceedings of the Coho Workshop*. British Columbia Department of Fisheries and Oceans, Vancouver, BC.

Mason, J.C. 1976. Response Of Underyearling Coho Salmon To Supplemental Feeding In A Natural Stream. *Journal of Wildlife Management* 40:775-778.

Miller, B.A., and S. Sadro. 2003. Residence Time and Seasonal Movements of Juvenile Coho Salmon in the Ecotone and Lower Estuary of Winchester Creek, South Slough, Oregon. *Transactions of the American Fisheries Society* 132:546-559.

National Marine Fisheries Service (NMFS). 2008. Endangered and Threatened Species: Final Threatened Listing Determination, Final Protective Regulations, and Final Designation of Critical Habitat for the Oregon Coast Evolutionarily Significant Unit of Coho Salmon. *Federal Register* [Docket No. 071227892–7894–01, February 11, 2008] 73 (28):7816–7873.

National Marine Fisheries Service (NMFS). 2011. Final Rule. Listing Endangered and Threatened Species: Threatened Status for the Oregon Coast Coho Salmon Evolutionarily Significant Unit. *Federal Register* Citation 76 FR 35755. June 20, 2011.

National Marine Fisheries Service (NMFS). 2016a. *Recovery Plan for Oregon Coast Coho Salmon Evolutionarily Significant Unit.* National Marine Fisheries Service, West Coast Region, Portland, Oregon. December 2016.

National Marine Fisheries Service (NMFS). 2016b. *2016 5-Year Review: Summary and Evaluation of Oregon Coast Coho Salmon.* National Marine Fisheries Service, West Coast Region, Portland, Oregon. May 26, 2016.

Nickelson, T. E., J. D. Rodgers, S. L. Johnson, and M. F. Solazzi. 1992a. Seasonal Changes in Habitat Use by Juvenile Coho Salmon (Oncorhynchus kisutch) in Oregon Coastal Streams. *Canadian Journal of Fisheries and Aquatic Sciences* 49:783-789.

Oregon Department of Fish and Wildlife (ODFW). 2007. *Oregon Coast Coho Conservation Plan for the State of Oregon*. Available: https://www.dfw.state.or.us/fish/CRP/docs/coastal_coho/final/Coho_Plan.pdf.

Oregon Department of Fish and Wildlife (ODFW). 2019. *Salmon and Steelhead Recovery Tracker.* Coho Data. Available: http://odfwrecoverytracker.org/. Accessed: May 2019.

Peters, R.J. 1996. *An Evaluation of Habitat Enhancement and Wild Fry Supplementation as a Means of Increasing Coho Salmon Production of the Clearwater River, Washington*. Ph.D. Thesis, University of Washington, Seattle, WA.

Peterson, N.P., and L.M. Reid. 1984. Wall-Base Channels: Their Evolution, Distribution, and Use by Juvenile Coho Salmon in the Clearwater River, Washington. Pages 215-225 in J.M. Walton and D.B. Houston (eds), *Proceedings of the Olympic Wild Fish Conference*. Peninsula College and Olympic National Park, Port Angeles, WA.

Peterson, N. P., A.P. Hendry, T. P. Quinn, 1992. *Assessment of Cumulative Effects on Salmonid Habitat: Some Suggested Parameters and Target Conditions*. Prepared for the Washington Department of Natural Resources and The Cooperative Monitoring, Evaluation and Research Committee Timber/Fish/Wildlife Agreement Olympia, Wash.

Ptolemy, R.A. 1993. Maximum Salmonid Densities in Fluvial Habitats in British Columbia. Pages 223–250 in L. Berg and P.W. Delaney (eds.), *Proceedings of the Coho Workshop*. British Columbia Department of Fisheries and Oceans, Vancouver, BC.

Roni, P., T. Bennett, R. Holland, G. Pess, K. Hanson, R. Moses, M. McHenry, W. Ehinger, J. Walter. 2012. Factors Affecting Migration Timing, Growth, and Survival of Juvenile Coho Salmon in Two Coastal Washington Watersheds. *Transactions of the American Fisheries Society* 141(4), 890–906.

Sandercock, F.K. 1991. Life History of Coho Salmon (*Oncorhynchus kisutch*). Pages 396-445 in C. Groot and L. Margolis (eds.), *Pacific Salmon Life Histories*. University of British Columbia Press, Vancouver, B.C.

Solazzi, M.F., T.E. Nickelson, S.L. Johnson, and J.D. Rodgers. 2000. Effects of Increasing Winter Rearing Habitat on Abundance of Salmonids in Two Coastal Oregon Streams. *Canadian Journal of Fisheries and Aquatic Sciences* 57:906–914.

Sounhein, B., E. Brown, M. Lewis and M. Weeber. 2017. *The Oregon Plan for Salmon and Watersheds: Status of Oregon stocks of Coho Salmon, 2016*. Monitoring Program Report Number OPSW-ODFW-2017-3, Oregon Department of Fish and Wildlife, Salem, Oregon. Available: https://odfw.forestry.oregonstate.edu/spawn/pdf%20files/reports/2016CohoAnnualReport.pdf.

StreamNet. 2019. Database (Version 98.3) [database downloaded to disk]. Portland (OR) : StreamNet. Available: https://www.streamnet.org/data/interactive-maps-and-gis-data/.

Tagart, J.V. 1984. Coho Salmon Survival from Egg Deposition to Fry Emergence. Pages 173-182 in J.M. Walton and D.B. Houston (eds.), *Proceedings of the Olympic Wild Fish Conference*. Peninsula College Fisheries Technology Program and Olympic National Park, Port Angeles, WA.

Torgersen, C., J. Ebersole, and D. Keenan. 2012. *Primer for Identifying Cold-Water Refuges to Protect and Restore Thermal Diversity in Riverine Landscapes.* Region 10, U.S. Environmental Protection Agency, Seattle, Washington under EPA Interagency Agreement No. DW-14-95755001-0.

Ward, B.R., D.J.F. McCubbing, and P.A. Slaney. 2003. Evaluation of the Addition of Inorganic Nutrients and Stream Habitat Structures in the Keogh River watershed for Steelhead Trout and Coho Salmon. Pages 127-147 in J.G. Stockner (ed.), *Nutrients in Salmonid Ecosystems: Sustaining Production and Biodiversity*. American Fisheries Society, Symposium 34, Bethesda, MD.

C2 Lower Columbia River Coho (*Oncorhynchus kisutch)*

The Lower Columbia River coho salmon evolutionarily significant unit (ESU) is one of 19 ESUs and distinct population segments of salmon and steelhead in the Pacific Northwest listed as threatened or endangered under the federal Endangered Species Act (ESA). The Lower Columbia River coho salmon ESU includes rivers and streams originating from rivers and streams in Oregon and Washington downstream and including the Big White Salmon River (WA) and Hood River (OR), and the Willamette River and its tributaries downstream of Willamette Falls.

Legal Status

State: Endangered

Federal: Threatened (Final listing National Marine Fisheries Service [NMFS] 2005; 70 *Federal Register* [FR] 37160)

Critical Habitat: Designated (NMFS 2016; 81 FR 9250)

Recovery Planning: Recovery plan approved (NMFS 2013; 78 FR 41911)

Photo: Native Fish Society

Lower Columbia River coho salmon are listed as Endangered under the Oregon State Endangered Species Act (ORS 496.171 to 496.192, 498.026, and 564.100 to 564.135). Oregon developed the Oregon State Lower Columbia River Conservation and Recovery Plan for the same Oregon populations as the federal listing, which includes Washington populations. The Oregon State Lower Columbia River Conservation and Recovery Plan addresses legal requirements for conservation planning under Oregon's Native Fish Conservation Policy. The conservation plan was approved by the Oregon Fish and Wildlife Commission in August 2010.

Taxonomy

Coho salmon (*Oncorhynchus kisutch*) were first described by Walbaum in 1792. Coho salmon are one of five recognized species of Pacific Salmon (*Oncorhynchus spp.*) that occur in North America.

Distribution

General

The Lower Columbia River coho salmon evolutionarily ESU (Figure C2-1) includes the Pacific Ocean and the freshwater and estuarine habitat in the Columbia River and tributaries to the Columbia River in Oregon and Washington downstream and including the Big White Salmon River (WA) and Hood River (OR), and the Willamette River and its tributaries downstream of Willamette Falls (OR).

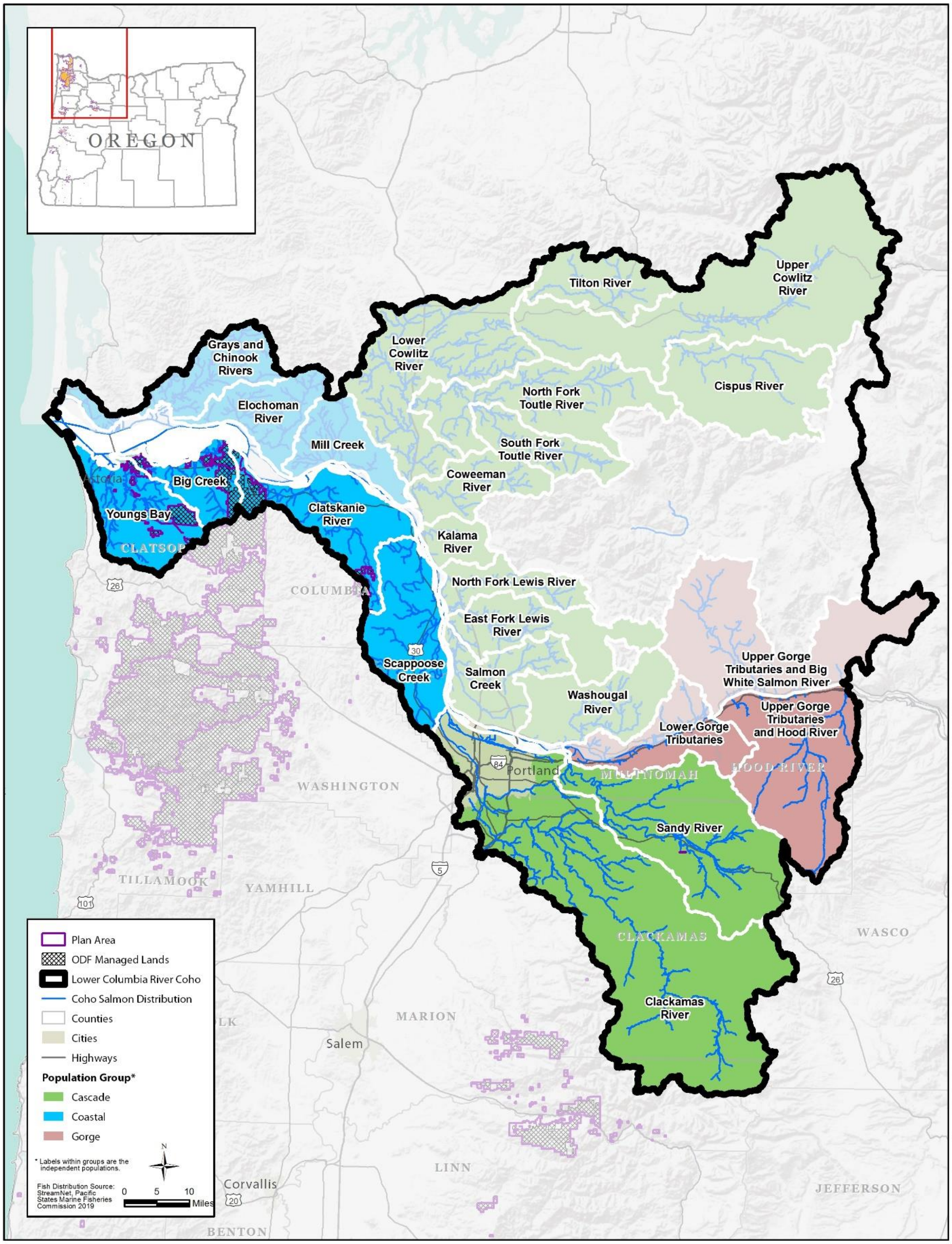
The Lower Columbia River coho salmon ESU historically consisted of a total of 24 independent populations. Because NMFS had not yet listed the ESU in 2003 when the Willamette-Lower Columbia Technical Recovery Team (WLC TRT) designated core and genetic legacy populations for other ESUs, there are no such designations for Lower Columbia River coho salmon.

NMFS (2013) identified three major population groups (MPG) in the lower Columbia River: (1) Coast, (2) Cascade, and (3) Gorge. Historically there were 24 independent populations in the Lower Columbia River coho salmon ESU across the three MPGs. In Oregon there were four populations in the Coast MPG (Youngs Bay, Big Creek, Clatskanie River, and Scappoose Creek). In the Cascade MPG there were three populations in Oregon (Clackamas River and Sandy River). In the Gorge MPG there were three populations with spawning in tributaries in Washington and Oregon (including the Hood River) (NMFS 2013).

ESU recovery is based on achieving sustainable independent populations with the ESU and across the MPGs. NMFS set three recovery criteria for recovery of the of the Lower Columbia River coho salmon ESU:

1. Within each MGP there should be at least two populations that have a 95% chance of persisting over a 100-year time frame.
2. Within each MPG approximately half the populations should have a persistence probability of high or very high.
3. Viable populations should be dispersed across the ESU, and include those that were historically most productive and represent the genetic diversity of the ESU. (NMFS 2013)

Figure C2-1. Lower Columbia River Coho Salmon ESU Strata and Independent Populations



Occurrences Within the Plan Area

Not all independent populations of coho salmon intersect or adjoin the plan area. Across the entire ESU four independent populations in Oregon intersect portions of the plan area to varying degrees (Figure C2-1). The independent populations that include portions of the plan area are (from north to south): (1) Youngs Bay, (2) Big Creek, (3) Clatskanie River, and (4) Sandy River.

Miles of streams with ODFW documented or assumed coho salmon presence within the plan area are summarized in Table C2-1. Stream miles are identified for independent populations by strata. The Big Creek and Youngs Bay independent populations have the highest occurrence of stream miles with coho salmon presence within the plan area.

Table C2-1. Miles of Lower Columbia River Coho Salmon Known or Presumed Coho Salmon Presence in the Oregon Portion of Their ESU

Biogeographic Stratum and Population	Stream Miles with Known or Presumed Coho Salmon Presence		
	Total Stream Miles	Miles Within or Adjacent to Plan Area	Percent of Total Within or Adjacent to Plan Area
Cascade Stratum	**572**	**0.1**	**0.02%**
Clackamas River	390	0	0%
Sandy River	181	0.1	0.06%
Gorge Stratum	**367**	**0**	**0%**
Lower Gorge Tributaries	125	0	0%
Upper Gorge Tributaries and Big White Salmon River	108	0	0%
Upper Gorge Tributaries and Hood River	134	0	0%
Coastal Stratum	**467**	**27**	**6%**
Big Creek	83	17	20%
Clatskanie River	104	3	3%
Scappoose Creek	139	0	0%
Youngs Bay	141	7	5%

Source: Streamnet 2019.

Natural History

See *Oregon Coast Coho* for the species natural history information.

Population Status and Trends

Wild coho in the Columbia basin have been in decline for the last 50 years. Historically at least 600,000 fish returned to the Columbia River; in 1996 the total return of wild fish was approximately 400 fish (ODFW 2010).

Most populations are believed to have very low abundance of natural-origin spawners (50 fish or fewer, compared to historical abundances of thousands or tens of thousands). Because of inadequate spawning surveys and, until recently, the presence of unmarked hatchery-origin spawners, data quality has been poor. Up through 2008, 25 artificial propagation programs produced coho salmon considered to be part of this ESU. However, two programs have been removed; now 23 coho salmon hatchery programs are currently included in the ESU. Low abundance, past stock transfers, other legacy hatchery effects, and ongoing hatchery straying may have reduced genetic diversity within and among coho salmon populations. It is likely that hatchery effects have also decreased population productivity. Only in the Clackamas and Sandy subbasins is there a clear record of continuous natural spawning from the 1990s to the present. Spawner abundance for both these populations is still well below long-term minimum abundance thresholds, although there was a generally positive trend from the 1990s through 2005. More recent spawning surveys indicate short-term increases in natural production in the Clatskanie, Scappoose, and Mill/Abernathy/Germany populations.

Of the 24 populations that make up this ESU, 21 are considered to have a very low probability of persisting for the next 100 years, and none are considered viable. All three strata in the ESU fall significantly short of the WLC TRT criteria for viability. The low abundance and productivity, loss of spatial structure, and reduced diversity can account for the very low persistence probability for most Lower Columbia River coho salmon populations. Although poor data quality prevents precise quantification, most populations are believed to have very low abundance of natural origin spawners. The general poor baseline population status of coho salmon reflects poor long-term trends.

Youngs Bay and Big Creek have been identified as subbasins that will not target improvements to the baseline trend, but rather continue to have a high proportion of hatchery origin spawners (NMFS 2013). These subbasins will continue to provide harvest opportunities though terminal fisheries.

Table C2-2. Adult Lower Columbia River Coho Salmon Abundance in Oregon

Biogeographic Stratum and Population	Coho Salmon Adult Abundance	
	Recent 5-year Average and Range (2014–2018)	**Percent of Total ESU Abundance**
Lower Columbia River ESU	**9,440 (468/14,420)**	
Coastal Stratum	**2,169 (389/5,786)**	**23%**
Youngs Bay[1]	93 (26/161)	1%
Big Creek[1]	400 (160/792)	4%
Clatskanie River	908 (25/3,246)	10%
Scappoose Creek	767 (178/1,587)	8%
Cascade Stratum	**7,017 (2,071/16,614)**	**74%**
Clackamas River	4,968 (1,628/10,672)	56%
Sandy River	2,049 (443/5,942)	22%
Gorge Stratum	**253 (0/502)**	**3%**
Lower Gorge Tributaries	201 (0/395)	2%
Upper Gorge Tributaries and Big White Salmon River	--	--
Upper Gorge Tributaries and Hood River	53 (0/107)	1%

Source: ODFW 2019.

[1] No data was available for 2014–2018; abundance based on data from 2008–2012.

Threats

A Lower Columbia River salmon and steelhead ESA recovery plan was finalized in July 2013. The plan provides guidance to improve the viability of the species to the point that it meets the delisting criteria and no longer requires ESA protection. The primary threat identified in the recovery plan for Lower Columbia River coho is the loss and degradation of tributary habitat (NMFS 2013).

The Lower Columbia Conservation and Recovery Plan for Oregon Populations of Salmon and Steelhead (Plan) was approved by the Oregon Fish and Wildlife Commission in 2010 (ODFW 2010). The Plan serves as a recovery plan under the federal ESA and addresses the legal requirements for conservation planning under Oregon's Native Fish Conservation Policy. The Plan is a strategic approach to recovery based on science, supported by stakeholders, built on existing efforts, and including new recovery actions.

NMFS determined that the depressed status of the ESU is the result of habitat degradation, hydropower impacts, harvest, and hatchery production (NMFS 2013). Impaired side channel and wetland conditions, degraded floodplain and riparian conditions, and channel structure and form issues are negatively affecting all populations throughout the ESU. Water quantity issues related to withdrawals or to land uses that alter hydrology are identified as a primary limiting factor for winter parr in Youngs Bay and Big Creek (NMFS 2013). NMFS identified threats to coho salmon, by recovery habitat category are shown in Table C2-3.

Table C2-3. Limiting Factors and Threats

Habitat Threat Category	Limiting Factors	Threats Contributing to Limiting Factors and Impacting Population Survival
Tributary	• Reduced access to and suitable spawning and rearing habitat • Degraded and lost floodplain, wetland, side channel, and riparian habitat • Impaired water quality and flow	• North Fork Toutle sediment retention structure • Land use practices • Reduced flow from surface water withdrawals • Increased fine sedimentation • Extensive channelization, diking, levees, wetland conversion, and gravel extraction
Estuary	• Lack of access to transitional habitats • Reduced habitat complexity and diversity Food web shifts • Impaired water quality and flow • Impaired sediment and sand routing	• Changes in hydrologic regimes and water quality from hydropower reservoirs and mainstem dams • Impaired sediment and sand routing • Extensive channelization, diking, levees, wetland filling, and tide gates
Hydropower	• Reduced spawning habitat quantity and access • Elevated water temperatures in late summer and fall	• Tributary and mainstem dams reduce access to spawning habitat and decrease floodplain rearing habitat • Large mainstem reservoirs associated with mainstem dams
Harvest	• Direct and incidental mortality	• Recreational, tribal, and commercial fisheries

Habitat Threat Category	**Limiting Factors**	**Threats Contributing to Limiting Factors and Impacting Population Survival**
Hatchery	• Limited food and space availability • Hybridization	• Columbia Basin hatchery- and natural-origin juveniles competing for limited food and space in the estuary • Stray hatchery-origin coho interbreeding with natural-origin coho
Predation	• Anthropogenic habitat alterations	• Increased predation pressure from piscivorous non-salmonid fish and birds in the Columbia River estuary and plume, above and Bonneville Dam, and in the reservoir

Source: NMFS 2013.

Literature Cited

National Marine Fisheries Service (NMFS). 2013. ESA Recovery Plan for Lower Columbia River Coho Salmon, Lower Columbia River Chinook Salmon, Columbia River Chum Salmon, and Lower Columbia River Steelhead. Northwest Region. June.

National Marine Fisheries Service (NMFS). 2016. *Recovery Plan for Oregon Coast Coho Salmon Evolutionarily Significant Unit.* National Marine Fisheries Service, West Coast Region, Portland, Oregon. December 2016.

Oregon Department of Fish and Wildlife (ODFW). 2010. Lower Columbia River Conservation and Recovery Plan for Oregon Populations of Salmon and Steelhead. ODFW Salem Oregon.

Oregon Department of Fish and Wildlife (ODFW). 2019. *Salmon and Steelhead Recovery Tracker. Coho Data*. Available: http://odfwrecoverytracker.org/. Assessed: July 2019.

StreamNet 2019. Database (Version 98.3) [database downloaded to disk]. Portland (OR) : StreamNet. URL: https://www.streamnet.org/data/interactive-maps-and-gis-data/

C3 Upper Willamette River Chinook (*Oncorhynchus tshawytscha)*

The Upper Willamette River Chinook salmon evolutionarily significant unit (ESU) is one of 19 ESUs and distinct population segments of salmon and steelhead in the Pacific Northwest listed as threatened or endangered under the federal Endangered Species Act (ESA). The Upper Willamette River Chinook salmon ESU includes spring-run Chinook salmon spawning in rivers and streams in the Willamette River basin upstream of Willamette Falls and the Clackamas River immediately downstream of Willamette Falls.

Legal Status

State: Sensitive-critical species

Federal: Threatened (Original listing National Marine Fisheries Service [NMFS] 1999, 64 *Federal Register* [FR] 14308; Revised listing NMFS 2005a, 70 FR 37160; Updated listing NMFS 2014, 71 FR 20802)

Critical Habitat: Designated (NMFS 2005b, 70 FR 52630)

Recovery Planning: Recovery Plan (Oregon Department of Fish and Wildlife [ODFW] and NMFS 2011), approved (NMFS 2011a, 76 FR 52317)

Photo: ODFW

Upper Willamette River Chinook salmon are listed as a sensitive-critical species under the Oregon State Sensitive Species List (OAR 635-100-0040) and are not listed under the Oregon Endangered Species Act (ORS 496.171 to 496.192, 498.026, and 564.100 to 564.135). ODFW and NMFS developed the Upper Willamette River Conservation and Recovery Plan for Chinook Salmon and Steelhead to address the conservation concerns for the species (ODFW and NMFS 2011). The Oregon State Upper Willamette River Conservation and Recovery Plan addresses legal requirements for conservation planning under Oregon's Native Fish Conservation Policy. The conservation plan was approved by the Oregon Fish and Wildlife Commission in August 2011 (OAR 635-500-6600).

Taxonomy

Chinook salmon (*Oncorhynchus tshawytscha*) were first described by Walbaum in 1792. Chinook salmon are one of five recognized species of Pacific salmon (*Oncorhynchus spp.*) that occur in North America.

Distribution

Chinook salmon distribution is described for their entire range, the Upper Willamette River ESU, and independent populations that intersect the HCP plan area and Oregon Department of Forestry (ODF) managed lands.

General

Chinook salmon have a wide range, second only to chum salmon. They can be found in Asia from Hokkaido, Japan, to the Anadyr River in Siberia, Russia, and in North America from Kotzebue Sound, Alaska. to the Central Valley and San Joaquin River in California (Healey 1991). Chinook salmon return to spawn in larger rivers from just above tidal influence to over 3,200 kilometers in the headwaters of the Yukon River, Alaska.

The Upper Willamette River Chinook salmon ESU includes spring-run Chinook salmon spawning in rivers and streams in the Willamette River basin upstream of Willamette Falls and the Clackamas River immediately downstream of Willamette Falls (NMFS 2005). Also included in the ESU are populations of spring-run Chinook salmon from six artificial propagation programs: the McKenzie River Hatchery Program; Marion Forks Hatchery/North Fork Santiam River Program; South Santiam Hatchery Program in the South Fork Santiam River and Mollala River; Willamette Hatchery Program; and the Clackamas Hatchery Program (NMFS 2014). Not included in the ESU are fall-run Chinook salmon in the Clackamas River and fall-run Chinook salmon that return to spawn in rivers and streams upstream of Willamette Falls (NMFS 1999). These fish were introduced to areas upstream of Willamette Falls by addition of an adult fish ladder at Willamette Falls first constructed in the 1880s and rebuilt in 1972 and by historical hatchery releases (Myers et al. 2006; ODFW 2019).

To achieve recovery of Upper Willamette River Chinook salmon ESU populations, NMFS requires attainment of desired levels of biological viability and reduction of the impact of the identified “listing factors” and “threats” that led to the population decline (ODFW and NMFS 2011). ODFW and NMFS (2011) based the ESA biological goals and delisting criteria on the viability criteria analyses of the Willamette/Lower Columbia Rivers Technical Recovery Team analyses (McElhany et al. 2003, as cited in ODFW and NMFS 2011; McElhany et al. 2006). Criteria that would need to be met in order to achieve delisting include (ODFW and NMFS 2011): that at least two populations in the ESU meet population viability criteria (McElhany et al. 2003, as cited in ODFW and NMFS 2011), the average of all population extinction risk category scores within the ESU is 2.25 or greater, three of four of the ESU’s “core” populations are restored to viable, the remaining “genetic legacy” population (the McKenzie population) is improved to very low risk of extinction, and that all populations not meeting population viability criteria do not deteriorate and are maintained at a minimum at their current risk of extinction. Specific threat delisting criteria are also described in the Recovery Plan in pass/fail terms (ODFW and NMFS 2011).

Additionally, the State of Oregon has a goal in the Recovery Plan to achieve a “broad sense recovery” that will provide for sustainable fisheries and other ecological, cultural and social benefits. The broad sense criteria are: all Upper Willamette River salmon and steelhead populations have a “very low” extinction risk and are “highly viable” over 100 years throughout their historic range; and the majority of Upper Willamette River salmon and steelhead populations are capable of contributing social, cultural, economic and aesthetic benefits on a regular and sustainable basis (ODFW and NMFS 2011).

To facilitate recovery of the Upper Willamette River Chinook salmon ESU, reintroduction of spring-run Chinook salmon is occurring to some areas of the Upper Willamette River basin where they are considered extirpated.

The Willamette Valley Flood Control Project (Willamette Project) consists of 13 dams operated by the U.S. Army Corps of Engineers (USACE) for flood control, hydroelectric power generation (operated by the Bonneville Power Administration), along with recreational and fishing opportunities, water quality benefits, and municipal and irrigation water (operated by the U.S. Bureau of Reclamation). NMFS' 2008 Biological Opinion for the Willamette Project found that the Willamette Project jeopardized the continued existence of the species; that project blocks access to historical major spawning and rearing habitat for four of seven spring-run populations of the Upper Willamette Chinook ESU (NMFS 2008). The Willamette Project includes operation/partial funding of a hatchery mitigation program, primarily operated by ODFW and funded by USACE.

Since the 1990s, ODFW has been out-planting excess hatchery adult spring Chinook collected at the Willamette Project facilities to areas upstream of Willamette Project dams in the South Santiam, North Santiam, McKenzie, and Middle Fork Willamette subbasins (NMFS 2008; ODFW and NMFS 2011). The Willamette Project Biological Opinion's Reasonable and Prudent Alternative included upgrades to the out-planting programs, as well as additions of downstream fish passage facilities at Cougar Dam (on South Fork McKenzie River), Lookout Point Dam (Middle Fork Willamette River), and Detroit Dam (North Santium River) to allow outmigration of juveniles resulting from successful production of out-planted adults upstream of the dams (NMFS 2008).

The Recovery Plan includes description of a hatchery program management strategy focused on conservation of native naturally-reproducing spring-run Chinook within the Upper Willamette Basin, with three primary tactics:

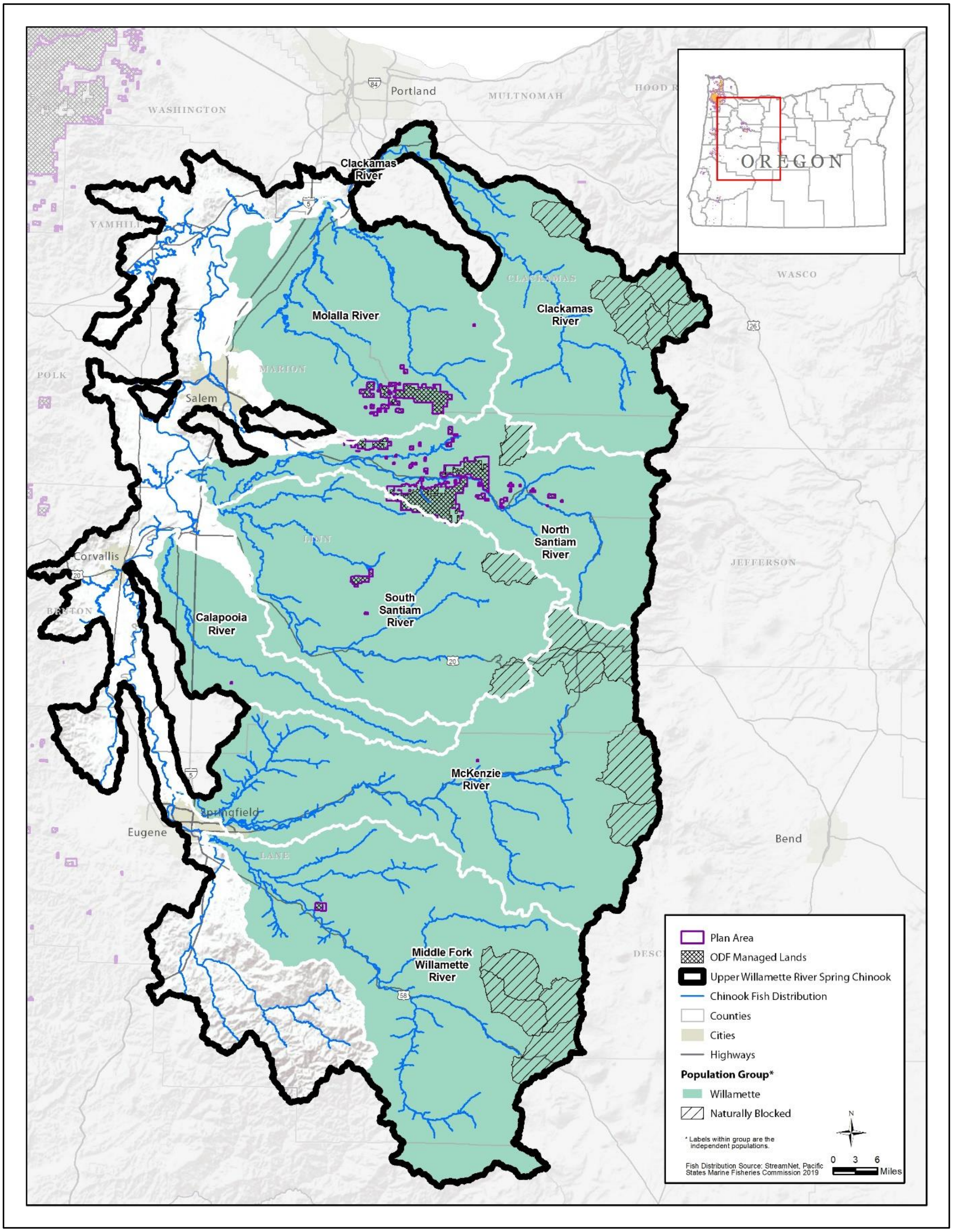
> …1) reduce and minimize the risks of hatchery programs in the populations where substantial natural reproduction currently occurs so that the population will continue to recover and be monitored without the continual infusion of hatchery production, 2) for populations that are at high risk of extinction, use the existing hatchery Chinook programs to lessen demographic risks by outplanting hatchery fish into historic habitat above the impassable, federal dams, and 3) manage the spawning of hatchery Chinook below the federal dams over the short and long term according to the population recovery goals and the current limiting factors/threats facing the natural population in the areas downstream of the dams. (ODFW and NMFS 2011)

To achieve the goal of biological recovery, the following specific strategies are described:

> …1) over the long term, reducing average [proportion hatchery origin spawners] to levels deemed appropriate by the [Willamette/Lower Columbia Technical Recovery Team] to meet different levels of population persistence for the Diversity VSP parameter, and 2) adjust aspects of the hatchery program to help re-introduce populations into areas where they are currently extirpated (example: above [Willamette Project] dams) in order to reestablish natural production in historic habitat to meet the [Abundance/Productivity] and [Spatial Structure Viability Salmonid population] parameters (and subsequently reducing [proportion hatchery origin spawners]) 3) in the short term, consider greatly reducing [proportion hatchery origin spawners] in some of the mitigation hatchery program areas, as described below. (ODFW and NMFS 2011)

More details on hatchery program management strategy for each subbasin can be found in Appendix E of the Recovery Plan and in individual Hatchery Genetic Management Plans available through ODFW's Fish Division website (ODFW 2018).

Figure C3-1. Upper Willamette River Chinook Salmon ESU Strata and Independent Populations in Oregon



Occurrences Within the Plan Area

Six of the seven independent populations of spring-run Chinook salmon intersect the plan area in some amount (Figure C3-1). The independent populations that include portions of the plan area are (from north to south): (1) Molalla River, (2) North Santiam River, (3) South Santiam River, (4) Calapooia River, (5) McKenzie River, and (6) Middle Fork Willamette River.

Miles of streams with ODFW documented or assumed spring-run Chinook salmon presence within the plan area are summarized in Table C3-1. Stream miles are identified for independent populations by strata. The plan area only intersects streams with known or presumed spring-run Chinook salmon presence within the North Santiam River population.

Table C3-1. Miles of Upper Willamette River Chinook Salmon Known or Presumed Chinook Salmon Presence

Biogeographic Stratum and Independent Populations	Stream Miles with Known or Presumed Chinook Salmon Presence		
	Total Stream Miles	Miles Within or Adjacent to Plan Area	Percent of Total Within or Adjacent to Plan Area
Willamette Stratum	**1,380**	**5**	**0.4%**
Clackamas River	140	0	0%
Molalla River	189	0	0%
North Santiam River	182	5	3%
South Santiam River	207	0	0%
Calapooia River	77	0	0%
McKenzie River	301	0	0%
Middle Fork Willamette River	284	0	0%

Source: Streamnet 2019.
Note: Independent populations shown in italics intersect with the plan area.

Natural History

Chinook salmon are the largest of the Pacific salmon species; adults may reach a weight of 45 kilograms (Healey 1991). Chinook salmon are anadromous and semelparous (i.e., die after spawning once), and generally have a 3- to 6-year life cycle (Healey 1991), though Upper Willamette River Chinook salmon predominantly return from the ocean at 4 to 5 years of age (ODFW and NMFS 2011). The typical freshwater period from the start of egg incubation to seaward migration is 12 to 14 months but can be as few as 2 to 5 months. Generally, after spending 1.5 to 4 years in the ocean, adult Chinook salmon return to freshwater between January and April (Healey 1991).

Within the Columbia River Basin, Upper Willamette River spring-run Chinook salmon are one of the most genetically distinct groups of Chinook. Historically, prior to laddering of Willamette Falls, passage of returning adult salmonids over the falls was possible only during the winter and spring high-flow periods. The early run timing of spring-run Chinook is believed to have developed as an adaptation to flow conditions at the falls; the populations of the ESU contain unique genetic resources compared to Chinook stocks in the Columbia River Basin (Myers et al. 2006).

Spring-run Chinook salmon ascend Willamette Falls April through August, and spawn in large headwater streams of the Upper Willamette basin between August and October. Females deposit eggs into a redd formed in the stream substrate. The eggs hatch in winter and alevins remain in the gravel until spring. Young Chinook salmon fry emerge from the gravel from December through March, sometimes as late as June, and rear in large tributaries and the mainstem Willamette River before migrating to sea the following spring, though some juveniles out-migrate to the ocean the same year of emergence (Myers et al. 2006).

Life History and Habitat Requirements

Throughout their life history stages, Upper Willamette River Chinook salmon utilize a range of habitats. They spawn in large headwater streams of the upper Willamette basin and rear in large tributaries and mainstem rivers. Adults migrate up, and juvenile migrate out, through the lower Columbia River system and estuary environments. Maturation occurs at sea, including ocean migration as far north as southeast Alaska (ODFW and NMFS 2011; Myers et al. 2006; Healey 1991).

The species has diverse and complex life history strategies, but in general, two freshwater life history types are: (1) stream-type Chinook salmon that reside in freshwater for a year or more following emergence before out-migrating to the ocean (i.e., “yearlings”), and (2) ocean-type Chinook salmon that out-migrate to the ocean within their first year following emergence (i.e., “sub-yearlings”) (Gilbert 1912, and Healey 1986, as cited in Myers et al. 2006).

The timing of adult entry to freshwater varies among Chinook salmon populations; the Upper Willamette River Chinook salmon ESU includes populations with adults that historically returned to freshwater in the early spring (spring-run), but started as early as January, and ascended Willamette Falls in the spring before low flow conditions made the falls impassible in the late summer and fall (Myers et al. 2006). Chinook salmon require varied habitats during different phases of their life cycle. Life history phases and corresponding habitat requirements are discussed below.

Upstream Migration and Spawning

Chinook salmon spawning habitat typically consists of gravels and cobbles in riffles and the tailouts of pools with clean silt-free substrate, in the mainstem of rivers and large tributaries (Healey 1991). In the Upper Willamette basin, adult spring-run Chinook may enter freshwater and migrate upstream as early as January, peaking April through August, and ending by October. Spawning occurs from August to November (NMFS 2008). Adult fish spawn in the fall and fry emerge in the following spring; thus, success of spawning is greatest where stream substrates are relatively stable such that eggs are not damaged by shifting substrate during high flow events (ODFW and NMFS 2011).

Spawning is timed so that fry emerge the following spring when productivity allows for survival and growth; exact spawn timing varies with water temperature with earlier spawning occurring in relatively cooler temperatures (Myers et al. 2006). In the Upper Willamette River, spring-run Chinook predominantly spawn in September and early October (Schroeder and Kenaston 2004, as cited in NMFS 2008).

Chinook salmon are most frequently observed spawning as seasonal water temperatures decline. Generally, water temperatures must be below 60°F (16°C) for Chinook spawning to be initiated, and water temperatures ranging from 42–55°F (5.6-12.8°C) are considered appropriate for Chinook spawning (USEPA 2001). Water temperatures above 69.8–71.6°F (21-22°C) may block or inhibit upstream adult migration (Alabaster 1988, as cited in USEPA 2001).

Upper Willamette River Chinook salmon enter freshwater between January and April, then ascend Willamette Falls from April through August (ODFW and NMFS 2011). Adult fish spend the summer in headwater streams of the larger tributaries in the basin, where cool waters are found, often holding in large deep pools, then spawn in the fall from August into October (ODFW and NMFS 2011; Healey 1991).

Incubation and Emergence

Following spawning and egg deposition in the fall, Upper Willamette River spring-run Chinook salmon incubate in redds until spring (NMFS 2008). After hatching, alevins remain in the gravel for a few more weeks, then emerge from redds predominantly at night (Healey 1991). Incubation success and timing is dependent on many factors including stream flow, water temperature, dissolved oxygen concentration, and the proportion of fine sediment in substrates (Healey 1991).

In general, constant water temperatures above 48.2–50°F (9–10°C) and daily maximum water temperatures above 56–58°F (13.5–14.5°C) may reduce survival of Chinook embryos and alevins; water temperatures above these thresholds become sub-optimal (USEPA 2001). Complete mortality during incubation has been observed at water temperatures from 57–66.9°F (13.9–19.4°C) (USEPA 2001).

Oxygen availability is an important factor in salmonid egg survival, and success of incubation (i.e., egg-to-fry survival) generally decreases as the percent of fines in the substrate increases (Jensen et al. 2009; Grieg et al. 2005a, as cited in Jensen et al. 2009). Oxygen content around eggs may be reduced due to impeded flow of oxygenated water through the gravel within a redd when interstitial spaces are filled with fine sediments (Lisle 1989, as cited in Jensen et al. 2009). Fine sediments reducing interstitial spaces between gravels can also physically prevent fry emergence (Beschta and Jackson 1979, as cited in Jensen et al. 2009). Localized stream conditions such as groundwater upwelling, which can provide increased dissolve oxygen availability, may facilitate survival despite high proportions of fine sediment in substrate composition (Jensen et al. 2009).

Due to the timing of Upper Willamette River spring-run Chinook salmon in the fall and emergence of fry in the spring, eggs must survive in the redd through the high-flow winter season (Myers et al. 2006; ODFW and NMFS 2011). Elevated flows or channel scour may wash Chinook eggs out of redds or result in sedimentation following transport of silts (Healey 1991).

Freshwater Residence and Outmigration

Upper Willamette River spring-run Chinook salmon spend as little as 2 months to 2 years of their lives rearing in freshwater before migrating to the ocean (NMFS 2008). Juvenile Chinook out-migrate from the tributaries into the mainstem Willamette River in three phases: (1) as fry (i.e., ocean-type or sub-yearlings) in late winter to early spring, (2) as fingerlings (i.e., ocean-type sub-yearlings) fall to early winter (October through December), and (3) as yearlings (i.e., stream-type) late winter to spring (February through early May) (Mattson 1962, as cited in Myers et al. 2006; Schroeder et al. 2016). In the Upper Willamette River basin, most spring-run Chinook salmon rear in natal reaches and emigrate as yearlings; however, alternative life history strategies are important in overall productivity in the basin (Schroeder et al. 2016).

Stream-type Chinook juveniles are relatively more dependent on freshwater stream habitats than ocean-type because of their extended residence in freshwater streams. While rearing in freshwater, juvenile Chinook primarily consume larval and adult insects. Habitat requirements for freshwater rearing juvenile Chinook salmon include habitat complexity, food availability, and suitable water quality. Habitat complexity is characterized by a mixture of habitat types (e.g., pools of varying depths, riffles, and runs), instream structure for cover from predators (e.g., large woody debris, boulders, and undercut banks), and refuges from high flow (edge waters, eddies, and side-channel habitats). Juvenile Chinook depend on aquatic insects as a primary food source, and mostly feed mid-water column on drift (Healey 1991).

Rearing of juvenile Chinook salmon usually occurs in streams with water temperatures ranging from 50–63°F (10–17°C) (USEPA 2001). The optimal growth temperature range for the species is approximately 50–60°F (10–15.6°C); zero net growth of juveniles may occur below 39.4°F (4.1°C) and above 66.4°F (19.1°C) (Armour 1990, as cited in USEPA 2001). Water temperatures above approximately 77°F (25°C) are considered lethal to Chinook salmon juveniles, though mortality also depends on acclimation to elevated water temperatures and other water quality factors such as dissolved oxygen concentration (USEPA 2001).

Estuary Residence and Ocean Life

Juvenile Chinook salmon require estuarine and nearshore marine habitat for migration, foraging, refuge, and osmoregulation processes. Juveniles spend several days to months in estuarine habitat before migrating into marine waters (Healey 1991). Juveniles rely on shallow nearshore habitats such as intertidal flats, tidal marshes, and subtidal channels in and near estuaries. Once juvenile Chinook salmon are large enough to eat small fish, they move away from shore into deeper marine waters (Healey 1991).

Estuary conditions such as changes in food availability, off-channel habitat availability, presence of contaminants, and predation can affect juvenile survival into ocean life. Juvenile Chinook salmon are subject to predation in the Columbia River Estuary by predatory fishes (e.g., pikeminnow), birds (e.g., terns and cormorants), and pinnipeds (e.g., sea lions) (NMFS 2011b).

Ocean-type juvenile salmonids (i.e., sub-yearlings) have a tendency to use shallow-water habitats and have longer estuary residence times than stream-type juvenile salmonids (i.e., yearlings); thus, ocean-type salmonids are more affected than stream-type salmonids by flow alterations that cause changes to habitat quantity, quality, or access in wetlands and floodplains. Stream-type salmonids have comparably short estuary residence times and use the Columbia River plume more extensively; thus, stream-type juvenile salmonids are affected by plume dynamics (Fresh et al. 2005, as cited in NMFS 2011b).

Yearling Chinook out-migrants have been found to use the Columbia River plume as habitat, in contrast to sub-yearlings, which stay closer to shore. Thus, characteristics of the Columbia River plume are believed to be significant to yearling outmigrant Chinook salmon during transition to ocean life (Fresh et al. 2005, as cited in NMFS 2008). Most juvenile Upper Willamette River spring-run Chinook salmon out-migrate as yearlings; few out-migrate as sub-yearlings (NMFS 2011b).

Ocean Life

Chinook salmon spend 6 months to 7 years maturing in the ocean before returning to freshwater to spawn (Healey 1991). After entering the ocean as juveniles, Upper Willamette River Chinook migrate coastally north to British Columbia and southeastern Alaska (Myers et al. 2006).

Chinook salmon are opportunistic feeders. Juveniles prey on a wide variety of food such as benthic, epibenthic, and pelagic crustaceans, as well as insects, fish larva, and juvenile fish. Adult salmon feed on squid and forage fish such as smelt, sandlance, and herring while in the estuarine and marine environment (Healey 1991).

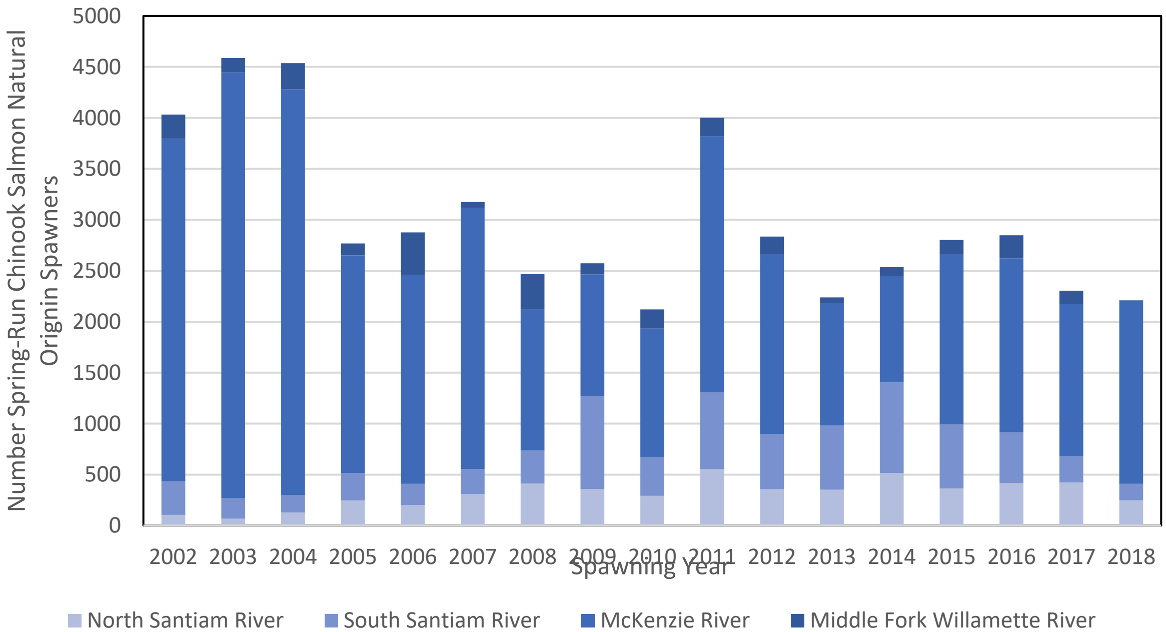
Population Status and Trends

The Upper Willamette River Conservation and Recovery Plan for Chinook Salmon and Steelhead assumes a historical (pre-development) spring-run Chinook salmon adult return to the Upper Willamette River Chinook salmon ESU of approximately 300,000 fish (Myers et al. 2003, as cited in ODFW and NMFS 2011).

Present-day natural production is mostly limited to the Clackamas River population and McKenzie River population, though the McKenzie population has declined some in the past decade (NMFS 2016; ODFW 2019). Hatchery programs release juvenile spring-run Chinook in many subbasins and adult returns are usually composed of 80–90% hatchery origin Chinook (McElhany et al. 2007, as cited in ODFW and NMFS 2011). Additionally, pre-spawning mortality is generally high in lower reaches of tributaries, possibly due to unsuitably warm water temperatures and high fish densities, though the cause is unknown (ODFW and NMFS 2011; NMFS 2016). Conditions in Pacific Northwest marine waters inhabited by salmon are also influenced by two ocean-basin scale drivers: the Pacific Decadal Oscillation (PDO) and the El Niño-Southern Oscillation (ENSO). Starting in late 2013, abnormally warm conditions in the Central Northeastern Pacific Ocean, known as the “warm blob,” created anomalous weather patterns, temperature, and rainfall; it influenced stream and marine habitats, resulting in poor marine and stream survival, and in depressed salmonid returns in subsequent years (NMFS 2016; NOAA Fisheries 2019).

Upper Willamette River spring-run Chinook salmon natural-origin spawner abundance from 2002 to 2018 by stratum and independent population is summarized in Table C3-2 and shown on Figure C3-2. The range during this period includes the high abundance in 2003 (4,587 adults) and low in 2010 (2,121 adults). The most abundant population in the stratum has consistently been the McKensie River with an annual average of over 2,000 adults across the past 5 years, or approximately 61% of the ESU’s average annual return. As shown in Table C3-2, the plan area overlaps with six of the seven populations geographically, though only the North Santiam population has stream miles known or presumed to contain Chinook that intersect directly with the plan area. This population comprised, on average, approximately 15% of the total ESU abundance during the past 5 years (Table C3-2).

Figure C3-2. Trends in Abundance of Adult Natural-Origin Spawning Spring-Run Upper Willamette River Chinook Salmon



Note: Clackamas River, Calapooia River, and Mollala River populations do not have data available for this period.

Source: ODFW 2019.

Table C3-2. Upper Willamette River Spring-Run Chinook Salmon Natural-Origin Spawner Abundance

Biogeographic Stratum and Population	**Coho Salmon Adult Abundance**	
	Recent 5-year Average and Range (2014–2018)	**Percent of Total ESU Abundance (5-year Average)**
Willamette Stratum	**2,540/(2,211–2,848)**	**100%**
Clackamas River	No Data	No Data
Molalla River	*No Data*	*No Data*
North Santiam River	***393/(248–517)***	***15%***
South Santiam River	*486/(162–887)*	*19%*
Calapooia River	*No Data*	*No Data*
McKenzie River	*1,544/(1,047–1,798)*	*61%*
Middle Fork Willamette River	*116/(3–226)*	*5%*

Source: ODFW 2019.

Note: Independent populations shown in italics have some overlap with the plan area. Only the North Santiam River population, also shown in bold, has populated stream miles that intersect with the plan area.

Threats

The Upper Willamette River Conservation and Recovery Plan for Chinook Salmon and Steelhead was finalized in July 2011. The plan provides guidance to improve the viability the Upper Willamette River spring-run Chinook ESU to the point that it meets the delisting criteria and no longer requires ESA protection. Threats to the ESU include human impacts of fishing, hatchery operations, flood control/hydropower system operations, introduction of non-native species, and land use practices. Naturally occurring threats include floods, drought, climate change, and cataclysmic events (e.g., volcanos). Additional threats are posed to the ESU as a result of increasing human population growth (ODFW and NMFS 2011).

NMFS determined that the depressed status of the ESU is the result of reduction of access to historical spawning and rearing habitat and juvenile habitat degradation. Extensive dam construction in the Willamette River basin severed access to the majority of high-quality spawning and rearing habitat for the species. Within the basin, there are also elevated water temperature issues for juvenile outmigrants, extensive losses of floodplain habitat from construction of levees and other bank armoring, major reductions of habitat-forming flows, and large reductions in available shallow water habitats used as winter velocity refuges in tributaries (NMFS 2016).

The Upper Willamette River Conservation and Recovery Plan for Chinook Salmon and Steelhead describes human-induced threats in the five broad categories described above (ODFW and NMFS 2011). Table C3-3 summarizes the limiting factor and threat (LFT) analysis results for human impacts and Table C3-4 summarizes threats from climate change and human population growth.

Table C3-3. Human Impact Limiting Factor and Threat (LFT) Analysis Results

Threat Category	Limiting Factors	How Do Threats Cause or Contribute to Limiting Factors?
Flood Control and Hydropower Management	• Hydrograph/water quantity • Physical habitat quality/quantity • Food web	• Stream modifications result in stream habitat loss or alteration • Changes to hydrologic regime and flow alter habitat and food webs
Land Management	• Physical habitat quality/quantity • Water quality	• Changes in land use degrade or destroy habitat quantity and functionality
Other Species	• Competition • Predation • Physical habitat quality/quantity	• Food competition and predation directly affect populations • Invasive/non-native plants degrade habitat
Harvest Management	• Population traits	• Direct and indirect mortality to individuals • Selective targeting (age/size)
Hatchery Management	• Competition • Disease • Population traits • Habitat access	• Increased food competition and predation • Disease introduction • Interbreeding with hatchery-origin fish can reduce wild fish fitness and genetic diversity • Hatchery weirs can block access to upstream habitat

Source: ODFW and NMFS 2011.

Table C3-4. Projected Climate Change and Human Population Growth Impacts for the Pacific Northwest

Threat Category	Projected Impact for the Pacific Northwest (PNW) and Description
Climate Change	• Air temperature: each decade warmer than the one before • Precipitation: increased in winter and decreased in spring, summer, and fall • Snowpack: substantial declines due to increased air temperatures and precipitation. • Storms and flooding: increased storm events and intensity • Timing of peak spring runoff: earlier snowmelt will lead to earlier peak stream flows • Summer streamflow: continued decline in sensitive PNW basins and declines becoming more widespread
Human Population Growth and Development	• Forests, water (surface and groundwater), and land: increased demands on shared resources key to fish and wildlife • Land conversion: demand for residential land increasing agricultural and forest land conversion • Development: spreading outwards from cities causes more habitat loss and fragmentation, increases infrastructure costs, and social conflict • Impervious surfaces: increased urbanization increases impervious surfaces (e.g., roofs, pavement, and transportation corridors) and reduces groundwater recharge • Combined effect with climate change: increased pressure on fish and wildlife habitats and demands for freshwater • External to Columbia River Basin: international trade, shipping, dredging, hazardous material transport, and airborne pollution

Source: ODFW and NMFS 2011.

Literature Cited

Groot, C. and L. Margolis. 1991. *Pacific Salmon Life Histories*. University of British Columbia Press, Vancouver, B.C.

Healey, M.C. 1991. Life History of Chinook Salmon (*Oncorhynchus tshawytscha*). In *Pacific Salmon Life Histories*, Groot and Margolis (eds.). UBC Press, 564 pp. Available partially online: http://books.google.com/books?id=I_S0xCME0CYC&dq=chum+salmon&lr=&source=gbs_navlinks_s.

Jensen, D.W., E.A. Steel, A.H. Fullerton, and G.R. Pess. 2009. Impact of Fine Sediment on Egg-To-Fry Survival of Pacific Salmon: A Meta-Analysis of Published Studies. *Reviews in Fisheries Science* 17(3):348–359.

Myers, J., C. Busack, D. Rawding, A. Marshall, D. Teel, D.M. Van Doornik, and M.T. Maher. 2006. *Historical Population Structure of Pacific Salmonids in the Willamette River and Lower Columbia River Basins.* NOAA Technical Memorandum NMFS-NWFSC-73. National Marine Fisheries Service, Northwest Fisheries Science Center. 311 p. February.

National Marine Fisheries Service (NMFS). 1999. Endangered and Threatened Species; Threatened Status for Three Chinook Salmon Evolutionarily Significant Units (ESUs) in Washington and

Oregon, and Endangered Status for One Chinook Salmon ESU in Washington. *Federal Register*; 64 FR 14308. March 24.

National Marine Fisheries Service (NMFS). 2005a. Endangered and Threatened Species; Final Listing Determinations for 16 ESUs of West Coast Salmon, and Final 4(d) Protective Regulations for Threatened Salmonid ESUs. *Federal Register*; 70 FR 37160. June 28.

National Marine Fisheries Service (NMFS). 2005b. Endangered and Threatened Species; Designation of Critical Habitat for 12 Evolutionarily Significant Units of West Coast Salmon and Steelhead in Washington, Oregon, and Idaho. *Federal Register*; 70 FR 52630. August 12.

National Marine Fisheries Service (NMFS). 2008. *Endangered Species Act Section 7(a)(2) Consultation Biological Opinion & Magnuson-Stevens Fishery Conservation & Management Act Essential Fish Habitat Consultation: Consultation on the "Willamette River Basin Flood Control Project."* Northwest Region. July 11.

National Marine Fisheries Service (NMFS). 2011a. Endangered and Threatened Species; Recovery Plans: Notice of Availability. *Federal Register*; 76 FR 52317. August 22.

National Marine Fisheries Service (NMFS). 2011b. *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead. Northwest Region; Portland, Oregon*. Prepared for NMFS by the Lower Columbia River Estuary Partnership (contractor) and PC Trask & Associates, Inc., subcontractor. January.

National Marine Fisheries Service (NMFS). 2014. Endangered and Threatened Wildlife; Final Rule To Revise the Code of Federal Regulations for Species Under the Jurisdiction of the National Marine Fisheries Service. *Federal Register*; 79 FR 20802. April 14.

National Marine Fisheries Service (NMFS). 2016. *2016 5-Year Review: Summary & Evaluation of Upper Willamette River Steelhead & Upper Willamette River Chinook*. West Coast Region; Portland, Oregon.

National Oceanic and Atmospheric Administration (NOAA) Fisheries. 2019. *New Marine Heatwave Emerges off West Coast, Resembles "the Blob".* Available: https://www.fisheries.noaa.gov/feature-story/new-marine-heatwave-emerges-west-coast-resembles-blob.

Oregon Administrative Rules (OAR). Sensitive Species List (OAR 635-100-0040). Department of Fish and Wildlife. Available: https://secure.sos.state.or.us/oard/viewSingleRule.action;JSESSIONID_OARD=48m67GbU0TypkHPut-5Qsa91AH9S7p1TK1q5waCD-uYNCCL1RIAt!41094264?ruleVrsnRsn=173209.

Oregon Administrative Rules (OAR). OAR 635-500-6600, Implementing the Upper Willamette River Conservation and Recovery Plan for Chinook Salmon and Steelhead. Available: https://secure.sos.state.or.us/oard/viewSingleRule.action?ruleVrsnRsn=174248.

Oregon Department of Fish and Wildlife (ODFW). 2018. Hatchery Genetic Management Plans (HGMP). Available: https://www.dfw.state.or.us/fish/HGMP/final.asp#5. Accessed September 2019.

Oregon Department of Fish and Wildlife (ODFW). 2019. Salmon and Steelhead Recovery Tracker Chinook Data. Available: http://odfwrecoverytracker.org/. Assessed: September 2019.

Oregon Department of Fish and Wildlife and National Marine Fisheries Service (ODFW and NMFS). 2011. *Upper Willamette River Conservation and Recovery Plan for Chinook Salmon and Steelhead*. August 5.

StreamNet 2019. Database (Version 98.3) [database downloaded to disk]. Portland (OR) : StreamNet. URL: https://www.streamnet.org/data/interactive-maps-and-gis-data/

United States Environmental Protection Agency (USEPA). 2001*. Issue Paper 5: Summary of Technical Literature Examining the Physiological Effects of Temperature on Salmonids.* EPA-910-D-01-005. Prepared as Part of EPA Region 10 Temperature Water Quality Criteria Guidance Development Project. May.

C4 Upper Willamette River Steelhead (*Oncorhynchus mykiss*)

The Upper Willamette River steelhead salmon distinct population segment (DPS) is one of 19 evolutionarily significant units (ESUs) and DPSs of salmon and steelhead in the Pacific Northwest listed as threatened or endangered under the federal Endangered Species Act (ESA). The Upper Willamette River steelhead DPS the only listed steelhead DPS within the plan/permit area. The DPS includes all winter-run steelhead from upstream of Willamette Falls up to and including the Calapooia River (NMFS 2006).

Legal Status

Photo: Oregon Conservation Strategy

State: Sensitive species

Federal: Threatened (Original listing National Marine Fisheries Service [NMFS] 1999; 64 *Federal Register* [FR] 14517; Revised listing NMFS 2006; 71 FR 834)

Critical Habitat: Designated (NMFS 2005; 70 FR 52630)

Recovery Planning: Recovery plan approved (NMFS 2011; 76 FR 52317)

In its 2006 listing decision, NMFS found "moderate risks" to the Upper Willamette steelhead DPS's abundance, productivity, spatial structure, and diversity. The ESA listing of steelhead offers protection for naturally spawned steelhead; however, it does not offer protection for rainbow trout, the freshwater resident form of the species.

Upper Willamette River steelhead are listed as a sensitive species under the Oregon State Sensitive Species List (OAR 635-100-0040) and are not listed under the Oregon Endangered Species Act (ORS 496.171 to 496.192, 498.026, and 564.100 to 564.135).

The Oregon State Upper Willamette River Conservation and Recovery Plan outlines recovery needs and priorities for steelhead trout populations in the Molalla, North Santiam, South Santiam, and Calapooia watersheds (ODFW and NMFS 2011). The Recovery Plan also addresses legal requirements for conservation planning under Oregon's Native Fish Conservation Policy. The conservation plan was approved by the Oregon Fish and Wildlife Commission in August 2011.

Taxonomy

Steelhead (*Oncorhynchus mykiss*) were first described by Walbaum in 1792. Steelhead and non-anadromous rainbow trout are close relatives of Pacific salmon (Oncorhynchus spp.) that occur in North America.

Myers et al. (2006) identified four historical demographically independent populations for Upper Willamette River winter steelhead: the Molalla, North Santiam, South Santiam, and Calapooia.

Distribution

Upper Willamette River steelhead distribution is described generally for their entire range, the Upper Willamette River ESU, and then specifically for independent populations that intersect the plan area and Oregon Department of Forestry (ODF) managed lands.

General

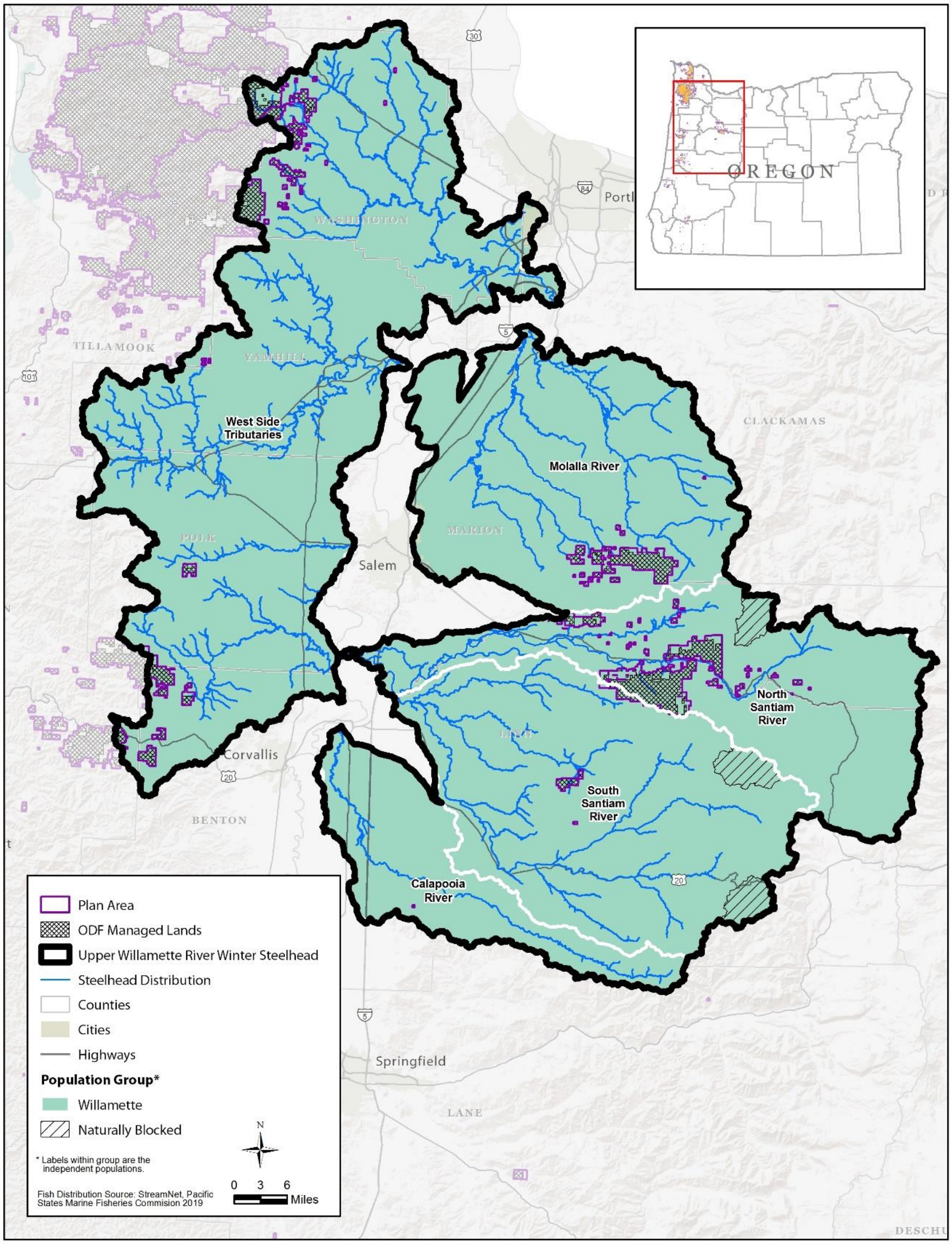
The Upper Willamette River steelhead DPS includes all naturally spawned winter-run steelhead from upstream of Willamette Falls up to and including the Calapooia River. NMFS has identified four independent populations in the Upper Willamette River steelhead DPS (Myers et al. 2006). From north to south they are: (1) Molalla River, (2) North Santiam River, (3) South Santiam River, and (4) Calapooia River.

Upper Willamette River steelhead have been observed spawning in west-side tributaries of the Willamette above the falls and are recognized by the Oregon Department of Fish and Wildlife (ODFW) as being part of the Willamette Winter Steelhead species management unit. However, these populations are not currently recognized by NMFS as being part of the Upper Willamette River steelhead DPS, likely because they are considered sink populations (where local reproductive success fails to keep pace with local mortality, per Pulliam 1998).

Approximately one-third of the DPS's historically accessible spawning habitat has been blocked by flood control structures associated with the Willamette Valley Flood Control Project (NMFS 2008; ODFW and NMFS 2011). The project consists of 13 dams, operated by the U.S. Army Corps of Engineers (USACE). Most of these dams are "high head" dams that are over 250 feet tall and do not provide fish passage.

In 2008, the Willamette River Basin Flood Control Project Biological Opinion (WP BiOp) was developed to ensure long-term ESA compliance with the dams. Stemming from the WP BiOp, in 2011, the Oregon State Legislature approved the Upper Willamette River Steelhead and Chinook Recovery Plan (ODFW and NMFS 2011), which further defined strategies and actions contained in the WP BiOp as well as in the Oregon Plan for Salmon and Watersheds and the Oregon Conservation Strategy. The recovery plan emphasizes the importance of successful reintroduction of naturally reproducing salmon and steelhead above the flood control dams in the Willamette River subbasins, and downstream passage for their offspring. This includes fish collection and transport for Detroit and Big Cliff dams on the North Fork Santiam River, which is located upstream of the nearby Santiam State Forest (USACE 2020).

Figure C4-1. Upper Willamette River Steelhead DPS Strata and Independent Populations in Oregon



Occurrences Within the Plan Area

Based on distribution maps published by Streamnet (2019), approximately 2% of Upper Willamette River winter steelhead ESU range occurs within the plan area (Table C4-1). The highest percentage of occurrence for any specific population is in the North Santiam River, where 5% of the range of the population occurs within the plan area.

Table C4-1. Miles of Steelhead Known or Presumed Presence

Biogeographic Stratum and Population	Stream Miles with Known or Presumed Steelhead Presence		
	Total Stream Miles	Miles Within or Adjacent to Plan Area	Percent of Total Within or Adjacent to Plan Area
Willamette Stratum	**1,741**	**29**	**2%**
Molalla River	296	2	1%
North Santiam River	174	9	5%
South Santiam River	326	2	1%
Calapooia River	88	0	0%
West Side Tributaries	857	16	2%

Source: Streamnet 2019.

Natural History

Life History and Habitat Requirements

Steelhead are considered by many to have the greatest diversity of life history patterns of any Pacific salmonid species, including varying degrees of anadromy, differences in reproductive biology, and plasticity of life history between generations (Busby et al. 1996). Steelhead can survive spawning and a small fraction of adults may live-spawn more than once (Steelquist 1992), although repeat spawning is relatively rare. Repeat spawners are usually females that migrate back to the ocean and then return to spawn the following spring (ODFW and NMFS 2011).

Spawning

Upper Willamette River winter steelhead run return to freshwater in January through April, pass Willamette Falls from mid-February to mid-May, and spawn in March through June, with peak spawning in late April and early May. Compared to spring Chinook, Upper Willamette River steelhead typically migrate farther upstream and can spawn in smaller, higher gradient streams (ODFW and NMFS 2011).

Incubation and Freshwater Residence

Juvenile steelhead reside in headwater tributaries and upper portions of the subbasins for typically 2 years, but may reside in freshwater for as little as 1 year to up to 4 years(ODFW and NMFS 2011). Smolts migrate in the spring (April through May) and are believed to move quickly to the ocean.

Ocean Life

Juvenile steelhead utilize estuaries as rearing and foraging habitat, but such use may be only brief, with peak use in May (ODFW and NMFS 2011).

Population Status and Trends

ODFW and NMFS (2011) found that the Calapooia River independent population was at modest risk of extinction and that the North Santiam, South Santiam, and Molalla populations were at low risk.

Table 4-2. Upper Willamette River Adult Steelhead Abundance

Biogeographic Stratum and Population	Steelhead Adult Abundance	
	Recent 5-year Average and Range (2004–2008)	Percent of Total ESU Abundance
Willamette Stratum	**6,611 (140/3,863)**	
Molalla River	1,484 (1,273/1,987)	22%
North Santiam River	2,826 (1,650/3,863)	43%
South Santiam River	1,988 (1,519/3,546)	30%
Calapooia River	312 (140/684)	5%

Source: ODFW 2019.
Note: italics populations occur in the plan area

Threats

The Upper Willamette River Conservation and Recovery Plan for Chinook Salmon and Steelhead (ODFW and NMFS 2011) describes human threats in five broad categories. In addition, the Recovery Plan for Upper Willamette River Chinook and Steelhead (ODFW and NMFS 2011) identifies a wide range of human impacts on these two ESUs, including the following related to forest management:

- Timber harvest on unstable slopes and riparian areas as leading to the decoupling of watershed processes.
- Improperly located, constructed, or maintained roads have degraded stream flow and sediment supply processes.
- The legacy effects of splash dams to transport logs continues to inhibit instream structural complexity and available spawning gravel in several stream systems.

Table C4-3 summarizes the limiting factor and threat (LFT) analysis results, and Table C4-4 summarizes threats from climate change and human population growth.

Table C4-3. Human Impact Limiting Factor and Threat (LFT) Analysis Results

Threat Category	Limiting Factors	How Do Threats Cause or Contribute to Limiting Factors?
Flood Control and Hydropower Management	• Hydrograph/water quantity • Physical habitat quality/quantity • Food web	• Stream modifications result in stream habitat loss or alteration • Changes to hydrologic regime and flow alter habitat and food webs

Threat Category	Limiting Factors	How Do Threats Cause or Contribute to Limiting Factors?
Land Management	• Physical habitat quality/quantity • Water quality	• Changes in land use degrade or destroy habitat quantity and functionality
Other Species	• Competition • Predation • Physical habitat quality/quantity	• Food competition and predation directly affect populations • Invasive/non-native plants degrade habitat
Harvest Management	• Population traits	• Direct and indirect mortality to individuals • Selective targeting (age/size)
Hatchery Management	• Competition • Disease • Population traits • Habitat access	• Increased food competition and predation • Disease introduction • Interbreeding with hatchery-origin fish can reduce wild fish fitness and genetic diversity • Hatchery weirs can block access to upstream habitat

Source: ODFW and NMFS 2011.

Table C4-4. Projected Climate Change and Human Population Growth Impacts for the Pacific Northwest

Threat Category	Projected Impact for the Pacific Northwest and Description
Climate Change	• Air temperature: each decade warmer than the one before • Precipitation: increased in winter and decreased in spring, summer, and fall • Snowpack: substantial declines due to increased air temperatures and precipitation • Storms and flooding: increased storm events and intensity • Timing of peak spring runoff: earlier snowmelt will lead to earlier peak stream flows • Summer streamflow: continued decline in sensitive PNW basins and declines becoming more widespread
Human Population Growth and Development	• Forests, water (surface and groundwater), and land: increased demands on shared resources key to fish and wildlife • Land conversion: demand for residential land increasing agricultural and forest land conversion • Development: spreading outwards from cities causes more habitat loss and fragmentation, increases infrastructure costs, and social conflict • Impervious surfaces: increased urbanization increases impervious surfaces (e.g., roofs, pavement, and transportation corridors) and reduces groundwater recharge • Combined effect with climate change: increased pressure on fish and wildlife habitats and demands for freshwater • External to Columbia River Basin: international trade, shipping, dredging, hazardous material transport, and airborne pollution

Source: ODFW and NMFS 2011.

Literature Cited

Busby, P.J., T.C. Wainwright, E.J. Bryant, L.J. Lierheimer, R.S. Waples, F.W. Waknitz, and I.V. Lagomarsino. 1996. Status Review of West Coast Steelhead from Washington, Idaho, Oregon, and California. NOAA Technical Memorandum 27.Myers, J., C. Busack, D. Rawding, A. Marshall, D. Teel, D.M. Van Doornik, and M.T. Maher. 2006. Historical Population Structure of Pacific Salmonids in the Willamette River and Lower Columbia River Basins. U.S. Department of Commerce, NOAA Tech. Memo. NMFS-NWFSC-73, 311 pp. February 2006.National Marine Fisheries Service (NMFS). 2005. Endangered and Threatened Species; Final Listing Determinations for 16 ESUs of West Coast Salmon, and Final 4(d) Protective Regulations for Threatened Salmonid ESUs. *Federal Register*; 70 FR 37160. June 28.

National Marine Fisheries Service (NMFS). 2006. Endangered and Threatened Species; Final Listing Determinations for 10 Distinct Population Segments of West Coast Steelhead. *Federal Register*; 71 FR 833. January 5.

National Marine Fisheries Service (NMFS). 2008. *Endangered Species Act Section 7(a)(2) Consultation Biological Opinion & Magnuson-Stevens Fishery Conservation & Management Act Essential Fish Habitat Consultation: Consultation on the "Willamette River Basin Flood Control Project."* Northwest Region. July 11.

National Marine Fisheries Service. 2011a. Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead. NMFS Northwest Region. Portland, OR. Prepared for NMFS by the Lower Columbia River Estuary Partnership (contractor) and PC Trask & Associates, Inc. (subcontractor). January 2011.

Oregon Department of Fish and Wildlife (ODFW). 2019. Salmon and Steelhead Recovery Tracker Steelhead Data. Available: http://odfwrecoverytracker.org/. Assessed: July 2019.

Oregon Department of Fish and Wildlife and National Marine Fisheries Service (ODFW and NMFS). 2011. *Upper Willamette River Conservation and Recovery Plan for Chinook Salmon and Steelhead.* August.

Pulliam, H.R. 1988. Sources, Sinks, and Population Regulation. *Am. Nat.* 132:652–661. https://www.journals.uchicago.edu/doi/abs/10.1086/284880

Steelquist, Robert. 1992. Field guide to the Pacific salmon: including salmon-watching in Alaska, British Columbia, Washington, Oregon, and Northern California. Sasquatch Books.

StreamNet. 2019. Database (Version 98.3) [database downloaded to disk]. Portland (OR) : StreamNet. URL: https://www.streamnet.org/data/interactive-maps-and-gis-data/

U.S. Army Corps of Engineers (USACE). 2020. *Minto Fish Collection Facility*. Available: https://www.nwp.usace.army.mil/Missions/Current/Minto-fish-facility/. Accessed: January 20, 2020.

C5 Columbia River Chum (*Oncorhynchus keta)*

The Columbia River chum salmon evolutionarily significant unit (ESU) is one of 19 ESUs and distinct population segments of salmon and steelhead in the Pacific Northwest listed as threatened or endangered under the federal Endangered Species Act (ESA). The Lower Columbia River chum salmon ESU includes the Columbia River and rivers and streams originating from Oregon and Washington. Legal Status

State: Sensitive-critical species

Federal: Threatened (Final listing NMFS 1999; 64 FR 14508. Revised NMFS 2005a; 70 FR 37160. Updated NMFS 2014; 79 FR 20802)

Critical Habitat: Designated (Final listing NMFS 2000; 65 FR 7764. Revised NMFS 2005b; 70 FR 52630)

Recovery Planning: Recovery plan approved (NMFS 2013; 78 FR 41911)

Status Review: 5-year status review (NMFS 2016)

Photo: NMFS

Columbia River chum salmon are listed as a sensitive-critical species under the Oregon State Sensitive Species List (ODFW 2019) per state regulation OAR 635-100-0040, and are not listed under the Oregon Endangered Species Act (ORS 496.171 to 496.192, 498.026, and 564.100 to 564.135). Oregon developed the Oregon State Lower Columbia River Conservation and Recovery Plan for the same Oregon chum salmon populations as the federal listing (ODFW 2010). The Oregon State Lower Columbia River Conservation and Recovery Plan addresses legal requirements for conservation planning under Oregon's Native Fish Conservation Policy. The conservation plan was approved by the Oregon Fish and Wildlife Commission in August 2010.

Taxonomy

Chum salmon (*Oncorhynchus keta*) were first described by Walbaum in 1792. Chum salmon are one of eight recognized species of Pacific Salmon (*Oncorhynchus* spp.) that occur in North America.

Distribution

Chum salmon distribution is described for their entire range, the Lower Columbia River ESU, and independent populations that intersect the plan area and Oregon Department of Forestry (ODF) managed lands.

General

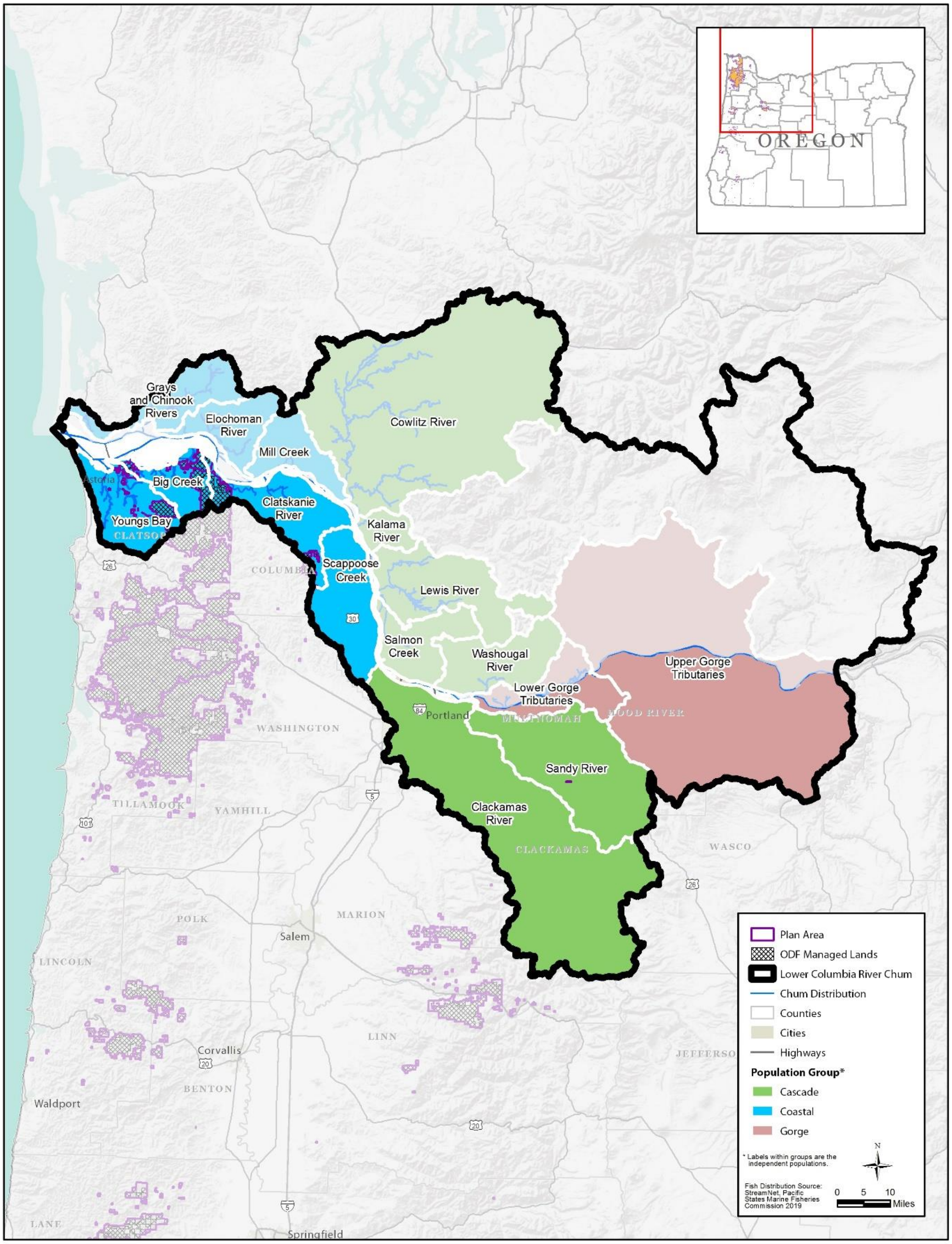
Chum salmon have the widest range of all Pacific salmon. They can be found in Asia from Japan to Siberia and in North America from Alaska to Monterey, California (Groot and Margolis 1991). Historically, Columbia River chum salmon were abundant and spawned throughout the lower Columbia Basin, as far upstream as the Walla Walla and Umatilla rivers (Nehlsen et al. 1991). Since the construction of Bonneville Dam, the species' distribution is mostly limited to the Columbia River mainstem and tributaries below the dam, and very few adult fish have been observed upstream of the dam (NMFS 2013; McElhany et al. 2004; NWFSC 2015).

The Lower Columbia River chum salmon ESU (Figure C5-1) includes naturally spawned chum salmon originating from the Pacific Ocean and the freshwater and estuarine habitat in the Columbia River and tributaries to the Columbia River in Oregon and Washington, as well as from two artificial propagation programs (NMFS 1999; 64 FR 14508, NMFS 2005a; 70 FR 37160, NMFS 2014; 79 FR 20802).

NMFS (2013a) identified three major population groups (MPG) in the Columbia River chum salmon ESU: (1) Coast, (2) Cascade, and (3) Gorge. Within these three MPGs, NMFS identified 17 independent populations, all occurring within Oregon and Washington. In Oregon, four independent populations are within the Coast MPG (Youngs Bay, Big Creek, Clatskanie River, and Scappoose Creek), two independent populations in the Cascade MPG (Clackamas River and Sandy River), and two independent populations in the Gorge MPG (Lower Gorge Tributaries and Upper Gorge Tributaries) (NMFS 2013). Within the ESU, most remaining natural production is limited to the Grays/Chinook population, and the Washougal River and Lower Gorge tributaries populations (NWFSC 2015). Within Oregon, chum salmon have been considered to be extirpated, or nearly so, from tributaries of the Columbia River, due to little or no observed spawning populations (McElhany et al. 2007; NWFSC 2015).

ESU recovery is based on achieving sustainable independent populations within the ESU and across the MPGs. NMFS set three recovery criteria for recovery of the of the Columbia River chum salmon ESU: (1) within each MGP, there should be at least two populations that have a 95% chance of persisting over a 100-year time frame; (2) within each MPG, approximately half the populations should have a persistence probability of high or very high; and (3) viable populations should be dispersed across the ESU, include those that were historically most productive, and represent the genetic diversity of the ESU (NMFS 2013).

Figure C5-1. Columbia River Chum Salmon ESU Strata and Independent Populations in Oregon



Occurrences Within the Plan Area

Five independent populations within two MPGs of the Columbia River chum salmon ESU intersect the plan area (Figure C5-1):

- Coastal MPG:
    - Youngs Bay independent population
    - Big Creek independent population
    - Clatskanie River independent population
    - Scappoose Creek independent population
- Cascade MPG:
    - Sandy River independent population

Miles of streams with documented or presumed chum salmon presence within the ESU and within the plan area are summarized in Table C5-1 (Streamnet 2019). Stream miles are identified for independent populations by strata. Only the Big Creek (18%) and Youngs Bay (2%) independent populations in the Coastal Stratum have stream miles with known or presumed chum salmon presence within the plan area.

Table C5-1. Stream Miles with Chum Salmon Known or Presumed Presence Within Biogeographic Strata in Oregon that Intersect with the Plan Area

Biogeographic Stratum and Independent Populations[1]	Stream Miles with Known or Presumed Chum Salmon Presence		
	Total Stream Miles Within ESU	Miles Within or Adjacent to Plan Area	Percent of ESU Total Within or Adjacent to Plan Area
Coastal Stratum			
Big Creek	45	8	18%
Youngs Bay	57	1	2%
Clatskanie River	25	0	0%
Scappoose Creek	0	0	0%
Cascade Stratum			
Sandy River	0	0	0%

Source: Streamnet 2019.

[1] Only independent populations located entirely and/or partially within Oregon and that intersect with the plan area are shown; populations that are located entirely outside of Oregon (i.e., entirely within Washington) or that do not overlap with the plan area are not listed.

Natural History

Chum salmon are found throughout the lower and mid-river mainstem reaches of streams entering the lower Columbia River. Columbia River chum salmon typically have a 4-year life cycle and all die after spawning. Most fish are fall-run; adults return to freshwater between mid-October and November, depending on geographic location, after 3 to 6 years in the ocean. Spawning primarily occurs in the lower reaches of mainstem rivers, tributaries, or side channels. Incubation in gravel can last approximately 1 to 6 months depending on water temperature. In the spring, the chum salmon fry emerge from the gravel, typically at night, and promptly migrate to estuarine habitats to rear. Once emerged from gravel, chum salmon fry spend less time in freshwater and more time in the estuary than other anadromous salmonids. Chum do not have a clearly defined smolt stage, but are nonetheless capable of adapting to seawater soon after emerging. Juveniles rear in estuaries prior to entering the ocean. This critical period allows for growth to occur prior to undertaking long-distance ocean migrations. Chum are dependent on different habitats through their life history, which are discussed in more detail below.

Life History and Habitat Requirements

Upstream Migration and Spawning

Chum salmon spend 2 to 6 years in the ocean before returning to their natal streams (Steelquist 1992, and Bigler 1985, as cited in Salo 1991; LCFRB 2010). In the fall, adult chum salmon return to tributaries of the Columbia River to spawn in the lower gradient reaches of large rivers and small tributaries. Upstream migration occurs from November through December. Spawning typically ranges from November through January (Salo 1991; LCFRB 2010). Historically, summer-run chum salmon returned to the Cowlitz River, and observations of this life history variation occur occasionally (Ford 2011, and Myers et al. 2006, as cited in NMFS 2013).

Spawning typically occurs close to salt water and can occur in the tidal zone (Salo 1991; Hale et al. 1985), though Chum salmon may utilize various habitats for spawning across the species' range (Smirnov 1975, as cited in Salo 1991; Bakkala 1970). Generally, the species does not pass substantial barriers during upstream migrations (Neave 1953, 1966, and Thorsteinson et al. 1971, as cited in Hale et al. 1985; Bakkala 1970). Within the lower Columbia River, chum salmon spawn in the lower mainstem just outside tidal reaches, in subbasin tributaries such as Grays River, Hamilton Creek, and Hardy Creek, and can also occur up to 60 miles from sea in the Columbia River system (LCFRB 2010).

Chum salmon generally spawn in areas of turbulence or upwelling (Smirnov 1975, as cited in Salo 1991; Bakkala 1970; Hale et al. 1985). Within the Lower Columbia River, spawning sites are usually in low-elevation and low-gradient reaches with no barriers (LCFRB 2010). Within the lower Columbia River watershed, spawning sites are typically found in areas with upwelling water (usually near the mouth of rivers) and clean gravel (LCFRB 2010).

Each spawning season, females typically construct four to six redds in substrates of gravel and mixed sand, with minimal fine sediments present. Females excavate a nest, then males and females spawn simultaneously, depositing fertilized eggs into the nest. Females cover the nest with gravel to complete the redd, then begin excavating another redd (Salo 1991). Females may lay approximately 2,000 to 4,000 eggs per year in North American chum salmon populations (Salo 1991).

Incubation

Chum salmon egg incubation generally begins sometime between November and January (spawning season) and lasts through March, but can extend into April of some years (LCFRB 2010). The species, like other salmonids, are dependent on clean, cold water with sufficient flow or upwelling. Duration of incubation may be influenced by factors such as dissolved oxygen, gravel size, salinity, nutritional condition, and/or even the behavior of alevins, though water temperature is thought to be the most influential factor in time to emergence (Bakkala 1970, and Koski 1975, as cited in Hale et al. 1985; Salo 1991; LCRFB 2010). Eggs generally incubate in gravel redds approximately 50 to 130 days before hatching (Bakkala 1970; Salo 1991), and low water temperatures can delay fry emergence by 1.5 to 4.5 months (Hale et al. 1985). Typical spawning temperature ranges from 39–61°F (4–16°C) (Neave 1966, as cited in Bakkala 1970). Upper thermal limits for chum salmon incubation are not yet known (LCRFB 2010), and mortality of eggs, alevin (post hatching), and fry increases when incubation temperatures fall below 34.7°F (1.5°C) (Schroder et al. 1974, as cited in LCRFB 2010).

Two habitat factors that affect chum salmon performance in freshwater are channel stability and fine sediment. These habitat relationships are likely the most important environmental factors affecting populations of chum salmon in freshwater in many streams and rivers of the Pacific Northwest (need citation). Increases in fine sediments negatively affect survival during the egg and alevin life stages (Jensen et al. 2009). Bed scour and channel instability can be major sources of mortality affecting the survival of incubating chum eggs and alevins. Montgomery et al. (1996) found that even minor increases in depth of bed scour due to land use practices can significantly reduce embryo survival. Scour and fill of gravel beds are normal physical processes that occur during high flow events, but watershed development can change their rates and associated equilibria. Fine sediment affects the survival of salmonid embryos in at least three ways: (1) by direct suffocation of eggs and alevins, (2) by reduction of intragravel water flow and dissolved oxygen content, and (3) by providing a physical barrier to emergence (entombment) (as synthesized in Salo 1991). Because chum salmon tend to spawn in the lower reaches of stream systems where gradient is low and fine sediments accumulate, they may be generally more exposed to increased sedimentation than most other salmonid species. Evidence for the effect of intra-gravel fine sediment on salmonids is well documented (Chapman and McLeod 1987; Bjornn and Reiser 1991; Kondolf 2000).

The relationship between fines and survival described above apply where flow through the redd is downwelling. None of the streams where the studies were conducted are strongly influenced by springs; therefore, downwelling would characterize flow through redds in these cases (see Bjornn and Reiser 1991; Waters 1995). In streams fed largely by springs, salmonid spawning is usually associated with upwelling due to the groundwater influx occurring through a reach. When spawning occurs in upwelling groundwater, the adverse effects of sediment on eggs and emerging fry are largely negated, resulting in high survival provided the groundwater is not low in dissolved oxygen (Bjornn and Reiser 1991; Garrett et al. 1998). Spawning areas at these locations may be very high in fines. This explains why salmonids may have very high rates of reproduction in some streams despite excessive deposits of fine sediment (e.g., chum and sockeye salmon are known to spawn heavily in groundwater fed streams, even in areas with high fines).

Emergence and Downstream Migration

Chum salmon fry emerge from the gravel, typically at night, and almost immediately emigrate downstream to estuary rearing habitat (Salo 1991). Factors affecting the initiation of outmigration in chum populations include day length (increasing), estuarine water temperatures (warming), and seasonal densities of plankton (high) (Walters et al. 1978, as cited in LCRFB 2010). Some additional factors influencing downstream migration timing include: stream temperatures, fry size and nutritional condition, physiological changes in the fry, population density, food availability, stream discharge volume and turbidity, and tidal cycles (Simenstad et al. 1982, as cited in LCRFB 2010; Salo 1991). Water temperatures above 23.8°C or below -0.1°C are lethal for fry within their first summer after hatching (Brett 1952, and Brett and Alderdice 1958, as cited in Bakkala 1970), and fry prefer water temperatures between 12°C and 14°C (Bakkala 1970).

Emigration timing in the Columbia River system is not well investigated, but is thought to last from March through May, peaking in April (LCRFB 2010), and some fry have been observed in the Columbia River estuary in February (Bottom et al. 2011).

Predators of juvenile chum salmon include coho juveniles, resident trout species, and sculpins, though predators depend on species composition in each system. Predation mortality during downstream emigration has been described as significant for chum salmon (ranging from 22% to 58%) because fry migrate at small sizes shortly after emergence (Beall 1972, and Hiyama et al. 1972, as cited in LCRFB 2010). Chum fry school and move in concert during downstream emigration to minimize predation mortality (Pitcher 1986, and Biller and Brannon 1982, as cited in LCRFB 2010).

Freshwater Residence

As described above, most chum salmon fry typically migrate to estuary habitats immediately after emerging from the gravel. Some fry may migrate slowly downstream while feeding in the spawning areas. In larger, northern rivers, juvenile chum may remain up to a year in freshwater. In larger rivers to the Columbia River, duration of emigration may be relatively longer (Salo 1991). Feeding within freshwater generally appears to be important within the larger rivers where emigration duration is extended (LCFRB 2010). In rivers that drain directly into the Pacific Ocean, chum fry may linger in freshwater longer before moving directly into the open ocean, compared to chum freshwater residence times in other rivers that drain to estuaries. Rivers that drain directly into the ocean have limited opportunities for fry to experience estuarine exposure and residency (citation needed).

Estuary Rearing and Growth

The period of estuarine residence appears to be the most critical phase in the life history of chum salmon, having a major role in determining the size of the subsequent adult run (Mazer and Shepard 1962, Mathews and Senn 1975, Fraser et al. 1978, Peterman 1978, Sakuramoto and Yamada 1980, Martin et al. 1986, Healey 1982, and Bax 1983a, as cited in Johnson et al. 1997; Bakkala 1970; Salo 1991). Chum salmon are considered second only to Chinook salmon in dependence upon estuarine waters (Salo 1991). Chum salmon typically may spend weeks to months in estuary habitat before ocean entry (NMFS 2011), though residence may be as short as a few days (Congleton 1979, Healey 1982, Simenstad et al. 1982, and Bax 1983a, as cited in LCRFB 2010). Roegner et al. (2016) noted that shallow water habitat conservation and restoration are particularly important for chum salmon, which exhibit an ocean-type life history (outmigrate shortly after emerging from gravel, spending little time in stream habitat).

Estuaries are ideal habitats for foraging and rapid growth of chum outmigrants. In general, chum salmon grow rapidly in estuaries. They prefer shallow sublittoral habitats before moving into neritic deepwater habitats. In the estuaries chum will continue feeding and smolt when they are between 50 and 80 millimeters (Simenstad et al. 1980). Estuarine survival may be primarily determined by timing of entry into estuaries, due to seasonal variations in plankton abundance (Gunsolus 1978, Helle 1979, Gallagher 1979, and Simenstad and Salo 1982, as cited in LCRFB 2010). Additionally, estuary plankton populations may be “overgrazed” when juvenile salmonids enter estuaries in large numbers simultaneously (Reimers 1973, and Healey 1991, as cited in LCRFB 2010), which could contribute to lowered chum growth and/or survival rates.

In the Columbia River Estuary, chum have been found primarily in shallow shoreline habitats, and some have been sampled from deep water channel habitats. Smaller fish (fry) tended to occupy shallow habitats, and larger fish (fingerlings) were found in the deeper habitats (Roegner et al. 2016). Sampling in the Columbia River Estuary has observed juvenile chum salmon from March through June (Roegner et al. 2016), and fish have been observed within the freshwater, brackish, and marine regions of the estuary (Bottom et al. 1984, 2011).

Predation in the Columbia River estuary on juvenile salmonids has potentially increased from historical levels following recovery of predator populations (Fresh et al. 2005, NMFS 2016). Predators include marine mammals (primarily pinnipeds), smallmouth bass (*Micropterus salmoides*), northern pikeminnow (*Ptychocheilus oregonensis*), and double-crested cormorants (*Phalacrocorax auritus*) (Beamesderfer et al. 1996, Collis et al. 2001b, and Ryan et al. 2003, as cited in Fresh et al. 2005).

Ocean Life

Pacific salmon are anadromous fish; adults migrate from the ocean to spawn in freshwater lakes and streams where their offspring hatch and rear prior to migrating back to the ocean to forage until maturity. The physiological and behavioral changes required for the transition of juveniles from freshwater to saltwater happens more rapidly in chum than it does in most other anadromous salmonids. Unlike most other salmonids, chum salmon do not have a defined smoltification period; they typically enter salt water while retaining parr marks, and are capable of osmoregulation at the fry and fingerling stages (Iwata 1982, as cited in Salo 1991). Chum generally migrate to coastal waters and continue feeding until they reach between 110 and 170 millimeters. From there, the offshore cold water and open ocean life stages begin.

Juvenile chum salmon mortality shortly after entry into the marine environment can be high, and early marine residence is considered a critical period in the marine phase of chum life history (Bax 1983a, as cited in Salo 1991). Factors affecting early marine residence include food availability/limitations (Gunsolus 1978, Helle 1979, Gallagher 1979, and Simenstad and Salo 1982, as cited in Salo 1991) and predation (Hargreaves and LeBrasseur 1986, as cited in Salo 1991).

Chum salmon spend 3 to 6 years in the ocean before returning to spawn in freshwater streams (Bigler 1985, as cited in Salo 1991; LCFRB 2010). Chum salmon generally spend their first year in the marine environment schooling with other salmonids (pink and sockeye juveniles), and remain near-shore (within a few dozen kilometers of shore). After migrating north toward Alaska, groups generally move offshore, and directional movement may be influenced by currents (Hart 1980, and Hart and Dell 1986, as cited in LCFRB 2010). North American and Asian chum salmon populations mix in high-seas environments in the North Pacific Ocean and Bering Sea (LCFRB 2010).

Habitat capacity for chum salmon on the Oregon Coast has significantly decreased from historical levels. During periods of poor ocean survival, high quality habitat is necessary to sustain chum populations. Disease and infection of juvenile chum salmon in the first few months of ocean residence is a key concern.

In May and June, maturing adults residing in the North Pacific migrate toward the coast, then reside in coastal waters from June to November before beginning upstream migrations for spawning (Neave et al. 1976, Fredin et al. 1977, and Hartt 1980, as cited in LCFRB 2010).

Ecological Relationships

Please refer to *Ecological Relationships* in Section C1, *Oregon Coast Coho* above.

Population Status and Trends

Historically, chum salmon returns to the Columbia River Basin numbered in the hundreds of thousands and approached a million, before declining in the 1940s and 1950s (Good et al. 2005). The historical chum run size in the Columbia River has also been estimated at nearly 1.4 million fish per year (LCFRB 2010). Since the mid-1900s, returns have been estimated to average a few thousand fish per year, only returning to a small subset of the historical range within the ESU (Good et al. 2005; NWFSC 2015; NMFS 2016).

As of 2010, it was estimated that 14 of 17 of the historical spawning populations, also known as demographically independent populations (DIPs), within the Columbia River chum salmon ESU had been extirpated or nearly so (Ford et al. 2011). Two populations are considered relatively stable: the Washougal River and Lower Gorge DIP each maintain moderate numbers of spawners (NWFSC 2015; NMFS 2016). One population is considered only at low risk of extinction: the Grays River DIP, which has spawner abundances in the thousands annually and has exhibited a recent positive trend (NWFSC 2015; NMFS 2016).

Within Oregon, chum salmon have been considered to be extirpated, or nearly so, from tributaries of the Columbia River, due to little or no observed spawning populations (McElhany et al. 2007; NWFSC 2015). The term “functionally extirpated” describes a species that has been extirpated from an area; although a few individuals may occasionally be found, there are not enough fish or habitat in suitable condition to support a fully functional population (NMFS 2013).

Additionally, four hatchery programs exist in the Lower Columbia River Basin that release juvenile chum fry: Grays River Hatchery (releases to Grays River), Big Creek Hatchery (releases to Big Creek), Lewis River Hatchery (releases to East Fork Lewis River), and Washougal Hatchery (releases into Duncan Creek) (NWFSC 2015). Integrated stocks are developed to supplement natural production. The majority of fry are unmarked and are released during their first spring. Total annual hatchery production has not exceeded 500,000 fish. Unmarked returning adults are allowed to spawn naturally above the Big Creek weir, and excess fish are released into nearby basins to assist in reestablishment of naturally spawning populations (NWFSC 2015).

The current population statuses and trends within each of the three MPGs (Coastal, Cascade, and Gorge) are discussed below.

Coastal Range MPG

Oregon Coastal Range DIPs

Within the Coastal MPG, the Big Creek DIP, Youngs Bay DIP, Clatskanie DIP, and Scappoose DIP overlap with the plan area.

Only the Big Creek and Youngs Bay DIPs have streams within the plan area that are known or presumed to have chum salmon presence. Refer to *Distribution* above, Figure C5-1, and Table C5-1 for details.

The Big Creek DIP (Oregon) has had observations of spawning chum salmon normally in the tens of fish, as counted at the Big Creek weir. Most other DIPs within the Coastal Range MPG exist at very low abundances (less than 10 observations per year), and some may be functionally extinct (NWFSC).

There are currently two hatchery programs in the Coastal MPG releasing juvenile chum salmon: Grays River Hatchery and Big Creek Hatchery. Some supplementation programs and reintroductions using hatchery broodstock occur in other tributaries in the Coastal MPG, and outmigrating fry observations have been made (NWFSC 2015).

Washington Coastal Range DIPs

Within the Coastal MPG, the Grays River DIP, the Elochoman/Skamakowa Rivers DIP, and the Mill/Abernathie/Germany Creeks DIP do not overlap with the plan area.

The Grays and Chinook Rivers DIP is considered a stronghold in the MPG and ESU (NWFSC 2015). Standardized mark-recapture surveys occur and population estimates are available for Grays River (NWFSC 2015). Since the early 2000s, the Grays River population has had spawner abundances in the thousands, peaking over 10,000 spawners in 2002. The population has demonstrated a recent positive trend and is estimated to consist of an average of 93.4% naturally produced fish (only 6.4% hatchery-produced fish); thus, it is considered to be at a low risk of extirpation (NWFSC 2015; NMFS 2016).

Very low numbers (<10) of returning adult chum salmon are observed occasionally in most other tributaries of the Coastal Range DIPs (NWFSC 2015).

Cascade MPG

Washington DIPs

Within the Cascade MPG, the Washougal River DIP, Salmon Creek DIP, Lewis River, Kalama River, and Cowlitz River summer/Cowlitz River fall-run DIP do not overlap with the plan area.

In the early 2000s, spawning chum salmon were observed in the Columbia River mainstem near the Interstate-205 bridge (at Woods Landing and Rivershore, in Washington), and are considered part of the Washougal population (Good et al. 2005). These populations were observed at groundwater seeps. The population has experienced large 5-fold fluctuations, but appears generally stable with a few thousand fish observed annually across two spawning aggregations (NWFSC 2015).

Very low numbers of spawners (e.g., less than 100) have been observed at the following locations on the Washington side of the ESU, within the Cascade MPG: Bonneville Dam, Cowlitz, Elochoman, North Fork Lewis, and Skamakawa (Good et al. 2005). Recurring observations have been made of early returning “summer” chum salmon at the Cowlitz Salmon Hatchery Trap on the Cowlitz River (NWFSC 2015).

There are currently two hatchery programs in the Cascade MPG releasing juvenile chum salmon: Lewis River Hatchery and Washougal Hatchery (NWFSC 2015).

Oregon DIPs

Within the Cascade MPG, the Sandy DIP overlaps with the plan area, and the Clackamas DIP does not overlap with the plan area.

As of 2005, Oregon spawning populations of Columbia River chum salmon were considered extirpated or nearly so, with the exception of the lower Columbia Gorge population (Good et al. 2005). Systematic surveys for chum are not undertaken in in Oregon tributaries within the Cascade MPG, and very few observations of spawning chum salmon are made in the streams of the Clackamas DIP and Sandy DIP. For example, in November 2013, two adults were observed at the North Fork Dam in the Clackamas River, and few (less than 10) adults are collected at hatcheries throughout the MPG annually (NWFSC 2015).

Gorge MPG

Lower Columbia Gorge DIP (Washington/Oregon)

Within the Gorge MPG, the Lower Columbia Gorge DIP (including all subpopulations) does not overlap with the plan area.

The lower Columbia Gorge populations consist of four subpopulations below Bonneville Dam: Hardy Creek (Washington), Hamilton Creek (Washington), Ives Island (within mainstem Columbia River, Washington), and the Multnomah area (within mainstem Columbia River, Oregon) (Good et al. 2005). Standardized mark-recapture surveys occur in the mainstem and population estimates are available for the lower Columbia River mainstem (NWFSC 2015). Additionally, spawning aggregations occur in Multnomah and Horsetail Creeks (Oregon) and St. Cloud area along the Washington shoreline (NWFSC 2015). Abundance estimates for all populations collectively within the Lower Columbia Gorge DIPs are a few thousand annually, though a negative trend has been observed (NWFSC 2015).

Upper Columbia Gorge DIP (Washington/Oregon)

Within the Gorge MPG, the Upper Columbia Gorge DIP (including all subpopulations) does not overlap with the plan area.

Though a large amount of chum salmon habitat upstream of Bonneville Dam is considered to have been eliminated by inundation after construction of the dam, small numbers of chum are recorded passing Bonneville Dam annually (Good et al. 2005). Between 2010 and 2014, chum salmon adult counts at the dam averaged approximately 105.6 ± 47.7(Standard Deviation) fish, and, in 2010, chum fry were observed at the Bonneville Dam juvenile monitoring facility (NWFSC 2015).

Threats

In general, Columbia River chum salmon population declines have resulted from the combined and compounded impacts of human activities on freshwater and estuary habitats, dam construction and operation, fishing, fish hatcheries, and ecological factors such as predation (LCFRB 2010). A federal recovery plan for the Columbia River chum salmon ESU was finalized in June 2013 (NMFS 2013). The plan provides guidance to improve the viability of Lower Columbia River chum salmon to the point that it meets the delisting criteria and no longer requires ESA protection. NMFS (2013) describes listing factors and threats to Columbia River chum salmon:

> Columbia River chum salmon have been—and continue to be—affected by loss and degradation of spawning and rearing habitat, the impacts of mainstem hydropower dams on upstream access and downstream habitats, and the legacy effects of historical harvest; together, these factors have reduced the persistence probability of all populations. Under baseline conditions, constrained spatial structure at the ESU level (related to conversion, degradation, and inundation of habitat) contributes to very low abundance and low genetic diversity in most populations and increases risk to the ESU from local disturbances.

Additionally, NMFS (2013) describes adverse effects of natural environmental variability from drought, floods, and poor ocean conditions that have been exacerbated by the degradation of habitat by human activities. The recovery strategy addresses threats influencing limiting factors for tributary habitat, estuary habitat, hydropower, harvest, hatcheries, and predation. NMFS describes restoration of tributary spawning and estuary rearing habitat as essential in the recovery of the species.

The most recent status review that addressed Columbia River chum salmon synthesized previous status conclusions and evaluated recent data and observations (NWFSC 2015). The status review determined that, as of 2015, some improvements and declines in individual populations have been observed, but the majority of DIPs in the ESU remain at a high or very high risk category, and most chum populations require substantial improvements to meet their recovery viability goals.

The Lower Columbia Conservation and Recovery Plan for Oregon Populations of Salmon and Steelhead, approved in August 2010, describes the population status and recovery plans for salmon and steelhead, including the Oregon sub-basin populations of the Columbia River chum salmon ESU. The document addresses federal legal requirements (under ESA) and state legal requirements (under Oregon's Native Fish Conservation Policy). It provides a strategic approach to recovery based on science, with stakeholder support, and using specific recovery actions. (ODFW 2010)

The Lower Columbia Conservation and Recovery Plan for Oregon Populations of Salmon and Steelhead includes Appendix I, Oregon's Columbia River Chum Salmon Recovery Strategy (ODFW 2010). All of the streams in the Oregon portion of the Columbia River chum ESU have been altered by human development, specifically the construction of Bonneville Dam, Interstate 84, and a railroad line and the development of the Portland Metropolitan Area. All Oregon populations are threatened by altered hydrology and land uses, which affect water quality, water quantity, and food web (plume) dynamics. Harvest from targeted fishery threatens both population abundance and diversity. Oregon's Columbia River Chum Salmon Recovery Strategy document focused mostly on recovery efforts for the Coastal stratum because the Oregon Department of Fish and Wildlife (ODFW) believed basins within the Coastal stratum have been altered to a lesser extent by human development than the Cascade and Gorge strata, and will focus efforts in the latter strata in the future.

Table C5-2 summarizes key threats and limiting factors facing each chum salmon DIP in Oregon.

Table C5-2. Threat Summary by Oregon Population

Oregon Population	Key Threats and Limiting Factors
Young's Bay	• Diking and wetland filling alters and degrades estuarine rearing habitat • Hatchery-origin coho, steelhead, and Chinook smolt predation on chum fry • Stray hatchery fish interbreeding with wild fish • Hatchery weirs block access to historical spawning and rearing habitat

Oregon Population	Key Threats and Limiting Factors
Big Creek	• Altered and degraded estuarine habitat • Excess fine sediment in spawning gravels • Hatchery-origin coho, steelhead, and Chinook smolt predation on chum fry • Stray hatchery fish interbreeding with wild fish • Hatchery weirs block access to historical spawning and rearing habitat
Clatskanie River	• Altered and degraded estuarine habitat • Excess fine sediment in spawning gravels • Low large woody debris (LWD) density and habitat complexity/diversity • Hatchery-origin coho, steelhead, and Chinook smolt predation on chum fry
Scappoose Creek	• Altered and degraded estuarine habitat • Excess fine sediment in spawning gravels • Marginal channel complexity and diversity • Hatchery-origin coho, steelhead, and Chinook smolt predation on chum fry
Clackamas	• Impaired physical habitat diversity and complexity • Elevated water temperatures from large hydropower reservoirs impair water quality • Stray hatchery fish interbreeding with wild fish
Sandy	• Impaired physical habitat diversity and complexity • Hatchery weirs block access to historical spawning and rearing habitat
Lower Gorge	• Transportation corridor development impairs habitat quality and quantity • Stray hatchery fish interbreeding with wild fish
Upper Gorge/Hood	• Irrigation withdrawals alter hydrology and water quantity • Impaired physical habitat diversity and complexity • Stray hatchery fish interbreeding with wild fish

Sources: ODFW 2010; NMFS 2013.

Literature Cited

Bakkala, R.G. 1970. Synopsis of Biological Data on the Chum Salmon, *Oncorhynchus keta*. Volume 315 of Ci

Bjornn, T.C and D.W. Reiser. 1991. Habitat Requirements of Salmonids in Streams. *Influences of Forest and Rangeland Management on Salmonid Fishes and Their Habitat.* American Fisheries Society.

Bottom, D.L., A. Baptista, J. Burke, L. Campbell, E. Casillas, S. Hinton, D.A. Jay, M. Austill Lott, G. McCabe, R. McNatt, M. Ramirez, G. Curtis Roegner, C. A. Simenstad, S. Spilseth, L. Stamatiou, D. Teel, and J.E. Zamon. *Estuarine Habitat and Juvenile Salmon: Current and Historical Linkages in the Lower Columbia River and Estuary. Final Report 2002-2008.* Northwest Fisheries Science Center, National Marine Fisheries Service; Seattle, Washington. Report Prepared for U.S. Army Corps of Engineers, Portland District. December. Available: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.386.4191&rep=rep1&type=pdf.

Chapman, D.W and K.P. McLeod. 1987. Development of Criteria for Fine Sediment in the Northern Rockies Ecoregion. Prepared for U.S. EPA. Boise, ID. 285 p.

Ford, M. J., A. Albaugh, K. Barnas, T. Cooney, J. Cowen, J. J. Hard, R. G. Kope, M. M. McClure, P. McElhany, J. M. Myers, N. J. Sands, D. J. Teel, and L. A. Weitkamp. 2011. Status review update for Pacific salmon and steelhead listed under the Endangered Species Act: Pacific Northwest. U.S. Department of Commerce NMFS-NWFSC-113, Seattle, WA

Fresh, KL, E. Casillas, L.L. Johnson, and D.L. Bottom. 2005. Role of the estuary in the recovery of Columbia River Basin salmon and steelhead: An evaluation of the effects of selected factors on salmonid population viability. U.S. Dept. Comm., NOAA Technical Memorandum NMFS-NWFSC-69, U.S. Department of Commerce, Seattle

Garrett, J. W., D. H. Bennett, F. O. Frost, and R. F. Thurow. 1998. Enhanced incubation success for kokanee spawning in groundwater upwelling sites in a small Idaho stream. North American Journal of Fisheries Management 18:925-930.Good, T.P., R.S. Waples, and P. Adams (editors). 2005. *Updated Status of Federally Listed ESUs of West Coast Salmon and Steelhead*. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-66, 598 pp.

Groot, C. and L. Margolis. 1991. *Pacific Salmon Life Histories*. University of British Columbia Press, Vancouver, B.C.

Hale, S. S., T. E. McMahon, and P. C. Nelson. 1985. Habitat Suitability Index Models and Instream Flow Suitability Curves: Chum Salmon. *U.S. Fish Wildl. Servo Biol. Rep*. 82(10.108). 48 pp.

Jensen, D.W., E.A. Steel, A.H. Fullerton, and G.R. Pess. 2009. Impact of Fine Sediment on Egg-to-Fry Survival of Pacific Salmon: A Meta-Analysis of Published Studies. *Reviews in Fisheries Science*; 17(3): pp. 348–359.

Johnson, O.W., W.S. Grant, R.G. Kope, K. Neely, F.W. Waknitz, and R.S. Waples. 1997. *Status Review of Chum Salmon from Washington, Oregon, and California.* NOAA Technical Memorandum NMFS-NWFSC-32. National Marine Fisheries Service, Northwest Fisheries Science Center, Conservation Biology Division; Seattle, WA. December.

Kondolf, G.M. 2000. Assessing Salmonid Spawning Gravel Quality. Transactions of the American Fisheries Society 129(1):262-281.

Lower Columbia Fish Recovery Board (LCFRB). 2010. Lower Columbia Salmon and Fish & Wildlife Subbasin Plan at: https://www.lcfrb.gen.wa.us/librarysalmonrecoveryMaher, M., M.B. Sheer, E.A. Steel, and P. McElhany. 2005. *Atlas of Salmon and Steelhead Habitat in the Oregon Lower Columbia and Willamette Basins*. Report for the Willamette-Lower Columbia Technical Recovery Team. Produced by the NOAA Northwest Fisheries Science Center. 203 pp.

McElhany, P., T. Backman, C. Busack, S. Kolmes, J. Myers, D. Rawding, A. Steel, C. Steward, T. Whiteset, and C. Willis. 2004. *Status Evaluation of Salmon and Steelhead Populations in the Willamette and Lower Columbia River Basins*. Northwest Fisheries Science Center; Seattle, WA.

McElhany, P., M. Chilcote, J. Myers, R. Beamesderfer. 2007. *Viability Status of Oregon Salmon and Steelhead Populations in the Willamette and Lower Columbia Basins, Review Draft*. National Marine Fisheries Service Northwest Fisheries Science Center, Seattle, Washington

National Marine Fisheries Service (NMFS). 1998. Threatened and Endangered Species: Proposed Threatened Status and Designated Critical Habitat for Hood Canal Summer-Run Chum Salmon and Columbia River Chum Salmon; Proposed Rule. *Federal Register*, 63 FR 1174. March 10, 1998.

National Marine Fisheries Service (NMFS). 1999. Endangered and Threatened Species: Threatened Status for Two ESUs of Chum Salmon in Washington and Oregon. *Federal Register*, 64 FR 14508. March 25, 1999.

National Marine Fisheries Service (NMFS). 2000. Designated Critical Habitat: Critical Habitat for 19 Evolutionarily Significant Units of Salmon and Steelhead in Washington, Oregon, Idaho, and California. *Federal Register,* 65 FR 7764. March 25, 1999.

National Marine Fisheries Service (NMFS). 2005a. Endangered and Threatened Species: Final Listing Determinations for 16 ESUs of West Coast Salmon, and Final 4(d) Protective Regulations for Threatened Salmonid ESUs. *Federal Register*, 70 FR 37160. February 16, 2005.

National Marine Fisheries Service (NMFS). 2005b. Designation of Critical Habitat for 12 Evolutionarily Significant Units of West Coast Salmon and Steelhead in Washington, Oregon, and Idaho. *Federal Register*, 70 FR 52630. September 2, 2005.

National Marine Fisheries Service (NMFS). 2011. *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead. NMFS Northwest Region.* Portland, OR. January. Prepared for NMFS by the Lower Columbia River Estuary Partnership (contractor) and PC Trask & Associates, Inc., subcontractor.

National Marine Fisheries Service (NMFS). 2013. *ESA Recovery Plan for Lower Columbia River Coho Salmon, Lower Columbia River Chinook Salmon, Columbia River Chum Salmon, and Lower Columbia River Steelhead. Northwest Region*. June.

National Marine Fisheries Service (NMFS). 2014. Endangered and Threatened Wildlife; Final Rule To Revise the Code of Federal Regulations for Species Under the Jurisdiction of the National Marine Fisheries Service. *Federal Register,* 79 FR 20802. April 14, 2014.

National Marine Fisheries Service (NMFS). 2016. *2016 5-Year Review: Summary & Evaluation of Lower Columbia River Chinook Salmon, Columbia River Chum Salmon, Lower Columbia River Coho, Salmon Lower Columbia River Steelhead*. West Coast Region; Portland, Oregon.

Nehlsen, W., J.E. Williams, and J.A. Lichatowich. 1991. Pacific Salmon at the Crossroads: Stocks at Risk from California, Oregon, Idaho, and Washington. *Fisheries* 16(2):4-21.

NWFSC. 2015. Status Review Update for Pacific Salmon and Steelhead listed under the Endangered Species Act: Pacific Northwest. December 21, 2015. Northwest Fisheries Science Center. National Marine Fisheries Service, Seattle, Washington. 356p.

ODFW (Oregon Department of Fish and Wildlife). 2005. *Oregon Native Fish Status Report, Volume I: Species Management Unit Summaries.* ODFW Fish Division, Salem, OR.

Oregon Department of Fish and Wildlife (ODFW). 2010. *Lower Columbia River Conservation and Recovery Plan for Oregon Populations of Salmon and Steelhead*. August.

Oregon Department of Fish and Wildlife (ODFW). 2019. ODFW Sensitive Species List. Accessed at: https://www.dfw.state.or.us/wildlife/diversity/species/docs/Sensitive_Species_List.pdf

Oregon Administrative Rules. 2016. Sensitive Species List (OAR 635-100-0040).

Roegner, G.C., L.A. Weitkamp, and D.A. Teel. 2016. Comparative Use of Shallow and Deepwater Habitats by Juvenile Pacific Salmon in the Columbia River Estuary Prior to Ocean Entry. *Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science*; 8:536–552.

Salo, E.O. 1991. Life History of Chum Salmon (*Oncorhynchus keta*). In *Pacific Salmon Life Histories*, Groot and Margolis (eds.). UBC Press, 564 pp. Available partially online: http://books.google.com/books?id=I_S0xCME0CYC&dq=chum+salmon&lr=&source=gbs_navlinks_s.

Simenstad, C., K.L. Fresh, and E.O Salo. 1980. The role of Puget Sound and Washington coastal estuaries in the life history of Pacific salmon: an unappreciated function. *Estuarine comparisons*. Academic Press, Inc.

Streamnet. 2019. Chum Salmon Distribution. File Geodatabase Feature Class. Pacific States Marine Fisheries Commission. Data available: http://www.streamnet.org. Accessed January 2019.

C6 Southern Oregon/Northern California Coast Coho (*Oncorhynchus kisutch)*

The Southern Oregon/Northern California Coast coho salmon evolutionarily significant unit (ESU) is one of 19 ESUs and distinct population segments of salmon and steelhead in the Pacific Northwest listed as threatened or endangered under the federal Endangered Species Act (ESA). The Southern Oregon/Northern California Coast coho salmon ESU includes rivers and streams from Cape Blanco, Oregon, to Punta Gorda, California.

Legal Status

State: Sensitive species

Federal: Threatened (Original listing National Marine Fisheries Service [NMFS] 1997, 62 *Federal Register* [FR] 24588; Revised listing NMFS 2005, 70 FR 37160)

Critical Habitat: Designated (NMFS 1999, 64 FR 24049)

Recovery Planning: Recovery plan approved (NMFS 2014a; NMFS 2014b, 79 FR 58750)

Photo: Native Fish Society

Southern Oregon coho salmon are listed as a sensitive species under the Oregon State Sensitive Species List (OAR 635-100-0040) and are not listed under the Oregon Endangered Species Act (ORS 496.171 to 496.192, 498.026, and 564.100 to 564.135). Oregon prepared a limiting factors and threats analysis for the same Oregon coho salmon populations as the federal listing (Nicholas et al. 2005). The Oregon State Lower Columbia River Conservation and Recovery Plan addresses legal requirements for conservation planning under Oregon's Native Fish Conservation Policy (ODFW 2010).

There is no critical habitat for Southern Oregon/Northern California Coast coho within the plan area.

Taxonomy

Coho salmon (*Oncorhynchus kisutch*) were first described by Walbaum in 1792. Coho are one of five recognized species of Pacific Salmon (*Oncorhynchus spp.*) that occur in North America.

Distribution

Coho salmon distribution for the species' entire range is described in the section for the Oregon Coast coho salmon ESU above. The following describes the distribution of coho salmon in the Southern Oregon/Northern California Coast coho salmon ESU as well as populations and portions of watersheds in Oregon.

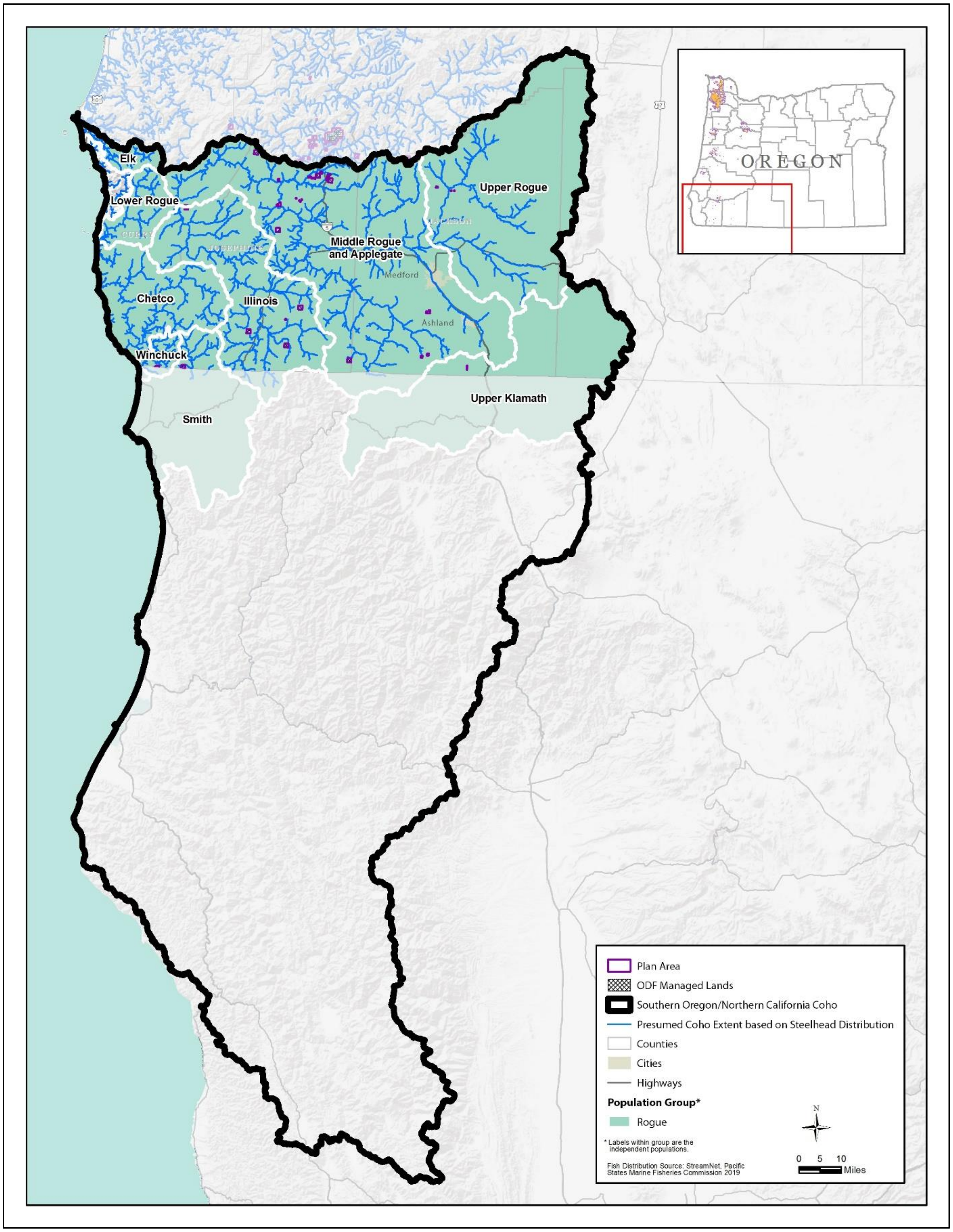
General

The Southern Oregon/Northern California Coast coho salmon ESU includes the Pacific Ocean and the freshwater and estuarine habitat along the Oregon and California Coast from the Cape Blanco on the north to Punta Gorda on the south (NMFS 2005, 70 FR 37160). Although most coho spawning occurs within 240 kilometers of the coast, large river systems like the Klamath, Trinity, Eel, and Rogue rivers have historically supported coho salmon in their upper tributaries (NMFS 2014a; Williams et al. 2006). Rivers in the Oregon portion of the ESU originate from the Oregon Coast Range, except for the Rogue River, which extends east through the Oregon Coast Range to drain the Cascade Mountains. Portions of the Upper Klamath River are also in Oregon.

NMFS identified seven diversity strata across the ESU (Williams et al. 2006). Of the seven diversity strata, five have all or portions in Oregon. They are: (1) North Coastal, (2) Interior Rogue, (3) Interior Klamath, and (4) Central Coastal. Across the seven strata, 59 historical populations were defined, which included 19 functionally independent populations, 12 potentially independent populations, 26 dependent populations, and 2 ephemeral populations (Williams et al. 2006). In the species' Recovery Plan, 40 populations in the ESU were identified for recovery goals, of which 14 are partially or wholly within Oregon (NMFS 2014a). Of these, seven populations were identified as functionally independent, three were identified as potentially independent, and four were identified as dependent (Table C6-1).

The ESU recovery strategy calls for achieving sustainable independent populations within the ESU (NMFS 2014). ESU recovery is based on achieving low risk of extinction in all "Core" populations. All Non-Core 1 populations should at least be at moderate risk of extinction or lower, and all Non-Core 2 and dependent populations should have juvenile presence indicating natural production (NMFS 2014; NMFS 2016). To define recovery of the Southern Oregon/Northern California Coast coho salmon ESU, NMFS set biological recovery criteria for each population role type, which address the four viability parameters: abundance (spawners), productivity (growth rates), spatial structure (distribution of occupied habitat), and diversity (proportion of hatchery origin fish and variation in life history parameters).

Figure C6-1. Southern Oregon/Northern California Coho (ESU) Strata and Independent Populations in Oregon



Occurrences Within the Plan Area

Across the entire ESU, six independent populations intersect portions of the plan area, within four diversity strata (Figure C6-1). The independent populations that include portions of the plan area or Oregon Department of Forestry (ODF) managed lands are:

- Northern Coastal Basins Stratum:
    - Winchuck River
- Central Coastal Basins Stratum:
    - Smith River
- Interior Rogue Stratum:
    - Illinois River
    - Middle Rogue and Applegate
    - Upper Rogue River
- Interior Klamath Stratum:
    - Upper Klamath River

However, not all independent populations intersecting or adjacent to the plan area or ODF managed lands have coho salmon distribution. Miles of streams with Oregon Department of Fish and Wildlife (ODFW) documented or assumed coho salmon presence within the plan area are summarized in Table C6-1. Stream miles are identified for independent populations by strata. The Smith River and Middle Rogue/Applegate rivers independent populations have the highest percentage of stream miles with Southern Oregon/Northern California Coast coho salmon presence within the plan area: 2% and 0.1%, respectively.

Table C6-1. Stream Miles with Coho Salmon Known or Presumed Presence Within Biogeographic Strata in Oregon that Intersect with the Plan Area

Biogeographic Stratum and Independent Populations[1]	Stream Miles with Known or Presumed Coho Salmon Presence		
	Total Stream Miles Within ESU	Miles Within or Adjacent to Plan Area	Percent of ESU Total Within or Adjacent to Plan Area
Northern Coastal Basins Stratum			
Winchuck River	63	0	0%
Central Coastal Basins Stratum			
Smith River	56	1	2%
Interior Rogue Stratum			
Illinois River	451	0.2	0%
Middle Rogue and Applegate rivers	826	1	0.1%
Upper Rogue River	253	0	0%
Interior Klamath Stratum			
Upper Klamath River	0	0	0%

Source: Streamnet 2019.

[1]Only independent populations located entirely and/or partially within Oregon and that intersect with the plan area are shown; populations that are located entirely outside of Oregon (i.e., entirely within Washington) or that do not overlap with the plan area are not listed.

Natural History

Southern Oregon and Northern California coho generally have a 3-year life cycle. Typically, adults begin their freshwater spawning migration in the late summer and fall, spawn by mid-winter, and then die. The run and spawning times vary between and within populations. Eggs incubate in redds for 1.5 to 4 months before hatching, depending on river temperatures. Coho salmon fry transition to the juvenile stage by about mid-June. Juveniles develop vertical dark bands, or parr marks, and begin partitioning available instream habitat through aggressive agonistic interactions with other juvenile fish. Juveniles rear in freshwater for up to 15 months, then migrate in spring to the ocean as smolts. Coho salmon typically spend 2 growing seasons in the ocean before returning to their natal stream to spawn as 3 year olds. However, some males, known as jacks, return to spawn after only 6 months at sea.

Life History and Habitat Requirements

Refer to Section C1, *Oregon Coast Coho* above for discussion of life history and habitat requirements for coho salmon. Additional life history and habitat requirements information specific to the Southern Oregon/Northern California Coast coho ESU are noted below.

Freshwater Residence

Extended freshwater residence, when fish spend a second winter in freshwater before outmigrating to the ocean, has been observed for age 1+ coho in California streams (Bell and Duffy 2007, and Ransom 2007, as cited in NMFS 2014a). In Northern California streams, extended freshwater residence is correlated to peak winter streamflow, and 0 to 30% of cohorts may exhibit the trait (Bell and Duffy 2007, Ransom 2007, as cited in NMFS 2014a). In California and Oregon watershed with adequate estuarine rearing habitat, some ocean-type coho salmon rear in the estuary during the spring, summer, and fall, and return upstream to overwinter (Miller and Sadro 2003, Jones et al. 2014, and Merrell and Koski 1978, as cited in NMFS 2014a).

Downstream Migration

Within the Southern Oregon/Northern California Coast coho ESU, downstream smolt migration begins in the spring between April and May, and continues into June (Shapovalov and Taft 1954). The earliest outmigration in ESU occurs at Roach Creek (a tributary to the Klamath) and at Ten Mile Creek (a tributary to the Eel River) in March or earlier. The latest outmigration occurs at the South Fork of the Eel River, beginning in mid-June or later; thus, the Eel River has the largest range of outmigrant timing in the ESU (March to August) (Weitkamp et al. 1995).

Timing of emigration commencement may be influenced by fish size, flow conditions, water temperature, dissolved oxygen levels, day length, and the availability of food (Shapovalov and Taft 1954). Most smolts are between 90 and 115 millimeters fork length when beginning downstream migration (Shapovalov and Taft 1954). The occurrence of age-0 “ocean-type” coho salmon migrants to the estuary, stream-estuary ecotone, or lower main-stem reaches is thought to be an alternative life-history strategy, and has been observed throughout the species' range (Chapman et al. 1961, Chapman 1962, Hartman et al. 1982, Murphy et al. 1984; Rodgers et al. 1987, Au 1972, Kahler et al. 2001, Ryall and Levings 1987, Miller and Sadro 2003, and Pinnix et al. 2013, as cited in NMFS 2014a).

In the Klamath River, a positive relationship between flow volume and travel time and survival of juvenile coho has been documented (Beeman et al. 2012, as cited in NMFS 2014a). Depending on a watershed's estuary characteristics, coho salmon on the Oregon and California coast may spend a few days to a few weeks in estuaries before continuing to the ocean (Miller and Sadro 2003, Clements et al. 2012, Pinnix et al. 2013, and Jones et al. 2014, as cited in NMFS 2014a). The average size of outmigrating coho salmon is approximately 128 millimeters, and the range of smolts sizes in the Southern Oregon/Northern California Coast coho salmon ESU is between 90 and 200 millimeters (Weitkamp et al. 1995).

Ocean Life

Compared to other coho populations, the ESU has a relatively small marine distribution (NMFS 2014a). Dispersal at sea is regionally specific; coho from northern California and Oregon south of Cape Blanco disperse locally to California and Oregon waters (Weitkamp and Neely 2002, as cited in NMFS 2014a).

Population Status and Trends

Historically, hundreds of thousands of coho salmon returned to spawn in the rivers and streams of Southern Oregon and Northern California (Good et al. 2005). As of the 1990s, run-size estimates combining the California portion of the ESU and the Rogue River Basin were approximately 10,000 naturally spawned fish and 20,000 hatchery fish (Weitkamp et al. 1995).

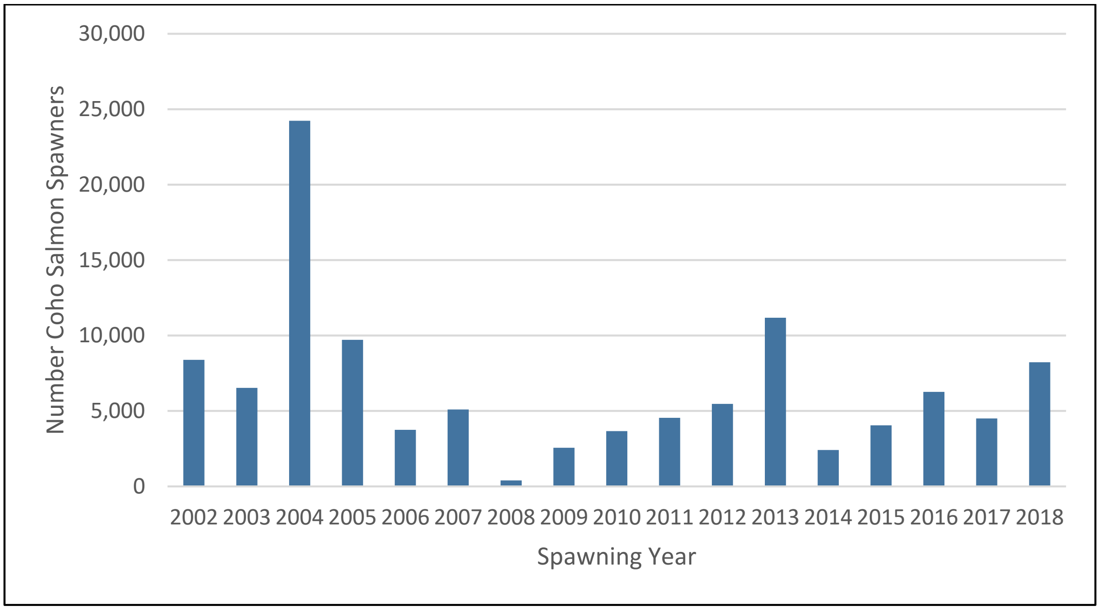
Long-term quantitative population-level estimates of adult spawner abundance are scarce for Southern Oregon and Northern California coho salmon (NMFS 2016). Available monitoring data indicate that spawner abundance has generally declined for populations in this ESU, a majority of independent populations are below low-risk abundance targets, and many may be below high-risk depensation thresholds (where a decrease in the breeding population leads to reduced production and survival of eggs or offspring) (Williams et al. 2011; NMFS 2016). Population-level estimates of abundance for most independent populations are lacking, and the best available data indicate that none of the seven diversity strata appears to support a single viable population, with one at low risk of extinction, though all seven strata are occupied by coho (NMFS 2014a).

Currently, over three quarters of Southern Oregon and Northern California coho salmon independent populations are at high risk of extinction (NMFS 2014a). NMFS (2016) predicted most populations in Oregon in this ESU currently have a high risk of extinction. The exception was the Upper Rogue River population with a moderate risk of extinction. Occasional annual estimates for other populations in Oregon range from 0 fish to several hundred (Table C6-2) (NMFS 2016).

Estimates of coho salmon spawner abundance are scarce for populations in this ESU, but long-term counts are available for some populations (NMFS 2016). An estimate of wild coho salmon returning to the Rogue River Basin is available for 2002 to 2018 (Figure C6-2). The estimate is a composite of coho salmon returning to the Lower Rogue and interior Rogue River populations (Illinois River, Middle Rogue/Applegate, and Upper Rogue River populations). The recent 5-year average abundance (2013 to 2018) for this population composite is 5,092 coho salmon (ODFW 2018, 2019).

As shown in Table C6-1, the plan area has the largest overlap with the Central Coastal Basins stratum, specifically the Smith River independent population. This population comprises, on average, 8% of the total ESU abundance (Table C6-2).

Figure C6-2. Trends Abundance Adult Spawning Coho Salmon in the Rogue River Basin



Source: ODFW 2019.

Table C6-2. Adult Coho Salmon Abundance Estimates

Biogeographic Stratum and Independent Populations[1, 2]	Coho Salmon Adult Abundance		
	Years of Data[2]	Arithmetic Mean[2]	Percent of Total ESU Abundance[3]
North Coastal Basins			**N/A**
Elk River	-	-	N/A
Lower Rogue River	-	-	N/A
Checto River	-	-	N/A
Winchuck River	-	-	*N/A*
Central Coastal Basins			**16%**
Smith River[a,b] (redd estimate)	*2*	*355*	*8%*
Lower Klamath River	-	-	
Redwood Creek[b, c] (redd estimate)	4	529	12%
Maple Creek/Big Lagoon[d]	-	-	N/A
Little River	-	-	N/A

Biogeographic Stratum and Independent Populations[1, 2]	Coho Salmon Adult Abundance		
	Years of Data[2]	Arithmetic Mean[2]	Percent of Total ESU Abundance[3]
Mad River	-	-	N/A
Southern Coastal Basins			**25%**
Humboldt Bay tributaries[b, e] (redd estimate)	4	1038	24%
Lower Eel/Van Duzen rivers	-	-	N/A
Bear River[a]	-	-	N/A
Mattole River[b, f] (redd estimate)	2	47	1%
Interior – Rogue			**N/A**
Illinois River	-	-	*N/A*
Middle Rogue/Applegate rivers	-	-	*N/A*
Upper Rogue River	-	-	*N/A*
Interior – Klamath			**22%**
Middle Klamath River	-	-	N/A
Upper Klamath River	-	-	*N/A*
Salmon River	-	-	N/A
Scott River[g] (video weir – adults)	8	810	19%
Shasta River[h] (video weir – adults)	14	127	3%
Interior – Trinity			**N/A**
South Fork Trinity River	-	-	N/A
Lower Trinity River	-	-	N/A
Upper Trinity River	-	-	N/A
Interior – Eel			**32%**
South Fork Eel River[b, i] (redd estimate)	4	1347	32%
Mainstem Eel River	-	-	N/A
North Fork Eel River[d]	-	-	N/A
Middle Fork Eel River[d]	-	-	N/A
Middle Mainstem Eel River	-	-	N/A
Upper Mainstem Eel River [d]	-	-	N/A

[1] Populations shown in *italics* occur in the plan area.

[2] Abundance data from Table 7 in *2016 5-Year Review: Summary & Evaluation of Southern Oregon/Northern California Coast Coho Salmon* (NMFS 2016).

Data notes, as described by NMFS:

- N/A indicates not available or applicable; dash (-) indicates no estimate of appropriate spatial scale or sampling design for viability analysis. Trends are shown only for populations where time series is at least 6 years; bold indicates significant trend.

  [a] Data from Garwood and Larson (2014). Data available for 2011 and 2012; data for 2013 and 2014 not available at time of analysis.

  [b] Redd counts (estimates), not adult escapement.

[c] Data from Ricker et al. (2014a, 2014b, 2014c, and 2014d); data from 2010 to 2013.
[d] Population unit designated by Williams et al. (2006 and 2008), not included in NMFS (2014).
[e] Data from Ricker et al. (2015a, 2015b, 2015c, and 2015d); data from 2010 to 2013.
[f] Data from Ricker and Lindke 2014 and Ricker et al. 2014e; data for 2011 and 2012.
[g] Data from Morgan Knechtle, California Department of Fish and Wildlife; data from 2007 to 2014.
[h] Data from Morgan Knechtle, California Department of Fish and Wildlife; data from 2001 to 2014.
[i] Data from Ricker et al. (2015e, 2015f, 2015g, and 2015h); data from 2010 to 2013.
[3] Percent of total ESU abundance does not sum to 100% due to rounding of percentages.

Threats

The combined effects of fish harvest, hatcheries, hydropower operations, and habitat alterations caused by land management led to declines in coho salmon populations, declining coho salmon abundance and productivity, as well as range reductions and diminished life-history diversity.

The most recent status review that addressed Southern Oregon/Northern California Coast coho synthesized previous status conclusions and evaluated recent data and observations (NMFS 2016). The status review determined that, as of 2016, the ESU on the whole is still at a high risk of extinction. Specifically, NMFS (2016) describes that, "Twenty-four out of thirty-one independent populations are at high risk of extinction, six are at moderate risk of extinction, and none is at low risk of extinction. All core populations (those intended to serve as anchors for recovery) are thousands of adults short of the numbers needed for them to play their role in recovery of the entire ESU." There has not been a trend toward recovery since the species' listing or since the previous status review in 2010–2011, and NMFS's overall concern for the species' continued existence has increased due to likely effects from increased water withdrawal in many parts of the species' known range and due to drought conditions.

In 2008, ODFW convened an expert panel to develop strategic guidance on limiting factors and threats to recovery of Oregon populations of the Southern Oregon/Northern California Coast coho ESU. Limiting factors were identified for each population and effects on all life stages were considered. Key concerns for populations that intersect with the plan area include: land management and water management impacts on habitat quality (e.g., loss of habitat complexity and loss of floodplain connectivity), water quality (e.g., high water temperatures), and habitat access (e.g., low flows and road crossings), as well as hatchery impacts (e.g., genetic effects of strays on limited numbers of wild spawners) (ODFW 2008).

Threats to this ESU are summarized by independent population in Tables C6-3 and C6-4 (NMFS 2014a). These threats are listed as "overall threat rank" categories in the NMFS Southern Oregon/Northern California Coast coho salmon ESU recovery plan. Key stressors to the independent populations that overlap the plan area include lack of floodplain and channel structure, impaired water quality, impaired estuary/mainstem function, altered hydrologic function, degraded riparian forest conditions, and barriers. These stressors are caused by threats including agricultural practices, channelization and diking, dams and diversions, road and stream crossings, roads, timber harvest, invasive and non-native species, high severity fire, hatcheries, mining and gravel extraction, development, fishing, and climate change.

NMFS (2016) concluded in the most recent status review that, "Over the next five years, the most important action to safeguard SONCC coho salmon against extinction is to ensure sufficient instream flows. The most important areas to carry out these actions are those that currently support coho salmon." Additionally, recovery actions suggested for areas where Southern Oregon/Northern

California Coast coho occur included: increasing habitat complexity, expanding population specific monitoring, revising Oregon's forest practices and agricultural water quality practices legislations so that those activities do not limit recovery, removing Klamath dams, implementing emergency efforts to prevent local extinctions of high-risk independent populations, and ensuring sufficient funds to enforce regulation of environmental impacts of marijuana cultivation (especially water use and clean up).

Table C6-3. Threats Summary by Independent Population for Populations that Overlap the Plan Area

	Biogeographic Strata and Independent Populations					
	Northern Coastal Basins	Central Coastal Basins	Interior Rogue Basin			Interior Klamath Basin
Threats	Winchuck River	Smith River	Illinois River	Middle Rogue/ Applegate Rivers	Upper Rogue River	Upper Klamath River
Agricultural Practices	High	High	High	Very High	Very High	High
Channelization/ Diking	Very High	High	High	Very High	High	Very High
Dams/Diversions	Medium	Low	Very High	Very High	High	Very High
Road/Stream Crossings	Medium	High	High	High	Medium	Medium
Roads	High	High	Very High	Very High	Very High	Very High
Timber Harvest	Medium	Low	High	High	Very High	Medium
Invasive/ Non-Native Species	High	Medium	Medium	Medium	Medium	Low
Climate Change	Low	Medium	High	Low	High	Very High
High Severity Fire	Medium	Medium	Medium	Medium	Medium	Medium
Hatcheries	Low	Medium	Medium	Medium	Medium	Very High
Mining/Gravel Extraction	Low	Medium	Very High	High	Medium	Low
Urban/Residential/ Industrial Development	Very High	Medium	Medium	Very High	Very High	Low
Fishing and Collecting	Low	Low	Medium	Low	Low	Low

Source: NMFS 2014a.

Table C6-4. Threats and Key Stressors by Independent Population for Populations that Overlap the Plan Area

Biogeographic Strata and Independent Populations	Key Stressors	Threats Contributing to Key Stressors and Impacting Population Survival
Northern Coastal Basins		
Winchuck River	• Lack of floodplain and channel structure • Impaired water quality	• Water diversions and degraded riparian habitat increase temperature in the lower mainstem, which has been listed as impaired under the Clean Water Act Section 303(d).
Central Coastal Basins		
Smith River	• Impaired estuary/mainstem function • Lack of floodplain and channel structure	• Over 70% of historical tidal wetland coho habitat lost through channelization, diking, dredging, tide gates, and wetland filling. • Reed canary grass reduces estuary function. • Lack of large woody debris and floodplain and channel structure, along with increased sediment, decrease suitable summer and rearing habitat for juvenile coho salmon.
Interior Rogue Basin		
Illinois River	• Altered hydrologic function • Degraded riparian forest conditions	• Water diversion dewaters and impairs Illinois River tributaries. • High road densities, particularly along streams, exceeding levels that may result in higher sediment input to streams and alter hydrology. • Two large dams, Lake Selmac Dam and Pomeroy Diversion Dam, can hinder salmonid migration.
Middle Rogue River/Applegate	• Degraded riparian forest conditions • Altered hydrologic function	• Agricultural, irrigation diversions diminish tributary flows and elevate water temperature. • Increased impervious surfaces, such as roads, can lead to higher peak flows, channelization, diking, and non-point source pollution.
Upper Rogue River	• Altered hydrologic function • Impaired water quality	• Potential for instream water diversions and groundwater pumping to result in decreased stream flows. • Agricultural impacts, such as grazing, removal of riparian vegetation, chemical application, and channelization can increase water temperature and decrease dissolved oxygen. • Increased development can lead to increases in impervious surface area, peak flows, non-point source pollution, and water demands.
Interior Klamath Basin		
Upper Klamath River	• Barriers • Altered hydrologic function	• Four dams (Iron Gate, Copco 1, Copco 2, and J.C. Boyle) currently block approximately 76 miles of upstream coho habitat. • Highway 96 at Tom Martin Creek and Seiad Creek Road at Canyon Creek are significant road-stream barriers in the watershed. • Surface water diversions and groundwater pumping in the mainstem Klamath River alter natural timing and volume of flows. Many Klamath River tributaries experience low flow conditions.

Source: NMFS 2014a.

Literature Cited

Good, T.P., R.S. Waples, and P. Adams (editors). 2005. *Updated Status of Federally Listed ESUs of West Coast Salmon and Steelhead.* U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-66, 598p

National Marine Fisheries Service (NMFS). 1997. Endangered and Threatened Species; Threatened Status for Southern Oregon/Northern California Coast Evolutionarily Significant Unit (ESU) of Coho Salmon. *Federal Register,* 62 FR 24588. May 6.

National Marine Fisheries Service (NMFS). 1999. Designated Critical Habitat; Central California Coast and Southern Oregon/Northern California Coasts Coho Salmon. *Federal Register,* 64 FR 24049. May 5.

National Marine Fisheries Service (NMFS). 2005. Endangered and Threatened Species: Final Listing Determinations for 16 ESUs of West Coast Salmon, and Final 4(d) Protective Regulations for Threatened Salmonid ESUs. *Federal Register*, 70 FR 37160. June 28.

National Marine Fisheries Service (NMFS). 2014a. *Final Recovery Plan for the Southern Oregon/Northern California Coast Evolutionarily Significant Unit of Coho Salmon (*Oncorhynchus kisutch*). West Coast Region*. Arcata, CA. Available: http://www.westcoast.fisheries.noaa.gov/protected_species/salmon_steelhead/recovery_planning_and_implementation/southern_oregon_northern_california_coast/southern_oregon_northern_california_coast_salmon_recovery_domain.html.

National Marine Fisheries Service (NMFS). 2014b. Final Endangered Species Act (ESA) recovery plan for the Southern Oregon/Northern California Coast coho salmon (*Oncorhynchus kisutch*) Evolutionarily Significant Unit (ESU) (Final Recovery Plan). *Federal Register,* 79 FR 58750. September 20.

National Marine Fisheries Service (NMFS). 2016. *2016 5-Year Review: Summary & Evaluation of Southern Oregon/Northern California Coast Coho Salmon*. National Marine Fisheries Service West Coast Region; Arcata, California.

Nicholas, J., B. McIntosh, and E. Bowles. 2005. Oregon Coastal Coho Assessment. Final Report. Oregon Watershed Enhancement Board and Oregon Department of Fish and Wildlife; State of Oregon. May 6.

OAR 635-100-0040. *Sensitive Species List*. Oregon Administrative Rules, Department of Fish and Wildlife. Available: https://secure.sos.state.or.us/oard/viewSingleRule.action;JSESSIONID_OARD=48m67GbU0TypkHPut-5Qsa91AH9S7p1TK1q5waCD-uYNCCL1RIAt!41094264?ruleVrsnRsn=173209.

Oregon Department of Fish and Wildlife (ODFW). 2008. *Limiting Factors and Threats to the Recovery of Oregon Coho Populations in the Southern Oregon-Northern California Coast Evolutionarily Significant Unit: Results of Expert Panel Deliberations*. September 5.

Oregon Department of Fish and Wildlife (ODFW). 2010. *Lower Columbia River Conservation & Recovery Plan for Oregon Populations of Salmon & Steelhead*. August 6.

Oregon Department of Fish and Wildlife (ODFW). 2018. *Estimated Abundance of Wild Adult Coho spawners in the Southern Oregon/Northern California Coast Coho ESU, 2002–2017 – Oregon*

Populations Only. Available: https://odfw.forestry.oregonstate.edu/spawn/cohoabund.htm. Accessed: June 2018.

Oregon Department of Fish and Wildlife (ODFW). 2019. *Estimated Abundance of Wild Adult Coho spawners in the Southern Oregon/Northern California Coast Coho ESU, 2004–2018 – Oregon Populations Only*. Available: https://odfw.forestry.oregonstate.edu/spawn/cohoabund.htm. Accessed: August 2019.

Shapovalov, L. and A.C. Taft. 1954. *The Life Histories of the Steelhead Rainbow Trout (*Salmo gairdneri gairdneri*) and Silver Salmon (*Oncorhynchus kisutch*)*. Fish and Game Bulletin. 98. 275 pp.

StreamNet 2019. Database (Version 98.3) [database downloaded to disk]. Portland (OR) : StreamNet. URL: https://www.streamnet.org/data/interactive-maps-and-gis-data/

Williams, T.H., E.P. Bjorkstedt, W.G Duffy, D. Hillemeier, G. Kautsky, T.E. Lisle, M. McCain, M. Rode, R.G. Szerlong, R.S. Schick, N.M. Goslin, and A. Agrawal. 2006. *Historical Population Structure of Coho Salmon in the Southern Oregon/Northern California Coasts Evolutionarily Significant Unit.* NOAA-TM-NMFS-SWFSC-390. National Marine Fisheries Service. June.

Williams, T.H., S.T. Lindley, B.C. Spence, and D.A. Boughton. 2011. *Status Review Update for Pacific Salmon and Steelhead Listed Under the Endangered Species Act: Southwest.* National Marine Fisheries Service, Southwest Fisheries Science Center, Fisheries Ecology Division; Santa Cruz, CA. May 20.

Weitkamp, L.A., T.C. Wainwright, G.J. Bryan, G.B. Milner, D.J. Teel, R.G. Kope, and R.S. Waples. 1995. *Status Review of Coho Salmon from Washington, Oregon, and California*. NOAA Technical Memorandum NMFS-NWFSC-24. National Marine Fisheries Service, Southwest Region, Protected Species Management Division; Long Beach, CA. September.

C7 Lower Columbia River Chinook (*Oncorhynchus tshawytscha)*

The Lower Columbia River Chinook salmon evolutionarily significant unit (ESU) is one of 19 ESUs and distinct population segments of salmon and steelhead in the Pacific Northwest listed as threatened or endangered under the federal Endangered Species Act (ESA). The Lower Columbia River Chinook salmon ESU includes fall-run and spring-run Chinook salmon spawning in rivers and streams in Oregon and Washington downstream and including the White Salmon River (WA) and Hood River (OR), and the Willamette River and its tributaries downstream of Willamette Falls. Not included in the ESU are spring-run Chinook salmon in the Clackamas River.

Legal Status

State: Sensitive-critical species

Federal: Threatened (National Marine Fisheries Service [NMFS] 2005; 70 *Federal Register* [FR] 37160)

Critical Habitat: Designated (NMFS 2005; 70 FR 52630)

Recovery Planning: Recovery plan approved (NMFS 2013; 78 FR 41911)


Photo: ODFW

Lower Columbia River Chinook salmon are listed as a sensitive species under the Oregon State Sensitive Species List (OAR 635-100-0040) and are not listed under the Oregon State Endangered Species Act (ORS 496.171 to 496.192, 498.026, and 564.100 to 564.135). Oregon developed the Oregon State Lower Columbia River Conservation and Recovery Plan for the same Oregon Chinook salmon populations as the federal listing. The Oregon State Lower Columbia River Conservation and Recovery Plan addresses legal requirements for conservation planning under Oregon's Native Fish Conservation Policy. The conservation plan was approved by the Oregon Fish and Wildlife Commission in August 2010 (NMFS 2013).

Taxonomy

Chinook salmon (*Oncorhynchus tshawytscha*) were first described by Walbaum in 1792. Chinook salmon are one of five recognized species of Pacific salmon (*Oncorhynchus spp.*) that occur in North America. Chinook salmon are the largest of the Pacific salmon species;, adults may reach a weight of 45 kilograms (Healey 1991). The timing of adult entry to freshwater varies among Chinook salmon populations. The Lower Columbia River Chinook salmon ESU includes populations with adult return to freshwater in the fall (fall-run) and populations with adult return to freshwater in the spring (spring-run).

Distribution

Chinook salmon distribution is described for their entire range, the Lower Columbia River ESU, and independent populations that intersect the plan area and Oregon Department of Forestry (ODF) managed lands.

General

Chinook salmon have a wide range, second only to chum salmon. They can be found in Asia from Hokkaido, Japan, to the Anadyr River in Siberia, Russa, and in North America from Kotzebue Sound, Alaska, to the Central Valley and San Joaquin River in California (Healey 1991). Chinook salmon return to spawn in larger rivers from just above tidal influence to over 3,200 kilometers in the headwaters of the Yukon River, Alaska.

The Lower Columbia River Chinook salmon ESU includes fall-run and spring-run Chinook salmon spawning in rivers and streams in Oregon and Washington downstream and including the White Salmon River (WA) and Hood River (OR), and the Willamette River and its tributaries downstream of Willamette Falls. Not included in the ESU are spring-run Chinook salmon in the Clackamas River and fall-run Chinook salmon that originated from an up-river population and spawn in the Columbia River and tributaries upstream of the Sandy River. Also not included are several spring-run Chinook salmon hatchery releases that originated from populations outside this ESU.

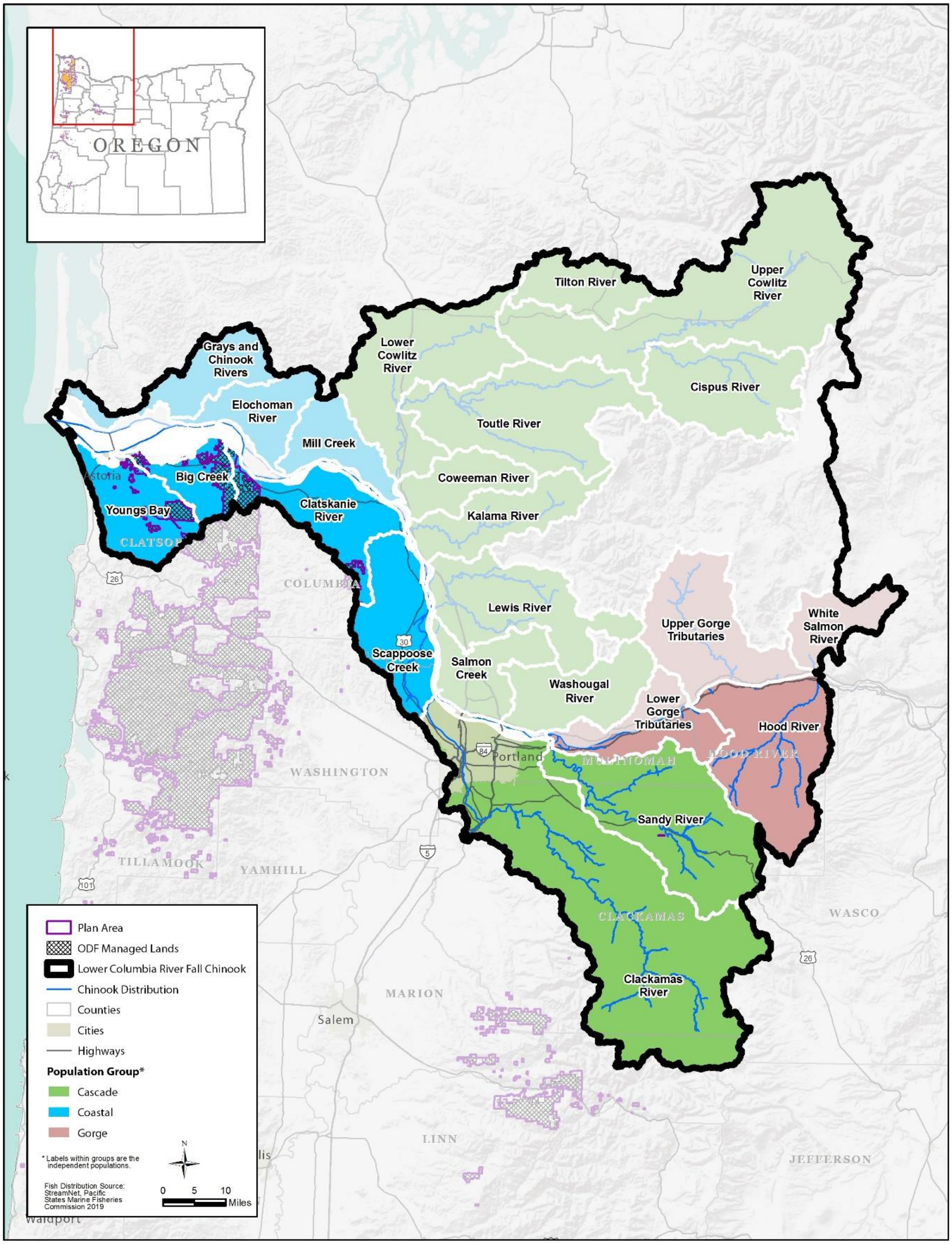
To achieve recovery of Lower Columbia River Chinook salmon ESU, NMFS aims to increase probability of persistence in all populations and reduce threats in all categories. The recovery strategies for the Lower Columbia River Chinook salmon ESU are presented below and organized by classification: spring, fall (tule), and late-fall (NMFS 2013)

The recovery strategy for the spring Lower Columbia River Chinook salmon aims to restore the Cascade spring stratum to a high probability of persistence and improving persistence probabilities of the two Gorge spring populations. The spring Lower Columbia River Chinook salmon recovery strategy also involved reducing threats in all categories with the highest priority elements entailing protection and improvement of the Sandy spring Chinook population; reestablishing naturally spawning populations above dams on the Cowlitz and North Fork Lewis rivers and in the mid- to upper-elevation habitat; protection and restoration of favorable tributary habitats; and reestablishing spring Lower Columbia River Chinook salmon in the White Salmon and Hood subbasins (NMFS 2013).

The recovery strategy for the fall (aka tule) Lower Columbia River Chinook salmon ESU aims to restore the Coast and Cascade tule strata to a high probability of persistence and improving persistence probabilities of all four Gorge-stratum populations. The tule Lower Columbia River Chinook salmon ESU recovery strategy also involved reducing threats in all categories with the highest priority elements entailing protection and improvement of the Coweemen and Lewis populations; filling information gaps regarding natural population extent and hatchery-origin spawner extent; focusing recovery efforts on populations that have the greatest change at recovery; protection of existing high-functioning habitat; aggressively implementing efforts to improve the quantity and quality of tributary and estuarine habitat; implementing aggressive efforts to reduce the influence of hatchery fish; adjusting harvest as needed to maintain abundance; and assessing habitat quantity, quality, and distribution (NMFS 2013).

The recovery strategy for the late-fall Lower Columbia River Chinook salmon ESU aims to maintain two healthy populations (the North Fork Lewis and Sandy populations) and increase persistence probability of the Sandy population. Key elements of this recovery strategy include implementation of the regional hatchery strategy aimed at minimizing impacts of hatchery releases; reducing harvest impacts on Sandy late-fall population and continuing to manage the fisheries to meet the spawning escapement goal for the Lewis River late-fall population; and implementing actions in the regional tributary and estuary habitat to benefit the tule fall Chinook salmon (NMFS 2013).

Figure C7-1. Lower Columbia River Chinook Salmon (ESU) Strata and Independent Populations in Oregon



Occurrences Within the Plan Area

The plan area does not intersect the range of any independent populations of Lower Columbia River Chinook salmon (Table 7-1).

Table C7-1. Miles of Lower Columbia River Chinook Salmon Known or Presumed Chinook Salmon Presence

Biogeographic Stratum and Independent Populations	Stream Miles with Known or Presumed Chinook Salmon Presence		
	Total Stream Miles	Miles Within or Adjacent to Plan Area	Percent of Total Within or Adjacent to Plan Area
Clackamas River	173	0	0
Sandy River	110	0	0
Lower Gorge Tributaries	68	0	0
Upper Gorge Tributaries	61	0	0
Hood River	107	0	0
Scappoose Creek	26	0	0

Source: Streamnet 2019.

Natural History

As discussed above, Chinook salmon are the largest of the Pacific salmon species and adults may reach a weight of 45 kilograms (Healey 1991), though the Lower Columbia River Chinook salmon are smaller and may approach weights of up to 25 kilograms (NMFS 2013). Chinook salmon are anadromous and semelparous (i.e., die after spawning once), and generally have a 3- to 6-year life cycle (Healey 1991); Lower Columbia River Chinook salmon return from the ocean to spawn at 2 to 6 years old (NMFS 2013).

The Lower Columbia River Chinook salmon are classified as either spring, fall, or late fall run depending on the time adults return to fresh waters. Differences between run types include time of spawning, incubation, emergence, migration, and maturation. This diversity fosters adaptability in a wide variety of systems including small streams to the large Columbia River mainstem (NMFS 2013). Lower Columbia River spring Chinook salmon enter the lower Columbia River between March and June several months prior to spawning. Lower Columbia River spring Chinook salmon are considered a “stream-type” and rear in the river for an extended period. Spring Chinook salmon usually rear in the river for a full year and migrate to the ocean as yearlings. Lower Columbia River fall (aka tule) Chinook salmon enter the lower Columbia River between August and September and spawn September through November. This run contains dark skin pigmentation and an advanced state of maturation when returning to the lower Columbia River. The Lower Columbia River fall Chinook salmon are considered “ocean-type,” and juveniles typically migrate to the ocean as subyearlings from 1 to 4 months old. They are known to use the estuary extensively and can be found there year-round (NMFS 2013). Lower Columbia River late-fall Chinook salmon, also referred to as “brights,” are the last run to return to the lower Columbia River, are less mature when they return, spawn the latest in the year, and exhibit a “stream-type” life history. They return to the lower Columbia River between August and October, and spawn from November to January.

Life History and Habitat Requirements

Throughout their life history stages, Lower Columbia River Chinook salmon utilize a range of habitats. They spawn in riffles, tailouts, and glides in tributaries and mainstems and rear in slow-water areas within large tributaries and mainstem rivers. Adults migrate up, and juvenile migrate out, through the lower Columbia River system and estuary environments. Maturation occurs at sea, including ocean migration as far north as southeast Alaska and the Aleutian Islands (NMFS 2013).

As described above, the species has diverse and complex life history strategies, but in general, there are two freshwater life history types: (1) stream-type Chinook salmon that reside in freshwater for a year or more following emergence before out-migrating to the ocean (i.e., "yearlings"), and (2) ocean-type Chinook salmon that out-migrate to the ocean within their first year following emergence (i.e., "sub-yearlings") (Gilbert 1912, and Healey 1986, as cited in Myers et al. 2006).

The timing of adult entry to freshwater varies among Chinook salmon populations; Lower Columbia River Chinook salmon ESU includes populations with adults that historically returned to freshwater in the early spring (spring-run), fall (fall run), and late fall (late-fall run) (NMFS 2013). Chinook salmon require varied habitats during different phases of their life cycle. Life history phases and corresponding habitat requirements are discussed below.

Upstream Migration and Spawning

Chinook salmon spawning habitat typically consists of gravels and cobbles in riffles and the tailouts of pools with clean silt-free substrate, in the mainstem of rivers and large tributaries (Healey 1991). In the Lower Columbia River, spawning occurs from August to January—adult Chinook may enter freshwater and migrate upstream as early as August (spring-run), through November (fall-run), and end by January (late-fall run) (NMFS 2013). Due to the variability in time of spawning between the three runs, rearing strategies vary. Spring and late-fall runs rear in the river an extended period (for up to a year) while fall run rear for 1–4 months before emigrating as sub-yearlings.

Incubation and Emergence

Following spawning and egg deposition in the fall or winter, Lower Columbia River Chinook salmon incubate in redds until for 1–2 months. After hatching, alevins remain in the gravel for a few more weeks, then emerge from redds predominantly at night (Healey 1991). Incubation success and timing is dependent on many factors including stream flow, water temperature, dissolved oxygen concentration, and the proportion of fine sediment in substrates (Healey 1991). Abiotic requirements and mortality thresholds are described in Section C3,*Upper Willamette River Chinook*.

As with Upper Willamette River Chinook, due to the timing of Lower Columbia River Chinook salmon spawning in the fall or winter and emergence of fry in the spring, eggs must survive in the redd through the high-flow winter season (Myers et al. 2006; ODFW and NMFS 2011). Elevated flows or channel scour may wash Chinook eggs out of redds or result in sedimentation following transport of silts (Healey 1991).

Freshwater Residence and Outmigration

Lower Columbia River Chinook salmon display both "stream-type" and "ocean-type" life histories. Both spring and late-fall runs display stream-type life histories while the fall run displays an ocean-type life history. Stream-type life histories entail rearing in the river for a full year, constituting an extended freshwater residency. This extended freshwater rearing occurs in watersheds with suitable rearing conditions occurring year-round. After rearing in freshwater, Spring stream-type Chinook salmon usually outmigrate quickly through the estuary and into open coastal waters. They migrate as far as the Aleutian Islands in the Northern Pacific and are widely distributed in open ocean away from the coast where they remain between 1 and 5 years (LCFRB 2010). In the ocean-type life history (fall-run), juveniles may begin to outmigrate to saline waters at 1–4 months old. Ocean-type juveniles spend weeks to months rearing in estuaries where they can be found year-round. After rearing in the estuary for weeks to months, the Lower Columbia River fall Chinook migrate northward into ocean waters in Washington, British Columbia, and Southeast Alaska where they remain for 1–5 years and return between 2–6 years of age in the late summer or fall and spawn within a few weeks. Specific rearing conditions and habitat requirements for Chinook salmon are described in Section C3 for Upper Willamette River Chinook.

Estuary Residence and Ocean Life

Like the Upper Willamette River Chinook salmon, the Lower Columbia River Chinook, and particularly the ocean-type fall-run Chinook out-migrants salmon, require estuarine and nearshore marine habitat for migration, foraging, refuge, and osmoregulation processes. Juveniles rely on shallow nearshore habitats such as intertidal flats, tidal marshes, and subtidal channels in and near estuaries. Once juvenile Chinook salmon are large enough to eat small fish, they move away from shore into deeper marine waters (Healey 1991).

Estuary conditions such as changes in food availability, off-channel habitat availability, presence of contaminants, and predation can affect juvenile survival into ocean life. Juvenile Chinook salmon are subject to predation in the Columbia River Estuary by predatory fishes (e.g., pikeminnow), birds (e.g., terns and cormorants), and pinnipeds (e.g., sea lions) (NMFS 2011b).

Ocean-type juvenile salmonids (i.e., sub-yearlings) have a tendency to use shallow-water habitats and have longer estuary residence times than stream-type juvenile salmonids (i.e., yearlings); thus, ocean-type salmonids are more affected than stream-type salmonids by flow alterations that cause changes to habitat quantity, quality, or access in wetlands and floodplains. Stream-type salmonids have comparably short estuary residence times and use the Columbia River plume more extensively; thus, stream-type juvenile salmonids are affected by plume dynamics (Fresh et al. 2005, as cited in NMFS 2011b).

Yearling Chinook out-migrants have been found to use the Columbia River plume as habitat, in contrast to sub-yearlings, which stay closer to shore. Thus, characteristics of the Columbia River plume are believed to be significant to yearling outmigrant Chinook salmon during transition to ocean life (Fresh et al. 2005, as cited in NMFS 2008).

Chinook salmon spend 6 months to 7 years maturing in the ocean before returning to freshwater to spawn (Healey 1991). After entering the ocean, Lower Columbia River Chinook migrate north to Washington, British Columbia, and southeastern Alaska (Myers et al. 2006).

Chinook salmon are opportunistic feeders. Juveniles prey on a wide variety of food such as benthic, epibenthic, and pelagic crustaceans, as well as insects, fish larva, and juvenile fish. Adult salmon feed on squid and forage fish such as smelt, sandlance, and herring while in the estuarine and marine environment (Healey 1991).

Population Status and Trends

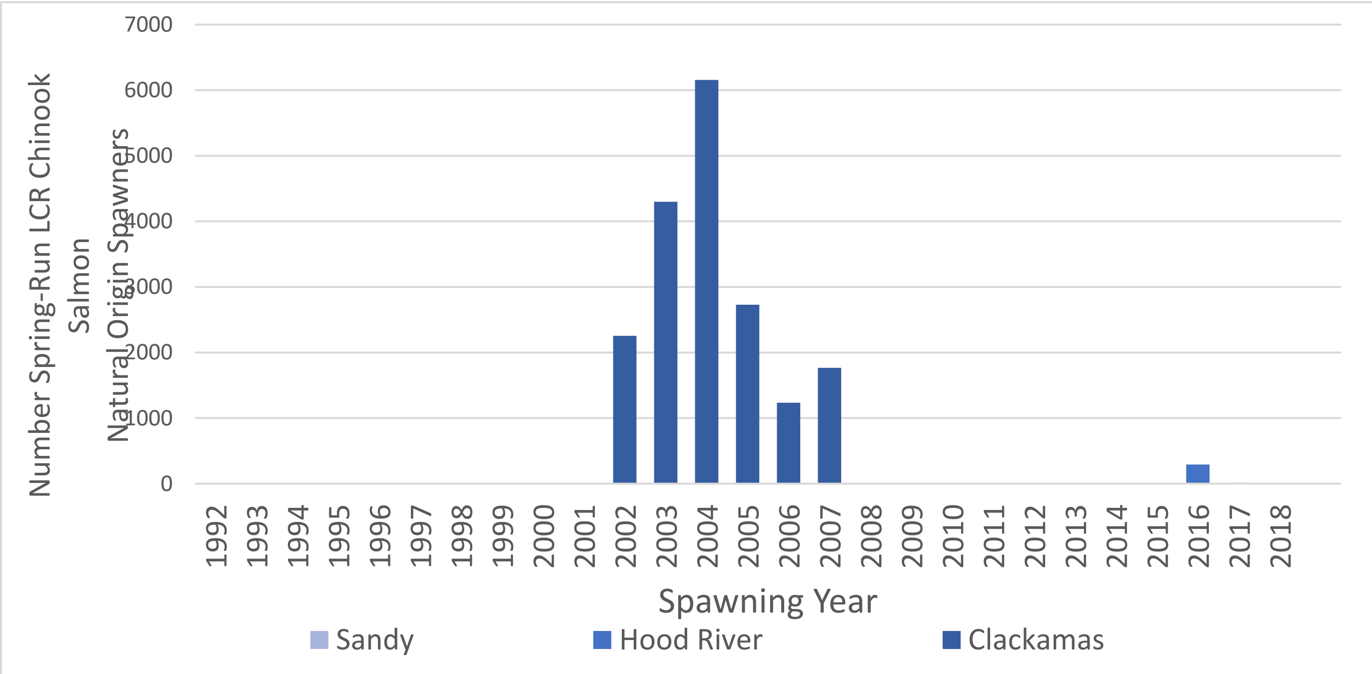
Historically, 32 independent populations once occurred in the Lower Columbia River Chinook salmon ESU: 21 fall, 2 late-fall, and 9 spring-run populations. Fourteen of these independent populations were considered highly productive "core" populations and six represent "legacy populations" which contain important genetic diversity. The Lower Columbia River Chinook Salmon Recovery Plan assumes a historical abundance off all runs in the ESU to be over 260,000 fish (NMFS 2013).

Lower Columbia River Chinook salmon population have declined significantly from once abundant historical levels, and present-day natural populations comprise less than 2% of the historical ESU abundance. Of the 32 independent populations in this ES, only 2 late-fall are considered viable (North Fork Lewis and Sandy) and most of the populations have a very low persistence probability over the next 100 years and are at high risk of extinction (NMFS 2013; LCFRB 2010; ODFW 2010; Ford et al. 2011). Low abundance, poor productivity, loss of habitat, habitat degradation, and reduced diversity are contributing to the very low persistence probability for the Lower Columbia River Chinook salmon populations.

According to the most recent status review (NMFS 2016), the majority of the populations in the Lower Columbia River Chinook salmon ESU remain at high risk, with low natural-origin abundance levels. A number of populations have a significant hatchery-origin contribution to naturally spawning fish.

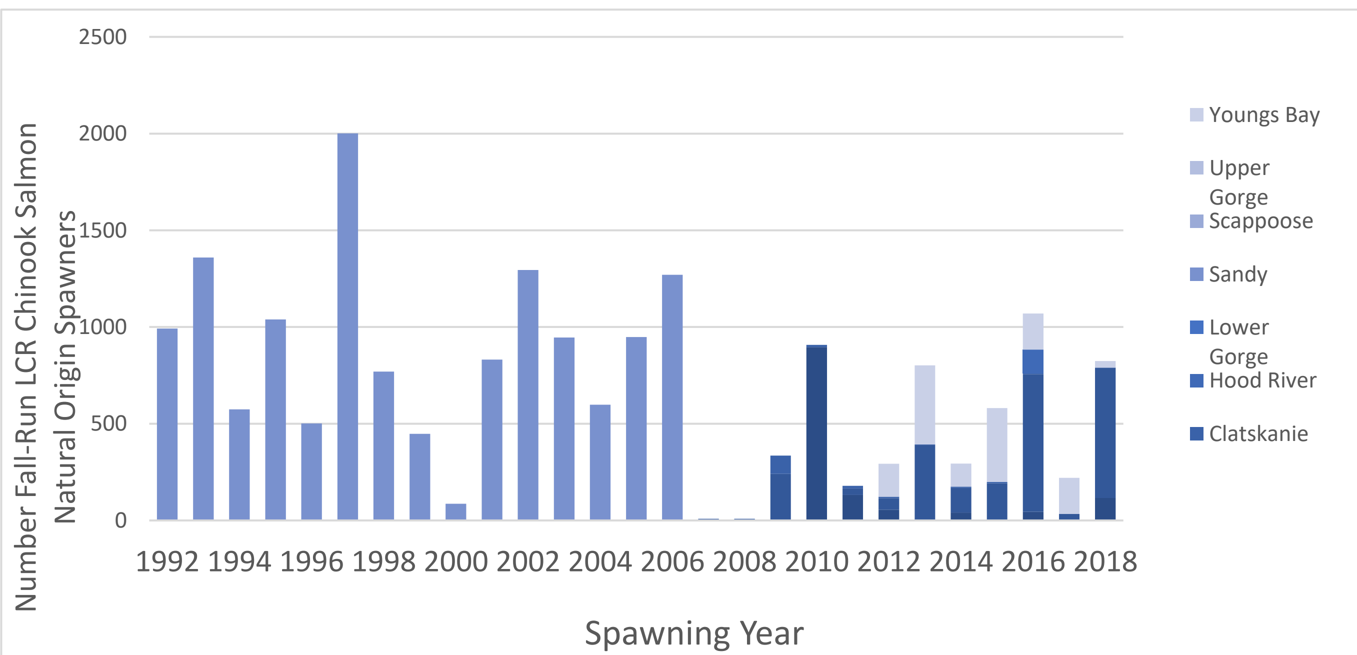
Lower Columbia River Chinook salmon natural origin spawner abundance by independent population from 1992 to 2018 is summarized in Table C7-2 and shown on Figures C7-2 and C7-3 below. The range during this period includes the high abundance in 2004 (6,157 spring-run Clackamas adults) and low in 2018 (1 fall-run Clatskanie adult), and many independent populations regularly having zero abundance during this period. The most abundant population in the ESU has consistently been the spring-run Clackamas River with an annual average of over 3,237 adults across the past 5 years of data (2003–2007), or approximately 64% of the ESU's average annual return.

Figure C7-2. Natural Origin Spring-Run Spawning LCR Chinook Abundance by Year and Independent Population



Note: the Sandy population has no data reported (1992–present).

Figure C7-3. Natural Origin Fall-Run Spawning LCR Chinook Abundance by Year and Independent Population



Note: Lower Gorge, Scappoose, and Upper Gorge have no reported abundance data (1992–present).

Table C7-2. Lower Columbia River Chinook Adult Salmon Abundance In Oregon

Biogeographic Stratum and Population	Chinook Salmon Adult Abundance		
	Recent 5-year Average and Range (2013–2017) Spring Run	Recent 5-year Average & Range (2013–2017) Fall Run	Percent of Total ESU Abundance
Clackamas River	3,237 (1,234/6157)[1]	347.4 (34/673)	71
Sandy River	No Data	1,011 (598/1,295)[3]	20
Lower Gorge Tributaries	Not Reported	No Data	No Data
Upper Gorge Tributaries	Not Reported	No Data	No Data
Hood River	153.5 (15/292)[2]	61 (0/122)[4]	4
Scappoose Creek	Not Reported	No data	No Data
Big Creek	Not Reported	40.4 (0/116)	1
Clatskanie River	Not Reported	4 (0/7)	0.08
Young's Bay	Not Reported	181.6 (34/382)	4
ESU Total	**5,037**		

Source: ODFW 2019.
1 - 2003-2007
2 - Data only available for 2016 and 2017
3- Data reported for 2002-2006
4- Data only available for 2016 and 2018

Threats

Tables C7-3 and C7-4 describe limiting factors impacting Lower Columbia River spring- and fall-run Chinook salmon population survival and the threats contributing to those limiting factors.

Table C7-3. Lower Columbia River Spring-Run Chinook Salmon Limiting Factors and Threats

Habitat Threat Category	Limiting Factors	Threats Contributing to Limiting Factors and Impacting Population Survival
Tributary	• Reduced access to historical spawning habitat • Degraded and lost floodplain, wetland, side channel, and riparian habitat • Impaired water quality and flow	• Dams and reservoirs • Land use practices • Roads and road crossings • Reduced flow from surface water withdrawals (dams, irrigation, municipal, hatchery) • Increased sedimentation
Estuary	• Toxic contaminants • Food web shifts • Impaired water quality and flow • Reduced habitat complexity and diversity	• Non-point source pollution from agricultural, urban, and industrial land practices • Changes in hydrologic regimes and water quality due to dams and reservoirs • Increased sedimentation • Extensive channelization, diking, levees, and tide gates

Habitat Threat Category	Limiting Factors	Threats Contributing to Limiting Factors and Impacting Population Survival
Hydropower	• Reduced habitat quantity access	• Tributary and mainstem dams reduce access to spawning habitat and decrease floodplain rearing habitat
Harvest	• Direct mortality	• Recreational and commercial fisheries
Hatchery	• Limited food availability • Hybridization	• Columbia Basin hatchery smolts competing for limited food resources • Hatchery fish interbreeding with wild fish
Predation	• Anthropogenic habitat alterations	• Increased predation pressure from piscivorous fish, birds, and marine mammals

Source: Adapted from Table 7-5 in NMFS 2013.

Table C7-4. Lower Columbia River Fall-Run Chinook Salmon Limiting Factors and Threats

Habitat Threat Category	Limiting Factors	Threats Contributing to Limiting Factors and Impacting Population Survival
Tributary	• Degraded and lost floodplain, wetland, side channel, and riparian habitat • Impaired water quality and flow • Increased sedimentation	• Extensive channelization, diking, levees, and wetland conversion • Land use and timber harvest practices • Reduced vegetative cover and increased impermeable surfaces • Roads and road crossings
Estuary	• Food web shifts • Impaired water quality and flow • Reduced habitat complexity and diversity	• Altered hydrologic regimes and water quality due to dams and reservoirs • Increased sedimentation • Extensive channelization, diking, levees, and tide gates • Land conversion
Hydropower	• Reduced habitat quantity access • Impaired sediment routing and estuarine food web	• Tributary dams reduce access to spawning habitat and decrease floodplain rearing habitat • Altered hydrologic regimes change natural sediment processes (i.e., Columbia River plume)
Harvest	• Direct mortality	• Recreational, tribal, and commercial fisheries
Hatchery	• Limited food availability • Hybridization	• Columbia Basin hatchery smolts competing for limited food resources • Hatchery fish interbreeding with wild fish
Predation	• Anthropogenic habitat alterations	• Increased predation pressure from piscivorous fish, birds, and marine mammals

Source: Adapted from Table 7-7 in NMFS 2013.

Literature Cited

Ford, M.J., A. Albaugh, K. Barnas, T.D. Cooney, J. Cowen, J.J. Hard, R.G. Kope, M.M. McClure, P. McElhany, J.M. Myers, and N.J. Sands. 2011. *Status Review Update for Pacific Salmon and Steelhead Listed Under the Endangered Species Act: Pacific Northwest*.

Healey, M.C., 1991. Life History of Chinook salmon (*Oncorhynchus tshawytscha*). *Pacific Salmon Life Histories*.

Lower Columbia Fish Recovery Board. 2010. *Washington Lower Columbia Salmon Recovery and Fish & Wildlife Subbasin Plan* Lower Columbia Fish Recovery Board, Washington.

Myers, J., C. Busack, D. Rawding, A. Marshall, D. Teel, D.M. Van Doornik, and M.T. Maher. 2006. *Historical Population Structure of Pacific Salmonids in the Willamette River and Lower Columbia River Basins*. NOAA Technical Memorandum NMFS-NWFSC-73. National Marine Fisheries Service, Northwest Fisheries Science Center. 311 p. February.

National Marine Fisheries Service (NMFS). 2005a. Endangered and Threatened Species: Final Listing Determinations for 16 ESUs of West Coast Salmon, and Final 4 (d) Protective Regulations for Threatened Salmonid ESUs. *Federal Register*, *70*(123 (28 June 2005), pp.37160–37204.

National Marine Fisheries Service (NMFS). 2005b. Endangered and Threatened Species; Designation of Critical Habitat for 12 Evolutionarily Significant Units of West Coast Salmon and Steelhead in Washington, Oregon, and Idaho; Final Rule. *Federal Register*, *70*, pp.52630–52858.

National Marine Fisheries Service (NMFS). 2008. *Endangered Species Act Section 7(a)(2) Consultation Biological Opinion & Magnuson-Stevens Fishery Conservation & Management Act Essential Fish Habitat Consultation: Consultation on the "Willamette River Basin Flood Control Project."* Northwest Region. July 11.

National Marine Fisheries Service. 2011. Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead. NMFS Northwest Region. Portland, OR. Prepared for NMFS by the Lower Columbia River Estuary Partnership (contractor) and PC Trask & Associates, Inc. (subcontractor). January 2011.

National Marine Fisheries Service (NMFS). 2013. *ESA Recovery Plan for Lower Columbia River Coho Salmon, Lower Columbia River Chinook Salmon, Columbia River Chum Salmon, and Lower Columbia River Steelhead*. Northwest Region. June.

Oregon Department of Fish and Wildlife (ODFW). 2010. *Lower Columbia River Conservation & Recovery Plan for Oregon Populations of Salmon & Steelhead*. August 6. Oregon Department of Fish and Wildlife, Salem, Oregon.

Oregon Department of Fish and Wildlife and National Marine Fisheries Service (ODFW and NMFS). 2011. *Upper Willamette River Conservation and Recovery Plan for Chinook Salmon and Steelhead.* August.

Oregon Department of Fish and Wildlife (ODFW). 2019. Salmon and Steelhead Recovery Tracker Chinook Data. Available: http://odfwrecoverytracker.org/. Assessed: September 2019.

State of Oregon. 1987. Oregon Endangered Species Act. (ORS 469.171 to 496.192, 498.026 and 564.135). Oregon Department of Fish and Wildlife, Salem, Oregon.

State of Oregon. 1997. Rules, O.A., Sensitive Species List (OAR 635-100-0040). State of Oregon, Oregon Department of Fish and Wildlife, Portland, Oregon.

StreamNet. 2019. Database (Version 98.3) [database downloaded to disk]. Portland (OR) : StreamNet. URL: https://www.streamnet.org/data/interactive-maps-and-gis-data/

C8 Oregon Coast Spring Chinook (*Oncorhynchus tshawytscha)*

Legal Status

The National Marine Fisheries Service (NMFS) does not currently consider Oregon Coast spring Chinook as a distinct population (evolutionarily significant unit/distinct population segment [ESU/DSP]) but rather consider them collectively with fall-run Chinook as part of the Oregon Coast Chinook ESU (NMFS 1999, ODFW 2014). However, the Native Fish Society, Center for Biological Diversity, and Umpqua Watersheds have petitioned the NMFS to list Oregon coast spring-run Chinook salmon as a threatened or endangered species under the federal Endangered Species Act (ESA) based on recent genetic evidence (Native Fish Society et al. 2019). NMFS is currently reviewing the petition, and listing of the species is considered sufficiently likely to justify including this ESU in the Habitat Conservation Plan (HCP).

State: Sensitive species

Federal: None

Critical Habitat: None

Recovery Planning: None

Photo: ODFW

Taxonomy

Oregon Coast spring Chinook have historically been considered collectively with fall-run as part of a single ESU (ODFW 2014; NMFS 1999). Waples et al. (2004) found that spring- and fall-run populations of Chinook on the Oregon coast were very similar genetically, indicating that the two forms have only recently diverged and may still occasionally interbreed. This is notably different from spring- and fall-run Chinook in the Columbia River, which are believed to be of distinct genetic lineages with much older divergence than coastal populations (Waples et al. 2004; Quinn 2018).

The recent petition for listing Oregon Coast spring Chinook (Native Fish Society et al. 2019) referenced recently published studies that the petitioners felt demonstrated a genetic basis for designating Oregon Coast spring Chinook populations as an ESU distinct from the fall-run (citing Prince et al. 2017; Davis et al. 2017; Narum et al. 2018; Thompson et al. 2019). Thompson et al. (2019) noted that widespread declines and extirpation of spring-run genetic lines will hinder recovery of spring-run populations.

Distribution

General

Based on available historical records, spring Chinook were likely present in almost all watersheds draining the Oregon Coast range that included an estuary (Native Fish Society et al. 2019), and naturally spawned Oregon Coast spring-run Chinook still occur in most Oregon coastal rivers south of the Columbia River. The Oregon Department of Fish and Wildlife (ODFW 2005) identified a Coastal spring Chinook Species Management Unit (SMU) that overlaps with the NMFS Oregon Coast Chinook ESU (Figure C8-1). The Coastal Spring-run Chinook SMU includes nine historic river populations between Tillamook Bay and the Coquille River (ODFW 2005):

- Tillamook River
- Nestucca River
- Siletz River
- Alsea River
- Siuslaw River
- South Fork Umpqua River
- North Fork Umpqua River
- Coos River
- Coquille River

The Coos River and Siuslaw River populations are presumed extinct (ODFW 2005).

Occurrences Within the Plan Area

Coastal spring-run Chinook can occur within the larger rivers and streams in any of the planning area within the Coast Range Ecoregion and in the Umpqua drainage, which includes the West Cascades Ecoregion. According to the Oregon Native Fish Status Report (2005), essentially all potential spring Chinook habitat within the Coastal ESU is accessible. Table C8-1 lists a general estimate of miles of habitat, as preliminarily identified in ODFW's Native Fish Status Report (2005). The overlap of potential occupied streams with the plan area is not provided because actual habitat usage by coastal spring Chinook is not currently quantifiable (ODFW 2005).

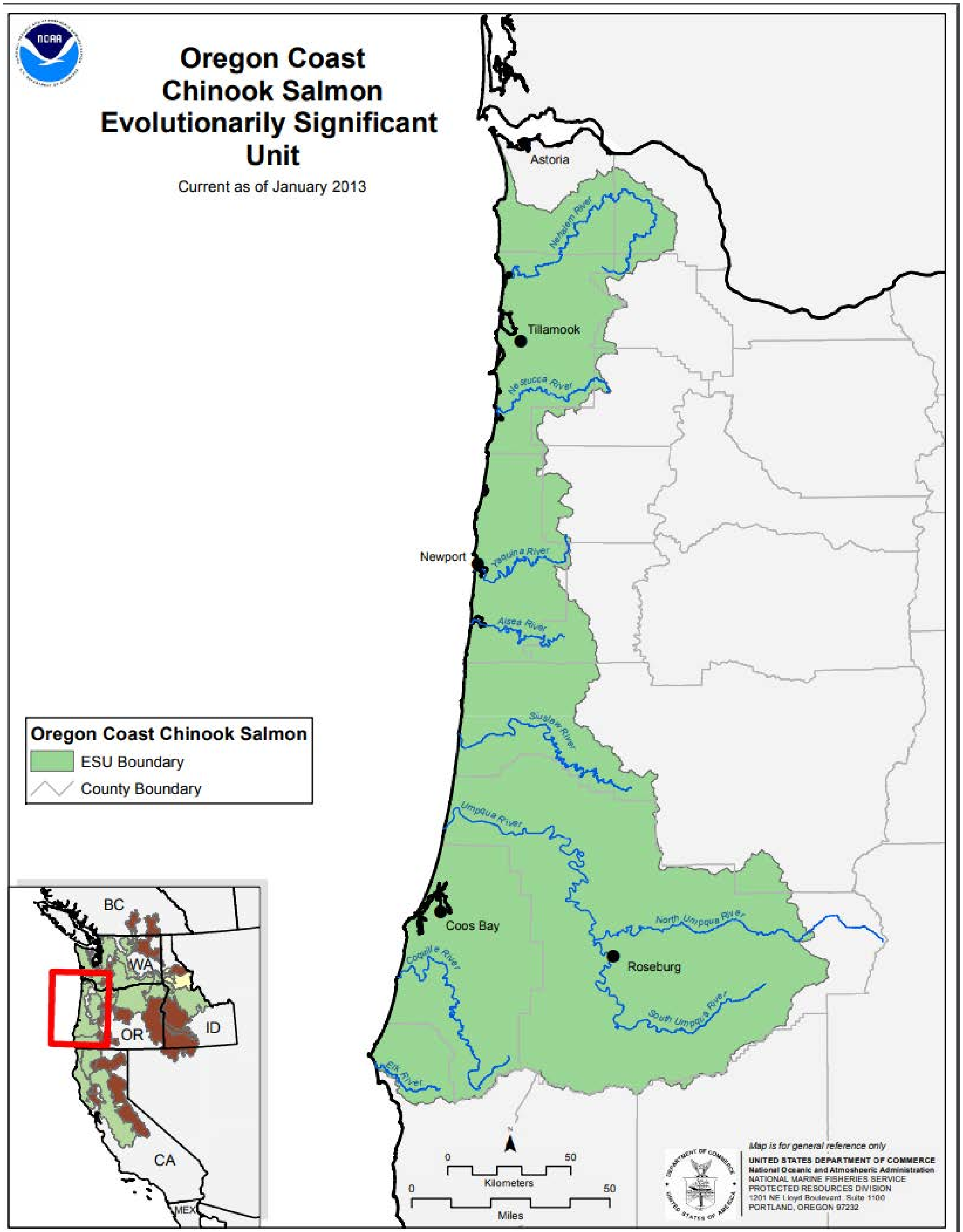
Table C8-1. Miles of Oregon Coast Spring-Run Chinook Salmon Known or Presumed Chinook Salmon Presence

Biogeographic Stratum and Independent Populations	Stream Miles with Known or Presumed Spring Chinook Salmon Presence
	Total Stream Miles
Tillamook	93
Nestucca	44
Siletz	87
Alsea	98

Biogeographic Stratum and Independent Populations	Stream Miles with Known or Presumed Spring Chinook Salmon Presence
	Total Stream Miles
Siuslaw	Presumed extinct
South Umpqua	72
North Umpqua	108
Coos	Presumed extinct
Coquille	158

Source: ODFW 2005b.

Figure C8-1. Oregon Coast Chinook Salmon ESU in Oregon



Natural History

Life History and Habitat Requirements

Upstream Migration and Spawning

Spring Chinook enter rivers during highwater in the spring to access upstream spawning areas, where they seek cold water in deep pools to hold over several months, where they sexually mature and wait for fall spawning (Quinn 2018). Low water temperature and the presence of cool, deep holding water over the dry summer season are key habitat requirements for spring-run adults.

Healey (1991) reported that Chinook spawning in general occurs in a wide range of depths, from upper reaches of streams to the mainstreams of major rivers. However, most authors note a preference for locations where subsurface flows are high, particularly near the head of riffles (shallower, rougher waters less intense than rapids). Other spawning habitat indicators noted by Healey (1991) include pools below log jams and the upstream sides of large gravel dunes oriented across the river channel.

Incubation and Emergence

Little specific information is available regarding spring Chinook incubation and emergence.

Freshwater Residence and Outmigration

Populations with spring-migrating adults often have stream-type juveniles, living in freshwater for at least a year following emergence (Quinn 2018). However, the petition to list the Oregon Coast spring-run Chinook states that this population exhibits an ocean-type life-history, migrating to sea during their first year of life, normally within 3 months after emergence from spawning gravels (Native Fish Society et al. 2019).

Estuary Residence and Ocean Life

Healey (1991) reported that Coastal Oregon stocks that spawn in rivers on the central and northern parts of the Oregon coast (from the Elk River north) migrate north to contribute to Oregon and Alaska fisheries, while stocks that spawn in rivers on the southern part of the Oregon coast (from the Rogue River south) migrate south and contribute to fisheries off Oregon and northern California.

Population Status and Trends

The 2005 Oregon Native Fish Status Report (ODFW 2005b) noted that little information was available regarding Oregon Coast spring Chinook populations, but based on available information and indirect indices, found that all river populations were at risk, with the exception of the North Umpqua. According to the listing petition (Native Fish Society et al. 2019), spring Chinook populations in every Oregon coastal basin declined significantly from historical abundance, with spring-run populations in the Siuslaw and Coos rivers potentially extirpated. Small, remnant populations of spring Chinook persist in the Tillamook, Nestucca, Siletz, Alsea, and Coquille rivers. The North Umpqua River is the only Oregon coast river to support large spring-run Chinook population, with annual returns ranging from 2,500 to 16,000.

Based on the literature review conducted by Native Fish Society et al. (2019), the population status of the nine coastal populations of spring Chinook are as follows:

- **Stable:** North Umpqua River
- **Declining:** Siletz River, Alsea River, Tillamook River, Nestucca River
- **Declining, near extinction:** Coquille River, South Umpqua River
- **Extirpated:** Siuslaw River, Coos River

Threats

Threats reported in the listing petition are similar to those reported for other salmon populations, including dams, water diversions, migration barriers, and habitat degradation due to logging and roads. Habitat effects noted include reduced stream shade, increased fine sediment levels, reduced levels of in-stream large wood, and altered watershed hydrology. The petition notes that logging can reduce summer and fall flows, which can be particularly harmful to spring Chinook during the summertime holding period of their reproduction cycle (Jones and Post 2004).

The petition also notes that hatchery spring Chinook are currently released in the Trask, Nestucca, and North Umpqua rivers and that hatcheries may inadvertently mix spring and fall stock, thereby reducing the genetic distinctness between spring and fall runs in these systems.

Literature Cited

Davis, C.D., J.C. Garza, and M.A. Banks. 2017. Identification of Multiple Genetically Distinct Populations of Chinook Salmon (*Oncorhynchus tshawytscha*) in a Small Coastal Watershed. *Environmental Biology of Fishes* 100:923–933.

Healey, M.C., 1991. Life History of Chinook salmon (*Oncorhynchus tshawytscha*). *Pacific Salmon Life Histories*.

Jacobs S., J. Firman, and G. Susac. 2001. *Status of Oregon Coastal Stocks of Anadromous Salmonids, 1999-2000*. Monitoring Program Report Number OPSW-ODFW-2001-3, Oregon Department of Fish and Wildlife, Portland, Oregon.

Jones, J. A., and Post, D. A. 2004. Seasonal and Successional Streamflow Response to Forest Cutting and Regrowth in the Northwest and Eastern United States. *Water Resources Research* 40(5):W05203, doi:10.1029/2003WR002952.

Narum, S. R., A. Di Genova, S.J. Micheletti, and A. Maass. 2018. Genomic Variation Underlying Complex Life-History Traits Revealed by Genome Sequencing in Chinook Salmon. *Proceedings of the Royal Society B: Biological Sciences* 285(1883):20180935.

Native Fish Society, Center for Biological Diversity, and Umpqua Watersheds. 2019. Petition to List the Oregon Coast ESU of Spring-Run Chinook Salmon (*Oncorhynchus tshawytscha*) under the Endangered Species Act. September 24.

National Marine Fisheries Service (NMFS). 1999. Endangered and Threatened Species; Threatened Status for Three Chinook Salmon Evolutionarily Significant Units (ESUs) in Washington and

Oregon, and Endangered Status for One Chinook Salmon ESU in Washington. *Federal Register*, 64 FR 14308. March 24.

ODFW (Oregon Department of Fish and Wildlife). 2005a. *Oregon Native Fish Status Report, Volume I: Species Management Unit Summaries.* ODFW Fish Division, Salem, OR.

ODFW (Oregon Department of Fish and Wildlife). 2005b. *Oregon Native Fish Status Report, Volume II: Assessment Methods & Population Results*. ODFW Fish Division, Salem, OR.

ODFW (Oregon Department of Fish and Wildlife). 2014. *Coastal Multi-Species Conservation and Management Plan.*

Prince, D.J., S.M. O'Rourke, T.Q. Thompson, O.A. Ali, H.S. Lyman, I.K. Saglam, T.J. Hotaling, A.P. Spidle, and M.R. Miller. 2017. The Evolutionary Basis of Premature Migration in Pacific Salmon Highlights the Utility of Genomics for Informing Conservation. *Science Advances* 3, August 16, 2017.

Quinn, Thomas P. 2018. *The Behavior and Ecology of Pacific Salmon and Trout*. University of Washington Press. Seattle, WA.

Thompson T.Q., R.M. Bellinger, S.M. O'Rourke, D.J. Prince, A.E. Stevenson, A.T. Rodrigues, M.R. Sloat, C.F. Speller, D.Y. Yang, V.L. Butler, M.A. Banks, and M.R. Miller. 2019. Anthropogenic Habitat Alteration Leads to Rapid Loss of Adaptive Variation and Restoration Potential in Wild Salmon Populations. *Proceedings of the National Academy of Sciences* 116 (1), 177-186.

Teel, D.J., B.J. Burke, D.R. Kuligowski, C.A. Morgan and D.M. Van Doornik. 2015. Genetic Identification of Chinook Salmon: Stock-Specific Distributions of Juveniles Along the Washington and Oregon Coasts. *Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science* 7: 274–300.

Waples, R., D.J. Teel, J.M. Myers and A.R. Marshall. 2004. Life-History Divergence in Chinook Salmon; Historic Contingency and Parallel Evolution. Evolution 58 (2):386-403.

C9 Southern Oregon/Northern California Spring Chinook (*Oncorhynchus tshawytscha*)

Legal Status

Southern Oregon/Northern California Coastal (SONCC) spring Chinook salmon are not listed as threatened or endangered under the Oregon State Endangered Species Act nor the California State Endangered Species Act.

The National Marine Fisheries Service (NMFS) does not currently consider SONCC spring Chinook as a distinct population (evolutionarily significant unit/distinct population segment [ESU/DSP]) but rather consider them collectively with fall-run Chinook as part of the SONCC Chinook ESU (NMFS 1999). However, there has been a petition to designate SONCC spring-run Chinook as a separate ESU and list them as a threatened or endangered species under the Endangered Species Act (Nawa 2020). NMFS has since reviewed the petition and concluded that SONCC spring-run Chinook salmon do not meet the criteria to be a designated separate ESU and thus do not warrant Endangered Species Act listing (Ford et al. 2021; NMFS 2021).

State: Oregon - Sensitive species, California – Moderate concern

Federal: None

Critical Habitat: None

Recovery Planning: None

Photo: ODFW

Taxonomy

SONCC spring Chinook have historically been considered collectively with fall-run as part of a single ESU (Moyle et al. 2015; ODFW 2014; NMFS 1999). Waples et al. (2004) found that spring- and fall-run populations of Chinook on the Oregon coast were very similar genetically, indicating that the two forms have only recently diverged and may still occasionally interbreed. This is notably different from spring- and fall-run Chinook in the Columbia River, which are believed to be of distinct genetic lineages with much older divergence than coastal populations (Waples et al. 2004; Quinn 2018).

The recent petition for listing SONCC spring Chinook (Nawa 2020) referenced recently published studies that the petitioner felt demonstrated a genetic basis for designating SONCC spring Chinook populations as an ESU distinct from the fall-run (citing Prince et al. 2017; Davis et al. 2017; Narum et al. 2018; Thompson et al. 2019). Thompson et al. (2019) noted that widespread declines and extirpation of spring-run genetic lines will hinder recovery of spring-run populations.

Distribution

General

Based on available historical records, SONCC spring Chinook were likely present in almost all watersheds along the Oregon Coast south to the Russian River in California that included an estuary (Native Fish Society et al. 2019). Because this HCP is a document for the state of Oregon, the scope of this section is limited to Oregon. Currently, spring Chinook in the SONCC Chinook ESU are essentially limited to Rogue River. However, spring Chinook have been observed incidentally in the Applegate, Pistol, Illinois, and Chetco Rivers during surveys conducted for other purposes (ODFW 2007).

The Oregon Department of Fish and Wildlife (ODFW 2005) identifies a Coastal spring Chinook Species Management Unit (SMU) that is a portion of the NMFS SONCC Chinook ESU (Figure C9-1). The Rogue Spring Chinook SMU consists of a single population in the upper Rogue River basin upstream of the historical site of Gold Ray Dam.

Occurrences Within the Plan Area

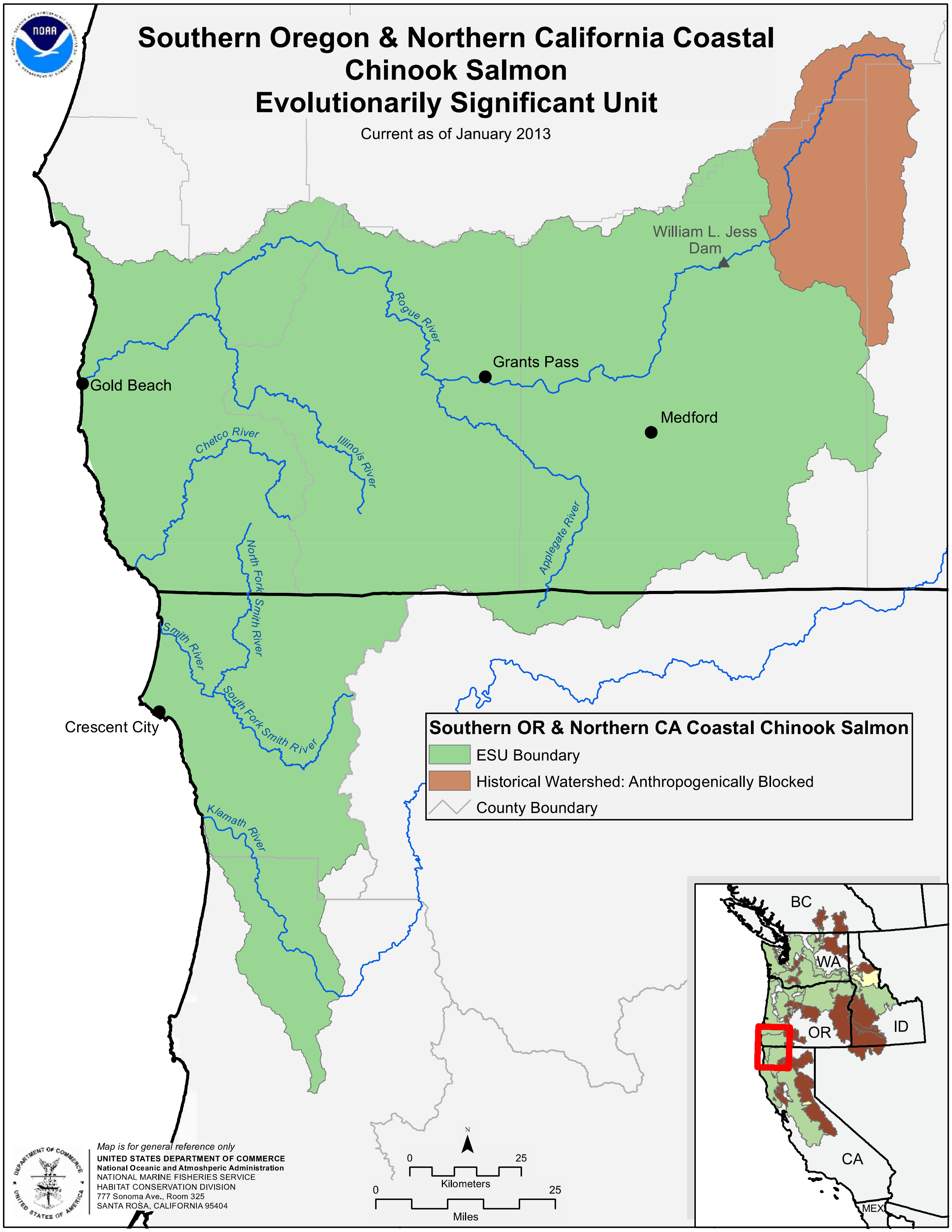
SONCC spring-run Chinook can occur within the larger rivers and streams in any of the planning area within the Coast Range Ecoregion and West Cascades Ecoregions. According to the Oregon Native Fish Status Report (2005), 79% of the potential spring Chinook habitat within the Rogue SMU is accessible. Table C9-1 provides an estimate of miles of habitat, as identified in ODFW's Native Fish Status Report (2005). The overlap of potentially occupied streams with the plan area is not provided because actual habitat usage by SONCC spring Chinook is not currently quantifiable (ODFW 2005).

Table C9-1. Miles of Southern Oregon and California Coastal Spring Chinook Salmon Known or Presumed Spring Chinook Salmon Presence

Biogeographic Stratum and Independent Populations	Stream Miles with Known or Presumed Spring Chinook Salmon Presence
	Total Stream Miles
Rogue	33

Source: ODFW 2005.

Figure C9-1. Southern Oregon and Northern California Coastal Chinook Salmon ESU in Oregon and California



Natural History

Life History and Habitat Requirements

Upstream Migration and Spawning

Spring Chinook enter rivers during highwater in the spring to access upstream spawning areas, where they seek cold water in deep pools to hold over several months, where they sexually mature and wait for fall spawning (Quinn 2018). Low water temperature and the presence of cool, deep holding water over the dry summer season are key habitat requirements for spring-run adults.

Healey (1991) reported that Chinook spawning in general occurs in a wide range of depths, from upper reaches of streams to the mainstreams of major rivers. However, most authors note a preference for locations where subsurface flows are high, particularly near the head of riffles (shallower, rougher waters less intense than rapids). Other spawning habitat indicators noted by Healey (1991) include pools below log jams and the upstream sides of large gravel dunes oriented across the river channel.

Incubation and Emergence

Peak spawning time tends to be during the second week of October with fry emergence from the gravel beginning in January and ending in late April or early May (ODFW 2000).

Freshwater Residence and Outmigration

In the Rogue River spring Chinook juveniles outmigrants were predominately sub-yearlings with a small portion outmigrating as yearlings (ODFW 2000). Outmigration timing begins in mid-May and continues through late-September with ocean entry tending to occur from August to October for sub-yearlings and May and June for yearlings (ODFW 2000). Sub-yearling tended to rearing in the Rogue for 4–5 months.

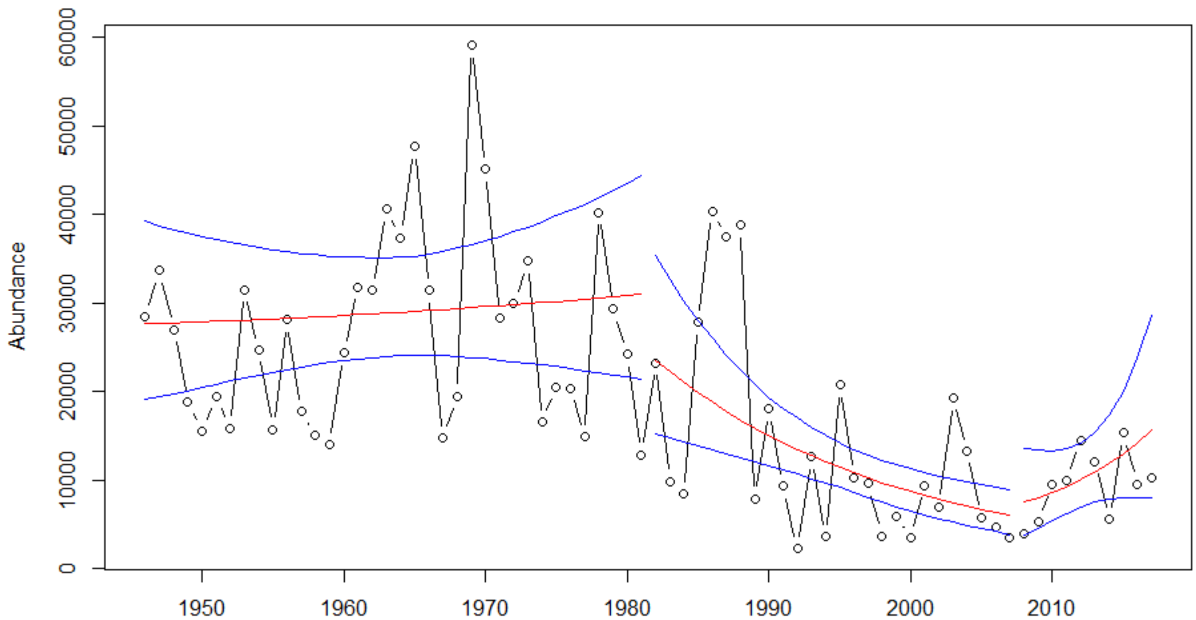
Estuary Residence and Ocean Life

Healey (1991) reported that stocks that spawn in rivers on the southern part of the Oregon coast (from the Rogue River south) migrate south and contribute to fisheries off Oregon and northern California.

Population Status and Trends

The rogue River has a long time series of spawner abundance estimates that started in 1942 and continues to today. Estimates of the number of spring Chinook salmon above the historic Gold Ray Dam site, 1942–2017, ranged from 1,617 to 57,797 (ODFW 2007). Though well below historic spawner abundance levels the current trend has been increasing abundance since 2000 (Figure C9-2).

Figure C9-2. Spring Chinook Spawner Abundance Estimates for Rogue River Above the Historic Gold Ray Dam Site, 1946–2017



Source: ODFW 2019

Threats

Threats reported in the listing petition are similar to those reported for other salmon populations, including dams, water diversions, migration barriers, and habitat degradation due to logging and roads. Habitat effects noted include reduced stream shade, increased fine sediment levels, reduced levels of in-stream large wood, and altered watershed hydrology. The petition notes that logging can reduce summer and fall flows, which can be particularly harmful to spring Chinook during the summertime holding period of their reproduction cycle (Jones and Post 2004).

The petition also notes that hatchery spring Chinook released into the Rogue River are inadvertently mixing with the wild spring stock on the spawning grounds, thereby reducing the fitness.

Literature Cited

Davis, C.D., J.C. Garza, and M.A. Banks. 2017. Identification of Multiple Genetically Distinct Populations of Chinook Salmon (*Oncorhynchus tshawytscha*) in a Small Coastal Watershed. *Environmental Biology of Fishes* 100:923–933.

Ford, M., E. Anderson, J. Carlos Garza, J. Myers, T. H. Williams, and R. Waples. 2021. *Report on a Review of the Oregon Coast and Southern Oregon Northern California Coastal Spring Chinook Salmon ESU Configuration.* National Marine Fisheries Service.

Healey M.C. 1991 Life History of Chinook Salmon (*Oncorhynchus tshawytscha*). Pages 313–393 in C. Groot and L. Margolis (eds.), *Pacific Salmon Life Histories*. University of British Columbia Press, Vancouver.

Jones, J. A., and Post, D. A. 2004. Seasonal and Successional Streamflow Response to Forest Cutting and Regrowth in the Northwest and Eastern United States. *Water Resources Research* 40(5):W05203, doi:10.1029/2003WR002952.

Moyle, P.B. 2002. *Inland Fishes of California*. University of California Press. 502pp.

Moyle, P.B., R. M. Quiñones, J. V. Katz, and J. Weaver. 2015. *Fish Species of Special Concern in California.* Sacramento: California Department of Fish and Wildlife.

Narum, S. R., A. Di Genova, S.J. Micheletti, and A. Maass. 2018. Genomic Variation Underlying Complex Life-History Traits Revealed by Genome Sequencing in Chinook Salmon. *Proceedings of the Royal Society B: Biological Sciences* 285(1883):20180935.

Native Fish Society, Center for Biological Diversity, and Umpqua Watersheds. 2019. Petition to List the Oregon Coast ESU of Spring-Run Chinook Salmon (*Oncorhynchus tshawytscha*) under the Endangered Species Act. September 24.

Nawa, Richard K. 2020. Petition to List the Southern Oregon and Northern California Coastal ESU of Spring-Run Chinook Salmon (Oncorhynchus tshawytscha) under the Endangered Species Act. May 4.

NMFS (National Marine Fisheries Service). 1999. Endangered and Threatened Species; Threatened Status for Three Chinook Salmon Evolutionarily Significant Units (ESUs) in Washington and Oregon, and Endangered Status for One Chinook Salmon ESU in Washington. *Federal Register*, 64 FR 14308. March 24.

NMFS (National Marine Fisheries Service). 2021. Listing Endangered and Threatened Wildlife; 12-Month Findings on Petitions To List Spring-Run Oregon Coast Chinook Salmon and Spring- Run Southern Oregon and Northern California Coastal Chinook Salmon as Threatened or Endangered Under the Endangered Species Act. *Federal Register*, 86 FR 45970. August 17.

ODFW (Oregon Department of Fish and Wildlife). 2000. *Effects of Lost Creek Dam on Spring Chinook Salmon in the Rogue River. Phase II Completion Report*. Oregon Department of Fish and Wildlife, Fish Research Project DACW 57-77-C-0033, Completion Report, Portland.

ODFW (Oregon Department of Fish and Wildlife 2005. *Oregon Native Fish Status Report, Volume II: Assessment Methods & Population Results*. ODFW Fish Division, Salem, OR.

ODFW (Oregon Department of Fish and Wildlife). 2007. *Rogue Spring Chinook Salmon Conservation Plan*. ODFW Fish Division, Salem, OR.

ODFW (Oregon Department of Fish and Wildlife). 2014. *Coastal Multi-Species Conservation and Management Plan*. ODFW Fish Division, Salem, OR.

ODFW (Oregon Department of Fish and Wildlife). 2019. *Rogue Spring Chinook Salmon Conservation Plan Comprehensive Assessment and Update*. ODFW Fish Division, Salem, OR.

Prince, D.J., S.M. O'Rourke, T.Q. Thompson, O.A. Ali, H.S. Lyman, I.K. Saglam, T.J. Hotaling, A.P. Spidle, and M.R. Miller. 2017. The Evolutionary Basis of Premature Migration in Pacific Salmon Highlights the Utility of Genomics for Informing Conservation. *Science Advances* 3, August 16, 2017.

Quinn, Thomas P. 2018. *The Behavior and Ecology of Pacific Salmon and Trout*. University of Washington Press. Seattle, WA.

Thompson T.Q., R.M. Bellinger, S.M. O'Rourke, D.J. Prince, A.E. Stevenson, A.T. Rodrigues, M.R. Sloat, C.F. Speller, D.Y. Yang, V.L. Butler, M.A. Banks, and M.R. Miller. 2019. Anthropogenic Habitat Alteration Leads to Rapid Loss of Adaptive Variation and Restoration Potential in Wild Salmon Populations. *Proceedings of the National Academy of Sciences* 116 (1), 177–186.

Waples, R., D.J. Teel, J.M. Myers and A.R. Marshall. 2004. Life-History Divergence in Chinook Salmon; Historic Contingency and Parallel Evolution. *Evolution* 58(2):386–403.

C10 Eulachon (*Thaleichthys pacificus*)

The southern distinct population segment (DPS) of pacific eulachon or smelt is listed as threatened under the federal Endangered Species Act (ESA). Critical habitat was designated in 2011 and includes 16 creeks and rivers within Washington, Oregon, and California.

Legal Status

State: Oregon Nearshore Strategy Species (Oregon Department of Fish and Wildlife [ODFW] 2006)

Federal: Threatened (National Marine Fisheries Service [NMFS] 2009, final rule 2010; 75 *Federal Register* [FR] 13012)

Critical Habitat: Designated (NMFS final rule 2011; 76 FR 65324)

Recovery Planning: Recovery plan approved (NMFS 2017; 81 FR 72572)

Status Review: 5-year status review (NMFS 2016; 81 FR 33468)

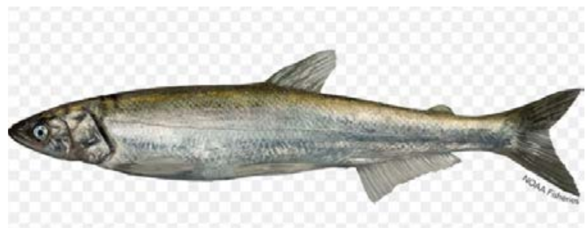


Photo: NOAA Fisheries

Taxonomy

Eulachon are anadromous smelt in the family Osmeridae. The genus *Thaleichthys* has only one species; subspecies have not been described (NMFS 2017).

Distribution

General

Eulachon range from Northern California to the southeastern Bering Sea in Bristol Bay, Alaska. The southern DPS includes four subpopulations: Klamath River, Columbia River, Fraser River, and British Columbia coastal rivers of the Nass River (NMFS 2017). Their distribution coincides closely with the distribution of the coastal temperate rain forest ecosystem on the west coast of North America. South of the U.S.-Canada border most eulachon production originates in the Columbia River Basin, with the Columbia and Cowlitz rivers having the largest and most consistent spawning returns. Spawning also occurs in other tributaries to the Columbia River, including the Grays, Elochoman, Kalama, Lewis, and Sandy rivers. The only other larger river basins in the contiguous U.S. with historically large, consistent spawning runs of eulachon are the Umpqua River in Oregon and Klamath River in northern California (NMFS 2011). Eulachon have also historically occurred in the following coastal creeks and rivers: Tenmile Creek, Siuslaw River, Winchuck River, Chetco River, Rogue River, Pistol River, Elk River, Sixes River, Coquille River, Coos River, Yaquina River, Hunter Creek, and Euchre Creek (NMFS 2017).

Occurrences Within the Plan Area

StreamNet does not report eulachon distribution data so distribution of eulachon in the plan area is based on the NMFS critical habitat extent. Within the DPS, eulachon occur primarily in the mainstem Columbia River and alcoves in the mouths of its tributaries (Figure C10-1). These mainstem rivers are outside the plan area, and eulachon are unlikely to migrate upstream into the streams that occur in the plan area. The Washington Department of Fish and Wildlife (WDFW) has maintained a eulachon monitoring location at river kilometer 55 across the Clifton Channel from the Oregon shore to Tenasillahe Island, which is adjacent to the plan area. Therefore, it is unlikely that eulachon will occur in the plan area. ODFW and WDFW (2014) report lower egg densities at this site than farther upstream at their Prince Island sites. This is likely due to the majority of eulachon spawning tributaries occurring on the Washington shore as well as eulachon generally spawning farther upstream than the Clifton Channel site (ODFW and WDFW 2014). Based on what is known about eulachon distribution throughout their range it is unlikely that they will occur in the plan area.

Natural History

Life History and Habitat Requirements

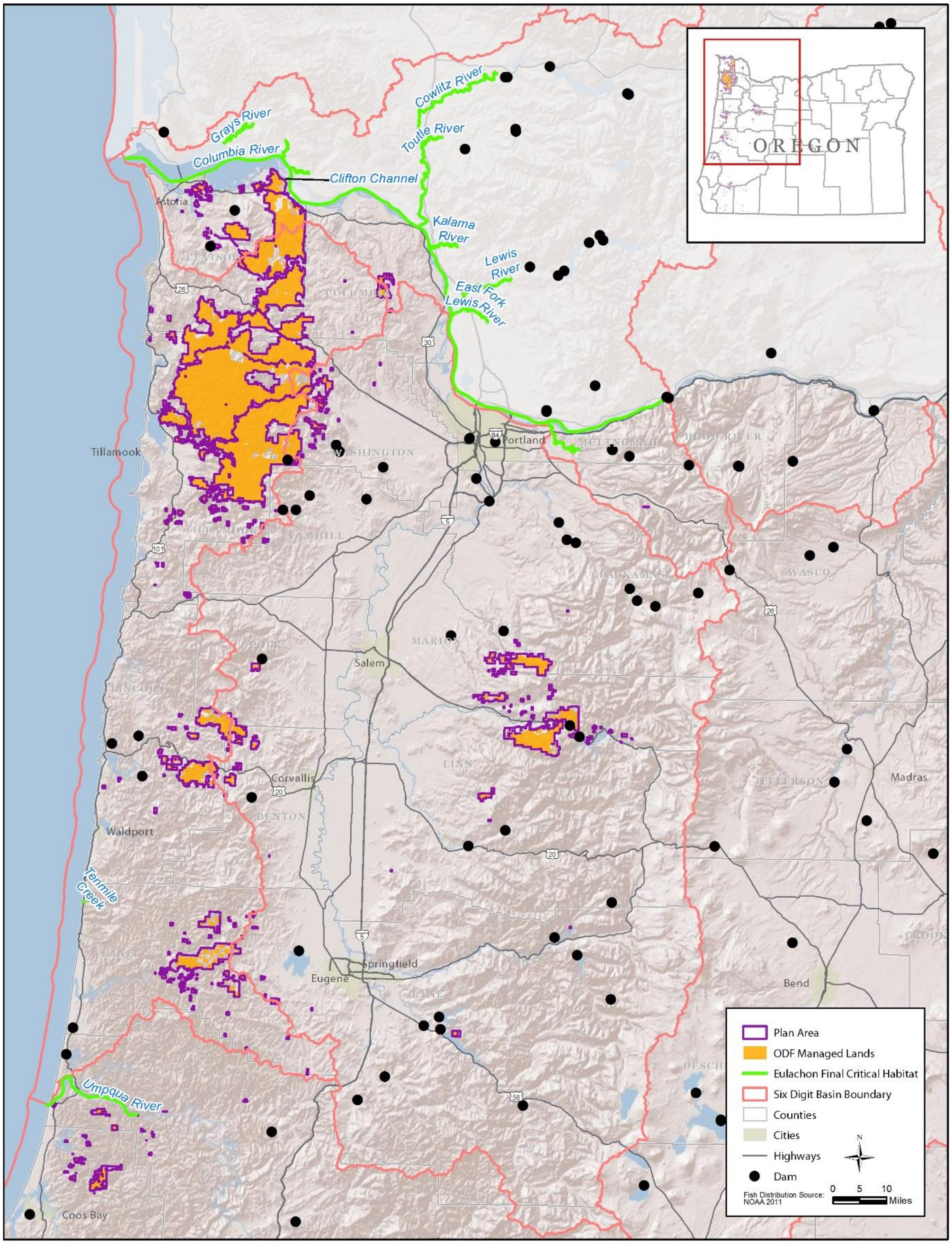
Eulachon are a short lived, high fecundity, high mortality forage fish, and tend to have extremely large population sizes. Eulachon abundance exhibits considerable year-to-year variability. Eulachon typically spend 3 to 5 years in saltwater before returning to freshwater to spawn from late winter through mid-spring.

Early Life History

Eulachon eggs average 1 millimeter in size and are broadcast into the water column, attaching to a variety of substrates from sand to pea-sized gravel. Eggs are fertilized in the water column. After fertilization, the eggs sink and adhere to the river bottom, typically in areas of gravel and coarse sand. Most eulachon adults die after spawning. Eulachon eggs hatch in 20 to 40 days with incubation time depending on water temperature (Howell 2001). Newly hatched young, transparent and 4 to 7 millimeters in length, are carried to the sea with the current (Hay and McCarter 2000). It is not known how long larval eulachon remain in the estuary before entering the ocean (NMFS 2011). Like salmon, juvenile eulachon are thought to imprint on the chemical signature of their natal river basins. However, because juvenile eulachon spend less time in freshwater environments than do juvenile salmon, researchers hypothesize that this short freshwater residence time may cause returning eulachon to stray between spawning sites at higher rates than salmon (Hay and McCarter 2000).

Once juvenile eulachon enter the ocean, they move from shallow nearshore areas to deeper areas over the continental shelf. Larvae and young juveniles become widely distributed in coastal waters, where they are typically found near the ocean bottom in waters 20 to 150 meters deep (66–292 feet) (Hay and McCarter 2000) and sometimes as deep as 182 meters (597 feet) (Barraclough 1964). Despite spending over 95% of their lives in the ocean, little is known about eulachon oceanic distribution and ecology (NMFS 2017).

Figure C10-1. Southern DPS Eulachon Critical Habitat Extent



Spawning

Eulachon are semelparous, meaning that they spawn once and then die. Eulachon generally spawn in rivers that are either glacier or snowpack fed and that experience spring freshets (Hay and McCarter 2000, as reported in Willson et al. 2006). Spawning grounds are typically in the lower reaches of larger rivers fed by snowmelt, and spawning typically occurs at night. In many rivers, spawning is limited to the part of the river that is influenced by tides (Lewis et al. 2002).

The Columbia River, below Bonneville Dam, is a very productive and preferred spawning area for eulachon. The mainstem of the Lower Columbia River provides spawning and incubation sites and a migratory corridor to spawning areas in the tributaries.

Spawning substrates can range from silt, sand, or gravel to cobble and detritus, but sand appears to be most common. Eulachon eggs are enclosed in a double membrane; after fertilization in the water, the outer membrane breaks and turns inside out, creating a sticky stalk, which anchors the eggs to the substrate (Hart and McHugh 1944; Hay and McCarter 2000).

Spawning occurs at between 0 and 10°C throughout the range of the species and is largely limited to the part of the river that is tidally influenced (Lewis et al. 2002). Entry into the spawning rivers appears to be related to water temperature and the occurrence of high tides (Ricker et al. 1954; Smith and Saalfeld 1955; Spangler 2002). Spawning generally occurs in January, February, and March in the Columbia River, the Klamath River, and the coastal rivers of Washington and Oregon. It has been argued that because these freshets rapidly move eulachon eggs and larvae to estuaries, it is likely that eulachon imprint and home to an estuary into which several rivers drain rather than to individual spawning rivers (Hay and McCarter 2000). There is some evidence that water velocity greater than 0.4 meters/second (1.3 feet/second) begins to limit the upstream movements of eulachon (Lewis et al. 2002).

Ecological Relationships

Eulachon adults feed on zooplankton, chiefly eating crustaceans such as copepods and euphausiids, including *Thysanoessa* spp. (Hay and McCarter 2000; WDFW and ODFW 2001), unidentified malacostracans (Sturdevant 1999), and cumaceans (Smith and Saalfeld 1955). Eulachon larvae and juveniles eat a variety of prey items, including phytoplankton, copepods, copepod eggs, mysids, barnacle larvae, worm larvae, and eulachon larvae (WDFW and ODFW 2001). Adults and juveniles commonly forage at moderate depths (20–150 meters [66–292 feet]) in nearshore marine waters (Hay and McCarter 2000). Eulachon adults do not feed during spawning (McHugh 1939; Hart and McHugh 1944).

Eulachon are very high in lipids, and their historical large spawning runs made them an important part of the Pacific coastal food web (Gustafson et al. 2010). They have numerous avian predators, including sea birds such as harlequin ducks, pigeon guillemots, common murres, mergansers, cormorants, gulls, and eagles (Gustafson et al. 2010). Marine mammals such as baleen whales, orcas, dolphins, pinnipeds, and beluga whales are known to feed on eulachon. Fish that prey on eulachon include white sturgeon, spiny dogfish, sablefish, salmon sharks, arrowtooth flounder, Pacific hake, salmon, Dolly Varden, Pacific halibut, and Pacific cod (Gustafson et al. 2010). Eulachon and their eggs seem to provide a significant food source for white sturgeon in the Columbia and Fraser rivers (Gustafson et al. 2010)

Population Status and Trends

Commercially landed eulachon in the Columbia River has declined from 2.1 million pounds annually from 1938–1989 to 5,000 pounds in 1999 (Gustafson et al. 2010). The current abundance of eulachon is low and declining in all surveyed populations throughout the DPS (NMFS 2011). Eulachon populations spawning in the Klamath River, lower Columbia River Basin, and Fraser River have declined substantially, and the southern DPS will likely become endangered in the foreseeable future if ongoing threats are not addressed (NMFS 2011). Past and ongoing federal, state, and local protective efforts (many of them habitat-based) have contributed to the conservation of the southern DPS, but these efforts alone do not sufficiently reduce the extinction risks faced by the southern DPS (NMFS 2011).

Threats

A federal recovery plan for the southern DPS eulachon was finalized in September 2017 (81 FR 72572). The plan provides guidance to increase the abundance and productivity through its geographical range and improve the viability of the species to the point that it meets the delisting criteria and no longer requires ESA protection. The primary threats identified in the recovery plan are deteriorating ocean, estuarine, and plume conditions as a result of climate change impacts, dams/water diversions; predation; and eulachon as bycatch in offshore shrimp fishery trawls (NMFS 2017).

Habitat loss and degradation threaten eulachon, particularly in the Columbia River basin (NMFS 2011). Hydroelectric dams block access to historical eulachon spawning grounds and affect the quality of spawning substrates through flow management, altered delivery of coarse sediments, and siltation. Freshwater and estuarine migration corridors need to be free of obstructions to support larval and adult movement. Nearshore and offshore marine foraging habitats for juveniles need to be rich with crustaceans such as copepods and euphausiids, mysids, barnacle larvae, and worm larvae for juveniles to feed after they have fully absorbed their yolk sac (NMFS 2011).

Literature Cited

Barraclough W. E. 1964. Contribution to the Marine Life History of the Eulachon *Thaleichthys pacificus*. *J. Fish. Res. Board Can*. 21:1333–1337.

Gustafson, R.G., M.J. Ford, D. Teel, and J.S. Drake. 2010. *Status Review of Eulachon (*Thaleichthys pacificus*) in Washington, Oregon, and California*. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-105, 360 p.

Gustafson, R., Y.-W. Lee, E. Ward, K. Somers, V. Tuttle, J. Jannot, and J. McVeigh. 2017*. Observed and Estimated Bycatch of Eulachon in US West Coast Ocean Shrimp Trawl Fisheries from 2004–2015.*

Hart, J. L. and J. L. McHugh. 1944. *The Smelts (Osmeridae) of British Columbia*. Fisheries Research Board of Canada Bulletin No. 64.

Hay, D. E. and P.B. McCarter. 2000. *Status of the Eulachon* Thaleichthys pacificus *in Canada*. Department of Fisheries and Oceans Canada, Canadian Stock Assessment Secretariat, Research Document 2000-145. Ottawa, Ontario.

Langer, O. E., B. G. Shepherd, and P. R. Vroom. 1977. *Biology of the Nass River Eulachon (*Thaleichthys pacificus*).* Canadian Fisheries and Marine Service Technical Report 77-10, 56 p.

____Lewis, A.F., M.D. McGurk, and M.G. Galesloot. 2002. Alcan's Kemano River eulachon (*Thaleichthys pacificus*) monitoring program 1988- 1998. Consultant report prepared by Ecofish Research Ltd. for Alcan Primary Metal Ltd., Kitimat, BC. 136 pp.

McHugh, J.L., 1939. The eulachon. Fish. Res. Board Can. Pac. Progr. Rep. 40:17-22.National Marine Fisheries Service (NMFS). 2011. *Critical Habitat for the Southern Distinct Population Segment of Eulachon. Final Biological Report*. NMFS Northwest Region, Protected Resources Division. Portland, OR. September 2011.

National Marine Fisheries Service (NMFS). 2016. 5-*year review: Summary & Evaluation of Eulachon.* National Marine Fisheries Service, West Coast Region, Portland, Oregon. May 26, 2016.

National Marine Fisheries Service (NMFS). 2017. Recovery *Plan for the Southern Distinct Population Segment of Eulachon (*Thaleichthys pacificus*).* National Marine Fisheries Service, West Coast Region, Protected Resources Division, Portland, OR, 97232. September.

Oregon Department of Fish and Wildlife and Washington Department of Fish and Wildlife (ODFW and WDFW). 2014. *Studies of Eulachon Smelt in Oregon and Washington*. Project Completion Report prepared for the National Oceanic and Atmospheric Association. 168 pp.

Ricker, W.E., D.F. Manzer, and E.A. Neave. 1954. The Fraser River Eulachon fishery, 1941-1953. Fisheries Research Board of Canada, manuscript report no. 583. 35p.Smith, W. E. and R.W. Saalfeld. 1955. Studies on Columbia River Smelt *Thaleichthys pacificus* (Richardson). *Washington Department of Fisheries, Fisheries Research Paper* 1(3):3–26.

Spangler, Elizabeth A.K., 2002. The ecology of eulatchon (Thaleichthys pacificus) in twentymile river, AK.

Sturdevant, M. V. 1999. Forage Fish Diet Overlap, 1994-1996. APEX Project: Alaska Predator Ecosystem Experiment in Prince William Sound and the Gulf of Alaska. Exxon Valdez Oil Spill Restoration Project Final Report (Restoration Project 98163C), Auke Bay Laboratory, National Marine Fisheries Service, Juneau, Alaska. Washington Department of Fish and Wildlife (WDFW) and Oregon Department of Fish and Wildlife (ODFW). 2001. *Washington and Oregon Eulachon Management Plan.*

Willson, M. F., R. H. Armstrong, M. C. Hermans, and K Koski. 2006. *Eulachon: A Review of Biology and an Annotated Bibliography*. Alaska Fisheries Science Center Processed Report 2006-12. Auke Bay Laboratory, Alaska Fish. Sci. Cent., NOAA, Natl. Mar, Fish. Serv., Juneau, AK.

C11 Columbia Torrent Salamander (*Rhyacotriton kezeri)*

Legal Status

Photo: Chris Roberts

State: Sensitive Species

Federal: Under Review, 2015 (FWS–R1–ES–2015–0083)

Critical Habitat: None

Recovery Planning: None

Taxonomy

Torrent salamanders are in the family Rhyacotritonidae, a small family endemic to the Pacific Northwest that is closely related to the Amphiumidae and Plethodontidae (Frost et al. 2006). The families' four species include the Olympic salamander (*Rhyacotriton olympicus*) (Gaige 1917), Cascade torrent salamander (*R. cascadae*) (Good and Wake 1992), Columbia torrent salamander (*R. kezeri*) (Good and Wake 1992), and southern torrent salamander (*R. variegatus*) (Stebbins and Lowe 1951). Less is known about the biology of Columbia torrent salamanders than of other species of *Rhyacotriton.* However, species of *Rhyacotriton* are likely to be similar in many ways.

Distribution

General

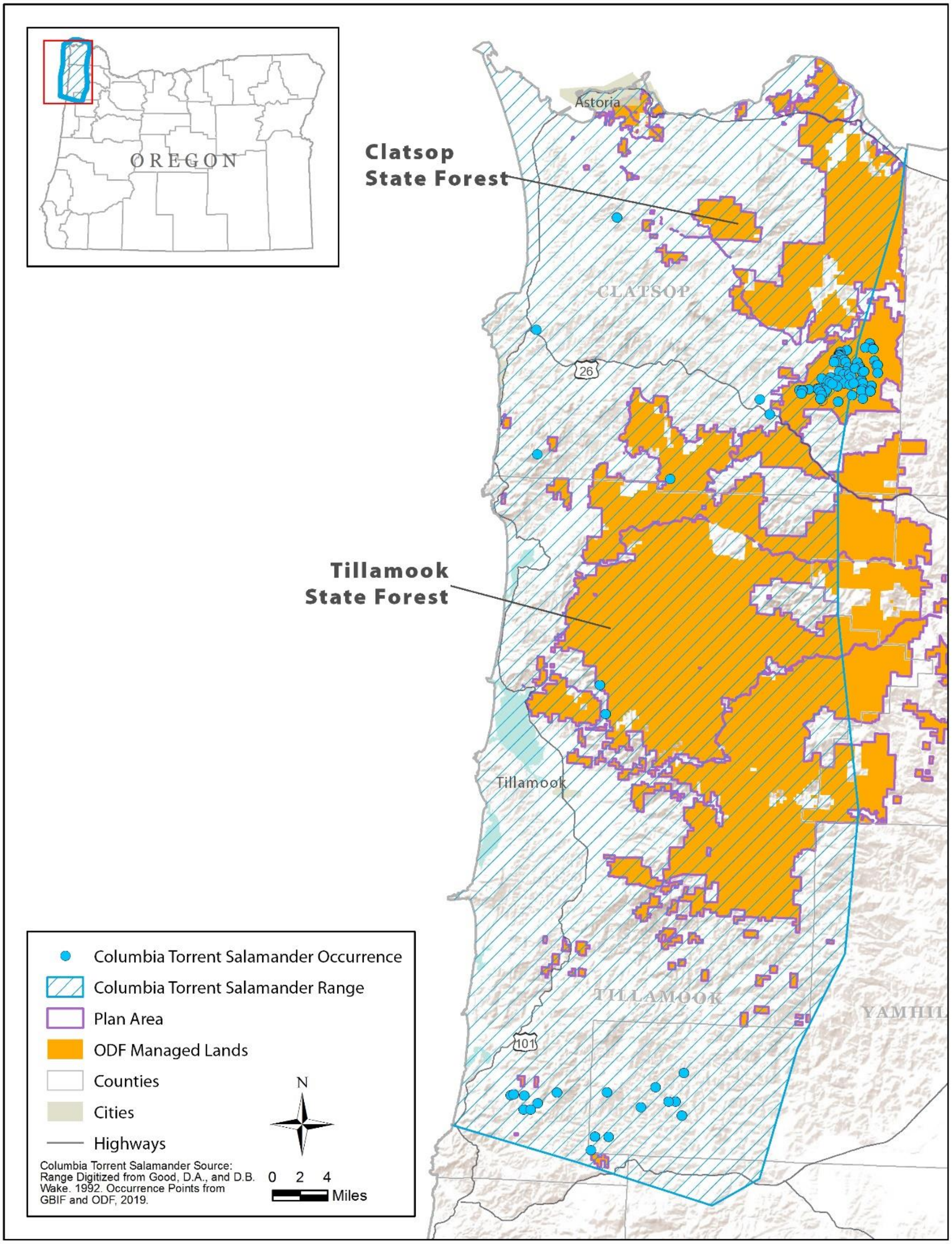
The Columbia torrent salamander is a small, semi-aquatic salamander restricted to coastal and near-coastal regions of northwestern Oregon and southwestern Washington. The species occurs from the Coast Range from just south of the Chehalis River, Grays Harbor County, Washington, south to the Little Nestuca River and the Grande Ronde Valley in Polk, Tillamook, and Yamhill Counties, Oregon (Good and Wake 1992). Across their range, Columbia torrent salamanders occur from near sea level to the highest elevations in the region, up to 3,280 feet. They occur in some upper reaches of the coastal part of the Willamette hydrographic basin (e.g., Upper Grand Ronde system, Oregon [Good et al. 1987]). However, their distribution across the region and their inland distribution in Washington are poorly known (McAllister 1995).

Like other species of *Rhyacotriton,* Columbia torrent salamanders occupy cold, fast-moving streams in forested areas. The larvae generally live in the rocky substrate, while adults occupy the splash zone at the edges of streams. These salamanders may also be found in seeps (Good and Wake 1992; Petranka 1998). In addition, Hayes et al. (2003) found that Columbia torrent salamander density was significantly greater in splash zones of waterfalls than other reach types.

Occurrences in the Plan Area

During an amphibian survey of the Buster Creek Basin in May 2004, the Oregon Department of Forestry identified 233 Columbia torrent salamander occurrences on state forest lands in the plan area (Oregon Department of Forestry 2019). The majority of known occurrences are clustered in Clatsop County, south of the Clatsop State Forest (Figure C11-1). Additional occurrences have been recorded in Tillamook, Washington, and Yamhill Counties (Figure C11-1).

Figure C11-1. Columbia Torrent Salamander Range and Occurrence



Natural History

Habitat Requirements

Descriptions of Columbia torrent salamander habitat requirements are generally limited to landscape and reach scale elements and a few studies on nest-site habitat characteristics.

Stebbins and Lowe (1951) generalize the microhabitat conditions of torrent salamanders as "one of a cold, permanent stream with small water-washed or moss-covered rock, usually rock rubble, in and along running water, seeps and small, trickling tributary streams with rocks of small dimensions." Torrent salamander are primarily found in older forest sites; however, Russell et al. (2004) found that at the landscape level, site occupancy and relative abundance of the Columbia torrent salamander was not related to age or composition of riparian vegetation, but rather to abiotic landform features (parent geology, elevation, aspect) and that variation in physical features of stream habitats (reach gradient, proximity to stream channel origin) influenced the distribution and abundance of Columbia torrent salamander at multiple spatial scales. Russell et al. (2004) observed higher relative abundance of salamanders in basalt streams compared to marine sediment streams, greater proportion of streams with northerly aspects contained salamanders compared to southerly aspect streams (although the abundance was similar), and streams with salamanders had a higher mean elevation. Of note, forest age was similar between salamander site occupancy and abundance and forest overstory composition was not related to occupancy and abundance. This finding suggests that although disturbance of vegetation (e.g., timber harvest) influences amphibian populations, abiotic habitat features, such as geology, topography, and climate, and the interaction of abiotic and biotic features, should not be discounted.

Wilkins and Peterson (2000) found the likelihood of habitat occupancy by torrent salamander increased as channel gradient increased and basin area decreased. Adjusting for basin area, torrent salamander abundance increased as the proportion of the active channel with flowing water decreased.

In western Oregon, Vesely (1996) found similar abundances of terrestrially occurring torrent salamanders between unmanaged forest and riparian buffer strips along first- to third-order streams; however, Vesely also found amphibian species diversity was lower in buffers than in unmanaged forest, and diversity was correlated with buffer strip width (Vesely 1996). Olson and Burton (2014) examined timber harvest and riparian buffer management approaches on headwater stream habitats and observed densities of *Rhyacotriton* species increased post-harvest in moderate-density thinning with no-entry buffers in wider streams with more pools and narrower streams with more down wood. However, they also found decreased densities along streams with narrow buffers (6 meters).

Reproduction

Due to few nests observed and described for Columbia torrent salamander, the reproductive ecology of the species is not well known. Based on data for other species of *Rhyacotriton,* courtship and mating probably occur over most of the year, concentrated in the fall and spring months. Females may oviposit at any time of the year, but egg laying in *Rhyacotriton* spp. is believed to primarily peak in late spring or early summer (Nussbaum and Tait 1977; Welsh and Lind 1992). The timing of egg deposition in Colombia torrent salamander is estimated as mid-August and late October to early November for the Washington and Oregon clutches described by Nussbaum (1969).

Information on parental care and communal nesting for Columbia torrent salamanders is unclear; both have been observed, but observations have not been consistent (Nussbaum 1969; Russell et al. 2002; Washington Department of Fish and Wildlife 2019). Egg deposition is assumed to occur in seeps and at the heads of springs (Nussbaum 1969). In 2002, Russell et al. described three nest sites of Colombia torrent salamander in Oregon; physical characteristics of the nests were similar to the nests described by Nussbaum (1969)—nest sites were within seeps of cold (8.3 to 9.1 °C) clear water flowing under and between rocky substrates, but were below the stream origin, and near the center of the stream channel. Russell et al.'s (2002) finding of singly laid, unattached eggs, and clutch size are also consistent with previous findings made by Nussbaum (1969). The lithology of nests described by Russell et al. (2002) consisted of unspecified marine sedimentary formation. Clutch frequency is once per year (Nussbaum and Tait 1977; Nussbaum et al. 1983). Based on data for other species of torrent salamanders (Nussbaum and Tait 1977), fecundity in Colombia torrent salamanders is likely low with clutch size range from 2 to 16 eggs (AmphibiaWeb 2019).

The incubation period of eggs is long and eggs laid in spring hatch 5 to 6 months later (Nussbaum 1969). Likewise, the larval period of Colombia torrent salamander is long and can take more than 2 years (Washington Department of Fish and Wildlife 2019). Columbia torrent salamanders likely have a long interval to reproductive maturity (4 years) with a moderately long lifespan (>10 years) (AmphibiaWeb 2019).

Movement

Data from other species of *Rhyacotriton* suggest that Columbia torrent salamanders are highly sedentary (Nussbaum and Tait 1977; Welsh and Lind 1992; Nijhius and Kaplan 1998) and have limited dispersal capabilities, with movements typically limited to distances of 10 to 15 feet. Limited dispersal may be related to adults being sensitive to desiccation and larvae being vulnerable to changes in streamflow (Ray 1958). Surface movement is likely reduced during late summer and early autumn when surface conditions are driest (AmphibiaWeb 2019). Although the species is closely associated with its water source, in times of heavy rainfall, torrent salamanders may move away from and be found away from streams in the nearby forest floor.

Torrent salamanders have limited dispersal abilities and small home ranges (Nussbaum et al. 1983). Available data on closely related Cascade torrent salamanders indicate high densities and restricted movements (Nussbaum and Tait 1977; Nijhius and Kaplan 1998), in which case, territorial behavior is unlikely.

Foraging Habitat

Based on data for other *Rhyacotriton*, Columbia torrent salamanders are opportunistic feeders and probably feed on invertebrates dwelling in moist forested habitats, especially amphipods, fly larvae, springtails, and stonefly nymphs (Bury and Martin, 1967; Bury, 1970). Larvae feed on aquatic invertebrates and adults feed on aquatic and semi-aquatic invertebrates. These taxa occur in semi-aquatic and aquatic microhabitats.

Ecological Relationships

Over their range, Columbia torrent salamanders are sympatric with 12 different amphibian species: northwestern salamanders (*Ambystoma gracile*), long-toed salamanders (*A. macrodactylum*), Cope's giant salamanders (*Dicamptodon copei*), coastal giant salamanders (*D. tenebrosus*), rough-skinned newts (*Taricha granulosa*), ensatinas (*Ensatina eschscholtzii*), Van Dyke's salamanders (*Plethodon vandykei*), western red-backed salamanders (*P. vehiculum*), Dunn's salamanders (*P. dunni*), coastal (Pacific) tailed frogs (*Ascaphus truei*), Pacific treefrogs (*Pseudacris regilla*), and northern red-legged frogs. However, degree of syntropy with each of these taxa has not yet been detailed (Amphibiaweb 2019)

Predators of Columbia torrent salamanders are unknown. However, the occurrence of giant salamander larva correlates with a lower abundance of torrent larva, which may be attributed to a predator avoidance response (Amphibiaweb 2019).

Population Status and Trends

No historical data on abundance are available, but some recent studies provide relative abundance data. In the Willapa Hills, Columbia torrent salamanders made up 21% of the individuals across eight amphibian species and ranked second only to giant salamanders (*Dicamptodon* sp.) in relative abundance (Wilkins and Peterson 2000). In two other unpublished studies conducted in the Willapa Hills, Columbia torrent salamanders ranked first in abundance among the 9 and 13 (unpublished data) amphibian species recorded; in both cases they represented > 60% of individuals of all species (AmphibiaWeb 2019). In the Russell et al. (2004) study, Columbia torrent salamander densities ranged from 0 to 68.3 individuals per square meter; the upper end is the highest recorded for any torrent salamander species.

Relative abundance of Columbia torrent salamanders is not always among the highest in amphibian assemblages. In a Kilchis River study, Columbia torrent salamanders ranked fourth in relative abundance among the 10 amphibian species recorded (AmphibiaWeb 2019). At least part of the reason for this disparity in relative abundance patterns across studies may depend on how sampling locations were selected within hydrographic basins, as Russell et al. (2004) indicated that Columbia torrent salamander density increases with proximity to the headwater channel origin.

Threats

The main threats to Columbia torrent salamanders include factors that degrade habitat quality, particularly those that result in increased water temperatures and sedimentation (Lannoo 2005). Also, any event that influences the inner-channel gorge of an occupied stream with the potential for destabilizing the geomorphology and hydrology of a stream (e.g., debris flow, altered peak flow from rain-on-snow event, or loss of upland canopy cover) may be problematic for Columbia torrent salamanders (Crisafulli et al. 2005). The primary anthropogenic threats to headwater stream and seep habitats include timber harvest and road construction/maintenance activities. In addition, stream-crossing culverts may fragment populations (Howell and Maggiulli 2011).

Timber Harvest

Torrent salamanders are among one of the stream amphibians reported to be at risk from timber harvest (Bury and Corn 1988; Bury and Corn 1989,; Good and Wake 1992; Welsh and Lind 1996).

Timber harvests have been shown to have impacts on Columbia torrent salamander. These impacts include reduced abundances of salamanders in young age classes of managed timber stands (i.e., clear-cut stands). In a study of the effects of timber harvest on terrestrial salamanders in southwest

Washington, Columbia torrent salamanders were only captured in older forests (forested areas between 45 to 60 years old) and not in adjacent forests that were clear cut 2 to 5 years previously (Grialou et al. 2000). Similar results have been found for other *Rhyacotriton* spp. on managed lands in Oregon and Washington with species occupancy being lowest in youngest and oldest sampled forest stands (Kroll et al. 2008).

In general, timber harvest removes riparian canopy cover resulting in increased stream temperatures, deposits sediments that degrade microhabitats, and possibly alters peak flow events (Bury and Corn 1988; Bury and Corn 1989; Welsh and Lind 1996). Based on where Columbia torrent salamanders have been documented (steep gradient systems with high flushing capacity), it is presumed that sediment input from ground-disturbing activities would have a negative effect on individuals. Likewise, in areas where timber harvesting causes increases in water temperature, decreases in oxygen, or increases in siltation, *Rhyacotriton* spp. have been rare or absent (Leonard et al. 1993). Likewise, stream sedimentation may result in degradation of overwintering habitat and asphyxiation of embryos and larvae (McAllister 1992). Some studies suggest riparian buffers offer protection to the salamanders (USFWS 2011).

Roads and Culverts

Culverts and roads may be sources of erosion that result in stream sedimentation. Roads may pose barriers to amphibian movement, and in the context of roads crossing streams, their culverts may pose barriers to species movement. An inability to disperse puts populations at risk because it limits gene flow and the ability to recolonize after disturbance (Jackson 2003). Specifically, perched culverts are problematic due to loss of substrate continuity and increased velocity of water above a surface that does not present any natural characteristics, such as instream structures, substrate, or quiet pools, which would facilitate animal movement. Given its close association to the stream channel and adjacent, saturated ground, Columbia torrent salamanders likely may not move upland to navigate around such barriers. These types of culverts have long been recognized as problems for fish and have only recently become a topic of concern for amphibians.

It is not known to what degree culverts and roads fragment habitat for Columbia torrent salamanders, as there have not been any studies on distribution specifically related to road locations. Nonetheless, Hayes et al. (2002) found that coastal tailed frogs (*Ascaphus truei*) engaged in upstream seasonal movements seeking invertebrate-rich intermittent headwater areas, and Olson et al. (2007) speculated that similar environmental situations may exist for post-metamorphic torrent salamanders to do the same.

Chemical Application

Because amphibians breathe through their skin, a variety of chemicals (e.g., pesticides, herbicides, fire retardant, salt, fertilizers) have the potential to negatively affect these animals. Broad-scale herbicide treatments applied to suppress the shrub layer on forest lands after harvest could have a negative impact on Columbia torrent salamanders. In addition, episodic release of chemicals trapped in snowmelt may have some direct and indirect effects on Columbia torrent salamander (Olson pers. comm., as cited in Howell and Maggiulli 2011). Salt and sand, as components of road and ski area management, have the potential to enter the stream channel and affect the species. Though wildfires are relatively rare events west of the Cascades (but could increase as climate patterns change), and the use of prescribed fire (particularly in riparian areas) is minimal, the effects from fire retardants are nevertheless not fully known. Compared to pesticides, herbicides, may pose less risk to amphibians because the chemical does not target species with a nervous system; however, no data on the specific effects of herbicides on torrent salamanders are available (Howell and Maggiulli 2011).

Climate Change

The effects of climate change on Columbia torrent salamanders are unknown. However, climate change models generally predict warmer temperatures (especially in the summer), increased rainfall, reduced snowpack, more variable temperature and precipitation, changes in snowline and melting, and increased risk of winter flooding in smaller streams west of the Cascades (Mote et al. 2003). Torrent salamanders are tied to aquatic environments due to their intolerance to desiccation (Ray 1958). Because of this physiological limitation coupled with limited dispersal abilities and small home ranges (Nussbaum et al. 1983), changes in water regimes make the Columbia torrent salamander vulnerable to the effects of climate change.

Literature Cited

AmphibiaWeb. 2019. University of California, Berkeley, Amphibiaweb website. Available: http://amphibiaweb.org. Accessed: May 8, 2019.

Bury, R.B. and M. Martin. 1967. The food of the salamander *Rhyacotriton variegatus*. Copeia 1967:487.Bury, R.B. 1970. Food similarities in the tailed frog, *Ascaphus truei*, and the Olympic salamander, *Rhyacotriton olympicus*. Copeia 1970:170–171.

Bury, R.B. 1970. Food similarities in the tailed frog, *Ascaphus truei*, and the Olympic salamander, *Rhyacotriton olympicus*. Copeia 1970:170–171.Bury, R. B. 1983. Differences in Amphibian Populations in Logged and Old Growth Redwood Forest. *Northwest Science* 57: 167–178.

Bury, R. B., and P. S. Corn. 1988. Responses of Aquatic and Streamside Amphibians To Timber Harvest: A Review. Pages 165-181 in Raedaeke, K., editor. *Streamside Management: Riparian Wildlife and Forestry Interactions.* Univ. Washington.

Bury, R. B., and P. S. Corn. 1988. Douglas-Fir Forests in the Oregon and Washington Cascades: Relation of the Herpetofauna to Stand Age and Moisture. Pages 11–22. In: R. C. Szaro, K. E. Severon, and D. R. Patton. Eds. *Management of Amphibians, Reptiles, and Mammals in North America: Proceedings of a Symposium.* General Technical Report RM-166. Corvallis, OR, U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Crisafulli, C. M., L. S. Trippe, C. P. Hawkins, and J. A. MacMahon. 2005. Amphibian Responses to the 1980 Eruption of Mount St. Helens, Chapter 13 in *Ecological Responses to the 1980 Eruption of Mt. St. Helen*s, V. H. Dale, F. J. Swanson, and C. M. Crisafulli, Eds., Springer Science+Business Media, Inc., New York, NY.

Frost, D. R., T. Grant, J. Faivovich, R. H. Bain, A. Haas, C. F. B Haddad, R. O. De Sa, A. Channing, M. Wilkinson, S. C. Donnellan, C. J. Raxworthy, J. A. Campbell, B. L. Blotto, P. Moler, R. C. Drewes, R. A. Nussbaum, J. D. Lynch, D. M. Green, and W. C. Wheeler. 2006. The Amphibian Tree of Life. *Bull. Amer. Mus. Nat. Hist.* 297, 370 pp.

GBIF.org. 2019. *GBIF Occurrence*. Available: https://doi.org/10.15468/dl.1xixsr.

Gaige, H. T. 1917. *Description of a New Salamander from Washington*. Occasional Papers of the Museum of Zoology, Number 40, University of Michigan, Ann Arbor, Michigan.

Good, D. A., G. Z. Wurst, and D. B. Wake. 1987. Patterns of geographic variation in allozymes of the Olympic salamander, *Rhyacotriton olympicus* (Caudata: Dicamptodontidae). Fieldiana Zoolgy No. 32 (1374). 15 pp.Good, D. A., and D. B. Wake. 1992. Geographic Variation and Speciation in the Torrent Salamanders of the Genus Rhyacotriton (Caudata: Rhyacotritonidae). *Univ. California Publication Zoology* 126:i-xii, 1-91.

Grialou, J. A., S. D. West, and R. N. Wilkins. 2000. The Effects of Forest Clearcut Harvesting and Thinning on Terrestrial Salamanders. *Journal of Wildlife Management* 64(1): 105–113.

Hayes, M. P., T. Quinn, L. V. Diller, L. L. C. Jones, J. G. McCracken, M. J. Raphael, and D. E. Runde. 2002. *Evaluation of Sampling Methods for Amphibians in Headwater Basins of Non-Fishbearing Streams: A Preliminary Analysis*. A final report submitted to the Cooperative Monitoring, Evaluation, and Research Co.

Hayes, M. P., D. J. Dugger, T. L. Hicks, and T. Quinn. 2003. Headwater Habitat Variation: Its Relationship to Stream Amphibian Distribution. *Northwestern Naturalist* 84(2): 100.

Howell, B. L., and N. M. Maggiulli. 2011. *Conservation Assessment for the Cascade Torrent Salamander (*Rhyacotriton cascadae). V.1. February 2011. U.S.D.A Forest Service Region 6 and U.S.D.I. Bureau of Land Management Interagency Special Status and Sensitive Species Program. Available: https://www.fs.fed.us/r6/sfpnw/issssp/species-index/fauna-amphibians.shtml. Accessed: May 2, 2019.

Jackson, S. D. 2003. Ecological Considerations in the Design of River and Stream Crossings. Pages 20–29. In: C. L. Irwin, P. Garrett, and K. P. McDermott. Eds. *Proceedings of the International Conference on Ecology and Transportation.* North Carolina State University, Center for Transportation and the Environment, Raleigh, NC.

Kroll, A. J., K. Risenhoover, T. McBride, E. Beach, B. J. Kernohan, J. Light, and J. Bach. 2008. Factors Influencing Stream Occupancy and Detection Probability Parameters of Stream-Associated Amphibians in Commercial Forests of Oregon and Washington, USA. *Forest Ecology and Management* 255: 3726–3735.

Lannoo, M., ed. 2005. *Amphibian Declines: The Conservation Status of United States Species*. University of California Press, Berkeley, California.

Leonard, W. P., H. A. Brown, L. L. C. Jones, K. McAllister, and R. M. Storm. 1993. *Amphibians of Washington and Oregon*. Seattle Audubon Society, Seattle, WA, 168 p.

McAllister, 1992. *Amphibian Management Standards*. Department of Wildlife, State of Washington.

McAllister, K. R. 1995. Distribution of Amphibians and Reptiles in Washington State. *Northwest Fauna* 3:81–112.

Mote, P. W., E. A. Parson, A. F. Hamlet, W. S. Keeton, D. Lettenmaier, N. Mantua, E. L. Miles, D. W. Peterson, D. L. Peterson, R. Slaughter, and A. K. Snover. 2003. Preparing for Climatic Change: The Water, Salmon, and Forests of the Pacific Northwest. *Climatic Change* 61:45–88.

Nijhuis, M. J., and R. H. Kaplan. 1998. Movement Patterns and Life History Characteristics in a Population of the Cascade Torrent Salamander (*Rhyacotriton cascadae*) in the Columbia River Gorge, Oregon. *Journal of Herpetology* 32(2):301–304.

Nussbaum, R.A. and C. Maser. 1969. Observations of Sorex palustris preying on Dicamptodon ensatus. Murrelet 50:23–24.Nussbaum, R. A., and C. K. Tait. 1977. Aspects of the Life History and Ecology of the Olympic Slalmander, Rhyacotriton olympicus (Gaige). *American Midland Naturalist* 98:176–199.

Nussbaum, R. A., E. D. Brodie, Jr., and R. M. Storm. 1983. *Amphibians and Reptiles of the Pacific Northwest.* University Press of Idaho, Moscow, Idaho. 332 pp.

Olson, D.H., P.D. Anderson, C.A. Frissell, H.H. Welsh, and D. F. Bradford. 2007. Biodiversity management approaches for stream–riparian areas: Perspectives for Pacific Northwest headwater forests, microclimates, and amphibians. Forest Ecology and Mgt 246(1):81-107.

Olson, D. H., and J. I. Burton. 2014. *Near-Term Effects of Repeated-Thinning with Riparian Buffers on Headwater Stream Vertebrates and Habitats in Oregon, USA.*

Oregon Department of Forestry. 2019. GIS data citation needed.

Petranka, J.W. 1998. Salamanders of the United States and Canada. Smithsonian Institution Press, Washington, D.C.Ray, C. 1958. Vital Limits and Rates of Desiccation in Salamanders. *Ecology* 39:75–83

Russell, K. R., T. J. Mabee, and M. B. Cole. 2004. *Distribution and Habitat of Columbia Torrent Salamanders at Multiple Scales in Managed Forests of Western Oregon*.

Russell K. R., A. A. Gonyaw, J. D. Strom, K. E. Diemer, and K. C. Murk. 2002. Three New Nests of the Columbia Torrent Salamander, Rhyacotriton kezeri, in Oregon with Observations of Nesting Behavior. *Northwestern Naturalist* 83(1): 19–22.

Stebbins, R. C., and C. H. Lowe, Jr. 1951. Subspecific Differentiation in the Olympic salamander *Rhyacotriton olympicus*. *University of California Publications in Zoology* 50: 465–484.

Vesely, D. G. 1996. *Terrestrial Amphibian Abundance and Species Richness in Headwater Riparian Buffer Strips, Oregon Coast Range.* MSc thesis, Oregon State University, Corvallis, OR. 48p.

Washington Department of Fish and Wildlife. 2019. *Species in Washington. Columbia Torrent Salamander*. Available: https://wdfw.wa.gov/species-habitats/species/rhyacotriton-kezeri. Accessed: May 8, 2019.

Welsh, H. H. Jr. 1990. Relictual Amphibians and Old-Growth Forests. *Conservation Biology* 4: 309–19.

Welsh, H. H., Jr. and A. J. Lind. 1991. *The Structure of the Herpetofaunal Assemblage in the Douglas-Fir/Hardwood Forests of Northwestern California and Southwestern Oregon.* Wildlife and Vegetation of Unmanaged Douglas-fir Forests, USDA Forest Service, General Technical Report PNW-GTR-285. USDA Forest Service, 394-413.

Welsh, H.H., Jr. and A.J. Lind. 1992. Population ecology of two relictual salamanders from the Klamath Mountains of northwestern California. Pp. 419–437. In McCullough, D.R. and R.H. Barrett (Eds.), Wildlife 2001: Populations. Elsevier Applied Science, London.Welsh Jr., H. H. and

A. J. Lind. 1996. Habitat Correlates of the Southern Torrent Salamander, *Rhyacotriton variegatus* (Caudata: Rhyacotritonidae), in Northwestern California. *Journal of Herpetology* 30(3):385–398.

Wilkins, R. N., and N. P. Peterson. 2000. Factors Related to Amphibian Occurrence and Abundance in Headwater Streams Draining Second-Growth Douglas-Fir Forests in Southwestern Washington. *Forest Ecology and Management* 139: 79–91.

C12 Cascade Torrent Salamander (*Rhyacotriton cascadae)*

Legal Status

Photo: Chris Roberts

State: Sensitive Species

Federal: Under Review, 2015 (*FWS–R1–ES–2015–0080*)

Critical Habitat: None

Recovery Planning: None

Taxonomy

Torrent salamanders are in the family Rhyacotritonidae, a small family endemic to the Pacific Northwest that is closely related to the Amphiumidae and Plethodontidae (Frost et al. 2006). The families' four species include the Olympic salamander (*Rhyacotriton olympicus*) (Gaige 1917), Cascade torrent salamander (*R. cascadae*) (Good and Wake 1992), Columbia torrent salamander (*R. kezeri*) (Good and Wake 1992), and southern torrent salamander (*R. variegatus*) (Stebbins and Lowe 1951).

Cascade torrent salamanders occupy cold, fast-flowing headwater streams, seeps, and waterfall splash zones in forested areas. They typically occur in reaches and off-channel habitat with gravel or cobble substrate and persistent, shallow water.

Distribution

General

The range of the Cascade torrent salamander includes Washington counties of Thurston, Lewis, Cowlitz, Skamania, and Clark, and the Oregon counties of Multnomah, Hood River, Clackamas, Marion, Linn, and Lane (Howell and Maggiulli 2011). Cascade torrent salamanders are restricted to the west slope of the Cascade mountains from the west bank of the Skookumchuck River in central Washington 0.4 mile north of the Thurston–Lewis County line; (Wilson and Larsen 1992; McAllister 1995) south to the Middle Fork of the Willamette River in central western Oregon Lane County; (Good et al. 1987; Good and Wake 1992). Within this area, the species is patchily distributed.

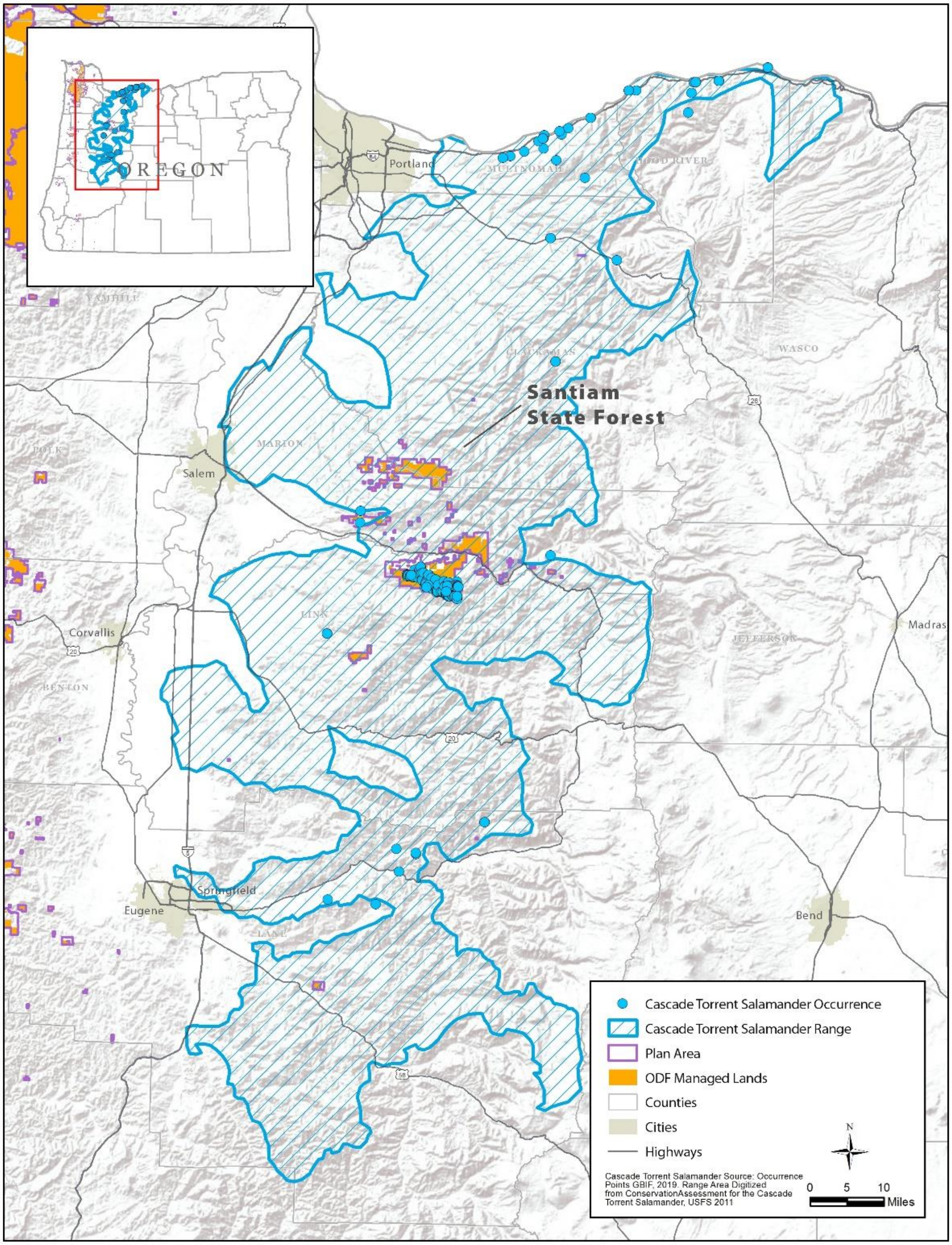
Cascade torrent salamanders are known to range in elevation to over 4,000 feet, but the real extent of their geographic range is ambiguous largely because upper- and lower-elevation limits, and how these change with latitude, are poorly understood. A watershed-wide study of the Blue River hydrographic basin near the southern end of their geographic range (Willamette River hydrographic basin, Oregon) revealed Cascade torrent salamanders at 52 of 273 (19%) sites, with the probability of occurrence peaking at an elevation of around 2,854 feet (Hunter 1998).

Known locations of Cascade torrent salamanders include state lands (39%), National Forests (37%), private lands (industrial and nonindustrial, 14%), and Bureau of Land Management lands (10%). These numbers may or may not reflect indicators of habitat availability or quality, but rather, the effort and emphasis on previous and current survey efforts (Howell and Maggiulli 2011).

Occurrences in the Plan Area

During an amphibian survey of the Rock Creek basin in June and July 2004, the Oregon Department of Forestry identified 274 Cascade torrent salamander occurrences on state forest lands in the plan area (Oregon Department of Forestry 2019). The majority of known occurrences based on ODF and GBIF data are clustered in Linn County, in the Santiam State Forest (Figure C12-1). Additional occurrences in the vicinity of the plan area have been recorded in Marion, Clackamas, and Lane Counties (Figure C12-1).

Figure C12-1. Cascade Torrent Salamander Range and Occurrence



Natural History

Habitat Requirements

Cascade torrent salamanders are associated with high-gradient,[1] permanent, cool or cold-water sources, such as seeps, waterfalls, headwaters, and edges of larger streams. They typically occur in reaches and off-channel habitat with gravel or cobble substrate and persistent, shallow water. Individuals may be located beneath rocks in the splash zone or on stream banks under rock, moss, or wood, but may favor rock cover (Jones et al. 2005; Lannoo 2005). This species requires continuous access to cold, silt-free water and moist adjacent forests. During heavy rains, Cascade torrent salamanders may be found far from the stream (potentially several hundred meters) under leaf litter, branches, and small logs (Rombough and Corkran pers. comm; Palazzotto pers. comm. 2019).

In the Blue River Watershed of the west-central Cascade Range of Oregon, which is managed primarily by the Willamette National Forest, Cascade torrent salamander larvae were encountered in 19% of 15-foot stream reaches surveyed (n=273 sites) (Hunter 1998). At the watershed scale, the species was associated with small, high-gradient streams, with a maximum basin size of 350 acres, and was most abundant at about 2,850 feet elevation. Hunter (1998) also found Cascade torrent salamanders were associated with an average stream depth of 4 to 5 centimeters; streams had limited amounts of riffle in channel units; the channel substrate consisted of cobbles and boulders; and streams had high canopy cover and mid-story cover was present along the stream.

In managed forests of western Oregon, Russell et al. (2005) found the occurrence and abundance of Cascade torrent salamanders at the stream-reach scale was associated with headwaters. Abiotic factors, such as cobble and gravel substrates with low percentages of fine sediment and sand, were associated with Cascade torrent salamander presence. Cascade torrent salamander occupancy and relative abundance at the landscape scale was also greater in streams with northerly aspects, as compared to southerly aspects, and increased with adjacent riparian forest age. In southern Washington, Pollett et al. (2010) found an abundance of the species to be lower in unbuffered streams than in streams with buffers or in second-growth forests. In privately managed forests of southwestern Washington, Steele et al. (2003) found a relative higher abundance of Cascade torrent salamanders in streams adjacent to older forest stands. In both studies (Russell et al. 2005; Steele et al. 2003), salamanders were found in forests between 0 and 90 years old, with the highest abundance occurring in those areas containing streams surrounded by forests between 43 and 59 years old. The lost abundance, in occupied stands, occurred in younger forest between 0 and 22 years old (Steele et al. 2003).

Habitat requirements for larval and juvenile stages of Cascade torrent salamanders have not been distinguished from adults in studies to date. Larval *Rhyacotriton* spp. may be associated with stable, low-flow volume areas with loose gravel and cobble with limited fine sediments (Nussbaum and Tait 1977; Diller and Wallace 1996; Welsh and Lind 1996).

Because torrent salamanders are adapted for life in cold water, stream water temperature is a critical factor for habitat requirement. Among amphibians, the thermal tolerances of *Rhyacotriton* spp. are among the lowest (Bury 2008). Pollett et al. (2010) found Cascade torrent salamanders

[1] Bed slope greater than 2%.

were almost absent from streams where water temperatures were ≥14 °C for greater than 35 consecutive hours. Due to the species' intolerance of warm water temperature, susceptibility to desiccation (Ray 1958), and possessing reduced lung capacity (resulting in the need for high oxygen absorption through moist skin) (Whitford and Hutchison 1966), inferences about the habitat characteristics of streams utilized by Cascade torrent salamanders have been made. Stebbins and Lowe (1951) infer streams utilized by the species have presence of leaf canopy and abundant understory vegetation.

Reproduction

Cascade torrent salamanders are likely a relatively long-lived amphibian, although longevity has not been determined. Larvae take approximately 4 to 5 years to reach metamorphosis (Nussbaum and Tait 1977) and presumably another year or so to reach sexual maturity, with animals living several years as adults.

Torrent salamanders likely have a prolonged courting season, as sperm caps of spermatophores have been found in the vents of *Rhyacotriton* spp. females every month of the year except August, September, December, and January (Nussbaum and Tait 1977). Courtship occurs between October and July, and most egg laying occurs during spring and early summer (Nussbaum and Tait 1977). Courtship and sperm transfer are believed to occur on land or in the splash zone. Gravid females in the Columbia River Gorge averaged eight ova per individual (Nussbaum and Tait 1977).

Very few nests or eggs for any species of torrent salamander have been found. Generally, it has been thought that *Rhyacotriton* spp. females deposit their eggs in deep, narrow cracks in rock (Nussbaum et al. 1983)., However, recent work by Karraker (1999) and Russell et al. (2002) showed that *R. variegatus* and *R. kezeri* also oviposit in mid-channel under boulders and logs. The Cascade torrent salamander, similar to other torrent salamanders, lays large eggs in seeps with coarse substrate, eggs are singly deposited, and are surrounded by a jelly layer. Based on breeding sites that have been observed in other *Rhyacotriton* species, torrent salamanders may nest communally (Russell et al. 2002).

Movement

Torrent salamanders are not known to be territorial (Marangio 1988). Recapture studies of *Rhyacotriton* spp. indicated larval movement is minimal, with more movement upstream than downstream (Nussbaum and Tait 1977). *Rhyacotriton* spp*.* in western Oregon are relatively sedentary (Corn and Bury 1989) and *Rhyacotriton variegatus*, the southern torrent salamander, does not disperse widely through streams (Diller and Wallace 1996). Additionally, the torrent salamanders are apparently unable to disperse overland through dry forests (Bury and Corn 1988; Bury et al. 1991), which may limit connectivity between populations in different streams.

In a population of Cascade torrent salamanders in the Columbia River Gorge of Oregon, Nijhuis and Kaplan (1998), demonstrated behavioral hydro- and thermoregulation and the species moved parallel to streams more often than perpendicular to streams; however, overall movements were minor. Additionally, the average range length (distance between the furthest points of capture for an individual animal) was 2.4 meters (7.8 feet), and the mean distance traveled per day was 0.359 meter (1.1 feet). Despite these minor movements, Nijhuis and Kaplan (1998) acknowledged that because of the small sample size of the study, longer-distance movement may have gone undetected. Likewise, Nussbaum and Tait (1977), in an earlier study in the Columbia River Gorge, found that of

191 recaptures of uniquely marked larvae, 134 (70%) had no net movement since the previous capture (i.e., they were found in the same 2-meter (6.6-foot) section where they were originally marked). Thirty-nine of these recaptures (20%) demonstrated net movement upstream and 18 (10%) moved downstream; the farthest distance traveled during the summer was 22 meters (72 feet).

Foraging Habitat

Based on data for other *Rhyacotriton* species, Columbia torrent salamanders probably feed on invertebrates dwelling in moist forested habitats, especially amphipods, fly larvae, springtails, and stonefly nymphs (Bury and Martin 1967; Bury 1970). These taxa occur in semi-aquatic and aquatic microhabitats.

Ecological Relationships

Olson and Weaver (2007) found amphibian assemblages with Cascade torrent salamanders to be associated with spatially intermittent streams at managed forest sites. Spatially intermittent streams were the most common detected in the headwaters sampled from Mt. Hood to Coos Bay, Oregon. Consistent with other studies, the assemblages were also associated with higher gradient reaches and reaches with larger substrate.

Cascade torrent salamanders are preyed upon by a variety of predators. Pacific giant salamanders (*Dicamptodon* spp.) are commonly cited as a predator, as well as, northwestern salamanders (*Ambystoma gracile*), red-legged frogs (*Rana aurora*), ringneck snakes (*Diadophus punctatus*), garter snakes (*Thamnophis* spp.), American robin (*Turdus migratorius*), American dipper (*Cinclus mexicanus*), and ground beetles (Rombough pers. comm., as cited in Howell and Maggiulli 2011). Other predators may include weasels (*Mustela* spp.), mink (*Mustela vison*), and water shrews (*Sorex* spp.).

Torrent salamanders consume a variety of aquatic and semi-aquatic invertebrates, including larval and adult beetles, flies, stoneflies, snails, millipedes, amphipods, and earthworms (Nussbaum et al. 1983; Marangio 1988). Nussbauem et al. (1983) documented the predominant food of larval Cascade torrent salamanders in the Columbia River Gorge was immature caddisflies. Cudmore and Bury (2014) documented differences in microhabitat use in creeks that may contribute to salamander diet differences, with Cascade torrent salamanders being more selective or gape-limited as compared to Coastal giant salamanders (*Dicamptodon tenebrousus*). The coastal giant salamander larvae were found to be opportunistic, dietary generalists, and most commonly found in pools and riffles, while Cascade torrent salamander diets were not closely tied to food availability and were found in riffles, splash zones, and seeps (Cudmore and Bury 2014).

Population Status and Trends

No long-term population data exist for Cascade torrent salamanders. The species is assigned a decreasing population trend on the International Union for Conservation of Nature (IUCN) Red List (Geoffrey Hammerson 2004), and it is possible that numbers are decreased from historical levels due to anthropogenic influences on both public and private lands.

Threats

The main suspected threats to Cascade torrent salamanders include factors that degrade habitat quality, particularly those that result in increased water temperatures and sedimentation (Lannoo 2005). Also, any event that influences the inner-channel gorge of an occupied stream with the potential for destabilizing the geomorphology and hydrology of a stream (e.g., debris flow, rain-on-snow event, or loss of upland canopy cover) may be problematic for Cascade torrent salamanders (Crisafulli et al. 2005). The primary anthropogenic threats to headwater stream and seep habitats include some timber harvest and road construction/maintenance. In addition, stream-crossing culverts may fragment populations. Additional potential threats include chemical applications, mining, recreation, fire, volcanism, disease, and climate change.

Timber Harvest

Timber harvests have been shown to affect Cascade torrent salamanders. These impacts include reduced abundances in young age classes of managed forest stands (i.e., clear-cut stands), through impact mechanisms that affect stream habitats, such as increasing stream temperatures, sedimentation, and changes to peak flow events. Also, interactions between timber harvest and some physical habitat parameters have been detected (Howell and Maggiulli 2011).

However, not all timber harvest practices have the same kind of effects on torrent salamanders. For example, Olson and Rugger (2007) did not find a negative effect from thinning on Cascade torrent salamander abundance with four different stream buffer widths ranging from 6 to145 meters (19.7 to 475.7 feet) on federally managed lands in western Oregon in the first 2 years post-harvest. In Washington, Pollett (2005) found lower density of Cascade torrent salamanders in high gradient streams (>10 °C) of managed forest stands than in unmanaged forests and the presence of the species did not differ among the forested stream buffer treatments (unbuffered, buffered 5 to 23 meters [16.4 to 75.5 feet] wide, buffered 200 meters [656.2 feet] wide, unmanaged).

Other studies suggest riparian buffers offer protection to the salamanders (Pollett et al. 2010; Howell and Maggiulli 2011). Maintaining stream-side buffers during clear cut operations reduces the negative impact of timber harvest to Cascade torrent salamanders. The salamander was nearly absent from streams with temperatures ≥14 °C. Additionally, the species was less abundant in unbuffered streams than in streams with buffers or streams located in second-growth forests. Pollett et al. (2010) suggested stream buffers had a positive ecological effect on the density of torrent salamanders.

In general, the harvest of timber in riparian areas can affect the stream by increasing water temperatures (from canopy removal) and by depositing sediment. Based on where Cascade torrent salamanders have been documented (steep gradient systems with high flushing capacity), it is presumed that sediment input from ground-disturbing activities would have a negative effect on individuals. Likewise, in one study, where timber harvesting caused increases in water temperature, decreases in oxygen, or increases in siltation, *Rhyacotriton* spp. have been rare or absent (Leonard et al. 1993).

Roads and Culverts

Culverts and roads can have multiple effects on Cascade torrent salamanders. They may be sources of erosion that result in stream sedimentation. Roads may also pose barriers to amphibian movement, and in the context of roads crossing streams, their culverts may pose barriers. An inability to disperse puts populations at risk because it limits gene flow and the ability to recolonize after disturbance (Jackson 2003). Specifically, perched culverts are problematic due to the loss of substrate continuity and increased velocity of water above a surface that does not present any natural characteristics, such as instream structures, substrate, or quiet pools, which would facilitate animal movement. Given its close association to the stream channel and adjacent, saturated ground, Cascade torrent salamanders likely may not move any significant distance upland to navigate around such barriers. These types of culverts have long been recognized as problems for fish and have only recently become more of a topic of concern for amphibians.

It is not known to what degree culverts and roads fragment habitat for Cascade torrent salamanders as there have not been any studies on distribution specifically related to road locations. Nonetheless, Hayes et al. (2002) found that coastal tailed frogs (*Ascaphus truei*) engaged in upstream seasonal movements seeking invertebrate-rich intermittent headwater areas and Olson et al. (2007) speculated that similar environmental situations may exist for post-metamorphic torrent salamanders to do the same.

Chemical Application

Because amphibians breathe through their skin, a variety of chemicals (e.g., pesticides, herbicides, fire retardant, salt, fertilizers) have the potential to negatively affect these animals. Broad-scale herbicide treatments applied to suppress the shrub layer on forest lands after harvest could negatively affect Cascade torrent salamanders. In addition, episodic release of chemicals trapped in snowmelt may have some direct and indirect effects on Cascade torrent salamanders, particularly where they may accumulate in the foothills of the Cascade Range (Olson pers. comm., as cited in Howell and Maggiulli 2011). Though wildfire is a relatively rare event west of the Cascades (but could increase as climate patterns change), and the use of prescribed fire (particularly in riparian areas) is minimal, the effects from fire retardants are nevertheless not fully known. Salt and sand, as components of roads and ski area management, have the potential to enter the stream channel and affect the species. Compared to pesticides, herbicides, may pose less risk to amphibians because the chemical does not target species with a nervous system; however, no data on the specific effects of herbicides on Cascade torrent salamanders are available (Howell and Maggiulli 2011).

Climate Change

The effects of climate change on Cascade torrent salamanders are unknown. However, climate change models generally predict warmer temperatures (especially in the summer), increased rainfall, reduced snowpack, more variable temperature and precipitation, changes in snowline and melting, and increased risk of winter flooding in smaller streams west of the Cascades (Mote et al. 2003). Climate change may affect suitable headwater habitat for the species. Because torrent salamanders are tied to aquatic environments and tolerate a narrow range of water temperatures, change water regime has the potential to affect the species.

Literature Cited

Bury, R.B. and M. Martin. 1967. The food of the salamander *Rhyacotriton variegatus*. Copeia 1967:487.Bury, R.B. 1970. Food similarities in the tailed frog, *Ascaphus truei*, and the Olympic salamander, *Rhyacotriton olympicus*. Copeia 1970:170–171.Bury, R. B., and P. S. Corn. 1988.

Douglas-Fir Forests in the Oregon and Washington Cascades: Relation of the Herpetofauna to Stand Age and Moisture. Pages 11–22. In: R. C. Szaro, K. E. Severon, and D. R. Patton. Eds. *Management of Amphibians, Reptiles, and Mammals in North America: Proceedings of a Symposium.* General Technical Report RM-166. Corvallis, OR, U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Bury, R. B, P. S. Corn, K. B. Aubry, F. F. Gilbert, and L. L. C. Jones. 1991. Aquatic Amphibian Communities in Oregon and Washington. Pages 352–362. In: L. F. Ruggiero, K. B. Aubry, A. B. Carey and M. H. Huff. Eds. *Wildlife and Vegetation of Unmanaged Douglas-fir Forests*, General Technical Report PNW-GTR-285. Portland, OR, U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Bury, R. B. 2008. Low Thermal Tolerances of Stream Amphibians in the Pacific Northwest: Implications for Riparian and Forest Management. *Applied Herpetology* 5:63–74.

Crisafulli, C. M., L. S. Trippe, C. P. Hawkins, and J. A. MacMahon. 2005. Amphibian Responses to the 1980 Eruption of Mount St. Helens, Chapter 13 in *Ecological Responses to the 1980 Eruption of Mt. St. Helen*s, V. H. Dale, F. J. Swanson, and C. M. Crisafulli, Eds., Springer Science+Business Media, Inc., New York, NY.

Corkran, C. C. 2009. Personal communication. Naturalist/Wildlife Consultant, Northwest Ecological Research Institute, 130 NW 114th Avenue, Portland, OR 97229

Corn, P. S., and R. B. Bury. 1989. Logging in Western Oregon: Responses of Headwater Habitats and Stream Amphibians. *Forest Ecology and Management* 29:39–57.

Cudmore, W. W., and R. B. Burry. 2014. Resource Partitioning in Two Stream Salamanders, Dicamptodon tenebrosus and Rhyacotriton cascade, from the Oregon Cascade Mountains. *The American Midland Naturalist* 172(1):191–199.

Diller, L. V., and R. L. Wallace. 1996. Distribution and Habitat of Rhyacotriton Variegatus in Managed, Young Growth Forests in North Coastal California. *Journal of Herpetology* 30(2):184-191.

Frost, D. R., T. Grant, J. Faivovich, R. H. Bain, A. Haas, C. F. B Haddad, R. O. De Sa, A. Channing, M. Wilkinson, S. C. Donnellan, C. J. Raxworthy, J. A. Campbell, B. L. Blotto, P. Moler, R. C. Drewes, R. A. Nussbaum, J. D. Lynch, D. M. Green, and W. C. Wheeler. 2006. The Amphibian Tree of Life. *Bull. Amer. Mus. Nat. Hist.* 297, 370 pp.

Gaige, H.T. 1917. Description of a new salamander from Washington. Occasional Papers of the Museum of Zoology, Number 40, University of Michigan, Ann Arbor, MichiganGeoffrey Hammerson 2004. *Rhyacotriton cascadae*. In International Union for Conservation of Nature (IUCN) 2009. IUCN Red List of Threatened Species. Version 2009.2. Available: www.iucnredlist.org. Accessed: February 9, 2010.

Good, D.A., G.Z. Wurst and D.B. Wake. 1987. Patterns of geographic variation in allozymes of the Olympic salamander, *Rhyacotriton olympicus* (Caudata: Dicamptodontidae). Fieldiana, Zoology, New Series, Number 32, Field Museum of Natural History, Chicago, Illinois.

Good, D. A., and D. B. Wake. 1992. Geographic Variation and Speciation in the Torrent Salamanders of the Genus Rhyacotriton (Caudata: Rhyacotritonidae). *University of California Publication in Zoology* 126:1-91.

Hayes, M. P., T. Quinn, L. V. Diller, L. L. C. Jones, J. G. McCracken, M. J. Raphael, and D. E. Runde. 2002. *Evaluation of Sampling Methods for Amphibians in Headwater Basins of Non-Fishbearing Streams: A Preliminary Analysis*. A final report submitted to the Cooperative Monitoring, Evaluation, and Research Co.

Howell, B.L, and N.M. Maggiulli. 2011. Conservation assessment for the Cascade torrent salamander (*Rhyacotriton cascadae*). USDA Forest Service Region 6 and U.S.D.I. Bureau of Land Management Interagency Special Status and Sensitive Species Program.

Hunter, M. G. 1998. *Watershed-Level Patterns Among Stream Amphibians in the Blue River Watershed, West-Central Cascades of Oregon*. Master's thesis, Oregon State University, Corvallis.

Hutchison, Victor & Whitford, Walter. (1966). Pulmonary and Cutaneous Gas Exchange in Ambystomatid Salamanders. *Copeia*. 1966. 573–577. 10.2307/1441084.

Jackson, S. D. 2003. Ecological Considerations in the Design of River and Stream Crossings. Pages 20–29. In: C. L. Irwin, P. Garrett, and K. P. McDermott. Eds. *Proceedings of the International Conference on Ecology and Transportation.* North Carolina State University, Center for Transportation and the Environment, Raleigh, NC.

Jones, L. C., W. P. Leonard, and D. H. Olson, eds. 2005. *Amphibians of the Pacific Northwest*. Seattle Audubon Society, Seattle, Washington.

Karraker, N.E. 1999. Natural history notes: *Rhyacotriton variegatus* (southern torrent salamander). Nest site. Herpetological Review 30:160–161.Karraker, N. E., L. M. Ollivier, and G. R. Hodgson. 2005. Oviposition Site of the Southern Torrent salamander (*Rhyacotriton variegates*) in Northwestern California. *Northwestern Naturalist* 86:34–36.

Lannoo, M., ed. 2005. *Amphibian Declines: The Conservation Status of United States Species*. University of California Press, Berkeley, California.

Leonard, W. P., H. A. Brown, L. L. C. Jones, K. McAllister, and R. M. Storm. 1993. *Amphibians of Washington and Oregon*. Seattle Audubon Society, Seattle, WA, 168 p.

MacCracken, J. G. 2004. *Rhyacotriton cascadae* (Cascade torrent salamander) Nest. *Herpetological Review* 35(4):367.

Marangio, M. 1988. Olympic Salamander. In: D.C. Zeiner, W.F. Laudenslayer, Jr., K.E. Mayer, and M.L. White. Eds. *California's Wildlife, Vol. I. Amphibians and* Reptiles. California Statewide Wildlife Habitat Relationship System. Sacramento, CA, Department of Fish and Game, The Resources Agency. 272 p.

McAllister, K.R. 1995. Distribution of amphibians and reptiles in Washington State. Northwest Fauna 3:81-112.

Mote, P. W., E. A. Parson, A. F. Hamlet, W. S. Keeton, D. Lettenmaier, N. Mantua, E. L. Miles, D. W. Peterson, D. L. Peterson, R. Slaughter, and A. K. Snover. 2003. Preparing for Climatic Change: The Water, Salmon, and Forests of the Pacific Northwest. *Climatic Change* 61:45–88.

Nijhuis, M. J., and R. H. Kaplan. 1998. Movement Patterns and Life History Characteristics in a Population of the Cascade Torrent Salamander (*Rhyacotriton cascadae*) in the Columbia River Gorge, Oregon. *Journal of Herpetology* 32(2):301–304.

Nussbaum, R. A., and C. K. Tait. 1977. Aspects of the Life History and Ecology of the Olympic Slalmander, Rhyacotriton olympicus (Gaige). *American Midland Naturalist* 98:176–199.

Nussbaum, R. A., E. D. Brodie, Jr. and R. M. Storm. 1983. *Amphibians and Reptiles of the Pacific Northwest*. The University Press of Idaho, Moscow, ID, 332 p.

Olson, D. H. 2007. Personal communication. Research Ecologist. USDA Forest Service—Pacific Northwest Research Station, 3200 SW Jefferson Way, Corvallis, OR 97331.

Olson, D. H., and K. M. Burnett. 2009. Design and Management of Linkage Areas Across Headwater Drainages to Conserve Biodiversity in Forest Ecosystems. *Forest Ecology and Management* 258S:S117-S126.

Olson, D. H. and C. Rugger. 2007. Preliminary Study of the Effects of Headwater Riparian Reserves with Upslope Thinning on Stream Habitats and Amphibians in Western Oregon. *Forest Science* 53(2):331–342.

Olson, D. H., and G. Weaver. 2007. Vertebrate Assemblages Associated with Headwater Hydrology in Western Oregon Managed Forests. *Forest Science* 53:343–355.

Oregon Department of Forestry. 2019. GIS data citation needed.

Palazzotto, N. 2019. Personal communication. State Forests Wildlife Biologist, Oregon Department of Forestry.

Pollett, K. L. 2005. *Responses of Stream-Breeding Amphibians to Riparian Buffers in Headwater Streams: Ameliorating the Effects of Regeneration Harvest*. Master's Thesis, Utah State University.

Pollett, K. L., J. G. MacCracken, and J. A. MacMahon. 2010. Stream Buffers Ameliorate the Effects of Timber Harvest on Amphibians in the Cascade Range of Southern Washington, USA. *Forest Ecology and Management* 260:1083–1087.

Ray, C. 1958. Vital Limits and Rates of Desiccation in Salamanders. *Ecology* 39:75–83.

Rombough, C. 2009. Personal communication. Herpetologist, Rombough Biological, P.O. Box 365, Aurora, OR 97002.

Russell, K. R. A. A. Gonyaw, J. D. Strom, K. E. Diemer, and K. C. Murk. 2002. Three New Nests of the Columbia Torrent Salamander, *Rhyacotriton kezeri*, in Oregon with Observations of Nesting Behavior. *Northwestern Naturalist* 83:19–22.

Russell, K. R., T. J. Mabee, M. B. Cole, and M. J. Rochelle. 2005. Evaluating Biotic and Abiotic Influences on Torrent Salamanders in Managed Forests of Western Oregon. *Wildlife Society Bulletin* 33(4):1413–1424.

Stebbins, R. C., and C. H. Lowe, Jr. 1951. Subspecific Differentiation in the Olympic Salamander, *Rhycotriton olympicus*. *University of California Publications of Zoology* 50:465–484.

Steele, C. A., E. D. Brodie, and J. G. MacCracken. 2003. Relationships Between Abundance of Cascade Torrent Salamanders and Forest Age. *Journal of Wildlife Management* 67(2):447–453.

Welsh Jr., H. H. and A. J. Lind. 1996. Habitat Correlates of the Southern Torrent Salamander, *Rhyacotriton variegatus* (Caudata: Rhyacotritonidae), in Northwestern California. *Journal of Herpetology* 30(3):385–398.

Whitford, W.G. and V.H. Hutchison. 1966. Cutaneous and pulmonary gas exchange in ambystomatid salamanders. Copeia 1966:573–577.Wilson, A.G. and J.H. Larsen Jr. 1992. Geographic distribution: *Rhyacotriton olympicus* (Olympic salamander). Herpetological Review 23:85

C13 Oregon Slender Salamander (*Batrachoseps wrighti*)

Legal Status

State: Sensitive Species

Federal: Species of Concern. In 2015, FWS published a 90~Day Finding on a Petition to List the Oregon Slender Salamander as a Threatened or Endangered Species (Federal Docket No. FWS-Rl- ES-2015-0057). The FWS found substantial scientific or commercial information indicating that the petitioned action may be warranted

Critical Habitat: N/A

Recovery Planning: N/A

Oregon Slender Salamander. Photo credit OSU via ODFW Oregon Conservation Strategy

Taxonomy

There is a high level of genetic divergence within Oregon slender salamander (*Batrachoseps wrighti*). Wagner (2000) and Miller et al. (2005) found evidence of two major lineages, a northern and southern population, and a pattern of isolation by distance. The northern population includes sites east of the Cascade crest and western sites from the Columbia River south to near Estacada, Oregon, in Multnomah, Clackamas, Hood River, and Wasco Counties. The southern population, in Marion, Linn, and Lane Counties, includes sites west of the Cascade crest north to near Silver Creek Falls.

Distribution

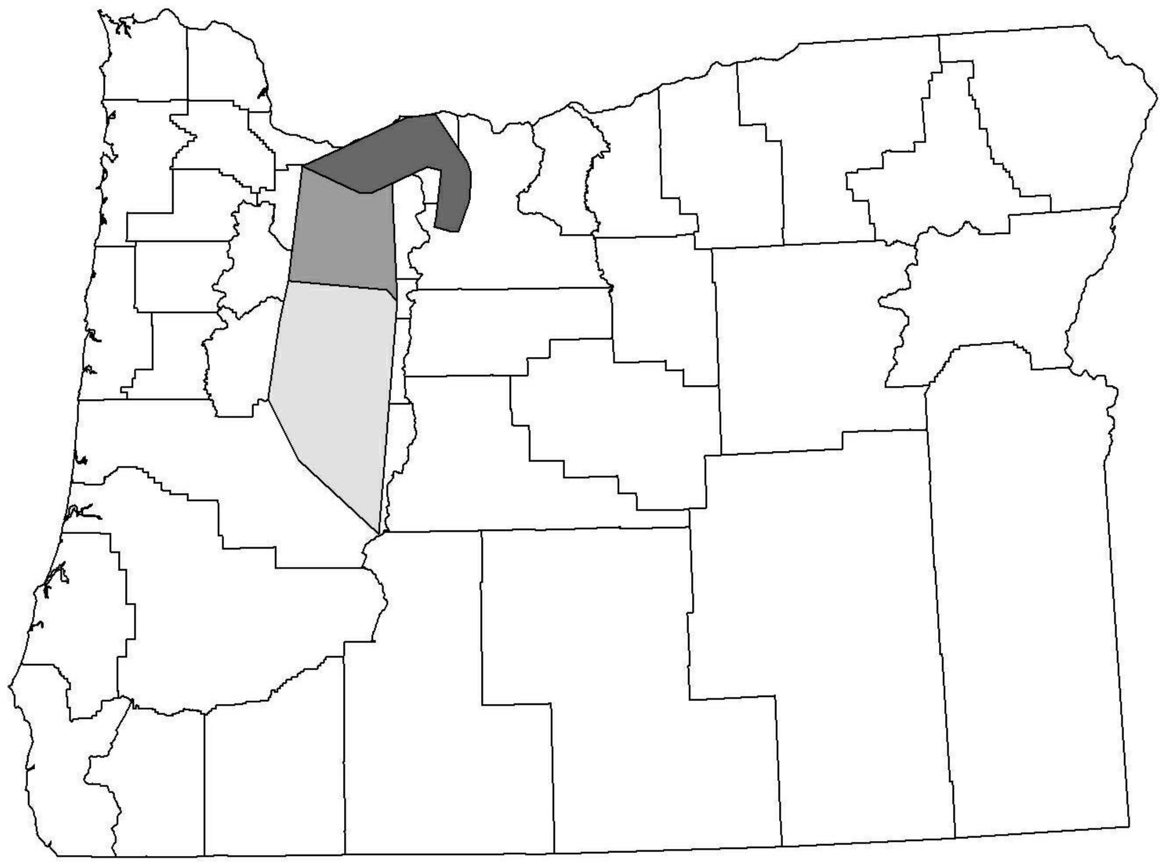
General

The Oregon slender salamander occurs in the northwestern Oregon Cascade Range and the foothills, from the Columbia River Gorge National Scenic Area, in the Multnomah and Hood River Counties southward in the Cascade Mountains, from Mt. Hood and Willamette National Forests, to southern Lane County (Clayton and Olson 2009) (Figure C13-1). The species is also found in northeast Oregon Cascade Range foothills from the Gorge to the Warm Springs Indian Reservation. Most of the species' range is on the western slopes of the Cascades, but several sites are on the eastern slope in Hood River and Wasco Counties (Stebbins 2003; Jones et al. 2005).

Clayton and Olson (2009) report the species occurring across a north-south range of close to 233 kilometers (145 miles), from approximately 24 meters (79 feet) in elevation (at the northern end of the species range in the Columbia Gorge) to approximately 1,700 meters (5,577 feet) (at the southern end of the species range on the west side of the Cascade Range crest).

Guderyahn et al. (2010) documented a breeding population of Oregon slender salamander among non-native plant species and small debris in a riparian buffer in the suburban residential development of Gresham, Oregon (Multnomah County). High densities of salamanders were found within soil layers, under small deciduous logs on soil, within fine woody debris, and within decaying deciduous logs and coniferous stumps. The finding suggests Oregon slender salamander need specific microhabitat conditions that may occur in other habitats apart from the species' primary association with late-successional forests.

Figure C13-1. Range Map of the Oregon Slender Salamander



Map shows the two genetic populations that have been distinguished, with the intervening area [medium shading] where population status is not known.
Source: Clayton and Olson (2009).

Occurrences Within the Plan Area

Oregon slender salamander occurs in the Western Cascades of the plan area in Clackamas, Marion, and Linn Counties. Operational surveys on public lands, including Oregon Department of Forestry

(ODF) lands, suggest that Oregon slender salamander are widespread in the plan area within their geographic and elevational range where suitable habitat features are present (see *Habitat Requirements* below) (N. Palazzotto, pers. comm.).

Natural History

The ecology and status of Oregon slender salamander are described in the Conservation Assessment for the Oregon Slender Salamander (Clayton and Olson 2009) and more recently summarized in Garcia et al. (2020).

Habitat Requirements

The Oregon slender salamander primarily occurs in old forests (generally older than 76 years) of Douglas-fir, bigleaf maple, hemlock, and western red cedar forests (Blaustein et al. 1995; Bury and Corn 1988; Gilbert and Allwine 1991; Vesely et al. 1999; Center for Biological Diversity 2012). Primary habitat characteristics include moisture, dead wood, and older forest (Clayton and Olson 2009).

Oregon slender salamander is highly associated with decayed large logs (Vesely et al. 1999; Clayton and Olson 2009; Kroll et al. 2015; Garcia et al. 2019). In the western Cascades, Oregon slender salamander density is positively correlated with large diameter (50 to 75 centimeters [20 to 30 inches]) logs and snags in forests with closed canopies, and negatively correlated with small (10 to 25 centimeters [4 to 10 inches]) logs and logs in intermediate levels of decay (Clayton and Olson 2009). This pattern is believed to reflect the species' selection of microhabitats that have a greater abundance of snags and large down logs in advanced decay stages. In surveys of 56 stands of 13 forest types, Vesely et al. (1999) found Oregon slender salamander to be more abundant in old growth than second growth stands; they did not find Oregon slender salamander in clear-cuts, possibly due to canopy removal and the low abundance of woody material. Large logs (50 to 75 centimeters), canopy closure, aspect, and snags were positively correlated with presence of Oregon slender salamander. Overall, canopy closure (median of 93% in old growth stands and 92% in second growth stands) and west- and east-facing slopes were the best predictors of relative density of salamanders. Vesely et al. (1999) suggest that mortality exceeds reproduction in intensively managed forests on short harvest rotations and cannot sustain populations of Oregon slender salamander in the long term. Forest practices that remove legacy down wood are most likely the cause of reduced abundances in harvested forests (Clayton and Olson 2009).

Oregon slender salamander may occur in younger forest stands, however, particularly if legacy downed wood has been retained (Clayton and Olson 2009). For example, Oregon slender salamander have been found in stands on the Cascades Resource Area clear-cut prior to 1960 with higher down wood (S. Dowlan, pers. comm., as cited in Clayton and Olson 2009), and volumes of large down, decayed wood in some of these stands are relatively high (Olson et al. 2006). Similarly, Oregon slender salamander abundance may not be significantly affected by thinning old clear-cuts, as long as legacy down wood is retained (Rundio and Olson 2007; Wessell 2005; Clayton and Olson 2009). Kroll et al. (2015) showed Oregon slender salamander occupancy was strongly associated with the amount of coarse wood debris, whereas Ensatina was not. Garcia et al. (2019) found a strong negative harvest effect on Ensatina but a lack of clear evidence for harvest effect on Oregon slender salamander. The study found the mean odds of occupancy for Oregon slender salamander was 20% lower in the post-harvest period (clear-cut units managed under standard practices including planting of Douglas-fir seedlings and herbicide applications) compared with pre-harvest period and 23% reduced mean abundance (Garcia et al. 2019). However, they did not find evidence of higher capture probabilities for slender salamanders than Ensatina in either control or treatment units (Garcia et al. 2019). Garcia et al. (2019) observed treatment differences for within structure temperatures and found evidence of positive association between occupancy and abundance of Oregon slender salamanders and Ensatina with downed wood count.

Suzuki (2009) developed habitat suitability models for Oregon slender salamander on federal lands in the west slope of the Oregon Cascade Range. The model that best classified salamander habitat as suitable or unsuitable included precipitation, minimum daily temperature, forest stand height, and basal area of Pacific fir. Analysis of the individual habitat attributes used to develop the models indicated that Oregon slender salamanders are more likely to occur at lower elevations, warmer temperatures, moderately lower precipitation, and taller, older forest stands with large basal areas and tree diameters. While studies have documented a strong association between downed wood and Oregon slender salamander occupancy or abundance (Vesely et al. 1999; Kroll et al. 2015; Garcia et al. 2019), downed wood was not significantly associated with presence of Oregon slender salamander. This is likely because amount and distribution of downed wood was not captured well by the landscape-level geographic information system (GIS) data used in the model (Suzuki 2008). East of the Cascades crest, the habitat associations for the species are not well known; the salamander has been reported using a variety of ground cover ranging from down logs to sloughed bark, and can occur in younger and older forests (Clayton and Olson 2009). The Oregon slender salamander also occurs under moss-covered rocks in the Columbia River Gorge and in stabilized talus and lava flows elsewhere (Jones et al. 2005).

Reproduction

Reproduction is terrestrial and mating occurs when the male transfers a spermatophore to the female. The species exhibits delayed onset of female oviposition until 4–5 years of age (Tanner 1953). Female Oregon slender salamanders have been found with clutches during April, May, and June (Blaustein et al. 1995). Based on gravid females observed, the clutch size ranges from 3 to 11 eggs. Oviposition likely occurs in spring and eggs hatch within 4 to 5 months (Storm 2005). Nests have been found under subsurface objects such as bark and in crevices in logs (Clayton and Olson 2009).

Diet

Oregon slender salamander consume a variety of small invertebrates such as springtails, mites, flies, spiders, snails, beetles, centipedes, and earthworms (Storm 2005).

Movement

Batrachoseps are thought to be sedentary. Oregon slender salamander is most active at the ground surface during wet periods (i.e., fall and spring) and when temperatures are cool (10–14°C)(Nussbaum et al. 1983). The movement capability of the Oregon slender salamander is indicated from genetic analysis studies. Wagner (2000) and Miller et al. (2005) documented divergence patterns suggestive of two discrete populations, which could be retained through time only as a result of limited gene flow between populations; this may be attributed to limited dispersal capabilities among other factors such as low reproductive rates, specific habitat requirements, and habitat fragmentation. Studies also suggest males disperse while females do not (Wagner 2000; Miller et al. 2005). Studies of the California slender salamander (*B. attenuates*), a close relative to the Oregon slender salamander, documented the salamander remaining in proximity to cover items at which they were discovered and moving approximately 1.5 meters from where they were originally found (Hendrickson 1954, as cited by Clayton and Olson 2009). Oregon slender salamander has been detected in forest stands that were clear-cut in the 1950s and 1960s, indicating the salamander either persisted after disturbance or dispersed into the area from nearby stands (Clayton and Olson 2009).

Ecological Relationships

Although, the predators of Oregon slender salamander are not well known or are undocumented (Clayton and Olson 2009), they likely include amphibians, reptiles, birds, and small mammals. Eggs and hatchlings are susceptible to cannibalism by adult salamanders even from the same species. The role of Oregon slender salamander in community or ecosystem processes has not been studied, though Plethodontid salamanders can comprise a large portion of the forest vertebrate biomass in some areas (e.g., Burton and Likens 1975).

Population Status and Trends

There is no information about population trends in this species (Clayton and Olson 2009). However, the International Union for Conservation of Nature (IUCN) Red List considers the Oregon slender salamander vulnerable to extinction.

Threats

The Oregon slender salamander is threatened by land-use activities that affect forest conditions, surface substrate/ground cover including down wood, soil compaction, fire, chemical application, changes in microhabitat and microclimate regimes that may impact individuals or populations at occupied site(s), and global climate change. Habitat loss and habitat degradation are the primary threats to the species (Clayton and Olson 2009). Clayton and Olson (2009) suggest short rotation clear-cut timber harvest, which removes canopy closure, disturbs substrates, and has potential to alter microhabitat refuges and microclimates, is the primary immediate threat to the salamander. The removal of large down wood and limited down wood recruitment decrease the availability of habitat and change habitat conditions, thereby negatively affecting the salamander. There is uncertainty about the effect of partial timber harvest or regeneration harvest with green tree and down wood retention on Oregon slender salamander (Clayton and Olson 2009), although most studies in the region of forest thinning indicate a decline in abundance of terrestrial salamanders. Habitat loss from development (e.g., urbanization, large recreation areas) resulting in loss of habitat connectivity leading to isolated populations, also poses a threat to the species (Clayton and Olson 2009).

The effect of fire (prescribed fire vs. natural fire) on Oregon slender salamander is poorly understood. Low intensity fires that retain large down wood and occur during the seasons when these salamanders are not active at the surface may not have adverse effects on the species. A high intensity fire could remove overstory canopy that moderates surface microclimates and reduce decayed down wood, and represents a larger disturbance to flora and fauna (Clayton and Olson 2009).

Although it is not known how chemical applications affect Oregon slender salamander, the species breathes through its skin. Contact with chemicals such as herbicides, pesticide, fungicides, fertilizers, and fire retardant may have a direct negative impact on the species.

While disease has not been implicated for Oregon slender salamander, chytrid fungus has recently been detected in a plethodontid salamander (Cummer et al. 2005).

The species' range includes habitat that is vulnerable to the effects of predicted climate change (Clayton and Olson 2009). West of the Cascade crest, warming could increase the elevational limits of the species and restrict Oregon slender salamander distribution at lower elevations. Foothills may become less suitable for the species. Habitat for the species may become restricted east of the Cascade crest.

Roads create direct and indirect threats to Oregon slender salamander. Roads can cause mortality, loss and modification of suitable habitat, and habitat fragmentation. Development can impact the species through loss of habitat and disturbance of habitat.

A landscape-level multivariate risk assessment (Suzuki 2008) showed the central-western portion of the species' range has high cumulative risk due to high concentrations of actively managed federal timber and private lands, as well as roads. The southwestern portion of the species' range has high potential cumulative risk due to high fire risk, and the northwestern corner of the species' range has the highest potential risk due to actively managed federal timber land, private lands, roads, and wildland-urban interface.

Literature Cited

Anderson, P. K. 1960. Ecology and Evolution in Island Populations of Salamanders in the San Francisco Bay Region. *Ecological Monographs* 30:359–386.

Blaustein, A., J. Beatty, D. Olson, and R. M. Storm. 1995. *Biology of Amphibians and Reptiles in Old-Growth Forests in the Pacific Northwest*. Forest Service general technical report.

Burton, TM, Likens GE. 1975. Salamander Populations and Biomass in the Hubbard Brook Experimental Forest, New Hampshire. *Copeia* 1975;3:541–546.

Bury, R. B., and P. S. Corn. 1988. Responses of Aquatic and Streamside Amphibians to Timber Harvest: a Review. Pages 165–166: Streamside Management: Riparian Wildlife and Forestry Interactions. College of Forest Resources, University of Washington, Seattle, WA.

Center for Biological Diversity. 2012. Petition to list 53 amphibians and reptiles in the United States as threatened or endangered species under the Endangered Species Act. Center for Biological Diversity, Tucson, Arizona. Prepared by C.L.A., Giese, D.N. Greenwald and T. Curry.

Clayton, D. R., and D. H. Olson. 2009. *Conservation Assessment for the Oregon Slender Salamander*. Page 76. version 2, USDA Forest Service Region 6 and USDI Bureau of Land Management.

Cummer, M.R.; Green, D.E.; O'Neill, E.M. 2005. Aquatic Chytrid Pathogen Detected in Terrestrial Plethodontid Salamander. *Herpetological Review* 36:248–249.

Garcia, T.S., J.J. Weyerhaeuser, J.J. Weyerhaeuser, and A. J. Kroll. 2019. *Experimental Results Indicate Variable Responses to Timber Harvest by Sympatric Plethodontid Salamander Species*. Final draft.

Gilbert, F.F.; Allwine, R. 1991. Terrestrial Amphibian Communities in the Oregon Cascade Range. Pages 319–324 in L.F. Ruggiero, K. B. Aubry, A. B. Carey, and M. H. Huff (technical coordinators). *Wildlife and Vegetation of Unmanaged Douglas-Fir Forests*. Gen. Tech. Rep. PNW-GTR-285. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 533 p 285.

Guderyahn, L., C. Musson, A. Smithers, B. Wishnek, and C. Corkran. 2010. Observations of Oregon Slender Salamanders (*Batrachoseps wrighti*) in Suburban Landscapes. *Northwestern Naturalist* 91:325–328.

Jones, L.L.C., W. P. Leonard, and D. H. Olson, editors. 2005. *Amphibians of the Pacific Northwest*. Seattle Audubon Society, Seattle, Washington. xii + 227 pp.

Kroll AJ, Garcia TS, Jones JE, Dugger K, Murden B, Johnson J, et al. (2015) Evaluating Multi-Level Models to Test Occupancy State Responses of Plethodontid Salamanders. *PLoS ONE* 10(11): e0142903. doi:10.1371/journal.pone.0142903

Miller, M. P., S. M. Haig, and R. Steven. Wagner. 2005. Conflicting Patterns of Genetic Structure Produced by Nuclear and Mitochondrial Markers in the Oregon Slender Salamander (*Batrachoseps wrighti*): Implications for Conservation Efforts and Species Management. *Conservation Genetics* 6:275–287.

Olson, D.H., Nauman, R.H., Ellenburg, L.L., Hansen, B.P., Chan, S.S. 2006. *Ensatina eschscholtzii* Nests at a Managed Forest Site in Oregon. *Northwestern Naturalist* 87:203–208.

Ruggiero, L. F., K. B. Aubry, A. B. Carey, and M. H. Huff. 1991. *Wildlife and Vegetation of Unmanaged Douglas-Fir Forests*. Gen. Tech. Rep. PNW-GTR-285. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 533 p 285.

Rundio, D.E., Olson, D.H., 2007. Influence of Headwater Site Conditions and Riparian Buffers on Terrestrial Salamander Response to Forest Thinning. *Forest Science* 53(2):320–330.

Stebbins, R. C. 2003. A *Field Guide to Western Reptiles and Amphibians*. Third edition. Houghton Mifflin Company, Boston.

Suzuki, N., and D. H. Olson. 2012. *Validation of the Oregon Slender Salamander Habitat Suitability Model and Map for the West Slope of the Oregon Cascade Range*. Available: https://www.fs.fed.us/r6/sfpnw/issssp/documents3/inv-rpt-ha-bawr-habitat-model-validation-20120726.pdf.

Suzuki, N., D. Olson, and E. C. Reilly. 2008. Developing Landscape Habitat Models for Rare Amphibians with Small Geographic Ranges: A Case Study of Siskiyou Mountains Salamanders in the Western USA. *Biodiversity and Conservation* 17:2197–2218.

Storm, R.M. 2005. Oregon Slender Salamander: *Batrachoseps wrighti* Bishop. In Jones, L.L.C.; Leonard, W.P.; Olson, D.H. (eds.). 2005. *Amphibians of the Pacific Northwest*. Seattle Audubon Society, Seattle, WA.

Tanner, W. 1953. Notes on the Life History of *Plethopsis wrightii* Bishop. *Herpetologica* 9:139–140. As cited in Clayton and Olson 2009.

Vesely, D.G., 1999. *Habitat Selection by Oregon Slender Salamanders (*Batrachoseps wrighi*) in Western Oregon Cascades.* Pacific Wildlife Research, Corvallis, OR, USA, pp. 16.

U.S. Forest Service. 2008. *2008 ISSSSP Surveys for Oregon Slender Salamander (Batrachoseps wrightorum)* on Federal Lands Managed by the Eugene Bureau of Land Management and the Willamette National Forest. Page 15. U.S. Department of Agriculture, Forest Service.

Wagner, R.S. 2000. *Phylogeny, Evolution, and Conservation in Forest-Associated Pacific Northwest Salamanders*. Ph.D. dissertation. Oregon State University, Corvallis, Oregon

Walcott, P. 2010. *Inventory for Oregon Slender Salamander,* Batrachoseps wrightorum*, on the Mt. Hood National Forest*. Report to the Interagency Special Status Sensitive Species Program FY 2009. Page 8. Mt. Hood National Forest.

Wessell, S.J., 2005. *Biodiversity in Managed Forests of Western Oregon: Species Assemblages in Leave Islands, Thinned, and Unthinned Forests.* M.Sc. Thesis, Oregon State Univ., Corvallis, Oregon, U.S.A., p. 161.

C14 Northern Spotted Owl (*Strix occidentalis caurina)*

Legal Status

State: Threatened

Federal: Threatened

Critical Habitat: Original designation in 1992 (57 *Federal Register* [FR] 1796–1838); revised in 2008 (73 FR 47326–47522); December 4, 2012 (77 FR 71875–72068); and January 15, 2021 (86 FR 4820-4860)

Recovery Planning: 2008; revised on June 28, 2011.

Photo: USFWS

Taxonomy

The northern spotted owl (*Strix occidentalis caurina*) is the largest of the three subspecies of spotted owls. The taxonomic separation of these three subspecies is supported by genetic, morphological, and biogeographical information (USFWS 2011). The distribution of the Mexican subspecies (*S.o. lucida*) is disjunct from those of the northern and California (*S.o. occidentalis*) subspecies (Gutierrez et al. 1995). Mitochondrial DNA and microsatellite studies also support the subspecies designation for northern and California spotted owls (Henke 2005; Barrowclough et al. 2005). A narrow hybridization zone between northern and California spotted owls is located in the southern Cascades and northern Sierra Nevada.

Distribution

General

Spotted owls are believed to have inhabited most old-growth forests or stands throughout the Pacific Northwest, including northwestern California, prior to the mid-1800s (USFWS 1989).

The current range of the northern spotted owl extends from southwest British Columbia through the Cascade Mountains, coastal ranges, and intervening forested lands in Washington, Oregon, and California, as far south as Marin County (USFWS 2011). The range of northern spotted owl is partitioned into 12 provinces based on landscape subdivisions with different physical and environmental features. The provinces are distributed across the species' range as follows.

- Four provinces in Washington: Eastern Washington Cascades, Olympic Peninsula, Western Washington Cascades, Western Washington Lowlands.
- Five provinces in Oregon: Oregon Coast Range, Willamette Valley, Western Oregon Cascades, Eastern Oregon Cascades, Oregon Klamath.

- Three provinces in California: California Coast, California Klamath, California Cascades.

Occurrences Within the Plan Area

Northern spotted owl occurs in the plan area in the Coast Range counties of Clastsop, Tillamook, Washington, Yamhill, Polk Lincoln, Benton, Lane, Douglas, Coos, Curry, Josephine, and Jackson and the Western Cascade counties of Clackamas, Marion, and Linn.

The permit area includes 20 "active" northern spotted owl activity centers confirmed to be occupied by pairs. For this HCP, active activity centers are defined as those activity centers that have been confirmed at one point and have had less than 6 consecutive years of surveys with no observations. Activity centers that have not been surveyed consistently were assumed to have their same status as of their most recent survey history.

There are 142 northern spotted owl sites with activity centers located outside of the permit area but within the provincial radius of permit area lands. Using the provincial radius, "owl circles" that overlap the permit area include 119 sites with confirmed pairs, 5 sites with unconfirmed pairs, and 18 sites with resident single owls. Because northern spotted owl numbers continue to decline throughout the species' range, not all of these sites are believed to currently support owls. However, for this HCP, sites with historic confirmed pair status but no confirmed absence (i.e., 6 consecutive years with no observations) were assumed to be occupied to minimize the potential for take.

Table C14-1. Northern Spotted Owl Active Sites Within the Permit Area, by ODF District.

District	Location	Pair	Unconfirmed Pair	Resident Single	Total
Astoria	**Permit Area**	**2**	**--**	**--**	**2**
	Adjacent	--	--	--	--
Coos	**Permit Area**	**3**	**--**	**--**	**3**
	Adjacent	24	--	3	27
Forest Grove	**Permit Area**	**2**	**--**	**--**	**2**
	Adjacent	1	--	--	1
North Cascade	**Permit Area**	**3**	**2**	**--**	**5**
	Adjacent	9	1	2	12
Southwest	**Permit Area**	**3**	**--**	**2**	**5**
	Adjacent	47	2	3	52
Tillamook	**Permit Area**	**3**	**2**	**3**	**8**
	Adjacent	4	1	--	5
West Oregon	**Permit Area**	**2**	**--**	**2**	**4**
	Adjacent	2	--	2	4
Western Lane	**Permit Area**	**2**	**--**	**--**	**2**
	Adjacent	32	1	8	41
	Total	139	9	25	173
	Total Permit Area	**20**	**4**	**7**	**31**
	Total Adjacent	**119**	**5**	**18**	**142**

Natural History

Habitat Requirements

The most recent and comprehensive review of northern spotted owl status and threats is in Chapter 4 of the 2018 Forest Service Science Synthesis Report (Lesmeister et al. 2018). The ecology of northern spotted owl is addressed in the 2012 designation of critical habitat for northern spotted owl (USFWS 2012).

Northern spotted owls generally occupy late-seral forest but may also use younger forests for foraging, movement, and dispersal. Northern spotted owl habitat requirements are commonly ascribed to the specific essential behaviors of nesting and roosting, foraging, and dispersal. Habitat associations for each of these essential behaviors is described in this section.

Nesting and Roosting Habitat

Nesting and roosting habitat provides structural features for nesting, protection from adverse weather conditions, and cover to reduce predation risks for adults and young. Stand structure at nest sites tends to vary little across the northern spotted owl's range. The U.S. Fish and Wildlife Service (USFWS) considers the following components important to nesting and roosting habitat (USFWS 2012).

- Moderate to high canopy cover (60% to over 80%).
- Multilayered, multispecies canopies with large (20- to 30-inch or greater diameter at breast height [dbh]) overstory trees.
- High basal area (greater than 240 square feet per acre).
- High diversity of tree diameters.
- High incidence of large live trees with various deformities (e.g., large cavities, broken tops, mistletoe infections).
- Large snags and large accumulations of fallen trees and other woody material on the ground.
- Sufficient open space below the canopy for northern spotted owls to fly.

Northern spotted owls do not construct nests, but instead rely on platforms provided by tree cavities, mistletoe brooms, and abandoned nests of other predatory birds such as northern goshawks (*Accipiter gentilis*) (Buchanan et al. 1993). Such nest sites are found in large snags or large live trees with structurally diverse crowns (e.g., broken tops or large cavities), features typically found in late-seral forest or in younger forest that retains residual large trees and snags.

Prey Species

Northern spotted owls are mostly nocturnal but will forage opportunistically during the day (USFWS 2011). The composition of the northern spotted owl's diet varies geographically and by forest type.

- Flying squirrels (*Glaucomys sabrinus*) are the most prominent prey for northern spotted owls in Douglas-fir and western hemlock (*Tsuga heterophylla*) forests in Oregon and Washington (Forsman et al. 1984; Hamer et al. 2001),

- Dusky-footed wood rats (*Neotoma fuscipes*) are a major part of the diet in the Oregon Klamath, California Klamath, and California Coastal provinces (Forsman et al. 1984, 2004; Ward et al. 1998).
- Depending on location, other important prey include deer mice (*Peromyscus maniculatus*), tree voles (*Arborimus longicaudus, A. pomo*), red-backed voles (*Clethrionomys sp.),* gophers (*Thomomys* sp.), snowshoe hare (*Lepus americanus*), bushy-tailed wood rats (*Neotoma cinerea*), birds, and insects, although these comprise a small portion of the northern spotted owl diet (Forsman et al. 1984, 2004; Ward et al. 1998; Hamer et al. 2001).

Foraging Habitat

Foraging habitat varies widely across the northern spotted owl's range. Within the West Cascades/Coast Ranges of Oregon and Washington, the USFWS defines foraging habitat as follows (USFWS 2012).

- Stands of nesting and roosting habitat; additionally, owls may use younger forests with some structural characteristics (legacy features) of old forests, hardwood forest patches, and edges between old forest and hardwoods.
- Moderate to high canopy cover (60 to over 80%).
- A diversity of tree diameters and heights.
- Large accumulations of fallen trees and other woody debris on the ground.
- Sufficient open space below the canopy for northern spotted owls to fly.

Reproduction

Northern spotted owls are monogamous, form long-term pair bonds, have a long reproductive life span (6–9 years) and provide extended parental care (USFWS 2011). There are no known examples of polygyny in this owl, although associations of three or more birds have been reported (Gutiérrez et al. 1995). Spotted owls are sexually mature at 1 year of age, but rarely start breeding until 2 to 5 years of age (Forsman et al. 2002). Females lay one to four eggs per clutch, with an average clutch size of two eggs. Most spotted owl pairs do not nest every year, nor are nesting pairs successful every year (Forsman et al. 1984; USFWS 1990; Anthony et al. 2006). The species has low fecundity due to its small clutch size, nesting success variability, and delayed onset of breeding (Gutierrez 1996).

Timing of nesting and fledging varies with elevation and latitude (Forsman et al. 1984). Courtship behavior usually begins in February or March, and eggs are typically laid in late March or April. Juveniles leave the nest in late May or June and are dependent upon their parents until they are able to fly and hunt on their own. Adults continue to provide parental care from fledging into September (Forsman et al. 1984; USFWS 1990). Adults will roost during the day with fledged young for the first few weeks, but by late summer the adults rarely roost with their young and only visit the juveniles at night to feed them (Forsman et al. 1984).

Territory and Home Range

Territory

Northern spotted owls are territorial; however, home ranges of adjacent pairs may overlap (Solis and Gutierrez 1990), suggesting that the territorial area is smaller than the area used for foraging. Northern spotted owls will actively defend their nests and young from predators (Gutierrez et al. 1995). Territorial defense is primarily achieved by hooting, barking and whistle type calls. Some northern spotted owls are not territorial but either remain as residents within the territory of a pair or move among territories (Gutiérrez 1996). These birds are referred to as "floaters."[2] Floaters have special significance in northern spotted owl populations because they may buffer the territorial population from decline (Franklin 1992). Little is known about floaters other than that they exist and typically do not respond to calls as vigorously as territorial birds (Gutiérrez 1996).

Home Range

A home range is the area in which a spotted owl conducts its activities during a defined period of time (USFWS 1992) that provides important habitat elements for nesting, roosting, and foraging. Home ranges vary geographically, generally increasing in size from south to north, which is likely a response to differences in habitat quality (USFWS 1990,).

The presence of barred owl has also been shown to influence the home range of spotted owls (Wiens et al. 2014). Estimates of median size of the annual home range (the area traversed by an individual or pair during normal activities) varies by province and range from 2,955 acres in the Oregon Cascades to 14,211 acres on the Olympic Peninsula in Washington (USFWS 2011). Within the home range is a smaller area of concentrated use during the breeding season, often referred to as the core use area.[3]

Spotted owl core use areas vary in size geographically and provide habitat elements that are needed for reproduction, such as the nest tree, roost sites, and foraging areas. Spotted owl home ranges contract during the breeding season and expand during fall and winter. Home range size is also influenced by stand characteristics, availability of prey, and presence of barred owls (Wiens et al. 2014).

Activity Centers and Provincial Radii

Spotted owls have been characterized as central-place foragers, where individuals forage over a wide area and subsequently return to a nest or roost location that is often centrally-located within the home range (Rosenberg and McKelvey 1999, in USFWS 2011). Activity centers are location or point within the core use area that represent this central location. Nest sites are typically used to identify activity centers, or in cases where nests have not been identified, breeding season roost sites or areas of concentrated nighttime detections may be used to identify activity centers.

---

[2] Floaters are referred to as "SU" for administrative purposes.

[3] Core Use Area: An area of concentrated use within a home range that receives disproportionally high use (Bingham and Noon 1993), and commonly includes nest sites, roost sites, and foraging areas close to the activity center. Core use areas vary geographically, and in relation to habitat conditions. This is a biological definition of core use area and is not the same as a 70-acre core as defined by the Oregon Forest Practices Act nor is it equivalent to the 100acre LSRs referred to as NSO cores on federal lands. The 70-acre core area has been expanded to 250-acre on the North Coast under the SOC policy.

The FWS has identified “provincial home ranges” as a management tool for northern spotted owls (USFWS 2011). The “provincial radius” is that of a circle centered on the activity center that represents the approximate home range for an owl in a given geographic location. Based on guidance from the USFWS, ODF uses the following provincial radii:

- Klamath Province (Southwest Unit), 1.3 miles;
- Oregon Cascades (North Cascade District), 1.2 miles;
- Oregon Coast Ranges (all other Districts), 1.5 miles.

Using the provincial radius, a circle is drawn around each activity center, creating an “owl circle” in which habitat effects may occur.

Dispersal Biology

Dispersal habitat is habitat through which young owls disperse from their parents’ territory to establish a new territory. Young owls generally begin to disperse in September and October, with a few individuals dispersing in November and December (Forsman et al. 2002). Natal dispersal occurs in stages. Young owls tend to disperse widely, often in a series of steps (Forsman et al. 2002), so that dispersing juveniles may occupy temporary home ranges for up to several months (Forsman et al. 2002). Studies have shown that spotted owls can disperse through highly fragmented forest landscapes (Forsman et al. 2002); however, owls are not able to disperse through large, non-forested valleys (such as the Willamette Valley) and may move around large water bodies rather than crossing them (Forsman et al. 2002).

USFWS defines dispersal habitat as follows (USFWS 2012).

- Stands with adequate tree size and canopy cover to provide protection from avian predators and minimal foraging opportunities; in general this may include, but is not limited to, trees that are at least 11 inches dbh and have a minimum 40% canopy cover.
- Younger and less diverse forest stands than foraging habitat, such as even-aged, pole-sized stands, if such stands contain some roosting structures and foraging habitat to allow for temporary resting and feeding during dispersal.
- Habitat supporting the colonization phase of dispersal, which is generally similar to nesting, roosting and foraging habitat, but may be smaller in area than habitat needed to support nesting pairs.

Dispersing juvenile northern spotted owls experience high mortality rates from starvation, predation, and accidents (Forsman et al. 2002). Dispersal distances have been reported to be in the range of 8 to 17 miles from natal areas to eventual home range (Courtney et al. 2004); the median natal dispersal distance is about 10 miles (16 kilometers) for males and 15.5 miles (25 kilometers) for females (Forsman et al. 2002).

Successful juvenile dispersal may depend on locating unoccupied suitable habitat in proximity to other occupied sites (LaHaye et al. 2001). Dispersing juveniles may be attracted to calls of other northern spotted owls and may look for suitable sites preferentially in the vicinity of occupied territories. When all suitable territories are occupied, dispersers may temporarily pursue a nonresident (nonbreeding) strategy as floaters (Forsman et al. 2002). Floaters prospect for territorial vacancies created when residents die or leave their territories.

Ecological Relationships

Known predators of northern spotted owls include great horned owls (Forsman et al. 1984) and possibly barred owls (Leskiw and Gutiérrez 1998). Other suspected predators include northern goshawks, red-tailed hawks, and other raptors (Courtney et al. 2004). Barred owls are also known to compete with northern spotted owls for habitat and resources for breeding, feeding and sheltering; evidence of a negative relationship between barred owl occurrence and population characteristics of northern spotted owl have been well documented and include declines in occupancy of historical northern spotted owl territories where barred owls are detected (Dugger et al. 2011; Lesmeister et al. 2018). Hybridization of northern spotted owls with barred owls and California spotted owls has also been confirmed (Lesmeister et al. 2018).

Population Status and Trends

Meta-analysis has documented the progressive and ongoing decline of spotted owl populations throughout their range (Anthony et al. 2006; Dugger et al. 2016; Forsman et al. 2011), with pronounced declines in annual survival, rate of population change, and site occupancy (Dugger et al. 2016). Dugger et al. (2016) reported the rate of decline was increasing in many areas, including southern Oregon and northern California. Dugger et al. (2016) reported a 3.8% annual rate of decline, which was higher than the 2.9% annual rate of decline reported by Forsman et al. (2011).

Threats

The northern spotted owl was listed as threatened throughout its range “due to loss and adverse modification of northern spotted owl habitat as a result of timber harvesting and exacerbated by catastrophic events such as fire, volcanic eruption, and wind storms” (USFWS 2008). Additional threats included limited habitat, declining habitat, inadequate distribution of habitat or populations, isolation of populations within physiographic provinces, predation and competition, lack of coordinated conservation measures, inadequacy of regulatory mechanisms, and vulnerability to natural disturbance (USFWS 1992).

*U.S. Fish and Wildlife Service Revised Recovery Plan for the Northern Spotted Owl (*2011) identifies past habitat loss, current habitat loss, and competition from barred owls as the most pressing threats to the spotted owl. Davis et al. (2011) report spotted owl habitat loss on federal lands resulting from harvest and natural disturbances from 1994/1996 to 2006/2007 in Oregon as follows.

- Oregon Coast Range – 611,200 acres with a total habitat loss of 3,300 acres (0.5% total percent loss).
- Oregon Klamath – 985,000 acres with a total habitat loss of 100,700 (10.2% total percent loss).
- Eastern Oregon Cascades – 402,900 acres with a total habitat loss of 25,900 (6.4% total percent loss).
- Western Oregon Cascades – 2,258,700 acres with a total habitat loss of 43,900 (1.9% total percent loss).
- Willamette Valley – 3,400 acres with a total habitat loss of 100 (2.9% total percent loss).

Additional threats to northern spotted owl include climate change, regulatory mechanisms, and disease. Glenn et al. (2010) noted that the potential consequences of global climate change on the Pacific Northwest forests remain unclear with models predicting warmer, wetter winters, and hotter drier summers. Climate change has the potential to cause fundamentally different patterns in weather, which may have unpredictable consequences for northern spotted owl populations.

One of the original reasons for listing the northern spotted owl was the inadequacy of applicable regulatory mechanisms that existed in 1990; since 1994 the Northwest Forest Plan has been implemented on federal lands throughout the northern spotted owl range, and as of 2016 Bureau of Land Management (BLM) lands in western Oregon are being managed under the Proposed Resource Management Plan (BLM 2016). State and private lands are regulated under various state authorities, and timber harvest within each state is governed by rules that provide varying degrees of protection of northern spotted owls or their habitat. In Oregon, the State Forest Practices Act regulates state and private lands. Various research indicates that habitat conservation measures on state and private lands may not be sufficient to maintain the northern spotted owl (Buchanan 2004; Sovern et al. 2015; Glenn et al. 2004). The *Revised Recovery Plan for the Northern Spotted Owl* (USFWS 2011) and *Northern Spotted Owl Habitat and Populations: Status and Threats* (Leismeister et al. 2018) identify a more important recovery role for state and private lands.

USFWS identified disease as a potential stressor for northern spotted owls in 1992 and in 2011. This stressor includes both avian disease (such as West Nile virus, avian flu, avian malaria, and trichomonosis) that may affect northern spotted owls directly and forest pathogens (such as sudden oak death) that may disturb or alter spotted owl habitat.

Literature Cited

Anthony, R. G., E. D. Forsman, A. B. Franklin, D. R. Anderson, K. P. Burnham, G. C. White, C. J. Schwarz, J. D. Nichols, J. E. Hines, G. S. Olson, S. H. Ackers, L. S. Andrews, B. L. Biswell, P. C. Carlson, L. V. Diller, K. M. Dugger, K. E. Fehring, T. L. Fleming, R. P. Gerhardt, S. A. Gremel, R. J. Gutiérrez, P. J. Happe, D. R. Herter, J. M. Higley, R. B. Horn, L. L. Irwin, P. J. Loschl, J. A. Reid, and S. G. Sovern. 2006. Status and Trends in Demography of Northern Spotted Owls, 1985–2003. *Wildlife Monographs* 163:1–48.

Barrowclough, G. F., J. G. Groth, L. A. Mertz, and R. J. Gutierrez. 2005. Genetic Structure, Introgression, and a Narrow Hybrid Zone Between Northern and California Spotted Owls (*Strix occidentalis*). *Molecular Ecology* 14:1109–1120.

Buchanan, J. B. 2004. In My Opinion: Managing Habitat for Dispersing Northern Spotted Owls—Are the Current Management Strategies Adequate? *Wildlife Society Bulletin* 32:1333–1345.

Buchanan, J. B., L. L. Irwin, and E. L. McCutchen. 1993. Characteristics of Spotted Owl Nest Trees in the Wenatchee National Forest. *Journal of Raptor Research* 27:1–7.

Bureau of Land Management. 2016. *Proposed Resource Management Plan/Final Environmental Impact Statement for the Resource Management Plans for Western Oregon—Coos Bay, Eugene, Medford, Roseburg, and Salem Districts, and the Klamath Falls Field Office of the Lakeview District. Vol. I–IV.* Bureau of Land Management, Portland, OR.

Courtney, S. P., J. A. Blakesley, R. E. Bigley, M. L. Cody, J. P. Dubmacher, R. C. Fleischer, J. F. Franklin, R. J. Gutiérrez, J. M. Marzluff, and L. Sztukowski. 2004. *Scientific Evaluation of the Status of the Northern Spotted Owl.* Sustainable Ecosystems Institute, Portland, OR.

Davis, R. J., K. M. Dugger, S. Mohoric, L. Evers, and W. C. Aney. 2011. *Northwest Forest Plan—The First 15 Years (1994–2008): Status and Trends of Northern Spotted Owl Populations and Habitats*. Page 147. Gen. Tech. Rep., U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station., Portland, OR.

Dugger, K. M., E. D. Forsman, A. B. Franklin, R. J. Davis, G. C. White, Carl J. Schwarz, Kenneth P. Burnham, James D. Nichols, James E. Hines, Charles B. Yackulic, Paul F. Doherty, Larissa Bailey, Darren A. Clark, Steven H. Ackers, Lawrence S. Andrews, B. Augustine, Brian L. Biswell, Jennifer Blakesley, Peter C. Carlson, Matthew J. Clement, Lowell V. Diller, Elizabeth M. Glenn, Adam Green, Scott A. Gremel, Dale R. Herter, J. Mark Higley, Jeremy Hobson, Rob B. Horn, Kathryn P. Huyvaert, Christopher McCafferty, Trent McDonald, Kevin McDonnell, Gail S. Olson, Janice A. Reid, Jeremy Rockweit, Viviana Ruiz, Jessica Saenz, and Stan G. Sovern. 2016. The Effects of Habitat, Climate, and Barred Owls on long-Term Demography of Northern Spotted Owls. *The Condor* 118:57–116.

Forsman, E. D., R. G. Anthony, K. M. Dugger, E. M. Glenn, A. Franklin, G. White, C. J. Schwartz, K. P. Burnham, D. R. Anderson, J. D. Nichols, J. Hines, J. B. Lint, R. J. Davis, S. H. Ackers, L. Andrews, B. L. Biswell, P. C. Carlson, L. Diller, S. A. Gremel, and S. Sovern. 2011. *Population Demography of Northern Spotted Owls.*

Forsman, E. D., R. G. Anthony, E. C. Meslow, and C. J. Zabel. 2004. Diets and Foraging Behavior of Northern Spotted Owls in Oregon. *Journal of Raptor Research* 38:214–230.

Forsman, E. D., R. G. Anthony, J. A. Reid, P. J. Loschl, S. G. Sovern, M. Taylor, B. L. Biswell, A. Ellingson, E. C. Meslow, G. S. Miller, K. A. Swindle, J. A. Thrailkill, F. F. Wagner, and D. E. Seaman. 2002. Natal and Breeding Dispersal of Northern Spotted Owls. *Wildlife Monographs*:1–35.

Forsman, E. D., E. C. Meslow, and H. M. Wright. 1984. Distribution and Biology of the Spotted Owl in Oregon. *Wildlife Monographs* 48:1–64.

Franklin, A.B. 1992. Population Regulation In Northern Spotted Owls: Theoretical Implications for Management. Pages 815–827 in D.R. McCullough and R.H. Barrett (eds.), *Wildlife 2001: Populations.* New York: Elsevier Press: 815-827.

Glenn, E. M., M. C. Hansen, and R. G. Anthony. 2004. Spotted Owl Home-Range and Habitat Use in Young Forests of Western Oregon. *The Journal of Wildlife Management* 68:33–50.

Glenn, E. M., R. G. Anthony, and E. D. Forsman. 2010. Population Trends in Northern Spotted Owls: Associations with Climate in the Pacific Northwest. *Biological Conservation* 143:2543–2552.

Gutierrez, R. J. 1996. Biology and Distribution of the Northern Spotted Owl. *Studies in Avian Biology* 17:2–5.

Gutierrez, R. J., A. B. Franlin, and W. S. Lahaye. 1995. Spotted Owl (*Strix occidentalis*), version 2.0. Page in A. F. Poole and F. B. Gill (eds.). *Birds of North America*. Cornell Lab of Ornithology, Ithaca, New York.

Hamer, T. E., D. L. Hays, C. M. Senger, and E. D. Forsman. 2001. Diets of Northern Barred Owls and Northern Spotted Owls in an Area of Sympatry. *Journal of Raptor Research* 35:221–227.

Henke, A. L. 2005. *Spotted Owl (*Strix occidentalis*) Microsatellite Variation in California*. M.S. thesis, San Jose State University.

Lahaye, W. S., R. J. Gutiérrez, and J. R. Dunk. 2001. Natal Dispersal of the Spotted Owl in Southern California: Dispersal Profile of an Insular Population. *The Condor* 103:691–700.

Leskiw, T., and R. J. Gutiérrez. 1998. Possible Predation of a Spotted Owl by a Barred Owl. *Western Birds* 29:225–226.

Lesmeister, D. B., R. J. Davis, P. H. Singleton, and J. D. Wiens. 2018. Chapter 4: Northern Spotted Owl Habitat and Populations: Status and Threats. In *Volume 2 – Synthesis of Science to Inform Land Management within the Northwest Forest Plan Area* 2:56.

Lorenz, T.J.; M.R. Raphael, T.D. Bloxton, P.G. Cunningham. 2017. Low Breeding Propensity and Wide-Ranging Movements by Marbled Murrelets in Washington. *Journal of Wildlife Management* 81:306–321.

M Dugger, K., R. G Anthony, and L. Andrews. 2011. *Transient Dynamics of Invasive Competition: Barred Owls, Spotted Owls, Habitat, and the Demons of Competition Present*.

Sovern, S. G., E. D. Forsman, K. M. Dugger, and M. Taylor. 2015. Roosting Habitat Use and Selection by Northern Spotted Owls During Natal Dispersal. *The Journal of Wildlife Management* 79:254–262.

Thomas, J. W., E. D. Forsman, J. B. Lint, E. C. Meslow, B. R. Noon, and J. Verner. 1990. *A Conservation Strategy for the Northern Spotted Owl. Interagency Scientific Committee to Address the Conservation of the Northern Spotted Owl*. U.S. Forest Service, U.S. Bureau of Land Management, U.S. Fish and Wildlife Service, and U.S. National Park Service, Portland, OR.

U.S. Fish and Wildlife Service (USFWS). 1989. *The Northern Spotted Owl: A Status Review Supplement.*

U.S. Fish and Wildlife Service (USFWS). 1990. Endangered and Threatened Wildlife and Plants: Determination of Threatened Status for the Northern Spotted Owl. *Federal Register* 55: 26114-26194.

U.S. Fish and Wildlife Service (USFWS). 1992. Endangered and threatened wildlife and plants: Determination of Critical Habitat for the Northern Spotted Owl. *Federal Register* 57:1796–1838.

U.S. Fish and Wildlife Service (USFWS). 2008. Endangered and Threatened Wildlife and Plants: Revised Designation of Critical Habitat for the Northern Spotted Owl. *Federal Register* 73(157): 47326–47522.

U.S. Fish and Wildlife Service (USFWS). 2011. *Revised Recovery Plan for the Northern Spotted Owl (*Strix occidentalis caurina*).* Page xvi + 258 pp. U. S. Fish and Wildlife Service, Portland, OR.

U.S. Fish and Wildlife Service (USFWS). 2012. Endangered and Threatened Wildlife and Plants; Designation of Revised Critical Habitat for the Northern Spotted Owl. Final Rule. *Federal Register* 77: 71875 72068.

Ward Jr., J. W., R. J. Gutierrez, and B. R. Noon. 1998. Habitat Selection by Northern Spotted Owls: The Consequences of Prey Selection and Distribution. *The Condor* 100:79–92.

Weathers, W. W., P. J. Hodum, and J. A. Blakesley. 2001. Thermal Ecology and Ecological Energetics of the California Spotted Owl. *The Condor* 103:678–690.

Wiens, J. D., Anthony, R. G. and Forsman, E. D. 2014. Competitive Interactions and Resource Partitioning Between Northern Spotted Owls and Barred Owls in Western Oregon. *Wildlife Monographs* 185:1–50.

C15 Coastal Marten (*Martes caurina)*

Legal Status

State: Sensitive

Federal: Threatened, listed in 2020 (FWS–R8–ES–2018–0076,

Critical Habitat: N/A

Recovery Planning: N/A

Photo: Mark Linnell/USDA Forest Service

Taxonomy

The coastal distinct population segment (DPS) of the Pacific marten (*Martes caurina*) is commonly called, and referred to herein as, the coastal marten. The DPS includes populations in the Coast Range of Oregon and northern coastal California. Historically, two subspecies of Pacific marten have been recognized in coastal western Oregon and northwestern California: *M. caurina* along the Coast Range and Cascade Mountains in western and central Oregon and *M. c. humboldtensis* in the coastal coniferous forests in northwestern California. Genetic analysis indicates that populations of *M. c. caurina* in the Coast Range are more closely related to *M. c. humboldtensis* (Humboldt marten) than to populations of *M. c. caurina* in the Cascade Mountains (Slauson et al. 2009; Schwartz et al. 2016, unpublished report, as cited in USFWS 2018) and may represent a single subspecies. At the time of the proposed rule (October 9, 2018; USFWS 2018) a taxonomic change to a subspecies status had not been published, so the U.S. Fish and Wildlife Service (USFWS) identifies the coastal marten as a DPS.

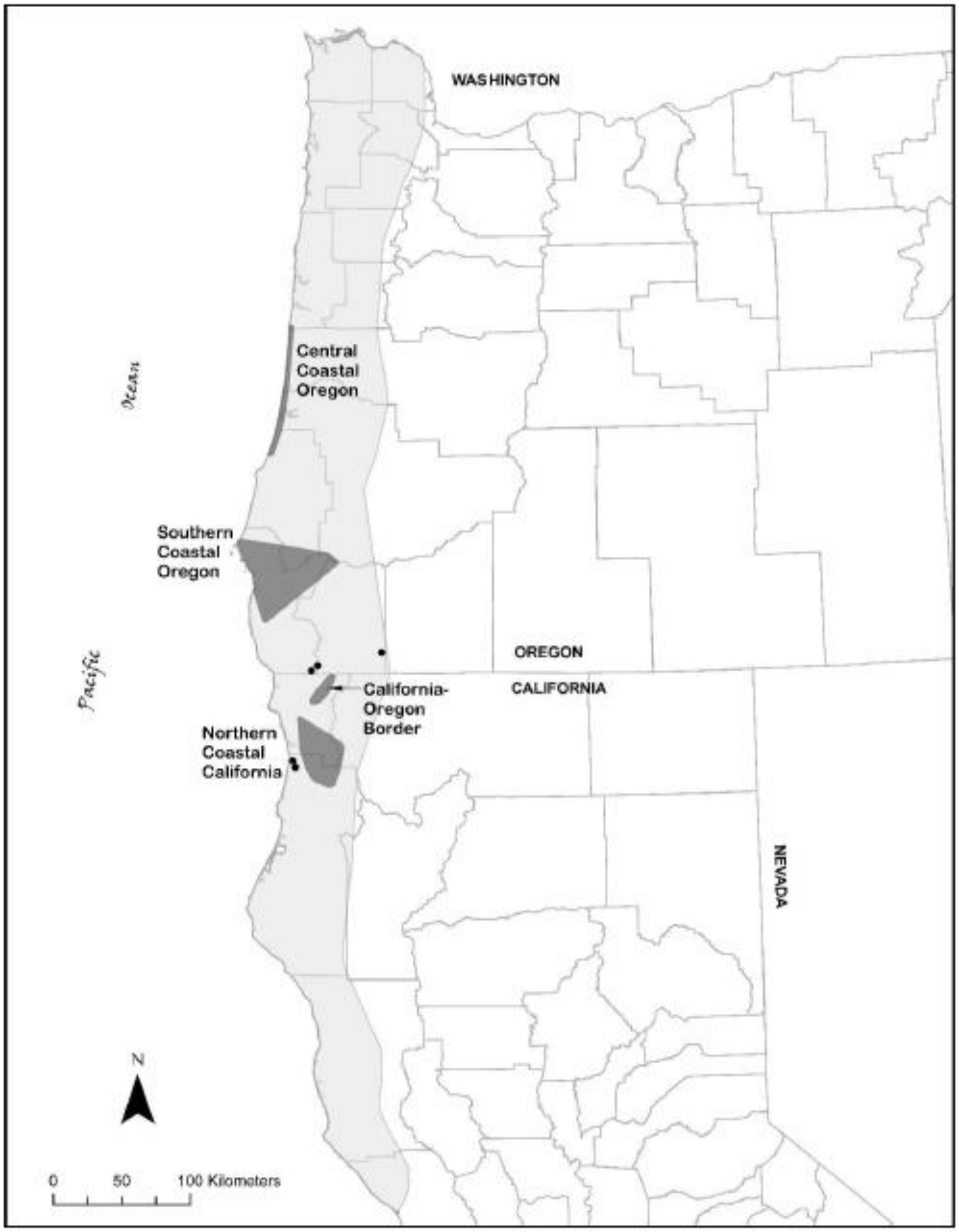
Distribution

General

Coastal martens historically occurred in the coastal forests of Oregon and California (USFWS 2018). Coastal martens have not been detected recently (since 1980) throughout much of the species' historic range, despite extensive surveys (USFWS 2018).

Coastal martens have been documented in four small (<100 individuals) populations and are absent from the northern and southern extents of their historical range (USFWS 2018). The populations were mapped by USFWS (2018) as Extant Population Areas, two of which occur in Oregon and in the region of the plan area (Moriarty et al. 2016a) (Figure C15-1).

Figure C15-1. Range of the Coastal Marten



Dark shaded areas indicated the four current populations of coastal marten. Points indicate detections that do not constitute a population. Light gray is historical range.
Source: USFWS 2018.

Two of the four populations are located in the vicinity of the plan area:

- **Central Coastal Oregon Extant Population Area** covers 403 square kilometers (km^2) in coastal forest in the Oregon Dunes Recreational Area, managed by the Siuslaw National Forest. The occupied area is less than 500 meters wide in coastal forest. This Extant Population Area is divided by the Umpqua River, a relatively large barrier to movement.

- **Southern Coastal Oregon Extant Population Area** covers 2,420 km^2 in Coos and Curry Counties. Land in this Extant Population Area is managed by Cape Blanco State Park, Siskiyou National Forest, the U.S. Department of the Interior Bureau of Land Management (BLM), and private landowners. Most detections in this Extant Population Area occurred on the Rogue River–Siskiyou National Forest. The occupied area is bisected by the Rogue River, which is likely a strong barrier to movement.

USFWS also verified two detection locations in Jackson County in southwestern Oregon, outside of the four Extant Population Areas. These locations did not meet USFWS criteria for inclusion in an Extant Population Area (i.e., there were less than five detections in an area buffered 2 kilometers around each detection and connected using a minimum convex polygon tool, or detections were separated by greater than 5 kilometers from other verified detections). Coastal martens have not been detected recently in this area over the past 4 to 8 years (USFWS 2018).

Occurrences in the Plan Area

There are no known recent occurrences of coastal martens in the plan area, though ODF lands are located within and just to the east of the Central Coastal Oregon Extant Population Area in Coos and Douglas Counties AND in the Southern Coastal Oregon Extant Population Area in Curry and Douglas Counties, and (see Figure C15-1).

Natural History

This section includes information on closely related Pacific marten and American marten when information is not available for coastal marten, as provided in the USFWS Species Status Summary (2018). In those cases, natural history is described for "martens" to distinguish from data on coastal marten.

Martens have three life stages (Strickland et al. 1982):

- Kits from birth until approximately 6 months of age when they begin dispersing from their natal habitat.
- Juveniles from approximately 6 months until 2 years of age when they begin reproducing.
- Adults after they become reproductive, with a lifespan generally less than 5 years.

These terms are applied in the following sections to describe life stage-specific natural history.

Habitat Requirements

Pacific and American martens have been shown to select habitat at four spatial scales (USFWS 2018). USFWS characterizes habitat for coastal martens at these primary spatial scales, including the microhabitat, stand, home range, and landscape scales.

Microhabitat-Scale

At the microhabitat scale, martens select habitat with suitable resting and denning structures. Structures used by coastal martens for resting include large-diameter trees with large horizontal limbs, cavities in snags, and downed hollowed logs (Slauson and Zielinski 2009; Moriarty et al. 2017;

Tweedy 2018). Coastal martens in the dune habitat of the Central Coastal Oregon Extant Population Area use squirrel nests in trees, branches, and basal hollows from overturned trees for resting habitat (Moriarty pers. comm., as cited in USFWS 2018).

Kits are born in a natal den and are subsequently moved to maternal dens (Buskirk and Ruggiero 1994). Dens provide shelter from weather and predators. Coastal martens tend to den in cavities in large, live and dead trees, as well as hollow logs, under rocks, log piles and squirrel nests (Slauson and Zielinski 2009; Thompson et al. 2012; Moriarty et al. 2017).

Stand-Scale

At the stand scale, martens select forest stands that provide structural features adequate to support one or more life-history requirements, such as enough food, large logs to run along when foraging for prey, and cavities.

Coastal martens in the Southern Coastal Oregon Extant Population Area use conifer-dominated forests with large, live trees (>51 centimeters diameter at breast height [dbh]) and extensive, ericaceous shrub cover dominated by evergreen huckleberry (*Vaccinium ovatum*) and salal (*Gaultheria shallon*) and large to very large snags and logs (e.g., >51 and >76 centimeters, respectively, and dbh for snags and trees) (Moriarty et al. 2019). Douglas-fir, Sitka spruce (*Picea sitchensis*), and western hemlock (*Tsuga heterophylla*) tend to dominate the overstory (Moriarty et al. 2019).

A coastal marten habitat distribution model for the Southern Coastal Oregon Extant Population Area predicts that stands with the highest value are neither young nor old, and predict highest habitat values for moderate tree diameter, height, diversity indices, and expected number of large trees. Based on their findings, Moriarty et al. (2019) recommend harvest practices that retain and recruit large trees and snags, encourage dense growth of salal and evergreen huckleberry shrubs, and retain or increase large downed woody material.

Coastal martens in the Southern Coastal Oregon Extant Population Area also occur in forests and shrub-dominated habitats on serpentine soils interspersed among more productive, non-serpentine soil, conifer-dominated habitats (Moriarty et al. 2019). Serpentine soils are derived from weathered ultramafic rock such as serpentinite, dunite, and peridotite, and are characterized by low plant growth and productivity, and generally have lower amounts of vegetation cover (McNaughton 1968). Serpentine habitats are more common in the California Extant Population Areas; there is little information on their use in Oregon. In California, serpentine habitats where coastal martens occur have conifer-dominated overstories, including lodgepole pine (*Pinus contorta* spp. *murrayana*), western white pine (*P. monticola*), and Douglas-fir. Serpentine habitat stands used by coastal martens can be of any seral stage and generally have a low basal area of trees and a high density of shrubs (Zielinski et al. 2001).

Coastal martens in the Central Coastal Oregon Extant Population Area occupy shore pine (*Pinus contorta* spp. *contorta*) and transitional shore pine—Douglas-fir hemlock forests less than 70 years old. These forests grow on nutrient-poor, sandy soils dominated by stands of Sitka spruce and shore pine less than 70 years old. Stands are composed of small-diameter trees and have few snags or downed logs (Moriarty et al. 2019). Occupied stands have a dense understory dominated by willow (*Salix hookeri*), Pacific waxmyrtle (*Myrica californica*), evergreen huckleberry, and salal (USFWS 2018; Moriarty et al. 2019). Compared to the Southern Coastal Oregon Extant Population Area, the Central Coastal Oregon Extant Population Area has more variable canopy cover, smaller trees, and fewer and smaller snags and downed logs. Occupied sites in the Central Coastal Oregon Extant Population Area have high shrub cover, though lower than the occupied sites in the Southern Coastal Oregon Extant Population Area, but higher fruit-bearing shrub cover than the Southern Coastal Extant Population Area (Moriarty et al. 2019).

Home-Range-Scale

At the home-range-scale, martens select enough habitat to meet their year-round life-history needs, such as home ranges with enough sources of seasonally available food to ensure food is available year-round, den sites, and access to mates while not overlapping with same-sex individuals (Katnik et al. 1994; Powell 1994). Types of structures needed for resting, denning, and foraging can vary within season, so a diversity of resting structures in a home range is important. Because only females raise young, they must have access to enough prey to support the nutrition and energetic demands of lactation and provide food for kits (USFWS 2018).

Landscape-Scale

The distribution of habitat patches large enough to support multiple home ranges in the landscape affects habitat selection and the ability of martens to disperse to new, suitable home ranges. Dispersal habitat is habitat that improves connectivity between larger habitat patches while providing adequate prey and cover from predators to facilitate successful movement between habitat patches (USFWS 2018).

Martens are susceptible to habitat loss and fragmentation; populations can become extirpated locally when as little as 25–33% of forest cover in a landscape is removed (Hargis et al. 1999; Potvin et al. 2000; Fuller 2006). There are little data on the effects of habitat distribution at the landscape-scale for coastal martens in Oregon; however, other North American martens select habitat based on the amount of habitat available in the landscape (e.g., Potvin et al. 2000; Kirk and Zielinski 2009) and size of available patches (e.g., Chapin et al. 1998; Slauson et al. 2007).

Diet

Coastal martens are dietary generalists, with types of food eaten depending on seasonal availability. Analysis of coastal marten diet is limited to scats collected in central coastal Oregon and northern coastal California populations. In central coastal Oregon populations, coastal martens were found to primarily consume mammals (mostly voles), birds, and berries. Berries were found in most scats collected in fall and winter (100% and 86% of the 90 scats collected, respectively), and mammals were found in scats collected throughout the sampling period (Eriksson et al., in review, as cited in USFWS 2018). Analysis of a larger number of scats (420) in northern coastal California from July to November found mammals in most scats, as well as berries, birds, insects, and reptiles (93%, 85%, 21%, 20%, and 7% of the scats, respectively). Squirrels (*Sciuridae*) and mice (*cricetid*) were the primary mammals consumed (Slauson and Zielinski, in press, as cited in USFWS 2018)

Many of the important prey species are at highest densities in structurally complex forests characteristic of older forests. For example, dense shrub layers provided by ericaceous shrubs are positively correlated with chipmunk density in coastal Oregon and other coastal marten prey species in Oregon coastal dune forests (Hayes et al. 1995; Eriksson et al., in review, as cited in USFWS 2018).

Reproduction

North American martens are polygamous, with only females responsible for raising young. Information on the timing of mating is primarily from captive martens, but mating is believed to occur from late June to early August, peaking in July (Markley and Bassett 1942, as cited in USFWS 2018). Delayed implantation results in females giving birth the following March and April.

Females do not mate until they are 15 months old, and with delayed implantation, do not give birth to their first litter until they are at least 24 months old. Not all female martens of reproductive age give birth in a year (Thompson and Colgan 1987; Slauson 2017). The limited data for coastal martens indicate that 75% of females are reproducing, with a mean litter size of 1.8 kits (Moriarty pers. comm., as cited in USFWS 2018). Due to delayed implantation, and with a life span of generally less than 5 years, approximately 10% of a marten population is reproducing for more than 3 years, contributing to a slow reproductive output (USFWS 2018).

Movement

American martens disperse from their natal home range at around 6 months of age. Juvenile Humboldt martens in northern California disperse as early as August and can continue through the following summer (Slauson and Zielinski, unpublished data, as cited in USFWS 2018). The timing of juvenile dispersal in coastal martens in Oregon is likely similar to coastal martens in northern coastal California. Once juveniles disperse and settle into new habitat, they tend to remain in their home ranges (USFWS 2018).

Most studies have found juvenile martens disperse less than 15 kilometers (e.g., Broquet et al. 2006; Pauli et al. 2012; Slauson 2017), though martens have been reported to disperse more than 70 kilometers (e.g., Fecske and Jenks 2002). Limited dispersal data on coastal martens suggest similar dispersal distances (Slauson pers. comm., as cited in USFWS 2018).

Habitat quality and the spatial distribution of higher-quality habitat affects marten movement. For example, forest thinning to reduce fuel load affected habitat selection and movement by Pacific martens in the Lassen National Forest in California. Martens generally avoided thinned stands with simplified structure and openings. When martens used thinned stands, they tended to move faster and more directly; movements consistent with predator avoidance or low resource availability (Moriarty et al. 2016b). Martens tend to travel faster and longer in unlogged versus logged forests in Canada and have higher mortality in logged forests (Johnson 2008). Martens in Canada have also been shown to have greater foraging efficiency (Andruskiw et al. 2008), longer dispersal distances, and higher likelihood of surviving to adulthood in unlogged landscapes (Johnson et al. 2009).

Ecological Relationships

Coastal martens exhibit intrasexual territoriality, where dominant males maintain home ranges that moderately overlap one or more female's home range (Moriarty et al. 2017). Coastal martens move regularly within their home range, maintaining the boundaries of their territories (Moriarty et al. 2017). Males have larger home ranges than females (Moriarty et al. 2017). Individuals in the Central Coastal Oregon Extant Population Area have the smallest home ranges reported for martens in North America. Three females were found to have a mean territory size of 0.84 km^2 and three males had a mean territory size of 3.06 km^2 (Moriarty et al. 2017). In a different study in the same Extant Population Area, seven females had a mean home range of 0.8 km^2 and four males had a mean home range of 1.5 km^2 (Linnell et al. 2018). Home ranges in the Southern Coastal Oregon Extant Population Area and northern California include large patches (median >1.5 km^2) of older forests and serpentine habitats and a high amount of vegetation cover (Slauson 2003; Slauson et al. 2007; Linnell et al. 2018). In the Northern Coastal California Extant Population Area, coastal martens have been found to select the largest available patches with old-growth, late-mature, or serpentine habitat (Slauson et al. 2007).

Martens are susceptible to predation by animals such as bobcat (*Felis rufus*), coyote (*Canis latrans*), red fox (*Vulpes vulpes*), fishers (*Pekania pennant*), and great horned owl (*Bubo virginianus*) (Thompson 1994; Lindstrom et al. 1995; Bull and Heater 2001; McCann et al. 2010).

Competition with other carnivores such as fisher, bobcat, gray fox (*Urocyon cinereoargenteus*), and coyote can restrict marten habitat use. In the Sierra Nevada in California for example, competition with fisher affects marten activity and access to parts of their home range (Zielinski et al. 2017). The effects of competition are likely greater in areas with moderate–high severity fires or intensive logging has removed structural complexity necessary for foraging and cover by martens (USFWS 2018).

Population Status

As described above, coastal martens exist in four small (<100 individuals) populations. A landscape habitat suitability model predicts that there is little habitat connectivity between the Oregon populations, though there is some potential habitat connectivity between the Southern Coastal Oregon and Northern Coastal California populations (Slauson et al. in review, and Slauson et al. in press, as cited in USFWS 2018).

The following is a summary of the population status for the DPS.

- **Central Coastal Oregon Extant Population Area**. There are approximately 71 adults in this Extant Population Area, with approximately 30 adults each in the two subpopulations separated by the Umpqua River (Linnell et al. 2018). There is no information on long-term trends in population size (USFWS 2018). This population has the highest density (1.13 martens/1 km^2) reported for North American martens (Linnell et al. 2018).
    - Using a population viability analysis, Linnell et al. (2018) assessed extinction risk for a subpopulation of 30 coastal martens. Extinction risk ranged from 32% to 99% within 30 years assuming two or three annual human-caused mortalities, such as vehicle strikes or trapping. The authors concluded that, other than efforts to expand the population, reducing human-caused mortalities would have the greatest impact on conservation.
    - The mature forest to the east of the Central Coastal Oregon Extant Population Area does not support a population of coastal martens and factors limiting coastal martens from expanding a population into these forests is unknown (Moriarty et al. 2016a; Linnell et al. 2018).
- **Southern Coastal Oregon Extant Population Area.** This Extant Population Area likely contains 100 or fewer individuals (Slauson pers. comm., as cited in USFWS 2018; Moriarty pers. comm., as cited in USFWS 2018). Most detections occurred on the Rogue River–Siskiyou National Forest (Moriarty et al. 2016a).

- **California–Oregon Border Extant Population Area.** There is no estimate of the size of this population, though given the small size of the Extant Population Area the area likely supports fewer than 100 individuals (Slauson pers. comm, as cited in USFWS 2018).
- **Northern Coastal California Extant Population Area.** This is the most surveyed Extant Population Area. The Extant Population Area includes approximately 60 to 80 individuals as of 2012, fewer than the greater than 100 individuals estimated in the area in 2008 (USFWS 2018).

Threats

Small home range, population size, and restricted distribution make coastal martens vulnerable to events that could severely reduce population size. USFWS identified threats directly and indirectly affecting coastal martens (USFWS 2018). Direct effects are those that cause direct mortality, including trapping, vehicle collisions, poisoning from rodenticides, predation, and disease. Indirect effects are those primarily affecting coastal marten habitat, including wildfire, disturbances to vegetation from causes other than wildfire (e.g., timber harvest), climate change, and tsunami.

Trapping

Trapping in the early 20th century is considered the primary reason for initial coastal marten range contraction (Zielinski et al. 2001). A small number of trappers currently pursue martens (around four to eight each year), with most martens harvested in the Cascades. Harvest of coastal martens in Oregon is infrequent: 35 martens were harvested in coastal Oregon between 1969 and 1995 (USFWS 2015) and 13 were harvested in coastal Oregon from 1989 to 2016 (Broman pers. comm., as cited in USFWS 2018). Howver, as described above, as few as two to three human-caused mortalities per year can lead to a high risk of extinction for a small population of coastal martens (Linnell et al. 2018).

Vehicle Strikes

Coastal martens are susceptible to mortality from vehicle strikes. Since 1980, 19 deaths caused by vehicles have been documented, all in Oregon, and most in or adjacent to the central coastal Oregon population or the general central Oregon coast area along U.S. Highway 101 (USFWS 2018). The central coastal Oregon population remains the most susceptible to vehicle strikes due to the proximity of U.S. Highway 101. USFWS considers traffic on forest roads to be a low risk to martens due to slow travel speeds and low levels of traffic (USFWS 2018).

Rodenticides

Exposure to rodenticides results from direct ingestion or by eating prey that consumed rodenticides. Coastal martens may ingest rodenticides such as strychnine and zinc phosphides, which are the rodenticides most commonly used in forest lands. In Oregon, a special use label on the anticoagulant chlorophacinone allows the use of chlorophacinone to control mountain beavers (*Aplodontia rufa*). Illegal marijuana cultivation is another source of the rodenticide (USFWS 2018).

Landscape-level changes in forest composition within the range of coastal martens has likely caused an increase in the species' depredation (USFWS 2018). Bobcats are the primary predator of coastal martens, and bobcats prefer regenerating harvest stands less than 30 years old and are almost absent from unfragmented conifer forest landscapes comprised preferred by martens (Powell et al. 2003; Linnell et al. 2018; Slauson et al., in press, as cited in USFWS 2018).

Disease

Martens are susceptible to diseases, including canine distemper viruses, rabies, viruses, parvoviruses, and the protozoan *Toxoplasma gondii*. Given the small size of the coastal marten populations, disease could have a catastrophic effect. Most of what is known about the presence or exposure to pathogens in coastal martens comes from 19 blood samples taken from the Central Coastal Oregon Extant Population Area. None of the samples taken were positive for canine distemper viruses, 5 had antibodies for canine parvovirus, and 14 had antibodies for *T. gondii* (Moriarty 2017, unpublished data, as cited in USFWS 2018).

Wildfire

Wildfire is a natural disturbance that helps maintain structural features and conditions of coastal marten habitat (e.g., snags, down logs, canopy structure). Low severity fire regimes are most prevalent in the southwestern portion of the coastal marten range in Oregon. This type of wildfire occurs every 5 to 25 years (Arno 2000), does not kill the overstory trees, and causes little structural damage to dominant vegetation, though it can reduce shrub cover important for coastal martens (USFWS 2018).

Moderate to high-severity wildlife regimes affect stand structure and can eliminate important structural habitat features that provide cavities and resting platforms (e.g., snags, downed logs, large trees). These types of fires occur infrequently (200 to 500 years in wetter forests [Arno 2000]). This type of fire regime occurs in much of the central coastal Oregon portion of the coastal marten range. The two Oregon Extant Population Areas have been subject to fewer large fires between 1987 and 2016 than the two California Extant Population Areas (USFWS 2018). Relatively recent fires that reduced habitat include the 2002 Biscuit Fire and the 2017 Chetco Bar Fire.

Timber Harvest

Changes in forest vegetation composition, age, and structure from timber harvest affects the quality, quantity, and distribution of coastal marten habitat. Timber harvests that reduce conifer forest structural complexity or the extent of the shrub layer increase fragmentation of habitat and reduce size of forest patches, affecting habitat quality or eliminating habitat entirely. While shrub cover develops post-harvest, the simple structure and species composition of post-harvest shrub cover is often not representative of the complex shade-tolerant shrub cover characteristic of coastal marten forest or coastal dune forest habitat (Slauson et al. 2007; USFWS 2018).

Intensively managed regenerating stands generally lack key habitat elements in great enough quantity to support coastal martens. Those habitat elements include resting and denning structures and dense ericaceous shrub cover (Slauson and Zielinski 2007; Slauson et al. 2010; USFWS 2018). Vegetation management practices in addition to harvest, such as thinning and fuel reduction, can also reduce habitat quality if they reduce structural complexity and remove key habitat features. Thinning, fuel reduction, and forest habitat restoration, however, can improve habitat quality in the long term if managed to accelerate development of late seral forest characteristics (Moriarty et al. 2016b; USFWS 2018).

Climate Change

Climate change is projected to cause warmer temperatures and a slight increase in precipitation in coastal Oregon; summers are expected to be warmer and dryer, with more extreme heat and precipitation events. With a changing climate, the distribution and type of vegetation communities are predicted to change. In coastal Oregon, the range and extent of temperate conifer forests is projected to shrink and be replaced by mixed evergreen forests. Coastal martens occupy both forest types, so the region is expected to continue to support suitable habitat conditions (Lenihan et al. 2008; Shafer et al. 2010; Dalton et al. 2017; USFWS 2018).

Climate change is also projected to affect other disturbance regimes that could, in turn, affect coastal martens. For example, warmer, drier summers and longer fire seasons could result in more frequent large fires that could burn large swaths of habitat. Warmer temperatures and more frequent drought could increase susceptibility of trees to insects and pathogens, resulting in an increase in damage to trees, which can affect forest structure and composition, and possibly reduce habitat quality and quantity for coastal martens (USFWS 2018).

Martens in North America are projected to shift ranges northward over the next century in response to climate change (Lawler et al. 2012). Fragmentation and landscape-level loss of coastal marten habitat could make dispersal to shifting habitats challenging (USFWS 2018).

Literature Cited

Andruskiw, M., J. M. Fryxell, I. D. Thompson, and J. A. Baker. 2008. Habitat-Mediated Variation in Predation Risk by the American Marten. *Ecology* 89:2273–2280.

Arno, S. F. 2000. Fire in Western Forest Ecosystems. Pages 97–120 in J. K. Brown and J. K. Smith (eds.), *Wildland Fire in Ecosystems: Effects of Fire on Flora.* U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Ogden, UT.

Broquet, T., C. A. Johnson, E. Petit, I. Thompson, F. Burel, and J. M. Fryxell. 2006. Dispersal and Genetic Structure in the American Marten, *Martes americana*: Marten Dispersal and Genetic Structure. *Molecular Ecology* 15:1689–1697.

Bull, E. L., and T. W. Heater. 2001. Survival, Causes of Mortality, and Reproduction in the American Marten in Northeastern Oregon. *Northwestern Naturalist* 82:1–6.

Buskirk, Steven W.; Ruggiero, Leonard F. 1994. Chapter 2: American marten. Pages 7–37 in Leonard F. Ruggiero, Keith B. Aubry, Steven W. Buskirk, L. Jack Lyon, and William J. Zielinski (tech. eds.), *The Scientific Basis for Conserving Forest Carnivores: American Marten, Fisher, Lynx, and Wolverine in the Western United States.* Gen. Tech. Rep. RM-254. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station.

Chapin, T. G., D. J. Harrison, and D. D. Katnik. 1998. Influence of Landscape Pattern on Habitat Use by American Marten in an Industrial Forest. *Conservation Biology* 12:1327–1337.

Dalton, M. M., K. D. Dello, L. Hawkins, P. W. Mote, and D. E. Rupp. 2017. *The Third Oregon Climate Assessment Report.* Oregon Climate Change Research Institute, College of Earth, Ocean and Atmospheric Sciences, Oregon State University, Corvallis, OR.

Fecske, D. M., and J. Jenks. 2002. *Dispersal by a Male American Marten,* Martes americana.

Fuller, A. K. 2006. *Multi-Scalar Responses of Forest Carnivores to Habitat and Spatial Pattern: Case Studies with Canada Lynx and American Martens*. Dissertation, University of Maine, Orono, Maine.

Hargis, C. D., J. A. Bissonette, and D. L. Turner. 1999. The Influence of Forest Fragmentation and Landscape Pattern on American Martens. *Journal of Applied Ecology* 36:157–172.

Hayes, J. P., E. G. Horvath, and P. Hounihan. 1995. Townsend's Chipmunk Populations in Douglas–fir Plantations and Mature Forests in the Oregon Coast Range. *Canadian Journal of Zoology* 73:67–73.

Johnson, C. A. 2008. *Mammalian Dispersal Behavior and its Fitness Correlates*. Ph.D. dissertation, University of Guelph, Guelph, ON, Canada.

Johnson, C. A., J. M. Fryxell, I. D. Thompson, and J. A. Baker. 2009. Mortality Risk Increases with Natal Dispersal Distance in American Martens. *Proceedings of the Royal Society B: Biological Sciences* 276:3361–3367.

Katnik, D. D., D. J. Harrison, and T. P. Hodgman. 1994. Spatial Relations in a Harvested Population of Martens in Maine. *Journal of Wildlife Management* 58:600–607.

Kirk, T. A., and W. J. Zielinski. 2009. Developing and Testing a Landscape Habitat Suitability Model for the American Marten (*Martes american*a) in the Cascades Mountains of California. *Landscape Ecology* 24:759–773.

Lawler, J., H. D. Safford, and E. H. Girvetz. 2017. *Martens and Fishers in a Changing Climate. Biology and Conservation of Martens, Sables, and Fishers: A New Synthesis*.

Lawler, J. J., H. D. Safford, and E. H. Girvetz. 2012. Martens and Fishers in a Changing Climate. Pages 371–397 in K. B. Aubry, W. J. Zielinski, M. G. Raphael, G. Proulx, and S. W. Buskirk (eds.), *Biology and Conservation of Martens, Sables, and Fishers: A New Synthesis.* Cornell University Press, Ithaca, New York, USA.

Lenihan, J. M., D. Bachelet, R. Neilson, and Drapek. 2008. Simulated Response of Conterminous United States Ecosystems to Climate Change at Different Levels of Fire Suppression, CO2 Emission Rate, and Growth Response to CO_2. *Global Planetary Change* 64:16–25.

Lindstrom, E. R., S. M. Brainerd, J. O. Helldin, and K. Overskaug. 1995. Pine Marten - Red Fox Interactions: A Case of Intraguild Predation? *Annales Zoologici Fennici* 32:123–130.

Linnell, M. A., K. Moriarty, D. S. Green, and T. Levi. 2018. Density and Population Viability of Coastal Marten: A Rare and Geographically Isolated Small Carnivore. *PeerJ* 6:e4530.

Markley, M. H., and C. F. Bassett. 1942. Habits of Captive Marten. *The American Midland Naturalist* 28:604–616.

McCann, N. P., P. A. Zollner, and J. H. Gilbert. 2010. Survival of Adult Martens in Northern Wisconsin. *Journal of Wildlife Management* 74:1502–1507.

McNaughton, S. J. 1968. Structure and Function in California Grasslands. *Ecology* 49:962–972.

Moriarty, K. M., J. D. Bailey, S. E. Smythe, and J. Verschuyl. 2016a. Distribution of Pacific Marten in Coastal Oregon. *Northwestern Naturalist* 97:71–81.

Moriarty, K. M., C. W. Epps, and W. J. Zielinski. 2016b. Forest Thinning Changes Movement Patterns and Habitat Use by Pacific Marten: Marten Behavior Affected by Structure. *The Journal of Wildlife Management* 80:621–633.

Moriarty, K. M., M. A. Linnell, B. E. Chasco, C. W. Epps, and W. J. Zielinski. 2017. Using High-Resolution Short-Term Location Data to Describe Territoriality in Pacific Martens. *Journal of Mammalogy* 98:679–689.

Moriarty KM, Verschuyl J, Kroll AJ, Davis R, Chapman J, Hollen B. 2019. Describing Vegetation Characteristics Used by Two Rare Forest-Dwelling Species: Will Established Reserves Provide for Coastal Marten in Oregon? *PLoS ONE* 14(1): e0210865. https://doi.org/10.1371/journal.pone.0210865

Pauli, J. N., W. P. Smith, and M. Ben-David. 2012. Quantifying Dispersal Rates and Distances in North American Martens: A Test of Enriched Isotope Labeling. *Journal of Mammalogy* 93:390–398.

Potvin, F., L. Bélanger, and K. Lowell. 2000. *Marten Habitat Selection in a Clearcut Boreal Landscape* 14.

Powell, R. A. 1994. Structure and Spacing of Martes Populations. Pages 101–121 in S. W. Buskirk, A. S. Harestad, M. G. Raphael, and R. A. Powell (eds.), *Martens, Sables and Fishers: Biology and Conservation.* Cornell University Press, Ithaca, NY.

Powell, R. A., S. W. Buskirk, and W. J. Zielinski. 2003. Fisher and Marten (*Martes pennanti* and *Martes americana*). Pages 635-649 in G. Feldhamer, B. Thompson, and J. Chapman (eds.), *Wild Mammals of North America*, 2nd Edition. Johns Hopkins University Press, Baltimore, MD, USA.

Schwartz et al. 2016

Shafer, S. L., M. E. Harmon, R. P. Neilson, R. Seidl, B. St. Clair, and A. Yost. 2010. The Potential Effects of Climate Change on Oregon's Vegetation. Pages 173–208 in K. D. Dello and P. W. Mote (eds.), *Oregon Climate Assessment Report.* Oregon Climate Change Research Institute. College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis, OR.

Slauson, K. M. 2003. *Habitat Selection by American Martens (*Martes americana*) in Coastal Northwestern California.* M.S. thesis, Oregon State University, Corvallis, OR.

Slauson, K. M. 2017. *Linking Landscape Pattern to Population Processes in a Carnivorous Mammal*. Ph.D. dissertation, University of Montana, Missoula, MT.

Slauson, K. M., and W. J. Zielinski. 2007. The Relationship Between the Understory Shrub Component of Coastal Forests and the Conservation of Forest Carnivores. Pages 241-243 in G. A. Standiford, G. A. Giusti, Y. Valachovic, W. J. Zielinski, and W. J. Furniss (eds.), *Proceedings of the Redwood Region Forest Science Symposium: What Does the Future Hold?* U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. Albany, CA.

Slauson, K. M., and W. J. Zielinski. 2009. Characteristics of Summer and Fall Diurnal Resting Habitat Used by American Martens in Coastal Northwestern California. *Northwest Science* 83:35–45.

Slauson, K. M., W. J. Zielinski, and J. P. Hayes. 2007. Habitat Selection by American Martens in Coastal California. *Journal of Wildlife Management* 71:458–468.

Slauson, Keith M.; Zielinski, William J.; Stone, Karen D. 2009. Characterizing the Molecular Variation Among American Marten (*Martes americana*) Subspecies from Oregon and California. *Conservation Genetics* 10(5):1337–1341.

Slauson, K. M., W. J. Zielinski, and T. A. Kirk. 2010. *Effects of Forest Restoration on Mesocarnivores in the Northern Redwood Region of Northwestern California.* Unpublished final report. On file with U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, Redwood Sciences Laboratory, 1700 Bayview Drive, Arcata, CA 95521.

Strickland, M. A., C. W. Douglas, M. Novak, and N. P. Hunziger. 1982. Marten (*Martes american*a). Pages 599–612 in J. A. Chapman and G. A. Feldhamer (eds.), *Wild Mammals of North America: Biology, Management and Economics*. Johns Hopkins University Press, Baltimore, MD, USA.

Thompson, C., and P. W. Colgan. 1987. Numerical Responses of Martens to a Food Shortage in North–Central Ontario. *Journal of Wildlife Management* 51:824–835.

Thompson, I. D. 1994. Marten Populations in Uncut and Logged Boreal Forests in Ontario. *Journal of Wildlife Management* 58:272–280.

Thompson, I. D., J. Fryxell, and D. J. Harrison. 2012. Improved Insights into Use of Habitat by American Martens. Pages 209-230 in K. Aubry, W. Zielinski, M. Raphael, G. Proulx, and S. W. Buskirk (eds.), *Biology and Conservation of Martens, Sables, and Fishers: A New Synthesis.* Cornell University Press, Ithaca, NY.

Tweedy, P. J. 2018. *Diel Rest Structure Selection and multiscale Analysis of Pacific Marten Resting Habitat in Lassen National Forest, California*. M.S. thesis, Oregon State University, Corvallis, OR.

U.S. Fish and Wildlife Service (USFWS). 2015. Endangered and Threatened Wildlife and Plants; 12-Month Finding on a Petition To List Humboldt Marten as an Endangered or Threatened Species. *Federal Register* 80:18742–18772.

U.S. Fish and Wildlife Service (USFWS). 2018. *Species Status Assessment for the Coastal Marten (*Martes caurina*) Version 2.0.* U.S. Fish and Wildlife Service, Arcata, CA.

Zielinski, W. J., K. M. Slauson, C. R. Carroll, C. J. Kent, and D. G. Kudrna. 2001. Status of American Martens in Coastal Forests of the Pacific States. *Journal of Mammalogy* 82:478–490.

Zielinski, W. J., J. M. Tucker, and K. M. Rennie. 2017. Niche Overlap of Competing Carnivores Across Climatic Gradients and the Conservation Implications of Climate Change at Geographic Range Margins. *Biological Conservation* 209:533–545.

C16 Marbled Murrelet (*Brachyramphus marmoratus)*

Legal Status

State: Listed as Threatened in 1995. Reclassified as Endangered in 2021

Federal: Threatened, listed in 1992

Critical Habitat: 2016 (81 *Federal Register* [FR] 51348)

Recovery Planning: September. 24, 1997

Photo: USFWS

Taxonomy

The marbled murrelet (*Brachyramphus marmoratus*) is a small sea bird that belongs to the Alcidae, or auk family. There are three recognized species within the *Brachyramphus* genius: (1)the marbled murrelet, which breeds in the western North America; (2) the long-billed murrelet (*B. perdix*), which breeds in eastern Asia; and (3) the Kittlitz's murrelet (*B. brevirostris*), which breeds in Russia and Alaska.

Researchers have found significant genetic distinction throughout the marbled murrelet's range, and the species appear to be composed of three genetic units: (1) western and central Aleutian Islands, (2) eastern Aleutian Islands to northern California, and (3) central California (Friesen et al. 2007). The U.S. Fish and Wildlife Service (2009) considers the Washington, Oregon, and California population of murrelet to be a valid distinct population segment (DPS) under the 1996 DPS Policy. The population of murrelets in Washington, Oregon, and California are considered discrete based on differences in conservation status, management of habitat, and regulatory mechanisms between the United States and Canada that would result without the federal protective measures afforded by the Endangered Species Act. The U.S. Fish and Wildlife Service also considers the coterminous United States murrelet population as significant in accordance with the criteria of the DPS Policy.

Distribution

General

Marbled murrelet breed along the Pacific coast of North America from the Bering Sea to the Santa Cruz mountains of California (Ralph et al. 1995; Burger 2002; Piatt et al. 2007). The center of population is in the northern part of southeast Alaska (Ralph et al. 1995) with large numbers of murrelets occurring in the Kodiak Archipelago, Prince William Sound, and the Alexander Archipelago, south along the coast to British Columbia (Piatt et al. 2007). The marbled murrelet population becomes more disjunct and sparse at the northern and southern range limits (Ralph et al. 1995; McShane et al. 2004). Within the range, there are large distribution gaps (Ralph et al. 1995; USFWS 2012). The murrelet winters throughout its breeding range south to southern California or northern Baja California (McShane et al. 2004; Piatt et al. 2007).

The USFWS has designated five recovery zones for marbled murrelet, ranging from San Francisco Bay to the Canada border with Washington State (Figure C16-1). Falxa and Raphael (2016) reported marbled murrelet population estimates in each zone as follows:

- 7,600 marbled murrelets in the Strait of Juan de Fuca, San Juan Islands, and Puget Sound in Washington (Zone 1).
- 2,000 marbled murrelets on the outer coast of Washington (Zone 2).
- 7,600 marbled murrelets from Coos Bay, Oregon, north to the Columbia River (Zone 3, which includes the HCP plan area).
- 6,600 marbled murrelets from Shelter Cove, California, north to Coos Bay, Oregon (Zone 4).
- “few” marbled murrelets remaining from San Francisco Bay north to Shelter Cove, California (Zone 5).

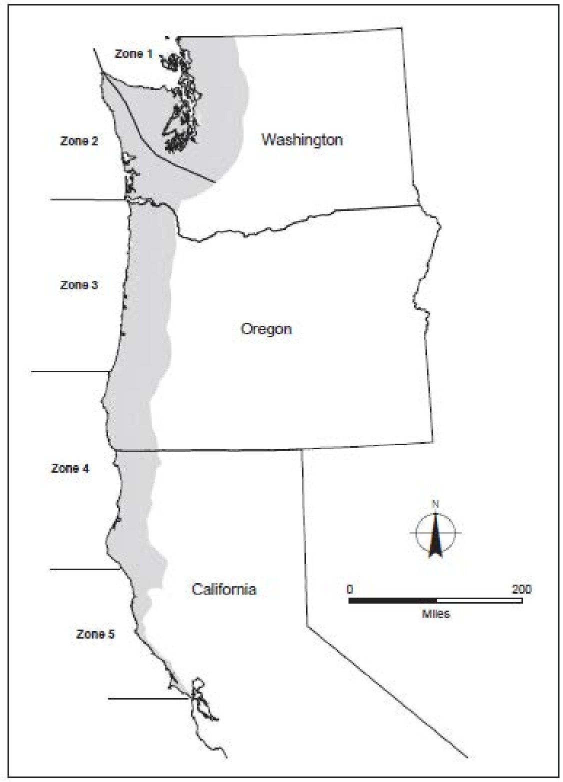


Figure C16-1. Marbled Murrelet Recovery Zones (from Falxa and Raphael 2016)

At the state scale, Falxa and Raphael (2016) found populations to be declining in Washington (4.6-percent decline per year), but no evidence of a trend in Oregon or California (Zone 4). Based on at-sea data, marbled murrelet populations in Oregon are highest in the central portion of the Coast Range near the Elliott State Research Forest and the Siuslaw National Forest, corresponding closely to the amount of habitat available inland from these at-sea foraging areas.

Occurrences Within the Plan Area

Historical

The marbled murrelet in Oregon is found mainly in the Coast Range and Klamath physiographic provinces (ODFW 2018). The species has been detected up to 80 miles inland in Oregon (Nelson 1997), but most occupancy/nesting behaviors have been detected within 40 miles of the ocean (Mack et al. 2003). During the breeding season in Oregon (generally April through September), foraging murrelets remain within 1.2 miles of the shore (Strong et al. 1995; Falxa et al. 2016).

Recent

Within the permit area, marbled murrelet nesting is concentrated in the northwest portion of the permit area (i.e., the Tillamook and Astoria districts) and in the central Oregon Coast area (West Oregon District) near the Elliott State Forest and Siuslaw National Forest (Figure C16-2).

Figure C16-2. Number of Unique Sites with "Significant Observations" of Marbled Murrelets, by ODF District

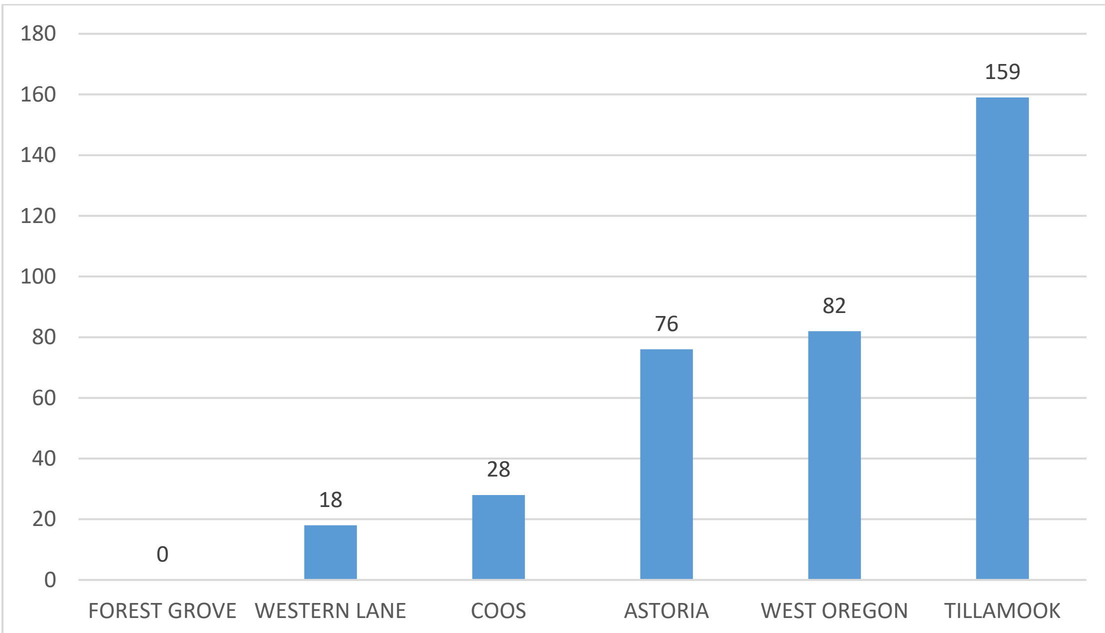
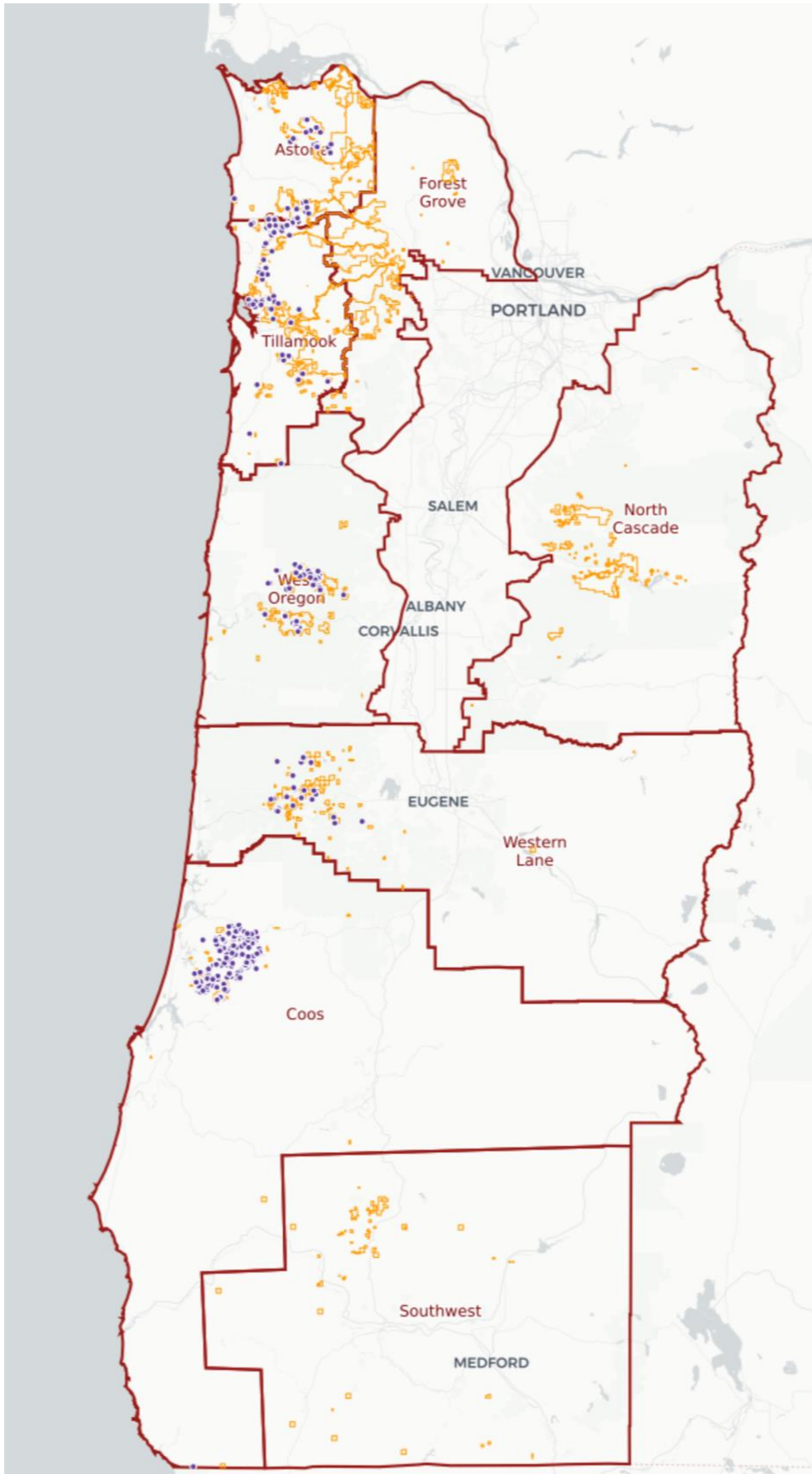


Figure C16-3. Location of Unique Sites with "Significant Observations" of Marbled Murrelets, by ODF District



Natural History

The ecology and status of marbled murrelet are reviewed in the Status Review of the Marbled Murrelet (*Brachyramphus marmoratus*) in Oregon and Evaluation of Criteria to Reclassify the Species from Threatened to Endangered under the Oregon Endangered Species Act (ODFW 2018) and in Chapter 5 of the 2018 Forest Service Science Synthesis Report (Raphael et al. 2018).

Habitat Requirements

Nesting and Roosting Habitat

Unlike other alcids, which nest in dense colonies on the ground, in burrows, on rocky cliffs, and sea stacks at the marine-terrestrial interface, marbled murrelets nest in trees in dispersed locations up to 55 miles inland (Spies et al. 2018). Throughout the forested portion of the species' range murrelets typically nest in large conifers in late-successional forests. Murrelets in Washington, Oregon, and California nest in the major types of conifer forest wherever older forests remain inland of the coast at elevations below 4,000 feet (Raphael et al. 2018; Spies et al. 2018). Murrelets have also been observed nesting in young stands with suitable nesting substrates (e.g., legacy trees with large limbs, and mistletoe brooms) (ODFW 2018). Murrelet nesting habitat characteristics vary throughout its range; however, some general characteristics, such as the presence of nesting platforms, adequate canopy cover over the nest, large patch size of mature forest, and within commuting distance to the marine environment to allow foraging, are present throughout the species' range (McShane et al. 2004; Ralph et al. 1995; Spies et al. 2018).

Marbled murrelets do not construct nests and rely on the availability of platforms formed on large or deformed branches with moss or other thick substrate. In Washington, Oregon, and northern California, platforms usually are found on trees at least 19 inches in diameter at breast height and greater than 98 feet tall (Spies et al. 2018). In Oregon, typical nest trees include Douglas-fir (*Pseudotsuga menziesii*), western hemlock (*Tsuga heterophylla*), western red cedar (*Thuja plicata*), or Sitka spruce (*Picea sitchensis*) (Raphael et al. 2018). However, marbled murrelets do not seem to preferentially select any particular tree species, and the nest tree species is usually the dominant species found within the area that provides suitable nest platforms and other preferred characteristics (ODFW 2018). Most nests have foliage cover above or to the side of the nest, and the platform must be large enough to support raising a nestling.

In his review of existing literature on nest trees across their range, Burger (2002) noted that, given a choice, it appears that marbled murrelets select nest trees with the following characteristics.

- Sufficient height to allow stall-landing and jump-off departures.
- Openings in the canopy for unobstructed flight access.
- Sufficient diameter to provide a nest site and landing platform.
- Some soft substrate to support a nest cup.
- Overhead foliage cover.

Between 1995 and 1999, Nelson and Wilson (2002, as cited in Wiekel 2018) studied the characteristics of marbled murrelet nesting habitat on Oregon state lands. This research confirmed that marbled murrelet select large conifer trees with numerous platforms for nesting. Nests were predominately found in trees more than 200 years old (two or three nests were found in 140- to 170-year-old trees). The presence of platforms is considered the most important characteristic of murrelet nesting habitat (Burger 2002; McShane et al. 2004).

Throughout their range, marbled murrelets nest primarily in low-elevation coniferous forests within 52 miles of the coast (McShane et al. 2004; Nelson et al. 2006). In 1997 the U.S. Fish and Wildlife Service reported that marbled murrelets nest disproportionately on lower slopes and near streams with mean distance to streams in the Pacific Northwest of 509 feet (USFWS 1997); however, more recent studies suggest the slope, aspect, or other topographical features may be equivocal (Pilssner et al. 2015).

Diet

Marbled murrelet primarily forages on small schooling fish and marine invertebrates (e.g., krill) in the nearshore (within 3.1 miles of shore) marine environment. The species is described as a "flexible forager" and will feed on the most abundant, suitable prey items (Burkett 1995; Nelson 1997). Studies suggest there are seasonal and geographic variations in diet across the murrelet range, as well as differences between adult and chick diet. During the breeding season, fish are the dominant prey (Nelson 1997; Piatt et al. 2007). During the winter and spring, invertebrates are the dominant prey (Piatt et al. 2007). Freshwater prey, such as salmonids, are also consumed in inland nesting habitat where large lakes are abundant (McShane et al. 2004). Fish consumed by adults and subadults tend to be small larval or juvenile fish classes, and those fed to nestlings are larger subadults or adult fish (Piatt et al. 2007). Studies show long-term declines in murrelet diet quality in portions of its range in central California, the Salish Sea, northern Washington, and British Columbia (Raphael et al. 2018, as cited in Spies et al. 2018). Becker and Beissinger (2006) present evidence of a decline in the trophic level of the murrelet, suggesting an increased importance of krill in modern, compared with historic, prebreeding diets of marbled murrelets. Other studies suggest that declines in murrelet diet quality may contribute to reduced reproductive success (Raphael et al. 2018, as cited in Spies et al. 2018).

Marbled murrelets have been shown to primarily forage in nearshore marine waters less than 98 feet deep off the Oregon coast, but may be found farther offshore during the non-breeding season (ODFW 2018). Mathews and Burger (1998) estimate, based on the bird's body size, the maximum diving depth is 154 feet. Marbled murrelet forage during the day, at dawn or dusk, solitarily or in groups; there is little evidence the species feeds at night (reviewed in ODFW 2018). Off the coast of Oregon, small groups of 2–3 murrelets have been observed (Strong et al. 1995), though aggregations comprising thousands of individuals have been observed in northern parts of the species range (Burkett 1995; Strachan et al. 1995).

Reproduction

Marbled murrelets have a long and asynchronous breeding season. In Oregon, Nelson and Hammer (1995) found the breeding period lasts up to 149 days, beginning in April and ending in September. Across the species' range, timing of breeding varies with latitude and is affected by food availability, weather, and ocean conditions (ODFW 2018). Birds may also breed later or forego breeding altogether when food availability is poor.

Marbled murrelets are monogamous and courtship takes place at sea in early spring, throughout the summer, and in winter (ODFW 2018). In Oregon, pairs have been observed "prospecting" or visiting potentially suitable nest trees prior to egg laying (Nelson and Wilson 2002). Copulation can take place in trees and on the water (Nelson 1997).

In some portions of the range, marbled murrelets start laying eggs in March, but they generally lay eggs from mid-May to mid-June, with some eggs laid as late as July. The clutch size is one, large egg. Incubation lasts approximately 30 days, with incubation shifts of 24 hours, shared equally by both sexes (Nelson 1997). Hatched chicks are semiprecocial and remain in the nest for approximately 3 weeks. The chick is left alone at the nest for most of the rearing period while both parents feed at sea (McShane et al. 2004). Adults commute to the nest up to 8 times per day, typically bringing one large fish to the chick on each trip (Nelson 1997). Feeding generally takes place at dawn or dusk but can occur during the day.

Young fledge between 27 to 40 days after hatching, from early July through early September. At fledging, young are believed to fly alone directly to the ocean; however, many are found grounded on the forest floor at varying distances from the ocean (as reviewed in ODFW 2018). No evidence of parental care has been documented once the young fledge (Nelson 1997). Renesting after early nest failure has been reported (Barbaree et al. 2014); however, evidence of a second brooding is lacking (McShane et al. 2004).

Site Fidelity

Marbled murrelets show highly variable home range sizes and nest-sea commuting distances; however, larger marine home ranges and commuting distances have been recorded in the federally listed range compared to Alaska (Lorenz et al. 2017).

McShane et al. (2004) suggest that marbled murrelets, like other alcids, show high philopatry (i.e., returning to breed where they hatched) and high site fidelity (i.e., typically breeding at the same location year after year). Strong nest-site fidelity in murrelets has been suggested by Divoky and Horton (1995), based on observations that murrelets have been observed in the same forest stands in California, Oregon, and Washington for over 20 years. Plissner et al. (2015) examined evidence of breeding site fidelity in the species at watershed-, stand-, tree-, and nest platform- levels. The study found consistent evidence of fidelity at the watershed scale and evidence of fidelity at the stand scale, fidelity at the tree scale was indicated from 19 of the 23 studies reviewed, and 13 of the 23 studies reviewed showed fidelity at the smaller scale of branch, nest-platform, or nest cup (Plissner et al. 2015). Plissner et al.'s review suggest areas used for nesting in one year are or can be occupied in subsequent years, but it is unknown whether these are the same birds or different individuals. Studies also suggest that nest site fidelity at the tree or nest platform may be lower in more contiguous habitat where suitable nest sites are more available (Burger et al. 2009).

Habitat Use and Selection

Marbled murrelets spend a lot of time in nearshore waters along exposed coastlines throughout their range, and in sheltered sounds and estuaries in Alaska, British Columbia, and Washington. Foraging, courtship, loafing, molting, and preening occur at sea (ODFW 2018).

Inland, murrelets use large coniferous trees for nesting, often in older forests. In Oregon, some nests have also been found in mature and young trees (66–150 years) containing older forest characteristics, such as platforms created by mistletoe infections or other deformities (Huff et al. 2006). The presence of platforms appears to be the most important stand characteristic for predicting murrelet occupancy of a given forest (Burger et al. 2002; McShane et al. 2004). Nesting in trees is unique among North American alcids; nesting on open ground (particularly in western Alaska where trees are absent), on cliffs, in rock crevices, or rarely in deciduous trees has been documented in parts of the northern marbled murrelet range, but not in Washington, Oregon, or California (McShane et al. 2004; Piatt et al. 2007).

Predation

Predation, particularly by Steller's jays (*Cyanocitta stelleri*), American crows (*Corvus brachyrhynchos*), and common ravens (*C. corax*), is a leading cause of marbled murrelet nest failure. Piatt et al. (2007) also reports bald eagle (*Haliaeetus leucocephalus*), peregrine falcon (*Falco peregrinus*), northern goshawk (*Accipiter gentilis*), and sharp-shinned hawk (*A. striatus*) predation on adult murrelets. Other reported predators include mice, squirrels, Western gull (*Larus occidentalis*), and California sea lion (*Zalophus californianus*). The U.S. Fish and Wildlife Service (2009) reports corvids as having the greatest impact on the species, although recovering populations of peregrine falcon and bald eagles are identified as an emerging concern (USFWS 2012).

Higher predation rates and numbers are generally associated with human presence (activities, food sources, etc.). Where parks, trails, and campgrounds overlap with marbled murrelet habitat, it is expected that predation pressures will remain high or increase in the future. Studies have reported behavioral responses of murrelets to boat traffic and boat disturbance can disrupt foraging or resting birds on the water, potentially increasing energetic costs or displacing them from preferred at-sea areas (USFWS 2009).

Ocean Conditions

Oceanic conditions influence the availability, distribution, and timing of prey resources available to murrelets (Piatt et al. 2007). Prey availability and prey quality affect breeding success and survival. A shift in murrelet diet to lower, poor quality trophic levels has been documented in parts of the murrelet range (Lorenz et al. 2017). Lower reproductive success has been correlated to warmer water events and El Nino years.

Population Status and Trends

There is limited information on the historical distribution and numbers of marbled murrelets. Available data suggest major population declines over the last 150 years (McShane et al. 2004; Piatt et al. 2007), with the steepest decline during the period of industrial logging of most murrelet habitat from 1850–1980. Assessments suggest the global murrelet population is on the order of 300,000–400,000 individuals, with roughly 70% in Alaska, 25% in British Columbia, and 5% in Washington, Oregon, and California combined (Committee on the Status of Endangered Wildlife in Canada 2012, Environment Canada 2014). McShane et al. (2004) suggest that Washington, Oregon, and California may have supported a larger population in the past.

Population decline has been attributed to loss of mature and old-growth forest from harvesting, low recruitment of young, and mortality at sea (USFWS 1997). The Oregon Coast Range has been identified by the *U.S. Fish and Wildlife Service Recovery Plan* (1997) as Conservation Zone 3, one of six recovery units or Conservation Zones for the marbled murrelet. Conservation Zone 3 and the northern portion of Conservation Zone 4 (the Siskiyou Coast Range) occur in Oregon. Conservation

Zone 3 extends from the Columbia River south to North Bend Oregon (USFWS 1997). Conservation Zone 4 extends from North Bend to the southern end of Humboldt County, California (USFWS 1997). Both zones include marine waters within 1.2 miles of the ocean shoreline and lands up to 35 miles from the coast plus any designated critical habitat units beyond that distance.

Lynch et al. (2017) estimated approximately 24,100 murrelets within the entire Northwest Forest Plan (NWFP) area in 2015, with approximately 10,975 of those in Oregon. Mclver et al. (2019) provides an all conservation zone estimate for 2017 of approximately 23,000 murrelets. Spies et al. (2018) estimated approximately 20,000 murrelets in the NWFP area, including those on Federal and nonfederal lands, and notes that population estimates are highly variable from year to year and have a broad confidence interval.

The all conservation zone trend for years 2001–2017 indicates no evidence of a trend (0.34% increase per year), and Conservation Zone 3 also shows no trend for years 2001 through 2018 (1.4% increase per year; 95% CI: -0.4% to 3.3%) (Mclver 2019). At the state scale, in years 2000–2017, Oregon and California showed significant positive trends, while Washington exhibited a significant declining trend (Mclver 2019).

Based on analyses summarized over the three states, murrelet populations appear to be stable or nondeclining in Oregon and northern California but are continuing to decline substantially in Washington (Spies et al. 2018).

Threats

Loss and degradation of late-seral forest in Oregon continue to threaten the marbled murrelet. In the Oregon Coast Range, Wimberly and Ohmann (2004) estimate that large-conifer forests declined by 58% between 1936 and 1996. Since the 1990s, further habitat loss has occurred, mainly due to timber harvest on nonfederal lands and wildfires on federal lands (Raphael et al. 2016). Raphael et al. (2016) found a net loss of approximately 2% of potential nesting habitat from 1993 to 2012 on federal lands, compared to a net loss of about 27% on nonfederal lands. For federal and nonfederal lands combined, the net loss of higher suitability habitat declined over all lands (both federal and nonfederal) from 2.53 to 2.23 million acres (a 12.1% decline). Loss of higher suitability habitat on nonfederal lands, mainly resulted from harvest and non federal lands most of the loss of higher suitability habitat was due to fire (62%) and the remaining due to harvest (23%) (Raphael et al. 2016).

Based on the NWFP estimates, higher-suitability nesting habitat declined in Oregon from approximately 853,400 acres in 1993 to 774,800 acres in 2012, a net loss of 78,600 acres (-9.2% change). Losses were greatest on nonfederal lands with 59,200 acres (21.1%) of higher-suitability habitat lost on nonfederal lands compared to 19,400 acres (3.4%) on federal lands. At the conservation-zone scale, which is the primary scale for marbled murrelet population estimate, the proportionate loss of higher suitability habitat was greatest in Conservation Zone 2 (-16.1% of baseline) and Conservation Zone 4 (-17.0% of baseline). The loss in Conservation Zones 3 and 4 were 10.9% and 7.90%, respectively.

Marbled murrelets are vulnerable to habitat fragmentation, with concern for hard edges created by clear-cuts located adjacent to nesting areas; habitat fragmentation has been linked to greater nest predation risk for the species (ODFW 2018). Malt and Lank (2007) found that disturbances by avian predators were significantly more frequent at hard edges relative to interiors, but less frequent at soft edges. The authors found no edge effects at natural-edged sites and inferred that edge-related predation may decline with time due to forest successional processes.

Disease has not been identified as a major threat to the marbled murrelet (McShane et al. 2004); however, Highly Pathogenic Avian Influenza (HPAI) and West Nile Virus have been detected in wild birds in Oregon and represent emerging concerns (ODFW 2018).

Emerging natural and anthropogenic threats to marbled murrelet include energy development projects, large oil spills, gill-net related mortalities, derelict fish gear, harmful algal blooms that produce biotoxins, surfactants that foul feathers, low oxygen "dead zones," and contaminants in prey that could biomagnify up the food chain (USFWS 2009). Golightly et al. (2009) documented murrelet nesting and nesting success as it relates to road disturbances and found that murrelets were more likely to nest farther away from paved roads than random sites.

Climate change is expected to increase potential for habitat loss from catastrophic wildfires, insect infestations, disease outbreaks, and severe storms, which may exacerbate unfavorable terrestrial nesting habitat (Spies et al. 2018). Climate change may influence the quality and availability of terrestrial nesting habitat (e.g., extent of fog zone and abundance of epiphytic plants that help create nesting platforms) and affect murrelet foraging habitat (e.g., prey abundance and distribution in the marine environment). In the 2009 Status Review of Marbled Murrelet, the U.S. Fish and Wildlife Service concluded that, based on climate model projections, the future conditions of forests where murrelets nest will largely be unfavorable for maintaining current forest structure and composition. Climate change may also result in changes to marine conditions for marbled murrelet, with the most likely effects on food resources. The U.S. Fish and Wildlife Service (2009) noted that the murrelet prey base will be adversely affected to some extent by climate change through changes in sea surface temperature, timing, intensity, and duration of cold-water upwelling. Acidification of marine waters may also impact marine food webs (Spies et al. 2018), resulting in cascading effects on murrelet foraging strategy. Lorenz et al. (2017) reported low breeding propensity, large marine ranges, and long nest-sea commutes in northwestern Washington, as compared to studies elsewhere in the murrelet's range, and hypothesized that the marine habitat in the study area had lower quality compared to elsewhere in the species' range. Changes to historical murrelet diet and annual variation in murrelet reproductive success suggest that warmer coastal waters tend to adversely affect prey quality and result in lowered reproduction (Becker et al. 2007; Becker and Beissinger 2006).

Literature Cited

Barbaree, B. A., S. K. Nelson, B. D. Dugger, D. D. Roby, H. R. Carter, D. L. Whitworth, and S. H. Newman. 2014. Nesting Ecology of Marbled Murrelets at a Remote Mainland Fjord in Southeast Alaska. *The Condor* 116:173–184.

Beauchamp, W. D., F. Cooke, C. Lougheed, L. W. Lougheed, C. J. Ralph, and S. Courtney. 1999. Seasonal Movements of Marbled Murrelets: Evidence from Banded Birds. *The Condor* 101:671–674.

Becker, B. H., and S. R. Beissinger. 2006. Centennial Decline in the Trophic Level of an Endangered Seabird after Fisheries Decline. *Conservation Biology* 20:470–479.

Becker, B., M. Zachariah Peery, and S. Beissinger. 2007. Ocean Climate and Prey Availability Affect the Trophic Level and Reproductive Success of the Marbled Murrelet, An Endangered Seabird. *Marine Ecology Progress Series* 329:267–279.

Bertram, D.F.; C.A. MacDonald, P.D. O'Hara, J.L. Cragg, M.H. Janssen, M. McAdie, W.S. Boyd. 2015. Marbled Murrelet (*Brachyramphus marmoratus*) Movements and Marine Habitat Use Near Proposed Tanker Routes to Kitimat, BC, Canada. *Marine Ornithology* 44: 3–9.

Bertram, D.F., MacDonald, C.A., O'Hara, P.D., Cragg, J.L., Janssen, M.H., McAdie, and M., Boyd, S. 2016. Marbled Murrelet *Brachyramphus marmoratus* Movements and Marine Habitat Use Near Proposed Tanker Routes to Kitimat, BC, Canada. *Marine Ornithology* 44: 3-9.

Burger, A. E., Canadian Wildlife Service, and Pacific and Yukon Region. 2002. *Conservation Assessment of Marbled Murrelets in British Columbia: A Review of the Biology, Populations, Habitat Associations, and Conservation*. Canadian Wildlife Service, Pacific and Yukon Region, Delta, BC.

Burger, A. E., I. A. Manley, M. P. Silvergieter, D. B. Lank, K. M. Jordan, T. D. Bloxton, and M. G. Raphael. 2009. Re-Use of Nest Sites by Marbled Murrelets (*Brachyramphus marmoratus*) in British Columbia. *Northwestern Naturalist* 90:217–226.

Burkett, E. E. 1995. Marbled Murrelet Food Habits and Prey Ecology. Pages 223-246 in C. J. Ralph, G. L. Hunt, Jr., M. G. Raphael, and J. F. Piatt (eds.) *Ecology and Conservation of the Marbled Murrelet, General Technical Report PSW-GTR-152*. U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, Albany, California.

Committee on the Status of Endangered Wildlife in Canada. 2012. *COSEWIC Assessment and Status Report on the Marbled Murrelet,* Brachyramphus marmoratus*, in Canada*. Committee on the Status of Endangered Wildlife in Canada, Ottawa, Ontario.

Divoky G. J. and M. Horton. 1995. Breeding and Natal Dispersal, Nest Habitat Loss, and Implications for Marbled Murrelet Populations. Pages 83–87 in C. J. Ralph, G. L. Hunt, Jr., M. G. Raphael, and J. F. Piatt (eds.) *Ecology and Conservation of the Marbled Murrelet, General Technical Report PSW-GTR-152*. U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, Albany, California.

Environment Canada. 2014. *Recovery Strategy for the Marbled Murrelet (*Brachyramphus marmoratus*) in Canada.*

Falxa, G. A., M. G. Raphael, and T. Coordinators. 2016. *Status and Trend of Marbled Murrelet Populations and Nesting Habitat*. Page 148. Gen. Tech. Rep., U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Friesen, V.L., Burg, T.M. & McCoy, K. 2007. Mechanisms of Population Differentiation in Seabirds. *Molecular Ecology* 16:1765–1785.

Golightly, R. T., C. D. Hamilton, and P. N. Hebért. 2009. *Characteristics of Marbled Murrelet (*Brachyramphus marmoratus*) Habitat in Northern California*: 49.

Halbert, P. and S. W. Singer. 2017. *Marbled Murrelet Landscape Management Plan for Zone 6.* California Department of Parks and Recreation, Felton, California.

Hamer, T. E. and S. K. Nelson. 1995. Nesting Chronology of the Marbled Murrelet. Pages 49-56 in C. J. Ralph, G. L. Hunt, Jr., M. G. Raphael, and J. F. Piatt (eds.) *Ecology and Conservation of the Marbled*

Murrelet, General Technical Report PSW-GTR-152. U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, Albany, California.

Huff, M. H., M. G. Raphael, S. L. Miller, S. K. Nelson, and J. Balwin. *2006. Northwest Forest Plan - The First 10 years (1994-2003): Status and Trends of Populations and Nesting Habitat for the Marbled Maurrelet.* Page 160. Gen. Tech. Rep., U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Lorenz, T. J., M. G. Raphael, T. D. Bloxton, and P. G. Cunningham. 2017. Low Breeding Propensity and Wide-Ranging Movements by Marbled Murrelets in Washington: Marbled Murrelet Space Use. *The Journal of Wildlife Management* 81:306–321.

Lynch, D., J. Baldwin, M. M. Lance, S. F. Pearson, M. G. Raphael, C. Strong, and R. Young. 2017. *Marbled Murrelet Effectiveness Monitoring, Northwest Forest Plan: 2016 Summary Report*.

Mack, E. D., W. P. Ritchie, S. K. Nelson, E. Kuo-Harrison, P. Harrison, and T. E. Hamer. 2003. *Methods for Surveying Marbled Murrelets in Forests: A Revised Protocol for Land Management and Research.* Page 82. Technical Publication, Pacific Seabird Group.

Malt, J. and D. Lank. 2007. Temporal Dynamics of Edge Effects on Nest Predation Risk for the Marbled Murrelet. *Biological Conservation* 140: 160–173.

Mathews, N. J. C. and A. E. Burger. 1998. Diving Depth of a Marbled Murrelet. *Northwestern Naturalist* 79:70–71.

McIver, W., J. Baldwin, M.M. Lance, S.F. Pearson, C. Strong, N. Johnson, D. Lynch, M.G. Raphael, R. Young, T. Lorenz and K. Nelson. 2019. *Marbled Murrelet Effectiveness Monitoring, Northwest Forest Plan: 2018 Summary Report*. 22 p.

McShane, C., T. Hamer, H. Carter, V. L. Friesen, D. Ainley, R. Tressler, S. K. Nelson, A. E. Burger, L. Spear, T. Mohagen, R. Martin, L. Henkel, K. Prindle, C. Strong, and J. Keany. 2004. *Evaluation Report for the 5-Year Status Review of the Marbled Murrelet in Washington, Oregon, and California*. Page 370.

Nelson, S. K., M. H. Huff, S. L. Miller, and M. G. Raphael. 2006. Marbled Murrelet Biology: Habitat Relations and Populations. Pages 9-30 in M. H. Huff, M. G. Raphael, S. L. Miller, S. K. Nelson, and J. Baldwin (eds.), *Northwest Forest Plan – The First 10 years (1994-2003): Status and Trends of Populations and Nesting Habitat for the Marbled Murrelet, General Technical Report PNW-GTR-650.* U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, Oregon.

Nelson, S. K. 1997. Marbled Murrelet (*Brachyramphus marmoratus*). *The Birds of North America Online*.

Nelson, S. K., and T. E. Hamer. 1995. Nesting Biology and Behavior of the Marbled Murrelet. Pages 57–67 in C. J. Ralph, G. L. Hunt, Jr., M. G. Raphael, and J. F. Piatt (Eds.), *Ecology and Conservation of the Marbled Murrelet.* General Technical Report PSW-GTR-152. U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, Albany, California.

Nelson, S. K. and R. W. Peck. 1995. Behavior of Marbled Murrelets at Nine Nest Sites in Oregon. *Northwestern Naturalist* 76:43–53.

Nelson, S. Kim and A. K. Wilson. 2002. *Marbled Murrelet Habitat Characteristics on State Lands in Western Oregon.* Unpublished Report, submitted to Oregon Department of Forestry, Oregon Department of Fish and Wildlife, U.S. Fish and Wildlife Service, and National Council for Air and Stream Improvement. As cited in Weikel, J. 2018. *Marbled Murrelet Technical Report Draft*. Page 37. Technical Report, Oregon Department of Forestry. Pg. 9.

Northrup, J.M., J.W. Rivers, S.K. Nelson, D.D. Roby, M.G. Betts. (2018) Assessing the Utility of Satellite Transmitters for Identifying Nest Locations and Foraging Behavior of the Marbled Murrelet *Brachyramphus marmoratus*. *Marine Ornithology* 46:47–55.

Oregon Department of Fish and Wildlife (ODFW). 2018. *Status Review of the Marbled Murrelet (*Brachyramphus marmoratus*) in Oregon and Evaluation of Criteria to Reclassify the Species from Threatened to Endangered under the Oregon Endangered Species Act*. Page 134.

Pearson, S. F. 2018. Marbled Murrelet Effectiveness Monitoring Team. Page 19. *Summary Report of 2017, Northwest Forest Plan Interagency Regional Monitoring Program*.

Piatt, J. F., A. E. Burger, K. J. Kuletz, S. A. Hatch, V. L. Friesen, T. P. Birt, M. L. Arimitsu, G. S. Drew, A. M. A. Harding, and K. S. Bixler. 2007. *Status Review of the Marbled Murrelet (*Brachyramphus marmoratus*) in Alaska and British Columbia*. Open-File Report, U.S. Department of the Interior.

Pilssner, J., H., B. A. Cooper, R. H. Day, P. M. Sanzenbacher, A. E. Burger, and M. G. Raphael. 2015. *A Review of Marbled Murrelet Research Related to Nesting Habitat Use and Nest Success.* Page 425. Final, Oregon Department of Forestry.

Ralph, J., C., G. L. Hunt, Jr., M. G. Raphael, and J. F. Piatt. 1995. *Ecology and Conservation of the Marbled Murrelet.* Page 13. General Technical Report PSW-GTR-152, U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, Albany, California.

Raphael, M. G., G. A. Falxa, D. Lynch, S. K. Nelson, S. F. Pearson, A. J. Shirk, and R. D. Young. 2016. Status and Trend of Nesting Habitat for the Marbled Murrelet Under the Northwest Forest Plan. Pages 37–94 in G. A. Falxa and M. G. Raphael (Tech. Coords*.), Northwest Forest Plan – The First 20 years (1994–2013): Status and Trend of Marbled Murrelet Populations and Nesting Habitat.* General Technical Report PNW-GTR-933. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, Oregon.

Raphael, M. G., G. A. Falxa, and A. E. Burger. 2018. Chapter 5: Marbled Murrelet. Page 72 in T. A. Spies, P. A. Stine, R. Gravenmier, J. W. Long, and J. W. Reilly (eds.), *Synthesis of Science to Inform Land Management within the Northwest Forest Plan Area*. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 301–370, Portland, OR.

Rodway, M. S., H. R. Carter, S. G. Sealy, and R. W. Campbell. 1992. Status of the Marbled Murrelet in British Columbia. Pages 17–41 in H. R. Carter and M. L. Morrison (eds.), *Status and Conservation of the Marbled Murrelet in North America*. Proceedings of the Western Foundation of Vertebrate Zoology, Camarillo, California.

Speich, S. M. and T. R. Wahl. 1995. Marbled Murrelet Populations of Washington – Marine Habitat Preferences and Variability of Occurrence. Pages 313–326 in C. J. Ralph, G. L. Hunt, Jr., M. G. Raphael, and J. F. Piatt (eds.), *Ecology and Conservation of the Marbled Murrelet, General Technical Report PSW-GTR-152*. U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, Albany, California.

Spies, T. A., P. A. Stine, R. Gravenmier, J. W. Long, M. J. Reilly, and R. Mazza. 2018. *Synthesis of science to Inform Land Management Within the Northwest Forest Plan Area: Executive Summary*. Gen. Tech. Rep. PNW-GTR-970. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 186 p. 970.

Strachan, G., M. McAllister, and C. J. Ralph. 1995. Marbled Murrelet At-Sea and Foraging Behavior. Pages 247–254 in C. J. Ralph, G. L. Hunt, Jr., M. G. Raphael, and J. F. Piatt (eds.), *Ecology and Conservation of the Marbled Murrelet, General Technical Report PSW-GTR-152*. U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, Albany, California.

Strong, C. S., B. S. Keitt, W. R. McIver, C. J. Palmer, and I. Gaffney. 1995. Distribution and Population Estimates of Marbled Murrelets at Sea in Oregon During the Summers of 1992 and 1993. Pages 339–352 in C. J. Ralph, G. L. Hunt, Jr., M. G. Raphael, and J. F. Piatt (eds.), *Ecology and Conservation of the Marbled Murrelet, General Technical Report PSW-GTR-152*. U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, Albany, California.

U.S. Fish and Wildlife Service (USFWS). 1997. Recovery *Plan for the Threatened Marbled Murrelet (*Brachyramphus marmoratus*) in Washington, Oregon, and California*. Page 286. U. S. Fish and Wildlife Service, Region 1.

U.S. Fish and Wildlife Service (USFWS). 2009. *Marbled Murrelet (*Brachyramphus marmoratus*) 5-Year Review*. U. S. Fish and Wildlife Service, Washington Fish and Wildlife Office, Lacey, WA.

U.S. Fish and Wildlife Service (USFWS). 2012. *Report on Marbled Murrelet Recovery Implementation Team Meeting and Stakeholder Workshop*. Page 66. U.S. Fish and Wildlife Service, Washington Fish and Wildlife Office, Lacey, Washington.

Weikel, J. 2018. *Marbled Murrelet Technical Report Draft*. Page 37. Technical Report, Oregon Department of Forestry.

Wimberly M.C. and J.L. Ohmann. 2004. A multi-scale Assessment of Human and Environmental Constraints on Forest Land Cover Change on the Oregon (USA) Range. *Landsc Ecol* 19:631–646.

C17 Red Tree Vole, North Oregon Coast DPS (*Arborimus longicaudus)*

Legal Status


Photo: USFWS

State: Sensitive

Federal: Candidate. 2011. 12-Month Finding on a Petition to List a Distinct Population Segment of the Red Tree Vole as Endangered or Threatened. 76 FR 63720-63762. Determined Not Warranted for Listing as Endangered or Threatened in 2019 (84 FR 69707- 69712)

Critical Habitat: N/A

Recovery Planning: N/A.

Species Status Assessment: Completed (USFWS 2019)

The taxonomy, biology, ecology, and status of the red tree vole, North Oregon Coast distinct population segment (DPS), are provided by the U.S. Fish and Wildlife Service (USFWS 2011 and 2019). Swingle and Forsman (2016) provide an annotated bibliography of the species.

Taxonomy

The animals now included in the North Oregon Coast DPS were originally classified in the species *Phenacomys longicaudus*, native to California and Oregon (USFWS 2008). When these animals were proposed for listing in 2007, they were recognized as subspecies *Arborimus longicaudus silvicola* by Wilson and Reeder (2005). Based on the listing proposal, the U.S. Fish and Wildlife Service (USFWS) determined that subspecies *silvicola* did not warrant recognition as a subspecies under the federal Endangered Species Act (ESA) (USFWS 2011). USFWS determined, however, that individuals from the North Oregon Coast population were genetically distinct enough from the rest of the red tree vole species to constitute a DPS, and described it as the red tree vole (*Arborimus longicaudus*), North Oregon Coast DPS, and classified it as a candidate species (USFWS 2011).

Distribution

General

Red tree vole is endemic to the lower elevation (generally below 1,300 meters [4,265 feet]) coniferous forests of western Oregon, generally west of the crest of the Cascade Range and northwestern California north of the Klamath River. Red tree voles have not been found north of the Columbia River (Verts and Carraway 1998). The species is absent from the Willamette Valley, though it can persist in the foothills along the valley edge. The range of the red tree vole, North

Oregon Coast DPS encompasses the Oregon Coast Range from the Columbia River south to the Siuslaw River, with the western edge of the Willamette Valley being the eastern boundary of the DPS (Figure C17-1) (USFWS 2011). Red tree vole, North Oregon Coast DPS is uncommon above 1,000 meters (Forsman et al. 2016).

The North Oregon Coast DPS is considered uncommon and sparsely distributed compared to red tree vole populations elsewhere in its range (Forsman et al. 2016), particularly the area within the DPS north of Highway 20, which accounts for nearly 75% of the DPS (Figure C17-1) (Forsman et al. 2016).

The historical northern limit of red tree voles in the North Oregon Coast DPS is unclear. The northernmost record of red tree voles in this region was near Saddle Mountain in central Clatsop County (Verts and Carraway 1998). Red tree voles have not been detected in recent survey efforts in northern Clatsop and Columbia Counties (Forsman and Swingle 2009; unpublished data, as cited in USFWS 2011; Price et al. 2015). This area historically had extensive forests with large Douglas-fir and western hemlock characteristic of red tree vole habitat. Much of this region was logged in the late 1800s, and it is likely that most suitable red tree vole habitat was removed in Clatsop, Columbia, and Washington Counties before red tree vole presence could be documented (USFWS 2016).

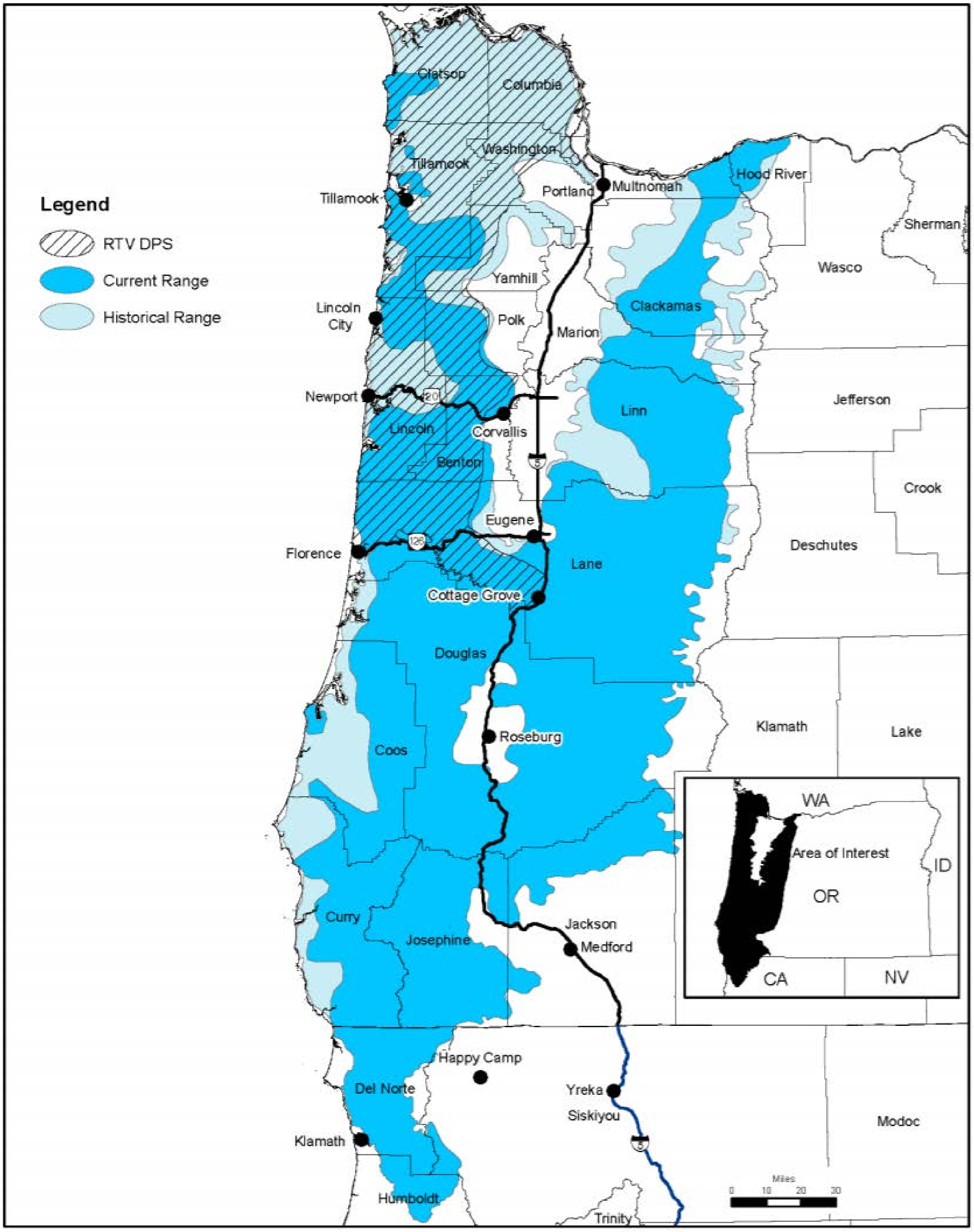
Occurrence in the Plan Area

Within the DPS, the red tree vole is mostly restricted to isolated populations in old forest stands in the northern half of the DPS and larger blocks of federal land in the southern half of the DPS, with smaller numbers occurring in younger stands (Forsman et al. 2016; Price et al. 2015). The species is uncommon in the northern third of the DPS, including the Clatsop State Forest and most of the Tillamook State Forest (Figure C17-2). Price et al. (2015) surveyed 86 randomly selected plots in Tillamook and Clatsop State Forests in 2011 to 2013. Thirty-three red tree vole nests were found in four plots. Of these, 20 (61%) nests were found in stands 90 to 125 years old, and 13 (39%) were found in one plot in a 65-year-old stand (located approximately 150 meters from a 140-year-old stand). Of the 33 nests, 6 (18%) were occupied or likely occupied. The four occupied plots were located on the western edge of the Tillamook State Forest in stands that did not burn during the 1933–1951 Tillamook Burn fires. Red tree voles also occur along the southern edge of the Tillamook State Forest in Tillamook and Yamhill Counties.

Natural History

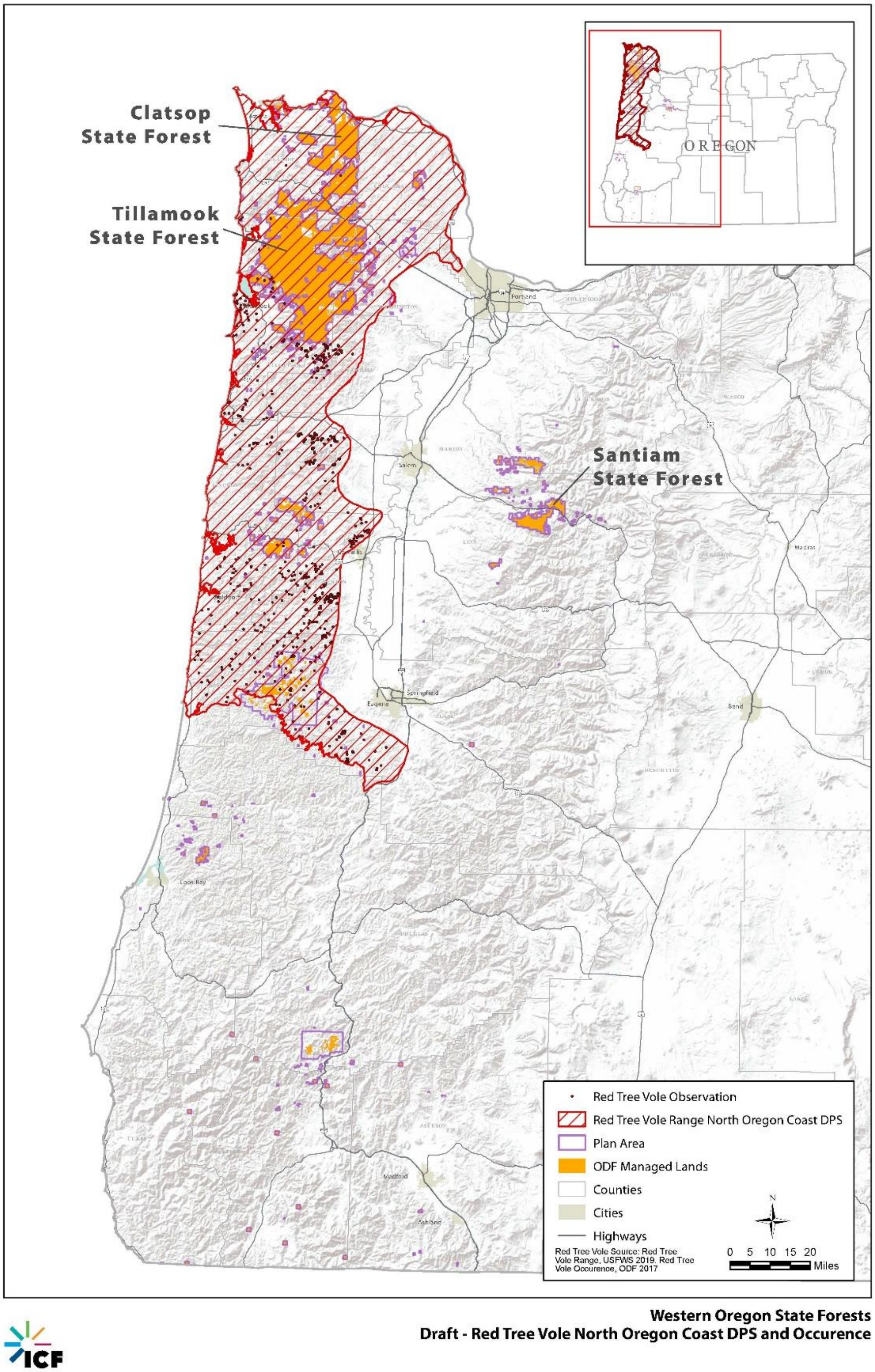
Published information on the red tree vole, North Coast DPS includes work on the red tree vole, and on the closely related Sonoma tree vole (*Arborimus pomo*). The red tree vole and Sonoma tree vole were considered a single species until 1991 (Johnson and George 1991). Where information is lacking or limited on the red tree vole, information on the Sonoma tree vole is presented because no ecological or life history differences have been noted for the two species (Smith et al. 2003).

Figure C17-1. Historical and Current Range of the Red Tree Vole (Forsman et al. 2016) and the North Oregon Coast Distinct Population Segment (Hashed Area)



Source: USFWS 2019.

Figure C17-2. Range of Red Tree Vole (North Oregon Coast DPS) and Known Occurrences



Sources: USFWS 2019

Habitat Requirements

Red tree vole occurs primarily in structurally complex late-seral conifer or mixed conifer-hardwood forests (Dunk and Hawley 2009; USFWS 2011; Forsman et al. 2016; Rosenberg et al. 2016; Linnell et al. 2017; Johnston and Moskal 2017). Attributes of late-successional forest positively correlated with habitat suitability include large-diameter trees (Dunk and Hawley 2009; Rosenberg et al. 2016; Johnston and Moskal 2017); density of large conifers; percent of conifer cover; percent of food-source trees such as Douglas-fir, Sitka spruce, and western hemlock (Forsman et al. 2016); structural diversity (Dunk and Hawley 2009; Forsman et al. 2016; Johnston and Moskal 2017); and extent of old forest cover (Linnell et al. 2017).

Within the westernmost portions of the North Oregon Coast DPS, red tree vole habitat is characterized by the Sitka spruce (*Picea sitchensis*) plant series. Sitka spruce is dominant in the tree canopy with grand fir (*Abies grandis*), red alder (*Alnus rubra*), coast readwood (*Sequoia sempervirens*), and western hemlock (*Tsuga heterophylla*); trees are less than 75 meters, the canopy is intermittent to continuous, shrub layer is sparse to continuous, and the herbaceous layer is usually abundant, especially with ferns (California Native Plant Society 2019). The series is highly productive, producing large trees relatively quickly, and contains plant associations that develop and maintain older forest characteristics (USFWS 2011). Two plant associations are identified for the series in southwestern Oregon: Sitka Spruce/Salal-Evergreen Huckleberry and Sitka Spurce-White Fir/Salmonberry (Hemstrom and Longan 1986). Although the Sitka spruce plant series occurs along most of the Oregon coast, it extends farthest inland in northwestern Oregon. Most of the Sitka spruce series can be found within 1 mile of the Pacific Ocean, in the wet and mild climate of coastal plains and headlines (U.S. Forest Service 1992). The Sitka spruce plant series setting is somewhat unique to the North Oregon Coast DPS, as most of the plant series in Oregon occurs in the North Oregon Coast DPS (USFWS 2016). It is within this portion of the DPS—in western Lincoln, Tillamook, and Clatsop Counties—where the red tree vole diet is dominated by Sitka spruce and western hemlock needles. East of the Sitka spruce plant series in the North Oregon Coast DPS, as well as throughout the rest of its range, the red tree vole consumes primarily Douglas-fir (see *Diet,* below) (USFWS 2016).

Red tree vole nest trees are located in the forest canopy and are constructed from twigs and resin ducts, fecal pellets, lichens, and conifer needles (Gillesberg and Carey 1991; Forsman et al. 2009). Red tree vole nest trees tend to be larger than trees without nests, even in stands of large trees (Johnston and Moskal 2017). Old-growth trees may be ideal for tree voles because primary production is high and needles are concentrated, providing maximum food availability (Carey 1991). Range-wide, the red tree vole is primarily associated with Douglas-fir. Within the North Coast DPS, however, red tree voles tend to favor western hemlock and Sitka spruce for diet and nest placement (Forsman et al. 2008; Price et al. 2015).

Though abundance is considerably higher in late seral forest structure, the red tree vole is sometimes found in early-to-mid seral stands (0 to 79 years old) (Price et al. 2015). Young forest stands may provide interim habitat for tree voles and connectivity between remnant patches of older forests (Linnell et al. 2017), but value in supporting viable populations is uncertain (USFWS 2011), and available evidence suggests tree vole occupation of younger forest stands is unlikely or relatively short-lived (Diller pers. comm., as cited in USFWS 2011; Hopkins pers. comm., as cited in USFWS 2011).

Landscape context of older forest habitat patches influences habitat suitability. Red tree voles are sensitive to habitat fragmentation (Martin and McComb 2002; Linnell et al. 2017; Rosenberg 2019) and avoid nesting at forest edges (Johnston and Moskal 2017), and their relatively short dispersal distance limits their ability to colonize or move to isolated old forest patches. Distance to old forest patches also influences the likelihood of occurrence in young forest (Johnston and Moskal 2016; Linnell et al. 2017). For example, Linnell et al. analyzed habitat and landscape-level factors affecting habitat suitability for the North Oregon Coast DPS and found that suitable habitat is correlated with old forest (≥80 years old). Suitability of young forest (<80 years old) was negatively correlated with distance from large patches of old forest and recent disturbance. Models found that if old forest contracted to only federal land (a 1.4% decrease regionally), average distance to nearest patch would increase from 3.1 kilometers to 11.1 kilometers. Alternatively, if there was an increase (1.4% in old forest of patches randomly distributed in the landscape), average distance between patches would be reduced by 1.8 kilometers. The authors conclude that even a small amount of restored or regenerated old forest would improve connectivity and increase population resiliency (Linnell et al. 2017).

Diet

Red tree voles eat conifer needles, stripping away resin ducts within the needles and eating the rest, and the tender bark of conifer twigs. In most of their range, diet comprises primarily Douglas-fir conifer needles (Forsman et al. 2016). In the North Oregon Coast DPS, however, red tree voles rarely forage on Douglas-fir, even where available, and instead eat needles from western hemlock and Sitka spruce (Forsman and Swingle 2009; unpublished data, as cited in USFWS 2011; Maser pers. comm., as cited in USFWS 2011).

Reproduction

Adult red tree voles live alone, except when females have litters; males and females only come together to breed. Females and males have nests made of vegetation and other materials. Nests can range from grapefruit-sized to that of a bushel basket (USFWS 2016).

Red tree voles can breed throughout the year, but most reproduction occurs between February and September (Swingle 2005). Red tree voles become sexually mature at 2.5 to 3.0 months of age (Clifton 1960). Litters average 2.9 young (range of 1 to 4) (Maser et al. 1981; Verts and Carraway 1998). Juveniles disperse when they are 1.6 to 2.0 months old (Swingle 2005; Forsman et al. 2009). Females can be impregnated immediately after a litter is born, so females can have two litters in their nests (Swingle 2005; Forsman et al. 2009).

Movement

Red tree voles spend most of their time in the tree canopy, coming to the ground rarely to move between trees. In a study of 45 radio-collared red tree voles in the southern Coast Range and Cascades in southwestern Oregon, Swingle and Forsman (2009) found 18 red tree voles to have small home ranges, consisting of their nest tree and a few adjacent trees. The remainder occupied up to six different nests up to 162 meters apart in different trees. Mean and median home ranges were 0.17 and 0.08 hectare, respectively. Home range sizes did not differ between sex, age, or age of forest.

Red tree voles tend to disperse short distances generally ranging from 3 to 75 meters (Swingle 2005), suggesting that relatively small distances (i.e., roughly less than 366 meters) between old forest patches may be barriers to dispersal (USFWS 2011).

Ecological Relationships

Swingle et al. (2010) found that weasels (*Mustela* spp.) are the primary predators of red tree voles. Other animals that prey on red tree voles include fisher, barred owl, and other raptors. Spotted owls are predators of red tree voles elsewhere in its range—but this interaction seems to be limited—in the DPS (Forsman et al. 2016). Western gray squirrel (*Sciurus griseus*), Douglas squirrel (*Tamiasciurus douglasii*), and raccoon (*Procyon lotor*) have been filmed chasing red tree voles or tearing into tree vole nests in apparent attempts to capture voles (Forsman pers. comm., as cited in USFWS 2011).

Population Status and Trends

Little is known about current and historical population sizes of the North Oregon Coast DPS due, in part, to the challenges of observing and capturing red tree voles. Historical surveys (e.g., late 1800s to mid-1900s) were generally conducted to inventory the presence of species, rather than to estimate abundance of a particular species (Jobanek 1988). Once red tree vole behavior was understood, searchers were typically able to find red tree voles. Once found, they were often able to find many nests in the same area (USFWS 2016).

More recent surveys for red tree voles in or near areas where they historically occurred have found relatively few tree voles. For example, Forsman and Swingle (2006, unpublished data, as cited in USFWS 2011) found 27 red tree voles over 1,143 person-hours searching potentially suitable habitat (one red tree vole per 42 person-hours search effort). Price et al. (2015) spent 50 person-hours per nest in the Clatsop and Tillamook State Forests and concluded that tree voles were likely absent because the area was either logged or burned in the early 1900s, and subsequently intensively managed on short rotations.

Although population size estimates are not available to estimate trends, data and anecdotal information such as what is provided here strongly suggest that current red tree vole abundance in the DPS is considerably lower than historical abundance (USFWS 2016).

Threats

The red tree vole, North Oregon Coast DPS is primarily threatened by habitat loss and fragmentation from timber harvest and wildfire (USFWS 2011). Logging and relatively short rotation intervals preclude the development of late-successional forest habitat, and maintain forests in early seral stages. Fragmentation by continued logging on short rotation intervals adjacent to old forest habitat further isolates and diminishes the quality of remnant patches of old forest habitat (USFWS 2016). Active management, such as thinning stands, can also reduce vole numbers or eliminate them (USFWS 2016).

Estimates of suitable habitat, derived from habitat models and historic forest maps, provide an index on the amount of potentially suitable habitat and changes in extent over time. Using this approach, Forsman et al. (2016) found that the amount of red tree vole habitat in Oregon declined by 65% between 1914 and 2006, with an 80% decline in the northern Coast Ranges overlapping the DPS.

Remaining older forests are distributed across the DPS mostly as small, isolated fragments. Using results from a habitat suitability model created by Dunk and Hawley (2009) and other unpublished data, USFWS estimates that only 0.3% of the DPS is in a forest type that red tree vole strongly selects, whereas almost 90% of the DPS is in a forest type condition that red tree voles tend to avoid (USFWS 2016). Using habitat modeling with airborne light detection and ranging (LiDAR), Johnston and Moskal (2017) found red tree vole nests were often in the largest trees in the stand and away from forest edges. Linnell et al. (2017) found red tree vole relative habitat suitability was positively correlated with current old forest cover at the local-scale and negatively correlated with distance from large patches of old forest. At the landscape level, proximity to old forest and the absence of recent disturbance contributes to the habitat suitability of young forests (Linnell et al. 2017).

Within the plan area, much of the Tillamook State Forest was burned by the Tillamook Burn, a series of four large fires from 1933 to 1951 that burned approximately 143,000 hectare (353,360.70 acres), much of it old forest (Wells 1999). The burned areas were subsequently subject to salvage logging and harvest at short rotation intervals. This area likely supported red tree voles historically, but extensive fires and subsequent management has made this area unsuitable for red tree voles (Price et al. 2015; Forsman et al. 2016). Similarly, the Yaquina Burn of 1847 to 1853 devastated 450,000 acres of the Coast Range west of Corvallis, Oregon, from South Fork of the Siletz River to the mouth of Siuslaw River, significantly altering habitat conditions for this species in the southern half of the DPS.

Literature Cited

California Native Plant Society (CNPS). 2019. *A Manual of California Vegetation*, Online Edition. Available: http://vegetation.cnps.org/alliance/44. Accessed: July 25, 2019. California Native Plant Society. Sacramento, CA.

Carey, A. B. 1991. *The Biology of Arboreal Rodents in Douglas-Fir Forests.* Page 46. Gen. Tech. Rep., U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, OR.

Clifton, P.L. 1960. *Biology and life History of the Dusky Tree Mouse* Phenacomys silvicola *(Howell).* Walla Walla, WA: Walla Walla College. 140 p. M.A. thesis.

Dunk, J. R., and J. J. V. G. Hawley. 2009. Red-Tree vole Habitat Suitability Modeling: Implications for Conservation and Management. *Forest Ecology and Management* 258:626–634.

Forsman, E. D., and J. K. Swingle. 2010. Doug Bake and red Tree Voles: A Tale of Discovery in the Pacific Northwest. *Northwestern Naturalist* 91:102–105.

Forsman, E. D., R. G. Anthony, and C. J. Zabel. 2004. Distribution and Abundance of Red Tree Voles in Oregon Based on Occurrence in Pellets of Northern Spotted Owls. *Northwest Science* 78:294–302.

Forsman, E. D., J. K. Swingle, and W. Price. 2008. *Red Tree Vole (*Arborimus longicaudus*) Surveys at Oswald West, Fort Stevens, and Ecola State Parks, 26–28 April 2008.* Page 8. Unpublished Report. On file with: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Corvallis, OR.

Forsman, E. D., J. K. Swingle, and N. R. Hatch. 2009. Behavior of Red Tree Voles (*Arborimus longicaudus*) Based on Continuous Video Monitoring of Nests. *Northwest Science* 83:262–272.

Forsman, E. D., J. K. Swingle, R. J. Davis, B. L. Biswell, and A. S. Lawrence. 2016. *Tree Voles: An Evaluation of their Distribution and Habitat Relationships Based on Recent and Historical Studies, Habitat Models, and Vegetation Change*. Page 119. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, OR.

Gillesberg, A.-M., and A. B. Carey. 1991. Arboreal Nests of *Phenacomys longicaudus* in Oregon. *Journal of Mammalogy* 72:784–787.

Hemstrom, M.A., and S.E. Logan 1986. *Plant Association and Management Guide Siuslaw National Forest. USDA Forest Service. Pacific Northwest Region*. E6-Ecol 220-1968a.

Jobanek, G. A. 1988. Searching for the Tree Vole: An Episode in the 1914 Biological Survey of Oregon. *Oregon Historical Quarterly* 89:369–399.

Johnson, M. L., and S. B. George. 1991. Species Limits within the *Arborimus longicaudus* Species–Complex (Mammalia: Rodentia) with a Description of a New Species from California. *Contributions in Science, Natural History Museum of Los Angeles County* 429:1–16.

Johnston, A. N., and L. M. Moskal. 2017. High-Resolution Habitat Modeling with Airborne LiDAR for Red Tree Voles: Red Tree Vole Habitat Models. *Journal of Wildlife Management* 81:58–72.

Linnell, M. A., R. J. Davis, D. B. Lesmeister, and J. K. Swingle. 2017. Conservation and relative Habitat Suitability for an arboreal Mammal Associated with old Forest. *Forest Ecology and Management* 402:1–11.

Martin, K. J., and W. C. McComb. 2002. Small Mammal Habitat Associations at Patch and Landscape Scales in Western Oregon. *Forest Science* 48:255–264.

Maser, C., B. R. Mate, J. F. Franklin, and C. T. Dyrness. 1981. N*atural History of Oregon Coast Mammals.* Page 496. Gen. Tech. Rep., USDA Forest Service, Portland, OR.

Price, A., Jason S Mowdy, James K Swingle, and Eric D Forsman. 2015. Distribution and Abundance of Tree Voles in the Northern Coast Ranges of Oregon. *Northwestern Naturalist* 96:37–49.

Rosenberg, D. K. 2019. A Tale of Two Voles: The Challenge of the Commonness-Rarity Continuum in Conservation Planning. *Forest Ecology and Management* 434:165–171.

Rosenberg, D. K., R. J. Davis, K. J. Van Norman, J. R. Dunk, E. D. Forsman, and R. D. Huff. 2016. Patterns of Red Tree Vole Distribution and Habitat Suitability: Implications for Surveys and Conservation Planning. *Ecosphere* 7:e01630. 10.1002/ecs2.1630.

Smith, W. P., R. G. Anthony, J. R. Waters, N. L. Dodd, and C. J. Zabel. 2003. Ecology and Conservation of Arboreal Rodents of Western Coniferous Forests. Pages 157-206. Chapter 6 in C. J. Zabel and R. G. Anthony (eds.), *Mammal Community Dynamics: Management and Conservation in the Coniferous Forests of Western North America.* Cambridge University Press, Cambridge, UK.

Swingle, J. K. 2005. *Daily Activity Patterns, Survival, and Movements of Red Tree Vol*es (Arborimus longicaudu*s) in Western Oregon*. Oregon State University.

Swingle, J. K., and E. D. Forsman. 2009. *Home Range Areas and Activity Patterns of Red Tree Voles (*Arborimus longicaudus*) in Western Oregon.* SPIE.

Swingle, J. K., and E. D. Forsman. 2016. *Annotated Bibliography of the Red Tree Vole (*Arborimus longicaudus*), Sonoma Tree Vole (*A. pomo*), and White-Footed Vole (*A. albipes*).* Page 184. Gen. Tech. Rep., U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, OR.

Swingle, J. K., E. D. Foreman, and A. G. Robert. 2010. Survival, Mortality, and Predators of Red Tree Voles (*Arborimus longicaudus*). *Northwest Science* 84:225–265.

U.S. Fish and Wildlife Service (USFWS). 2008. Endangered and Threatened Wildlife and Plants; A 90-Day Finding on a Petition to List the Dusky Tree Vole (*Arborimus longicaudus silvicola*) as Threatened or Endangered. *Federal Register* 209:63919–63926. Google Scholar.

U.S. Fish and Wildlife Service (USFWS). 2011. Endangered and Threatened Wildlife and Plants; 12-Month Finding on a Petition to List a Distinct Population Segment of the Red Tree Vole as Endangered or Threatened. *Federal Register* 76: 63720–63762.

U.S. Fish and Wildlife Service (USFWS). 2016. *U.S. Fish and Wildlife Service Species Assessment and Listing Priority Assignment Form, Red Tree Vole (*Arborimus longicaudus*)*. U.S. Fish and Wildlife Service, Region 1.

U.S. Fish and Wildlife Service (USFWS). 2019. Species *Status Assessment North Oregon Coast Population of the Red Tree Vole (*Arborimus longicaudus*).* Version 1.0. Available: https://ecos.fws.gov/ServCat/DownloadFile/169143.

U.S. Forest Service. *1992. Sitka Spruce Series PIS*I. Authored by Paula Fong R. Available: https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5319843.pdf.

Verts, B. J., and L. N. Carraway. 1998. *Land Mammals of Oregon.* University of California Press, Berkeley.

Wells, G. 1999. *The Tillamook: A Created Forest Comes of Age.* Oregon State University Press, Corvallis, OR.

Wilson, D.E. and D.M. Reeder (eds.). 2005. *Mammal Species of the World: A Taxonomic and Geographic Reference.* 3rd ed. Baltimore, MD: John Hopkins University Press:963 p.

Appendix D
Species Considered for Coverage

Table C-1. Species Considered for Coverage in the Western Oregon State Forests Habitat Conservation Plan

Species	Status[a]		Criteria[b]				Recommended Covered Status[c]	Notes
	State	Federal	Range	Status	Impact	Data		
Fish								
Oregon coast coho ***Oncorhynchus kisutch***	**SS**	**FT**	**Y**	**Y**	**Y**	**Y**	**Y**	Occurs in multiple locations throughout the plan and permit area
Lower Columbia River coho ***Oncorhynchus kisutch***	**SE**	**FT**	**Y**	**Y**	**Y**	**Y**	**Y**	Occurs in multiple locations throughout the plan and permit area
Upper Willamette River spring chinook ***Oncorhynchus tshawytscha***	**--**	**FT**	**Y**	**Y**	**Y**	**Y**	**Y**	Occurs in multiple locations throughout the plan and permit area
Upper Willamette River winter steelhead ***Oncorhynchus mykiss***	**--**	**FT**	**Y**	**Y**	**Y**	**Y**	**Y**	Occurs in multiple locations throughout the plan and permit area
Columbia River chum ***Oncorhynchus keta***	**--**	**FT**	**Y**	**Y**	**Y**	**Y**	**Y**	Occurs in multiple locations throughout the plan and permit area
Southern Oregon/Northern California coho ***Oncorhynchus kisutch***	**SS**	**FT**	**Y**	**Y**	**Y**	**Y**	**Y**	Occurs in multiple locations throughout the plan and permit area
Lower Columbia River chinook ***Oncorhynchus tshawytscha***	**SSC**	**FT**	**Y**	**Y**	**Y**	**Y**	**Y**	Occurs in multiple locations throughout the plan and permit area
Eulachon ***Thaleichthys pacificus***	**--**	**FT**	**Y**	**Y**	**Y**	**Y**	**Y**	Limited to the Columbia and Umpqua Rivers but does utilize confluence of streams and rivers on state forest
Oregon Coast Spring Chinook ***Oncorhynchus tshawytscha***	**--**	**--**	**Y**	**(Y)**	**Y**	**Y**	**Y**	Occurs in multiple locations throughout the plan and permit area, likely to be listed during the permit term
Lower Columbia River steelhead *Oncorhynchus mykiss*	SSC	FT	N	Y	N	Y	N	Unlikly to occur in the plan and permit area. There is a single CSL parcel adjacent to Boulder Creek where LCR steelhead could occur. Conservation measures identified in the HCP would be applied throughout the permit area and chance for take is remote.

Species	Status[a] State	Status[a] Federal	Criteria[b] Range	Criteria[b] Status	Criteria[b] Impact	Criteria[b] Data	Recommended Covered Status[c]	Notes
Bull trout *Salvelinus confluentus*	--	FT	N	Y	N	Y	N	Unlikly to occur in the plan and permit area. There is a single CSL parcel adjacent to the Middle Fork Willamette River where bull trout could occur. Conservation measures identified in the HCP would be applied throughout the permit area and chance for take is remote.
Green sturgeon *Acipenser medirostris*	SS/S S C	FT	N	Y	N	N	N	Could occur in the lower reaches of large coastal rivers. Downstream effects from ODF management activites would be attenuated, chance for take is remote.
Shortnosed sucker *Chasmistes brevirostris*	SE	FE	N	Y	N	Y	N	Plan area is outside of range or current known distribution
Lost River sucker *Deltistes luxatus*	--	FE	N	Y	N	Y	N	Plan area is outside of range or current known distribution
Pacific lamprey *Lampetra tridentatata*	SS	FSOC	Y	N	Y	Y	N	Not expected to become listed during permit term
Western river lamprey *Lampetra ayresii*	SS	--	Y	N	Y	N	N	Not expected to become listed during permit term
Great Basin redband trout *Oncorhynchus mykiss gibbsi*	SS	FSOC	Y	N	N	Y	N	Plan area is outside of range or current known distribution
Amphibians								
Oregon slender salamander *Batrachoseps wrighti*	**SS**	**UR**	**Y**	**Y**	**Y**	**Y**	**Y**	Occurs in multiple locations throught the plan and permit area and expected to become listed during the permit term
Columbia torrent salamander *Rhyacotriton kezeri*	**SS**	**UR**	**Y**	**Y**	**Y**	**Y**	**Y**	Occurs in multiple locations throught the plan and permit area and expected to become listed during the permit term
Cascade torrent salamander *Rhyacotriton cascadae*	**SS**	**UR**	**Y**	**Y**	**Y**	**Y**	**Y**	Occurs in multiple locations throught the plan and permit area and expected to become listed during the permit term

Species	Status[a]		Criteria[b]				Recommended	Notes
	State	Federal	Range	Status	Impact	Data	Covered Status[c]	
Oregon spotted frog *Rana pretiosa*	SSC	FT	Y	Y	N	Y	N	Within the range but no overlap of covered activities with current occupied site. Unlikely to recolonize without habitat restoration and reintroduction.
Reptiles								
Leatherback sea turtle *Dermochelys coriacea*	SE	FE	N	Y	N	Y	N	Plan area is outside of range or current known distribution
Loggerhead sea turtle *Caretta caretta*	ST	FE	N	Y	N	Y	N	Plan area is outside of range or current known distribution
Olive ridley sea turtle *Lepidochelys olivacea*	ST	FT	N	Y	N	Y	N	Plan area is outside of range or current known distribution
Birds								
Northern spotted owl ***Strix occidentalis***	**ST**	**FT**	**Y**	**Y**	**Y**	**Y**	**Y**	**Occurs in multiple locations throughout the plan and permit area**
Marbled murrelet ***Brachyramphus marmoratus***	**ST**	**FT**	**Y**	**Y**	**Y**	**Y**	**Y**	**Occurs in multiple locations throughout the plan and permit area**
Short-tailed albatross *Phoebastria albatrus*	--	FE	N	Y	N	Y	N	Plan area is outside of range or current known distribution
Streaked horned lark *Eremophila alpestris strigata*	--	FT	N	Y	N	Y	N	Plan area is outside of range or current known distribution
Western snowy plover *Charadrius nivosus nivosus*	--	FT	N	Y	N	Y	N	Plan area is outside of range or current known distribution
Yellow-billed cuckoo *Coccyzus americanus*	--	FT	Y	Y	N	Y	N	Range is highly restricted in Oregon and habitat is limited to large cottonwood galley type riparan areas not found on ODF-managed lands.
Northern goshawk *Accipiter gentilis atricapillus*	SS	--	Y	N	Y	Y	N	Not expected to become listed during permit term. Can manage around nest sites if they become apparent.
Olive-sided flycatcher *Contopus cooperi*	SS	--	Y	N	Y	Y	N	Not expected to become listed during permit term
American peregrine falcon *Falco peregrinus anatum*	SS	--	Y	N	Y	Y	N	Not expected to become listed during permit term

Species	Status[a] State	Status[a] Federal	Criteria[b] Range	Criteria[b] Status	Criteria[b] Impact	Criteria[b] Data	Recommended Covered Status[c]	Notes
Mammals								
Coastal marten ***Martes caurina***	**SS**	**PT**	**Y**	**Y**	**Y**	**Y**	**Y**	Occurs in multiple locations throughout the plan and permit area and expected to become listed during permit term
Red tree vole (North Oregon Coast DPS) ***Arborimus longicaudus***	**SS**	**FC**	**Y**	**Y**	**Y**	**Y**	**Y**	Occurs in multiple locations throughout the plan and permit area and expected to become listed during permit term.
Red tree vole (Southern DPS) *Arborimus longicaudus*	--	--	Y	N	Y	(Y)	N	Review with Scoping Team
Pacific fisher *Martes pennanti*	SSC	PT	Y	Y	Y	Y	N	Potential for overlap in dispersed SW OR parcles. ODF is using a CCAA for this species.
Gray wolf (Western DPS) *Canis lupus*	SE	PE	Y	Y	N	N	N	Potential impacts are too hypothetical at this point in time. Focus would be on den sites, which are currently limited.
Columbia white-tailed deer *Odocoileus virginianus leucurus*	--	FT	Y	Y	N	Y	N	Assumes riparian strategies would avoid impacts
North American wolverine *Gulo gulo luscus*	ST	--	N	N	N	Y	N	Plan area is outside of range or current known distribution
Killer whale (Southern resident DPS) *Orcinus orca*	--	FE	N	Y	N	Y	N	Plan area is outside of range or current known distribution
Blue Whale *Balaenoptera musclus*	SE	FE	N	Y	N	Y	N	Plan area is outside of range or current known distribution
Fin Whale *Balaenoptera physalus*	SE	FE	N	Y	N	Y	N	Plan area is outside of range or current known distribution
Gray Whale *Eschrichtius robustus*	SE	--	N	Y	N	Y	N	Plan area is outside of range or current known distribution
Humpback Whale *Megaptera novaeangliae*	SE	FE	N	Y	N	Y	N	Plan area is outside of range or current known distribution
North Pacific Right Whale *Eubalaena japonica*	SE	FE	N	Y	N	Y	N	Plan area is outside of range or current known distribution
Sei Whale *Balaenoptera borealis*	SE	FE	N	Y	N	Y	N	Plan area is outside of range or current known distribution

Species	Status[a] State	Status[a] Federal	Criteria[b] Range	Criteria[b] Status	Criteria[b] Impact	Criteria[b] Data	Recommended Covered Status[c]	Notes
Sperm Whale *Physeter macrocephalus*	SE	FE	N	Y	N	Y	N	Plan area is outside of range or current known distribution
Fringed myotis *Myotis thysanodes*	SS	--	Y	N	Y	Y	N	Not expected to become listed during permit term. HCP and FMP policies will minimize disturbance
Long-legged myotis *Myotis Volans*	SS	--	Y	N	Y	Y	N	Not expected to become listed during permit term. HCP and FMP policies will minimize disturbance
Silver-haired bat *Lasionycteris noctivagans*	SS	--	Y	N	Y	Y	N	Not expected to become listed during permit term. HCP and FMP policies will minimize disturbance
Hoary bat *Lasiurus cinereus*	SS	--	Y	N	Y	Y	N	Not expected to become listed during permit term. HCP and FMP policies will minimize disturbance
Townsend's big-eared bat *Corynorhinus townsendii*	SSC	--	Y	N	Y	Y	N	Not expected to become listed during permit term. HCP and FMP policies will minimize disturbance
Pallid Bat *Antrozous pallidus*	SS	--	Y	N	Y	Y	N	Not expected to become listed during permit term. HCP and FMP policies will minimize disturbance
California myotis *Myotis californicus*	SS	--	Y	N	Y	Y	N	Not expected to become listed during permit term. HCP and FMP policies will minimize disturbance
American pika *Ochotona princeps*	SS	--	Y	N	N	Y	N	Not expected to become listed during permit term. Talus slopes are generally avoided during covered activities.
Insects								
Fender's blue butterfly *Icaricia icarioides fenderi*	--	FE	Y	Y	N	Y	N	Not likely to occur in the plan area due to lack of suitable habitat
Oregon silverspot butterfly *Speyeria zerene hipolyta*	--	FT	N	Y	N	Y	N	Plan area is outside of range or current known distribution

Species	Status[a]		Criteria[b]				Recommended Covered Status[c]	Notes
	State	Federal	Range	Status	Impact	Data		
Taylor's checkerspot *Euphydryas editha taylori*	--	FE	N	Y	N	Y	N	Plan area is outside of range or current known distribution
Vernal pool fairy shrimp *Branchinecta lynchi*	--	FT	N	Y	N	Y	N	Plan area is outside of range or current known distribution

Notes:

[a] **Status**

State Status

SE = State listed as endangered
ST = State listed as threatened
SS = State sensitive
SSC = State sensitive-critical
– = Not state listed

Federal Status

FE = Federally endangered
FT = Federally threatened
UR = Under review
PT = Federally proposed threatened
PE = Federally proposed endangered
– = Not federally listed.

[b] **Criteria**

Range: The species is known to occur or is likely to occur within the plan area, based on credible evidence, or the species is not currently known in the study area but is expected in the study area during the permit term (e.g., through range expansion or reintroduction to historic range).

Status: The species meets one or more of the following criteria.

- Listed under the federal Endangered Species Act (ESA) as threatened or endangered, or proposed for listing.
- Listed under the Oregon ESA as threatened or endangered or a candidate for such listing.
- Expected to be listed under Federal or State ESA within the permit term (50 years). Potential for listing during the permit term is based on the current listing status, consultation with Wildlife Agency staff and other experts, evaluation of species population trends and threats, and best professional judgment.

Impact: The species or its habitat would be adversely affected by covered activities or projects that may result in take of the species.

Data: Sufficient data exist on the species' life history, habitat requirements, and occurrence in the study area to adequately evaluate impacts on the species and to develop conservation measures to mitigate these impacts to levels specified by regulatory standards.

Species proposed for coverage in the Western Oregon State Forests Habitat Conservation Plan were limited to those species for which impacts from covered activities were likely, in order to provide take authorization for the highest priority species.

[c] **Recommended Covered Status**

Y = Recommended as covered species in the Western Oregon State Forests Habitat Conservation Plan.
N = Not recommended for coverage in the Western Oregon State Forests Habitat Conservation Plan.

Appendix E
Effects Analysis Approach

Fish Limiting Factors

Lower Columbia River Coho

Population Group	Populations	Key Limiting Factors2	Adult Abundance1: Recent 5 yr Average & Range (2014 – 2018)3	Adult Abundance1: Percent of Total ESU Abundance	Total Stream Miles	Stream Miles in Plan Area: Miles in Plan Area	Stream Miles in Plan Area: Percent (%) in Plan Area	Stream Miles in Plan Area: Miles of Critical Habitat in Plan Area	Contributing Streams in Plan Area (outside species distribution)2: *Total Fish Bearing in Plan Area*	Contributing Streams in Plan Area (outside species distribution)2: Fish Bearing	Contributing Streams in Plan Area (outside species distribution)2: Non-Fish Bearing	Stream Miles in Permit Area: Total Miles	Stream Miles in Permit Area: BOF Miles	Stream Miles in Permit Area: CSL Miles	Stream Miles in Permit Area: Percent (%) in Pemit Area (BOF/CSL)	Stream Miles in Permit Area: Miles of Critical Habitat in Permit Area	Contributing Streams in Permit Area (outside species distribution)2: *Total Fish Bearing in Permit Area*	Contributing Streams in Permit Area (outside species distribution)2: Fish Bearing	Contributing Streams in Permit Area (outside species distribution)2: Non-fish Bearing
Coastal	Youngs Bay	Population Diversity (A) Habitat Quantity (A)	93 (26/161)	1%	141	7	5%	6.7	*88.3*	81.4	96.9	4.8	4.8	0.0	3.4%	4.6	73.4	68.5	91.2
	Big Creek	Population Diversity (A) Habitat Quantity (A)	400 (160/792)	4	83	17	20%	16.9	*169.2*	152.2	135.1	15.1	15.1	0.0	18.2%	15.0	148.8	133.7	126.7
	Clatskanie River	Population Diversity (A) Riparian Condition (J)	908 (25/3,246)	10%	104	3	3%	6.9	*143.2*	140.6	94.8	2.7	2.7	0.0	2.6%	4.9	106.6	103.9	88.0
	Scappoose Creek	Riparian Condition (J) Peripheral and Transitional Habitats (J)	767 (178/1,587)	8%	139	0	0%	0.0	*0.0*	0.0	0.0	0.0	0.0	0.0	0.0%	0.0	0.0	0.0	0.0
	Coastal Total		**2,169 (389/5,786)**	**23%**	**326**	**20**	**6%**	**30.5**	***400.7***	**374.2**	**326.7**				**0.0%**	**24.5**	**328.8**	**306.2**	**305.8**
Cascade	Clackamas River	Population Diversity (A) Water Quality (A & J)	4,968 (1,628/10,672)	56%	390	0	0%	0.0	*0.0*	0.0	0.0	0.0	0.0	0.0	0.0%	0.0	0.0	0.0	0.0
	Sandy River	Riparian Condition (J) Peripheral and Transitional Habitats (J)	2,049 (443/5,942)	22%	181	0.1	0.06%	0.1	*1.0*	0.9	0.0	0.1	0.0	0.1	0.1%	0.1	1.0	0.9	0.0
	Cascade total		**7,017 (2,071/16,614)**	**74%**	**572**	**0.1**	**0.02%**	**0.1**	***1.0***	**0.9**	**0.0**				**0.0%**	**0.1**	**1.0**	**0.9**	**0.0**

Population Group	Populations	Key Limiting Factors2	Adult Abundance1		Total Stream Miles	Stream Miles in Plan Area			Contributing Streams in Plan Area (outside species distribution)2			Stream Miles in Permit Area					Contributing Streams in Permit Area (outside species distribution)2		
			Recent 5 yr Average & Range (2014 – 2018)3	Percent of Total ESU Abundance		Miles in Plan Area	Percent (%) in Plan Area	Miles of Critical Habitat in Plan Area	*Total Fish Bearing in Plan Area*	Fish Bearing	Non-Fish Bearing	Total Miles	BOF Miles	CSL Miles	Percent (%) in Pemit Area (BOF/CSL)	Miles of Critical Habitat in Permit Area	*Total Fish Bearing in Permit Area*	Fish Bearing	Non-fish Bearing
Gorge	Lower Gorge Tributaries	Population Diversity (A) Habitat Quantity (A)	201 (0/395)	2%	125	0	0%	0.0	*0.0*	0.0	0.0	0.0	0.0	0.0	0.0%	0.0	0.0	0.0	0.0
	Upper Gorge Tributaries and Big White Salmon River	Habitat Quantity (A) Riparian Condition (J)	-	-	108	0	0%	0.0	*0.0*	0.0	0.0	0.0	0.0	0.0	0.0%	0.0	0.0	0.0	0.0
	Upper Gorge Tributaries and Hood River	Population Diversity (A) Habitat Quantity (A&J)	53 (0/107)	1%	134	0	0%	0.0	*0.0*	0.0	0.0	0.0	0.0	0.0	0.0%	0.0	0.0	0.0	0.0
	Gorge total		**253 (0/502)**	**3%**	**367**	**0**	**0**	**0.0**	***0.0***	**0.0**	**0.0**					**0.0**	**0.0**	**0.0**	**0.0**

some occurrence in plan/permit area

1 - ODFW Salmon and Steelhead Recovery Tracker

2 - A = Adult; J = Juvenile

3 - Youngs Bay and Big Creek abundance is reported for 2008-2012. Data is not avaible for these populations from 2014-2018

Oregon Coast Coho

			Adult Abundance1			Stream Miles in Plan Area				Contributing Streams in Plan Area (outside species distribution)2		Stream Miles in Permit Area						Contributing Streams in Permit Area (outside species distribution)2	
Population Group	**Populations**	**Key Limiting Factor(s)**	**Recent 5 yr. Average & Range (2013– 2017)**	**Percent of Total ESU Abundance**	**Total Stream Miles**	**Miles in Plan Area**	**Percent (%) in Plan Area**	**Miles of Critical Habitat in Plan Area**	***Total Fish Bearing in Plan Area***	**Fish Bearing**	**Non-Fish Bearing**	**Total Miles**	**BOF Miles**	**CSL Miles**	**Percent (%) in Permit Area (BOF/CSL)**	**Miles of Critical Habitat in Permit Area**	**Total Fish Bearing in Permit Area**	**Fish Bearing**	**Non-fish Bearing**
North Coast	Necanicum	Stream Complexity	1,767 (529/5,727)	1%	99.5	1.1	1%	1.1	2.85	1.7	7.8	0.8	0.0	0.8	0.8%	0.8	12.2	11.4	14.4
	Nehalem	Steam Complexity Water Quality	10,246 (3,079/30,577)	8%	769.1	241.5	31%	215.0	544.61	303.1	1,420.5	214.6	212.3	2.3	27.9%	192.2	2,870.6	2,656.0	3,145.3
	Tillamook Bay	Steam Complexity Water Quality	7,173 (1,345/20,090)	5%	461.5	233.3	51%	196.9	414.63	181.3	1,627.8	225.3	223.6	1.7	48.8%	189.9	3,409.0	3,183.8	3,528.5
	Nestucca	Steam Complexity	3,050 (946/6,369)	2%	255.7	4.2	2%	2.4	10.64	6.4	20.5	4.2	4.2	0.0	1.7%	2.4	137.4	133.1	137.4
	Sand Lake (North Coast Dependents)	Steam Complexity Water Quality	1,245 (206/4,607)	<1%	57.0	0.0	0%	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0%	0.0	0.0	0.0	0.0
	North Coast Total		**23,481 (6,740/67,370)**	**17%**	**1642.7**	**480.2**	**29%**	**415.4**	**972.74**	**492.5**	**3,076.6**				**0.0%**	**385.3**	**6,429.2**	**5,984.2**	**6,825.6**
Mid-Coast	Salmon	Hatchery Impacts Steam Complexity	1,336 (332/3,680)	1%	57.8	0.0	0%	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0%	0.0	0.0	0.0	0.0
	Siletz	Stream Complexity	7,518 (2,216/19,496)	6%	283.5	7.3	3%	7.0	27.68	20.4	49.9	5.7	3.3	2.4	2.0%	5.5	77.0	71.3	106.9
	Yaquina	Stream Complexity Water Quality	7,551 (2,400/25,582)	6%	280.5	19.1	7%	17.2	65.93	46.8	76.9	13.1	9.2	3.9	4.7%	11.1	180.6	167.5	230.0
	Beaver	Spawning Gravel Stream Complexity	2,435 (332/6,564)	2%	55.9	0.6	1%	0.5	1.01	0.4	1.6	0.6	0.6	0.0	1.0%	0.5	2.6	2.1	2.6
	Alsea (harvest occurs in this HUC, no fish streams though)	Steam Complexity Water Quality	10,566 (4,288/25,733)	8%	423.5	0.0	0%	0.0	0.37	0.4	0.0	0.0	0.0	0.0	0.0%	0.0	1.9	1.9	2.5
	Siuslaw	Steam Complexity Water Quality	15,927 (7,129/38,896)	12%	840.9	33.5	4%	29.7	64.07	30.5	44.1	16.3	16.3	0.0	1.9%	15.1	206.6	190.3	356.5
	Rock Creek (Mid-Coast Dependents)	Stream Complexity Spawning Gravel	1,406 (473/2,012)	1%	43.9	0.0	0%	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0%	0.0	0.0	0.0	0.0
	Tenmile (Mid-Coast Dependents)	Stream Complexity Spawning Gravel			62.8	0.0	0%	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0%	0.0	0.0	0.0	0.0
	Yachats (Mid-Coast Dependents)	Stream Complexity Spawning Gravel			51.9	0.0	0%	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0%	0.0	0.0	0.0	0.0
	Mid Coast total		**46,739 (22,673/121,963)**	**34%**	**1423.0**	**33.5**	**2%**	**54.4**	**159.06**	**98.6**	**172.5**				**0.0%**	**32.2**	**468.8**	**433.2**	**698.6**

Population Group	Populations	Key Limiting Factor(s)	Adult Abundance1		Total Stream Miles	Stream Miles in Plan Area				Contributing Streams in Plan Area (outside species distribution)2		Stream Miles in Permit Area						Contributing Streams in Permit Area (outside species distribution)2	
			Recent 5 yr. Average & Range (2013– 2017)	Percent of Total ESU Abundance		Miles in Plan Area	Percent (%) in Plan Area	Miles of Critical Habitat in Plan Area	*Total Fish Bearing in Plan Area*	Fish Bearing	Non-Fish Bearing	Total Miles	BOF Miles	CSL Miles	Percent (%) in Permit Area (BOF/CSL)	Miles of Critical Habitat in Permit Area	Total Fish Bearing in Permit Area	Fish Bearing	Non-fish Bearing
Lakes	Siltcoos	Non-Native Fish Species Stream Complexity/Water Quality	3,134 (715/7,178)	2%	96.7	0.0	0%	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0%	0.0	0.0	0.0	0.0
	Tahkenitch	Non-Native Fish Species Stream Complexity/Water Quality	1,941 (269/3,691)	1%	52.6	0.0	0%	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0%	0.0	0.0	0.0	0.0
	Tenmile	Non-Native Fish Species Stream Complexity/Water Quality	4,874 (318/11,141)	4%	89.5	0.8	1%	0.5	1.66	0.8	4.8	0.8	0.8	0.0	0.9%	0.5	7.0	6.1	7.1
	Mercer (Lakes Dependent)	Non-Native Fish Species Stream Complexity/Water Quality			23.7	0.0	0%	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0%	0.0	0.0	0.0	0.0
	Lakes Total		**9,949 (1,302/22,010)**	**7%**	**23.7**	**0.8**	**3.4%**	**0.5**	**1.66**	**0.8**	**4.8**				**0.0%**	**0.5**	**7.0**	**6.1**	**7.1**
Umpqua	Lower Umpqua	Stream Complexity Water Quality	12,746 (3,725/36,942)	9%	610.2	2.4	0.4%	2.7	4.19	1.7	5.5	1.9	1.9	0.0	0.3%	2.1	12.8	10.9	17.0
	Middle Umpqua	Water Quality Stream Coplexity	4,681 (1,159/13,939)	3%	559.4	0.3	0.1%	0.3	0.33	0.0	0.9	0.3	0.0	0.3	0.1%	0.3	1.2	0.9	1.2
	North Umpqua	Hatchery Impacts Stream Complexity	2,537 (1,148/3,979)	2%	215.8	0.0	0%	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0%	0.0	0.0	0.0	0.0
	South Umpqua	Water Quality Stream Coplexity	6,263 (765/12,178)	5%	816.1	8.8	1%	6.5	15.34	6.5	92.3	8.3	7.3	1.0	1.0%	6.0	92.1	83.9	121.8
	Umpqua total		**26,227 (7,494/66,272)**	**19%**	**1591.4**	**9.2**	**1%**	**9.5**	**19.86**	**8.2**	**98.7**				**0.0%**	**8.4**	**106.2**	**95.7**	**140.1**
Mid-South Coast	Coos	Stream Complexity Water Quality	11,221 (2,689/38,880)	8%	483.2	13.7	3%	14.0	19.42	5.7	47.3	11.0	11.0	0.0	2.3%	11.0	69.3	58.3	92.0
	Coquille	Stream Complexity Water Quality	16,558 (3,357/41,660)	12%	597.8	0.0	0%	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0%	0.0	0.0	0.0	0.0
	Flores	Stream Complexity Water Quality	1,236 (693/1,936)	1%	120.0	0.0	0%	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0%	0.0	0.0	0.0	0.0
	Sixes	Stream Complexity Water Quality	267 (69/567)	0%	71.7	0.0	0%	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0%	0.0	0.0	0.0	0.0
	Mid-South Coast Dependents	Stream Complexity Water Quality	27 (0/105)	<1%	NA	0.0	NA	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0%	0.0	0.0	0.0	0.0
	Mid-South Coast total		29,309 (8,092/82,077)	22%	**1272.7**	**13.7**	**1%**	**14.0**	**19.42**	**5.7**	**47.3**					**11.0**	**69.3**	**58.3**	**92.0**

some occurrence in plan/permit area

1 - ODFW Salmon and Steelhead Recovery Tracker

2 - StreamNet and the Statewide hydo layer do not always align. These values are a general estimate, not an accurate total.

Columbia River Chum

Population Group	Populations	Key Limiting Factors	Total Stream Miles	Stream Miles in Plan Area			Contributing Streams in Plan Area (outside species distribution)2			Stream Miles in Permit Area					Contributing Streams in Permit Area (outside species distribution)2		
				Miles in Plan Area	Percent (%) in Plan Area	Miles of Critical Habitat in Plan Area	*Total Fish Bearing in Plan Area*	Fish Bearing	Non-Fish Bearing	Total Miles	BOF Miles	CSL Miles	Percent (%) in Pemit Area (BOF/CSL)	Miles of Critical Habitat in Permit Area	*Total Fish Bearing in Permit Area*	Fish Bearing	Non-fish Bearing
Gorge	Lower Gorge Tributaries	Riparian Conditions (A&J) Peripheral and Transitional Habitats (A&J)	75	0	0%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Upper Gorge Tributaries	Habitat Quantity (A&J) Riparian Condition (A&J)	55	0	0%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Hood River	Not Listed	0	0	0%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Gorge total		**130**	**0**	**0%**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0%**	**0.0**	**0.0**	**0.0**	**0.0**
Coastal	Big Creek	Habitat Quantity (A) Sediment Conditions (J)	45	8	18%	0.0	169.2	161.1	135.1	8.1	8.1	0.0	17.8%	0.0	148.8	140.7	126.7
	Clatskanie River	Sediment Conditions (J) Water Quality (A)	25	0	0%	0.0	143.2	143.2	94.8	0.0	0.0	0.0	0.0%	0.0	106.6	106.6	88.0
	Youngs Bay	Habitat Quantity (A) Sediment Conditions (J)	57	1	2%	0.0	88.3	87.2	96.9	0.3	0.3	0.0	0.5%	0.0	73.4	73.1	91.2
	Coastal total		**127**	**9**	**7%**	**0.0**	**400.7**	**391.5**	**326.7**	8.4	8.4	0.0	7%	**0.0**	**328.8**	**320.4**	**305.8**

some occurrence in plan/permit area

note: no ODFW abundance data

2 - StreamNet and the Statewide hydo layer do not always align. These values are a general estimate, not an accurate total.

Upper Willamette River Steelhead

Population Group	Populations	Key Limiting Factors	Adult Abundance1		Total Stream Miles	Stream Miles in Plan Area			Contributing Streams in Plan Area (outside species distribution)2			Stream Miles in Permit Area					Contributing Streams in Permit Area (outside species distribution)2		
			Recent 5 yr Average & Range (2014 – 2018)	Percent of Total ESU Abundance		Miles in Plan Area	Percent (%) in Plan Area	Miles of Critical Habitat in Plan Area	*Total Fish Bearing in Plan Area*	Fish Bearing	Non-Fish Bearing	Total Miles	BOF Miles	CSL Miles	Percent (%) in Permit Area (BOF/CSL)	Miles of Critical Habitat in Permit Area	*Total Fish Bearing in Permit Area*	Fish Bearing	Non-fish Bearing
	Molalla River	Habitat Quality Water Quality	1,484 (1,273/1,987)	22%	296	2	1%	0.61	31.7	29.9	75.6	0.6	0.6	0.0	0.2%	0.15	24.6	24.0	60.2
	North Santiam River	Habitat Access Water Quality	2,826 (1,650/3,863)	43%	174	9	5%	7.50	90.8	82.1	252.9	6.3	6.3	0.0	3.6%	5.11	68.1	61.8	173.2
	South Santiam River	Habitat Access Water Quality	1,988 (1,519/3,546)	30%	326	2	1%	2.40	6.0	3.6	25.6	2.4	2.4	0.0	0.7%	2.40	6.0	3.5	21.9
	Calapooia River	Water Quanity Habitat Access	312 (140/684)	5%	88	0	0%	0	0.0	0.0	0.4	0.0	0.0	0.0	0.0%	0.00		0.0	0.4
	West Side Tributaries	Habitat Access Water Quality	NA	NA	857	16	2%	7.95	243.8	227.9	214.0	14.4	14.4	0.0	1.7%	6.50	221.5	207.2	156.8
	Willamette total				**1741**	**29**	**2%**	**18.5**	**372.3**	**343.3**	**568.5**					**14.16**	**320.2**	**296.5**	**412.6**

some occurrence in plan/permit area

1 - ODFW Salmon and Steelhead Recovery Tracker

2 - StreamNet and the Statewide hydo layer do not always align.

These values are a general estimate, not an accurate total.

Upper Willamette River Chinook

			Adult Abundance1			Stream Miles in Plan Area			Contributing Streams in Plan Area (outside species distribution)2			Stream Miles in Permit Area					Contributing Streams in Permit Area (outside species distribution)2		
Population Group	**Populations**	**Key Limiting Factors**	**Recent 5 yr Average & Range (2014 – 2018)**	**Percent of Total ESU Abundance**	**Total Stream Miles**	**Miles in Plan Area**	**Percent (%) in Plan Area**	**Miles of Critical Habitat in Plan Area**	***Total Fish Bearing in Plan Area***	**Fish Bearing**	**Non-Fish Bearing**	**Total Miles**	**BOF Miles**	**CSL Miles**	**Percent (%) in Permit Area (BOF/ CSL)**	**Miles of Critical Habitat in Permit Area**	***Total Fish Bearing in Permit Area***	**Fish Bearing**	**Non-fish Bearing**
Willamette	Calapooia River	Water Quality Water Quantity			77	0	0	0.0	0.0	0.0	0.4	0	0	0	0.0%	0.0	0.0	0.0	0.4
	Clackamas River	Habitat Access Population Diversity			140	0	0	0.0	0.0	0.0	0.0	0	0	0	0.0%	0.0	0.0	0.0	0.0
	McKenzie River	Habitat Access Water Quantity			301	0	0	0.0	0.0	0.0	0.0	0	0	0	0.0%	0.0	0.0	0.0	0.0
	Middle Fork Willamette River	Water Quality Water Quantity			284	0	0	0.0	2.6	2.6	4.6	0	0	0	0.0%	0.0	2.2	2.2	2.2
	Molalla River	Habitat Quality Water Quality			189	0	0	0.0	31.7	31.7	75.6	0	0	0	0.0%	0.0	24.6	24.6	60.2
	North Santiam River	Water Quality Water Quantity			182	5	3%	0.0	90.8	85.5	252.9	4.1	4.1	0	2.3%	0.0	68.1	64.0	173.2
	South Santiam River	Water Quality Water Quantity			207	0	0	0.0	6.0	6.0	25.6	0	0	0	0.0%	0.0	6.0	6.0	21.9
	Willamette total				**1380**	**5**	**0.4%**	**0.0**	**131.1**	**125.8**	**359.1**					**0.0**	**100.9**	**96.8**	**257.9**
Z-Outside (area outside independent population)	Z-Outside				498	0	0		1.0	1.0	1.0	0	0	0	0		1.0	1.0	1.0

some occurrence in plan/permit area

1 - ODFW Salmon and Steelhead Recovery Tracker

2 - StreamNet and the Statewide hydo layer do not always align. These values are a general estimate, not an accurate total.

S. OR/N. CA Coho

Population Group	Populations	Key Limiting Factors	Total Stream Miles	Stream Miles in Plan Area			Contributing Streams in Plan Area (outside species distribution)2			Stream Miles in Permit Area					Contributing Streams in Permit Area (outside species distribution)2		
				Miles in Plan Area	**Percent (%) in Plan Area**	**Miles of Critical Habitat in Plan Area**	***Total Fish Bearing in Plan Area***	**Fish Bearing**	**Non-Fish Bearing**	**Total Miles**	**BOF Miles**	**CSL Miles**	**Percent (%) in Pemit Area (BOF/CSL)**	**Miles of Critical Habitat in Permit Area**	***Total Fish Bearing in Permit Area***	**Fish Bearing**	**Non-fish Bearing**
Rogue	Chetco	Urban/Residential/Industrial Development Channelization/Diking	281	0	0%	0.0	0.0	0.0		0	0	0	0.0%	0.0	0.0	0.0	0.0
Rogue	Elk	Channelization/Diking Urban/Residential/Industrial Development	69	0	0%	0.0	0.0	0.0		0	0	0	0.0%	0.0	0.0	0.0	0.0
Rogue	Illinois	Roads Dams/Diversions	451	0.2	0%	0.0	1.3	1.1	13.8	0.18	0	0.18	0.0%	0.0	1.3	1.1	13.8
Rogue	Lower Rogue	Roads Urban/Residential/Industrial Development	101	0	0%	0.0	0.0	0.0		0	0	0	0.0%	0.0	0.0	0.0	0.0
Rogue	Middle Rogue and Applegate	Urban/Residential/Industrial Development Dams/Diversions	826	1	0.1%	0.0	8.6	7.5	43.6	1.16	0.67	0.49	0.1%	0.0	8.6	7.5	43.0
Rogue	Smith	Channelization/Diking Agriculture	56	1	2%	0.0	1.5	0.4	2.1	1.18	0	1.18	2.1%	0.0	1.5	0.4	2.1
Rogue	Upper Klamath	Dam/Diversions Roads	0	0	0%	0.0	0.0	0.0	0.5	0	0	0	0.0%	0.0	0.0	0.0	0.5
Rogue	Upper Rogue	Agricultural Practices Urban/Residential/Industrial Development	253	0	0%	0.0	0.0	0.0	1.2	0	0	0	0.0%	0.0	0.0	0.0	1.2
Rogue	Winchuck	Channelization/Diking Urban/Residential/Industrial Development	63	0	0%	0.0	0.2	0.2	0.8	0	0	0	0.0%	0.0	0.2	0.2	0.8
	Rogue Total		**2099**	**3**	**0.1%**	**0.0**	**11.7**	**9.2**	**62.0**	**2.5**	**0.7**	**1.9**	0%	**0.0**	**11.7**	**9.2**	**61.4**

some occurrence in plan/permit area

2 - StreamNet and the Statewide hydo layer do not always align. These values are a general estimate, not an accurate total.

Lower Columbia River Chinook

Population Group	Populations	Key Limiting Factors1	Total Stream Miles	Stream Miles in Plan Area			Contributing Streams in Plan Area (outside species distribution)2			Stream Miles in Permit Area				Contributing Streams in Permit Area (outside species distribution)2		
				Miles in Plan Area	Percent (%) in Plan Area	Miles of Critical Habitat in Plan Area	*Total Fish Bearing in Plan Area*	Fish Bearing	Non-Fish Bearing	Total Miles	BOF Miles	CSL Miles	Miles of Critical Habitat in Permit Area	*Total Fish Bearing in Permit Area*	Fish Bearing	Non-fish Bearing
Cascade	Clackamas River	Sediment Conditions (A) Population Diversity (A)	173	0	0	0.0	0.0	0.0	0.0	0	0	0	0.0	0	0.0	0.0
	Sandy River	Sediment Conditions (A) Population Diversity (A)	110	0	0	0.0	1.0	1.0	0.0	0	0	0	0.0	1.0	1.0	0.0
Gorge	Lower Gorge Tributaries	Population Diversity (A) Water Quantity (A)	68	0	0	0.0	0.0	0.0	0.0	0	0	0	0.0	0.0	0.0	0.0
	Upper Gorge Tributaries	Population Diversity (A) Mortality (A)	61	0	0	0.0	0.0	0.0	0.0	0	0	0	0.0	0.0	0.0	0.0
	Hood River	Population Diversity (A) Habitat Quantity (A)	107	0	0	0.0	0.0	0.0	0.0	0	0	0	0.0	0.0	0.0	0.0
Coastal	Scappoose Creek	Population Diversity (A) Sediment Conditions (A)	26	0	0	0.0	0.0	0.0	0.3	0	0	0	0.0	0.0	0.0	0.3
	Big Creek	Habitat Quanitity Population Diversty				0.0	169.2	169.2	135.1					148.8	148.8	126.7
	Clatskanie River	Population Diversity Sediment Conditions				0.0	143.2	#VALUE!	94.8					106.6	106.6	88.0
	Young's Bay	Habitat Quantity (A) Sediment Conditions (A)				0.0	88.3	#VALUE!	96.9					73.4	73.4	91.2
						0.0	**401.7**	**#VALUE!**	**327.1**				**0.0**	**1.0**	**1.0**	**0.3**

1 - A= Adult

Eulachon

Species	Key Limitng Factors	Notes	Stream Miles in Plan Area
Southern DPS Eulachon	Climate Change Bycatch	Eulachon are not expected to occur in streams on ODF land. There is ODF land adjacent to the Columbia, which is used by the species.	Limited - assume BGO's for salmonids would also benefit eulachon.

Temperature Protection Memo

Western Oregon State Forest HCP

Riparian Conservation Area and Temperature Protection

Introduction

The Oregon Department of Forestry (ODF) is preparing a multi-species Western Oregon State Forests Habitat Conservation Plan (HCP) to support the issuance of incidental take permits (ITPs) under the federal Endangered Species Act (ESA) for Western Oregon State Forests that are managed by ODF. The HCP is a long-term plan that will support the conservation of threatened and endangered species, or those species that are likely to become listed, while allowing management of the forest including ongoing timber harvest activities.

Covered species are those species for which US Fish and Wildlife Service (USFWS) and National Marine Fisheries Services (NMFS) will provide take authorization to ODF to conduct the covered activities. The permit area provides habitat for a variety of species, including species listed under state and federal endangered species protection laws, and others that are not yet listed, but may become listed during the permit term. ODF selected the covered species for the HCP based on review of all species of conservation concern known or suspected to occur in the plan area during the permit term.

As part of HCP development agencies coordinated on the development of riparian buffers that would protect watershed processes, and specific to this memo, stream temperatures to benefit the covered species that utilize streams and adjacent riparian forests. These include nine fish and two amphibians: Oregon Coast coho, Oregon Coast spring chinook, Lower Columbia River coho, Lower Columbia River chinook, Columbia River chum, Upper Willamette River spring chinook, Upper Willamette River steelhead, Southern Oregon/Northern California coast coho, eulachon, Columbia torrent salamander, and Cascade torrent salamander.

Riparian Conservation Area Designation

Degraded water quality, especially elevated stream temperature, is one of the primary threats to many of the covered fish species (NMFS 2013, 2014; ODFW and NMFS 2011). The restoration of riparian function, through the implementation of riparian conservation areas (RCAs) in the permit area, will help reduce stream temperature increases by maintaining or increasing shading, the primary driver of stream temperature (Beechie et al. 2012). This will benefit the covered species and provide longer-term climate change resilience.

ODF will establish Riparian Conservation Areas (RCAs) adjacent to streams. The functions of streams within the permit area will be maintained by retaining vegetation in riparian areas during adjacent harvest activities. No harvest will occur within the RCAs.

The buffer widths provided for RCAs represent a minimum buffer and are reported in horizontal distance unless otherwise noted, meaning that the width is applied and measured in the field horizontally, regardless of slope. It is measured beginning at the aquatic zone, which can be one of the following: the average high-water level of the water body, the edge of the stream-associated wetland or side channel, or the channel migration zone,[1] whichever is farthest from the waterway, and extends perpendicular from the stream toward the uplands. Since the buffers are reported using horizontal distance, as slope increases, the effective width (i.e. distance along slope) of the conservation area in the field also increases.

[1] The area where the active channel of a stream or river is prone to move, and the movement results in a potential near-term loss of riparian function and associated habitat adjacent to the stream.

Scientific Basis for the Temperature Protection Zone

Harvest activities adjacent to fish bearing streams can increase summer stream temperatures through reduction of shade that results in increased solar radiation reaching the water's surface. This can also occur on small, non-fish bearing streams that flow into fish bearing streams, particularly in stream reaches immediately above fish bearing streams. Temperature increases, if not managed, can extend downstream into fish bearing waters and affect the covered fish species. To address potential effects to the covered species from harvest activities in the permit area, the width of RCAs have been designated based on fish presence, stream size and flow duration (perennial versus seasonal), and potential to deliver wood.

RCAs adjacent to small non-fish bearing perennial and seasonal streams will be narrower than RCAs adjacent to fish bearing and medium and large non-fish streams (see Chapter 4 *Conservation Actions* for full RCA description). Small perennial non-fish bearing streams will have RCAs that extend 120 feet (horizontal distance) from the aquatic zone for the first 500 feet upstream of the end of fish use to protect stream temperatures in water within that 500 feet, as well as allowing for some temperature recovery from upstream, as it flows from a small non-fish perennial stream into a fish bearing stream. Upstream of the 500-foot process protection zone, the buffer will be 35 feet (horizontal distance) from the aquatic zone (Table ; Figure).

Table 1. Minimum Riparian Conservation Area Widths (Horizontal Distance) for Small Perennial and Seasonal Type N Streams

	Within Process Protection Zone		Upstream of 500-foot Process Protection Zone
Stream Type	Temperature	Wood	
Perennial Small Type N	120	--	35
Potential debris flow track (Seasonal Type N) [a]	--	50	35
High energy (Seasonal Type N) [b]	--	50	35
Seasonal other (Type N)[c]	0[d]	0[d]	0[d]

Notes:

[a] Potential debris flow tracks: Reaches on seasonal Type N streams that have a high potential of delivering wood to a Type F stream by debris flow.

[b] High Energy: Reaches on seasonal Type N streams that have a high potential of delivering wood and sediment to a Type F stream during a high-flow event.

[c] Seasonal: A stream that does not have surface flow after July 15.

[d] Seasonal other (Type N) streams will have a 35' equipment restriction zone.

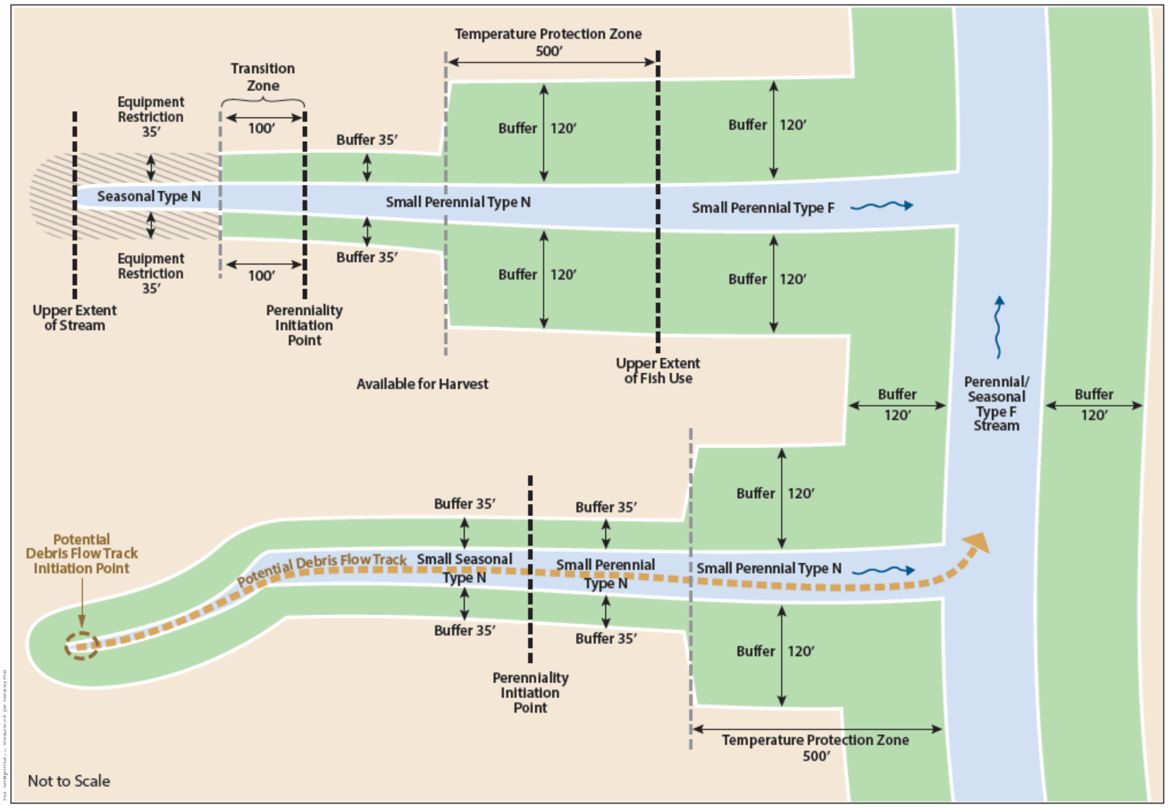


Figure 1. Riparian Conservation Areas Scenarios with Temperature Protection Zones

The 120-foot RCA (horizontal distance) within the 500-foot temperature zone at the intersection of fish and small perennial non-fish streams will help ameliorate stream temperature increases. The temperature protection zone was identified based on a literature review process with the Western Oregon State Forest HCP Scoping Team[2]. A list of sources reviewed by the Scoping Team to assess how forestry activities and riparian management strategies affect downstream temperatures and identify the proposed temperature protection zone is provided in Attachment 1 and summarized below.

Julie Firman (ODFW) performed a literature review (Figure 2) and assessment (Figure 3) of heating related to buffer width, and Blandon et al. (2018) performed a similar analysis for buffer length (Figure 4). In addition, Leinenbach (2016) Bayesian model of stream temperature response to buffering was reviewed (Figure 5). The results of these analysis and the studies discussed below indicate that while a 120-foot wide by 500-foot long temperature protection zone buffer will not entirely dissipate accumulated heat from the harvested area, it will allow stream temperatures to return to near the pre-harvest temperature regime prior to reaching a fish bearing stream.

Effects of rising temperature on the listed species could include physiological stress and reduced growth, disruption of life cycle timing, and increased predation and disease that would potentially reduce survival and

[2] The Scoping Team is comprised of representatives from: Oregon Department of Forestry, Oregon Department of State Lands, Oregon Department of Environmental Quality, Oregon Department of Fish and Wildlife, U.S. Fish and Wildlife Service, and National Marine Fisheries Service.

reproductive success (NMFS 2016). During the summer months, many of the streams coho salmon juveniles inhabit are already close to lethal temperatures, and with the expectation of rising stream temperatures due to global climate change, increases in infection rates of juvenile coho salmon by parasites may become an increasingly important stressor both for freshwater and marine survival (NMFS 2016).

Lestelle (2007) summarized several studies on effects of water temperature on juvenile coho salmon. For example, a study in the Mattole River (Northern California) reported coho were not found in streams that exceeded a maximum weekly temperature[3] of 18°C (Welsh et al. 2001 in Lestelle 2007). Another study in the Sixes River (Southern Oregon) reported juvenile coho salmon to be absent or rare in stream segments where temperatures exceeded 21°C (Frissell 1992 in Lestelle 2007). Overall, it is recommended that water temperatures not exceed 20-21°C to avoid lethality to coho salmon (Richter and Kolmes 2005).

While the 500-foot by 120-foot temperature protection zone is not expected to totally offset the effects of harvest on stream temperature, it would result in substantial reduction of water temperature changes prior to entering fish bearing streams. Bladon et al. (2018) found that while maximum daily stream temperatures were elevated in small, non-fish bearing headwaters after harvest there was not measurable downstream warming related to upstream harvest activities.

Numerous upstream-downstream longitudinal studies examined temperature recovery downstream of single harvest units. Davis et al. (2015), in an analysis of sites from ODF's RipStream study, found that the temperature change 300m (984ft) downstream of harvest units on small and medium fish bearing streams was approximately 56% of the change at the harvest unit, on average (range of 1-82% of harvest unit change). However, this behavior was highly site-dependent (streams with lower gradients and/or greater surface area showed lower temperature change magnitudes at 300m). Arismendi and Groom (2018), in another RipStream analysis, also showed a tendency for downstream sites to converge towards the pre-harvest equilibrium, that the tendency generally strengthened with time, and post-harvest temperature regimes with wide buffers returned to behavior that was statistically similar to their pre-harvest characteristics while sites with narrow buffers often did not. Several other studies examining the extent of stream temperature recovery towards pre-harvest conditions downstream of harvest units show incomplete downstream mitigation of single harvest unit temperature increases that were due to narrow streams buffers (Keith et al. 1998: 0.5° of 5.0°C of the temperature increase remaining after 73m (240ft) and 0.5° of 6.0°C temperature increase remaining after 46m (151ft); MacDonald et al. 1998: 2° of 3.0°C increase remaining after 500m (1640ft); Rutherford et al. 2004: 0.77 to 7.18°C increase reduced by 0.35 to 2.51°C, over distances of 153 to 892m (502 to 2,926ft); Wilkerson et al. 2006 (unbuffered streams): 1.8° of 2.8°C of increase remaining and 1.3° of 2.5°C increase remaining after 100m (328ft); and Zwieniecki and Newton 1999: study mean across sites was 0.4° of 1.09°C increase remaining after 150m (492ft).

Unlike the small non-fish bearing streams observed by Bladon et al. 2018, some of the above studies were primarily on fish bearing streams. Non-fish bearing headwater streams often have very high groundwater inputs, low flow volumes relative to fish bearing streams, and substantial post-harvest flow increases so heat loss and dilution may be a greater factor in return to equilibrium than in fish bearing streams (e.g. Moore et al. 2003, Story et al. 2003, Kibler et al. 2013). Heated water from harvested sites around non-fish bearing headwaters can rapidly decrease in temperature and move towards pre-harvest equilibrium upon flowing through fully forested stream reaches in the absence of subsequent harvest units, depending on site conditions such as gradient and cold water inputs. With other harvest units present, measureable cumulative

[3] Seven-day maximum temperature

heating is probable unless harvest site BMPs prevent substantial riparian shade loss. Cole and Newton (2013) showed cumulative temperature increases through multiple harvest units with private forest-type buffers (0 to 50 feet), even when separated by uncut reaches, on 3 of 4 study streams. The 120ft wide buffers in the temperature protection zone will likely prevent additional harvest related heating through this reach.

While temperature recovery may not be total through the 500ft temperature protection zone, the relative total flow contribution of non-fish streams in a harvest unit to the receiving fish bearing stream is critical. For example, a temperature increase of 0.5°C in a non-fish stream will be undetectable (≤0.2°C) if it provides 40% or less of the total fish-bearing stream's flow, while an increase of 1.5°C must comprise no more than 13% of the total combined flow. Figure 3 shows an average increase of 1°C for a 35ft buffer, which falls within the range of responses in the longitudinal studies described above. With attenuation to 0.75°C at 500ft (see figure 3 in Davis et al. 2015), temperature increases may be undetectable if the non-fish streams' contributions in a particular harvest area are no more than 27% of the combined total flow of the receiving fish bearing stream. Using Figure 4 derived from Bladon et al (2018), that non-fish stream contribution could be as high as 67%. Considering the range of temperature recovery responses in the literature, the semi-conservative nature of heat pollution, and the dependence on site-specific characteristics, the 500 foot temperature protection zone provides a reasonable degree of certainty that measureable temperature impacts to fish bearing reaches will be avoided.

Buffer width (m)	Buffer width (ft)	Heating C	Location	Reference
0	0	6.1	HJ Andrews	Johnson and Jones 2000
0	0	5.5	Alsea	Harris 1977
0	0	5	BC coastal mtns	Moore et al. 2005
0	0	4	Newfoundland	Curry et al. 2002
0	0	3.9	BC coastal mtns	Feller 1981
0	0	3.6	Maine	Wilkerson et al. 2006
0	0	3	Bull Run	Harr and Fredriksen 1988
0	0	2.9	Maine	Wilkerson et al. 2006
0	0	2.5	Vancouver Island	Holtby and Newcombe 1982
0	0	2.5	SW BC	Kiffney et al. 2003
0	0	2	Alsea	Harris 1977 (patches)
0	0	1.5	W. WA	Janisch et al. 2012
8	26	0.3	Trask	Bladon et al. 2018
8	26	0.5	Trask	Bladon et al. 2018
10	33	0.6	W. WA	Janisch et al. 2012
10	33	1.1	W. WA	Janisch et al. 2012
10	33	3	WA coast range	Jackson et al. 2001
10	33	2.4	WA coast range	Jackson et al. 2001
10	33	2.4	WA coast range	Jackson et al. 2001
10	33	1	BC coastal mtns	Gomi et al. 2006
11	36	1.2	Maine	Wilkerson et al. 2006
11	36	0.4	Trask	Bladon et al. 2018
12	39	0.6	Trask	Bladon et al. 2018
15	49	0	Alsea	Bladon et al. 2016
15	49	0.3	Alsea	Bladon et al. 2018
15	49	0.7	W. OR	Groom et al 2011
17	56	0.4	Trask	Bladon et al. 2018
18	60	0.6	N. Umpqua	ODEQ for science team review 2008
20	66	1	Newfoundland	Curry et al. 2002
23	75	0	Maine	Wilkerson et al. 2006
30	98	0	Deschutes	Reiter
30	98	0.5	N. Umpqua	ODEQ for science team review 2008
30	98	0.1	BC coastal mtns	Gomi et al. 2006
46	150	0.03	N. Umpqua	ODEQ for science team review 2008
50	164	0	W. OR	Groom et al 2011

Figure 2. Sources Reviewed for Heating Related to Buffer

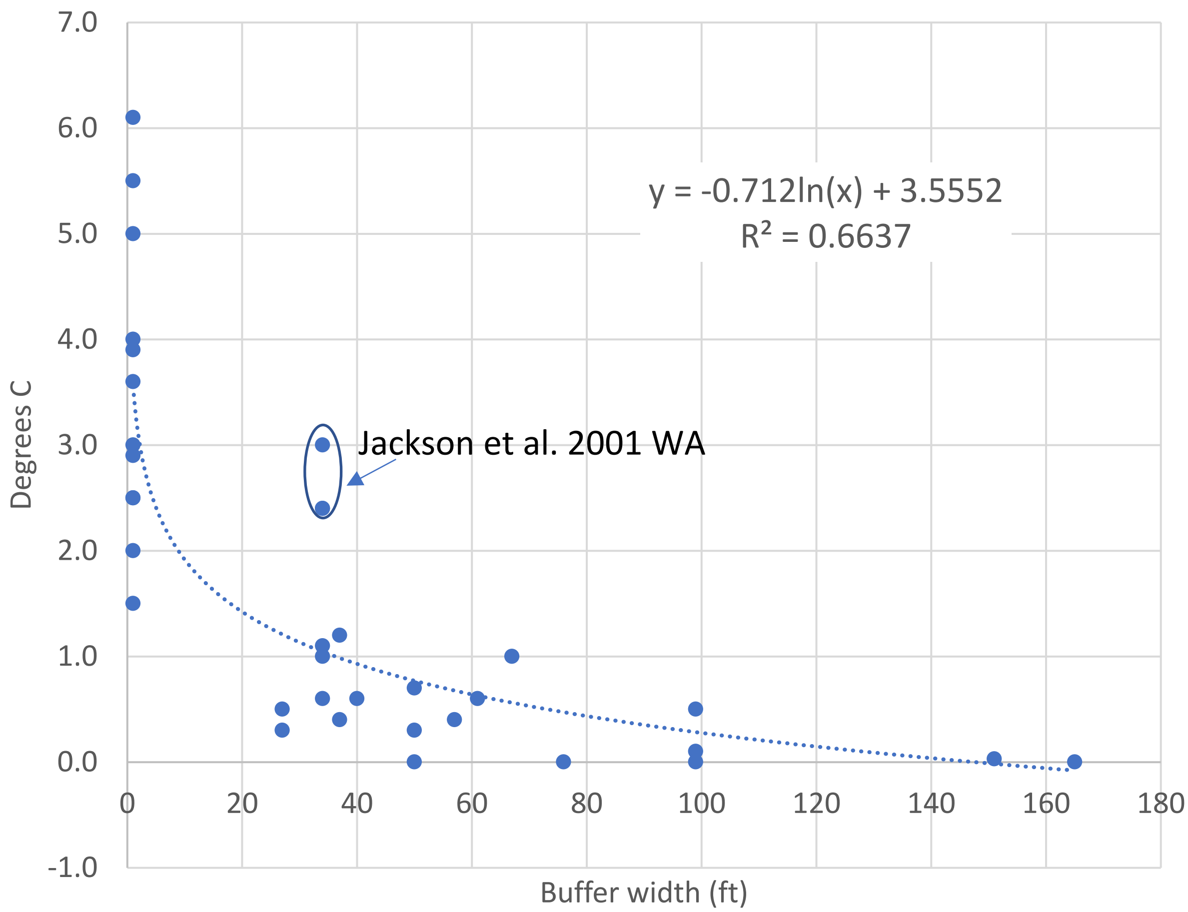


Figure 3. Heating Related to Buffer Width

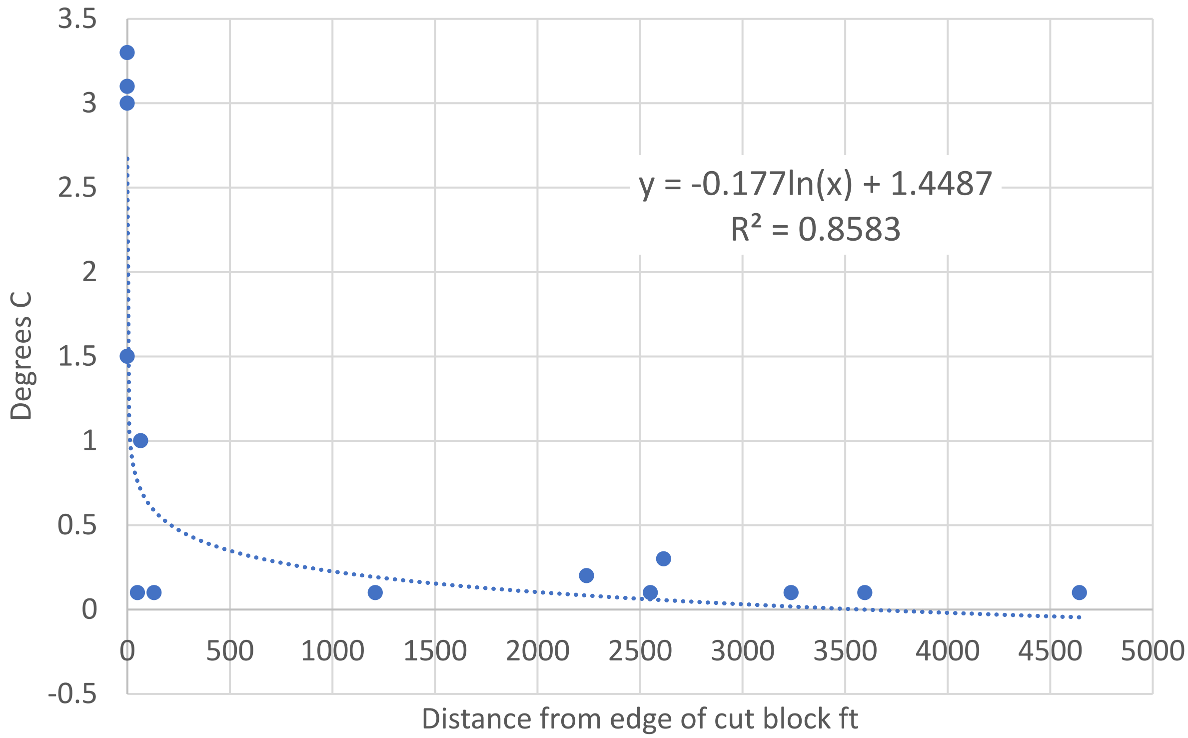


Figure 4. Temperature Exceedance or Elevation Changes as Water Moves Downstream from a Harvested Area (Bladon et al. 2018)

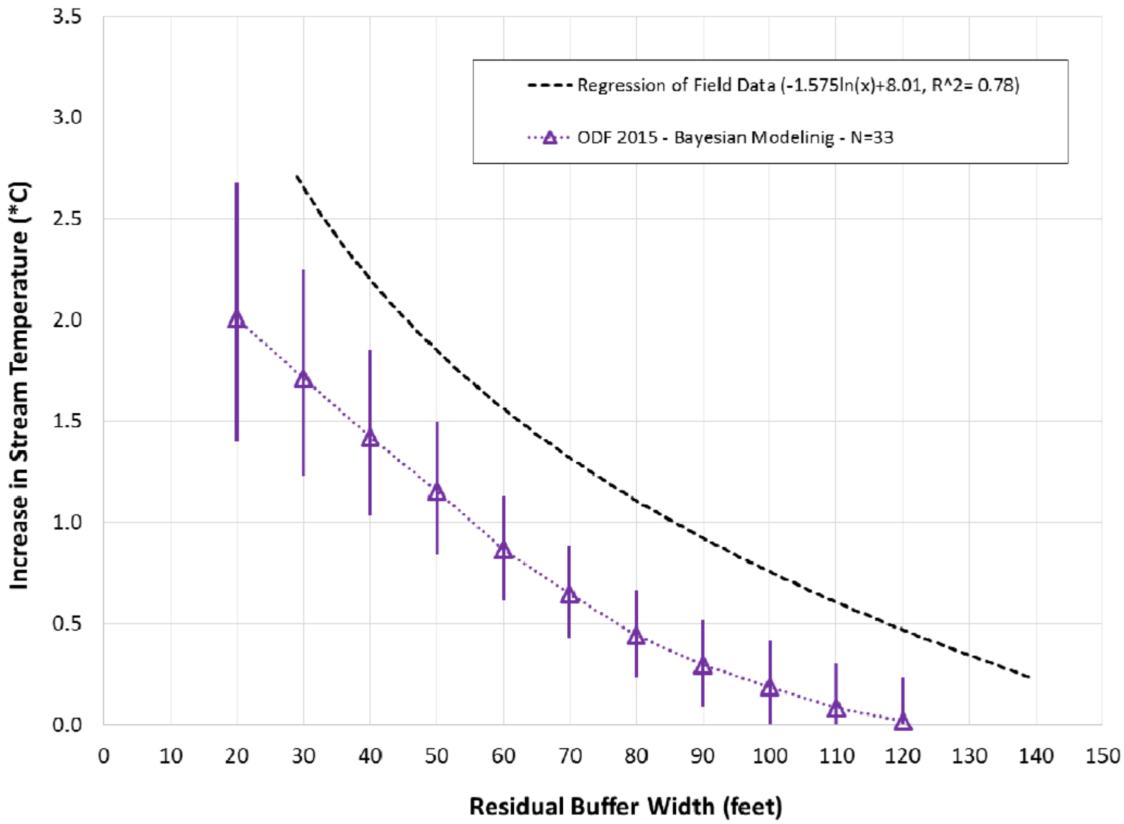


Figure 5. Modeled mean stream temperature response associated with "no-cut" riparian buffers with adjacent clearcut harvest (Leinenbach 2016)

Attachment 1 – References

Arismendi, I., & J.D. Groom. 2019. A novel approach for examining downstream thermal responses of streams to contemporary forestry. Science of the Total Environment 651: 736-748.

Beschta, R. L., & Taylor, R. L. 1988. Stream temperature increases and land-use in a forested Oregon watershed. Water Resources Bulletin, 24, 19‐25.

Bladon, K. D., N.A. Cook., J.T. Light., and C. Segura. 2016. A catchment-scale assessment of stream temperature response to contemporary forest harvesting in the Oregon Coast Range. Forest Ecology & Management, 379, 153‐164.

Bladon, K.D., C. Segura, N. Cook, S. Bywater-Reyes, and M. Reiter. 2018. A multicatchment analysis of headwater and downstream temperature effects from contemporary forest harvesting. Hydrological Processes 32(2): 293-304.

Cole, E, and M Newton. 2013. Influence of streamside buffers on stream temperature response following clear-cut harvesting in western Oregon. *Canadian Journal of Forest Research* **43:** 993-1005.

Curry, R.A., D. A. Scruton, and K. SD. Clarke. 2002. The thermal regimes of brook trout incubation habitats and evidence of changes during forestry operations. Canadian Journal of Forest Research 32: 1200–1207.

Davis, L.J., Reiter, M., and J. D. Groom. 2015. Modelling temperature change downstream of forest harvest using Newton's law of cooling. Hydrological Processes 30: 959-971.

Drake, D., J. Hagar, C. Jordan, G. Lettman, C. Sheridan, T. Spies, and F. Swanson. 2008. Western Oregon Plan Revision Draft Environmental Impact Statement: Science Team Review. March 3. 98 pp. Access at: https://www.blm.gov/or/plans/wopr/files/Science_Team_Review_DEIS.pdf

EPA (United States Environmental Protection Agency). 2013. Potential Modeling Approach to Evaluate the Effects of Thinning Activities on Stream Shade. EPA Comment to BLM 11/19/2013. Portland, OR.

Gomi, T., R.D. Moore, and A.S. Dhakal. 2006. Headwater stream temperature response to clear-cut harvesting with different riparian treatments, coastal British Columbia, Canada. Water Resources Research, 42, W08437.

Groom, J. D., L. Dent, L.J. Madsen., and J. Fleuret. 2011. Response of western Oregon (USA) stream temperatures to contemporary forest management. Forest Ecology and Management, 262, 1618‐1629.

Groom, J.D., S.L. Johnson, J.D. Seeds, G.G. Ice. 2017. Evaluating links between forest harvest and stream temperature threshold exceedances: The value of spatial and temporal data. Journal of the American Water Resources Association. August 761-773.

Jackson, C.R., C.A. Sturm, and J.M. Ward. 2001. Timber harvest impacts on small headwater stream channels in the Coast Ranges of Washington. Journal of the American Water Resources Association 37(6):1533–1549.

Janisch, J. E., S. M. Wondzell, and W. J. Ehinger. 2012. Headwater stream temperature: Interpreting response after logging, with and without riparian buffers, Washington, USA. Forest Ecology and Management, 270, 302-313.

Johnson, S. L., and J. A. Jones. 2000. Stream temperature responses to forest harvest and debris flows in western Cascades, Oregon. Canadian Journal of Fisheries and Aquatic Sciences 57:30-39.

Keith, R.M., T.C. Bjornn, W.R. Meehan, N.J. Hetrick, and M.A. Brusven. 1998. Response of juvenile salmonids to riparian and instream cover modifications in small streams flowing through second-growth forest of southeast Alaska. *Transactions of the American Fisheries Society* **127:** 889-907.

Kibler, K.M., A. Skaugset, L.M. Ganio, and M.M. Huso. Effect of contemporary forest harvesting practices on headwater stream temperatures: Initial response of the Hinkle Creek catchment, Pacific Northwest, USA. Forest Ecology and Management 310: 680-691.Kiffney, P.M., J.S. Richardson, and J.P. Bull. 2003. Responses of Periphyton and Insects to Experimental Manipulation of Riparian Buffer Width Along Forest Streams. Journal of Applied Ecology 40 (6): 1060–76.

Leinebach, P., G. McFadden, and C. Torgersen. 2013. Effects of Riparian Management Strategies on Stream Temperature. Science Review Team Temperature Subgroup. January 17.

Leinenbach, Peter. 2016. Review of literature describing the relationship between stream shade loss and the subsequent stream temperature increase. Memorandum to Terasa Kubo, USEPA. January 12, 2016. 6 p.

Macdonald, J.S., J.C. Scrivener, D.A. Patterson, and A. Dixon-Warren. 1998. Temperatures in aquatic habitats: the impacts of forest harvesting and the biological consequences to sockeye salmon incubation habitats in the interior of B.C. *In* M.K. Brewing and D.M.A. Monita (eds.) Forest-Fish Conference: Land Management Practices Affecting Aquatic Ecosystems. Natural Resources Canada, Canadian Forest Service Information Report NOR-X-356: 313-324.

Moore, R.D., J.S. Macdonald, H. Herunter. 2003. Downstream thermal recovery of headwater streams below cutblocks and logging roads. *In* E.A. MacIsaac (*ed.*) Forestry Impacts on Fish Habitat in the Northern Interior of British Columbia: A Compendium of Research from the Stuart-Takla Fish-Forestry Interaction Study. *Canadian Technical Report of Fisheries and Aquatic Sciences* **2509:** 179-189.

Moore, R.D., D.L. Spittlehouse, and A. Story. 2005. Riparian Microclimate and Stream Temperature Response to Forest Harvesting: A Review. Journal of the American Water Resources Association. 41(4):813-834.

Poole, G. C., J. Risley, and M. Hicks. 2001. Spatial and temporal patterns of stream temperature. Issue Paper 3, EPA Region 10 Temperature Water Quality Criteria Guidance Development Project, U.S. Environmental Protection Agency, Portland, Oregon.

Reiter, M., R.E. Bilby, and J. Heffner. 2015. Stream temperature patterns over 35 years in a managed forest of western Washington. Journal of the American Water Resources Association, 51, 1418‐1435.

Rutherford, J.C., N.A. Marsh, P.M. Davies, and S.E. Bunn. 2004. Effects of patchy shade on stream water temperature: how quickly do small streams heat and cool? *Marine and Freshwater Research* **55:** 737-748.

Story, A., R.D. Moore, and J.S. Macdonald. 2003. Stream temperatures in two shaded reaches below cutblocks and logging roads: Downstream cooling linked to subsurface hydrology. Canadian Journal of Forest Research, 33, 1383‐1396.

Wilkerson, E., J.M. Hagan, D. Siegel, and A.A. Whitman. 2006. The effectiveness of different buffer widths for protecting headwater stream temperature in Maine. *Forest Science* **52:** 221-231.

Zwieniecki, M.A. and M. Newton. 1999. Influence of streamside cover and stream features on temperature trends in forested streams of Western Oregon. *Western Journal of Applied Forestry* **14:** 106-113.

Frequency Tables

Aquatic Frequency Table

	Activity		Frequency												Notes
			Frequently[1]			Infrequently[2]			Rarely[3]			Not Expected to Occur			
			All RCAs	35' ERZ Perennial	35 ' ERZ Seasonal	All RCAs	35' ERZ Perennial	35 ' ERZ Seasonal	All RCAs	35' ERZ Perennial	35 ' ERZ Seasonal	All RCAs	35' ERZ Perennial	35 ' ERZ Seasonal	
Timber Harvest Methods	Cable Corridors		X	X	X										
	Skid Roads					X		X					X		
	Climb/Top Trees for a Tailhold					X		X					X		
	Guylines					X	X	X							
	Using Equipment as Mobile Anchors								X		X		X		Won't apply in most circumstances, but could happen.
	Hazard and Downed Tree Removal - Individual Trees								X	X	X				Within 100' of open roads, campgrounds and other publicly accessed infrastructure, or >100' where such infrastructure is threatened.
	Yarding Slash		X		X								X		
	Burn Slash										X	X	X		
Timber Harvest Types	Regeneration Harvest	Clear Cut			X							X	X		Removal of all trees, with the exception of green trees and snags
		Retention Cut			X							X	X		Removal of all trees, with additional retention of green trees (e.g. "shelterwood")
	Partial Cut Harvest	Heavy Thinning			X							X	X		A portion of trees across diameter ranges are harvested to promote continued stand growth and health
		Moderate Thinning			X							X	X		A portion of trees across diameter ranges are harvested to promote continued stand growth and health
		Light Thinning			X							X	X		A portion of trees across diameter ranges are harvested to promote continued stand growth and health
Reforestation and Young Stand Management	Site Preparation	Mechanical			X							X	X		Mechanical piling of slash to the extent of equipment reach from outside ERZ
		Prescribed Burning									X	X	X		Limitations of equipment reach for piling will make burning less frequent in ERZ, compared to the rest of the harvest unit
	Tree Planting	Initial Planting			X							X	X		Assuming that initial planting will occur frequently in ERZ, as a result of harvest activities, and not in RCA, due to lack of harvest.
		Interplanting							X	X	X				Occurs when stocking levels fall below Forest Practice Act minimums, or when adding a new tree component into an RCA (such as during a restoration activity).
	Release Treatments	Manual	X	X	X										
		Invasive Species Treatment	X	X	X										Manual and Herbicide
	Animal Damage Control			X	X	X									
	Precommercial Thinning and Pruning					X							X	X	Thinning dense, young forest trees by mechanical means, including felling individual trees or mechanically sawing or chipping rows or groups of trees
	Hazard Mitigation									X	X	X			Generally occurs in response to natural disturbance effects that have affected forest health (i.e. larger events than individual tree fall on roads, or other hazard situations). Selected hazard trees are felled and left within the RCA, where feasible.
	Livestock Grazing									X	X	X			Grazing activity has been insignificant on state forests in both northwest and southwest Oregon and is expected to remain so. ODF would not issue new permits under the HCP.

Aquatic Frequency Table

	Activity		Frequency												Notes
			Frequently[1]			Infrequently[2]			Rarely[3]			Not Expected to Occur			
			All RCAs	35' ERZ Perennial	35 ' ERZ Seasonal	All RCAs	35' ERZ Perennial	35 ' ERZ Seasonal	All RCAs	35' ERZ Perennial	35 ' ERZ Seasonal	All RCAs	35' ERZ Perennial	35 ' ERZ Seasonal	
Road System Management Activities	New Road Construction	With Type F stream crossings				X	X	X							"Includes Bridge Installation and landings; Routinely build spur roads and install culvert crossings on small type N streams both seasonal and perennial "
		Non-Type F stream crossings				X	X	X							
	Road Use	During Timber Harvest	X	X	X										
		Post Harvest	X	X	X										
	Road Maintenance and Improvement	With stream crossings	X	X	X										Bridge Replacement, Culvert Replacement, Road Widening
		No stream crossings	X		X		X								Haul Routes/Existing Roads (grading and rocking)
	Road Vacating					X	X	X							Some roads, including legacy roads, may need to be vacated due to their proximity to a fish-bearing stream, high erosion potential, or landslide hazards that could affect the covered species, and because these issues cannot be addressed with road improvement activities.
	Drainage Structure Construction and Maintenance	Temporary Perennial Stream Crossing				X	X								Short-term crossings that are used for harvest activities and removed after
		Temporary Seasonal Stream Crossing			X										
		Permanent Type N Stream Crossing	X	X											Long-term crossings, using bridges and culverts, that will remain on the landscape post-harvest and be utilized by other forest users.
		Permanent Type F Stream Crossing				X	X								
	Landing Construction and Maintenance											X	X	X	
	Water Drafting and Storage	North Cascades	X	X	X										Mostly from fire ponds wherever possible but occasionally from streams as well, primarily small/med non fish. Rarely med fish
		Astoria	X	X	X										Mostly ponds and non-fish streams, but also at bridge crossings of some large/med fish streams that provide access to draft
		Forest Grove				X	X	X							Only for road processing, spray projects and recreation purposes
		Western Oregon				X	X	X							Mostly small non fish with catchment basins
		Western Lane							X	X	X				Drafting usually done by contractors off ODF ownership due to fragmented ownership pattern
Minor Forest-Product Harvest	Collection or harvest of special forest products (e.g., edible fungi, greenery) for commercial income or personal use		X	X	X										ODF issues permits for firewood collection, permit conditions will exclude collection within RCAs. With the exception of opening existing roads within RCAs.

Aquatic Frequency Table

		Frequency												
		Frequently[1]			Infrequently[2]			Rarely[3]			Not Expected to Occur			
	Activity	**All RCAs**	**35' ERZ Perennial**	**35 ' ERZ Seasonal**	**All RCAs**	**35' ERZ Perennial**	**35 ' ERZ Seasonal**	**All RCAs**	**35' ERZ Perennial**	**35 ' ERZ Seasonal**	**All RCAs**	**35' ERZ Perennial**	**35 ' ERZ Seasonal**	**Notes**
Quarries, Borrow Sites, and Stockpile Sites	Existing Rock Quarries						X	X	X					
	Rock Quarry Development										X	X	X	
	Existing Borrow Sites							X	X	X				
	Borrow Site Development							X	X	X				These would be developed in consultation with the aquatic specialist.
	Existing Stockpile Sites							X	X	X				
	Stockpile Site Development										X	X	X	
Fire Management	Controlled Burning						X	X				X		
	Fire Line Construction							X		X		X		
Recreation Infrastructure and Maintenance	New Trail Construction				X	X	X							
	Trail Maintenance and Improvement	X	X	X										ERZ activity would be primarily associated with stream crossings.
	Trail Vacating							X	X	X				
	Permanent Stream Crossings				X	X	X							Activity would be associated with new trail construction and replacement of existing trail bridges.
	Temporary Stream Crossings							X	X	X				
	Recreation Facility Construction							X	X	X				The only new facility development that would be allowed within an RCA would be a boat launch/boat ramp.
	Recreation Facility Improvement Campgrounds, trailheads, interpretive sites							X	X	X				Improving a component within the footprint of an existing recreation facility.
	Recreation Facility Maintenance Campgrounds, trailheads, interpretive sites	X				X	X							Maintenance of existing infrastructure
Conservation Strategy Implementation Activities	Aquatic Habitat Restoration: Instream Habitat Projects				X	X	X							
	Aquatic Habitat Restoration: Road Decommissioning							X	X	X				Would be done as a restoration action
	Research Activities				X	X	X							

[1] Frequently = Activity intersects RCAs multiple times annually, on every State Forests district. Amount of activity varies by district, dependent on habitat and forest health goals.

[2] Infrequently = Activity intersects RCAs a few times annually, but is generally not be present on every State Forests district, every year.

[3] Rarely = Activity intersects RCAs no more than once annually, for any given State Forests district.

Terrestrial Frequency Table

	Activity		Frequency in HCAs			Notes
			Frequently[1]	**Infrequently[2]**	**Rarely[3]**	
Timber Harvest Methods	Cable Corridors		X			
	Skid Roads		X			
	Climb/Top Trees for a Tailhold		X			
	Guylines		X			
	Using Equipment as Mobile Anchors		X			Won't apply in most circumstances, but could happen.
	Hazard and Downed Tree Removal - Indiviudal Trees		X			Within 100' of open roads, campgrounds and other publicly accessed infrastructure, or >100' where such infrastructure is threatened.
	Yarding and Burn Slash		X			
Timber Harvest Types	Regeneration Harvest	Clear Cut	X			Removal of all trees, with the exception of green trees and snags. Within HCA, must address forest health or vigor issue that is limiting natural habitat development
		Retention Cut	X			Removal of all trees, with additional retention of green trees (e.g. "shelterwood"). Within HCA, must address forest health or vigor issue that is limiting natural habitat development
	Partial Cut Harvest	Heavy Thinning	X			A portion of trees across diameter ranges are harvested to promote continued stand growth and health. Within HCA, must address forest health or vigor issue that is limiting natural habitat development
		Moderate Thinning	X			A portion of trees across diameter ranges are harvested to promote continued stand growth and health. Within HCA, must address forest health or vigor issue that is limiting natural habitat development
		Light Thinning	X			A portion of trees across diameter ranges are harvested to promote continued stand growth and health. Within HCA, must address forest health or vigor issue that is limiting natural habitat development

Terrestrial Frequency Table

	Activity		Frequency in HCAs			Notes
			Frequently[1]	Infrequently[2]	Rarely[3]	
Reforestation and Young Stand Management	Site Preparation	Mechanical	X			
		Prescribed Burning	X			
	Tree Planting	Initial Planting	X			
		Interplanting			X	Occurs when stocking levels fall below Forest Practice Act minimums
	Release Treatments	Manual	X			
		Invasive Species Treatment	X			Manual and Herbicide
	Animal Damage Control		X			Control or removal of wildlife from an area to minimize damage to tree seedlings planted after harvest.
	Precommercial Thinning and Pruning		X			Thinning dense, young forest trees by mechanical means, including felling individual trees or mechanically sawing or chipping rows or groups of trees
	Salvage			X		Generally occurs in response to natural disturbance effects that have affected forest health (i.e. larger events than individual tree fall on roads, or other hazard situations)
	Unmanned Aircraft Systems			X		Assuming this will become a more frequently used tool, including for certain types of wildlife monitoring
	Livestock Grazing				X	Grazing activity has been insignificant on state forests in both northwest and southwest Oregon and is expected to remain so

Terrestrial Frequency Table

	Activity		Frequency in HCAs			Notes
			Frequently[1]	Infrequently[2]	Rarely[3]	
Road System Management Activities	Road Construction		X			Includes Bridge Installation and landings; Routinely build spur roads and install culvert crossings on small type N streams both seasonal and perennial
	Road Use	During Timber Harvest	X			
		Post Harvest	X			
	Road Maintenance and Improvement		X			Bridge Replacement, Culvert Replacement, Road Widening
	Road Vacating			X		Some roads, including legacy roads, may need to be vacated due to their proximity to a fish-bearing stream, high erosion potential, or landslide hazards that could affect the covered species, and because these issues cannot be addressed with road improvement activities.
	Landing Construction and Maintenance		X			
Minor Forest-Product Harvest	Collection or harvest of special forest products (e.g., edible fungi, greenery) for commercial income or personal use		X			ODF issues permits for firewood collection, permit conditions in HCAs will limit collection to areas with slash on landings that result from management within HCAs and existing roads in HCAs that have downed wood.
Quarries, Borrow Sites, and Stockpile Sites	Existing Rock Quarries			X		
	Rock Quarry Development				X	
	Existing Borrow Sites			X		
	Borrow Site Development				X	
	Existing Stockpile Sites			X		
	Stockpile Site Development				X	
Fire Management	Controlled Burning			X		
	Fire Line Construction				X	

Terrestrial Frequency Table

<table>
<tr><th rowspan="2"></th><th rowspan="2" colspan="2">Activity</th><th colspan="3">Frequency in HCAs</th><th rowspan="2">Notes</th></tr>
<tr><th>Frequently[1]</th><th>Infrequently[2]</th><th>Rarely[3]</th></tr>
<tr><td rowspan="6">Recreation Infrastructure and Maintenance</td><td colspan="2">New Trail Construction</td><td>X</td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Trail Maintenance and Improvement</td><td>X</td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Trail Vacating</td><td></td><td></td><td>X</td><td>ODF designated trails only</td></tr>
<tr><td colspan="2">Recreation Facility Construction</td><td></td><td></td><td>X</td><td></td></tr>
<tr><td colspan="2">Recreation Facility Improvement Campgrounds, trailheads, interpretive sites</td><td></td><td>X</td><td></td><td></td></tr>
<tr><td colspan="2">Recreation Facility Maintenance Campgrounds, trailheads, interpretive sites</td><td>X</td><td></td><td></td><td></td></tr>
<tr><td rowspan="4">Conservation Strategy Implementation Activities</td><td rowspan="2">HCA Enhancement/ Development</td><td>Stand Development</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Tree Planting</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Barred Owl Management</td><td>X</td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Research Activities</td><td>X</td><td></td><td></td><td></td></tr>
</table>

[1] Frequently = Activity intersects HCAs multiple times annually, on every State Forests district. Amount of activity varies by district, dependant on habitat and forest health goals.

[2] Infrequently = Activity intersects HCAs a few times annually, but is generally not be present on every State Forests district, every year.

[3] Rarely = Activity intersects HCAs no more than once annually, for any given State Forests district.

Terrestrial Modeling Information

Terrestrial Modeling Information

The following four tables describe the modeling parameters and rationales used to identify, classify, map, and quantify acres of habitat for the four terrestrial species covered in the HCP. ODF developed and applied the models used in consultation with the U.S. Fish and Wildlife Service, and the models are considered to be the best available science on determining habitat quantity and quality within the permit area for each species. Key references used to develop model rationale are presented under each table.

As described in Chapter 5, projected effects on covered terrestrial species over the permit term was quantified based on the expected loss, modification, and future growth of habitat, as determined by applying habitat models to the outcomes of forest management activity modeling. A modeled, habitat-based approach is a common practice of the USFWS in the development of HCPs, and a similar approach was used for the Washington State Department of Natural Resources in its recent amendment to its HCP that addressed a long-term conservation strategy for marbled murrelets (USFWS 2019).

While model outputs may represent the best available science, they do not represent precise predictions. Habitat estimates are based on many modeling assumptions and some variation is to be expected. The habitat commitments in the biological goals and objectives of this HCP are derived from these outputs, taking into account uncertainty associated with habitat models, growth and yield projections, and forest activity modeling.

References

USFWS (U.S. Fish and Wildlife Service). 2019. Washington State Department of Natural Resources Marbled Murrelet Long-term Conservation Strategy Amendment to the 1997 Habitat Conservation Plan. Endangered Species Act - Section 7 Consultation. Biological Opinion. Reference: 0IEWFW00-2019-F-1650. x-reference: 1-3-96-FW-594. U.S. Fish and Wildlife Service Washington Fish and Wildlife Office. Lacey, Washington.

Table 1. Model parameters and rationales for the Oregon slender salamander habitat suitability and distribution model.

Habitat Parameter	Stand Level Inventory Variable	Weight	Habitat Suitability Probability Assignments	Rationale
Downed Wood	Large Downed Wood	0.4	2500 ft^3 per acre = 0.8 2000 ft^3 per acre = 0.6 400 ft^3 per acre = 0.4 200 ft^3 per acre = 0.2	Large downed wood is included in the Oregon slender salamander habitat suitability model to identify stands with greater amounts of large downed wood. Large downed wood quantifies the volume of downed logs per acre >24" diameter at the large end in all decay classes (1-4). ODF considers stands with more than 600 – 900 ft^3 downed wood cubic feet per acre to be characteristics of late seral forests, so this range of values or more is considered to be highly suitable for Oregon slender salamander.
Forest height	Top Height	0.3	141 feet = 0.8 118 feet = 0.6 84 feet = 0.4 37 feet = 0.2	Oregon slender salamander occur in late seral forests with tall trees, generally > 20-25 meters (66-82 feet) in height (Suzuki 2009). Tall trees provide a source of future large, downed wood. Top height was used to identify stands with tall trees. The same habitat suitability probabilities for top height in the northern spotted owl model are used for Oregon slender salamander, as both species occur in late-seral forests. Forest top height ≥ 140 feet was considered to be highly suitable, as forests with top height greater than 140 feet in the Santiam State Forest tend to exhibit late seral stage structural characteristics. Stands with top height lower than 85 feet tend to exhibit mid-seral stage structural characteristics, and likely have lower amounts of large, decayed downed wood than stands with considerably taller top height.
Seral Stage	Stand Density Index (SDI)	0.3	300 = 0.67 150 = 0.33	SDI was used to identify stands with late-seral stage structural characteristics such as natural mortality of larger trees and loss of understory. SDI measures the degree of crowding or stocking in a stand and is a function of the number of trees per acre and DBH. ODF considers stands with an SDI > 300 to be characteristic of late seral forest.

References

Clayton, D.R.; Olson, D.H. 2007. Conservation assessment for the Oregon Slender Salamander (*Batrachoseps wright*i). Version 1.0. USDA Forest Service, Region 6, and Oregon BLM, Special Status Species Program. http://www.fs.fed.us/ r6/sfpnw/issssp/documents/planning-docs/ca-habawr-2007-05-17.doc.

Garcia, T.S., J. Johnson, J. Jones, and A.J. Kroll. 2020. Experimental Evidence Indicates Variable Responses to Forest Disturbance and Thermal Refugia by Two Plethodontid Salamanders. Forest Ecology and Management 464.

Suzuki, Nobuya and Deanna Olson. 2012. Validation of the Oregon slender salamander habitat suitability model and map for the west slope of the Oregon Cascade Range. Pacific Northwest Research Station, Corvallis, OR. https://www.fs.fed.us/r6/sfpnw/issssp/documents3/inv-rpt-ha-bawr-habitat-model-validation-20120726.pdf

Table 2. Model parameters and rationales for the northern spotted owl habitat suitability and distribution model for nesting and roosting habitat.

Habitat Parameter	Stand Level Inventory Variable	Weight	Habitat Suitability Probability Assignments	Rationale
Seral stage	Stand Age	0.15	170 years old = 0.8 118 years old = 0.6 80 years old = 0.4 60 years old = 0.2	Northern spotted owl relies on older forested habitats for nesting, foraging, and roosting (e.g., U.S. Fish and Wildlife Service 2012, Davis et al. 2016). In the Oregon Coast Range, average (and standard deviation [SD]) stand age for the nesting and roosting habitat classes in the Davis et al. (2016) model is: • Highly suitable: 159 years old (56) • Suitable: 118 years old (61) • Marginal: 60 years old (22) • Unsuitable: 29 years old (20) This HCP model assumes that habitat suitability increases with stand age, with approximately 159-year-old stands having highly suitable late seral structural features. (The suitability threshold for 0.8 was set at 170 years old to result in an Excel Solver value of approximately 0.8 for 159-year-old stands.) The model also assumes that stands as young as 60 years old can support nesting and roosting northern spotted owls, assuming suitable remnant nest trees are present, but that younger forests provide only marginally suitable habitat for nesting and roosting. Stands between 29 and 60 years old are unsuitable for nesting and roosting but may provide foraging habitat and stands less than 29 years old may provide dispersal habitat.

Habitat Parameter	Stand Level Inventory Variable	Weight	Habitat Suitability Probability Assignments	Rationale
Structural Diversity	Diameter Diversity Index (DDI)	0.15	7 DDI = 0.8 6 DDI = 0.6 5 DDI = 0.4 2 DDI = 0.2	A structurally diverse, multi-canopy forest with large trees is an important component of late seral conifer forests used by northern spotted owl for nesting and roosting (U.S. Fish and Wildlife Service 2012). DDI provides a quantitative index of canopy layering. DDI describes the relative similarity of a given stand to an old growth stand in terms of the number of trees per acre in each of 4 diameter classes. Stands can range from a DDI of almost 0 up to a maximum of 10, with 0 represent the least layering and 10 representing the most laying. Stands with older forest structure have DDI ranging from 6.5 to 10. In the Oregon Coast Range, average (and standard deviation [SD]) DDI for the nesting and roosting habitat classes in the Davis et al. (2016) model is: • Highly suitable: 7 (1) • Suitable: 6 (1) • Marginal: 5 (1) • Unsuitable: 1 (2)
Large Trees	Trees per acre 30”+ DBH	0.4	18 large trees per acre = 0.8 10 large trees per acre = 0.6 2 large trees per acre = 0.4 0 large trees per acre = 0.2	Large trees are important components of structurally complex late seral conifer forests for nesting and roosting northern spotted owl (U.S. Fish and Wildlife Service 2012). In the Oregon Coast Range, average (and standard deviation [SD]) large conifer (≥ 30” DBH for the nesting and roosting habitat classes in the Davis et al. (2016) model is: • Highly suitable: 18 (8) • Suitable: 10 (7) • Marginal: 2 (3) • Unsuitable: 0 (1)

Habitat Parameter	Stand Level Inventory Variable	Weight	Habitat Suitability Probability Assignments	Rationale
Forest Height	Top Height	0.15	200 feet = 1.0 141 feet = 0.8 118 feet = 0.6 84 feet = 0.4 37 feet = 0.2	Northern spotted owl uses multilayered, multispecies canopies with large overstory trees (U.S. Fish and Wildlife Service 2012). In the Oregon Coast Range, average (and standard deviation [SD]) average stand height for the nesting and roosting habitat classes in the Davis et al. (2016) model is: • Highly suitable:141 (26) • Suitable: 118 (27) • Marginal: 84 (20) • Unsuitable: 37 (25) Top height was used to characterize stands average stand height. Top height of 200 feet was assigned a habitat suitability probability of 1.0 because ODF forests with top height 200 feet or greater provides highly suitable habitat for northern spotted owl.

References

Davis, R.J., B. Hollen, J. Hobson, J.E. Gower, and D. Keenum. 2016. Status and Trends of Northern Spotted Owl Habitats. Northwest Forest Plan. The First 20 Years (1994–2013). Pacific Northwest Research Station. General Technical Report. PNW-GTR-929. Portland, OR.

USFWS (U.S. Fish and Wildlife Service). 2012. Endangered and Threatened Wildlife and Plants; Designation of Critical Habitat for the Northern Spotted Owl. 50 CFR Part 17. Federal Register / Vol. 77, No. 233 / Tuesday, December 4, 2012.

USFWS (U.S. Fish and Wildlife Service). 2019. Washington State Department of Natural Resources Marbled Murrelet Long-term Conservation Strategy Amendment to the 1997 Habitat Conservation Plan. Endangered Species Act - Section 7 Consultation. Biological Opinion. Reference: 0IEWFW00-2019-F-1650. x-reference: 1-3-96-FW-594. U.S. Fish and Wildlife Service Washington Fish and Wildlife Office. Lacey, Washington.

Table 3. Model parameters and rationales for Marbled murrelet habitat suitability and distribution model. Habitat distribution and suitability was mapped 50 miles inland.

Habitat Parameter	Stand Level Inventory Variable	Weight	Habitat Suitability Probability Assignments	Rationale
Large Trees	Trees per acre 30”+ DBH	0.3	12 large trees per acre = 0.8 8 large trees per acre = 0.6 5 large trees per acre = 0.4 1 large trees per acre = 0.2	Marbled murrelet use tall, late-seral structured forest for nesting. Presence of nest platforms is considered the most important marbled murrelet nest characteristic (Raphael et al. 2018). ODF does not have data that captures presence of nest platforms. Stand Level Inventory data for number of large trees per acre (30”+ DBH) is used as an indicator of trees that may have suitable nest platforms, as large limbs with forked branches, deformities, and other platform characteristics are expected to develop on larger trees. Not all large trees will have suitable nest platforms, however (Evans Mack et al. 2003), though tree diameter and height can be positively correlated with the size and abundance of nest platforms (Raphael et al. 2018). Nest platforms are usually found on trees at least 19 inches in diameter at breast height and greater than 98 ft tall (Raphael et al. 2018) with nest trees in Oregon having a mean DBH of 56 inches (SD = 19) (Oregon Department of Forestry 2019). The mean of the covariate trees of DBH 100 cm (39.4 in) per hectare in the marbled murrelet 2012 habitat model was 12.7 (SD = 10.8) which is 5 large trees per acre. Five large trees per acre was assigned a 0.4 suitability probability based on this mean value (Falxa and Raphael 2016).

Habitat Parameter	Stand Level Inventory Variable	Weight	Habitat Suitability Probability Assignments	Rationale
Forest Height	Top Height	0.3	276 feet = 0.95 170 feet = 0.8 150 feet = 0.6 130 feet = 0.4 110 feet = 0.2 92 feet = 0.05	Maximum canopy height and stand height was found to be an important predictor of marbled murrelet occupancy in the Coos Bay BLM district and the Siuslaw National Forest (Hagar et al. 2018) and Oregon-wide (Falxa and Raphael 2016), respectively. Top height was used as an index for maximum stand height in the model. Top height represents the average height of the 40 largest trees per acre. Little data are available about the relationship between stand height and habitat suitability. In Oregon, mean nest tree height for 70 nests was 184 ft (SD = 46; range 108 – 279) (Oregon Department of Forestry 2019). The HCP uses expert opinion to extrapolate habitat suitability probability assignments based on data for mean nest tree height and mean stand height from Oregon Department of Forestry (2018). Stands with a top height of 92 feet or shorter and 276 feet are assumed to be unsuitable and very highly suitable, respectively. These values were selected because they are ± 2 SD from the mean nest tree height (Oregon Department of Forestry 2019).
Seral Stage	Stand Age	0.3	206 years old = 0.95 150 years old = 0.8 130 years old = 0.6 100 years old = 0.4 60 years old = 0.2	Marbled murrelet is typically associated with late-seral forests but may nest in young stands with suitable nesting substrates. Most nest in old-growth forests (>200 years old), but marbled murrelet also nest in mature to residual mature to old-growth forest (66 – 150 years old) (Nelson 1997, Oregon Department of Forestry 2019). Stands less than 60 years old are unsuitable for marbled murrelet nesting. Stands 206 years old are assumed to be very highly suitable in this HCP's model.

References

Evans Mack, D., W.P. Ritchie, S.K. Nelson, E. Kuo-Harrison, P. Harrison, and T.E. Hamer. 2003. Methods for Surveying Marbled Murrelets in Forests: A Revised Protocol for Land Management and Research. Pacific Seabird Group unpublished document. Available: http://www.pacificseabirdgroup.org.

Falxa, G.A., and M.G. Raphael. 2016. Status and Trend of Marbled Murrelet Populations and Nesting Habitat. Northwest Forest Plan. The First 20 Years (1994–2013). Pacific Northwest Research Station. General Technical Report. PNW-GTR-929. Portland, OR.

Oregon Department of Forestry. 2019. Marbled Murrelet Technical Report Final. April 24, 2019. Report developed by Jennifer Weikel, Wildlife Biologist Private Forest Program, Oregon Department of Forestry. Salem, OR.

Raphael, M.G., G.A. Falxa, and A.E. Burger. 2018. Marbled Murrelet. Chapter 5 in T.A. Spies, P.A. Stine, R. Gravenmier, J.W. Long, and J.W. Reilly (eds.), Synthesis of Science to Inform Land Management in the Northwest Forest Permit Area. General Technical Report PNW-GTR-966. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Table 4. Model parameters and rationales for red tree vole habitat suitability and distribution model.

Habitat Parameter	Stand Level Inventory Variable	Weight	Habitat Suitability Probability Assignments	Rationale
Seral Stage	Stand Age	0.25	95 years old = 0.8 92 years old = 0.6 75 years old = 0.4 60 years old = 0.2	Red tree vole is associated with structurally complex late seral conifer or mixed conifer-hardwood forests (Dunk and Hawley 2009, U.S. Fish and Wildlife Service 2011, Forsman et al. 2016, Rosenberg et al. 2016, Linnell et al. 2017, Johnston and Moskal 2017). Abundance is higher in forests > 80 years old (Price et al. 2015) and models have found that old forest (i.e., > 80 years old) is an important predictor of red tree vole presence (Rosenberg et al. 2016, Linnell et al. 2017). Suitability categories are based on mean forest stand characteristics based on forest inventory plot data (Table 3-4 in Forsman et al. 2016).
Structural Diversity	Diameter Diversity Index (DDI)	0.25	7.0 DDI = 0.8 6.0 DDI = 0.6 5.0 DDI = 0.4 4.0 DDI = 0.2	Red tree vole generally requires a structurally diverse, multicanopy conifer forest with large trees (Forsman et al. 2016, Rosenberg et al. 2016). DDI provides a quantitative index of canopy layering. DDI describes the relative similarity of a given stand to an old growth stand in terms of the number of trees per acre in each of 4 diameter categories. Stands can range from a DDI of almost 0 up to a maximum of 10, with 0 represent the least layering and 10 representing the most laying. Stands with older forest structure have DDI's ranging from 6.5 to 10. Forsman et al. (2016) found that red tree vole habitat suitability increased sigmoidally with increasing DDI. Suitability categories are based on mean forest stand characteristics for modeled red tree vole habitat categories based on forest inventory plot data (Table 3-4 in Forsman et al. 2016).
Large Trees	Trees per acre 30"+ DBH	0.5	14.0 large trees per acre = 0.8 10.0 large trees per acre = 0.6 5.0 large trees per acre = 0.4 3.0 large trees per acre = 0.2	Large trees are important components of structurally complex late seral conifer forests for red tree vole (Forsman et al. 2016, Rosenberg et al. 2016). Rosenberg et al. found density of large conifers (≥ 75 cm DBH [29.5 inches]) to be strongly associated with red tree vole habitat, with suitability increasing logarithmically with increasing density of large conifers. Suitability categories are based on mean forest stand characteristics based on forest inventory plot data (Table 3-4 in Forsman et al. 2016).

References

Dunk, J.R. and J.J.V.G. Hawley. 2009. Red-tree vole habitat suitability modeling: Implications for conservation and management. Forest Ecology and Management 258:626-634

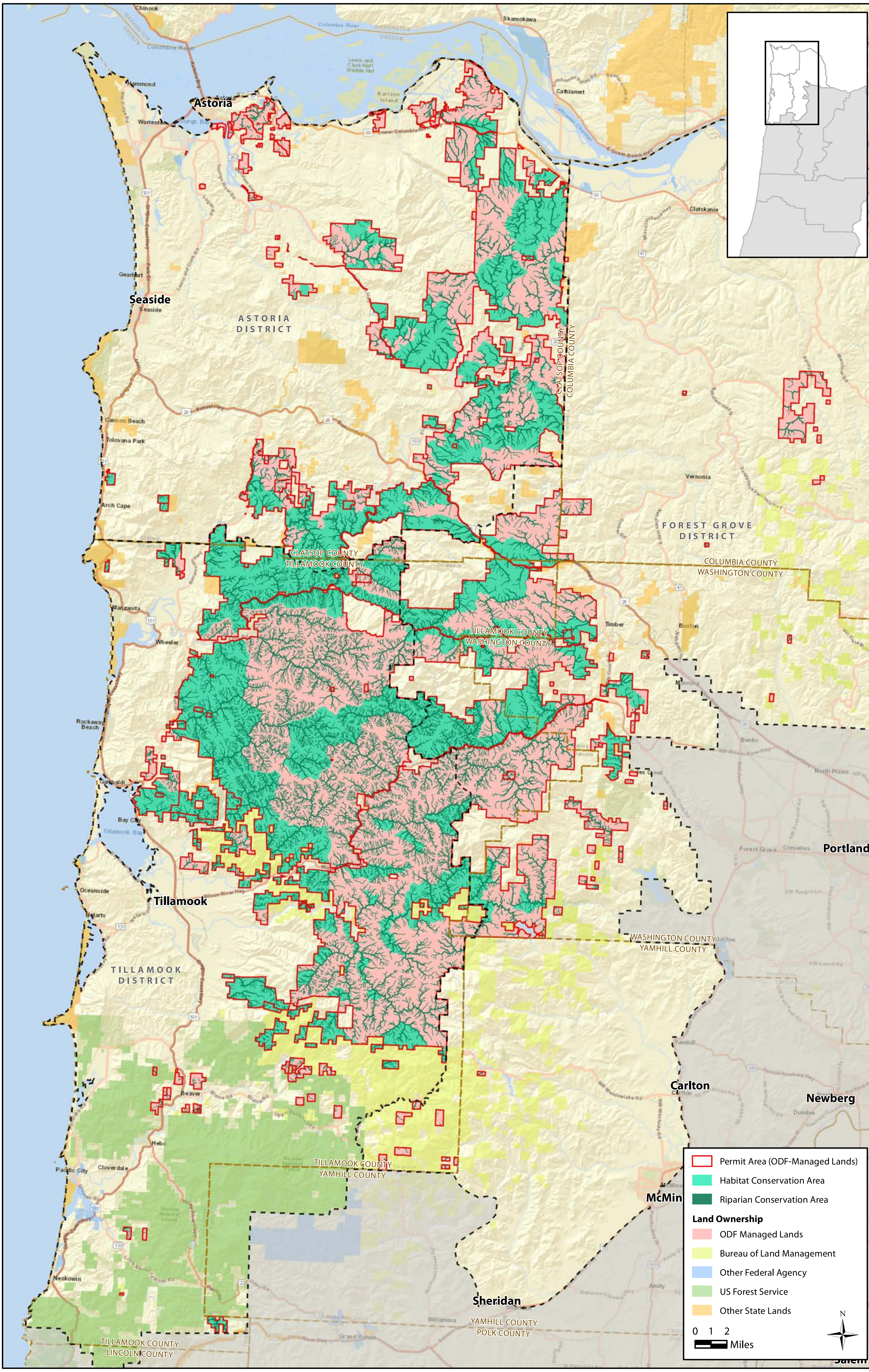
Forsman, E.D., J.K. Swingle, R.J. Davis, B.L. Biswell, and L.S. Andrews. 2016. Tree Voles: An Evaluation of Their Distribution and Habitat Relationships Based on Recent and Historical Studies, Habitat Models, and Vegetation Change. Gen. Tech. Rep. PNW-GTR-948. Portland, OR: US Department of Agriculture, Forest Service, Pacific Northwest Research Station. 119 p., 948.

Linnell, M.A., R.J. Davis, D.B. Lesmeister, and J.K. Swingle. 2017. Conservation and Relative Habitat Suitability for an Arboreal Mammal Associated with Old Forest. Forest Ecology and Management 402:1–11.

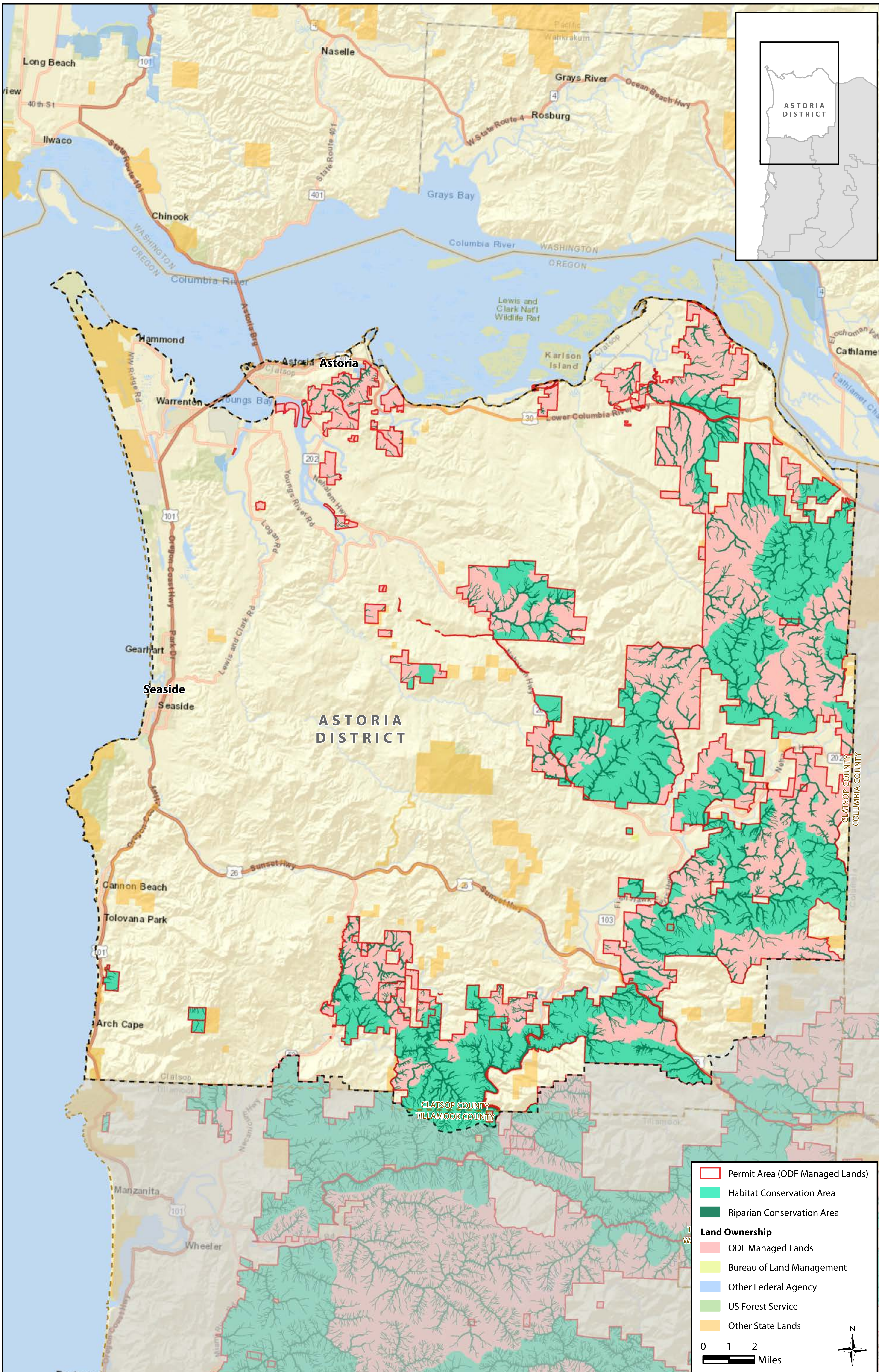
Rosenberg, D.K., R.J. Davis, K.J. Van Norman, J.R. Dunk, E.D. Forsman, and R.D. Huff. 2016. Patterns of Red Tree Vole Distribution and Habitat Suitability: Implications for Surveys and Conservation Planning. Ecosphere 7(12):e01630. 10.1002/ecs2.1630.

U.S. Fish and Wildlife Service. 2011. 50 CFR Part 17. Endangered and Threatened Wildlife and Plants; 12-Month Finding on a Petition to List a Distinct Population Segment of the Red Tree Vole as Endangered or Threatened; Proposed Rule. Vol. 76/Thursday, No. 198/October 13, 2011.

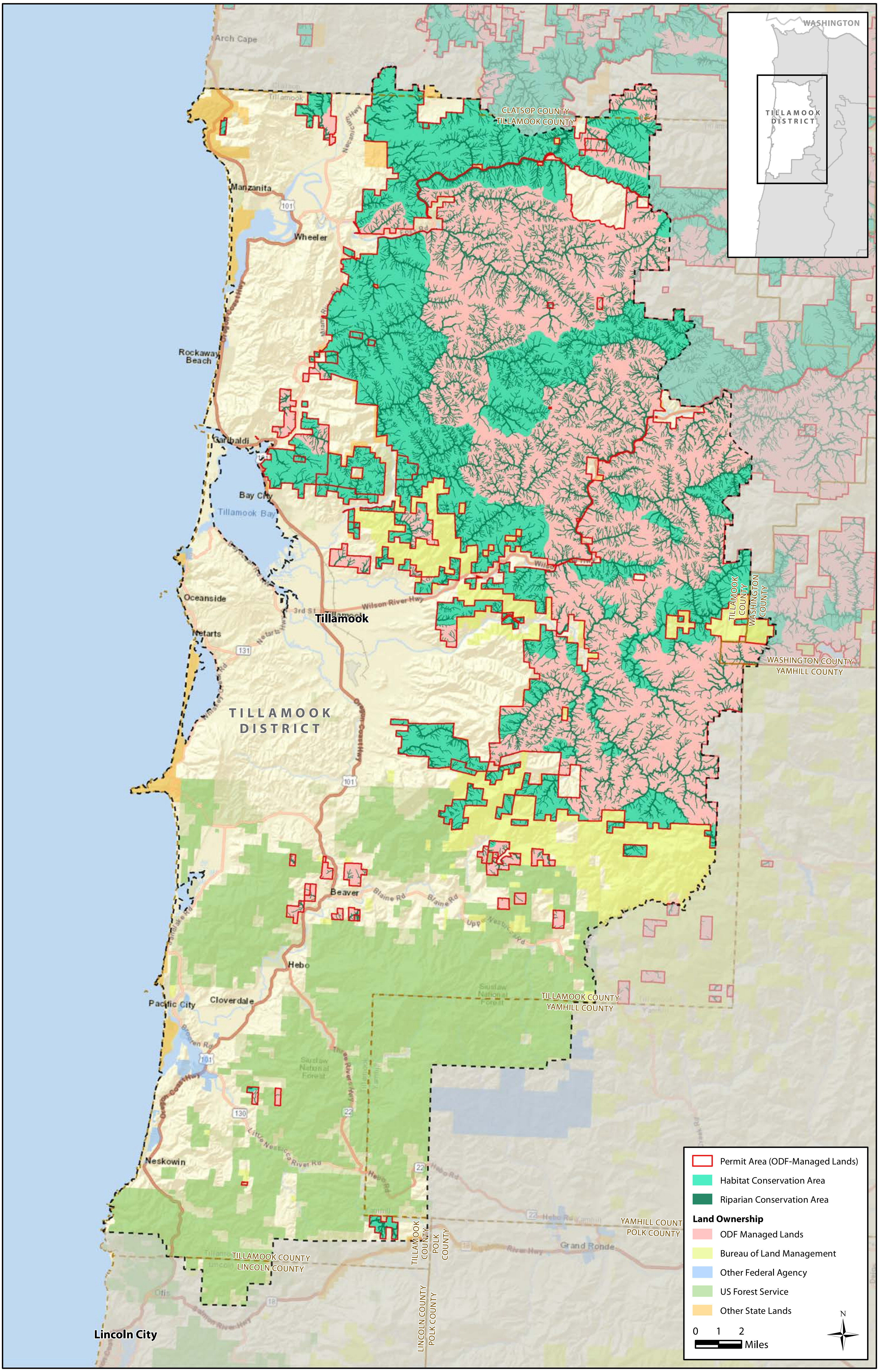
Appendix F
Habitat Conservation Area Maps



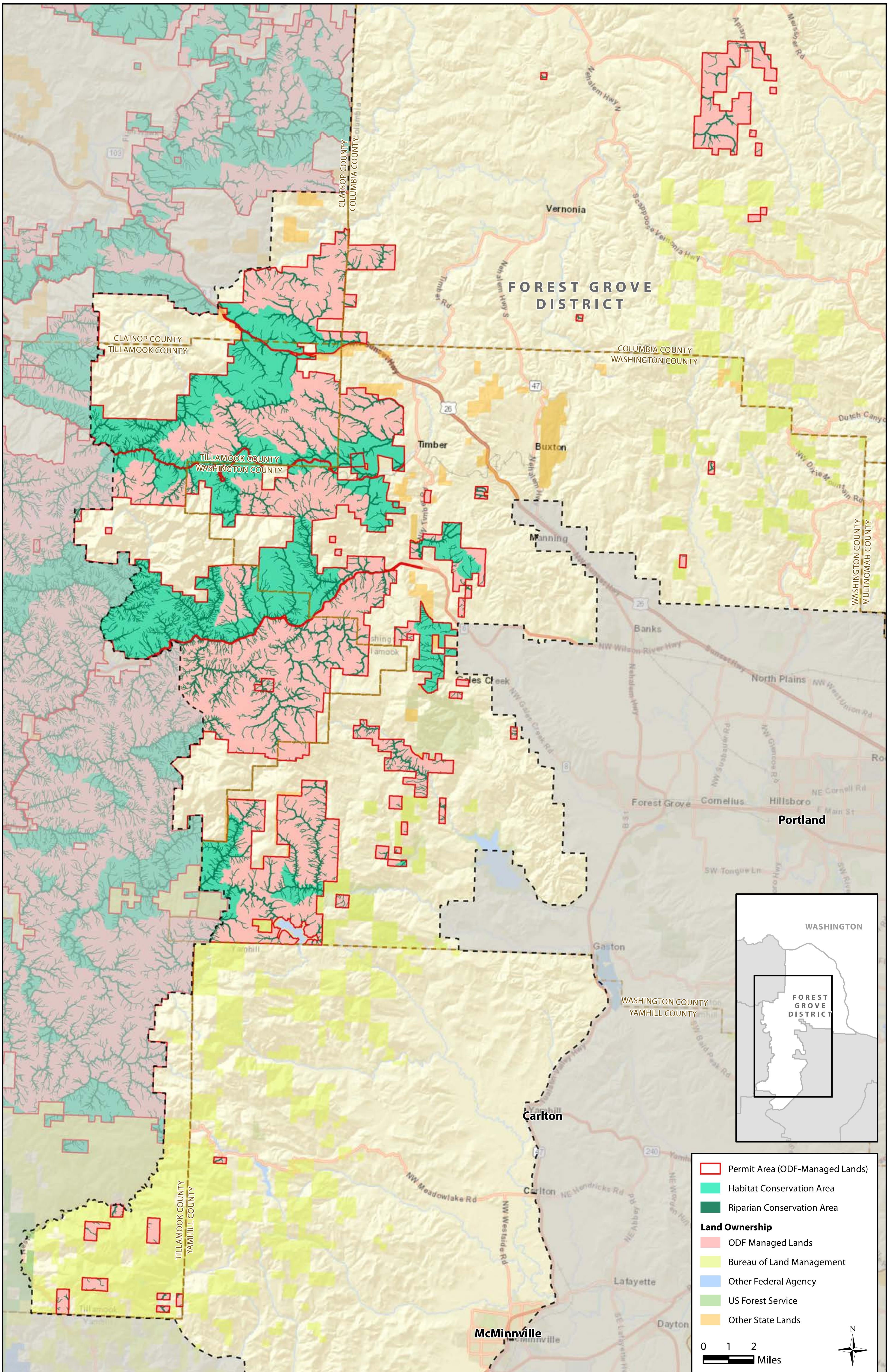
Western Oregon State Forest HCP – Habitat Conservation Areas, Astoria, Forest Grove, and Tillamook Districts



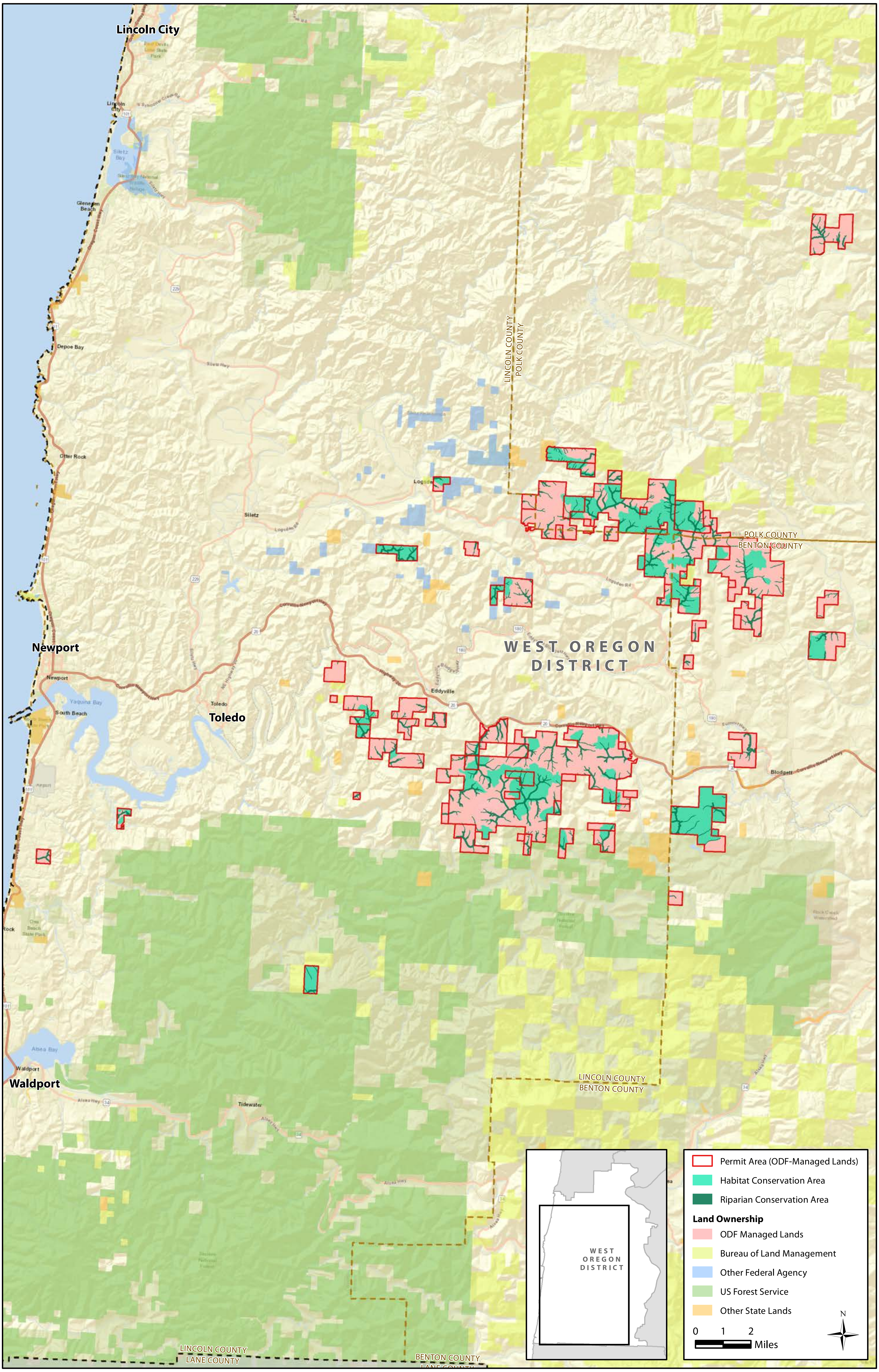
Western Oregon State Forest HCP – Habitat Conservation Areas, Astoria District



Western Oregon State Forest HCP – Habitat Conservation Areas, Tillamook District

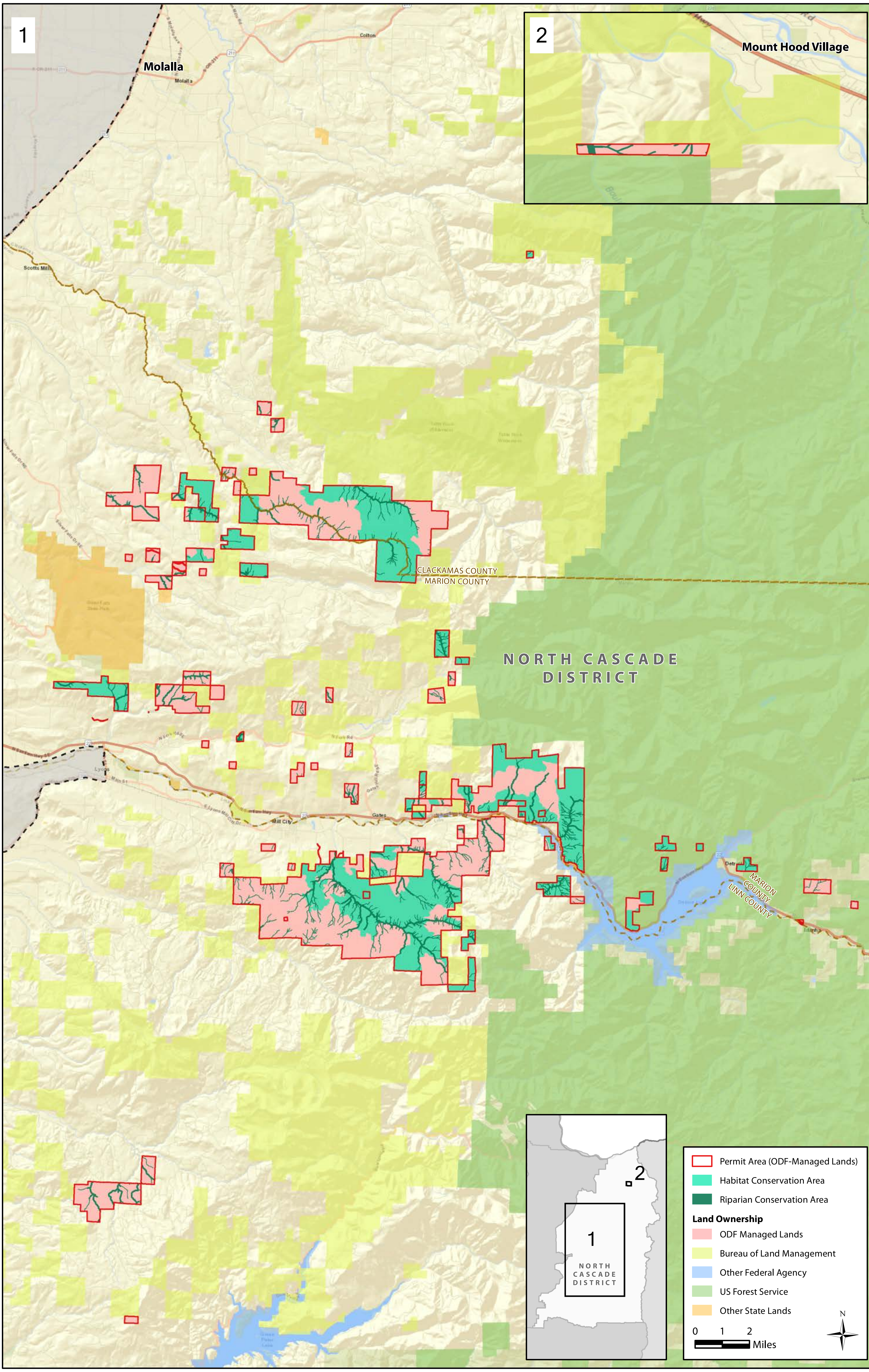


Western Oregon State Forest HCP – Habitat Conservation Areas, Forest Grove District

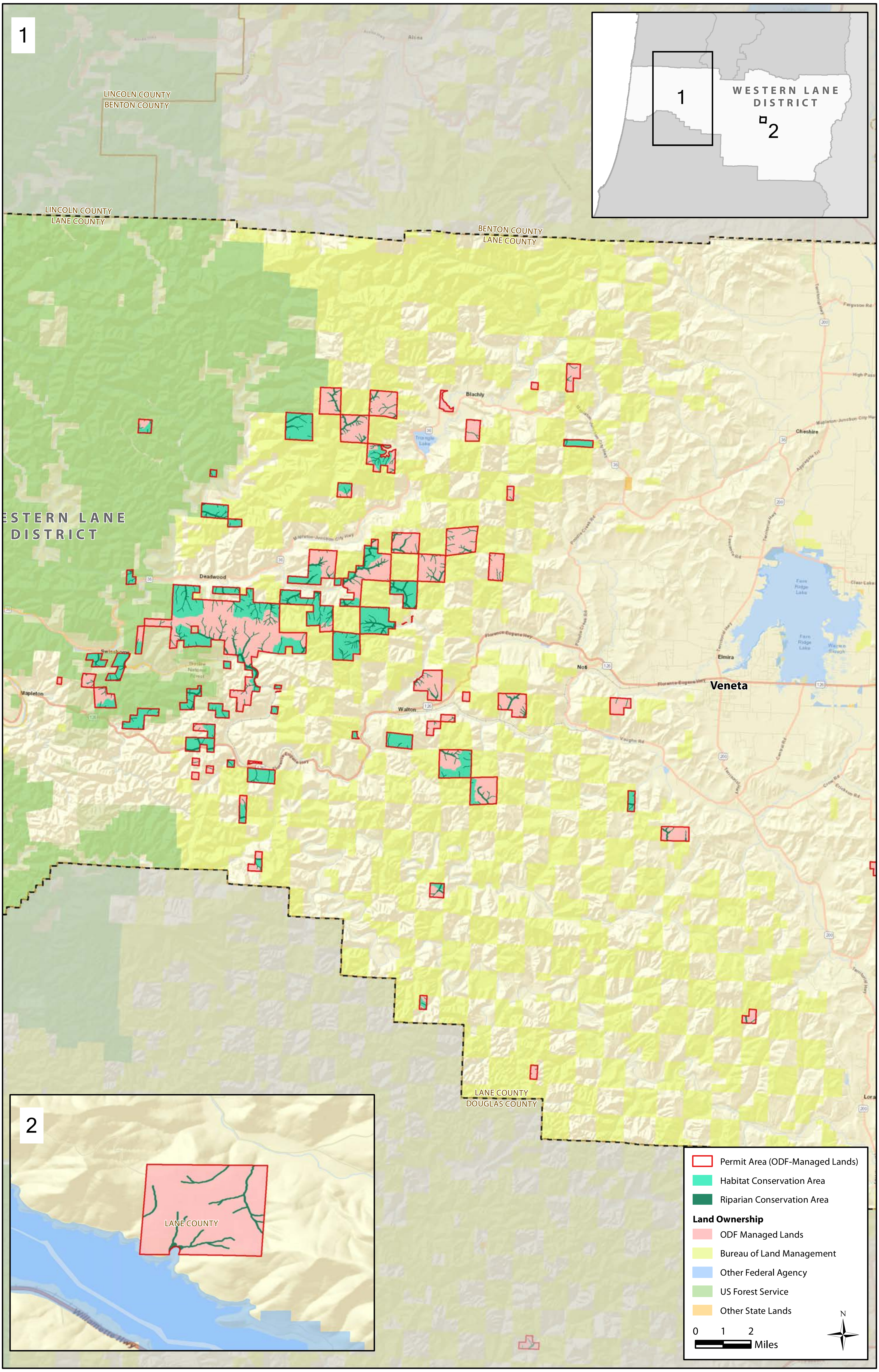


ICF

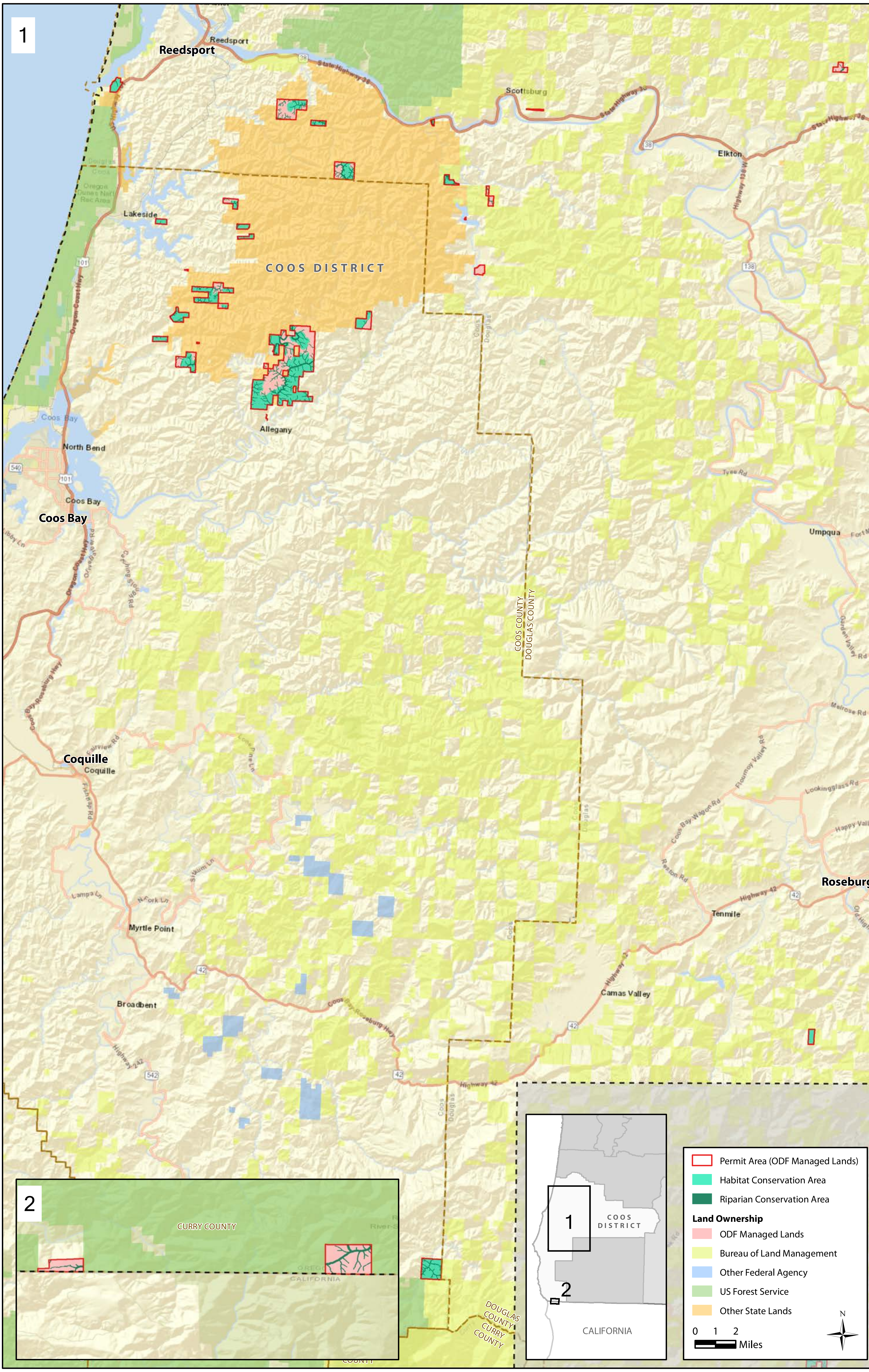
Western Oregon State Forest HCP – Habitat Conservation Areas, West Oregon District



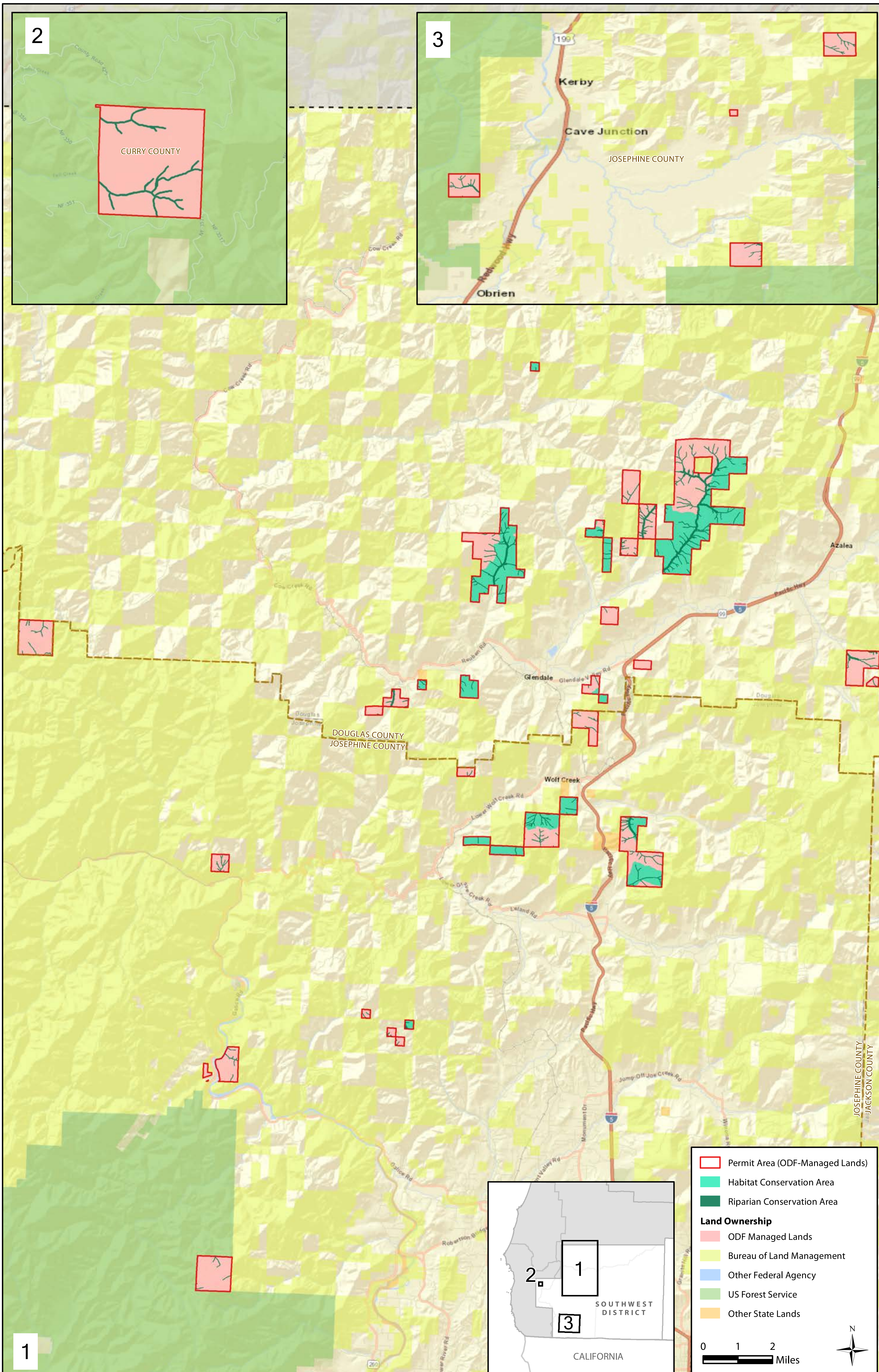
Western Oregon State Forest HCP – Habitat Conservation Areas, North Cascade District

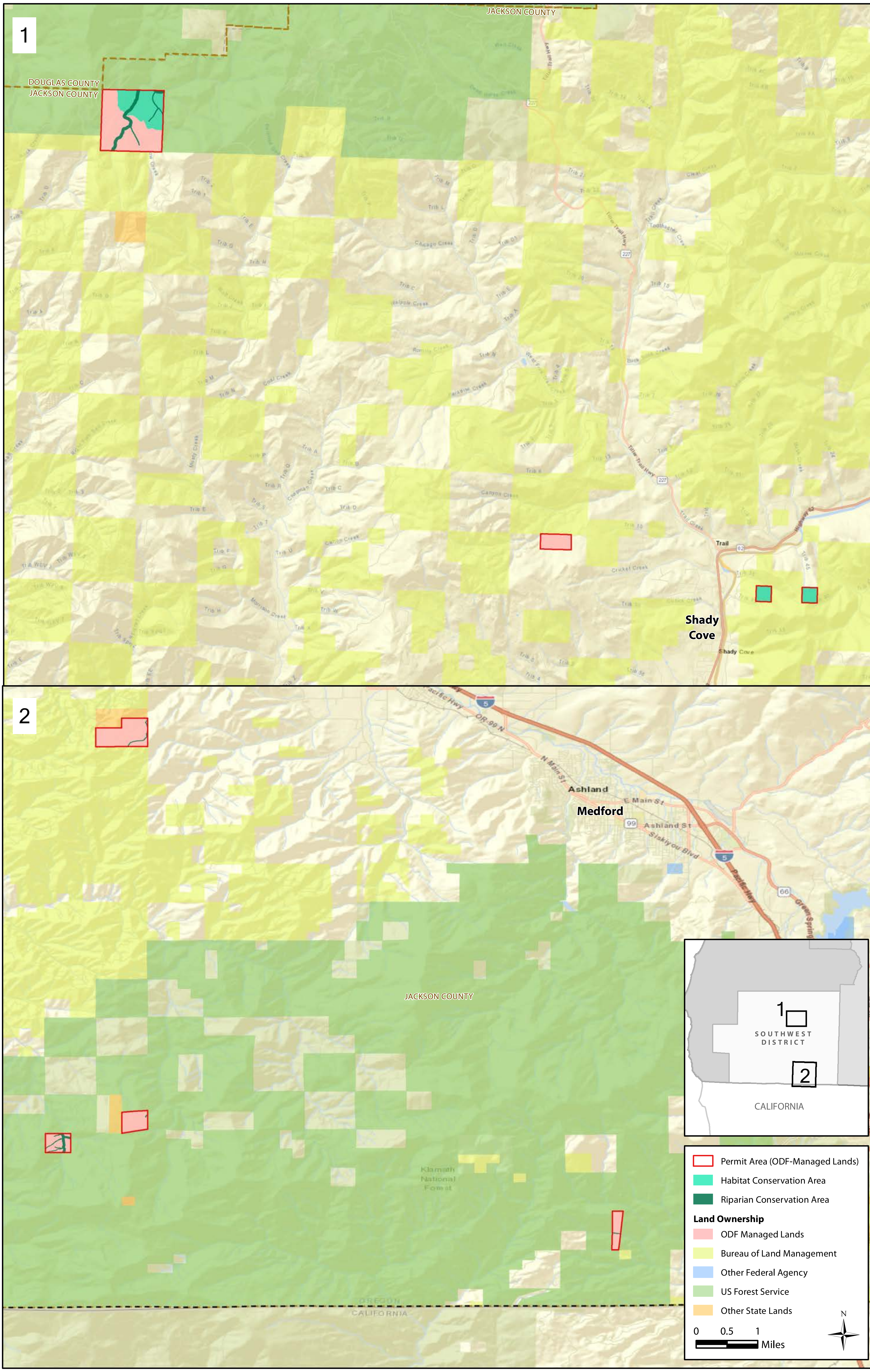


Western Oregon State Forest HCP – Habitat Conservation Areas, Western Lane District



Western Oregon State Forest HCP – Habitat Conservation Areas, Coos District


2
CURRY COUNTY
3
Kerby
Cave Junction
JOSEPHINE COUNTY
Obrien
Azalea
Glendale
DOUGLAS COUNTY
JOSEPHINE COUNTY
Wolf Creek
JOSEPHINE COUNTY
JACKSON COUNTY
Grants Pass
1
Permit Area (ODF-Managed Lands)
Habitat Conservation Area
Riparian Conservation Area
Land Ownership
ODF Managed Lands
Bureau of Land Management
Other Federal Agency
US Forest Service
Other State Lands
0 1 2 Miles
N
SOUTHWEST DISTRICT
CALIFORNIA


1
JACKSON COUNTY
DOUGLAS COUNTY
JACKSON COUNTY
Trail
Shady
Cove
2
Ashland
Medford
E Main St
Ashland St
Siskiyou Blvd
N Main St
OR-99 N
Pacific Hwy
JACKSON COUNTY
Klamath
National
Forest
OREGON
CALIFORNIA
1
SOUTHWEST
DISTRICT
2
CALIFORNIA
Permit Area (ODF-Managed Lands)
Habitat Conservation Area
Riparian Conservation Area
Land Ownership
ODF Managed Lands
Bureau of Land Management
Other Federal Agency
US Forest Service
Other State Lands
0 0.5 1
Miles
N

Appendix G

Hydrological Unit Code 10 Analysis

Table G-1 - Percent of Watershed (HUC 10) and Permit Area within the Oregon Coast Coho ESU that will be less than 10 Years Old During the Permit Term

Population Group	HUC 10	Area	2023	2028	2033	2038	2043	2048	2053	2058	2063	2068	2073	2078	2083	2088	2093	Average
Alsea	Drift Creek	Entire HUC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Permit Area in HUC	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Beaver	Beaver Creek-Frontal Pacific Ocean	Entire HUC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Permit Area in HUC	4%	17%	17%	13%	44%	34%	4%	25%	25%	4%	4%	4%	6%	13%	12%	15%
Coos	Coos Bay-Frontal Pacific Ocean	Entire HUC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Permit Area in HUC	5%	5%	6%	4%	4%	7%	8%	5%	3%	6%	7%	4%	3%	3%	3%	5%
	Millicoma River	Entire HUC	0%	0%	0%	0%	0%	0%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
		Permit Area in HUC	3%	4%	5%	5%	5%	6%	11%	12%	7%	10%	12%	8%	8%	10%	8%	8%
Lower Umpqua River	Lower Umpqua River	Entire HUC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Permit Area in HUC	6%	2%	2%	2%	2%	4%	13%	11%	4%	13%	15%	5%	15%	15%	4%	7%
	Mill Creek	Entire HUC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Permit Area in HUC	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	17%	28%	27%	35%	10%
	Umpqua River - Sawyers Rapids	Entire HUC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Permit Area in HUC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Upper Smith River	Entire HUC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Permit Area in HUC	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	100%	100%	1%	1%	14%
Middle Umpqua	Elk Creek	Entire HUC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Permit Area in HUC	47%	2%	2%	2%	2%	2%	19%	19%	2%	2%	29%	29%	2%	2%	2%	11%
Necanicum	Necanicum River-Frontal Pacific Ocean	Entire HUC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Permit Area in HUC	12%	5%	10%	10%	10%	13%	20%	17%	23%	23%	10%	11%	6%	5%	10%	12%
Nehalem	Headwaters Nehalem River	Entire HUC	2%	4%	5%	5%	4%	3%	3%	3%	3%	2%	2%	3%	2%	2%	1%	3%
		Permit Area in HUC	8%	14%	20%	18%	14%	12%	10%	10%	10%	8%	9%	11%	9%	6%	6%	11%
	Lower Nehalem River	Entire HUC	2%	5%	7%	6%	7%	9%	10%	9%	8%	7%	5%	5%	7%	9%	10%	7%
		Permit Area in HUC	3%	6%	9%	8%	9%	11%	13%	11%	10%	9%	6%	6%	9%	11%	12%	9%
	Middle Nehalem River	Entire HUC	8%	6%	8%	8%	7%	5%	4%	5%	5%	6%	8%	7%	7%	6%	6%	6%
		Permit Area in HUC	13%	10%	14%	13%	11%	8%	7%	8%	9%	11%	13%	11%	11%	10%	10%	10%
	North Fork Nehalem River	Entire HUC	3%	3%	4%	5%	5%	5%	5%	4%	3%	3%	3%	3%	2%	2%	3%	4%
		Permit Area in HUC	10%	8%	12%	14%	14%	13%	14%	12%	9%	9%	8%	8%	6%	5%	8%	10%
	Salmonberry River	Entire HUC	4%	4%	5%	5%	5%	4%	5%	6%	7%	5%	3%	5%	4%	3%	3%	5%
		Permit Area in HUC	7%	6%	8%	9%	8%	7%	8%	10%	11%	8%	5%	8%	7%	5%	5%	8%
	Upper Nehalem River	Entire HUC	3%	5%	6%	4%	4%	3%	3%	4%	4%	5%	5%	4%	5%	4%	3%	4%
		Permit Area in HUC	11%	18%	21%	14%	14%	11%	10%	12%	13%	15%	17%	14%	16%	12%	11%	14%
	Little Nestucca River	Entire HUC	0%	0%	0%	1%	1%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%
		Permit Area in HUC	4%	16%	18%	24%	31%	15%	12%	10%	8%	8%	4%	9%	19%	16%	5%	13%
	Nestucca River	Entire HUC	0%	1%	1%	1%	1%	2%	2%	1%	1%	1%	1%	1%	1%	1%	1%	1%
		Permit Area in HUC	3%	7%	15%	19%	20%	23%	26%	19%	15%	14%	11%	9%	11%	18%	19%	15%
Siletz	Lower Siletz River	Entire HUC	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	1%	0%	0%	0%	0%	0%
		Permit Area in HUC	4%	4%	4%	4%	4%	4%	4%	4%	4%	24%	27%	6%	4%	4%	4%	7%
	Rock Creek	Entire HUC	2%	1%	2%	3%	5%	5%	3%	4%	3%	2%	3%	3%	2%	4%	3%	3%
		Permit Area in HUC	7%	6%	8%	11%	21%	19%	12%	14%	12%	8%	10%	10%	9%	16%	14%	12%

Population Group	HUC 10	Area	2023	2028	2033	2038	2043	2048	2053	2058	2063	2068	2073	2078	2083	2088	2093	Average
Siuslaw	Deadwood Creek	Entire HUC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Permit Area in HUC	1%	1%	1%	1%	1%	1%	1%	1%	2%	2%	9%	9%	1%	1%	1%	2%
	Lake Creek	Entire HUC	1%	2%	3%	2%	3%	2%	1%	1%	1%	1%	0%	1%	1%	0%	1%	1%
		Permit Area in HUC	8%	12%	18%	16%	16%	13%	8%	5%	7%	6%	3%	4%	4%	3%	4%	8%
	Lower Siuslaw River	Entire HUC	1%	1%	1%	2%	2%	2%	1%	1%	1%	1%	0%	0%	0%	0%	0%	1%
		Permit Area in HUC	6%	5%	10%	15%	15%	15%	13%	11%	11%	9%	4%	2%	3%	4%	4%	8%
	Upper Siuslaw River	Entire HUC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Permit Area in HUC	5%	5%	2%	2%	2%	5%	19%	16%	15%	22%	9%	7%	9%	4%	3%	8%
	Wildcat Creek	Entire HUC	1%	2%	2%	2%	2%	1%	0%	1%	1%	1%	1%	1%	1%	1%	1%	1%
		Permit Area in HUC	11%	12%	17%	13%	12%	6%	3%	6%	7%	6%	6%	5%	4%	4%	7%	8%
	Wolf Creek	Entire HUC	1%	0%	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Permit Area in HUC	22%	13%	28%	25%	13%	10%	9%	13%	20%	12%	3%	16%	17%	4%	3%	14%
South Umpqua	Clark Branch-South Umpqua River	Entire HUC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Permit Area in HUC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Days Creek-South Umpqua River	Entire HUC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Permit Area in HUC	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	23%	23%	6%	8%
	Lower Cow Creek	Entire HUC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Permit Area in HUC	4%	4%	4%	4%	6%	6%	7%	7%	4%	4%	4%	4%	4%	4%	31%	7%
	Middle Cow Creek	Entire HUC	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	0%	1%	1%	1%	1%
		Permit Area in HUC	9%	6%	6%	6%	6%	7%	6%	9%	11%	9%	6%	5%	6%	7%	10%	7%
	Olalla Creek - Lookingglass Creek	Entire HUC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Permit Area in HUC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Upper Cow Creek	Entire HUC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Permit Area in HUC	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
	West Fork Cow Creek	Entire HUC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Permit Area in HUC	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Tenmile	Tenmile Creek-Frontal Pacific Ocean	Entire HUC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Permit Area in HUC	2%	4%	9%	8%	2%	2%	7%	7%	2%	2%	18%	18%	2%	2%	2%	6%
Tillamook Bay	Kilchis River	Entire HUC	2%	2%	2%	4%	6%	7%	7%	6%	4%	3%	2%	2%	3%	4%	4%	4%
		Permit Area in HUC	3%	3%	3%	5%	8%	9%	9%	7%	5%	4%	3%	2%	3%	5%	5%	5%
	Miami River	Entire HUC	1%	3%	4%	4%	6%	6%	4%	4%	3%	3%	2%	2%	3%	3%	3%	3%
		Permit Area in HUC	2%	5%	7%	7%	10%	9%	7%	6%	5%	5%	4%	4%	5%	6%	5%	6%
	Tillamook Bay	Entire HUC	0%	1%	1%	1%	1%	1%	1%	1%	0%	0%	0%	0%	0%	0%	0%	1%
		Permit Area in HUC	5%	10%	10%	6%	8%	10%	11%	7%	5%	5%	5%	5%	5%	5%	5%	7%
	Tillamook River	Entire HUC	0%	1%	1%	1%	1%	1%	2%	1%	1%	0%	1%	1%	0%	1%	1%	1%
		Permit Area in HUC	3%	5%	6%	5%	6%	6%	10%	10%	4%	3%	3%	3%	3%	4%	4%	5%
	Trask River	Entire HUC	2%	6%	9%	10%	**11%**	**11%**	10%	8%	6%	6%	8%	8%	10%	**13%**	**13%**	9%
		Permit Area in HUC	4%	10%	16%	18%	20%	19%	17%	13%	10%	11%	14%	14%	16%	22%	22%	15%
	Wilson River	Entire HUC	5%	7%	10%	**11%**	**12%**	**12%**	10%	8%	7%	8%	8%	8%	9%	**11%**	**11%**	9%
		Permit Area in HUC	6%	8%	12%	14%	15%	15%	12%	10%	9%	10%	10%	10%	11%	14%	14%	11%

Population Group	HUC 10	Area	2023	2028	2033	2038	2043	2048	2053	2058	2063	2068	2073	2078	2083	2088	2093	Average
Yaquina	Big Elk Creek	Entire HUC	2%	2%	2%	2%	3%	3%	2%	2%	2%	2%	2%	2%	2%	2%	1%	2%
		Permit Area in HUC	10%	10%	11%	16%	18%	16%	15%	12%	11%	13%	12%	11%	12%	10%	8%	12%
	Lower Yaquina River	Entire HUC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Permit Area in HUC	22%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	3%
	Upper Yaquina River	Entire HUC	2%	2%	2%	2%	3%	3%	3%	3%	3%	2%	2%	2%	2%	3%	3%	2%
		Permit Area in HUC	9%	9%	9%	12%	16%	16%	18%	16%	14%	13%	11%	10%	11%	17%	17%	13%

Table G-2 - Percent of Watershed (HUC 10) and Permit Area within the Lower Columbia River Coho, Chinook, and Columbia River Chum ESUs that will be less than 10 Years Old During the Permit Term

Population Group	HUC 10	Area	2023	2028	2033	2038	2043	2048	2053	2058	2063	2068	2073	2078	2083	2088	2093	Average
Big Creek	Big Creek-Frontal Columbia River	Entire HUC	2%	5%	7%	6%	6%	4%	3%	4%	4%	6%	6%	5%	6%	5%	4%	5%
		Permit Area in HUC	8%	18%	26%	25%	24%	17%	14%	15%	18%	23%	23%	21%	24%	19%	15%	19%
Clatskanie River	Clatskanie River	Entire HUC	1%	1%	2%	1%	1%	1%	1%	2%	2%	2%	2%	1%	0%	0%	0%	1%
		Permit Area in HUC	10%	15%	23%	16%	8%	14%	20%	24%	28%	33%	32%	17%	6%	5%	5%	17%
	Plympton Creek-Frontal Columbia River	Entire HUC	3%	4%	4%	4%	4%	3%	3%	2%	2%	3%	3%	3%	4%	3%	2%	3%
		Permit Area in HUC	8%	11%	12%	10%	11%	9%	7%	6%	6%	8%	8%	8%	11%	8%	5%	9%
Sandy River	Salmon River	Entire HUC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Permit Area in HUC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Youngs Bay	Youngs River-Frontal Columbia River	Entire HUC	1%	2%	2%	2%	2%	2%	2%	2%	3%	3%	3%	2%	2%	1%	1%	2%
		Permit Area in HUC	12%	15%	18%	16%	16%	16%	15%	18%	23%	27%	28%	20%	14%	10%	13%	17%

Table G-3 - Percent of Watershed (HUC 10) and Permit Area within the Southern Oregon/Northern California Coast ESU that will be less than 10 Years Old During the Permit Term

Population Group	HUC 10	Area	2023	2028	2033	2038	2043	2048	2053	2058	2063	2068	2073	2078	2083	2088	2093	Average
Illinois	Althouse Creek	Entire HUC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Permit Area in HUC	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	9%	9%	4%	5%
	Deer Creek	Entire HUC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Permit Area in HUC	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
	Indigo Creek	Entire HUC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Permit Area in HUC	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%
	Josephine Creek-Illinois River	Entire HUC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Permit Area in HUC	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%
	Lawson Creek-Illinois River	Entire HUC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Permit Area in HUC	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
	Sucker Creek	Entire HUC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Permit Area in HUC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%	7%
	West Fork Illinois River	Entire HUC	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
		Permit Area in HUC	56%	56%	56%	56%	56%	56%	56%	56%	56%	56%	56%	56%	56%	56%	56%	56%
Middle Rogue and Applegate	Bear Creek	Entire HUC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Permit Area in HUC	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
	Grave Creek	Entire HUC	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
		Permit Area in HUC	12%	11%	12%	12%	12%	12%	11%	12%	12%	13%	13%	15%	15%	12%	15%	13%
	Headwaters Applegate River	Entire HUC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Permit Area in HUC	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
	Hellgate Canyon-Rogue River	Entire HUC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Permit Area in HUC	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%	28%	29%	28%
	Horseshoe Bend-Rogue River	Entire HUC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Permit Area in HUC	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	12%	12%	6%
	Jumpoff Joe Creek	Entire HUC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Permit Area in HUC	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	0%
	Little Applegate River	Entire HUC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Permit Area in HUC	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%
	Shasta Costa Creek-Rogue River	Entire HUC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Permit Area in HUC	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
Smith	North Fork Smith River	Entire HUC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Permit Area in HUC	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%	7%
Upper Klamath	Cottonwood Creek	Entire HUC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Permit Area in HUC	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%
Upper Rogue	Shady Cove-Rogue River	Entire HUC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Permit Area in HUC	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%
	Trail Creek	Entire HUC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Permit Area in HUC	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%	14%
Winchuck	Winchuck River	Entire HUC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Permit Area in HUC	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%

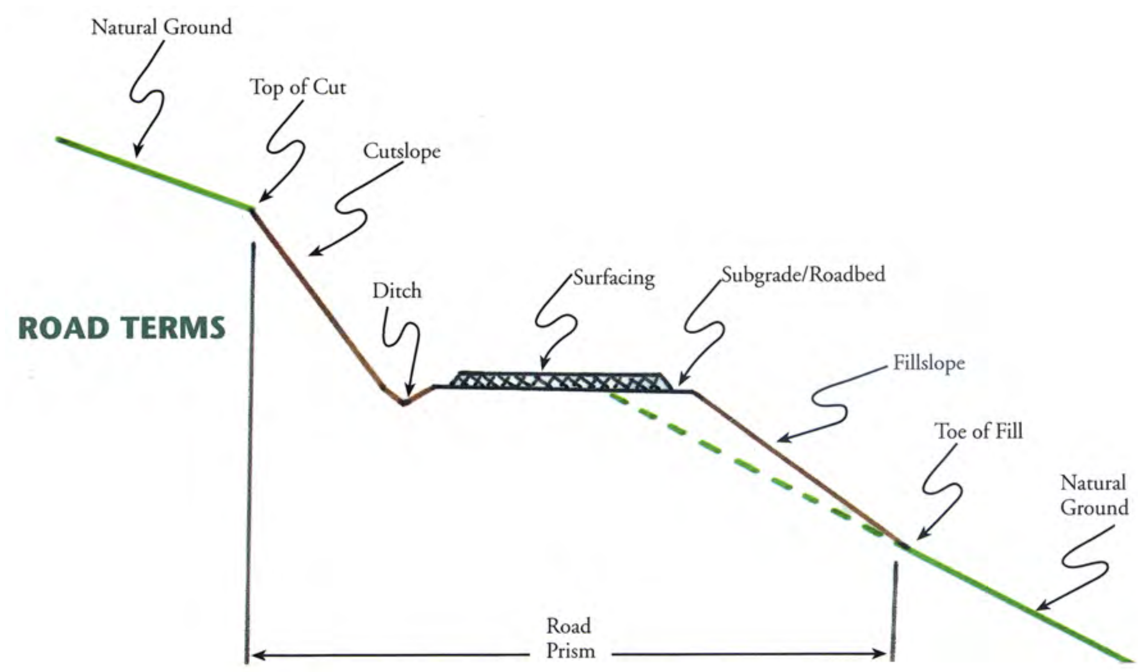
Table G-4 - Percent of Watershed (HUC 10) and Permit Area within the Upper Willamette River Chinook and Steelhead ESUs that will be less than 10 Years Old During the Permit Term

Species	Population Group	HUC 10		2023	2028	2033	2038	2043	2048	2053	2058	2063	2068	2073	2078	2083	2088	2093	Average
Chinook	Willamette	Fall Creek	Entire HUC	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
			Permit Area in HUC	1%	19%	62%	45%	17%	17%	18%	18%	1%	1%	1%	1%	1%	1%	1%	14%
		Lookout Point Lake-Middle Fork Willamette River	Entire HUC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
			Permit Area in HUC	33%	26%	41%	18%	20%	27%	9%	2%	2%	2%	2%	2%	2%	2%	2%	13%
	Z-Outside	Mill Creek	Entire HUC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
			Permit Area in HUC	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
Chinook and Steelhead	Willamette	Abiqua Creek-Pudding River	Entire HUC	1%	2%	2%	1%	1%	1%	1%	1%	1%	1%	0%	1%	0%	0%	0%	1%
			Permit Area in HUC	6%	18%	24%	11%	6%	10%	12%	9%	10%	8%	5%	6%	5%	3%	3%	9%
		Butte Creek-Pudding River	Entire HUC	2%	2%	5%	4%	2%	2%	2%	2%	2%	2%	2%	2%	2%	1%	2%	2%
			Permit Area in HUC	11%	12%	24%	23%	12%	13%	13%	9%	12%	12%	9%	8%	8%	7%	8%	12%
		Crabtree Creek	Entire HUC	1%	0%	1%	1%	0%	0%	0%	1%	0%	0%	1%	1%	0%	0%	1%	0%
			Permit Area in HUC	33%	7%	19%	18%	6%	3%	11%	15%	7%	13%	26%	23%	15%	8%	17%	15%
		Hamilton Creek-South Santiam River	Entire HUC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
			Permit Area in HUC	62%	3%	3%	3%	3%	7%	31%	27%	8%	8%	3%	29%	29%	3%	3%	15%
		Headwaters North Santiam River	Entire HUC	0%	0%	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
			Permit Area in HUC	3%	3%	32%	32%	17%	17%	3%	5%	9%	9%	5%	3%	7%	7%	5%	10%
		Little North Santiam River	Entire HUC	1%	0%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
			Permit Area in HUC	14%	11%	13%	16%	21%	22%	14%	15%	15%	12%	21%	19%	12%	12%	17%	16%
		Lower North Santiam River	Entire HUC	1%	1%	3%	3%	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%
			Permit Area in HUC	10%	17%	34%	31%	16%	7%	5%	4%	4%	4%	4%	4%	4%	4%	4%	10%
		Middle North Santiam River	Entire HUC	3%	5%	8%	7%	6%	6%	5%	5%	4%	3%	2%	2%	2%	2%	3%	4%
			Permit Area in HUC	7%	13%	22%	20%	17%	15%	13%	12%	11%	8%	6%	6%	6%	6%	7%	11%
		Quartzville Creek-Green Peter Lake	Entire HUC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
			Permit Area in HUC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
		Thomas Creek	Entire HUC	0%	1%	2%	2%	2%	2%	1%	1%	1%	1%	0%	0%	0%	0%	1%	1%
			Permit Area in HUC	4%	11%	30%	28%	34%	34%	14%	14%	17%	11%	4%	4%	4%	5%	10%	15%
		Upper Calapooia River	Entire HUC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
			Permit Area in HUC	0%	0%	0%	92%	92%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	12%
		Upper Molalla River	Entire HUC	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	0%	1%	1%
			Permit Area in HUC	13%	11%	19%	17%	11%	13%	13%	12%	14%	17%	15%	13%	11%	9%	12%	13%
		Upper North Santiam River	Entire HUC	1%	1%	1%	1%	1%	1%	1%	2%	1%	1%	1%	1%	1%	1%	1%	1%
			Permit Area in HUC	15%	13%	13%	13%	13%	13%	16%	17%	14%	13%	13%	13%	13%	13%	13%	14%

Species	Population Group	HUC 10		2023	2028	2033	2038	2043	2048	2053	2058	2063	2068	2073	2078	2083	2088	2093	Average
Steelhead	Willamette	Dairy Creek	Entire HUC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
			Permit Area in HUC	27%	25%	31%	13%	12%	12%	21%	21%	7%	17%	17%	7%	7%	7%	7%	15%
		Gales Creek	Entire HUC	2%	2%	3%	3%	3%	3%	3%	3%	2%	1%	1%	2%	1%	1%	1%	2%
			Permit Area in HUC	8%	8%	13%	13%	10%	10%	11%	11%	8%	5%	4%	6%	5%	3%	3%	8%
		Luckiamute River	Entire HUC	0%	1%	1%	1%	1%	1%	1%	1%	1%	0%	0%	0%	0%	0%	0%	1%
			Permit Area in HUC	9%	21%	37%	30%	18%	20%	22%	16%	17%	11%	6%	7%	10%	9%	6%	16%
		Marys River	Entire HUC	3%	3%	3%	2%	3%	3%	3%	3%	2%	1%	1%	1%	2%	2%	2%	2%
			Permit Area in HUC	15%	16%	16%	13%	15%	16%	19%	15%	11%	9%	7%	8%	10%	10%	9%	13%
		Rickreall Creek-Willamette River	Entire HUC	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
			Permit Area in HUC	9%	99%	99%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	21%
		Scoggins Creek-Tualatin River	Entire HUC	3%	3%	6%	5%	5%	4%	3%	3%	3%	2%	2%	3%	3%	1%	1%	3%
			Permit Area in HUC	13%	14%	24%	22%	20%	17%	14%	15%	13%	7%	7%	13%	11%	4%	3%	13%
		Willamina Creek	Entire HUC	0%	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
			Permit Area in HUC	3%	46%	69%	26%	11%	15%	7%	10%	10%	3%	3%	3%	3%	3%	3%	14%

Appendix H
ODF Roads Manual

Oregon Department of Forestry



State Forests Program

Forest Roads Manual

Acknowledgments

The Oregon Department of Forestry, State Forests Program has developed this manual.

Development has been through a team effort of the following people, all Oregon Department of Forestry employees: Scott Wilbrecht, project leader; Tony Klosterman, Bill Metcalf, Dave Michael, Greg Miller, and Darrel Spiesschaert, final editing. Without their valuable participation, this project would not have been possible. I extend my gratitude for their help and understanding on this undertaking that became more work than any of us envisioned.

Other Resource Specialist providing input and draft review:

Keith Mills, Forest Practices Geotechnical Specialist, Oregon Department of Forestry
Ross Holloway, Policy and Planning Manager, Oregon Department of Forestry
Rosemary Mannix, Technical Services Manager, Oregon Department of Forestry
Many Oregon Department of Forestry Engineers, Road Specialists and Foresters from around the state.

Special thanks to Oregon State University's Forest Engineering Department for draft review by Brian W. Kramer, P.E.

Special thanks for many of the graphic illustrations provided from the Forest Practices Program's " Forest Road Management Guidebook".

Cover Design: Laura Lynn, Oregon Department of Forestry, Graphics Department

Contact for information:
Scott Wilbrecht
Oregon Dept. of Forestry
Forest Engineering Coordinator
2600 State Street
Salem, OR 97310
503-945-7371
swilbrecht@odf.state.or.us

Forest Engineering Roads Manual

June 2000

Table of Contents

Section 4. Forest Road Construction

Section 11. Appendixes

Introduction

Roads provide essential access for the active management of the resources found on state-owned forest lands. Forest management, timber removal, recreation, and fire protection, as well as other activities, are all heavily, if not totally, dependent on road access into the forest.

Besides being an asset, roads are recognized as sources of erosion and sedimentation, impact wildlife and aquatic habitats, remove valuable timberland from production and require significant work and expense to build and maintain. For these reasons, an environmentally sound, economically efficient and effective road management program must be utilized on state-owned forest lands.

Road Management Policy

The goal for the management of forest lands owned by the Board of Forestry is to secure the greatest permanent value to the citizens of Oregon as described in OAR 629-035-0000 through 629-035-0100. The goal for the management of Common School Forest Land is to obtain the greatest benefit for the people of Oregon as described in the Oregon Constitution.

Therefore, it is the policy of the Department of Forestry to establish and maintain a road system that will facilitate securing the greatest permanent value on Board of Forestry lands and obtaining the greatest benefit on Common School Forest Lands. This policy is implemented through activities in transportation planning, road

design, road construction and improvement, road maintenance and closing or vacating unneeded roads.

Purpose of the Manual

The purpose of this manual is to provide guidance and standards for road management on state-owned forest lands. The manual contains information that is considered to be the current state-of-the-art. As additional information becomes available through research and monitoring the manual will be updated.

The Vision for Forest Roads on State-owned Forest Lands

(Note to the reader: The vision is written in the present tense as if we were already in the future and actually looking at the idealized forest road system on state-owned forest lands)

The forest road system on state-owned forest lands is providing efficient, effective access that facilitates securing the greatest permanent value on Board of Forestry lands and obtaining the greatest benefit on Common School Forest Lands. The forest road system is managed actively, not passively. Roads are designed, constructed and maintained in the most cost-efficient manner, while providing a high level of protection to other natural resources. The amount of land occupied by roads is at a minimum. Fish are able to move upstream and downstream where roads cross streams. Roads are constructed in the best locations for carrying out anticipated activities, while minimizing the impacts on natural resources. The standard for roads in the forest is a suitable match for the terrain and type of access needed. The roads are effectively maintained to retain their longevity and to prevent adverse effects to natural resources. Unneeded roads are closed or vacated and, where appropriate, the land they occupied is returned to active forest management.

Guiding Principles for Road Management

The guiding principles of state forest road management are presented here, with a brief explanation of each. These principles are some (certainly not all) of the most significant components of the “state-of-the-art” knowledge needed to ensure sound practices in forest road management. The reader is directed to the specific sections of this Forest Engineering Roads Manual for a more detailed explanation and application.

Guiding Principle 1. The amount of road on state-owned forest land will be the minimum necessary to achieve the goals of Forest Management Plans.

Access through the forest is essential to achieve forest management goals. Access requirements are dependent on management goals, geographic location, harvest methods utilized, and other on-site factors. Minimizing total miles of road in the forest reduces road construction & maintenance costs, and reduces land taken out of the forest management base. Less road means less potential for adverse effects on other natural resources.

Guiding Principle 2. New roads will be located to provide the best protection to natural resources and meet the objective of the road.

Determining the best location for new forest roads is one of the first and most important steps in minimizing road impact problems. Road locations will fit the terrain. Ridge top locations are preferred over mid-slope roads. Modifying road grades to avoid undesirable locations will be used wherever possible. To the extent possible, roads will be located away from streams, wetlands, unstable areas, and sensitive resource sites. Alternative route locations will be considered on all new roads. The location that best protects natural resources and meets the objective of the road will be selected.

Guiding Principle 3. High-risk sites will be avoided wherever possible. Where high-risk sites cannot be avoided, state-of-the-art design and construction practices will be used.

The construction of road segments through high-risk sites will be avoided whenever possible through the use of alternate routes or different logging systems.

At times road locations will be necessary through high-risk sites. When this occurs, a geotechnical specialist will evaluate the location. In most cases, the geotechnical specialist will make site visits and develop site specific, state-of-the-art recommendations concerning the site. Those recommendations will be incorporated into the design and construction of the project.

The evaluation of both the risk of a landslide and the values at risk below the site is critical. The road may need to be relocated if either of the risks is considered too high.

Guiding Principle 4. New roads will be located, designed and built for economically efficient and effective forest operations.

Only roads that provide benefits that outweigh the costs of the roads will be constructed. Benefits from roads are measured both from financial gains and for achievement of overall management goals.

By coordinating transportation and forest management plans, a reduction in the total amount of road needed to accomplish management goals will be achieved.

Guiding Principle 5. Roads will be designed to meet access needs, to have low impacts on natural resources and the forest, and to be economical to construct and maintain.

Road design will match road use. This usually means limiting the width of the road to that necessary for the expected use. Minimizing road width and the resultant cut and fill slopes will minimize environmental impacts from roads.

The use of excavated material will be carefully considered in the design of roads. A balanced cut and fill cross section design will be used where slopes are gentle and stable. Where a balanced cross section design is not used, excess material will be used in fills and/or to raise the road grade. A full bench end-haul design will be used where slopes are steep and risks of landslides are high.

Road designs will provide for proper drainage of surface water. Grade breaks, out-sloping, in-sloping, ditching, road dips, water bars and relief culverts are some of the techniques that must be considered.

Road surfacing will be included in the design of roads that will be subject to use during wet weather. The amount and type of road surfacing will be determined by the expected use of the road.

As mentioned in the Guiding Principle on Fish Passage, stream crossings will be designed to assure fish passage.

Guiding Principle 6. Temporary roads will be used to meet short-term access needs. When the need no longer exists, the temporary road will be vacated.

Temporary roads can be used to minimize road density and associated impacts where resource concerns indicate a need. The use of temporary spurs and special construction practices that provide protection while planning to vacate the temporary road (at a later time) can serve a very specific and beneficial purpose. These roads must be planned and managed properly to ensure the desired environmental protection.

Guiding Principle 7. Forest roads on state-owned forest lands will be designed constructed and maintained to provide effective and efficient drainage of surface water.

Effective drainage systems are needed to protect both the environment (water quality and fish habitat) and the capital investment in the road. These systems must be included in the road design, ensured through road construction and maintained through road maintenance.

Sometimes the efficiency of getting water off the road is in conflict with environmental protection (sediment into streams), and proper design and maintenance may require specific problem solving for the site. For example, where the risk of landslides is high, the location of cross drainage must be carefully considered. The sections of this manual on Forest Road Design, Forest Road Construction, and Forest Road Maintenance discuss the concepts and strategies involved in road drainage.

Guiding Principle 8. Fish passage will be provided where roads cross fish-bearing streams.

Providing fish passage where roads cross fish-bearing streams will ensure that fish can access habitat. Forest Practices Act guidance on fish passage is the state-of-the-art and will be used for evaluating and deciding on proper design and construction of stream crossings.

Stream crossings for new road construction and road improvement projects will be designed and constructed using state-of-the-art practices. Ongoing repair or replacement of stream crossings on existing roads that do not provide adequate fish passage will be conducted systematically within the limitations of workload priorities and the availability of funds.

Guiding Principle 9. Waste areas for depositing excess road excavation material will be located on stable sites.

Where excess road excavation materials are generated, especially where full bench end-haul road construction design is used, waste areas for depositing excess road excavation materials are needed. Waste areas will be located on stable sites.

The proper selection of waste areas is critical. Waste area failures can have serious impacts on water quality and fish habitat. They are expensive to repair and difficult to mitigate.

Foresters or engineers, oftentimes aided by the geotechnical specialist, will thoroughly investigate potential waste area locations in order to ensure a high level of confidence in their stability. Uncertainties of geologic subsurface conditions will prevent complete confidence in the stability of waste area locations. Monitoring of waste areas after construction (during the first few winters) ensures timely action in the case of unrecognized slope instability.

Guiding Principle 10. Rock pits and quarries will be designed and developed to provide for environmental protection and site reclamation.

Design considerations for environmental protection include: drainage of the quarry floor, screening berms, filtering of surface water, proper location of stockpile and overburden, clearing limits, and other site-specific design mitigation. The Geotechnical specialist may be requested to assist in rock pit and quarry design.

At the conclusion of use, rock pits and quarries will be reclaimed to the extent practical.

Guiding Principle 11. An active road maintenance program will be used to protect the capital investment in the road, to minimize adverse effects to water quality and aquatic habitat, and to provide for safe use of the road.

Proper road maintenance minimizes the impacts roads have on natural resources and ensures that roads are available for their intended use. Road maintenance protects the State's investment in the transportation system. An active road maintenance program includes an ongoing and up-to-date inventory of road maintenance needs, a means of systematically addressing the needs, and a response to emergency situations. Road maintenance includes the repair and upkeep of the road prism, road surface, and road drainage. It also includes vegetation management along roads.

Guiding Principle 12. Roads that are determined to be unnecessary for forest management will be vacated. In addition, roads that are causing or likely to cause serious environmental problems, very near fish-bearing streams, or have very high maintenance costs will be considered for vacating.

Vacating roads, when appropriate, can reduce environmental impacts, lessen maintenance costs and move the transportation system toward the desired condition. Roads will be vacated when their use is judged to be unnecessary to forest management. In addition the following roads will be considered for vacating: roads where serious erosion is occurring or likely to occur, where the costs of adequate maintenance (over the long term) will exceed the cost of vacating, or where the road is very near a fish-bearing stream. The section of the manual on Forest Road Vacating describes the processes and techniques for vacating roads.

Transportation Planning

Introduction

As used in this section "Transportation Planning" means any planning activities involving new road construction, road improvement or road maintenance. This section is intended to guide Oregon Department of Forestry managers of state-owned forest lands (unit foresters, forest engineering supervisors, road specialists, and foresters) in the transportation planning effort for state forest roads. It may also serve to explain the basic transportation planning approach of the department to other interested parties. The levels of transportation planning as well as the goals, objectives and strategies for transportation planning are described.

Goals of Transportation Planning

1. Provide plans for a road system that will facilitate the implementation of Forest Management Plans.
2. Provide plans for a road system that is efficiently, effectively, and environmentally constructed and maintained.

Objectives of Transportation Planning

1. Develop a vision of the desired forest road system.
2. Know and evaluate the condition of the existing forest road system.
3. Develop efficient, effective, and environmentally sound plans that can be used to move from the existing condition of the road system toward the vision or desired condition.

Levels of Planning

Transportation planning for state-owned forest lands will occur at three levels:

<u>Level I</u> This is a broad level, long range planning effort that establishes long term goals and determines strategies for achieving the goals. Road management goals and strategies need to be consistent with legal requirements and the goals and strategies for the management of other forest resources. Specific operations are not identified. Level I planning usually occurs in the development of forest management plans, watershed assessments and similar documents.

Example: The forest management plan provides a broad, general description of the current condition of forest roads on state-owned forest lands, establishes broad, general goals for the access system and describes the strategies for achieving the goals.

<u>Level II</u> This is a mid level, moderate range planning effort that describes the vision for the forest road system of the future, determines the current condition of the road system, and identifies the general needs to move from the current condition to the vision. This level of planning usually does not span more than a decade and needs to be updated periodically. Major activities such as mainline and primary spur road construction and significant road improvements are identified. The Level II plan will be consistent with the goals and strategies determined in Level I planning. Level II planning usually occurs in the development of implementation plans and similar documents. Guidance on the development of Level II transportation plans may be a part of the overall guidance for the development of these documents.

Example: A district implementation plan calls for significant timber harvesting in a given basin in the next decade. A road system is needed to facilitate the harvesting activities. A transportation plan would be developed that would supplement and support the implementation plan for the basin. The transportation plan would describe the vision for the road system in the basin and determine the current condition of the road system. It would then identify any new construction of mainline or primary spur roads that are needed, any significant reconstruction of existing roads, and any road improvement needs such as replacement of stream crossing structures. Approximate locations of activities may be identified on maps or photos. Approximate scheduling of individual projects may also be included.

<u>Level III</u> This is a detailed level of planning that considers specific projects or operations over a relatively short time frame, usually two years or less. Projects or operations must be consistent with Level II planning for the geographic area. Oftentimes the need for the project or operation and a general location has been identified in the Level II plan. In the Level III plan the projects are site-specific and locations are identified on the ground. Some design criteria and specifications may be included in the Level III plan. Projects often are associated with other operations such as timber sales. Level III planning usually occurs as part of the development of annual operations plans, annual road maintenance plans, timber sale contracts, service contracts and similar documents.

Example: A planned timber sale requires access to facilitate harvesting operations. A plan must be developed that will identify the location and standards for roads, landings, waste areas, road surfacing rock, and any other items needed to facilitate the harvesting operations. Alternatives may need to be developed and evaluated. Aerial photos, maps, and reconnaissance on the ground are used to determine the general location of the project. Information from the Level III planning effort is included in the pre-sale plan report.

Transportation Planning Strategies

Transportation planning strategies are the specific actions that will be taken to achieve the goal(s) of transportation planning and move towards the vision for forest roads on state-owned forest land. These strategies will be applied at all levels of transportation planning. As the planning moves from Level I to Level III the strategies will become more detailed and more specific.

Develop a Vision of the Transportation System

Successful planning of a transportation system requires the planner to have a vision of the desired system. This manual describes a vision for the road system across all state-owned forest land. That broad scale vision will be supplemented with a vision that is specific for the local planning area and that is commensurate with the level of planning that is being performed. For example, transportation planning is being done as part of a district implementation plan for a specific basin. A vision statement for the transportation system for the basin will be developed. The vision will include the elements of the vision statement in this manual and then add the details that are needed to describe the desired condition for that specific basin.

Visions are usually written statements that describe the desired condition. They should provide enough detail to provide a clear image of what is desired so that the vision can be used throughout the development and implementation of the transportation plan. For example, the vision statement for a specific road construction project would be used in determining the design specifications and construction standards for the project.

Visions will be consistent with the goals and strategies in the appropriate resource management plans and consider the physical conditions in the planning area. Resource management plans include forest management plans (Level I), implementation plans (Level II), annual operations plans (Level III), etc. The resource management plan that is considered will depend upon the level of transportation planning. Physical conditions include those items that will affect the desired road system. Physical conditions to consider in developing a vision statement include topography, soils, streams, geologic hazards and risks, sensitive resources, special habitats, etc. Before developing a vision for the transportation system in a given area, the planner should have an understanding of the appropriate resource management plans and the physical conditions. Consultation with natural resource specialists (biologists, geotechnical specialists, engineers, etc.) will be used to supplement the planner's knowledge base and understanding.

Inventory and Describe the Current Conditions

The current conditions of roads on state-owned forest lands are the result of weather and other natural processes and of a variety of road construction techniques, road maintenance efforts, and uses over time. There are roads that are in good condition and suitable for continued use. And, there are roads that are not in a desired condition and need improvement work or need to be considered for vacation.

The current conditions and needs of roads on state-owned forest lands will be inventoried. Each district will maintain an intensive inventory of the road network on state-owned lands in the district. The inventory will categorize roads, identify drainage systems (culverts, ditches, waterbars, outsloping, etc.) and rate their condition, identify and assess road-related slope stability problems, identify barriers to fish passage where roads cross streams, and gather other information that is needed for planning road improvement, road maintenance, or vacation of roads.

As of January 2000 the minimum level inventory system that will be used for roads on state-owned forest land will be the **Road Hazard Inventory Protocol** (see Appendix 1) developed as part of the Oregon Coastal Salmon Recovery Initiative. This inventory system gathers information related to fish passage barriers where roads cross streams, information related to road drainage systems and their condition, and information related to slope stability problems. This information will be useful in describing some but not all of the current conditions of roads. In the future, a more comprehensive inventory system will be developed and added to this manual. Until the new inventory system is in place, districts may gather additional information on the current condition of roads that the district determines to be necessary to efficiently and effectively manage the district road system.

Upon completion of the inventory, the information that was gathered will be processed and/or displayed in a way that will provide a description of the current condition of the road system. As of January 2000 a standard approach for processing and displaying the information was not available. Along with the development of a more comprehensive road inventory system a method for processing and displaying the information will be developed.

Until a methodology is developed, districts will utilize a local system for describing the current condition of the state forest roads in their district. As a minimum the description will include a brief narrative supported by data from the inventory that show the needs related to road drainage, fish passage, and slope stability. Districts may also choose to use GIS to record inventory information and to describe, through maps and tables, the current condition of roads.

Inventories are only valuable if they are current. The inventory of the current condition of roads will be updated as changes are made to the road system and/or new information is obtained. Information in the inventory that is more than five years old should be reviewed and updated or deleted if it is no longer current.

Develop Transportation Plans Consistent With the Planning Level

Transportation plans will describe the means of moving from the current condition to the desired condition (Vision). The amount of detail in the plan will depend upon the level of planning. This will generally mean less detail in Level I planning, more in Level II and the most in Level III. The amount of detail in the plan will also vary with the geographic scope of the plan. In general, plans covering a large geographic area (a district e.g.) will have less detail than plans covering a small geographic area (a timber sale area e.g.).

As mentioned in the discussion of the levels of planning, Level I transportation plans are broad, long-range plans for large geographic areas. They establish goals for moving from the current condition to the desired condition and strategies for achieving the goals.

These plans are generally in a narrative form and will not involve the use of maps or photos. Specific activities or projects are not identified.

Level II transportation plans will describe how the desired condition will be achieved over a span of time for a given area. Generally, these plans are associated with district implementation plans and are developed for a decade of time in a given basin. These plans will have a combination of a narrative description and a graphic display (usually maps and/or photos). These plans provide a description of the vision for the road system, the current condition of the road system, and what is planned to achieve the desired condition. The narrative will describe the amount and type of road maintenance that is planned, the amount and character of minor spur road construction that is planned, and the amount and nature of minor sections of road that will be vacated or closed. Mainline road construction, collector spur roads, significant road improvement projects and closure or vacation of large sections of road should be located on maps or photos. Input from resource specialists (biologists, engineers, geotechnical specialists, etc.) and the use specific resource information (soils maps, fish presence surveys, endangered species surveys, etc.) may be needed in the development of these plans. Level II plans should be updated as new information is obtained or as specific projects are accomplished. As a minimum, these plans will be updated once a decade.

Level III plans describe how the desired condition will be achieved in the near future for a specific area. Many of these plans are site specific and deal with an individual project or a series of projects related to a specific objective. Examples of a Level III plan would be a transportation plan for a proposed timber sale or a specific road maintenance project.. A lengthy narrative is not required. However, the objective of the plan and any critical decision points in the implementation of the plan should be described. These plans will generally contain enough detail that the design of specific projects can be started. Projects are located on maps or photos and critical portions are “ground truthed”. Specifications and standards will be identified and recommended in the plan. District budgets will be developed to include funding for projects not accomplished through timber sale project requirements. A high level of input from resource specialists and site specific resource information will be used to develop the plan.

*Footnote
As noted in the Northwest Oregon State Forests Management Plan (July 2000 draft) pg. 4-72, "Initial district implementation plans will not contain all of the transportation planning elements described in this Roads Manual. Following completion of watershed assessments and as district implementation plans are subsequently revised and updated the complete transportation planning process will be applied."

Forest Road Design

Introduction

A well planned, designed, constructed, and maintained system of forest roads is essential to facilitate forest management and protection of natural resources. Road design is the process of determining the "what, where, when, and how" for a new road construction, road improvement, or extra-ordinary road maintenance project. It begins after careful planning has determined that the project is necessary.

The designer of a project will consider the following factors:

- The purpose and intended use of the project. Included in this factor are length of use (temporary or permanent), amount and timing of use, and type of use (commercial, recreational, or administrative).
- The physical conditions affecting the project. Included in this factor are soils, topography, high landslide hazard locations, streams, wetlands, bedrock, weather, etc.
- Environmental conditions affecting the project. Included in this factor are fish bearing streams, threatened and endangered species, environmentally sensitive sites, scenic values, recreational use, etc.
- Benefits, costs, and risks associated with the project. Included in this factor is the consideration of alternative designs and locations for the project. The design will strive for maximizing benefits and minimizing costs and risks.

Goals of Road Design

1. Design roads that meet access needs.
2. Design roads to meet or exceed all Forest Practices Act road design rules to minize environmental impacts on natural resources.
3. Design roads that are economical to construct and maintain.

Objectives of Road Design

1. Facilitate building roads in the best locations to meet forest management needs and minimize impacts to natural resources.
2. Ensure that the proper standard of road is constructed to facilitate the projected use without overbuilding or excessive cost.
3. Provide drainage that removes water from the road prism before it can cause problems and that will:
   - Allow the use of roads during the seasons of desired use.
   - Minimize the impact on water quality and aquatic habitat that is caused by roads.
   - Maintain the stability of forest slopes that are impacted by roads.
   - Minimize the disruptions to natural drainage patterns.
   - Reduce the amount and cost of road maintenance.
   - Minimize the impacts if drainage failures occur.

4. Provide project direction that will aid efficient, economical construction of the project.
5. Provide road designs that contain accurate information to facilitate:
    - Clear communication of specifications and expectations for road projects. The written specifications should help project administrators and contractors construct projects as designed.
    - Accurate, fair cost estimates for construction projects, which will support doing the project as planned.

Road Design Strategies

Road design strategies are the specific actions and standards that will lead to achieving the goals and objectives of this section of the manual.

Engineering Procedures

The engineering procedures listed in this section are the minimum standards of engineering design work that will be utilized when designing road projects. The road designer should go beyond the minimum engineering procedures when circumstances dictate.

Generally, the engineering procedures that are utilized are dependent upon two factors. The first is the level of risk to natural resources posed by the road. The higher the chance that serious damage could occur to a natural resource as a result of the road project, the higher the level of engineering procedures that should be used to design the project. The second is the grade and alignment of the road. Steeper grades and more difficult alignments require higher levels of engineering procedures.

The road designer should visualize the desired finished road and determine what engineering procedures are needed to be sure that the project can and will be completed as desired. Unneeded engineering procedures waste time and energy in designing projects and may require wasteful construction practices. Likewise, not using adequate engineering procedures can result in the project not meeting objectives and damaging natural resources.

The road designer must be familiar with and understand the relationship between engineering procedures (this section) and road design standards (the following section). Engineering procedures and road design standards are not interchangeable. For example, to design a spur may require upper level engineering procedures if a portion of the road crosses a high landslide hazard location.

Base Level Engineering Procedures

Base level engineering procedures are applicable when all of the following criteria are met:

- Spur roads, usually less than ¼ mile in length, often temporary use.
- Gentle road grades that are less than 10%.
- Gentle side slopes of less than 35%, or ridgetop roads.
- High landslide hazard locations or other Natural Resource concerns are not involved.

Base level engineering procedures include:

- Reconnaissance.
- Flag or stake centerline.
- Reference beginning and ending points and other control points as needed.

Mid-Level Engineering Procedures

Mid-level engineering procedures are applicable when one or more the following criteria are met:

- Spur roads longer than ¼ mile, usually permanent.
- A portion of the road has grades that exceed 10% but are less that 17%.
- A portion of the road is located on slopes greater than 35% but less than 60% and high landslide hazard locations or deep seated landslides are not involved.

Mid-level engineering procedures will be applied to any portion of the road meeting the above criteria. Mid-level engineering procedures include:

- Reconnaissance of P-line(s) and topography.
- Run grade line.
- Field design final centerline location.
- Mark centerline with paint on stumps and hang flagging
- May be slope-staked, but generally reference tags are adequate (see section on "Referencing Centerline")

Upper Level Engineering Procedures

Upper level engineering procedures are used when one or more of the following criteria are met:

- Mainline roads.
- Portions of the road:
    a) Are located on slopes over 60%, or
    b) Cross a high landslide hazard location, or
    c) Cross a sharp “V” draw, or
    d) Cross a sharp ridge and horizontal and/or vertical curves are a concern, or
    e) Have sections of “through cut” or fills where the fill or cut heights exceed 10 feet, or
    f) Cross fish bearing streams, or
    g) Have long stretches of continuous road grades greater than 16%, or
    h) Require end hauling, or
    i) Require critical alignment, or
    j) Cross through or are adjacent to environmentally sensitive sites.

Upper level engineering procedures will be applied to roads or portions of roads meeting the above criteria. Upper level engineering procedures include:

- Reconnaissance.
- P-Line.
- Grade Line.
- Plan.
- Profile.
- Office-locate L-line.
- Cross-section.
- Slope stake or reference L-line. (See section on “Referencing Centerline Location”)

Where a planned road has segments that meet the criteria for upper level engineering procedures and the remainder of the road meets the criteria for base or mid level engineering procedures, a combination of procedures may be used. For example, a permanent spur road has moderate grades and is located on moderate slopes. However, it crosses a fish-bearing stream. The stream crossing will be designed using upper level engineering procedures, while the remainder of the road can be designed using mid-level engineering procedures.

Road Design Standards

Roads on state-owned forest land will be designed to meet the planned use of the road. The design will limit the alteration of natural slopes and drainage patterns to that which will safely accommodate the anticipated use of the road, protect water quality and aquatic habitat, and maintain site productivity. The standard of road will be consistent with good safety practices, while keeping construction and maintenance costs to a minimum.

When determining the road design standard, the following factors will be evaluated:

- The volume of traffic that will use the road at any given period of time and that will be expected to use the road over its duration.
- The type of vehicles that will use the road.
- The topography and soils where the road will be located.
- Duration of use (permanent, temporary, seasonal, or year around).
- Public use(s) of the road.
- Sensitive natural resources that may be affected by the road.
- Future road maintenance requirements.

Design Standards for Spurs

Description: These are generally roads that are used for a short term, intermittently and/or have a low traffic volume. Use may be heavy during periods of log hauling but minimal at other times.

Design standards:

Subgrade	12 to 16 feet wide, may have a 2 foot ditch
Running Surface	12 feet wide
Drainage	out-sloped, in-sloped, or crowned with ditch, dips, waterbars, may have temporary stream crossings (removed after road use is completed)
Surfacing	optional (consider pit or jaw run)
Minimum curve radius	50 feet plus curve widening
*Grade limitations	up to 35%, roads over 20% will be closed after use

Design Standards for Collectors

Description: These are permanent roads that access multiple logging units and may receive moderate use by the public during portions of the year.

Design Standards:

Subgrade	16 to 20 feet wide including a 2 to 3 foot ditch
Running Surface	12-16 feet wide
Drainage	Normally crowned with ditch, relief culverts, and stream crossings.
Surfacing	Crushed rock
Minimum curve radius	60 feet plus curve widening
*Grade limitations	up to 20%, usually under 18%

Design Standards for Mainlines

Description: These are permanent roads with high traffic volumes, higher speeds, movement of heavy equipment and/or a high level of public use during portions of the year. They are useable by a lowboy truck, which is a key design vehicle. They may have high public and recreational usage during parts of the year.

Design Standards:

Subgrade	20 to 24 feet wide including 2 to 3 foot ditch
Running Surface	16-20 feet wide
Drainage	Crowned, with ditches, relief culverts, and stream crossings including bridges
Surfacing	pit run, jaw run or crushed rock for base and crushed rock for driving surface
Minimum curve radius	70 feet plus curve widening
*Grade limitations	up to 14%

**Grades over 20% require assist vehicles (OAR 437-80-065). Rock surfaced grades over 16% require special surfacing design to alleviate traction problems (consult geotechnical specialist or staff engineer).*

Road Design Criteria

A number of criteria must be considered in designing roads. These are discussed in the following paragraphs.

Coordinated Planning and Location of Roads

Forest management operations planning and planning for forest transportation are dependent on each other. These two plans must be coordinated to provide for an efficient and effective overall plan. Professional foresters, roads specialists and engineers with knowledge, skills and abilities in the access requirements for forest management operations and the design, construction, and maintenance of forest roads make these important decisions. Management activities will be planned to take advantage of existing road systems when appropriate. Environmental and economical evaluations of both planned management operations and planned road construction/improvement will be performed to achieve the optimum design combination for the two activities. Careful planning and location of roads will ensure that roads are located where potential impacts to natural resources such as water quality and aquatic habitat are minimized. The areas served by each road will be maximized where possible; thus minimizing the amount of road needed to meet management objectives.

Reconnaissance

Reconnaissance involves reviewing the area and then identifying and evaluating the best locations for roads, landings and logging settings. Aerial photos, maps, and local knowledge as well as walking the ground are used to determine the best locations for the road. This is the time to identify potential control points such as landing locations, ridgetops, stream crossings, benches and other locations that may be desirable locations for the road. Location/reconnaissance will include a route assessment of alternatives and ending location(s). Sensitive natural resources on or near these routes will be identified. These include all streams (with special recognition for Type F(ish) and Type D(omestic), wetlands, slopes over 50 percent (especially high landslide hazard locations), and wildlife sites. To avoid these resource areas, the road location will use grade and alignment changes up to the upper limits as defined in the road design standards. Where the sensitive natural resources cannot be avoided, minimize the length of road in these areas and direct the road away from them as quickly as possible. In addition, when it is necessary to cross these areas, the appropriate technical specialist(s) will be consulted (geotechnical specialist, wildlife/fish biologist, hydrologist, staff forest engineer, etc.).

Road Location

Road locations should minimize the risk of materials entering waters of the state and minimize disturbance to stream channels, lakes, wetlands and floodplains. Where viable alternatives exist, avoid locating roads on steep slopes, slide areas, or high landslide hazard locations, and in wetlands, riparian management areas, channels or floodplains. When possible, avoid locating roads parallel to and in close proximity to streams because they have a higher than normal potential to deliver sediments directly into the channel. Roads that are close to and parallel streams also displace part of the riparian management area. Stream crossings will be as close as possible to a right angle in order to enter and exit the stream zone and the adjacent riparian management area as quickly as possible. Use variable grades and alignments to locate roads on the most suitable terrain.

Alternative road locations will be considered where natural resources are impacted. Locations will be favored that provide the best combination of meeting objectives and minimizing economic and environmental costs.

Make use of good, existing roads to reduce the duplication of road systems and associated ground disturbance. Where roads are present on an adjacent ownership and the roads will adequately serve the planned forest management operation, investigate options for using those roads before constructing new roads.

Road Prism Design

Roads will be no wider than necessary to accommodate the anticipated use. See the ranges listed in the road design standards.

Roads will be designed to be constructed with a balanced cut and fill cross section where possible and where this does not pose a risk of slope instability. Where a balanced cross section is not used, excess excavation material should be used in the road design, when possible, and not wasted. Designs will call for full bench construction and end-hauling of excess excavation material when roads are located on steep slopes, high landslide hazard locations and deep seated landslides

To prevent fill failures, road designs will provide for stable fills by using compaction, buttressing, subsurface drainage, rock facing or other effective means.

Road Drainage

Good road drainage is one of the most important features designed into a road. The prompt removal of water from the road prism will help avoid many problems related to road construction and maintenance. Water is a critical factor affecting:

- Subgrade load bearing capacity (poor subgrade strength results in potential rutting caused by traffic)
- Slope stability
- Stream sedimentation

It is inevitable that roads will intercept, interrupt and interact with natural water flow patterns. The management of this interaction between roads and water is critical to a successful road system. Establishing proper drainage of water from roads and passage of water through roads is one of the most important techniques to minimize adverse impacts on water quality and aquatic habitat.

Surface Drainage

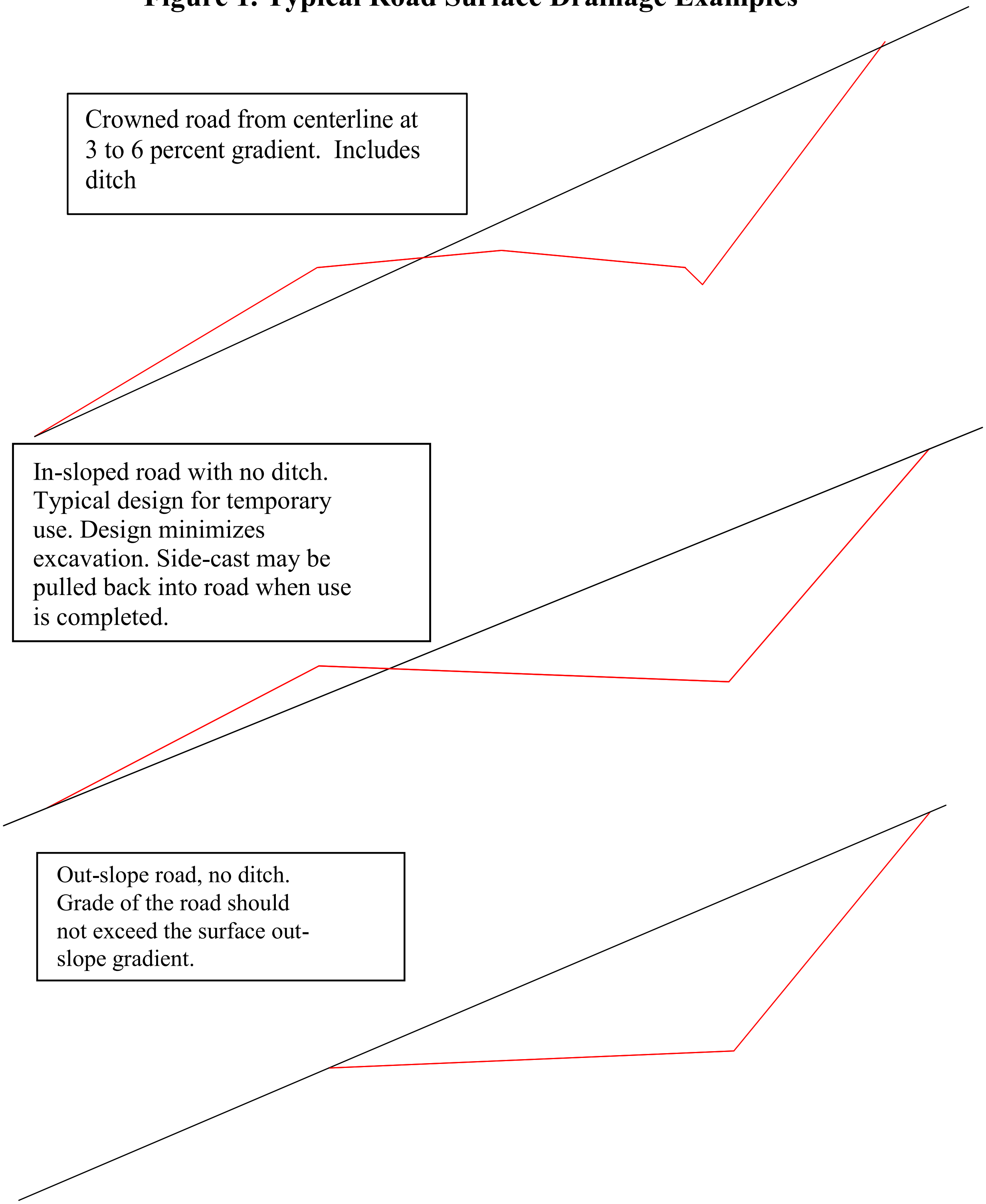
Good road surface drainage is important for keeping siltation to a minimum and to keep subgrades firm and stable to support the designed loads. Water intercepted by roads will be returned to natural flow processes as quickly as practical. Methods of achieving this are listed below.

1. **Subgrade shapes.** The running surface and subgrade must be shaped to move water off the road. Road surfaces will be crowned, in-sloped, or out-sloped for drainage. A "crowned road surface" is often preferred since it provides the shortest distance for

water to travel off the road (from centerline to either road edge). Out-sloped roads can save on excavation and material costs since there is no ditch or cross drain. Outsloping will generally be limited to roads with grades less than 8 percent unless they are temporary and will be closed or vacated after use. Water bars and water dips can also be used on temporary roads and spurs in lieu of a ditch. See “Figure 1. Typical Road Surface Drainage Examples" in this section.

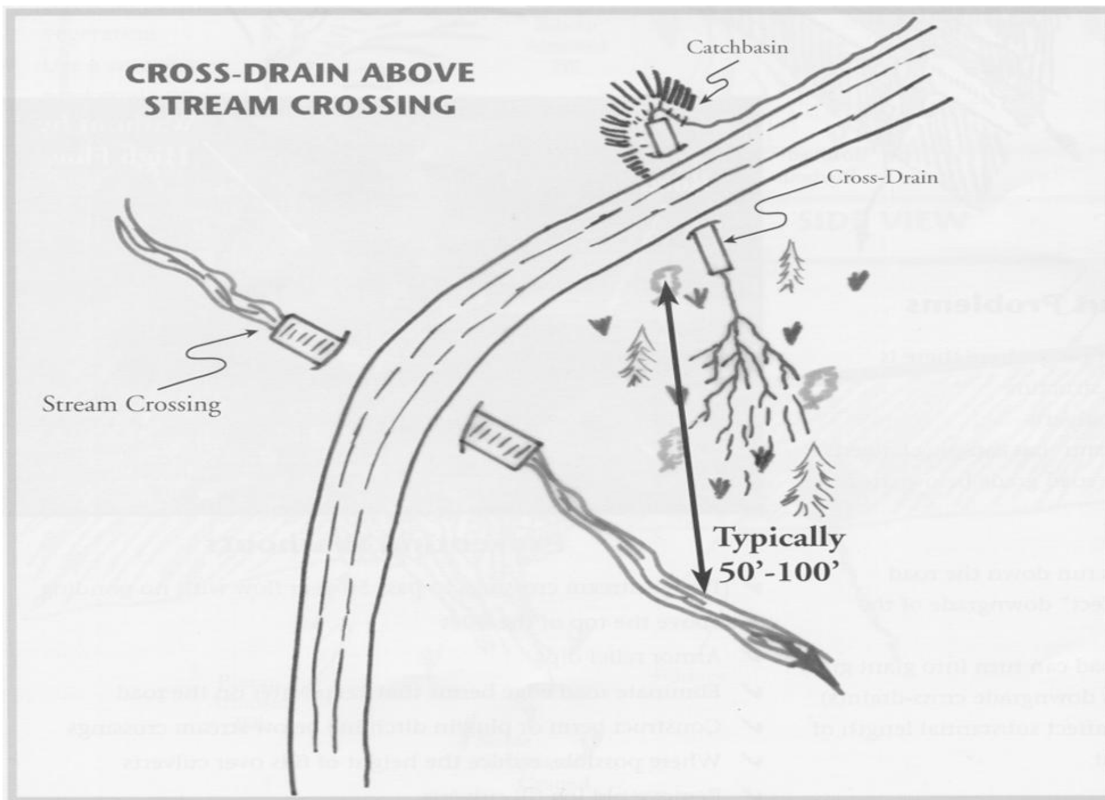
2. **Road Grades.** Road grades will be kept between 2% and 18% whenever possible. Flat grades will be avoided where possible; a minimum of 2% road grade will be favored to help to drain water out of the road prism. Steep grades above 15% should also be avoided. When steep grades are used, closer scrutiny of drainage for proper spacing of culverts, water bars, water dips, road grade reversals, and road surface maintenance is required.

Figure 1. Typical Road Surface Drainage Examples



3. **Drainage Structures.** A properly designed road will provide a drainage system using grade reversals, ditches, culverts, dips and/or water bars as necessary to effectively control and disperse surface water to minimize erosion of the road. Water will not be diverted from normal channels except as necessary to construct stream crossings. Drainage will be provided when roads cross or expose springs, seeps, or wet areas. Road drainage water should not be dispersed into headwalls, slide areas, or high landslide hazard locations.

Dips, water bars, or cross-drainage culverts should be located above and away from stream crossings so that road drainage water may be filtered before entering streams. Wherever possible, locate relief drainage 50 to 100 feet above stream crossings to eliminate the direct connection between road water and streams. The ditch-disconnect structure should be located in an area that will have at least 50 feet of filter distance to the stream.



Ditch relief culverts will be placed at appropriate distances and locations along roads to prevent large accumulations of water running down ditchlines and to prevent direct discharge of ditch water into streams. See "Table 1. Guide Table for Water Bar and Relief Culvert Spacing".

Table 1. Guide Table for Water Bar and Relief Culvert Spacing

Recommended Maximum Spacing in Feet of Lateral Drainage

ROAD GRADE in %	SOIL EROSION RATING*					
		High		Normal		Low
0-4%		800		1000		1500
5-9%		500		800		1000
10-14%		300		400		500
15-19%		200		300		400
over 19%		150		200		300

**High = Cohesionless fine-grained soil*
Normal = Sandy loam
Low = Rocky /gravelly soil

The table above will be used as a guide. The road designer should also examine other roads in the immediate area to find out how well ditches and existing culvert spacing are performing. If necessary, the spacing should be adjusted to fit the local conditions.

The smallest culvert used will be 18 inches in diameter. Culverts smaller than 18” plug easily and present maintenance problems. Smaller diameter culverts will only be used in temporary applications where the culvert will be removed at the end of the use of the road.

Culverts will be located away from high landslide hazard locations and deep seated landslides whenever possible, in order to disperse water on to stable locations (noses or ridges). When this is not possible, the geotechnical specialist will be consulted.

4. **Running surface.** The running surface of the road will be designed for the anticipated use. Rock surfacing can provide two important functions. First, a Layer of rock surfacing will help to spread vehicle tire loads over a larger area of the subgrade to help prevent rutting and subgrade failure. Secondly, a compacted layer of rock helps to seal the running surface, thus serving to move water away from the subgrade. Roads that will be open and used for hauling during wet weather will have rocked surfacing that will provide subgrade reinforcement and resist the erosive effects of water. Surfacing design is **found in Appendix 8** of this manual. There are a number of factors identified below that will influence the decision to use surfacing.

Advantages of rocking a road:

- Allows use of the road during wet periods
- Increases road subgrade strength, thus reducing the chance of wheel rutting during use.
- Provides a more stable, erosion resistant surface to the road, thus improving overall road drainage
- Provides base material (instead of dirt) that a grader can shape into a stable and longer lasting subgrade profile
- Reduces the amount of sedimentation produced by the road
- Reduces road maintenance needed to keep road performing properly
- Improves traction during wet weather
- All season access may increase the value of the area accessed for both commercial and non-commercial purposes. For example: reducing down time for wet weather could enhance the efficiency of a logging operation or a road could provide access for recreation throughout the year.

Disadvantages of rocking a road

- Cost, by far this is the single biggest factor - surfacing expense will often double the total cost of the road.
- May increase the cost to decommission the road in the future

Table 2 will be used as an aid in deciding when a road should be rocked and when it should not be rocked.

Table 2. Guidelines for Rocking a Road

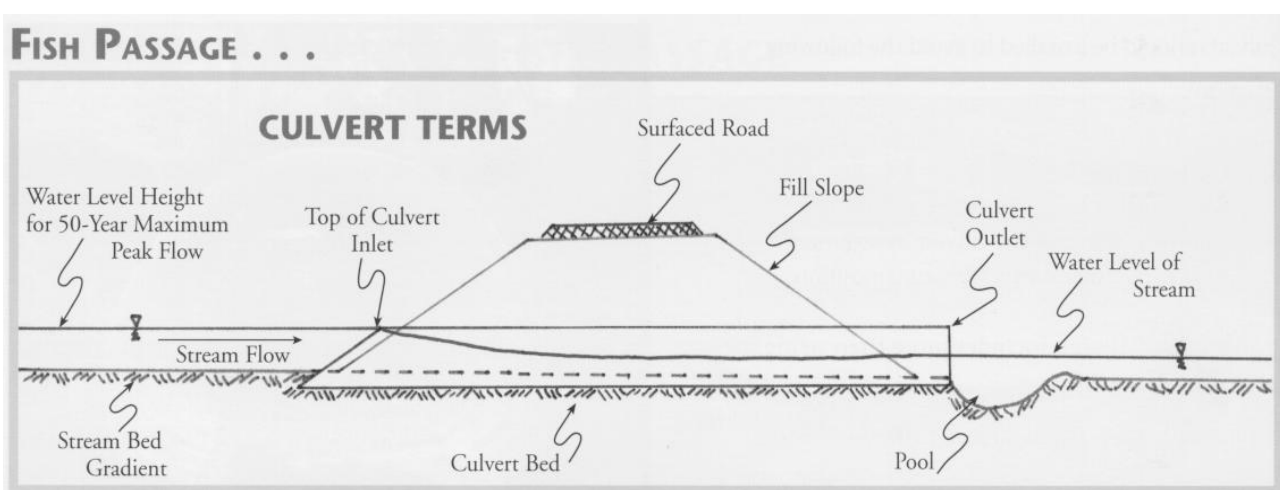
Factors "<u>for</u>" rocking the road	Factors for "<u>not</u>" rocking
Road is in a coastal or valley climate	Road is in a dry climate such as Eastern or Soputhwest Oregon
Soil type is weak and poor draining, prone to erosion	Well drained gravely soil
Grade of road is steep, any water will have potential to run down the road and erode the surface	Gentle road grade, less than 8%
Road is close to a stream and could deliver sediments easily	Road is not near streams and there are filtering opportunities for runoff from the road prior to entering a stream
	Road is located on a ridge or high on the hill slope and there is little risk of damage from sedimentation.
The road use is permanent and access is needed throughout the year.	This is a one time or one season road use that could be timed to occur during dry periods of the year
It is not practical or possible to close the road during un-needed periods	The road can be vacated or closed after short-term use.
Heavy use is planned for the road; several million board feet of timber will be hauled over the road.	Only a small amount of timber hauling anticipated on the road, part of one sale for example.
	Operations requiring this road could be shut down during wet periods and access to other parts of timber sale could be operated on at that time.
Rock is readily available and relatively inexpensive.	Rock is scarce, must be hauled long distances and is expensive to apply.
High use recreation area that would make it difficult to keep traffic off road during wet seasons.	Road can easily and effectively be blocked until weather permits use.

5. **Special Drainage.** Special drainage may be needed for areas containing springs or areas that have slope stability problems that are caused by subsurface water. The geotechnical specialist should be consulted for advice and assistance to design drainage structures that will help alleviate problems in these areas.

Design of Stream Crossing Structures

Stream crossing structures must protect aquatic and riparian habitats and provide fish passage, as well as preserve the stability and use of the road. The following requirements must be considered when designing stream crossings:

1. Streams will be kept in their natural channel and not diverted to crossing structures.
2. The number of acres in the drainage above the stream crossing structure will be determined from orthophotos, maps, aerial photography, or other comparable methods. This information is needed to determine the appropriate size for a stream crossing structure.
3. As a minimum, all new stream crossing installations or replacements of existing crossings will be sized to pass stream flow levels as predicted by the 50-year storm return interval. Oregon **Forest Practices Technical Note # 4** guidance provides a culvert-sizing design method that can be used for minimum design standards of stream crossings on state-owned forest lands.
4. Include design features that will minimize damage in the event the structure becomes plugged and fails. In many cases this is more effective than simply designing larger structures for larger storm events. Designed safety features may include some or all of the following:
    - Lowered fill heights to minimize back-watering effects and dam break floods.
    - Dips in the road, downgrade from the stream crossing, that would divert water off the road and onto the best available locations.
    - Armored fills at stream crossing and/or dip locations.
    - Overflow culverts
5. Road crossings over fish-bearing streams will be designed to allow fish passage. The design of stream crossings will follow the guidance in **Forest Practices Technical Notes 4 and 5.**
6. All permanent bridges will be designed and approved by a licensed civil engineer.



Temporary Road Design by Purchasers of Timber Sale Contracts

At times the purchaser of Department timber sale contracts will request and/or the Department will require that the purchaser locate, design, and construct temporary roads to facilitate the logging of Department of Forestry timber sales. This approach enables the purchaser to match road and landing locations with the planned yarding system. When this approach is used, the location and design of the roads and landings will be approved by the Department as part of the Operations Plan required by the timber sale contract. Roads and landings designed under this approach will meet all of the goals and objectives of this section of the manual. Variances from the procedures, standards and criteria set forth in this section of the manual must be approved the Department.

Since these roads are temporary, consideration will be given to vacating the road at the completion of use. If the Department does not need the road for management purposes (i.e. site preparation, reforestation, animal damage control, vegetation management, etc.), the Operations Plan should include the requirement for the purchaser to prepare the road for vacation. (See Section 8 on Forest Road Vacating)

Road Design by Easement Holders

At times adjacent landowners will be granted easements to construct roads across state-owned forest land in order to access their property. When these easements are granted, the Department will approve the location and design of the roads on state-owned forest land. The design of the roads will meet all of the procedures, criteria, and standards included in this section of the manual.

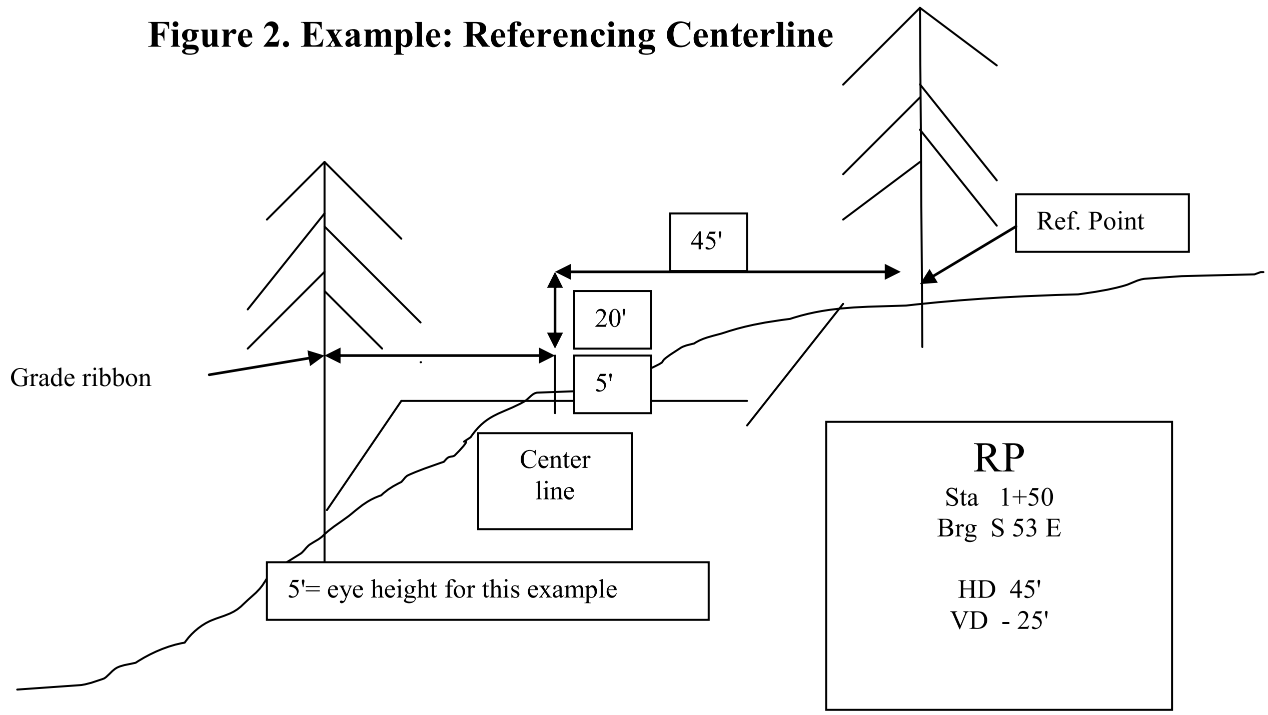
Road Construction

The design of a road construction or reconstruction/improvement project will include specifications that will minimize adverse impacts during the construction phase. Items to include are:

- Limiting construction activities to drier periods of the year, especially any activity involving exposed soil such as grubbing, excavation or grading.
- Curtailing activities on exposed soil during rain events, even when they occur during the dry season.
- Establish and maintain drainage throughout the construction phase.
- Take precautions to prevent siltation when rain is likely to occur. Precautions include hay bales, filter cloth, or other measures placed in ditch lines or other strategic locations to filter runoff water.
- When in-stream work is necessary, it should be accomplished during seasonal periods recommended by a fish biologist. A written plan is required by the Oregon Forest Practices Act and must be approved before working in a Type F (fish bearing) or Type D (domestic use) stream.
- Soils exposed by road construction or improvement that could enter streams will be seeded with grass or other vegetation to prevent erosion. These areas will be seeded at a time conducive to growing new grass and prior to the start of the wet season. Spring and fall periods are generally preferred for grass seeding.

Referencing Centerline Location Centerlines on new roads and road improvement projects are referenced so that the centerlines may be located at any time during or after construction. The number of reference points needed will vary and should be determined by the complexity and sensitivity of the project i.e. the more complex and/or the more sensitive the project, the more reference points that should be established.

Figure 2. Example: Referencing Centerline



A typical reference tag (4" aluminum tag) should have the following information or more if desired:

- Stationing.
- Bearing to centerline.
- Vertical and horizontal distance to centerline.

Reference spacing guidelines are:

- Slopes less than 50%: reference every 200 to 300 feet.
- Slopes greater than 50%: reference every 100 to 200 feet.
- Critical end haul areas: reference every 50 to 100 feet, or as needed.

The most common method of establishing road grade is to tie grade ribbons so that when your eyes are level with the ribbon your feet are on grade. In order to mark a reference tag you need to measure and calculate the following:

- Horizontal distance from tag to centerline.
- Vertical distance from tag to grade ribbon plus eye height.
- Bearing to centerline point and stationing.

The information on the reference tag will represent distances and bearings from the tag (not the ground) to the centerline of the designed road at the grade (ground) elevation.

Culvert Referencing

All culvert installations will be referenced with a 4" aluminum tag prior to the completion of road design work. The standard reference tag shall have the following information as a minimum:

- Structure description, i.e., "culvert".
- Stationing.
- Size of culvert, i.e., "18 x 24'

Optional information:

- Attachments such as 1/2 rounds.
- Horizontal and vertical distance to culvert inlet, outlet.
- Bearing to either end of culvert
- Skew angle of culvert.

It is also a good idea to paint culvert information on the tree in case the tag falls off.

Figure 5. Example: Culvert Tag

Culvert

18 X 24
Sta 23 + 50
Brg to inlet
S 43 E

HD 54'
VD 22'

Some surface drainage culvert locations are more apparent after the subgrade is constructed. The project administrator may relocate relief culverts in these instances.

Cut and Fill Slopes

The angle of the cut and fill slopes of a road can have a significant impact on the amount of ground taken up by the road and the stability of the hillside in the area around the road. The steeper the road slopes are, the less ground that is taken up by the road prism. The main problem with steep cut and fill slopes is that they can become unstable if they are constructed overly steep. The following table provides guidelines for cut and fills slope angles that will minimize slope instability and the foot print of the road on the hillside.

Table 3. Road Cut and Fill Slopes Angle Guidelines

Material	Compacted Fill Slope	Sidecast Fill Slope	Cut Slope
SOIL			
Silty sand No groundwater *High groundwater	 1.5:1 2:1	 2:1 3:1	 .75:1 1.5:1
Soft clay, silts	Variable		
Sandy gravel No groundwater *High groundwater	 1.5:1 1.75:1	 1.5:1 1.5:1	 .75:1 1.5:1
ROCK			
Solid – Fresh			**.25:1 to Vertical
Weathered – Stained			.25:1 to .75:1
Partially decomposed rock			.75:1 (with extra maintenance for ravel) 1.5:1 (slope with no ravel)
Cemented sands, silts, gravels			Vertical or .25:1

* May require special drainage, buttress, or other means of stabilization.

** With controlled blasting the back-slope will not shatter, and vertical slopes are usually the best design unless there is rock structure, bedding, jointing or fracturing which dips steeply out of the road cut. If this is the case, cut angle should be equal to the angle of the rock structure.

Contact the geotechnical specialist for "special problem rock slope design recommendations."

Landings and Turnouts

Landing size requirements vary with size and kind of equipment, log size, loader configuration (heel boom, front end, etc.), sorting situation, cold decking vs. hot decking, the possibility of skidding logs to a different loading area, yarding configuration, lead (square, straight, V), and other factors.

Landing size should be:

- Large enough to heel and swing logs without striking standing timber, rigging, or other equipment or objects. Operators will be directed to keep landings as small as possible. The maximum size should not exceed 1/5 acre.
- Long and level enough so that at least 2/3 of the longest bucked log to be yarded will rest on the ground. (Exception: this is not intended to restrict the yarding or loading of logs for poles piling, or an infrequent long break or tree length, provided the log is secured before unhooking the choker.)
- See figures 6 snd 7 (this section) for landing size examples.

Figure 6. Example of Road Bed Used as Landing

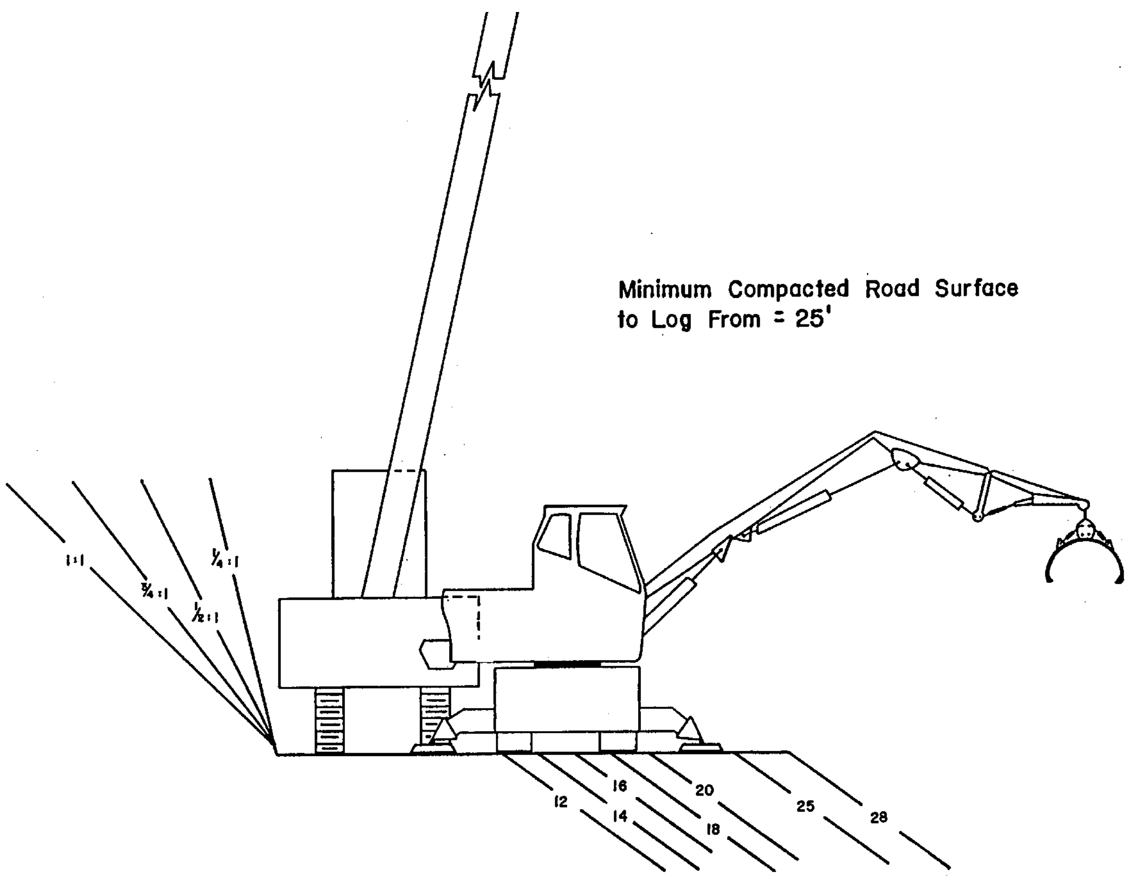
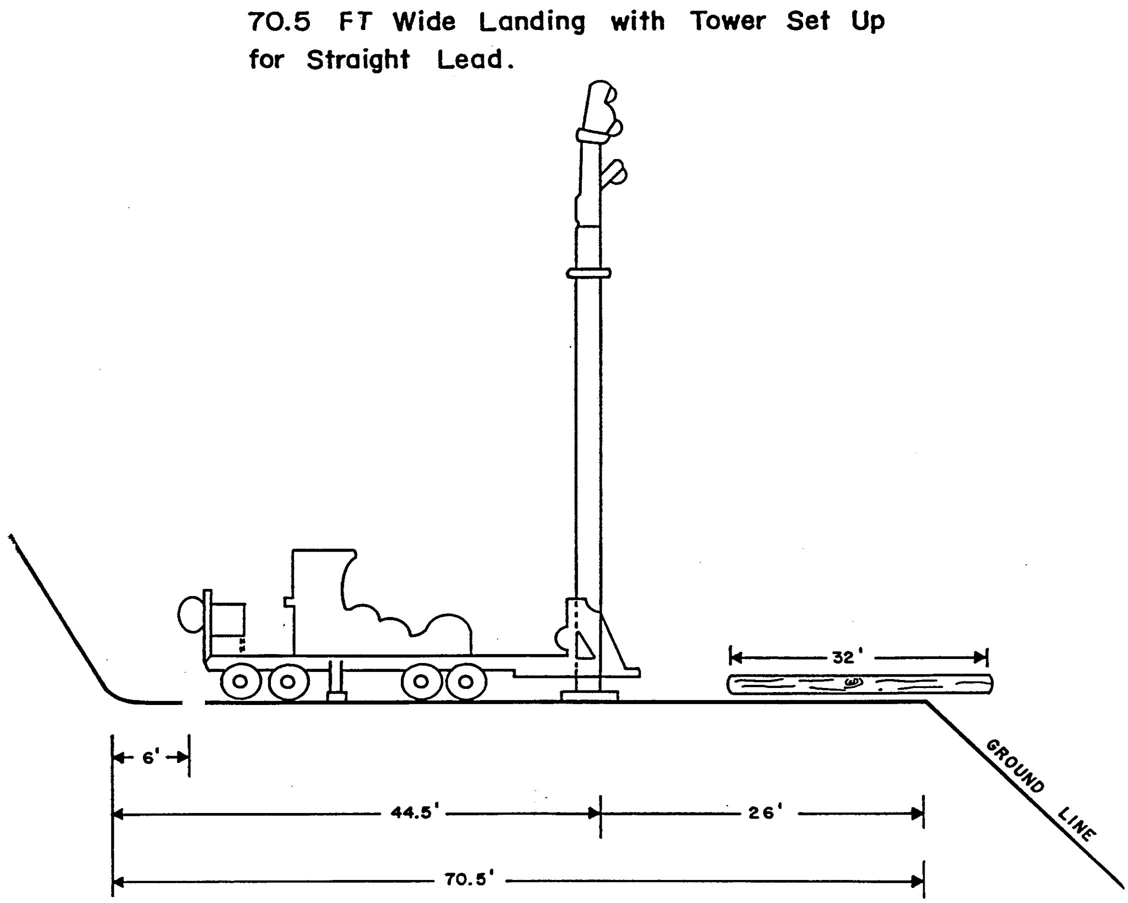


Figure 7. Example of Landing for Large Yarder



Landing construction should be:

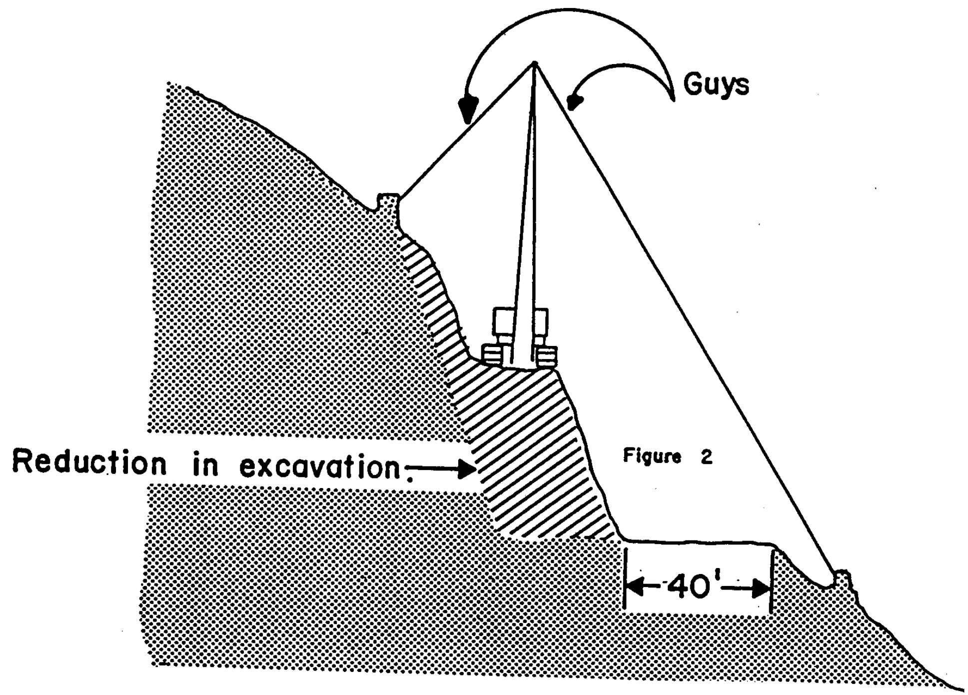
- Reasonably level but with enough slope to provide drainage. Maximum slope should not exceed 8 %.

  Usually an empty log truck ready for loading can start on about a 6 % grade, on a good crushed rock surface. If the truck has to maneuver on a steep grade, assistance may be needed.

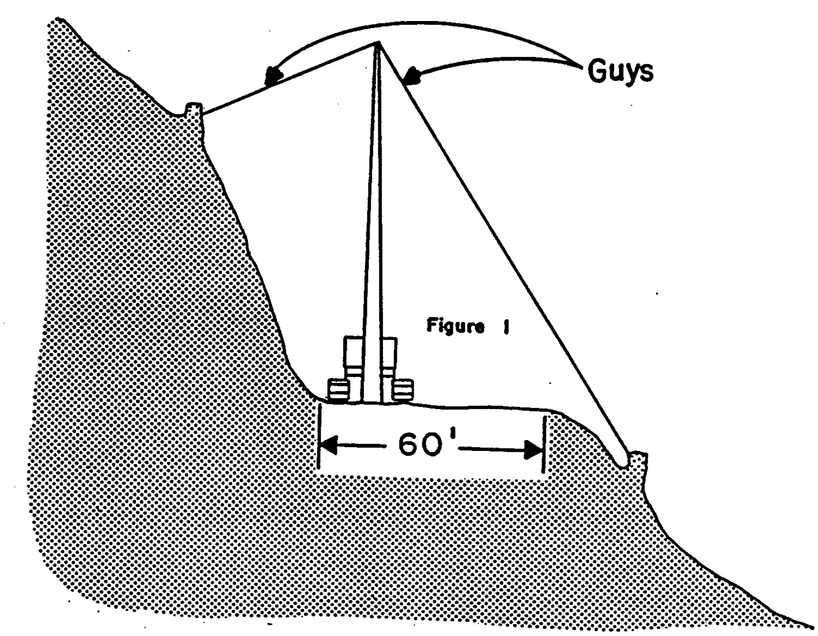
- The slope in log chute areas can be up to 20 % if logs are decked perpendicular to slope. High decks will require flatter areas.

- Split-level construction can often save up to half the excavation required for a single level landing. See Figures 8 and 9 this section for example of split-level landing construction.

Figure 8. & Figure 9.



SPLIT LEVEL UPHILL SETUP



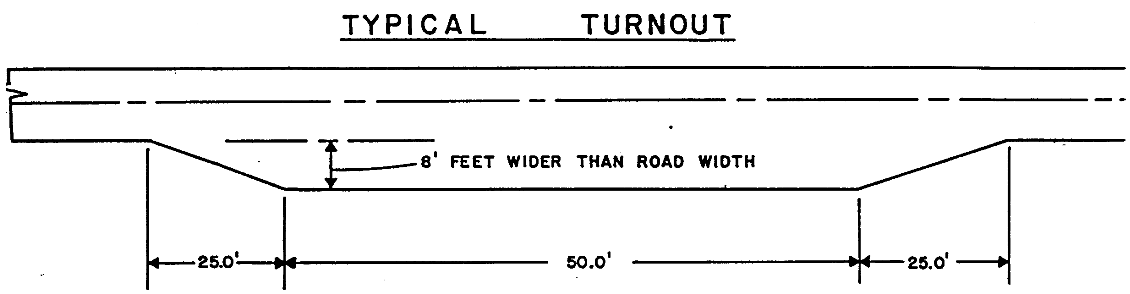
NORMAL UPHILL SETUP

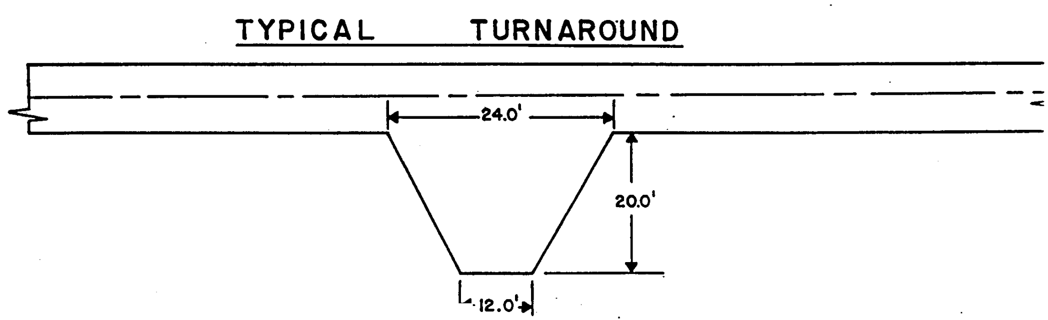
- Cut and fill construction can save excavation, but avoid landing fills on slopes over 50 % because of the likelihood for these fills to become overhangs of mixed dirt and slash during use. Such overhangs may slide out years after use, causing soil and stream damage below. Consider end hauling the clearing and grubbing debris around landings where slopes are 50% or greater, due to the slope instability potential and safety hazard for the loggers working below the landing. Do not place landing fill on slopes over 65%.

Turnouts are to be intervisible with a maximum road distance of 750 feet between turnouts on mainline roads. Turnouts on shorter spur roads may be placed where the terrain allows. Since speeds are reduced on spur roads and most logging operations now use CBs it is not as important that turnouts be intervisible. They should be at least 8 feet in width and 50 feet long with a 25-foot transition at each end. (See Figure 10 for diagram of typical turnout and Figure 11 for diagram of typical turnaround

Figure 10. & Figure 11.

LOGGING ROAD SPECIFICATIONS.





Curve Widening

The rear wheels of most vehicles will not track in the same path as the front wheels when traveling around a curve. This is called off-tracking. Extra subgrade and surfacing width may be necessary on the inside of the curve to accommodate the off tracking of the rear wheels. The amount of curve widening needed depends on the type of vehicle, the original subgrade width, the radius of the curve, and the central angle of the curve.

There are three critical types of vehicles that travel forest roads that may be impacted by curve width: the log truck, the logging yarder (on wheels), and the lowboy truck and trailer. The standard log truck tracks the best of these three, due to the configuration of the truck utilizing a stinger as the attachment point for the trailer. The logging yarder does not track as well as a log truck, due to its longer wheelbase. Finally, the lowboy truck will not track as well as the yarder, due to the long wheelbase of the truck and the longer wheelbase of the trailer. The trailer-mounted yarder pulled by a truck will usually off-track somewhere between the lowboy and self-propelled yarder. Sometimes yarders can be moved around corners with crawler tractors or other assist vehicles, which could improve their tracking ability on a temporary basis.

Since roads on state-owned forest land are designed as logging roads and not highways, not every factor will be evaluated in calculating extra curve width. The rule of thumb below, while not exact, will provide adequate curve width for the following vehicles.

Log Trucks and Yarders

Rule of Thumb: 400 divided by the radius = additional curve width

For a narrow subgrade (under 16 ft.), additional widening may be necessary, since the margin of safety or error for off-tracking on a narrow road would be less than on a wider subgrade. The amount of subgrade width less than 16' will be added on to the curve-widening formula as shown below.

Rule of Thumb: (400 ÷ Radius) + (16'- subgrade width) = additional curve width

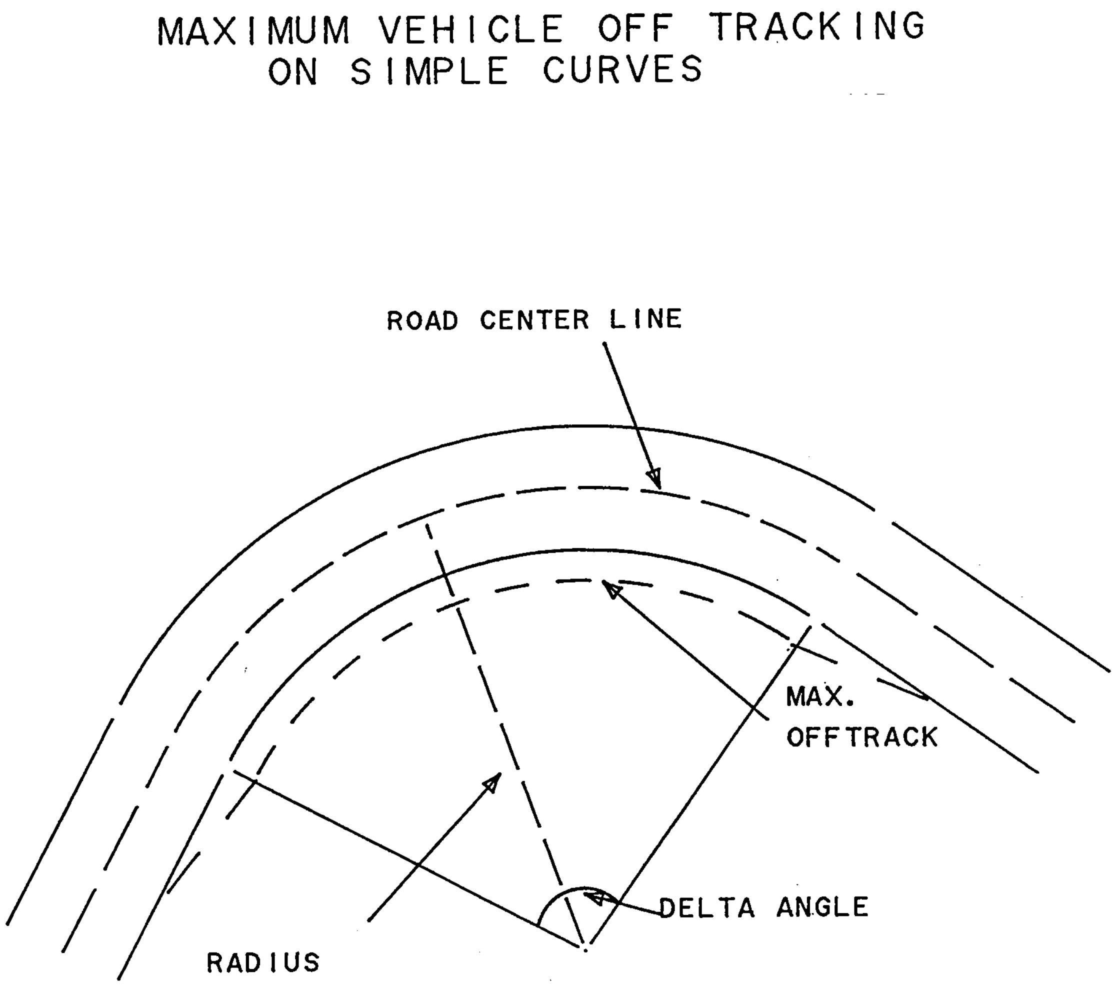
Lowboy Truck and Trailer

See Appendix 2 for Maximum Vehicle Off-Tracking for lowboy trailer (36'). The amount of off-tracking equals the amount of curve widening needed.

Good judgement and engineering skills must be used to design roads when vehicles with long overhangs will be traveling around curves. A vehicle such as a yarder with the tower down and traveling around a curve may have clearance problems with the cut-slope on the outside of the curve. This is particularly problematic for narrow roads with vertical cut-banks in solid rock.

Note: curve widening is normally added to the inside of the curve. If curve widening is to be put on the outside of the curve, the radius of the curve is effectively changed and the amount of road width needed for that radius curve will be calculated.

Figure 12.


MAXIMUM VEHICLE OFF TRACKING
ON SIMPLE CURVES
ROAD CENTER LINE
MAX.
OFFTRACK
DELTA ANGLE
RADIUS

Maximum Vehicle Off-tracking on Simple Curves

Maximum Vehicle Off tracking

On Simple Curves

Vehicle: 36 ft. Lowboy Trailer

Curve Rad. (ft)	Delta angle (deg.)	Off Track in ft.
50	10	2
50	20	4
50	30	5
50	40	7
50	60	9
50	80	11
50	120	13
50	180	14

Curve Rad. (ft)	Delta angle (deg.)	Off Track in ft.
60	10	2
60	20	4
60	30	5
60	40	7
60	60	8
60	80	10
60	120	11
60	180	12

Curve Rad. (ft)	Delta angle (deg.)	Off Track in ft.
70	10	2
70	20	4
70	30	5
70	40	6
70	60	8
70	80	9
70	120	10
70	180	10

Maximum Vehicle Offtracking

On Simple Curves

Vehicle: 21 ft. BU-199 Yarder (self propelled)

Curve Rad. (ft)	Delta angle (deg.)	Off Track in ft.
50	10	1
50	20	2
50	30	3
50	50	4
50	90	4
50	180	5

Curve Rad. (ft)	Delta angle (deg.)	Off Track in ft.
60	10	1
60	20	2
60	40	3
60	70	4
60	180	4

Curve Rad. (ft)	Delta angle (deg.)	Off Track in ft.
70	10	1
70	20	2
70	40	3
70	**180**	**3**

Forest Road Construction

Introduction

During the construction phase of a road project, the planning and design decisions that were made earlier are carried out on the ground to achieve the desired road standard in a way that is efficient and effective and results in minimal impact to the environment. Each phase of road construction will be conducted according to the formulated plans, unless exceptions are approved by the appropriate supervisor. Poor execution of plans, no matter how well designed, can result in a poorly constructed road that may have a serious impact on the environment. Untrained project administrators or unskilled operators most often are the cause for poor execution of plans. Thus, the skill and experience of administrators and equipment operators selected to complete the road project will play a key part in determining its success.

Plans and designs may need to be modified during construction as changing conditions are encountered in the field. Experienced administrators and equipment operators can accomplish minor changes in the proposed work in the field. However, substantial changes in road design will be made only by qualified personnel and through the proper procedures and approval processes for contract modifications.

Goals of Road Construction

1. Construct roads that will become an efficient and effective part of the overall transportation system by constructing them according to the plans and design specifications and using the best management practices for road construction.
2. Protect water quality, aquatic habitat and other natural resources.

Objectives of Road Construction

1. Construct roads according to design.
2. Minimize soil disturbance during road construction.
3. Minimize impacts to water quality during construction.
4. Minimize impacts to aquatic and terrestrial wildlife habitats.
5. Make on-the-ground decisions and/or changes to the road design specifications that react to unforeseen conditions during road construction in a manner that will achieve the goals of the project. Professional level expertise and input will be utilized in the formation of the decisions and/or changes.

Road Construction Strategies

Road construction strategies are the specific actions and standards that will lead to achieving the goals and objectives of this section of the manual.

Timing

While planning, design and field reconnaissance work can be conducted at any time of year, the timing of each phase of road construction is critical to completing a successful project. Roads must be constructed during the time of year when the best results can be achieved with the least damage to the environment. For example, scheduling road construction on steep slopes during the drier months can be an effective erosion control measure.

The best time for conducting each of the road-building activities (clearing, grubbing, excavation and grading, compaction, stream crossing installation and surfacing) varies.

Some clearing (cutting and removal of trees and brush from the right-of-way*)* can be performed during wetter weather. However, it must be conducted in a manner that does not result in large amounts of bare soil being exposed to surface erosion and/or the soil is not subjected to rutting, puddling or other damage. The clearing of shrubs, low vegetation and organic material from the soil surface should be delayed until the threat of erosion from the disturbed areas is minimal.

Grubbing (the removal stumps and protruding objects) will result in significant exposure of the soil surface and should be performed only when the threat of erosion from the disturbed areas is minimal.

Grading (the excavation and creation of the road bench) creates large expanses of bare soil, and should therefore be performed only during dry spring, summer or early fall conditions.

Soils require an optimum moisture content to achieve the proper compaction of fill materials used in stream crossings, landings, and along cut-and-fill road benches. Rocky, coarse-textured soils may be compacted under a relatively wide range of moisture content. On the other hand, fine textured soils that are overly dry or very wet often cannot be compacted enough to produce the soil strength needed to support loaded trucks or to remain stable on steep slopes. If the soils are too wet, they should be allowed to dry, and if they are too dry, they should be watered to achieve adequate compaction. An experienced engineer or geotechnical specialist can recognize improper soil moisture conditions by using simple field tests. They should be consulted whenever soil moisture conditions are in question.

The timing of a stream crossing installation is critical to maintaining and protecting water quality. Timing is also important to fisheries in many watersheds. Work should be performed as quickly as possible during the dry period of summer, when streamflows are at a minimum (or the channel has dried up) and there will be minimal soil disturbance and risk of sedimentation. An ODFW Fish Biologist will be consulted for the proper time to construct stream crossings across fish bearing streams.

All road construction activities, including the installation of stream crossings and erosion control work, will be scheduled for completion before the onset of the rainy period, which is usually around the middle of October. Final grading and proper installation of road drainage structures are critical to keeping erosion from the new road to a minimum during the first winter. Likewise, all temporary stream crossings must be removed, and all erosion control measures installed before the winter begins.

The Oregon Forest Practices Act’s rules and guidance, Department of Forestry biologists and Geotechnical Specialists, Oregon Department of Fish and Wildlife (ODFW) biologists, or other sources will be consulted for timing guidelines related to road construction, particularly as they pertain to streams, threatened and endangered wild life species, or other sensitive resources. These guidelines will be used wherever they are applicable.

Clearing and Grubbing

One of the first steps in forest road construction is clearing and grubbing. The method of disposal of clearing debris is important to the future stability of the road. The clearing debris must be removed from the area of the road prism to eliminate the bridging effect that occurs when dirt is deposited against the debris. This also eliminates a safety hazard to anyone working below the road.

The clearing and grubbing method used will be consistent with good safety and environmental practices while keeping construction costs to a minimum.

Depending upon the design standard that was used, the road centerline and/or the cut and fill staking should be marked on the ground prior to clearing.

The upslope and downslope boundaries of the right-of-way should be marked prior to clearing and grubbing. The boundaries will provide the minimum width needed to construct the desired road. This will help prevent over-clearing or under-clearing. The lower boundary will be located at the base of the fillslope. The upper boundary will be located at the top of the cut slope plus enough distance to assure that the root systems of remaining trees will not be damaged by the excavation of the road prism.

Clearing. Trees and other large vegetation within the right-of-way boundaries should be felled and bucked. In addition hazardous snags and unsafe trees adjacent to the right-of-way should also be felled at this time.

Merchantable logs should be yarded to decking areas that will not interfere with the construction of the road or turnouts. Unmerchantable material should be disposed of according to the design specifications and follow the guidance listed later in this section.

Grubbing. During grubbing of the surface, all stumps and protruding objects should be removed from within the road prism, and anywhere fill or sidecast material will be deposited. Stumps overhanging the top of cut banks should also be removed. Stumps and other large organic debris in the road fill should never be left in the road prism because the voids that form when the wood decomposes will affect the stability of the fill. All chunks, logs and slash over approximately 3 inches in diameter and 3 feet in length should be removed and disposed of outside of the road prism. Small amounts of miscellaneous fine slash and small limbs are usually not a problem if they are scattered throughout the road prism and not left in concentrations.

On slopes over 35 percent in gradient, the organic layer (duff) on the soil surface should be substantially disturbed or removed prior to fill placement or sidecasting. If substantial amounts of this material are left in place, the material can create a slip plane for fill or sidecast failure when it decomposes.

Options for Disposal of Clearing and Grubbing Debris

There are several options for disposing of clearing and grubbing debris. Oftentimes contract specifications or the road design will indicate the option that will be used. If an option is not specified, the one that is chosen should match the road design and the on-site conditions.

1. **Sidecast.** This is very common and usually the most economical technique used for forest road construction. Clearing debris is pushed outside of the road prism a minimum of 5 feet from the top and bottom of cut and fill slopes. It is very important that clearing debris not be incorporated into any sidecast or fill material supporting the road. Clearing debris that is sidecast on steep ground is difficult to control and can create a safety hazard for logging crews that may be working below the road at a later time. Stumps and logs could become dislodged and roll down the hill during the logging operation. Sidecasting will be limited to slopes less than 55%. Clearing debris should not be left lodged against standing trees.

2. **Scattering.** Debris is pushed or placed outside the right-of-way where natural openings in the stand exist, provided that:

    a. Debris is not pushed against trees.

    b. Tops and limbs are lopped to lie flat on the ground.

    c. Excessive accumulations do not result.

    Scattering should be limited to slopes less than 55% for safety and economic reasons. Scattering should also be limited to stands that are open enough to facilitate this technique (e.g., dense reproduction and very thick hemlock stands are not conducive to scattering.)

3. **Pile and Burn.** Right-of-way debris is piled in clean, burnable piles within portions of the right-of-way, or at locations approved by the project administrator and burned. The burning may take place prior to, during, or after subgrade construction, depending on the situation. Right-of-way debris should be burned so that there is no residual material greater than 3 inches in diameter and 3 feet in length. Material remaining after burning should be buried or scattered. Burning should be required when other options are not suitable, the clearing debris must be removed from the right-of-way and there are no waste areas for the debris available within a reasonable distance.

4. **End-haul.** Right-of-way debris is pulled, pushed and/or loaded and hauled to a designated waste area. End-hauling of clearing and grubbing debris should be considered where sideslopes are greater than 55%. It may be more economical to dispose of the limbs, tops and other small debris using another option such as chipping and only require the end-haul of the larger debris such as stumps and cull logs.

5. **Chipping and dispersal.** Right-of-way debris is fed through a chipper and chips are dispersed through openings in the trees in layers less than 36 inches thick. This method works well in thick-growing young trees (less than about 14" in diameter) where there is limited room for scattering debris and the average size of the clearing and grubbing debris is small enough to be chipped.

Balanced Cut and Fill (BCF) Construction

In BCF construction, the dozer starts at the top of the proposed cutslope, excavating and sidecasting material until the desired road grade and width is obtained. Material is pushed or "drifted" in front of the blade to areas where fill is needed. Road fill is used to cover culverts and build up flat or low areas along the alignment. Since fill must support traffic, it needs to be spread and compacted as much as is possible to develop sufficient strength. Unfortunately, this common method of BCF road construction does not always lend itself to standard compaction methods, where fill is placed and compacted in thin layers. Therefore, additional compaction should be required in areas where the stability of fills is important such as adjacent to streams and/or where required in the design specifications of the project.

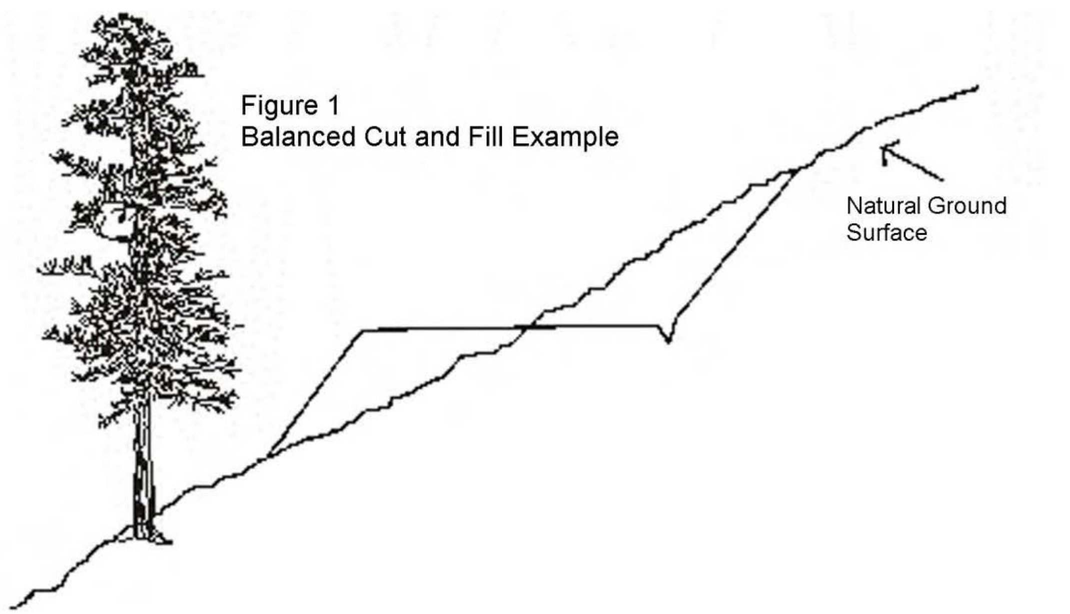


Figure 1
Balanced Cut and Fill Example

In BCF construction, some of the waste material moves down the slope below the final roadbed and cannot be adequately compacted or contained. For this reason, BCF construction methods are <u>not</u> suitable on steep slopes (over 55%) or moderate slopes (40% - 55%) that are near streams where uncompacted material could become saturated during wet weather and move downslope.

During BCF construction, it is critical to avoid letting sidecast or waste material enter streams or placing it where it could erode and be delivered to a watercourse.

A good rule-of-thumb is not to sidecast on slopes of over 55%.

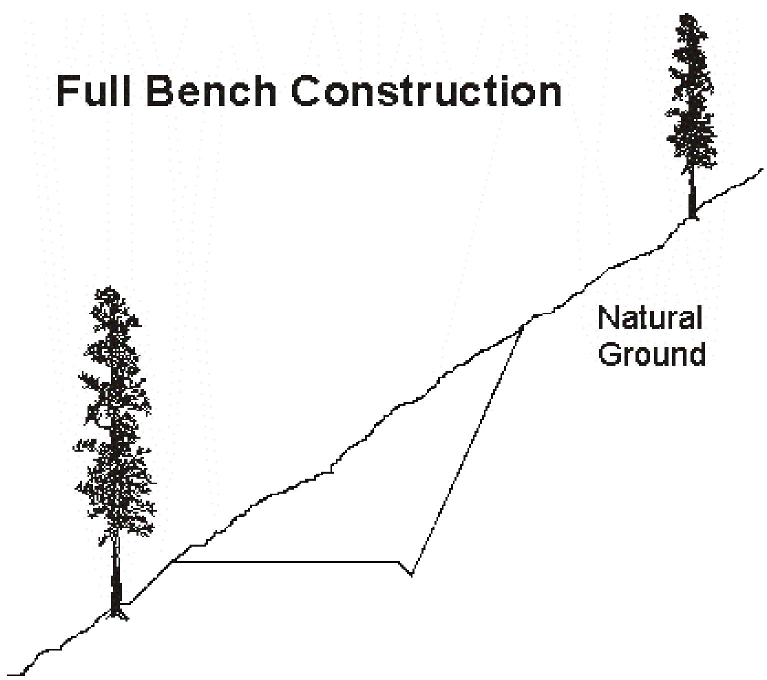
On moderate slopes (<45%) sidecast material should not exceed five feet in depth (measured vertical to the original slope). A more protective method of BCF construction is gaining popularity with many road builders. This method utilizes a hydraulic excavator, instead of a dozer, to pioneer the road bench. The excavator is able to cleanly remove slash, stumps and logs and place them at the base of the fillslope so they are not incorporated in the fill. It then grubs or cleans off the organic layer, excavates mineral soil and places it bucket by bucket, beginning at the base of the slope. The powerful hydraulic systems of large excavators permit them to partially compact the fill as it is placed. Waste material carefully placed using this method is more stable and less susceptible to failure than material that is pushed or sidecast by a dozer. Excavators can be used to place free draining fills on natural slopes as steep as 60 percent in some cases. Excavators can carefully set large angular rocks to make stable fill slopes in some cases as steep as 1:1.

Full Bench Construction

Full bench construction typically involves excavation of the roadbed using a hydraulic excavator. A bench is cut into the rock or soil equal to the width of the road plus the width of any ditch that may be required. Normally, no material is sidecast, and excavated waste is used to fill low areas or stream crossings along the road alignment. Usually, only a very minor amount can be safely drifted down the road and compacted on the road bench or feathered over the edge. The most efficient use of the excavated waste is to construct road fills such as in saddles, fills over culverts, or other BCF sections of the road. Excess material can be hauled off-site to a stable storage location.

Full bench road construction is typically reserved for slopes over 55%, or where a road approaches or parallels a stream channel that could be impacted by sidecasting excess material.

Figure 2.



Endhauling of waste material can be expensive, and full bench construction can cost four to seven times more than balanced cut and fill methods. However, full bench road construction on steep slopes without endhauling is very likely to result in sidecast material failing on many sites, with the resultant impacts to downslope stream channels.

Full bench roads often result in tall cut slopes. Several rock and soil types may not support these large cut slopes. Unstable rock, rock structure, including soft or highly fractured sedimentary rocks may not be suitable for full-bench cuts. Cut slopes in these areas can remove critical support at the toe of the natural slope and initiate upslope failure. Silt clays and other unstable earth materials may be unsuitable for tall cut slopes. Special design features must be considered when cut slopes exceed 20 feet in vertical height in these areas. It may not be feasible or possible to build the road where slopes are steep and the rock or soil material is weak. In these cases, alternative road locations should be considered.

Waste material should be endhauled and placed at a stable location. Rock pits, wide stable sections of roads, ridges, benches, and the inside edges of landings are typical locations where waste material can be stored. Sites judged to be of uncertain stability should be reviewed by a geotechnical specialist before they are used. Those sites where emerging ground water, thick organic layers, unstable geology, or other instability factors are present could experience slope failure after loading and should not be used.

In most situations, endhaul material is loaded directly into dump trucks by the excavator and hauled to the storage site, where it is spread in layers that can be reworked by a dozer. In some cases, dozers can economically carry (push) waste material to stable storage sites for distances up to 200 feet. The resulting waste pile at the storage site should generally conform to the local topography to provide for natural drainage, and should be mulched and planted with vegetation to control erosion.

Construction on Marginally Stable Slopes

Marginally stable slopes are areas where, because of steepness, geologic conditions and/or hydrologic conditions, improper road construction could cause landslides to occur. Construction in these areas should only be done after the road is carefully located and designed by qualified personnel, such as forest engineers and geotechnical specialists. The operator performing the construction should know and understand all of the design specifications prior to beginning any work.

Road construction on marginally stable slopes may require techniques as simple as full bench end-haul or as complex as a project requiring a large rock buttress keyed into bedrock. Each area will require a unique design that meets the conditions in that area. Therefore, it is beyond the scope of this manual to define all of the design and construction techniques for these areas. However, the following should be considered during the construction phase of these projects:

- Does the design show that slope stakes have been set in the field? If yes, have they been located?
- Does the design show that reference tags have been set in the field? If yes, have they been located?

- Does everyone responsible for the construction of the project have a copy of the design? If yes, does everyone understand the design?
- Does the design specify special equipment? If yes, is the equipment on the site?
- Does the design specify special materials? If yes, are the materials on the site or readily available?
- Does the design specify a certain time of year or other conditions (such as weather)? If yes, is the time of year appropriate and are the conditions being met?
- Does the design specify the use of unusual construction techniques or practices? If so, does everyone have the knowledge, skills, and abilities to perform the techniques or practices?

If the answer to any of the above questions is no, the construction should not proceed until the answer is yes, or there are justifiable reasons for the answer to be no.

The questions above are not a complete list. More could be asked, depending upon the project. The above list of questions is intended to illustrate and to emphasize the importance of constructing projects on marginally stable slopes according to design specifications.

Grading and Compaction

Most forest roads are built by excavating a roadbed out of naturally sloping ground. Grading is the process of excavating and/or filling the subgrade to final grade. Thus, grading is when the bulk of soil excavation and disturbance occurs. For a given road width, the steeper the ground the greater will be the volume of soil that is excavated or displaced during road construction. Road design and layout (flagging, staking and/or reference points on the ground, together with plans, maps and/or design specifications) show equipment operators the correct alignment and the proper cut slope angle and height to be developed along the new road. Operators may be asked to either construct roads using BCF construction methods on gentle terrain, to use cut-and-fill (with true compaction) on moderate slopes, or to employ full bench construction techniques on steep slopes or where the road is near stream channels.

The methods of compaction and where they are to be applied should be specified in the road design specifications. The importance of compacting excavated material cannot be over-emphasized. The specifications for compaction may be as simple as using loaded rock trucks or crawler tractors, or may require special equipment such as vibratory rollers, vibratory compactors, and grid rollers. Always consult the design for compaction methods and specifications.

Subgrade and Surfacing

<u>Before</u> surfacing the road:
The condition of the subgrade is critical to the performance of the road surfacing. The shape of the subgrade plays a central roll in providing road drainage. Do not rely on producing the surface shape (crowned, insloped or outsloped) of the road by shaping the rock surfacing alone. The ditch, if required, should be shaped and clear prior to applying surfacing. The subgrade should be at or near the optimum moisture content for compaction and then shaped and compacted prior to rocking.

<u>During</u> the rocking project:
Process the rock as specified by the contract. It will enhance performance of the road surfacing. Proper mixing, watering, shaping and compaction of the rock should be done to allow the surface rock to set up correctly.

There are several rocking accountability methods available to assure that operators comply with project requirements. Rock is a very valuable resource and accounting for the volume and quality of rock is important to make sure the State gets its value.

The "depth measurement" method works well when is it easy to verify the new surfacing from the existing road surface. Un-surfaced roads and roads that will be re-surfaced with a continuous new lift of rock are good candidates for depth measurement. Rock spikes driven into the surfacing or digging test holes in the surfacing and measuring depth can be utilized. Re-surfacing projects that are applying very thin rock lifts or spot-rock are not good candidates to be measured by depth, due to the varying road segment lengths and depths of rock of road being surfaced. An advantage of depth measurement is that it does not require that some one monitor the project 100% of the time. Depth measurement may be performed during and at completion of road rocking.

"Rock checking" works well for many types of rocking projects. Rock can be placed where needed only. Rock checkers can direct or monitor the rocking project. Rock checkers track the number of loads of rock and make sure trucks are full. The main drawback with this method is that it is labor intensive and rock checkers are not always available when they are needed.

"Rock Load Receipts" can work if rock is purchased from commercial sources and the other two methods are not suitable for accountability. The provider of the rock submits the number of loads of rock provided for the project. One disadvantage is that the state has little control over the volume of rock in each load.

Erosion Control

Soil erosion and stream sedimentation can occur during and following road construction. Some erosion is the result of poor road location and design, but some clearly occurs as a result of the road construction phase. Proper construction practices will reduce erosion and stream sedimentation. However, even when roads are properly located, designed and constructed, they will still need erosion control measures to minimize soil loss and sediment production.

Both mechanical and vegetative measures are needed to minimize erosion from roads and landings under construction. As mentioned in the design section; effective erosion prevention is also achieved through proper road design and location, preplanning of cuts and fills, minimizing soil exposure, compacting fills, endhauling loose fill materials from steep slopes and streamside areas, developing stable cut and fillslopes, mulching to control surface erosion for the first year. Seeding and planting will provide for longer-term erosion prevention.

Perhaps the best tool for preventing erosion is to keep vegetation removal and soil disturbance to an absolute minimum during construction. Clearing and grubbing should be limited to the minimum needed to construct the road prism. Cuts and fills on gentle and moderate slopes should be balanced to minimize the amount of excavation and soil exposure.

Most construction activities should be conducted during the dry season. Even during the dry season, construction activities should be suspended if rainy weather is occurring. Soils that are saturated with water and would become muddy when disturbed should be allowed to drain before construction resumes.

All road drainage structures (ditches, outsloping, culverts, waterbars, dips, etc.) should be in place as soon as possible during the construction of the road. In any event they must be in place before the start of the rainy season. Surface water drainage must also be provided for sites associated with road construction such as waste areas, borrow areas and rock pits. All drainage water should be filtered through natural vegetation before it enters streams.

Construction of roads near running water may require silt fences, hay dams or other filtration methods in ditches and streams to prevent eroded material from getting into the water. These structures should be put in place as soon as possible during road construction.

Areas of bare soil, which could deliver sediment to waters of the state, should be mulched and/or seeded before the start of the rainy season. This includes unsurfaced road grades, cut slopes, fill slopes, waste areas, borrow areas, and rock pits.

When the road construction project is partially completed at the start of the rainy period (mid-October), the project should be left in a condition that will minimize erosion and the sedimentation of streams during the rainy period. Drainage measures should be performed on uncompleted subgrades such as smoothing the surface, outsloping, waterbarring, and installing dips. Mulching and/or grass seeding should be done on all cut and fill slopes that are completed and on any other areas of bare soil where erosion and sedimentation could affect water quality. Silt fences and/or hay dams should be used near streams to prevent sedimentation. The road should be barricaded to prevent unauthorized use.

Shallow failures or small slumps on the cut slope or fill slope should be repaired and stabilized. Where the material is blocking a ditch, it should be excavated and removed. Where fill slopes are indicating failure, the fill material may need to excavated and end hauled to a waste area site. To prevent further failure or slumping of cut or fill slopes, rock buttressing or retaining walls may be needed. A geotechnical specialist or engineer should be consulted if these measures are needed.

Road Improvement

Introduction

As used in this section, road improvement means the repair and/or upgrade of existing roads. Road improvement is distinguished from road maintenance by the nature and extent of the work. Road improvement includes changes to road alignment, subgrade widening, significant repair/upgrade of road surfacing, repair/replacement of stream crossings, repair/replacement of drainage structures, and repair/removal of unstable material. Road maintenance includes routine shaping of the road surface, cleaning and maintenance of drainage structures, spot treatment/repair of road surfaces, and vegetation control alongside roads.

Conditions commonly leading to a road improvement project:

- Road subgrades, alignments and/or surfacing need to be upgraded to meet current or future transportation needs.
- Fill slopes with old sidecast material are at risk of failure.
- Cut slopes show signs of failure
- Road fills are showing signs of failure
- Drainage structures are in need of repair, upgrading, or replacing.
- Stream crossings are in need of repair, upgrading, or replacing.
- Unsafe conditions in the transportation system must be repaired.
- Other unsatisfactory conditions are in need of repair.

Road improvement provides an opportunity to upgrade, improve, or repair a road that is substandard in one or more of its design elements. Improvements may include, but not be limited to, the following:

- Re-aligning the horizontal and/or vertical alignment of the road.
- Upgrading the size and/or number of culverts to current standards.
- Upgrading stream crossings to current fish passage standards.
- Installing additional cross drainage structures.
- Reshaping the roadbed and/or ditchline for improved surface drainage.
- Upgrading the road surface by adding new rock.

- Removing and/or stabilizing fill slopes that exhibit instability.
- Relocating sections of roads away from sensitive areas such as streams.
- Repair of washouts, fill or cut slope failures, and severe damage to road surfacing.

In general, stream crossings and unstable fill and cut slopes present the greatest challenge to road improvement, and the greatest opportunities for future erosion prevention and rehabilitation.

Goals of Road Improvement

The goals of road improvement are:

1. Upgrade existing roads to meet current and future needs, rather than construct new roads, where it is economically and environmentally feasible to do so.
2. Correct an existing unsatisfactory situation.
3. Update roads to current standards where necessary.
4. Prevent environmental damage.

Objectives of Road Improvement

1. Plan road improvement projects that will efficiently and effectively move the road system from the current condition toward the vision or desired condition.
2. Design road improvement projects that efficiently and effectively correct unsatisfactory conditions, upgrade the road system as needed, and prevent environmental damage.
3. Construct improvements according to design specifications.
4. Minimize soil disturbance during road improvement construction.
5. Minimize impacts to water quality, aquatic and wildlife habitats, and other natural resources during construction of road improvement projects.
6. Utilize professional level expertise and input in the formation of on-the-ground decisions and/or changes during the construction of road improvement projects.
7. Make on-the-ground decisions and/or changes to the road design specifications that react to unforeseen conditions during the construction of road improvement projects in a manner that will achieve the goals of the project. Professional level expertise and input will be utilized in the formation of the decisions and/or changes.

Road Improvement Strategies

Road improvement strategies are the specific actions and standards that will lead to achieving the goals and objectives of this section of the manual.

All of the strategies listed in the sections on Transportation Planning, Road Design and Road Construction apply to Road Improvement as well. To avoid redundancy those strategies will not be listed in this section. However, there are some additional strategies that apply to Road Improvement, which will be listed in this section.

Road Improvement Planning

Road improvement planning will use all of the strategies listed in the section on Transportation Planning. A key strategy from that section is the inventory of the current condition of the road system. The inventory will include information on: road surface drainage; road surfacing condition; stream crossing structures; landslide risks; and areas of the road system that need upgrading to meet current and future needs. The **Forest Road Hazard Inventory Protocol** developed as part of the Oregon Coastal Salmon Recovery Initiative provides a system for gathering much of this information. As mentioned in the section on Transportation Planning, a more comprehensive road inventory system will be developed in the future. Until the new inventory system is in place, districts will need to gather supplemental information to efficiently and effectively plan for road improvement projects.

Information from the road inventory can be used to help identify priorities for road improvement projects. Conditions identified in the inventory that will be considered a priority for repair include:

Stream Crossings/Fish Passage

- Culvert outlet drops in fish bearing streams
- Non-embedded culvert with gradients above 0.5% slope
- Structures such as old log fills
- High washout potential due to an undersized structure and/or long steady grades below a stream crossing
- Scour, oversteepening or other erosion around culvert inlets and outlets
- Structural deterioration of culverts

Sidecast Failures/ Slope Stability

- Steep slopes
- Nearby slope failures
- High cut slopes—over 15 feet high
- Sidecast over two feet deep on steep slopes
- Fills supported by trees and/or organic debris
- Arc shaped cracks in the fill or other evidence of fill movement

Water Quality/Sediment Delivery

- Direct delivery of sediment in runoff water from roads to streams
- Ditch downcutting
- Increase in heavy traffic
- Inadequate depth and/or poor quality road surfacing
- Damaged, collapsing, and/or inadequate drainage structures

- Eroding soil on cut and fill slopes
- Buried culverts
- Fill erosion at culvert outlet

Current/Planned Uses of the Road

- Unsafe conditions are present—width, alignment, visibility, etc.
- Volume of traffic exceeds road design
- Road surfacing will not accommodate current/planned uses

A number of factors will affect the final ranking of road improvement projects. Included are factors such as the need and timing of the planned uses of the road; the costs and benefits of the project; the amount and type of environmental damage that is occurring or could occur; the likelihood that damage will occur and the risk of impacts to human life/safety or private property. Factors such as the availability of funds, equipment, and manpower and the time of the year will affect the scheduling of road improvement projects.

Road Improvement Design

The design of road improvement projects will use all of the strategies listed in the section on Forest Road Design. However, because of the nature of some road improvement projects additional engineering and design work may be needed before construction begins. For example, an engineered solution such as a reinforced fill or a crib wall may be needed to repair a road fill that has failed.

Some design criteria that will be considered for road improvement projects are:

- Roads will be surfaced to handle the wettest road conditions that are expected
- Use geotextiles under the surfacing where the subgrade is wet, soft, and cannot be effectively drained.
- Crossings on fish-bearing streams will meet the design criteria listed in the **Oregon Road/Stream Crossing Restoration Guide.** (See list of useful references)
- Install cross drainage above stream crossings to divert ditch water on to vegetated ground for filtering.
- Revegetate all disturbed cut and fill slopes.
- Install measures such as flumes, downspouts, or armoring on the outlets of cross drains where erosion of steep slopes is occurring.
- Install measures such as armored relief dips, trash racks, or oversized culverts to prevent the road from being washed out.
- Install additional cross drains where downcutting of the ditch is occurring.
- Pull back and endhaul unstable fill material. Pull back should remove all "perched" fill material, flatten upper slopes on "sliver fills," and create a uniform slope that will drain well.

Figure 1.

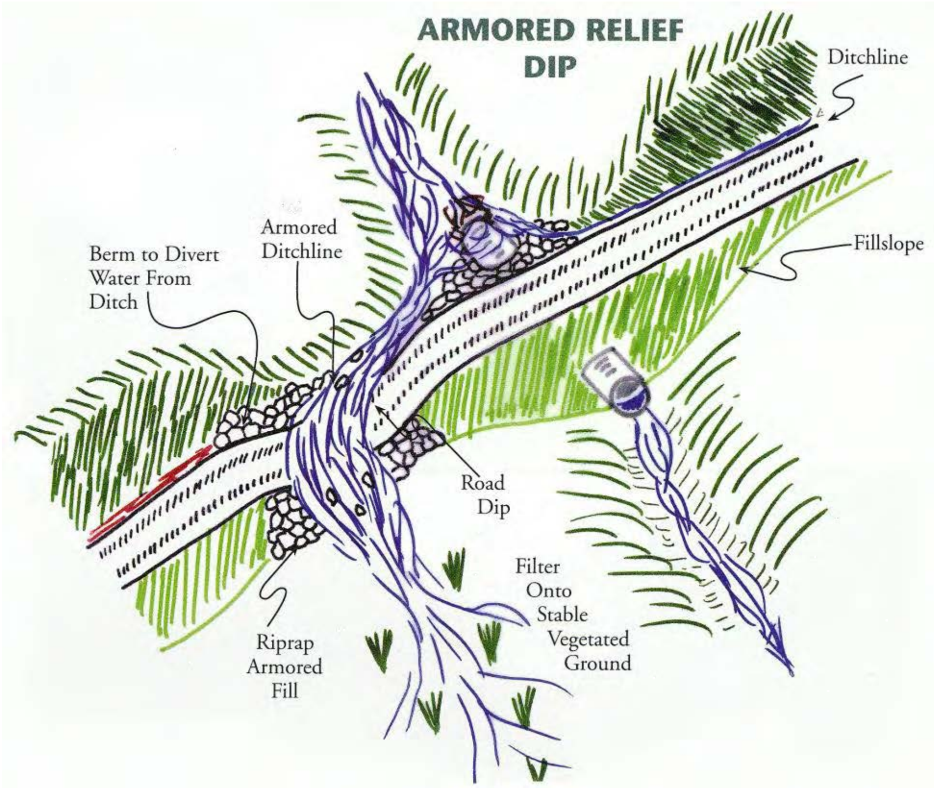


Figure 2.

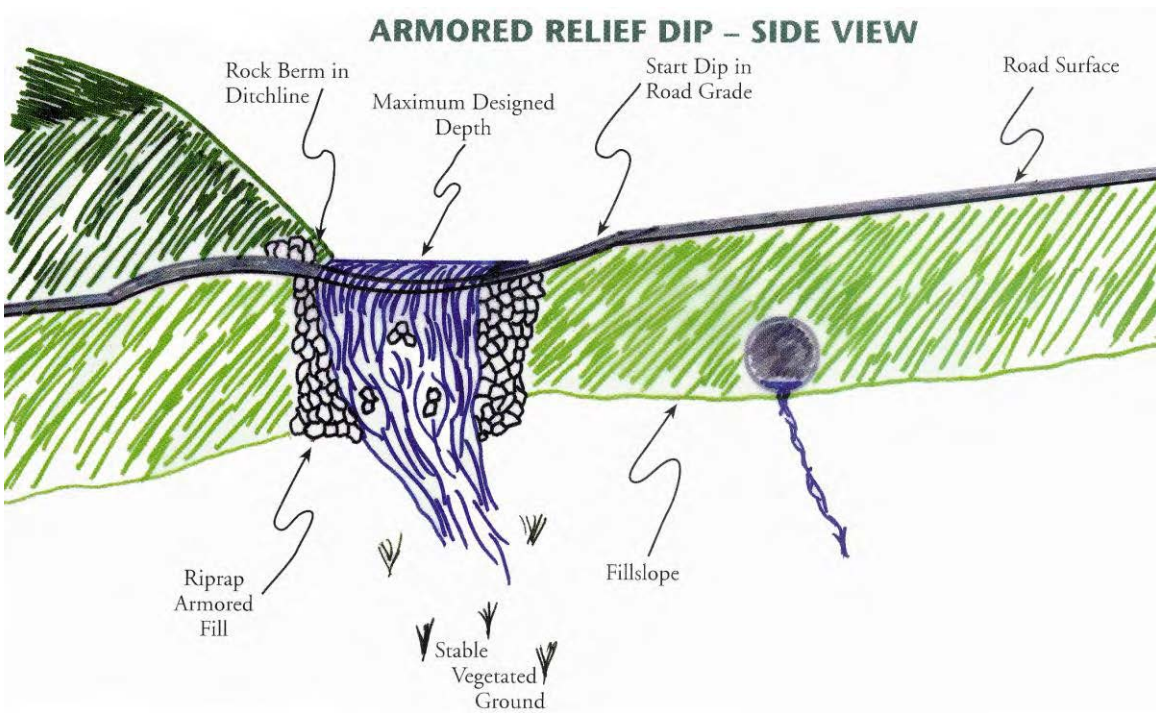
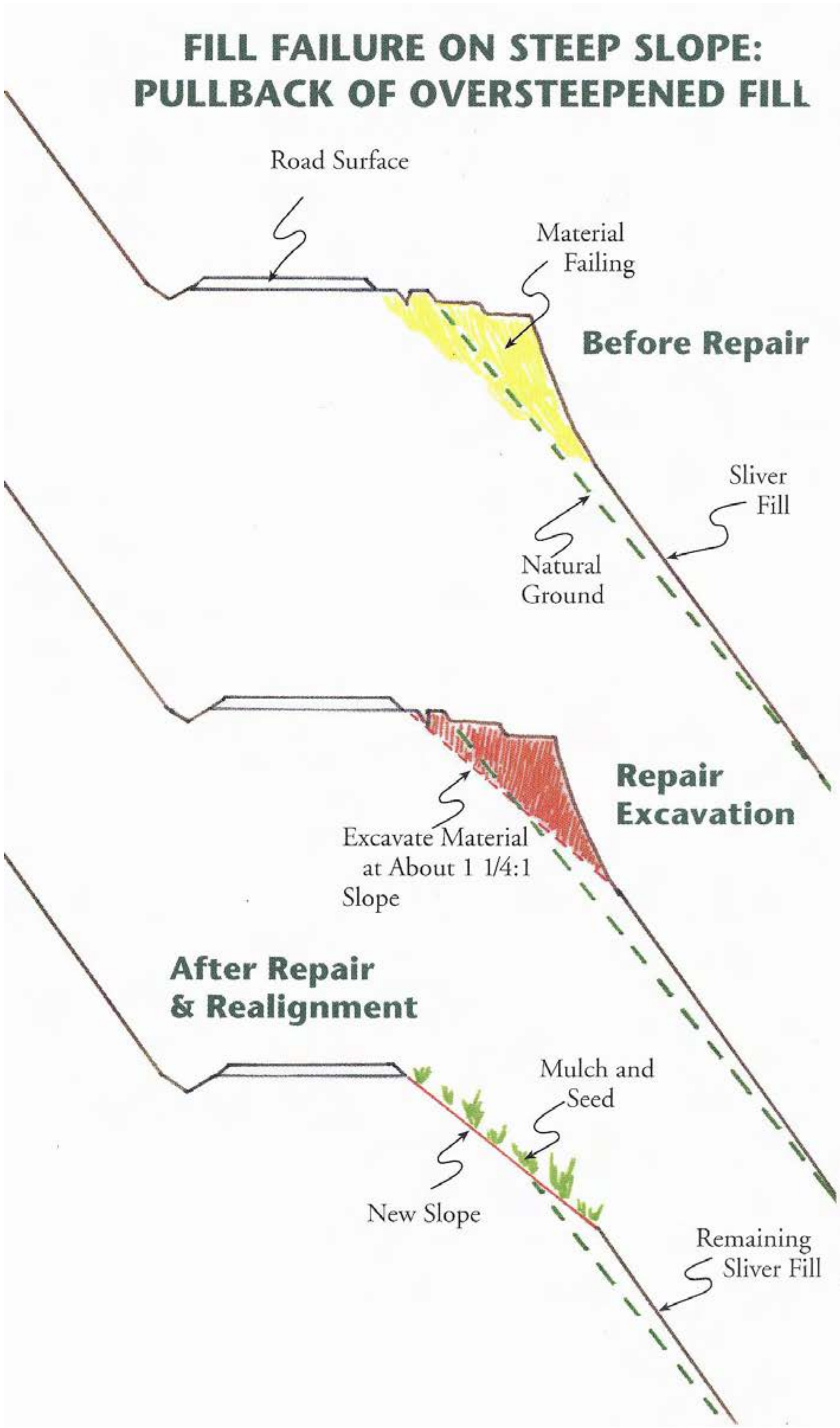


Figure 3.



It is not possible to identify and list all of the additional design criteria and standards for road improvement projects. Each project will be designed to meet the specific goals and objectives for that project. Where needed, additional expertise such as geotechnical specialists, hydrologists, biologists, and civil engineers will be used in the design of road improvement projects.

Construction of Road Improvement Projects

The construction of road improvement projects will use all of the strategies listed in the section on Road Construction. However, because of the unique designs used for some road improvement projects, additional strategies may be required. Some items to consider when constructing road improvement projects are:

- Additional compaction or special compaction techniques may be needed when repairing road fills that have failed.
- Buried organic material must be removed from the road subgrade before replacing or repairing old log fills or log culverts.
- Before replacing some culverts, removing the fill (and the associated old culvert) and allowing the stream to “self excavate” over a winter in order to find its natural channel is often the best solution where stream sediment has built up behind the fill.
- The use of specialized equipment may be required. The equipment will be used within its limitations and capabilities.

It is not possible to identify and list all of the additional construction criteria and standards for road improvement projects. Each project will be constructed to meet the specific design for that project. When it appears to be necessary to modify the project design and or the construction strategy, appropriate expertise such as geotechnical specialists, hydrologists, biologists, and civil engineers will be consulted regarding the proposed modifications.

Project Administration for Road Projects

Introduction

Virtually all forest road construction and road improvement projects are performed under timber sale contracts, with a few being accomplished by general service contracts or by district road crews. Regardless of the approach that is used a project/contract administrator will be designated for each project.

The construction phase is when planning and design decisions are carried out on the ground. Well-designed projects and good execution of plans will result in well-constructed projects that will minimize impacts to the watershed and environment. Thus, the knowledge, skill and abilities of the project administrator will play a key role in accomplishing successful road construction projects.

Goals of Project Administration

The goals of contract administration are to:

1. Insure that construction/improvement projects are completed according to design/contract specifications.
2. Initiate appropriate changes in the design/contract specifications to accommodate unforeseen problems.

Objectives of Project Administration

The objectives of contract administration are to:

1. Establish good communication with contractors and operators.
2. Make inspections as frequently as needed to ensure contract compliance.
3. Issue clear written and verbal instructions in timely manner.
4. Answer operator's questions in a timely manner.
5. Utilize professional level expertise and input (geotechnical specialists, engineers, biologists, etc.) for sensitive and/or unique operations. The same level of expertise will be utilized when it is necessary to make changes to the design/contract specifications.

Project Administration Strategies

Project administration strategies are the specific actions and standards that will lead to achieving the goals and objectives of this section of the manual.

KSA’s for Project Administrators

Project administrators will have the following knowledge, skills, and abilities (KSA’s) to successfully administer road construction/improvement projects:

- Knowledge and understanding of the project’s design and/or contract specifications and the ability to efficiently and effectively administer them.
- Knowledge of Oregon Forest Laws, rules, policies and administrative procedures related to forest practices, fire protection and the management of state-owned forest land.
- Knowledge of basic engineering practices related to forest road construction/improvement and the ability to evaluate their application on the ground.
- Knowledge of basic geology, forest soils, and hydrology for the local area and the relationships between these factors and forest road operations.
- Knowledge of basic water quality management, aquatic biology and wildlife biology; and the impacts forest road operations might have on these factors; and knowledge of the appropriate measures for avoiding or lessening adverse impacts to these factors caused by forest road operations.
- Ability to give clear oral and written instructions.
- Ability to work effectively with operators, contractors, and other agencies.
- Ability to develop and maintain an effective record keeping system including reports, instructions, and records.
- Ability to recognize when corrective action is needed and to take appropriate measures to get the desired results.

Before Construction Begins

The supervisor responsible for the project will assign a project administrator with the appropriate KSA’s, as listed above. The project administrator will review and understand all requirements of the project. Any unclear requirements will be reviewed with the supervisor and/or the designer of the project. The project administrator will be the State’s designated field representative(s) and will be authorized to receive notices, inspect progress of the work, and issue instructions in regard to performance on the project.

A pre-operations meeting is required by all timber sale contracts to be held between the State (Department of Forestry) and Contractor, and an Operations Plan is required to be submitted and approved by State, prior to the contractor beginning any work. All designated representatives of the contractor and the State should attend this meeting. The purpose of the meeting is to explain the requirements of the contract and to answer any questions from the contractor. The contractor will be given copies of any special designs required by the contract. The project administrator will explain:

- Any threatened or endangered species concerns or requirements.
- Oregon Forest Practices Act requirements such as written plans.
- Timing of construction for projects.

- Specifications and requirements for all projects.

The pre-operations meeting is the ideal time for the project administrator to begin the important process of communication. The project administrator should be prepared to answer most questions at this meeting. Any questions not answered by the administrator at the meeting will be researched, and the answers provided to the contractor within a reasonable time.

The project administrator will thoroughly understand the operations plan and pre-operations meeting requirements of the contract.

Similar meetings will be conducted when road construction/improvement projects are completed through a service contract or by Department of Forestry personnel and equipment.

Responsibilities of Project Administrators During Construction

The project administrator should attempt to establish a good working relationship with the contractor early in the contract. In addition, the administrator will make every effort to ensure that the contractor and their representatives fully understand all of the contract requirements and will explain the reasons for the requirements and what will be expected of the contractor.

After the pre-operations meeting, the administrator will document the meeting with the use of the standard form letter developed for this purpose. The letter will summarize what was discussed at this meeting.

Administrators will make sure that other required written documents have been submitted and approved prior to the contractor beginning any work, such as Notifications of Operations, Written Plans required by the Forest Practices Act, and Rock Pit Development Plans.

Administrators will make field inspections as often as required to make sure that the contractor is complying with all specifications required by the contract, and to answer questions from the operator. This may be a minimum of two per week for normal road construction, or continuously during critical road construction projects. Whenever the administrator cannot be on site continuously during critical road construction projects, he/she will arrange for an on-site observer for the critical projects. Critical projects may include:

- Installation of fish passage culverts.
- Removal of existing road fills over 15 feet in height.
- Full bench road construction.
- Installation of road fills over 15 feet in height.
- Areas of critical alignment such as switchbacks.
- Installation of special structures such as retaining walls

Administrators are responsible for recognizing and initiating needed changes during construction that were unforeseen or unrecognizable in the design phase. Prior to initiating any changes to a contract, the administrator must first verify the need to make a change. This may require review and input from a geotechnical specialist, engineer, and/or biologist. New design specifications will be developed for substantial changes. The administrator will review proposed changes with his/her supervisor prior to initiating any changes. Guidance on changes to a timber sale contract is well covered in the “Timber Sale Contract Administration Handbook” and these guidelines will be followed for any contract changes.

The contract administrator will keep a log of all inspections and telephone conversations with the contractor and/or their representatives.

Administrators will issue written and verbal instructions as necessary to direct the contractor to comply with all specifications and requirements of the contract and/or other written plans. These will be on standard forms when applicable, such as: Weekly Inspection Reports, Status Reports, Important Notice, and Work To Do letters.

Administrators will take immediate action anytime a contractor violates the Forest Practices Act, does not operate within the scope of the contract, or causes unnecessary environmental disturbance.

The approved operations plan becomes a part of the contract and the administrator should refer frequently to the operations plan to determine if the contractor is complying with the plan. If the contractor deviates from the original plan and fails to file a supplemental plan or begins work that is not covered by the plan, those portions of the operation not adequately covered by a plan will be halted until the appropriate plan is submitted.

Final Inspection and Approval

As required by the timber sale contract, the project administrator will inspect projects within 10 days after a written notification of completion has been received from the contractor. Work in this case must be an entire project or projects, and not a portion of a project. If, for some reason, the contract administrator cannot make an inspection within the 10-day period, the contractor will be notified in writing of this fact and given an estimate of when the inspection will be made.

After a final inspection has been made, the administrator will complete an inspection report and indicate whether the work was acceptable or not acceptable. If the work was acceptable, the administrator will also submit a status report to the division office indicating the work that has been accepted.

If the work is not fully acceptable, the administrator will issue an inspection report specifying the work that is acceptable, and what work is not acceptable. For work that is not acceptable, clear instructions must be given to the contractor that describe what will be required to make the project(s) acceptable.

The administrator <u>cannot</u> approve a project until <u>all</u> portions of the project are completed according to the contract. The State’s ability to collect costs for uncompleted project work may be forfeited if final approval is given prior to the total completion of a project.

Forest Road Maintenance

Introduction

The Oregon Department of Forestry has made a significant investment to develop and improve the road system on state-owned forest land. The road system provides access to the forest for a full range of activities, including timber management, fire protection, recreational use, and many others.

There are a number of reasons to maintain the road system on state-owned forest lands and to keep it in good condition. The first is that properly maintained roads will have a minimum impact on natural resources. The commitment to good stewardship will be a driving force for any road maintenance program. Secondly, a good road maintenance program will ensure that the roads are available for their intended use. The third reason is to protect the investment that has been made in the development and improvement of the road system on state-owned forest land. Finally, the Oregon Forest Practices Act establishes a regulatory obligation to maintain forest roads.

Goals of Forest Road Maintenance

The goals of road maintenance are to:

1. Minimize the adverse impacts to water quality, fish habitat, wildlife habitat and other natural resources that may be caused by the presence of the road system on state-owned forest land.
2. Ensure continued access to state-owned forest lands for the planned uses.
3. Protect the State's investment in the infrastructure.
4. Comply with the regulatory requirements of the Oregon Forest Practices Act.

Objectives of Forest Road Maintenance

1. Maintain existing roads and structures to the intended design standards.
2. Maintain a fully functional drainage system.
3. Minimize soil disturbance during maintenance activities.
4. Minimize impacts to water quality, aquatic habitat, wildlife habitat, and other natural resources during maintenance.
5. Combine professional level expertise and operator experience in the formation of on-the-ground decisions.
6. Provide a protocol for identifying and responding to immediate maintenance needs.

Road Maintenance Strategies

Road maintenance strategies are the specific actions and standards that will lead to achieving the goals and objectives of this section of the manual.

Planning and implementation of a road maintenance program is a complex task. Districts will designate a person in each district with the overall responsibility for road maintenance. This person will be responsible for identifying maintenance needs, developing a plan to accomplish the maintenance, and ensuring that the plan is properly implemented.

Inventory

The basis for the development of a road maintenance plan is a thorough understanding of the road system, its characteristics, and its needs. This is accomplished by establishing and maintaining an intensive inventory of the road system. The inventory provides the information necessary for identifying and prioritizing required maintenance. In addition, the inventory will also provide the basis for the development of road improvement plans.

Each district will maintain an intensive inventory of the road system on state-owned forest lands in the district. As a minimum, this inventory will categorize roads, identify drainage structures and rate their condition, identify and assess potential slope stability problems, and maintain information related to the condition of the road surface.

As of January 2000 the minimum level inventory system that will be used for roads on state-owned forest land will be the **Road Hazard Inventory Protocol** developed as part of the Oregon Coastal Salmon Recovery Initiative. This inventory system gathers information related to fish passage barriers where roads cross streams, information related to road drainage systems and their condition, and information related to slope stability problems. This information will be useful in describing some but not all of the current conditions of roads. In the future, a more comprehensive inventory system will be developed and added to this section of the manual. Until the new inventory system is in place, districts may gather additional information on the current condition of roads on state-owned forest land that the district determines to be necessary to efficiently and effectively maintain the road system.

Information for the inventory can be gathered and kept in many different forms, but it makes sense to take advantage of available technology to manage the data. Data can be recorded electronically, transferred to appropriate data management programs, and extensively queried using existing technology. Data will ultimately reside in the Department's GIS database, where it can be seamlessly integrated with all resource information.

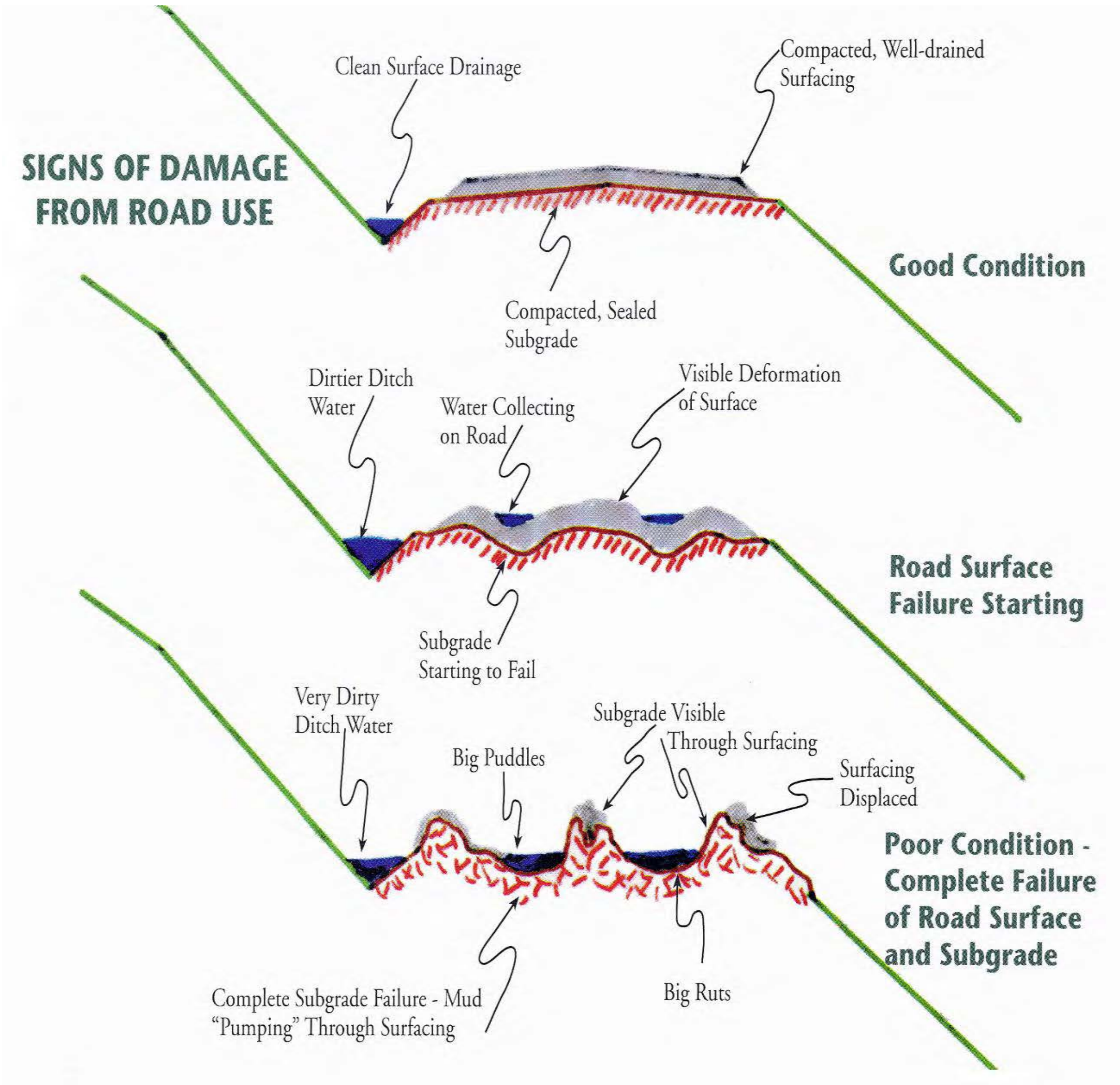
Since the road system is dynamic and constantly changing, regular updates to the inventory are essential. These updates will reflect new roads that have been added to the infrastructure, changes made to a road through maintenance or road improvement work, damage caused by storms or other environmental factors and changes caused by road use.

Inspection

Roads will be inspected on an annual basis or more frequently as the level of road use varies or local conditions warrant. The inspection will assess the condition of the road, identify any maintenance activity that is required, and provide information necessary to update the inventory. Particular attention will be paid to culvert inlets and outlets, ditches, road surface drainage and cut slope or fill slope stability. The inspection will take place early enough that any work identified can be completed prior to the start of the fall rains.

Roads will also be inspected regularly during periods of heavy hauling in order to detect early signs of damage. Standing water or ruts indicate that the strength of the road subgrade and/or the road surface is deteriorating and that immediate attention is needed. Often, a small amount of maintenance early can save thousands of dollars in road repairs later.

Figure 1. Signs of Damage From Road Use



Planning

As the inventory, supplemented by frequent inspections, reveals the required maintenance needs, it becomes important to develop a plan for accomplishing the required work. The plan will identify the work to be accomplished, the timing, the resources required to efficiently complete the work, and the methods for implementing the plan. Priorities will be assigned to each task, with the highest priority being assigned to sites that have the highest potential for damage to the road or damage to downslope natural resources.

When allocating road maintenance resources, it is important to match the type and size of maintenance equipment to the maintenance activity being performed, and to ensure that operators are properly trained to perform the function. For example, using a 1-1/2 cubic yard hydraulic excavator to clean culvert catch basins is generally not efficient, and can easily cause more damage than a more appropriate piece of equipment such as a tractor-mounted backhoe. Conversely, the larger hydraulic excavator would be a more appropriate choice when excavating and loading large amounts of material as opposed to the backhoe. If adequate resources are not available, plans must be made to secure the necessary resources.

It must be remembered that because forest road systems exist in a dynamic environment, any plan for road maintenance must also be dynamic. Rather than a static plan that covers a specific period of time, the plan must constantly adjust to changing conditions. Enough flexibility and adaptability must be built into the plan to allow for changing conditions and needs.

Factors that need to be considered when planning maintenance include:

1. Design Standards. Earlier sections in this manual related to the planned use and selection of appropriate design standards for any given road. Once the design standard has been established and the road has been constructed accordingly, that road will be maintained to the original design standard. If the road is not to be maintained to the original design standard, it must be due to a conscious decision to alter the design standard.

Equally as important as maintaining a road to its original design standard is limiting its use to the designed standard. This will prevent maintenance problems from developing and prevent damage to natural resources. A road that is surfaced with a minimal amount of crushed rock will not support timber hauling in the winter months, and will not be expected to do so. Likewise, heavy hauling on well surfaced roads will not be permitted during periods of heavy rains, melting snow, or during thawing periods. Care must be taken during the planning process to ensure that roads are adequately designed, constructed, and maintained for the planned use. If a road is not capable of supporting its planned use, then the plan will be modified or the road standard will be upgraded accordingly.

2. Frequency of Maintenance. Several factors help determine how frequently road maintenance activities will need to be performed:

A. Planned Use and Design

A road that has been planned and designed to accommodate a large volume of traffic will require more frequent maintenance. This applies to routine maintenance as well as the replacement of surfacing material. These roads might be mainline logging roads or roads that will carry a high level of recreational traffic. A road that is designed for occasional use, such as a short spur to access a timber sale will require less frequent maintenance. To reduce the maintenance load, roads that are seldom or occasionally used become good candidates for road vacation or closure at the end of their primary use.

B. Position on Slope

Roads located on ridge tops will require less frequent maintenance due to fewer drainage structures, shorter cut banks, and a higher degree of slope stability. Roads located in valley bottoms require somewhat more frequent maintenance, due to the greater number of drainage structures and their proximity to larger streams. Depending upon their proximity to valley slopes, roads in valley bottoms may or may not have greater cut and fill slope stability than roads on ridge tops. Roads located on side hills require the greatest maintenance frequency. Cut banks are higher and more prone to raveling, cut and fill slope stability issues are more frequent, and there are generally a large number of drainage structures.

C. Local Knowledge of Chronic Problem Areas

Local conditions may dictate more frequent maintenance on certain roads or at certain sites, such as culverts that are prone to beaver activity, recurring slide areas, or streams that carry unusually high sediment loads. The knowledge and experience of district employees are important in identifying these sites and ensuring that they get the attention they need. Solutions will also be explored to determine if the particular chronic problem could be mitigated.

Timing

Regular and timely road maintenance helps to ensure that the forest road system remains fully functional. Conversely, poorly timed maintenance can create problems that might have greater consequences than not maintaining a road. As examples, cleaning ditches during wet weather can cause excessive sedimentation, and grading a road during a hard rain event can lead to the contamination of the surfacing material. On the other hand hand cleaning culvert inlets and minor blockages of ditches during rain events can prevent more serious damage.

It is extremely important that any maintenance activity be conducted at a time when weather conditions allow for a minimal amount of soil disturbance and sediment movement. It is essential to maintain the integrity of the road surface and subgrade while conducting maintenance activities.

Coordination

At times, multiple users will be utilizing the same segment of road, each with its own maintenance obligation. For example, purchasers of State timber sales and third party users of roads under easement or permit are responsible to perform road maintenance activities related to their use of the road. When the use is simultaneous, it is necessary to coordinate the maintenance activities. Each district will coordinate these maintenance activities to ensure that there is no duplication of effort, and more importantly, that there are no gaps in the maintenance effort. All responsibilities for road maintenance must be fully identified, understood and fulfilled.

In the conduct of their normal day-to-day activities, district employees may observe or identify road maintenance needs. Districts will develop a methodology for recording the information and forwarding it to person or party responsible for maintaining that segment of road.

Districts will utilize geotechnical specialists, biologists, or other professionals to provide design input for mitigation of chronic maintenance problem areas.

Implementation Options

Three options are available to accomplish needed road maintenance. Each district will analyze its maintenance requirements and select the option or combination of options to efficiently accomplish the work.

1. Department of Forestry Personnel and Equipment

This road maintenance option provides the greatest flexibility. Personnel and equipment are in place and can easily be allocated to projects. Employees' experience and local knowledge can be invaluable in identifying chronic problem areas and developing appropriate road maintenance solutions. In addition, the personnel and equipment are available to support other functions, such as fire suppression.

The greatest advantage of Department personnel and equipment is the ability to react promptly to high priority situations, especially when unplanned emergencies arise.

The cost of maintaining the staff and heavy equipment that is required to accomplish the work is the biggest disadvantage of this option.

2. Timber Sale Purchasers

Purchasers of timber sales are responsible for the normal maintenance of all roads used in connection with a given sale during those periods that there is activity on the sale. While timber sales are a good way of accomplishing road maintenance, they may not meet all of a district's maintenance needs. The district is still responsible for maintaining roads during periods of inactivity and maintaining those roads not associated with a timber sale.

3. Service Contracts

Road maintenance can also be accomplished by entering into agreements with contractors who have the experience, equipment, and personnel necessary to properly do the work. Large districts with enough maintenance to provide full-time work for a contractor enjoy the same degree of flexibility that having district crews and equipment might provide. However, districts with a smaller workload will not provide full-time work to a contractor and may have to compete with the contractor's other commitments. Care must be taken to ensure that the contract is constructed with enough flexibility to satisfy the contractor and enough certainty to meet the district's needs.

Advantages to using service contracts include the ability to accomplish required maintenance at a lower cost by not incurring the full-time cost of personnel and equipment and by taking advantage of competitive bidding to minimize the cost. Disadvantages are the risk of reduced flexibility and the extra workload and costs associated with administration of the contract.

Knowledge, Skills, and Abilities for Maintenance Personnel

Regardless of the method employed, the road maintenance knowledge, skills, and abilities (KSA's) of supervisors, contract administrators, and equipment operators, are crucial to the successful maintenance of the road system. The following KSA's are the minimum for Department personnel involved in road maintenance:

Department of Forestry Maintenance Supervisors and Maintenance Personnel

- Knowledge of the Departments road maintenance standards for roads on state-owned forest lands and the ability to maintain roads according to the standards.
- Knowledge of good road maintenance practices and the ability to apply them in the proper situations.
- Ability to recognize unusual conditions that may require the use of specialized equipment and/or input from technical specialists.
- Knowledge of the road maintenance requirements of the Oregon Forest Practices Act.

Contract Administrators (Timber Sale Contracts and Service Contracts)

- Knowledge of the contract specifications and the policies and procedures related to administering the contracts.
- Knowledge of road maintenance standards and practices and the ability to apply them properly.
- Ability to recognize unusual conditions that may require the use of specialized equipment and/or input from technical specialists and the ability to initiate appropriate action.
- Knowledge of the road maintenance requirements of the Oregon Forest Practices Act.

Documentation

An important aspect of a road maintenance program is documentation. Maintenance activities will be documented for a number of reasons such as planning future maintenance needs and the tracking of maintenance costs. Documentation can also provide some protection in the event that there is a legal dispute relating to road maintenance. Each district will develop and use an interim system that documents road maintenance activities. When the Information Management section of this manual is completed, it will contain guidance on the documentation of road maintenance activities.

Monitoring

The success of a maintenance program can be determined only through observation. Roads will be checked on a regular basis to see if the maintenance work has been effective. For example, an inspection of a road during the first fall rains will determine if the culverts have been properly cleaned, whether or not the ditches are functioning properly, and if the road surface is properly crowned. Where monitoring identifies an ongoing maintenance need, actions will be taken to correct the situation.

Priority Maintenance

Each district will develop plans for patrolling roads during periods when there is a high potential for damage to the road system such as periods of high intensity rainfall. The plan will include established patrol routes and a protocol to report observed problems. Conditions that represent high risk of imminent damage to waters of the state will be repaired as soon as safety and weather conditions allow. These conditions include; actively failing road sidecast; blocked drainage structures; and repeated road cut slope failure areas.

Established patrol routes ensure that there is no duplication or skips in the patrol effort. Patrol routes will be mapped and available on short notice to the personnel that will be doing the patrolling. Routes will be prioritized to emphasize attention to areas where there is a prior history of problems.

A reporting protocol will be specified and will contain the following elements:

- Who receives the report. This will usually be the person on the district that is responsible for coordinating normal road maintenance.
- The nature and location of the problem.
- Other resources that might be threatened.
- What will it take to correct the problem, including an estimate of the equipment and time required to do the work.

Because of the severe nature of the weather usually associated with these periods, safety of personnel must be given the highest priority.

Road Closure or Vacation

One strategy that can be used to minimize the amount of maintenance required and the associated costs is to close or vacate roads that are not necessary for planned activities. See the section on Forest Road Vacating in this manual for additional information.

Road closure involves limiting access to the road while keeping the road in a useable condition. Road closure reduces the amount of traffic on a road and the amount of maintenance required due to wear and tear. It does not completely eliminate the maintenance obligation, but may reduce the frequency of maintenance. Road closure can be accomplished either by the installation of a gate or by the construction of a physical barricade. When choosing one of these methods, keep in mind that gates are themselves a high maintenance item, while barricades require extra effort to open when access is needed for maintenance or some other management activity.

Vacating a road involves leaving it in a condition where traffic cannot use the road and where erosion is unlikely. Road vacating is a semi-permanent/permanent technique that, if done properly, completely eliminates the need to maintain a road.

Maintenance Functions

Road maintenance activities can be divided into five basic categories: drainage, surface maintenance, cut and fill slopes, erosion control, and vegetation control. Each district will ensure that these categories are properly addressed during maintenance work. Improper maintenance of a road will reduce the useful life of the road, increase erosion and sediment transport to streams, and may represent a safety hazard to the road's users.

Drainage Maintenance

Culverts, catch basins, and ditches will be cleaned as necessary to ensure proper drainage. Often, culvert cleaning is done in the summer months as part of routine maintenance. Culverts also need to be inspected and cleaned during high rainfall events to prevent plugging. Problems found during high rainfall events must be corrected immediately, because delay can result in serious road damage and costly repairs.

During cleaning, floatable debris and accumulated sediment will be removed from the catch basin and placed where it cannot reenter the drainage system. Culvert ends that have been bent or damaged will be straightened and opened. Culvert outlets that show signs of erosion will be armored with riprap, fitted with a downspout, or use some other erosion control technique.

Ditch maintenance is important in order to maintain the flow capability required to remove surface runoff. Inspecting ditches during periods of high rainfall is a good time to determine if ditches need cleaning to improve their capacity, or if ditches are carrying too much water. Ditches that show signs of erosion or down cutting will have additional culverts installed or be armored with riprap to prevent further erosion.

Frequent grading or "pulling" of ditches is usually unnecessary, and can actually cause excessive erosion, undermine cut slopes, and expose the toe of cut slopes to erosion. If cut slope failures have blocked the ditch, clear out the material and place it in a stable disposal site. Remove other debris and vegetation only if obvious drainage problems are evident. Do not remove any more grass or vegetation than is necessary, as they prevent scouring and filter out sediment.

When “pulling” a ditch, avoid pulling the material across the road surface. This can lead to contamination of the surfacing material and increased erosion, especially during the first rains. Material pulled from the ditch can be windrowed on the inside road shoulder and hauled away for proper disposal.

Road Surface

Road surfaces should be graded only when needed to maintain a smooth, stable running surface and to retain the original surface drainage. Excessive grading can result in increased rock wear and loss and can actually lead to unnecessary erosion.

Grading should cut deep enough into the surfacing material so that loosened material will mix, compact, and bind with underlying materials. If deep chuckholes or ruts cannot be graded out, the surface will be ripped and then graded and re-compacted to achieve proper binding. Otherwise, holes and ruts that are just filled or patched will quickly reform in the same locations.

Oversized material that is brought to the surface during grading can be moved off to the side of the road.

Berms from road grading will concentrate water and prevent the drainage system from working properly. In most cases berms will be removed either by grading or by hauling the material away to a disposal sites. Where roads cross high-risk sites, berms may be used on the outer edge of the road to keep drainage water from flowing over the high-risk site and to direct the water on to stable ground.

Over a prolonged period of use and maintenance, surfacing materials gradually break down or are lost to the side of the road. Steep road segments and curves experience the highest rate of rock loss. Eventually, the road will not match its designed standard. At such a time, it will be necessary to add surfacing material in order to bring the road back into standard.

Cut and Fill Slopes

The key to maintaining cut and fill slopes, including sidecast materials, is to regularly observe them and note when and how changes to these features occur. Often, small slope failures can be symptoms of larger slope stability issues. Left untreated, these unstable features can fail suddenly and develop into debris flows and landslides that cause considerable downslope damage. When changes to cut or fill slopes are noticed or suspected, consultation with geotechnical specialists can help ensure that the real problem is identified and the proper solution is formulated. Proper corrective measures can then be planned and implemented.

Typical cutslope problems include raveling, erosion, or slumping, each of which can lead to blocked ditches or contaminated surfacing. These areas often require more frequent ditch cleaning and maintenance. Long-term solutions might be to flatten the cut slope, revegetate areas of bare soil, widen the ditch so it doesn’t plug as easily, or build a retaining structure to contain or prevent slope movement. Often, simply loading the toe of a small cutbank slump with heavy riprap can provide sufficient support to stabilize the feature. Again, consultation with a geotechnical specialist may be needed to ensure that the real problem is identified and the proper solution is formulated.

Local slides and slumps in the road bed or shoulder often occur where material was placed or pushed over groundwater springs or seeps, where the road crosses deep draws, where organic material such as stumps, logs, or other organic debris has been buried, or where material has been sidecast onto steep slopes. Instability in fill slopes and sidecast materials often shows up on the surface or outer shoulder of the road as tension cracks and small scarps along the boundary of the unstable material. Some settling of recently placed sidecast can be expected, but if movement persists and scarps continue to develop, appropriate action needs to be taken before the slope fails. These actions might include improved drainage (extra culverts and ditches, free-draining structures), retaining structures, or the excavation and removal of unsuitable or excess materials. Any materials that have been excavated must be properly placed in a waste disposal area. For older roads on slopes over 65 percent, however, cracks in the road are likely evidence of a potential landslide. If drainage does not arrest movement immediately, or if the slope is directly above a stream, pullback may be required very quickly to prevent damage. Consultation with the geotechnical specialist may be needed.

Erosion Control

Erosion and sediment control structures will be maintained or repaired as necessary to ensure their proper function. Culvert downspouts will be inspected regularly to see if they are long enough and are carrying all the water passing through the culvert. Silt fences (used only for temporary measures) will be inspected to see if they are properly located and functioning. Fences that have trapped considerable sediments may have to be cleaned or replaced. Filtering devices such as straw bales or “bio-bags” may also need to be cleaned or replaced. Exposed soil on cut or fill slopes needs to be reestablished with appropriate vegetation such as grass seed and mulch.

Vegetation Control

Over time various species of trees and shrubs will be established on the surface of the road prism. This vegetation may cause safety problems by reducing visibility. In some cases the vegetation may also reduce the effectiveness of the drainage system or the stability of slopes. Where these conditions exist, some form of vegetation control may be needed.

Vegetation can be controlled manually, mechanically, or chemically. The method used will depend upon the characteristics of the vegetation, its location, and other factors.

When using chemicals, precautions will be used to avoid harm to non-target plants to prevent any of the pesticide from contaminating water.

Forest Road Vacating

Introduction

Road access management is necessary to help meet management goals and objectives for fisheries, wildlife, recreation, timber and other forest resources as well as to reduce maintenance costs and sediment loads by restricting traffic. Roads can be grouped into four management categories:

- **Active Use.** Active use roads are those that are part of the permanent road system and those temporary roads that are currently in use or will be in use in the near future. These roads are usually available for use at any time of the year. Use may be continuous or intermittent. Roads in this category require active maintenance and have a full maintenance obligation under the Oregon Forest Practices Act.
- **Road closure.** Road closure involves restricting access to the road for part or all of the year. This may be as simple as placing a sign or other marker at the start of the road as might be the case in a cooperative travel management area for wildlife protection. Or, it might involve placing a semi-permanent barricade at the start of the road. This barricade can be a gate, large boulders, stumps and logs, or a trench. This strategy does not significantly alter the nature of the road, and the obligation to maintain the road remains. Road maintenance needs and sediment loads are reduced due to the elimination of traffic-related wear.
- **Partial vacation.** Partial vacation involves barricading the road and installing minor drainage structures, which might include the construction of water bars or rolling drains. This strategy is best suited for roads that will be needed again after long periods (perhaps as much as 15 to 20 years) of inactivity. Ridge top roads or other roads where drainage and sediment issues are negligible are good candidates to consider. The nature of the road may be somewhat altered through the addition of waterbars and other drainage structures, but the obligation to maintain the road

remains. Sediment loads are reduced due to the elimination of traffic-related wear, and road maintenance needs are greatly reduced.

- **Full vacation.** Full vacation involves removing all stream crossing structures, installing maintenance-free drainage (outsloping, water bars, rolling dips, etc.), pulling back any sidecast material, grass seeding disturbed soil, and barricading the road. The road is effectively "put to bed." All access is prevented, and there is no maintenance obligation. Cross drain culverts may be left in place but will not be considered as a functional drainage feature.

There are many reasons for proactively vacating a forest road. Most involve excessive maintenance costs, lack of continued need, or continuing water quality problems. Not all roads need to be part of a permanent road system. For example, temporary roads are used once, then "put-to-bed" until they are needed again. In addition to newly built temporary roads, there are existing roads that may no longer be needed, and older abandoned roads that are now overgrown. The same techniques can be used to erosion-proof these roads to prevent further erosion and sediment yield, and, as an added benefit or incentive, save the work and expense of continued maintenance.

All forest managers that may have a future management need for a road should be involved in the decision to vacate a road. See the Road Proposed for Vacating form at the end of this section.

Landings associated with any road that is vacated must also be left in a maintenance free condition. The considerations used in vacating roads will also be applied to landings.

This section of the manual will cover goals, objectives and strategies for forest road vacating.

Goals of Forest Road Vacating

The primary goal for vacating forest roads is to leave the vacated road in a condition where road related damage to the waters of the state is unlikely. Achieving this goal contributes to the achievement of the following supplemental goals:

1. Reduces the impacts of roads on water quality, aquatic habitat, wildlife habitat and other forest resources.
2. Reduces the amount of forestland occupied by roads.
3. Reduces the overall costs of road maintenance.
4. Provides opportunities to use vacated roads for other uses such as hiking trails.

Forest Road Vacating Objectives

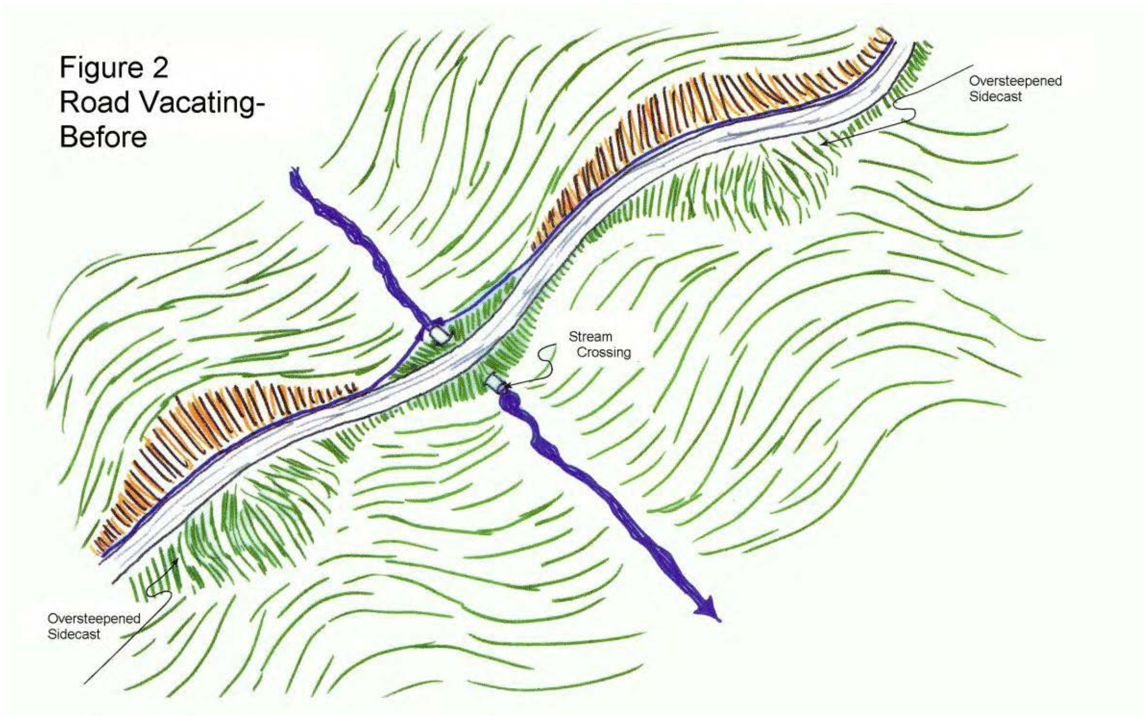
When a road is to be vacated and taken off the active road network, erosion prevention work will be performed so that continued maintenance is not necessary. All vacated roads will be "erosion-proofed" by excavating stream crossings and removing culverts, excavating unstable road and landing fills, treating the ditch and road surface to disperse runoff and prevent surface erosion, and revegetation of exposed soils.

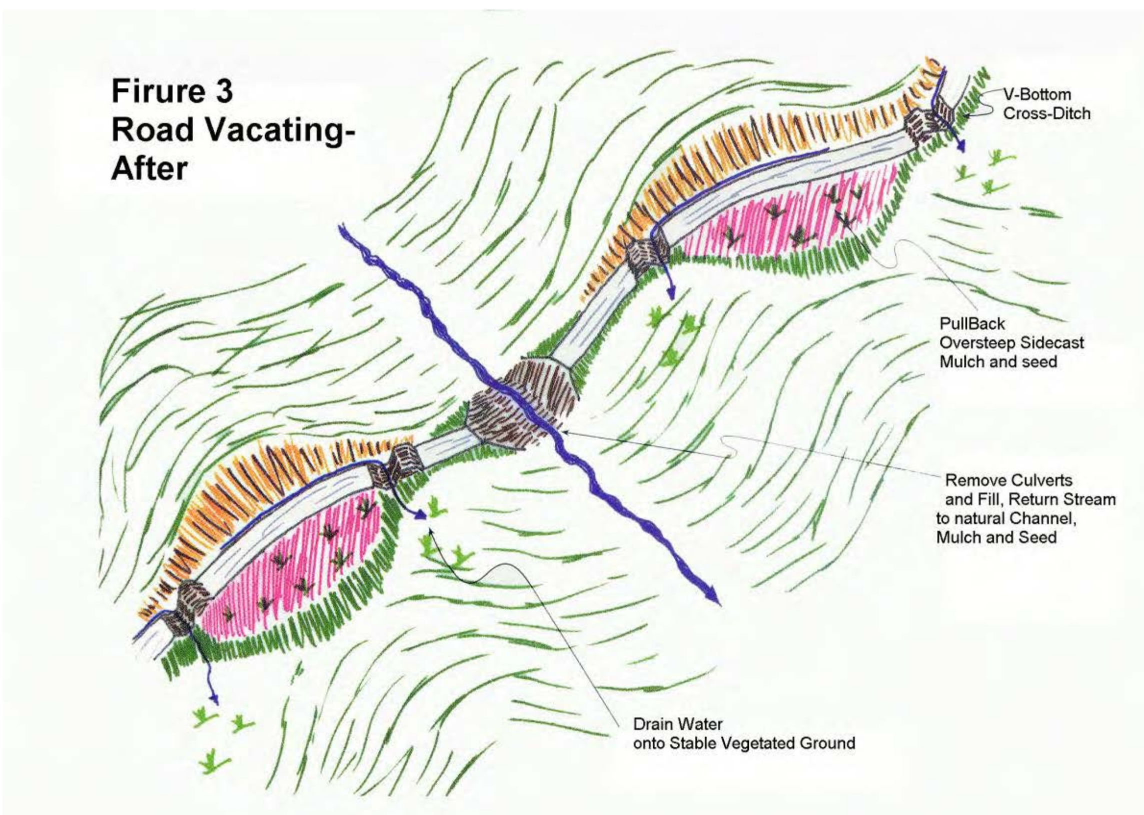
Vacating a road does not imply that every foot of the road needs intensive treatment to prevent future erosion. Segments of a road that have near natural levels of risk for sediment delivery can be left intact and receive minimal road drainage improvements. When or if the road is needed again, it can be reconstructed with minimal effort.

The objectives for forest road vacating include:

1. Returning stream channels to natural conditions by removing all stream crossing structures including any fill associated with the crossing.
2. Establishing maintenance free surface drainage by removing berms and installing drainage structures such as water bars and drainage dips.
3. Eliminating unstable or potentially unstable road or landing fills or sidecast material by removing the material to a stable location.
4. Preventing surface erosion by revegetating all areas of exposed soils.
5. Preventing the use of the roadbed by mechanized equipment by installing permanent barricades.
6. Complying with the requirements of the Oregon Forest Practices Act regarding the vacation of roads.

Figure 2. Road Vacating – Before





Road Vacating Strategies

Road vacating strategies are the specific actions and standards that will lead to achieving the goals and objectives of this section of the manual.

Road Vacating Assessment

The first step in vacating a road is to determine in a logical manner those roads that are candidates for vacating. Factors to consider include the need for current and future use of the road, the amount of environmental damage that road is currently causing or likely to cause, and the short-term cost of vacating the road versus the long-term cost of maintaining the road.

Implementation plans and forest management operations plans can be used to help determine the current and future use of the road. The Road Proposed for Vacating form provides a checklist for determining the current and future uses of a road. It also serves a review mechanism for the managers that are involved in making the decision to vacate a road.

The assessment will also include an evaluation of the environmental damage that is currently occurring or likely to occur at some time in the future from the road. The proximity to streams, the stability of road fills and sidecast material, the condition of the road's drainage system, and chronic maintenance problems are some of the factors to be considered in the evaluation. Roads that are causing significant damage or likely to cause significant damage will be considered as a high priority candidate for vacating.

A comparison of the short-term cost of vacating the road with the long-term cost of maintaining the road should be made. Any time the cost of vacating a road is less than the cost of maintaining the road and the road is not essential for management purposes, the road will be considered as a candidate for vacation.

There is no formula that will determine when a road should be vacated. Managers will need to weigh all of the factors affecting the decision and estimate the costs and benefits of vacating the road. The following is a list of roads that might be candidates for vacation:

1. Roads constructed for temporary access.
2. Roads that will not be needed for fire protection, forest management, recreation or other uses for several years.
3. Roads with excessively high maintenance costs.
4. Roads with persistent erosion and water quality problems.
5. Roads crossing steep slopes where landslide risk is high.
6. Roads exhibiting potential for fill slope or cutbank failures, often showing tension cracks.
7. Roads built with excessive sidecast or fill, in unstable locations, or perched above stream channels.
8. Roads built in, along or immediately adjacent to stream channels.

9. Old roads that have not been used for some time and have overgrown with vegetation, especially those with washed-out stream crossings and/or fill failures.

Stream Crossing Excavations

Removing a stream crossing involves removing the stream crossing structure (bridge, culvert, etc.) and excavating and removing all fill materials placed in the stream channel when the crossing was built. Fill material will be excavated to recreate the original channel grade, width and orientation.

All drainage structures in streams (live or intermittent), and culverts covered with over 2 feet of fill, in gullies or draws will be removed. Natural drainage will be restored during vacating.

Removal of stream crossing structures and fill material will be at a time that does not conflict with any restrictions on in-stream activities.

Road Surface Runoff and Other Drainage Structures

Roads that are to be vacated will have adequate, self-maintaining surface drainage. The drainage system will disperse rather than concentrate surface water and should maintain natural drainage patterns. Drainage water will be kept away from steep slopes and unstable areas.

Cross road ditches will be installed and take the place of cross-drainage culverts. The cross road ditches should intercept water from inside ditches, be deeper that standard waterbars, and drain onto stable, vegetated ground. As a minimum, cross road ditches will use 1/2 distance of spacing guidelines used for culverts. (See **Table 1. Guide Table for Water Bar and Relief Culvert Spacing** in the section on forest road design)

Removal of outside berms and/or outsloping of the road surface may also be needed to aid in the dispersal of drainage water.

Treatment of Unstable Areas

Any unstable or potentially unstable road or landing fills or sidecast will be excavated and placed in a stable location so that material does not enter a stream or destroy downslope vegetation. A stable location may be the inside part of the road prism or may be a waste area some distance away. Excavated areas will be shaped for natural drainage as will the excavated material that is deposited in a stable location.

Consult with the geotechnical specialist where risk assessment and confidence in technical design is needed. A slope stability investigation may be needed to ensure the proposed action is appropriate for the site. A slope stability investigation can provide interpretation of the geology in the area and increased confidence in the risk and design of the project.

Erosion and Sediment Control

Erosion control measures will be used where soil has been exposed. Vegetation is the ultimate, long-term erosion control agent. Seeding with grass and legumes will reduce surface erosion and can improve soil productivity. However, because it may take time to grow a thick, effective cover, some short-term erosion control measures (such as straw mulch or silt fences) may be needed for the first year or two after a road is vacated.

Planting with trees and shrubs can provide a long lasting vegetative cover and provide stronger root systems, which enhance soil stability for long term erosion and sediment control.

Blocking the Road

The vacated road needs to be blocked to vehicular traffic to prevent road surface rutting and damage to vegetation and crossroad ditches. One method used to block a road is to construct a trench across the entrance that is large enough to make it difficult to bridge or fill. Other methods include piling large stumps, boulders, concrete blocks or other debris in the entrance to block access.

Posting a sign stating that the road is closed may be helpful in advising the public that the access to the road is restricted to prevent damage to forest resources and that the road may be unsafe for use by mechanized equipment.

Timing

To prevent unnecessary damage or erosion, the work needed to vacate roads will be performed during periods when soil moisture is low. The work will also be timed to be in compliance with any restrictions on in-stream activities.

While it is assumed that properly vacated roads will not need further maintenance, their condition will be monitored. If unforeseen road drainage or stability problems develop after the road is vacated, consideration will be given to correcting the problems. The decision to take corrective action will depend upon the feasibility and practicality of the action.

Guidelines for Areas of Special Concern

Removal of fills over 10 feet in vertical height will have a project administrator present during removal. The project administrator should have some background regarding the removal of large fills. Natural slopes associated with large fills will be reestablished as closely as is feasible.

Removal of stream crossing structures in fish-bearing streams, including round culverts, arch pipes, bottomless arch pipes, and bridges, will have a project administrator present during removal. These structures will be removed with the least soil disturbance feasible. Removal of structures in fish-bearing streams will involve consultation with an ODFW fish biologist to ensure that removal will have a minimal impact on aquatic habitat and the fish.

Any unstable slopes or wet areas encountered during vacating must have immediate action taken to minimize the risk of failure. Consultation with a geotechnical specialist may be needed to determine the proper course of action.

All activities conducted while vacating forest roads on state-owned forest land will meet or exceed the requirements of the Oregon Forest Practices Act.

Road Proposed for Vacating Form

The Road Proposed for Vacating form will be found on the next page. The form provides a checklist for determining the current and future uses of the road. It also serves as a review mechanism for the managers that are involved in making the decision to vacate a road. Managers should keep in mind; there may be other uses besides forestry for a road that will warrant keeping the road in an active state. The Recreation Coordinator is one example of a check off point that will help make a road vacating decision. Additional input or approvals may by be added to the forms approval list as needed.

ROAD PROPOSED FOR VACATING

ROAD NAME ____

The road on the attached map is being considered for vacating. This may involve culvert removal, water barring and blocking to vehicular traffic. Please look over your needs and check [yes] or [no] in the appropriate areas. If you are currently using the road but will have no future use after the project is completed, please fill in project completion date under -NO-(DATE). If you are not currently using the road, but expect a future use, please fill in date under -YES- (YEAR).

CURRENT USE -NO-	CURRENT USE -YES-	ROAD USE	FUTURE USE -NO-(DATE)	FUTURE USE -YES-(YEAR)
____	____	Fire Protection Net	____________	____________
____	____	Management Net	____________	____________
____	____	Timber Sales - Clear cut	____________	____________
____	____	Commercial Thinning	____________	____________
____	____	Cedar Sale Activities	____________	____________
____	____	Woodcutting Activities	____________	____________
____	____	Bough Sales	____________	____________
____	____	Slash Burning	____________	____________
____	____	Tree Planting	____________	____________
____	____	Spray Projects	____________	____________
____	____	Hand Release	____________	____________
____	____	Precommercial Thinning	____________	____________
____	____	Tree Pruning	____________	____________
____	____	Stocking Surveys	____________	____________
____	____	Progeny Site Access	____________	____________
____	____	Property Survey Access	____________	____________
____	____	Recreation Access	____________	____________
____	____	Easements	____________	____________
		Other (describe):		
____	____	________________________	____________	____________
____	____	________________________	____________	____________

TYPE OF VACATING RECOMMENDED:____

____

____

____

APPROVED:

______________________________ ______________________________

Reforestation Unit Forester | District Engineering Supervisor.

______________________________ ______________________________

Management Unit Forester | Recreation Coordinator

____

Assistant District Forester

Information Management

It is recognized that the efficient and effective management of a road system requires the collection and management of a large amount of information about the system. Construction costs, maintenance costs, road condition information, construction plans and maintenance plans are a few of the many types of information that need to be collected and managed. Where possible, modern technology such as Global Positioning Systems, Geographic Information Systems, data recorders and data base software will be used to collect and manage the information.

The details of this chapter will be developed and added to the manual as soon as possible.

Responsibilities

The effective implementation of the elements of this manual involves numerous people at different levels and different locations in the Department of Forestry. The following listing of responsibilities is intended to provide a general view of how responsibilities are assigned for road management on state-owned forest land. In some cases staffing levels are different and responsibilities may be shifted to different personnel. In other cases responsibilities may be shifted to different personnel for organizational reasons. It is not as important where the responsibilities are assigned as it is that all of them are assigned to someone. Managers and supervisors are responsible for assuring that qualified personnel are assigned to carry out the responsibilities for road management identified in this manual.

State Forests Program Director

The State Forests Program Director is responsible for developing the overall policies, goals and objectives for forest road management on state-owned forest land.

State Forests Program Staff Engineer

The State Forests Program Staff Engineer is responsible for:

- Providing input and assistance to the Program Director in the development of policies, goals, and objectives for forest road management.
- Providing guidance, including training, on the implementation of the policies, goals, and objectives for forest road management.
- Providing technical assistance in the implementation of the policies, goals, and objectives for forest road management.
- Providing technical assistance in planning, designing, constructing, maintaining, and/or vacating specific road projects on state-owned forest land.
- Track and evaluate new methods and technology such as GIS and computer software for possible use in The State Forest Program.

Area Director

The Area Director is responsible for ensuring the elements of forest road management identified in this manual are efficiently and effectively accomplished in his/her geographic area.

District Forester

The District Forest is responsible for:

- Ensuring the elements of forest road management identified in this manual are efficiently and effectively accomplished in the district.
- Providing oversight and support in the staffing, budgeting, and organizing of road management on state-owned forest land in the district.

Assistant District Forester/Unit Forester

The Assistant District Forester/Unit Forester is responsible for:

- The overall supervision and management of the road management program on state-owned forest land in the district or unit.
- Identifying the long-term, mid-term, and short-term needs of the road management program in the district or unit and then staffing, budgeting, and organizing to meet the identified needs. Assuring that transportation plans have been developed and are being followed.
- The review and approval of critical and/or sensitive road construction, improvement, maintenance or vacation projects.
- The review and approval of significant changes to contracted road projects.
- Approval and documentation of exceptions to the standards and processes specified in this manual.

Timber Sale Layout Personnel

Timber Sale Layout Personnel are responsible for:

- Reconnaissance of proposed locations for roads and landings, including alternative locations that will be used to access planned timber sales.
- Marking proposed road and landing locations on the ground.
- Developing design specifications for roads that require basic level engineering procedures.
- Recognizing when proposed roads and/or landings will cross a critical or sensitive location and requesting the appropriate technical assistance in the location and design of that portion of the project.

District Engineer

The District Engineer is responsible for:

- Designing roads or portions of roads that require the use of mid-level or advanced level engineering procedures.

- Designing critical road structures such as culverts on fish bearing streams, bridges, or retaining walls.
- Assisting timber sale layout personnel in locating roads in sensitive areas such as high-risk sites or wetlands.
- Assisting project administrators in the review of unforeseen problems on road construction or improvement projects.
- Designing modifications to road construction or improvement projects when unforeseen problems arise.
- Providing technical assistance to project administrators and/or equipment operators on the use of various road construction, improvement, maintenance or vacating practices.
- Maintaining an inventory of the current condition of roads in the district on state-owned forestland and using the inventory to identify, plan, and schedule the road improvement and road maintenance needs in the district.
- Supervise the maintenance program for roads in the district that are on state-owned forestland.
- Developing and implementing a plan for "emergency road maintenance" during periods of severe weather.
- Provide input for transportation planning at the level II planning level in coordination with forest management planning.

For districts that do not have a district engineer, the above responsibilities must be assigned to other district personnel or fulfilled through other means such as assistance from adjacent districts or contracts.

Project Administrator

The Project Administrator is responsible for:

- Administering contract and/or project specifications to result in the project being completed as planned and designed.
- Documenting work on the project through diaries, inspection reports, instructions, and other written communications.
- Recognizing and initiating needed changes to contract and/or design specifications when unforeseen problems arise.
- Requesting technical assistance and/or input from geotechnical specialists, engineers, biologists, or other professionals for critical or sensitive situations.
- Taking appropriate administrative action when results are not consistent with contract or design specifications.

- Making progress inspections including a final inspection at the completion of the project. Approving or recommending approval of the project at its completion.

Geotechnical Specialist

Geotechnical specialists are a part of the area organization and provide assistance to several districts in the area. The Geotechnical Specialist is responsible for:

- Providing technical assistance in the location, design, and construction of roads and landings especially when high-risk sites, unstable areas, or other critical or sensitive geologic formations are involved.
- Providing technical assistance in designing modifications to projects when unforeseen situations are encountered.
- Providing technical assistance in the design and construction of road improvement projects especially when high-risk sites, unstable areas, or other critical or sensitive geologic formations are involved.
- Providing technical assistance in the vacating of roads especially when high-risk sites, unstable areas or other critical or sensitive geologic formations are involved.
- Providing technical assistance for repair of road prism failures especially when high-risk sites, unstable areas, or other critical or sensitive geologic formations are involved.

Appendixes

Appendix 1. Protocol for Road Hazard Inventories

Road Hazard Inventory

Background

The most common sources of sediment in rural and forested areas are from unsurfaced roads. Monitoring source areas of sediment can identify inputs of sediment to the stream system that may need to be mitigated. Ideally this should be done on a watershed scale. There are undoubtedly other sources of sediment in the watershed. This protocol only addresses road-related sources of sediment. Erosion associated with roads and ditches typically includes both surface erosion and landslides. Road construction disturbs and compacts soils and prevents revegetation. Therefore, in the forested landscape, roads are the greatest potential source of sediment outside the stream channels. This can occur in the form of surface erosion or landsliding. Past monitoring indicates three major areas of concern for road erosion. One concern is excess spacing of cross drainage on steep gradient roads. Another is a side ditch routed over long distances with direct discharge into channels. Finally, road-related landslides are typically associated with steep sidecast material. There are three major elements (Table F-1) of the road hazard inventory that address these road concerns.

Table F-1. Elements of road hazard inventory

Inventory Elements	Area of concern
Stream crossing structures	Washouts of crossings and fish passage through culverts
Sidecast fill on steep slopes	Sidecast-related landslides entering channels
Road surface drainage systems	Muddy drainage waters delivered to streams

In order to use this protocol, several terms need to be understood by monitoring participants:

Road prism

Cross section of roadway from the top of the excavated area (cut) to the toe of the fill.

Cutslope

Slope created by excavation into the natural hillslope, is steeper than the natural slope.

Sidecast

Unconsolidated excavated material pushed to the slope below the road, generally not used as part of the road, and steeper than the natural slope.

Fillslope

Excavated material placed below the road and intended to serve as part of the road.

Inslope

Road surface that is sloped so that all water drains toward the ditch or cutslope.

Outslope

Road surface that is sloped so that all water drains toward the fillslope or sidecast.

Berm

A continuous pile of fill and/or aggregate, usually on the outside edge of a road which prevents surface water from leaving the road.

Cross drain culvert

A culvert installed under and across a road to carry ditch water to the downslope side of a road..

Stream crossing culvert

A culvert installed in a stream channel intended to carry stream flow under the road.

Bridge

A structure intended to carry vehicles over a stream or other feature, usually consisting of a span and abutments.

Log puncheon

A drainage structure made of logs (often cedar) and no longer in common use.

Ford

A stream crossing where stream flow covers the crossing for all or part of the year.

Waterbar

A constructed ditch and berm designed to direct water across the road.

Dips

A cross drainage structure where a low spot is excavated along the profile of the road and where surface water of stream flow is directed across the road.

Grade break

Location where road grade reverses (typically on a saddle or ridge) and surface water automatically is drained away from the road surface in question.

Ditch

Trench constructed at the toe of a cutslope and intended to keep water off the road surface. Ditch water is drained down slope along the road to some point of relief or cross drain.

Landing

An area constructed for logging equipment and log handling operations. Landings may be at the end of roads, or constructed as wide spots in the road. They are typically wider than the rest of the logging road.

Ridge Road

Ridge roads are located on or near the ridgeline (most or all of the road on the top one-third of the slope).

Midslope Road

A road located between a ridge and stream channel

Valley Road

Any road which generally parallels a stream in places, usually in the former riparian area of the stream.

Equipment Needs

In order to successfully and efficiently collect road data, the following equipment is needed.

- Vehicle—a vehicle (pick-up or utility rig) is preferred for road access, although a mountain bike can also be used where access is poor.
- Two person crew—a single person can collect the necessary data, although a crew of two can be more effective. The inventory person or crew can also be used to mark culverts and to flag locations needing immediate maintenance attention.
- Distance Measuring Instrument (DMI) and Hip Chain (String Box)—a DMI or other device that records vehicle travel distance in feet is recommended to accurately record distances while traveling along roads. Impassable roads are measured with a hip chain (string box).
- Clinometer—a clinometer is used to determine average road gradient and hillslope steepness. More accurate measurement tools (engineer's level) are required for any actual repair activity.
- Scaled rod or staff and a measuring (loggers) tape—lengths of culverts and bridges will be measured with these tools.
- ODF stream classification maps—on USGS 7.5 minute quad maps and/or other maps showing roads and streams are also needed.
- Global Positioning System (GPS)—GPS may be used to map road features. However, use of GPS to date has significantly slowed data collection, and is not an essential component of this protocol. GPS efficiency is poor in areas of narrow canyons or when the canopy is wet.

- Data Logger—direct data entry into a field data-logger as it is being collected can be very efficient.
- Computer System and Software—inventory information should be entered into relational databases. Relational databases are probably the most effective tool for making sense of large amounts of information. Commonly available software can be used to query the database to find high erosion hazards or barriers to fish migration.
- Geographic Information System (GIS)—data can be entered into a GIS system without GPS data using *dynamic segmentation*. If GPS has been used, the locations of features can be directly input to a GIS system.

Site Selection

The road hazard inventory is designed to assess all roads under a given ownership or within a given watershed. The protocol provides information to help landowners identify roads of concern and prioritize repair activities. It does not provide all the information necessary to implement those repairs. Timely inspection and subsequent maintenance or repair activity on forest roads will benefit fish and fish habitat. Therefore, it should eventually be conducted on all road miles that potentially affect fish habitat. Prioritizing site selection depends on the monitoring question being asked. However, in general, road inventories should first be conducted in areas where roads pose higher risk to anadromous fish and their habitats. This can be determined from:

- Landowner knowledge
- Topographic maps showing:
  - stream crossings of fish bearing streams,
  - midslope roads on steep slopes, and/or
  - steep, long road grades leading to channel crossing

Landowners are encouraged to use this protocol for road management purposes other than erosion hazard reduction. Possible uses include routine maintenance and surfacing decisions.

Road Hazard Field Methods

Overall Methodology

Begin at a road junction or other landmark. Take measurements described in the **Surface Drainage Section** below. As you travel along the road, measure the distance (DMI or other device starting at 0), until encountering a drainage feature and or stream crossing. This is referred to as road stationing. Record distance traveled, repeat surface drainage measurements and take **Culvert/Bridge and/or Stream Crossing Details** (described below), whichever are applicable. Record observations of general road characteristics (described in next section) for the entire road.

General Road Characteristics

Each road should be identified by name or number, according to the system normally used by the landowner. General characteristics are normally collected only once for each road. The following observations are used to classify each road and can be documented on a from as in Table F-2:

Road identification by name, numbering system or other means.

Road use by management activity.

> <u>active roads</u>: have been used for timber haul in the past year
>
> <u>inactive roads</u>: include all other roads used for management since 1972; and
>
> <u>orphaned roads</u> are overgrown roads or railroad grades not used since 1972.

Surfacing material is described as asphalt, clean rock (new quarry rock); old rock (more common); or dirt.

Road location is described as ridge, midslope, or valley as the location of most of the road.

Width of the entire road is estimated (from the outside edge to the base of the cutslope).

For ownerships where *georegion, geology or soils* are variable and have a great influence on erosion, these classifications should also be documented.

Record whether the road is *outsloped* or has a *ditch*.

Record the *location* of the road with respect to a landmark. This may be done with the GPS unit or on a map.

Surface Drainage

Between drainage features, information is collected on the erosion potential and sediment delivery potential of the roadway. The typical road conditions between each drainage feature are categorized to identify erosion problems. The following observations and measurements are made to identify symptoms of high erosion on road segments that best describe the condition of the entire segment:

Road Grade

Road grade (slope) is measured in percent, with an estimated average when the slope changes. Slope is recorded as positive if the direction is up from the measuring point or feature, and negative when the direction is down from the feature. A positive slope drains toward the feature, a negative slope drains away from the feature.

Road Surface Condition

Road surface condition is described as good, rutted, bermed, or eroded (gullied).

Ditch

Ditch is described by function as good (capable of holding runoff without serious erosion), cutting, diverted, or full.

Cutslope

Cutslope is described as good (stable), ravel problems, or slides into the road.

Delivery

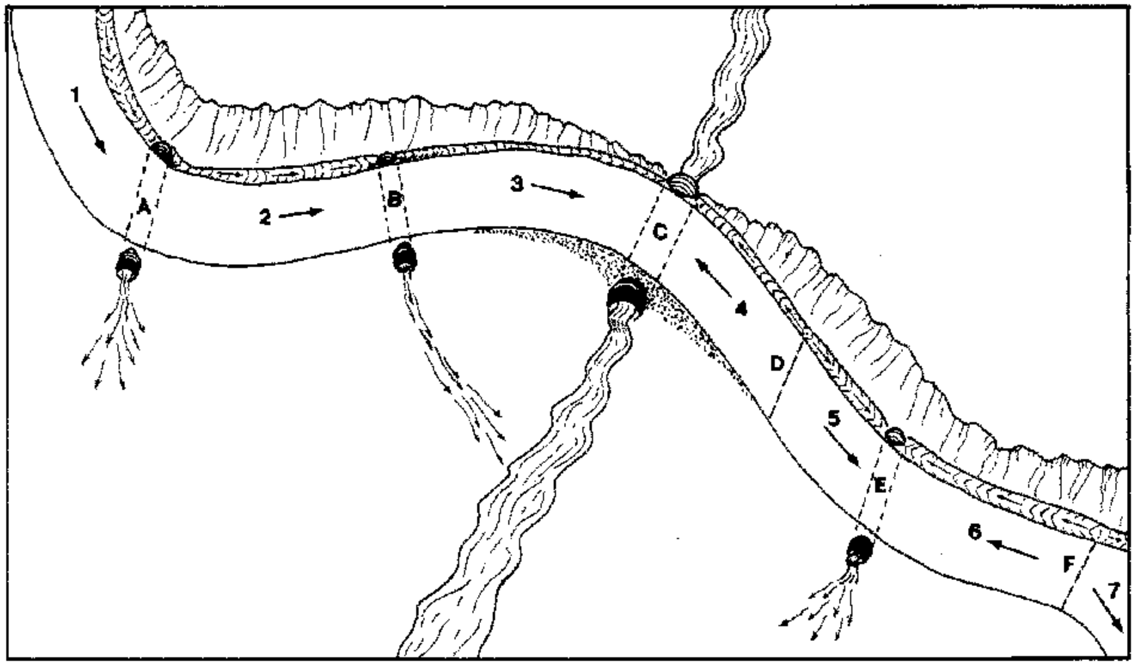
Delivery of sediment to streams from that length of road is described as "yes," "possible," "no," or "bypassed" (water flows past the drainage feature and not off of the road).

Road length draining to drainage.

The length of road draining to each drainage feature can be calculated by use of several commonly available database or spreadsheet programs. For properly functioning outsloped roads there are no cross drainage features, only stream crossing features.

Drainage and Stream Crossings

Drainage data is collected at each drainage feature where collected drainage water is directed away from or under the roadway, and also at drainage divides. Drainage features include: stream crossing culverts, bridges, log puncheons, fords, cross-drain culverts, waterbars, dips, other relief, landings, and grade breaks. For each drainage feature, record the distance from road stationing and the type of feature so that drainage spacing can be determined. Landowners may also choose to locate features such as gates and water pump chances. A typical length of road with drainage patterns and features is shown in Figure F-1.



A. Cross-drain culvert, sediment filtered and not delivered to stream.
B. Cross-drain culvert with sediment delivery from segment 2 to stream.
C. Stream-crossing culvert, sediment from road segments 3 and 4 delivered to stream.
D. Drainage divide.
E. Cross-drain culvert, possible sediment delivery to stream.

Figure F-1. Typical road surface drainage and drainage features.

Culvert (and bridge) Detail

The following information is collected for all culverts (stream crossing and cross drain) and bridges.

Diameter/Span

Diameter/span of the culvert (diameter for round, rise and span for arch) or span length (for bridge) is measured in inches (for culverts) and feet (for bridges).

Condition

Condition of the culvert is described as good; mechanical damage, sediment blockage, rusted, bottom out, collapse, animal (beavers), wood blockage, natural bottom (gravel) [more than one description may be appropriate in this category].

Inlet Opening

Inlet opening is estimated as a percent or original (design) opening.

Stream Crossing Detail

Stream crossings are an extremely important part of the road system. Improperly functioning stream crossings can result in loss of the roadway through washouts and channel diversions. Stream crossings can also be barriers to fish movement. At each crossing structure, information should be collected by getting out of the vehicle and taking measurements at the inlet end and near the outlet end of the structure. In addition to the culvert detail, the following information should be collected at each stream-crossing culvert (Figure F-2).

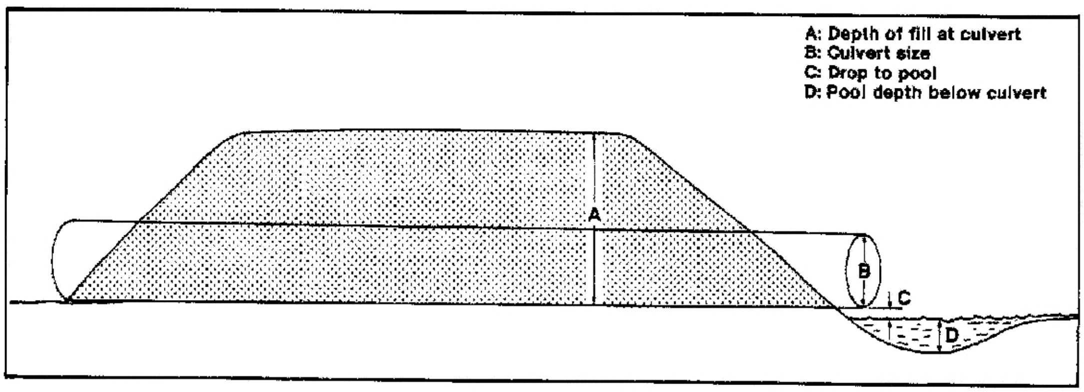


Figure F-2. Stream-crossing culvert with key dimensions.

Fish Presence

Fish presence (species, if known, from ODF classification maps or other sources) as fish use known; unknown fish use; no fish use; or anadromous fish use.

Diversion Potential

Diversion potential (for streamflow directed down and eroding the roadway) is described as high, medium or low.

Culvert Slope

Culvert slope is measured for fish use, or unknown fish use streams only.

Fill Height

Fill height is estimated from the channel bottom to the road surface at the downstream end.

Outlet Drop

Outlet drop is the distance from the bottom of the pipe to the elevation of the pool, in feet (countersunk outlets get a negative drop). This can vary with discharge so measurement should generally be taken during summer flow.

Resting Pool

Resting Pool below the pipe is categorized for fish use, or possible fish use streams only as good (at least two feet deep and six feet long); fair (at least one foot deep and four feet long); or absent.

Sediment Filtering

Sediment filtering opportunities around the crossing are noted as utilized, not utilized, or not available.

Sidecast Detail

Sidecast-related landslides are reasonably expected along particularly steep sections of road (Table F-3). Depending on georegion, geology, soil, and drainage, the natural slopes (below the road) for a steep section can be as gentle as 50% (in wet areas with weak sidecast and drainage problems). In areas with well-drained materials with uniform slopes and no or very limited signs of old slides, the appropriate slope may be 65 or 70%. Sections of road which have experienced past sidecast-related landslides should also be inventoried. The beginning and ending points used to characterize sidecast stability will be different than those used to characterize drainage. Therefore, a separate database is used (Figure F-3). Begin characterizing sidecast stability at the point in the road where steepness indicates there is a slope failure hazard. This may be, and usually is, at some distance between drainage features. Record this station distance from the road junction or landmark the same as the drainage features. Also record the ending point in the same manner. The following features are then used to describe typical conditions over the steep sections:

Average Natural Slope Steepness

Average natural slope steepness under the sidecast (if present).

Indicators of Movement

Indicators of movement described as none; cracks, a drop in the outside of the prism; or signs of old sidecast slides.

Vegetation

Vegetation on the sidecast is described as none, cover (grass or brush), reproduction (plantation), or forest.

Fill Condition

Fill condition is described as "at least 15% steeper than the natural slope," logs exposed, or good.

Fill Depth

Fill depth at the outside edge of the road is estimated to the nearest foot, vertical measurement.

Downslope Risk

Downslope risk to streams is described by a qualitative rating of slope to nearest stream channel low, moderate, or high based on the presence and size of bench terrain between the site and the nearest channel.

Forms

Example data sheets suitable for relational databases are shown in Tables F-2 and F-3. There is one data sheet for surface drainage and stream crossings (Table F-2), and another data sheet for sidecast (Table F-3), since the beginning and ending points of areas of sidecast concern rarely coincide with drainage location. Codes for the data sheet are explained on the pages following the data sheets. The codes have been designed with one or two digits (underlined) to reduce the size of the code sheets.

Table F-2. Field data sheet for surface drainage and stream crossing details and examples of collected data. In this example attention is required on the last entry because the culvert is partially blocked.

Road name/number _______________________ Road Use: Active, Inactive, Orphaned Surfacing: Dirt, Rock, Clean rock

Road Location: Ridge, Midslope, Valley ______ Avg. Width ______________________________________ Ditch: yes/No Outslope: Yes/no

Inventoried by: ______________________ Date___________________________________ Geology/Soils________________

			Surface Drainage					Culvert Detail					Stream Crossing Detail						
Station	Fea-ture	Attn.	Grade	Ditch	Cut-slope	Sur-face	Deli-very	Diam/span	Mat	Cond-ition	% open	Outlet	Fish	Diver	Fill	Filter	Slope	Drop	Pool
0	JN	N	12	G	G	G	Y												
352	GB	N	-1	G	G	R	Y												
537	DP	N	6	G	G	G	Y												
681	BR	N	11	G	G	G	Y	56											
1686	DP	N	10	G	G	G	Y												
2016	SC	N	14	G	G	G	Y	24	S	G	100	6	N	H	9	N	6	6	N
2026	SC	Y	16	G	G	G	Y	12	S	M	20	G	N	H	7	N	8	5	N

Feature codes:

SC = stream crossing culvert CC = cross drain culvert BR = bridge JN = road junction GB = grade breakPN = log puncheon

DR = any other ditch relief I = features requiring immediate attention WB = waterbar DP = dip LD = landing

PC = pump chance G = gate

Table F-3. Field data sheets for sidecast details. Example included.

Road name/Number:____________________ Date______________
Inventoried by_____________________

Sidecast Detail								
Station Start (ft)	Station end (ft)	% slope Below	Movement Indicators.	Vegetation	Fill condition	Fill depth	Downslope Risk	Remarks
3413	3814	70	S	F	C	2	H	Stream has washed out road.

Codes:	Codes:	Codes	Codes:
Cracks	None	Steep 15	Low
Drop	Veg.	Logs	Moderate
Slide Activity	Reprod.	Good	High
None	Forested		

Road Data Analysis

Road data should be analyzed to determine which roads, drainage systems, and/or stream crossings:

- are not functioning properly,
- may be delivering sediment to fish-bearing streams,
- do not pass fish (calculated from the data collected, refer to ODF&W fish passage protocol),
- and/or pose a risk to fish bearing streams (road-related landslides).

There are a number of red flags to look for. Examples include:

- Average distance to first cross drain is over 500 feet and road grade is greater than 6%,
- Culverts that are more than 50% blocked,
- Logs in fills,
- Steep sidecast with high downslope risk,
- Fish bearing streams with culverts that have a >0 foot outlet drop, gradient over 1%, and are not retaining sediment or do not have baffles.

Calculations of the road data can be done with a spreadsheet or database to address these road maintenance, sediment, and fish-passage related concerns.

Road-related results can be combined with turbidity and channel information to understand erosion and sediment processes in your watershed. It is important to recognize that a correlation between the three measurements may not reflect cause-and-effect relationships. In general such relationships can only be achieved with a properly designed and controlled study. However, over time the data will be useful for understanding environmental trends.

Appendix 2. Exhibits for Timber Sale Contracts/Service Contracts

State Timber Sale Contract — Page __ of __
No. 341-00-__

____
[Sale Name]

(XB1)

EXHIBIT "*___"

FOREST ROAD SPECIFICATIONS

SUBGRADE WIDTH	SURFACED WIDTH	POINT TO POINT	STATION TO STATION	DRAINAGE
*feet	feet	to	to	
feet	feet	to	to	
feet	feet	to	to	
feet	feet	to	to	

CLEARING. This work shall consist of clearing, removing, and disposing of all trees, snags, down timber, brush, surface objects, and protruding obstructions within the clearing limits.

Where clearing limits have not been staked, the clearing limits shall extend 10 feet back of the top of the cutslope and 5 feet out from the toe of the fill slope, or as directed by STATE. Clearing debris shall not be placed or permitted to remain in or under any road embankment sections. Clearing debris shall not be left lodged against standing trees.

All danger trees, leaners, and snags outside the clearing limits which could fall and hit the road shall be felled.

All stumps shall be completely removed within the limits of required grubbing. Stumps overhanging cutslopes shall be removed. Grubbing debris shall not be placed or permitted to remain in or under any road embankment sections. Grubbing debris shall not be left lodged against standing trees. Grubbing classifications are as follows:

New construction - From the top of the cutslope to the toe of the fill.

Improvements and reconstructions - 4 feet back from the shoulder of the subgrade or ditch, whichever is widest, or as marked in the field.

CLEARING AND GRUBBING DISPOSAL. * Scatter through openings in the timber outside of the cleared right-of-way, except areas where end-haul is required.

____
[Sale Name] (XB2)

EXHIBIT "*___"

FOREST ROAD SPECIFICATIONS

EXCAVATION. Excavation and grading shall not be done when weather and/or ground conditions are such that damage will result to existing subgrade or cause excessive erosion.

Excavation shall conform to STATE-engineered lines, grades, dimensions, and plans when provided.

All suitable excavated material shall be used where possible for the formation of fills, shoulders, and drainage structure backfills. Embankment materials shall be free of woody debris, brush, muck, sod, frozen material, and other deleterious materials. All fills and drainage structure backfills shall be machine compacted in lifts not to exceed 8 inches in depth.

Unless road design plans show otherwise, all roads shall be on a balanced cross section, except when the slope is over 50 percent; the road shall be on full bench for the width specified.

Excess excavation shall not be sidecast where material will enter a stream course or where material will accumulate in areas deemed a high-risk site by STATE.

ROAD WIDTH LIMITATIONS. PURCHASER shall obtain advance written approval from STATE to construct the road to a greater width than specified. Extra subgrade width shall be required for:

Fill Widening. Add to each fill shoulder 1 foot for fills 3 feet to 6 feet high; 2 feet for fills over 6 feet high.

Curve Widening. Widen the inside shoulder of all curves as follows: 400 divided by the radius of the curve equals the amount of extra width.

DRAINAGE

TURNOUTS. Increase roadbed width an additional 8 feet for both subgrade and surfacing. Length shall be a minimum 25 feet, or as staked on the ground, plus 25-foot approaches at each end.

Location: *( ) Intervisible but not greater than 750 feet.
*( ) As marked in the field.

GRADING	Back Slopes	Fill Slopes
Rock	Vertical to 1/4:1	Not steeper
Common - side slopes 50% and over	*1/2:1	than 1½:1
Common - side slopes less than 50%	*3/4:1	
Common - turnpike (level) section	2:1	

Top of cutslope shall be rounded.

*( ) LANDINGS. Landings shall be constructed no less than 50 feet wide and no more than 70 feet wide. Surface is to be crowned for drainage, with general grade no more than 3 percent. Surface as shown on Exhibit *____, Page *____.

*( ) TURNAROUNDS. Increase subgrade width an additional 20 feet for a length of 20 feet at locations marked in the field.

____
[Sale Name]

(XB3)

EXHIBIT "*___"

ROAD IMPROVEMENT INSTRUCTIONS

[NOTE: Use this separate page when instructions are
too lengthy or detailed to be contained in the project work section.]

(XB3a)

EXHIBIT "*___"

ROAD CONSTRUCTION INSTRUCTIONS

[NOTE: Use this separate page when instructions are too lengthy or detailed to be contained in the project work section.]

(XB4)

EXHIBIT "*___"

LOGGING ROAD BRUSHING SPECIFICATIONS

REQUIREMENTS

Brush and trees shall be cut to a maximum height of 6 inches above the ground surface or obstructions such as rocks or existing stumps.

Debris resulting from the brushing operation shall be removed from the roadway, cutslope, ditches, and water courses and may be scattered downslope from the road or placed in other stable locations. Large debris, 6 inches or larger in diameter, shall be cut into lengths of 6 feet or less to facilitate rapid decay, unless otherwise approved by STATE.

Conifer trees larger than 6 inches in diameter at stump height, located within clearing limits but outside of the ditchline or shoulder, shall not be cut down, but shall be limbed for road visibility.

[NOTE: Clearing widths must be filled in on the diagram.]

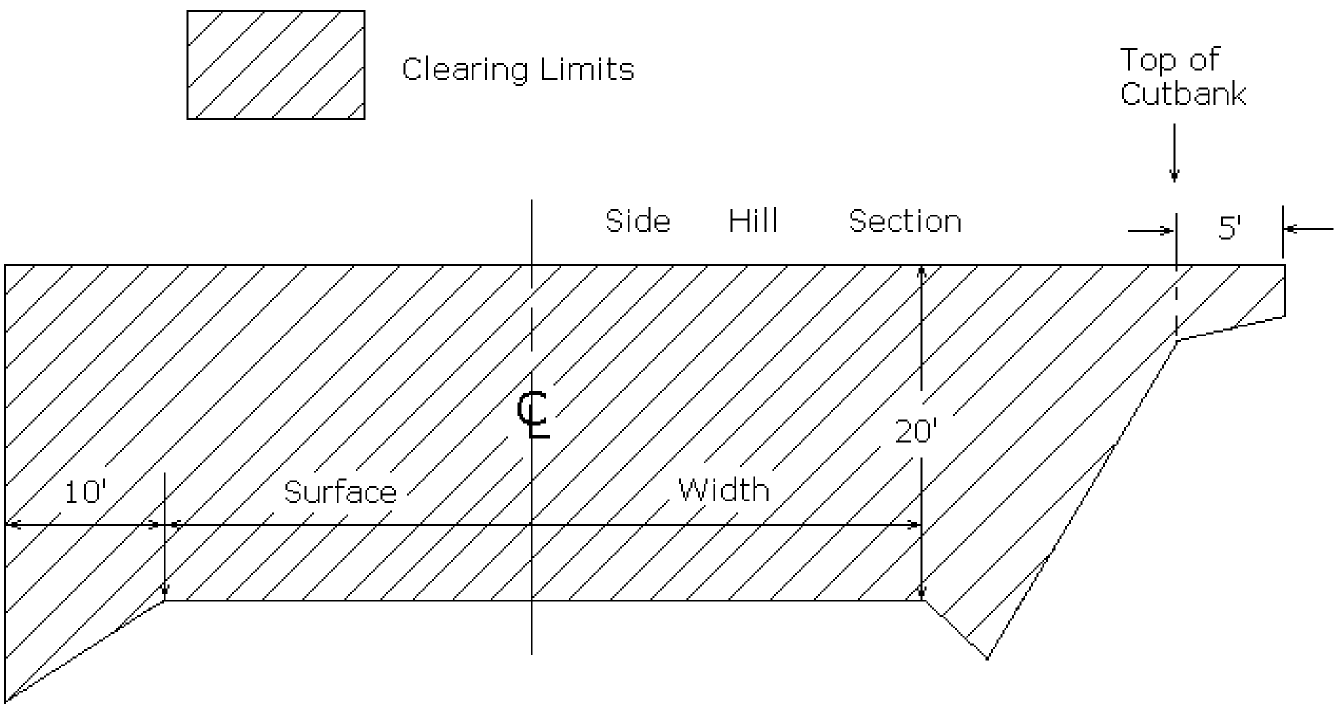
State Timber Sale Contract
No. 341-00-__

____
[Sale Name]

(XB5)

EXHIBIT "*___"

LOGGING ROAD BRUSHING SPECIFICATIONS



REQUIREMENTS

The minimum height of clearing shall be 15 feet, and the minimum width of clearing on the cutslope side(s) of the road shall be 5 feet beyond the top of the cutbank.

Brush and trees shall be cut to a maximum height of 6 inches above the ground surface or obstructions such as rocks or existing stumps.

Debris resulting from the brushing operation shall be removed from the roadway, cutslope, ditches, and water courses and may be scattered downslope from the road or placed in other stable locations. Large debris, 6 inches or larger in diameter, shall be cut into lengths of 6 feet or less to facilitate rapid decay, unless otherwise approved by STATE.

Conifer trees larger than 6 inches in diameter at stump height, located within clearing limits but outside of the ditchline or shoulder, shall not be cut down, but shall be limbed for road visibility.

[NOTE: Clearing widths must be filled in on the diagram.]

(XB6)

EXHIBIT "*___"

END-HAULING REQUIREMENTS

POINT TO POINT	STA. TO STA.	CONTAINMENT	WASTE AREA LOCATION	WASTE AREA TREATMENT
to	to			
to	to			
to	to			
to	to			

End-Haul Areas General Requirements

Material shall not be intentionally sidecast.

Clearing and grubbing debris shall be end-hauled.

When blasting is required, it shall be accomplished using timing devices, delayed charges, low intensity shots, or other suitable means to contain as much material as possible within the road prism.

Containment

(1) Full containment: The amount of material lost over the outside edge of the road shall not exceed 6 inches in depth measured perpendicular to the natural ground slope. Pioneer excavation shall be removed by digging, loading, and hauling rather than by pushing or scraping methods.

(2) Average containment: The amount of material lost over the outside edge of the road shall not exceed
*___ inches in depth measured perpendicular to the natural ground slope.

Trees and stumps may have up to 12 inches of material directly above them. Any amount of material exceeding the containment requirements shall be removed by operator from the slope, by whatever means necessary, and end-hauled to a designated waste area.

Waste Area Location

(1) As shown on Exhibit A and as marked in the field.

(2) *

Waste Area Treatment

(1) Deposit at waste area, spread evenly, compact, and provide adequate drainage.

(2) Pile woody debris separate from other waste material.

(3) *

____
[Sale Name]   (XC1)   [DEPTH MEASUREMENT]

EXHIBIT "*__"

ROAD SURFACING

TYPE OF ROCK	SIZE OF ROCK	COMPACTED DEPTH	POINT TO POINT	STATION TO STATION	APPROX. TOTAL TRUCK MEASURE VOLUME
		"			CY
		"			CY
		"			CY
TURNOUTS:			**NO. OF T.O.**	**POINT TO POINT**	
		"			CY
		"			CY
		"			CY
TURNAROUNDS:			**NO. OF T.A.**		
		"			CY
		"			CY
		"			CY
LANDINGS AND JUNCTIONS:			**NO. OF LDGS.**	**NO. OF JCTS.**	
		"			CY
		"			CY
		"			CY
MISCELLANEOUS: [Riprap, drain rock, etc.]		**AMOUNT**	**POINT TO POINT**	**STATION TO STATION**	
		CY			CY
		CY			CY
		CY			CY

Additional rock for curve widening is required and has been included in the volume estimates.

Roads shall be uniformly graded and approved by STATE prior to rocking. For typical cross section, see Forestry Department Drawing Nos. 351-C and 351-D at the Forestry Department district office.

State Timber Sale Contract
No. 341-00-__

____
[Sale Name]

(XC2)

[ROCK CHECKERS
OR
LOAD RECORDS]

EXHIBIT "*___"

ROAD SURFACING

TYPE OF ROCK	**SIZE OF ROCK**	**VOLUME PER STATION**	**POINT TO POINT**	**STATON TO STATION**	**TOTAL VOLUME**
		CY			CY
		CY			CY
		CY			CY
		CY			CY
		CY			CY
TURNOUTS:			**NO. OF T.O.**	**POINT TO POINT**	
		CY			CY
		CY			CY
		CY			CY
TURNAROUNDS:			**NO. OF T.A.**		
		CY			CY
		CY			CY
		CY			CY
LANDINGS AND JUNCTIONS:			**NO. OF LDGS.**	**NO. OF JCTS.**	
		CY			CY
		CY			CY
		CY			CY
MISCELLANEOUS:		**AMOUNT**	**POINT TO POINT**	**STATION TO STATION**	
		CY			CY
		CY			CY
		CY			CY

Roads shall be uniformly graded and approved by STATE prior to rocking. For typical cross section, see Forestry Department Drawing Nos. 351-C and 351-D at the Forestry Department district office.

(XC3)

EXHIBIT "*__"

CRUSHED ROCK SPECIFICATIONS

Materials. The material shall be fragments of rock or other hard, durable particles crushed to the required size and a filler of finely crushed stone, sand, or other finely divided mineral matter. The material shall be free from vegetation and lumps of clay.

Quality and Grading Requirements. The stone base materials shall be crushed rock, including sand.

*( ) River gravel shall not be used. [Fracture of Gravel deleted]
*( ) River gravel shall conform to the specifications listed below under Fracture of Gravel.
*( ) River gravel may be used for 3/4"-0" crushed rock and shall conform to the specifications listed below under Fracture of Gravel.

The material from which base material is produced or manufactured shall conform to the general requirements of Section 2630 of the "Standard Specifications for Highway Construction" prepared by the Highway Division, Oregon Department of Transportation, and shall meet the following test requirements:

Hardness - Test Method AASHTO T 96 35% Maximum

Durability - Test Method ODOT TM 208
Passing No. 20 Sieve: 30% Maximum
Sediment Height: *_____" Maximum

Fracture of Gravel. Base materials produced from river gravel shall be crushed as required to provide at least 1 mechanically fractured face to a prescribed minimum percentage of materials retained on a 1/4-inch sieve.

The minimum percentage of fractured material in the "1/4-inch plus" fraction of each designated size of material shall be as follows:

2½"-0", 2"-0", 1½"-0" 50%
1"-0", 3/4"-0", 1/2"-0" 70%

[NOTE: Fracture of Gravel requirements do not apply to quarry rock.]

[Grading requirements to follow.]

(XC3-a)

EXHIBIT "*__"

CRUSHED ROCK SPECIFICATIONS

[OPTIONS – PARAGRAPHS]

( ) For the purpose of crushing rock specified under the projects in the section titled, "Project Work," PURCHASER shall utilize a three-stage rock crusher, or equivalent, unless otherwise approved by STATE.

( ) A sample of the rock shall be supplied to STATE for testing and approval prior to crushing. The rock crusher must be calibrated to produce rock as specified in Exhibit *____. Rock must be accepted by STATE prior to any production by the crusher. Any rock crushed prior to such acceptance shall not be credited to the required rock quantity. Rock is to be stockpiled according to STATE instructions. Crushing equipment shall not be removed until all stockpiling and measurements have been accepted by STATE.

( ) The rock crusher shall be calibrated to produce rock as specified in Exhibit *____. Prior to the commencement of production crushing, PURCHASER shall sample, test, and provide rock test results meeting STATE specifications. STATE may then sample and test crushed rock for approval to proceed. PURCHASER shall take one sample of each 2,000 cubic yards of crushed rock material produced thereafter, using approved AASHTO sampling procedures. PURCHASER shall submit samples to a certified laboratory or shall perform testing for gradation requirements using AASHTO T 11 and AASHTO T 27 testing procedures. Prior to testing, each sample shall be split, making one-half of the sample, with proper identification, available for testing by STATE. Each sample and the results of PURCHASER testing shall be made available to STATE within 24 hours of sampling. Any rock crushed prior to STATE approval to proceed shall not be credited to the required rock quantity. Any subsequent rock tests not meeting STATE specifications shall be reason for rejection of that portion of crushed rock produced after that test and shall not be credited to the required rock quantity. STATE may sample the crushed rock at any time during the operation. Results of STATE's tests shall prevail over all other test results.

____

[Sale Name] (XC4) [STATEWIDE]

EXHIBIT "*__"

CRUSHED ROCK SPECIFICATIONS

Grading Requirements

For 3/4"-0"	Passing	1" sieve	100%
	Passing	3/4" sieve	90-100%
	Passing	3/8" sieve	55-75%
	Passing	1/4" sieve	40-60%

Of the fraction passing 1/4" sieve, 40% to 60% shall pass the No. 10 sieve.

For 1½"-0"	Passing	2" sieve	100%
	Passing	1½" sieve	95-100%
	Passing	3/4" sieve	55-75%
	Passing	1/4" sieve	35-50%

Of the fraction passing 1/4" sieve, 40% to 60% shall pass the No. 10 sieve.

For 2"-0"	Passing	2½" sieve	100%
	Passing	2" sieve	95-100%
	Passing	1" sieve	55-75%
	Passing	1/4" sieve	30-45%

Of the fraction passing 1/4" sieve, 40% to 60% shall pass the No. 10 sieve.

For 2½ "-0"	Passing	3" sieve	100%
	Passing	2½" sieve	95-100%
	Passing	1¼" sieve	55-75%
	Passing	1/4" sieve	30-45%

Of the fraction passing 1/4" sieve, 40% to 60% shall pass the No. 10 sieve.

	Passing	3" sieve	95-100%
	Passing	1½" sieve	55-75%
	Passing	¼" sieve	30-45%

Of the fraction passing 1/4" sieve, 40% to 60% shall pass the No. 10 sieve.

For 4"-0"	Passing	4½" sieve	100%
	Passing	4" sieve	95-100%
	Passing	2" sieve	55-75%
	Passing	1/4" sieve	30-45%
For Jaw-Run	Passing	6" sieve	100%
	Passing	3" sieve	45-65%
For 6"-0" Pit-Run	Passing	10" sieve	100%
	Passing	6" sieve	65%

The referenced sieve shall have square openings as set forth in AASHTO M 92, Woven Cloth Series.
The determinations of size and gradings shall be as set forth in AASHTO T 27.

Rev. 5/99

(XC5) [COOS ONLY]

EXHIBIT "*__"

CRUSHED ROCK SPECIFICATIONS

Grading Requirements

For 3/4"-0"	Passing	1" sieve retained on 3/4" sieve	0-10%
	Passing	3/4" sieve retained on 3/8" sieve	30-60%
	Passing	1/4" sieve	30-50%
For 1½"-0"	Passing	2" sieve retained on 1½" sieve	0-10%
	Passing	1½" sieve retained on 3/4" sieve	10-50%
	Passing	3/4" sieve retained on 1/4" sieve	20-60%
	Passing	1/4" sieve	10-30%
For 2½"-0"	Passing	3" sieve retained on 2½" sieve	0-10%
	Passing	2½" sieve retained on 1¼" sieve	30-60%
	Passing	1/4" sieve	24-40%
For 3"-0"	Passing	3½" sieve retained on 3" sieve	0-5%
	Passing	3" sieve retained on 1½" sieve	20-50%
	Passing	1½" sieve retained on 1/4" sieve	20-40%
	Passing	1/4" sieve	15-30%
For 4"-0"	Passing	6½" sieve retained on 4" sieve	0-5%
	Passing	4" sieve retained on 2½" sieve	20-50%
	Passing	2½" sieve retained on 1/4" sieve	20-50%
	Passing	1/4" sieve	10-25%

The referenced sieve shall have square openings as set forth in AASHTO M 92, Woven Cloth Series. The determinations of size and gradings shall be as set forth in AASHTO T 27.

(XC6) [MULTIPLE METHODS]

EXHIBIT "*___"

ROCK ACCOUNTABILITY

The rock shall meet the quality and size specifications in Exhibit *___. A sample of the rock must be supplied to STATE for testing and approval prior to rocking. Subgrades must be approved by STATE prior to rocking. Rocking must be done only when weather conditions are acceptable to STATE, and must be suspended when muddy water could enter streams from runoff.

Rock accountability shall be determined by the following methods, as directed by STATE. STATE shall be given 24 hours' notice prior to rocking.

Rock Checking. All rock spreading shall be done only when a STATE representative is present. STATE shall issue a receipt for each load delivered, and rock shall be measured without allowance for shrinkage or shakedown during hauling. Total truck measure volume for each road segment shall be as shown on Exhibit
*___. Deliver at least *_____ cubic yards per 8-hour shift, unless otherwise approved by STATE. A penalty of
$*______ for each 10 cubic yards which are not delivered during a single shift shall be billed, and payment shall be required prior to final acceptance of the project by STATE.

Depth Measurement. Rock shall be spread and compacted according to the depths specified in Exhibit *___. Truck measure volumes are given, but shall not limit the amount of rock spread.

Depth shall be determined in the most compacted area of the surface cross section. If additional rock is required because of insufficient depth, it shall be added by truck measure to those areas that were slighted. The conversion from compacted yardage to truck yardage is 1.3 multiplied by the compacted yardage equals truck yardage.

The depth of compacted aggregates shall not vary more than 1 inch from the depth specified in Exhibit * . The average depth for each road segment shall be the specified depth or greater. Surfacing areas shall be staked by STATE.

Junctions shall have a surfaced area of at least *____ square yards each at the compacted depths specified in Exhibit *___.

Turnouts shall have a surfaced area of at least *____ square yards each at the depths shown in Exhibit * .

Landings shall have a surfaced area of at least *____ square yards each at the depths shown in Exhibit * .

Load Records. Notify STATE before spreading the rock and maintain a record of all rock delivered for spreading. Make the record available for STATE inspection. A report listing the amount of rock delivered the prior month must be submitted no later than the 15th of each month.

(XC7) [DEPTH MEASUREMENT]

EXHIBIT "*__"

ROCK ACCOUNTABILITY

The rock shall meet the quality and size specifications in Exhibit *___. A sample of the rock must be supplied to STATE for testing and approval prior to rocking. Subgrades must be approved by STATE prior to rocking. Rocking must be done only when weather conditions are acceptable to STATE, and must be suspended when muddy water could enter streams from runoff.

Rock accountability shall be determined by depth measurement. STATE shall be given 24 hours' notice prior to rocking.

Depth Measurement. Rock shall be spread and compacted according to the depths specified in Exhibit *___. Truck measure volumes are given, but shall not limit the amount of rock spread.

Depth shall be determined in the most compacted area of the surface cross section. If additional rock is required because of insufficient depth, it shall be added by truck measure to those areas that were slighted. The conversion from compacted yardage to truck yardage is 1.3 multiplied by the compacted yardage equals truck yardage.

The depth of compacted aggregates shall not vary more than 1 inch from the depth specified in Exhibit * . The average depth for each road segment shall be the specified depth or greater. Surfacing areas shall be staked by STATE.

Junctions shall have a surfaced area of at least *____ square yards each at the compacted depths specified in Exhibit *___.

Turnouts shall have a surfaced area of at least *____ square yards each at the depths shown in Exhibit * .

Landings shall have a surfaced area of at least *____ square yards each at the depths shown in Exhibit * .

Curve Surfacing. Extra surface width shall be required for the inside of all curves as follows: 400 divided by the radius of the curve equals the amount of extra width to be surfaced at the depths shown in Exhibit *_______.

(XC8) [ROCK CHECKERS]

EXHIBIT "*__"

ROCK ACCOUNTABILITY

The rock shall meet the quality and size specifications in Exhibit *___. A sample of the rock must be supplied to STATE for testing and approval prior to rocking. Subgrades must be approved by STATE prior to rocking. Rocking must be done only when weather conditions are acceptable to STATE, and must be suspended when muddy water could enter streams from runoff.

Rock accountability shall be determined by rock checking. STATE shall be given 24 hours' notice prior to rocking.

Rock Checking. All rock spreading shall be done only when a STATE representative is present. STATE shall issue a receipt for each load delivered, and rock shall be measured without allowance for shrinkage or shakedown during hauling. Total truck measure volume for each road segment shall be as shown on Exhibit *___. Deliver at least *_______ cubic yards per 8-hour shift, unless otherwise approved by STATE. A penalty of $*_______ for each 10 cubic yards which are not delivered during a single shift shall be billed, and payment shall be required prior to final acceptance of the project by STATE.

(XC9)

EXHIBIT "*__"

ROCK SPREADING, PROCESSING, AND COMPACTION

Pit-Run Rock. Pit-run surfacing rock shall be spread on roads with a crawler tractor and continuously walked-in. Rock spreading shall begin at nearest point from the rock source and progress toward the end of the project, unless otherwise approved in writing by STATE. (*Compaction shall be accomplished by using one or more of the approved equipment options listed below:) (*Compaction shall be accomplished by using the approved equipment listed below or others approved by STATE:)

*( ) Rock shall be compacted and processed during the same project period it is spread, unless otherwise approved in writing by STATE.

*( ) Rock shall be crowned at 4 to 6 percent unless otherwise specified.

ROAD SEGMENT	COMPACTION EQUIPMENT OPTIONS

Crushed Rock. The rock shall be uniformly mixed and spread in layers on the approved roadbed. Each layer of crushed rock shall be moistened or dried to a uniform moisture content suitable for maximum compaction and compacted in layers not to exceed 6 inches in depth. When more than 1 layer is required, each shall be shaped and compacted before the succeeding layer is placed. Any irregularities or depressions that develop during compaction of the top layer shall be corrected by loosening the material at these places and adding or removing material until the surface is smooth and uniform. A minimum of 3 passes shall be made over the entire width and length of the road. A pass is defined as traveling a road section in one direction and then back over that same section again. (*Compaction shall be accomplished by using one or more of the approved equipment options listed below:) (*Compaction shall be accomplished by using the approved equipment listed below or others approved by STATE:)

*( ) Rock shall be compacted and processed during the same project period it is spread, unless otherwise approved in writing by STATE.

*( ) Rock shall be crowned at 4 to 6 percent unless otherwise specified.

ROAD SEGMENT	COMPACTION EQUIPMENT OPTIONS

____
[Sale Name] (XC10) [SUBGRADE & FILL]

EXHIBIT "*__"

COMPACTION AND PROCESSING REQUIREMENTS

Subgrade. Subgrade surfaces of the road segments listed below shall be graded and compacted prior to rocking. Compaction shall be accomplished by traveling all surfaces from shoulder to shoulder until visible deformation ceases, or in the case of a sheepsfoot roller, the roller "walks out." A minimum of 3 passes shall be made over the entire width and length of the road. A pass is defined as traveling a road section in one direction and then back over that same section again. (*Compaction shall be accomplished by using one or more of the approved equipment options listed below:) (Compaction shall be accomplished by using the approved equipment listed below or others approved by STATE:)

*( ) Rock shall be compacted and processed during the same project period it is spread, unless otherwise approved in writing by STATE.

*( ) Rock shall be crowned at 4 to 6 percent unless otherwise specified.

ROAD SEGMENT	COMPACTION EQUIPMENT OPTIONS

Fills. Embankments and fills shall be placed in (approximately) horizontal layers not more than 8 inches in depth. Each layer shall be separately, and thoroughly, compacted. Compaction equipment shall be operated over the entire width of each layer until visible deformation of the layers ceases or, in the case of a sheepsfoot roller, the roller "walks out." A minimum of 3 passes shall be made over the entire width and length of each layer. A pass is defined as traveling a fill layer in one direction and then back over that same layer again.

Placing individual rocks or boulders with more depth than the allowed layer thickness shall be permitted, provided the embankment will accommodate them. Such rocks and boulders shall be at least 6 inches below the subgrade. They shall be carefully distributed and the voids filled with finer material, forming a dense and compacted mass. (*Compaction shall be accomplished by using one or more of the approved equipment options listed below:) (*Compaction shall be accomplished by using the approved equipment listed below or others approved by STATE:)

*( ) Rock shall be compacted and processed during the same project period it is spread, unless otherwise approved in writing by STATE.

*( ) Rock shall be crowned at 4 to 6 percent unless otherwise specified.

ROAD SEGMENT	COMPACTION EQUIPMENT OPTIONS

(XC11)

EXHIBIT "*___"

COMPACTION AND PROCESSING REQUIREMENTS

Pit-Run Rock. Pit-run surfacing rock shall be spread on roads with a crawler tractor and continuously walked-in. Rock spreading shall begin at nearest point from the rock source and progress toward the end of the project, unless otherwise approved in writing by STATE. (*Compaction shall be accomplished by using one or more of the approved equipment options listed below:) (*Compaction shall be accomplished by using the approved equipment listed below or others approved by STATE:)

*( ) Rock shall be compacted and processed during the same project period it is spread, unless otherwise approved in writing by STATE.

*( ) Rock shall be crowned at 4 to 6 percent unless otherwise specified.

ROAD SEGMENT	COMPACTION EQUIPMENT OPTIONS

Crushed Rock. The rock shall be uniformly mixed and spread in layers on the approved roadbed. Each layer of crushed rock shall be moistened or dried to a uniform moisture content suitable for maximum compaction and compacted in layers not to exceed 6 inches in depth. When more than 1 layer is required, each shall be shaped and compacted before the succeeding layer is placed. Any irregularities or depressions that develop during compaction of the top layer shall be corrected by loosening the material at these places and adding or removing material until the surface is smooth and uniform. Each layer shall be compacted with a minimum of 3 passes over the entire width and length of the road. A pass is defined as traveling a road section in one direction and then back over that same section again. (*Compaction shall be accomplished by using one or more of the approved equipment options listed below:) (*Compaction shall be accomplished by using the approved equipment listed below or others approved by STATE:)

*( ) Rock shall be compacted and processed during the same project period it is spread, unless otherwise approved in writing by STATE.

*( ) Rock shall be crowned at 4 to 6 percent unless otherwise specified.

ROAD SEGMENT	COMPACTION EQUIPMENT OPTIONS

(XC12)
EXHIBIT "*__"

COMPACTION EQUIPMENT OPTIONS

( ) Smooth-Wheel Power Rollers. Smooth-wheel power rollers shall either be of the 3-wheel type, weighing not less than 10 tons, or of the tandem type, 2-wheel or 3-wheel, weighing not less than 8 tons. Smooth-wheel rollers shall provide compression of 325 pounds per lineal inch of width of rear wheels or drum.

( ) Pneumatic-Tired Rollers. Pneumatic-tired rollers shall be of the double-axle type equipped with pneumatic tires of equal size and type. The spacing between the sidewalls of adjacent tires shall not exceed 5 inches; the rear tires shall be staggered with relation to the front tires. The rolling width of the unit shall be not less than 60 inches exclusive of the power unit. The roller shall be so constructed that the contact pressure is uniformly distributed on all of the tires. The tires shall be inflated to maintain the air pressure in the several tires within a total tolerance of 5 pounds per square inch. The roller shall be so constructed that the total weight is between 1,000 and 2,000 pounds per tire. The actual operating weight of the rollers shall be as ordered by STATE.

Each pneumatic-tired roller shall be drawn by equipment having sufficient power and sufficient weight, under normal conditions, to pull the roller at a minimum speed of 5 miles per hour, or may be self-propelled to obtain a minimum speed of 5 miles per hour.

( ) Vibratory Rollers. The drum shall have a smooth surface, a diameter not less than 48 inches, a width not less than 58 inches, and a turning radius of 15 feet or less. Vibration frequency shall be regulated in steps to 1400, 1500, and 1600 VPM, corresponding to engine speeds of 1575, 1690, and 1800 RPM. The centrifugal force developed shall be 7 tons at 1600 VPM. It shall be activated by a power unit of not less than 25 horsepower. The vibratory roller shall be self-propelled and operated at speeds ranging from 0.9 miles to 1.8 miles per hour, as directed by STATE.

( ) Vibratory Compactors. Vibratory compactors shall consist of multiple or gang type compacting units or pads with a minimum variable width of 2 feet. It shall be self-contained and capable of compacting material as required.

( ) Rock Trucks. Rock spreading shall begin at the nearest point to the rock source and progress toward the end of the project. Rock trucks shall be routed over the entire cross section of rock layers.

(XC13)

EXHIBIT "*___"

COMPACTION EQUIPMENT OPTIONS

( ) Tampingfoot Compactors. Tampingfoot or sheepsfoot compactors shall exert a minimum pressure of 250 pounds per square inch on the ground area in contact with the tamping feet. The compactor shall cover a minimum width of 60 inches per pass and weigh a minimum of 16,000 pounds.

( ) Grid Rollers. Pit-run rock shall be processed by grid rolling with a Hyster Grid Roller Model D or equivalent, fully equipped with 32,000 pounds or more of ballast weights. Twenty passes shall be made with a grid roller over the entire length and width of the road, unless STATE requires fewer passes. A grader weighing at least 20,000 pounds shall work the pit-run surface during grid rolling so that all pit-run rock comes in contact with the grid roller. Grid rolling shall be performed when the subgrade is dry and firm. Road surface shall be uniformly shaped and graded prior to and during grid rolling.

( ) Vibratory Grid Compactors. The roller shall have a grid surface and have an operating weight of 32,000 pounds or more. The rock shall be worked with a grader weighing at least 20,000 pounds during the grid rolling process.

All rock shall come in contact with the vibratory grid compactor. A minimum of 10 passes shall be made with the grader and vibratory grid compactor over the entire length of the road, unless STATE requires fewer passes.

( ) Crawler Tractors. D-7 Caterpillar or equivalent **(*or larger)**.

[Provide additional or different specifications, if necessary.]

[OPTIONS]

( ) Rubber-Tired Skidders. A rubber-tired skidder weighing a minimum of 20,000 pounds shall be operated over the fill layers so that the entire layered surface comes in contact with the tires. Skidders with oversized tires (high flotation) are not acceptable for compaction.

____
[Sale Name]   (XD)

EXHIBIT "*___"

ROCK PIT DEVELOPMENT AND USE

(1) PURCHASER shall conduct the operations relative to the disposal of waste material in such manner that silt, rock, debris, dirt, or clay shall not be washed, conveyed, or otherwise deposited in any stream. All waste shall be deposited at an approved "waste disposal site."

(2) Where overburden removal limits have not been staked, they shall extend for a distance of at least 20 feet beyond the developed rock source. Overburden and woody debris shall be hauled to a designated waste area. Overburden shall be spread evenly, grass seeded, and compacted at the waste area and woody debris stacked separately. Prior to drilling or rock removal, completion of overburden removal shall be approved (*in writing) by STATE.

(3) The rock pit floor shall be developed to provide drainage away from the rock pit. Rock pit drainage ditches shall be developed and maintained. Benches shall be constructed at intervals of 40 feet or less in height and shall be a minimum of 20 feet in width. Any gravel or talus slopes shall be left with a working face at an angle of 60 degrees or less. There shall be a minimum of 1 bench with an access road to it. Said bench shall be easily accessible with tractors.

(4) Blasting shall be accomplished using timing devices, delay charges, low intensity shots, or other suitable means to contain as much material as possible in the rock pit prism.

(5) Pit face shall be developed in a uniform manner.

[SELECT ONE OF THE 6's]

(6) Oversized material that is produced shall be piled in a designated area adjacent to the pit.

It shall not be wasted.

(6) Oversized material that is produced or encountered during development shall be broken down and utilized for crushing.

(7) PURCHASER shall prepare a written development plan for the pit area. The plan shall be submitted to STATE for approval prior to conducting any operation in the pit area.

The plan shall include, but not be limited to:

(a) Location of benches and roads to benches.

(b) Disposal site for debris and overburden.

(8) Upon completion of use, the pit site and access roads shall be left in a condition free from overburden and debris. Access roads to the pit, and the pit floor, shall be cleared at the termination of use. Rock pit access roads shall be blocked upon completion of rock pit use as directed by STATE. Rock pit roads shall be waterbar constructed to provide drainage as specified in Exhibit *____ and be blocked as directed by STATE.

(XE1)

EXHIBIT "*___"

CULVERT SPECIFICATIONS

All culvert materials shall be furnished and installed by PURCHASER, unless otherwise specified in the contract. Culverts shall be constructed of corrugated galvanized iron or steel, (*or aluminized steel,) **(*or corrugated aluminum alloy,)** and shall conform to the material and fabricating requirements of Sections 2410 and 2420 of the "Standard Specifications for Highway Construction" prepared by the Highway Division of the Oregon State Department of Transportation. Corrugation types and shapes other than those meeting the above minimum Highway requirements, shall be approved in writing by STATE. Corrugated polyethylene culverts may be used for sizes up to 36 inches in diameter.

The joints between bands and pipe of unlike material shall be coated with an approved bituminous material.

Culverts shall be located according to the alignment and grade as shown on the Plan and Profile, and/or as staked in the field, or as stipulated in special instructions.

(*The STATE Representative shall determine final culvert locations and stake the locations in the field prior to installation.)

(*Culvert grade shall slope away from ditch grade at least 2 percent unless otherwise specified.)

(*Camber shall be incorporated into all culvert trench beds by increasing the lower half of the trench bed slope 1 percent.)

(*Culverts less than 36 inches in diameter shall be installed with the lock seam on the inlet end placed within 45 degrees of the bottom of the trench.)

The foundation and trench walls for all culverts shall be free from logs, stumps, limbs, stones over 3 inches, and other objects which would dent or damage the pipe during installation or use. If tamping is required, the trench shall be excavated wide enough to permit working on each side of pipe. Bedrock shall be excavated as required to provide a uniform foundation for the full length of the culvert.

[OPTION - SELECT ONE OF THE "BEDDING" PARAGRAPHS](*A bedding of granulated material or job-excavated soil shall be placed to provide a wide band of support and to transmit the load from above evenly over the entire length of the pipe.)

(*A bedding of job-excavated granulated soil shall be placed to provide a wide band of support and to transmit the load from above evenly over the entire length of the pipe.)

Transporting of the pipe shall be done carefully. Dragging or allowing free fall from trucks or into trenches shall not be permitted. Damage to bituminous coating shall be repaired before the pipe is covered.

On new installations, joining shall be done with bands of like material and corrugations. Manufacturers' instructions shall be followed for prefabricated pipe assembly.

[OPTION - SELECT ONE OF THE "BACKFILL" PARAGRAPHS

(*Backfill shall consist of granulated material or job-excavated soil free of stumps, limbs, rocks, or other objects which would damage the pipe.)

(*Backfill shall consist of job-excavated granulated soil free of stumps, limbs, rocks, or other objects which would damage the pipe.)

Tamping (when required) shall be done in 8-inch lifts, 1 pipe diameter each side of the pipe to 85 percent density or over, and to the minimum fill height as specified below. Additional fill shall be embankment material.

Fill heights, if not shown on a road plan and profile, shall be in accordance with those shown in Drawing No. 2094, "Fill Height Tables," prepared by the Highway Division of the Oregon State Department of Transportation. Any deviation must be approved by STATE.

(XE2)

EXHIBIT "*__"

CULVERT SPECIFICATIONS

Minimum height of cover over top of culvert to subgrade when road is to be rocked shall be as follows: 12" for aluminized steel culverts 18” to 36”, 18” for aluminized steel culverts 42” to 96”, **(*12" for aluminum culverts 12" to 42", 24" for aluminum culverts 48" to 96",)** and 12" for polyethylene culverts (add 6" for roads which will not be rocked). Minimum vertical cover for other steel **(*or aluminum)** designs shall be as specified by STATE.

Lengths of individual culvert sections shall be not less than 10 feet, unless otherwise provided for in special instructions.

The ends of each culvert shall be free of logs and debris which would restrict the free flow of water. Culverts in Type F streams must allow free passage of fish as provided in the Oregon Forest Practice Rules. The intake end of relief culverts shall be provided with a sediment catching basin 3 feet in diameter at the bottom. The outlet end of any culvert which would allow water to erode embankment soil into waters of the State shall be provided with a downspout or other approved slope protection device.

Following are the minimum standard gauges for pipe and coupling bands. All other designs shall be in accordance with the minimum requirements of the Highway Division (Drawing Nos. 2091-A and B), or as approved by STATE.

(")	Pipe Gauge		Band Gauges		Band Widths (")			Hugger Band Widths	
Dia.	Aluminum	Steel	Aluminum	Steel	Annular	Helical	Dimpled	Annular	Helical
12-15	16	16	16	16	7	12	12	13 1/8	10 1/2
18-24	16	16	16	16	12	12	12	13 1/8	10 1/2
30-36	14	16	14	16	12	12	*12	13 1/8	10 1/2
42	12	14	12	16	12	12	NA	13 1/8	10 1/2
48	12	14	12	16	24	24	NA	13 1/8	10 1/2
54	12	14	12	16	24	24	NA	13 1/8	10 1/2
60	10	12	10	16	24	24	NA	13 1/8	10 1/2
66-72	10	12	10	16	24	24	NA	13 1/8	10 1/2
78	10	12	10	16	24	24	NA	13 1/8	10 1/2
84	8	12	8	16	24	24	NA	14 3/4	10 1/2
90-120 (3"x1")	8	12	8	16	26	26	NA	NA	NA

*Up to 33"

Aluminized steel culverts larger than 60” in diameter shall have 3” x 1” corrugations.

Polyethylene culverts between 3" to 10" in diameter shall meet the requirements of AASHTO M-252-851. Polyethylene culverts between 10” to 36" in diameter shall be double walled and meet the requirements of AASHTO M-294-901, Type S.

The STATE Representative shall determine final culvert locations and stake the locations in the field prior to installation.

(XE1-a)

EXHIBIT "*__"

CULVERT SPECIFICATIONS

[USED MOSTLY BY ASTORIA]

All culvert materials shall be furnished and installed by PURCHASER, unless otherwise specified in the contract. Culverts shall be constructed of corrugated, double-walled polyethylene, unless use of other culvert materials with an equivalent life expectancy is approved in writing by STATE. Pipe and fittings shall be made of polyethylene compounds which meet or exceed the requirements of Type III, Category 4 or 5, Grade P33 or P34, Class C per ASTM D-1248 with the applicable requirements defined in ASTM D-1248. Double-walled polyethylene pipe shall meet the requirements of AASHTO M-294-901, Type S. Clean, reworked material may be used.

Culverts shall be located according to the alignment and grade as shown on the Plan and Profile, and/or as staked in the field, or as stipulated in special instructions.

(*The STATE Representative shall determine final culvert locations and stake the locations in the field prior to installation.)

The foundation and trench walls for all culverts shall be free from logs, stumps, limbs, stones over 3 inches, and other objects which would dent or damage the pipe during installation or use. If tamping is required, the trench shall be excavated wide enough to permit working on each side of pipe. Bedrock shall be excavated as required to provide a uniform foundation for the full length of the culvert.

A bedding of granulated material or job-excavated soil shall be placed to provide a wide band of support and to transmit the load from above evenly over the entire length of the pipe.

Transporting of the pipe shall be done carefully. Dragging or allowing free fall from trucks or into trenches shall not be permitted. Damage to bituminous coating shall be repaired before the pipe is covered.

Joints shall be made with split couplings, corrugated to engage the pipe corrugations, and shall engage a minimum of 4 corrugations, 2 on each side of the pipe joint.

Backfill shall consist of granulated material or job-excavated soil free of stumps, limbs, rocks, or other objects which would damage the pipe.

Tamping (when required) shall be done in 8-inch lifts, 1 pipe diameter each side of the pipe to 85 percent density or over, and to the minimum fill height as specified below. Additional fill shall be embankment material.

A manufacturer's certification that the product was manufactured, tested, and supplied in accordance with this specification shall be furnished to the Project Engineer upon request.

____
[Sale Name]

(XE2-b)

EXHIBIT "*__"

CULVERT SPECIFICATIONS

[USED MOSTLY BY ASTORIA]

Minimum height of cover over top of culvert to subgrade when road is to be rocked shall be 12 inches for polyethylene culverts (add 6" for roads which will not be rocked). Minimum vertical cover for other steel or aluminum designs shall be as specified by STATE.

Lengths of individual culvert sections shall be not less than 10 feet, unless otherwise provided for in special instructions.

The ends of each culvert shall be free of logs and debris which would restrict the free flow of water. Culverts in Type F streams must allow free passage of fish as provided in the Oregon Forest Practice Rules. The intake end of relief culverts shall be provided with a sediment catching basin 3 feet in diameter at the bottom. The outlet end of any culvert which would allow water to erode embankment soil into waters of the State shall be provided with a downspout or other approved slope protection device.

This specification applies to high density polyethylene corrugated pipe with an integrally formed smooth interior.

This specification is applicable to nominal sizes 4- to 36-inch diameter. Requirements for test methods, dimensions, and markings are those found in AASHTO Designations M-252 and
M-294-901, Type S.

Rev. 1/96

(XE3)

EXHIBIT "*___"

CULVERT LIST

CULVERT NO.	DIAMETER (Inches)	LENGTH (Feet)	ROAD SEGMENT POINT TO POINT	STATION

[OPTIONS - PARAGRAPHS]

( ) The intake ends of culverts shall be marked by driving or placing steel posts within 6 inches of the downgrade side. Posts shall be painted with a rust-resistant paint and be a minimum of 5 feet long, with the spade driven 2 feet into the ground.

( ) Culverts 36 inches in diameter or larger shall have 1:1 beveled inlets.

( ) All culverts shall be constructed of **(*corrugated,)** double-walled polyethylene.

( ) Tamping is required.

( ) All metal culverts scheduled for replacement shall (*become property of PURCHASER and) be removed from State land.

( ) Half rounds shall be installed within 72 hours of culvert installation, unless otherwise approved in writing by STATE.

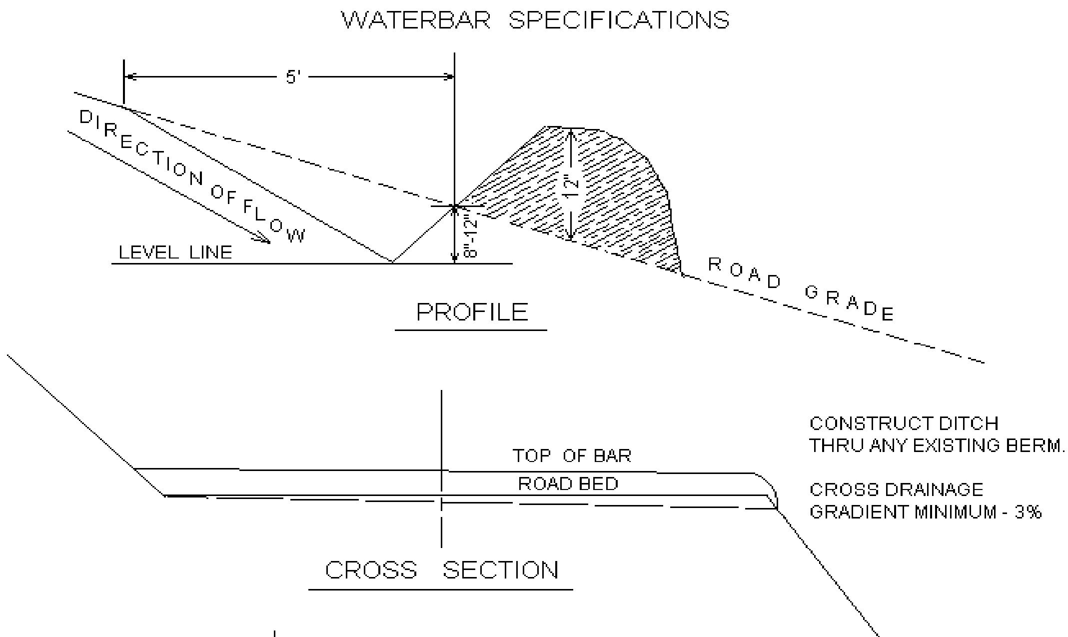
____
[Sale Name]

EXHIBIT "*___"

____
[Sale Name]

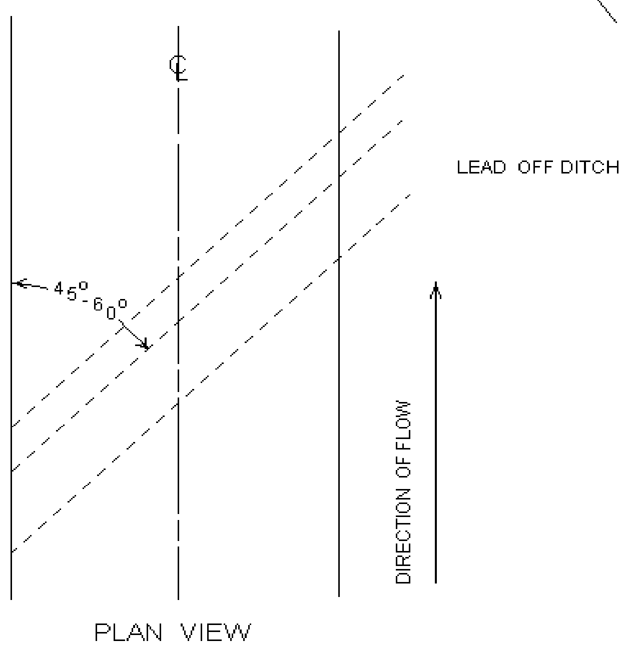
EXHIBIT "*__"

WATERBAR SPECIFICATIONS



SPACING OF WATERBARS

ROAD GRADE	CLAY	SANDY LOAM
5%	700'	600'
10%	400'	300'
15%	200'	150'
20%	100'	100'



**WATERBAR SPECIFICATIONS
FOR CROSS DITCHING**

____
[Sale Name]

EXHIBIT "*___"

(XX1)

EXHIBIT "*__"

WATERSHED REGULATIONS

PURCHASER shall take precautions necessary to protect the watershed from damage and to prevent pollution to the water supply. Precautions shall include, but not be limited to, the following regulations.

Laws, Rules, and Regulations. Comply with Oregon laws and with the rules and regulations of the Oregon State Board of Health relative to protection of watersheds and sanitation of public water supply.

Debris in Streams. Prevent, insofar as possible, logs, chunks, and other debris, resulting from logging and road building operations, from being deposited in streams. If such material should become deposited in streams, immediately remove the material to restore normal stream flow, using necessary care to prevent unnecessary damage to the stream channel and banks.

General Sanitary Conditions. Do not create any conditions which may permit breeding of flies or mosquitoes. Machinery, equipment, soil, and fuel storage shall not be located near streams. Waste oil shall be removed from the watershed. Camping shall not be permitted.

Privies. Place a clean, sanitary, and usable privy at each landing and other main points of operation and require all personnel to use the privies. Privies shall be placed at locations approved by STATE not closer than 100 feet to any stream. The privies shall be constructed as follows, unless other types are approved by STATE prior to being placed in use:

The housing shall be waterproof and flyproof, and the toilet shall be equipped with a seat and cover. A receptacle shall be provided for all refuse and the privy shall be equipped with a separate urinal draining into the receptacle. The receptacle shall be not less than 45-gallon capacity and the refuse shall be removed from the receptacle and disposed of off the watershed area. The receptacle shall be vented through the roof of the privy housing.

Pit type privies shall not be permitted on the watershed.

Personnel. Persons with a history of typhoid fever, amoebic dysentery, or infectious hepatitis shall not be employed on the watershed. All personnel shall be required to use the privies. PURCHASER shall verbally instruct all personnel employed on the watershed in the required sanitary precautions to be observed and shall give each such person a copy of these regulations.

Overnight Camping Prohibited. No person shall remain on the watershed overnight, unless authorized in writing by STATE.

(XX6)

EXHIBIT "*___"

SEEDING **(*AND FERTILIZING)**

This work shall consist of preparing seedbeds and furnishing and placing required seed **(*and fertilizer)**.

Seeding Seasons. Seeding shall be performed only from March 1 through June 15 and August 15 through October 31. Seeding materials shall not be applied during windy weather or when the ground is excessively wet or frozen. Work shall be performed during each specified seeding season on all completed and previously untreated sections. **(*OPTION:** PURCHASER shall notify STATE 24 hours prior to seeding.)

Soil Preparation. Areas to be seeded that have been damaged by erosion or other causes shall be restored prior to seeding. All areas to be seeded shall be finished and then cultivated to provide a reasonably firm, but friable seedbed. A minimum of 1/2 inch of surface soil shall be in a loose condition.

Application Methods for Seed **(*and Fertilizer)**

Dry Method. Mechanical seeders, seed drills, landscape seeders, cultipacker seeders, **(*fertilizer spreaders,)** or other approved mechanical seeding equipment shall be used to apply the seed **(*and fertilizer)** in the amounts and mixtures specified. Hand-operated seeding devices may be used when seed **(*and fertilizer) (*is *are)** applied in dry form.

Application Rates for Seed **(*and Fertilizer)**

Seed listed below shall be applied at the following rates per acre:

Species	Lb./Acre	Mixture	Pure Live Seed	Poison and/or Repellent
Highland Bentgrass	12	40%	98%	0
Annual Ryegrass	9	30%	98%	0
Perennial Ryegrass	9	30%	98%	0

(*Fertilizer: Chemical analysis shall be 16-20-0 and shall be applied at the rate of 300 pounds per acre.)

[NOTE: Delete fertilizer language in ( ) if fertilizer is not being used.]

Rev. 1/93

____
[Sale Name]

(XX7)

EXHIBIT "*___"

FABRIC SPECIFICATIONS

<u>FABRIC SPECIFICATIONS</u> - shall be woven fabric designed for forest road subgrade surfacing purposes and shall meet or exceed the following requirements, unless otherwise approved in writing by STATE:

(1)	Grab Tensile	300 lbs.	ASTM D1682
(2)	Modulus Load at 10% Elongation	140 lbs.	ASTM D1682
(3)	Mullen Burst	600 lbs.	ASTM D751
(4)	Width – 12.5 feet		

<u>INSTALLATION REQUIREMENTS</u> - fabric shall be installed according to the following requirements:

(1) Typical cross section:

(2) Subgrade surface shall be leveled and smoothed to remove humps and depressions which exceed 6 inches in height and depth. Small pieces of woody debris shall be removed or pushed below subgrade surface. Light vegetation (grass, weeds, leaves, and fine woody debris) may be left in place.

(3) Fabric shall be installed directly on the prepared surface. Longitudinal and traverse joints shall be overlapped at least 3 feet.

(4) Surfacing course material shall be placed to the designated thickness in one lift and spread in the direction of fabric overlap. Hauling and spreading equipment shall not be operated on the fabric until the total thickness of surfacing course material is placed.

(5) Torn, punctured, or separated sections of the fabric shall be repaired by installing a fabric patch over the break prior to placing the surfacing course material. The patch shall be at least 4 feet larger in horizontal dimensions than the break to be repaired.

Fabric failures resulting after rock placement and as evidenced by subgrade pumping or roadbed distortion shall be corrected. Correction measures shall consist of: (1) removing at least three-quarters the depth of surfacing course material in the affected area, (2) placing a fabric patch over the affected area with a minimum 4-foot overlap around the circumference of the area, and (3) replacing enough rock to cover the patch and blend in with the rest of the road.

(XX8)

EXHIBIT "___"

MULCHING

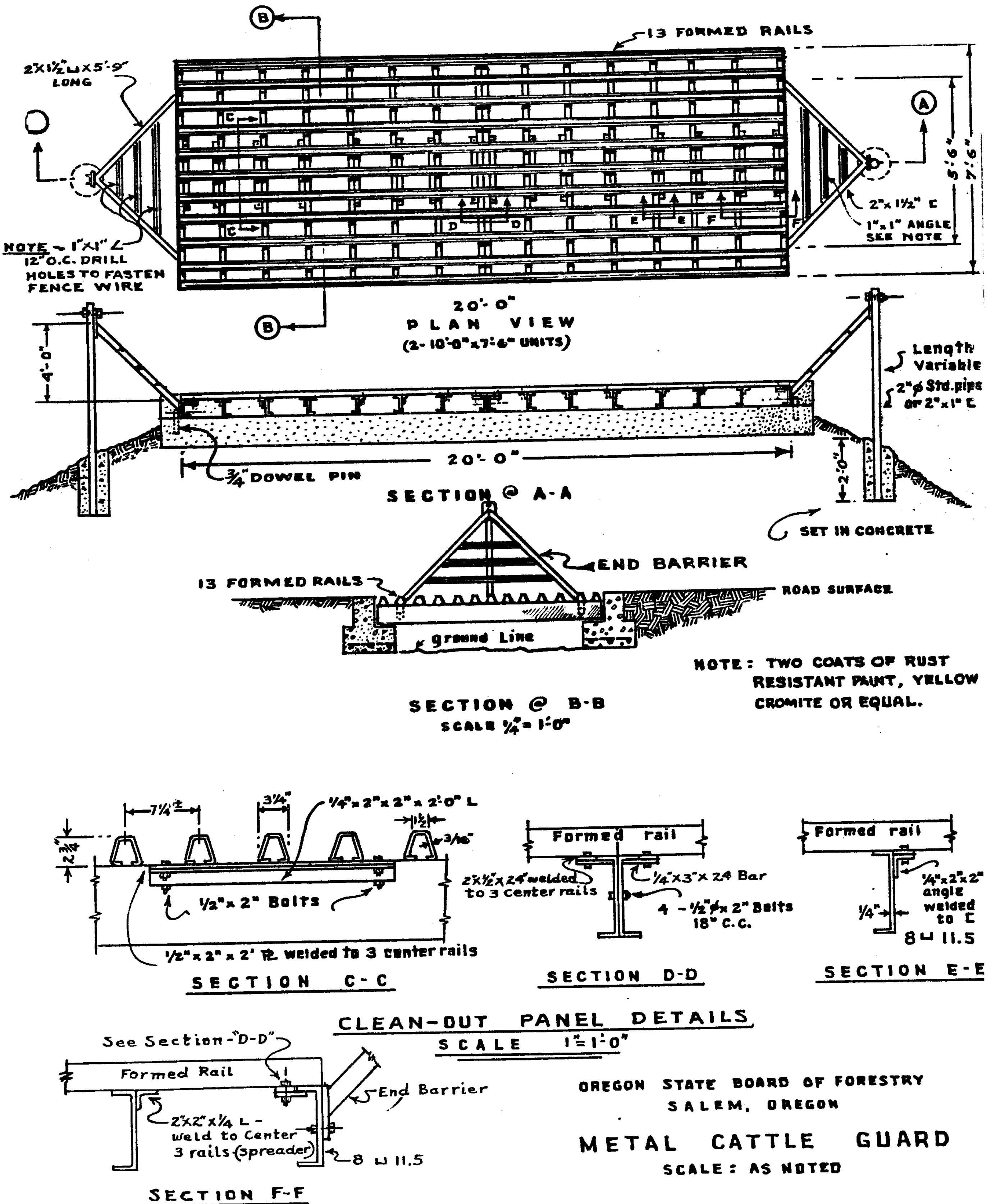
This work shall consist of furnishing and placing required mulch. Mulch shall consist of straw that is free of noxious weeds.

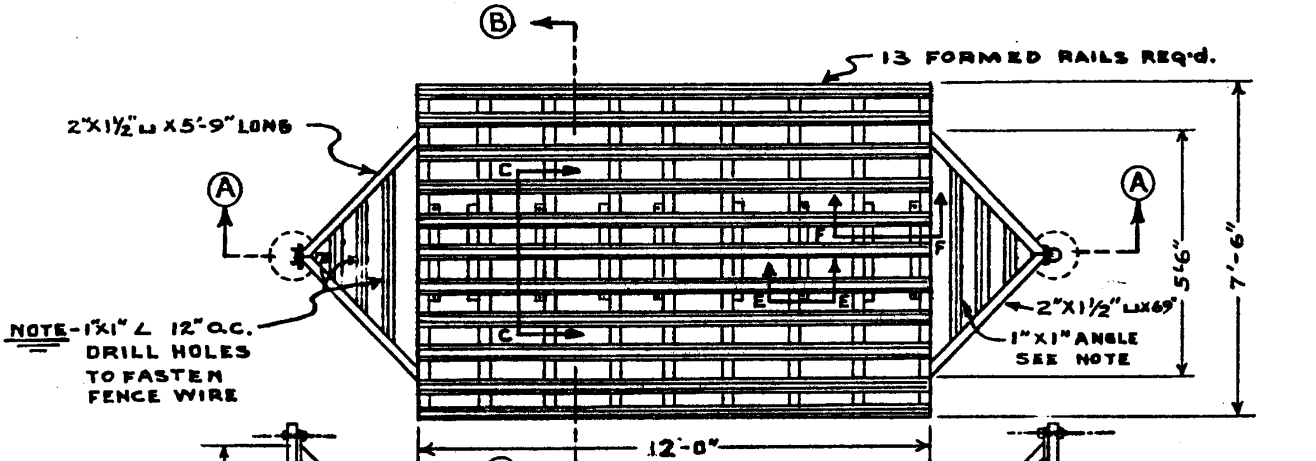
Mulching Period. Straw mulch shall be applied within 24 hours of spreading grass seed and fertilizer.

Application Rates for Mulch

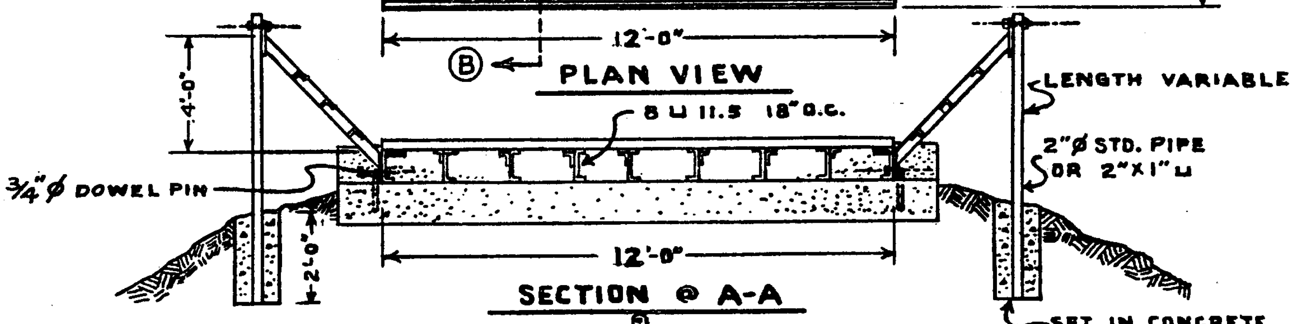
Place straw mulch to a reasonably uniform thickness of 1½ to 2½ inches. This rate requires between 2 and 3 tons of dry mulch per acre.

Added 7/99

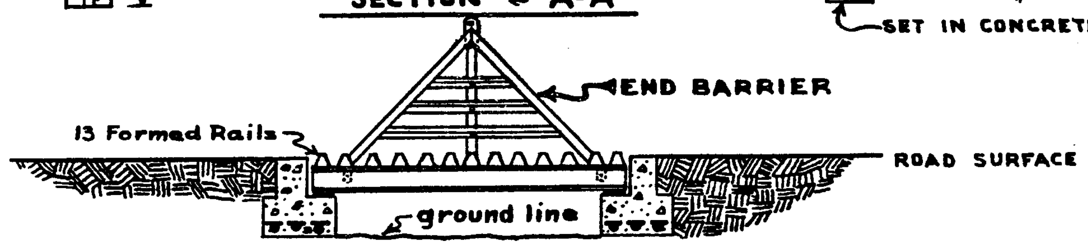

13 FORMED RAILS
2"x1½" ⊔ x 5'-9" LONG
NOTE ~ 1"x1" ∠ 12" O.C. DRILL HOLES TO FASTEN FENCE WIRE
2"x 1½" ⊏
1"x1" ANGLE SEE NOTE
5'-6"
7'-6"
20'-0"
PLAN VIEW
(2-10'-0"x7'-6" UNITS)
4'-0"
Length Variable
2" ϕ Std. pipe or 2"x1" ⊏
20'-0"
¾" DOWEL PIN
2'-0"
SECTION @ A-A
SET IN CONCRETE
END BARRIER
13 FORMED RAILS
ROAD SURFACE
ground Line
NOTE: TWO COATS OF RUST RESISTANT PAINT, YELLOW CROMITE OR EQUAL.
SECTION @ B-B
SCALE ¼"=1'-0"
7¼"±
3¼"
¼"x2"x2"x2'-0" L
1½"
3/16"
2¾"
½"x 2" Bolts
½"x2"x2' ℞ welded to 3 center rails
SECTION C-C
Formed rail
2"x½"x24" welded to 3 center rails
¼"x3"x24 Bar
4 - ½" ϕ x 2" Bolts 18" C.C.
SECTION D-D
Formed rail
¼"x2"x2" angle welded to ⊏
¼"
8 ⊔ 11.5
SECTION E-E
CLEAN-OUT PANEL DETAILS
SCALE 1"=1'-0"
See Section-"D-D"
Formed Rail
End Barrier
2"x2"x¼ L - weld to Center 3 rails (spreader)
8 ⊔ 11.5
SECTION F-F
OREGON STATE BOARD OF FORESTRY
SALEM, OREGON
METAL CATTLE GUARD
SCALE: AS NOTED



PLAN VIEW



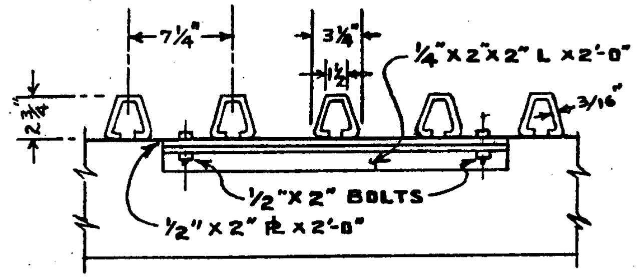
SECTION @ A-A



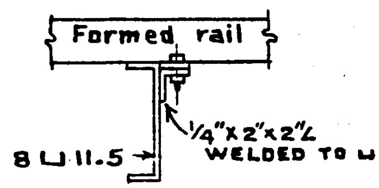
NOTE: (2)- TWO COATS RUST RESISTANT PAINT, YELLOW CROMITE, OR EQUAL.

SECTION @ B-B

SCALE ¼"=1'=0"



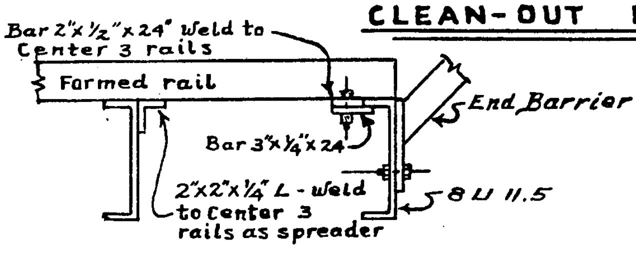
SECTION C-C



SECTION E-E

SCALE 1"=1'-0"

CLEAN-OUT PANEL DETAILS

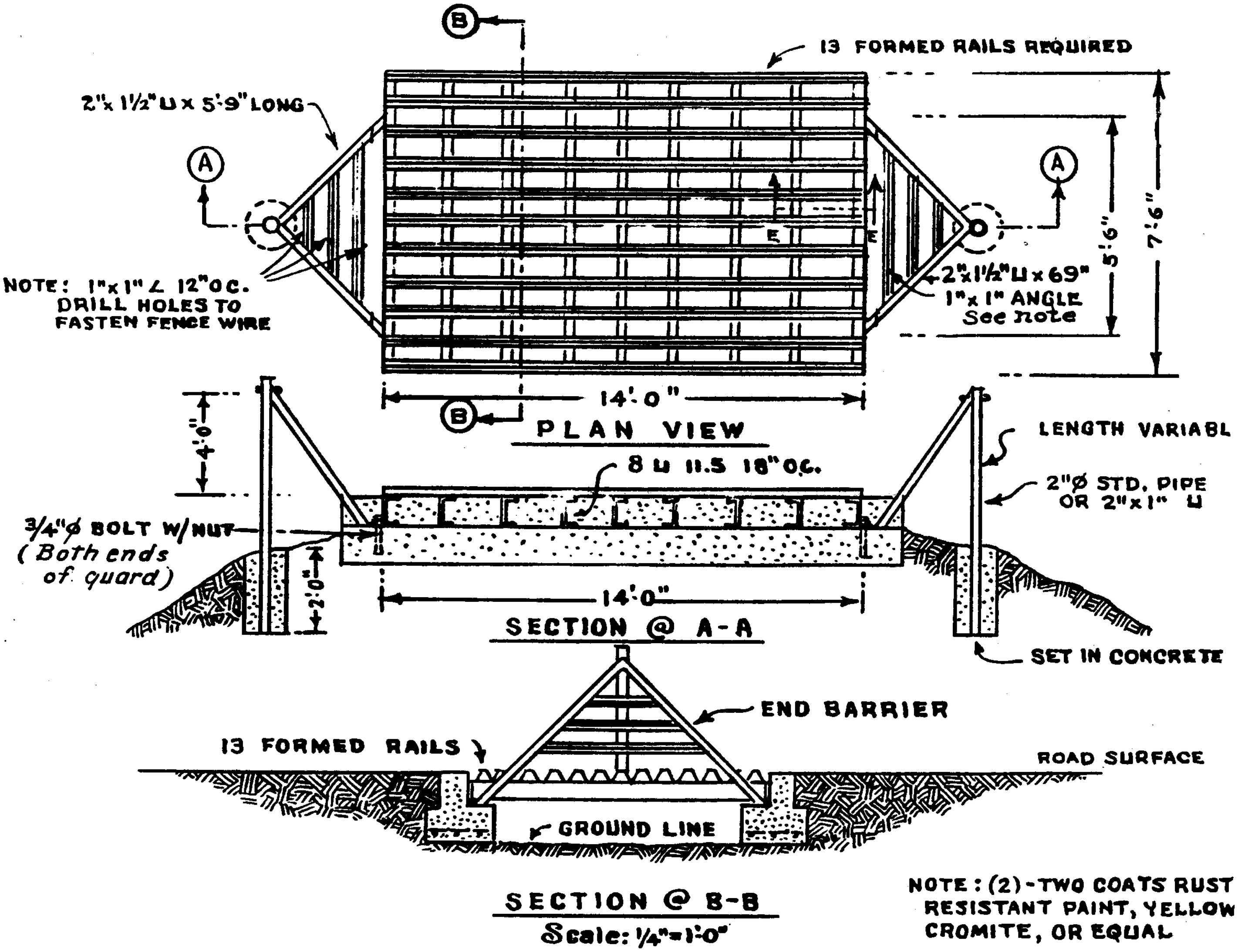


SECTION F-F

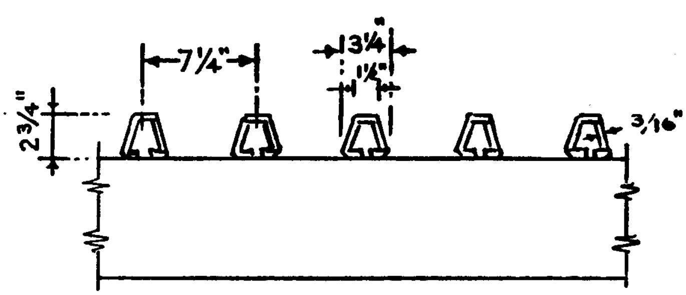
OREGON STATE BOARD OF FORESTRY
SALEM, OREGON

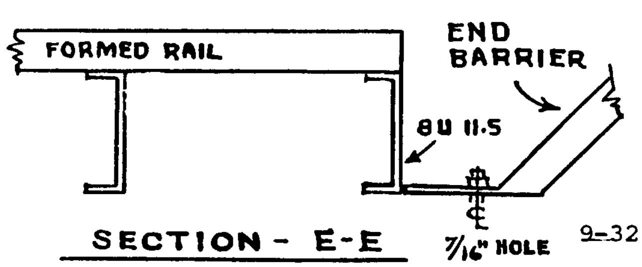
METAL CATTLE GUARD

· SCALE AS NOTED ·



NOTE: (2)-TWO COATS RUST RESISTANT PAINT, YELLOW CROMITE, OR EQUAL





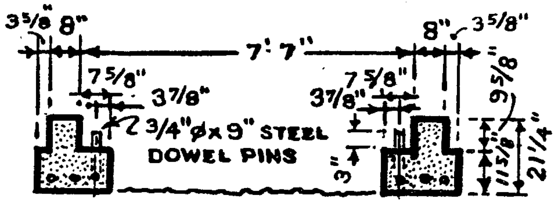
SECTION - E-E

SCALE: 1"=1'-0"

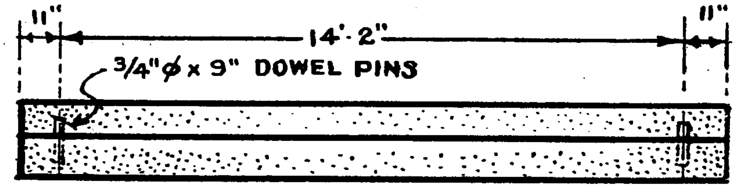
STATE OF OREGON - DEPARTMENT OF FORESTRY
SALEM, OREGON

METAL CATTLE GUARD

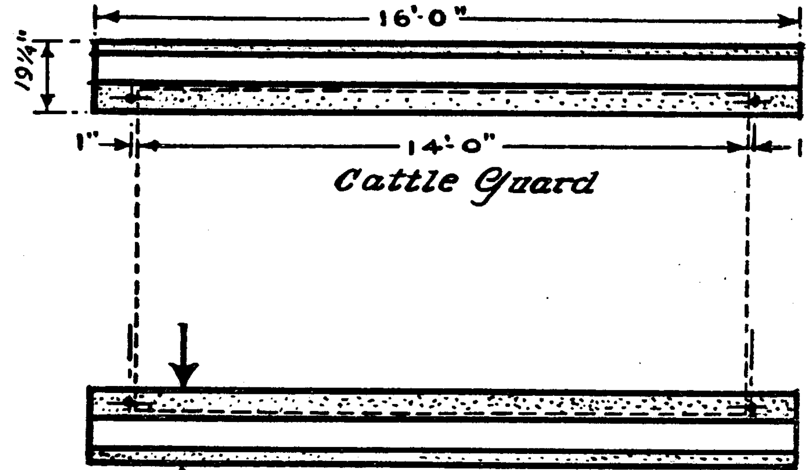
SCALE: AS NOTED



END ELEVATION

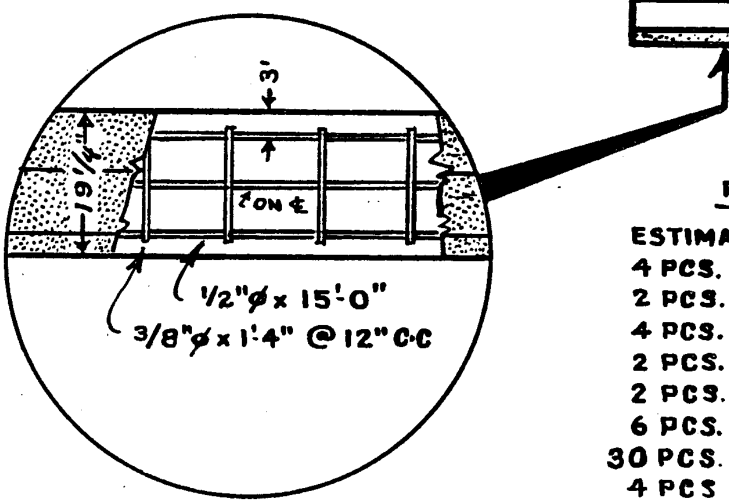


ELEVATION



PLAN VIEW

SCALE: 1/4" = 1'-0"



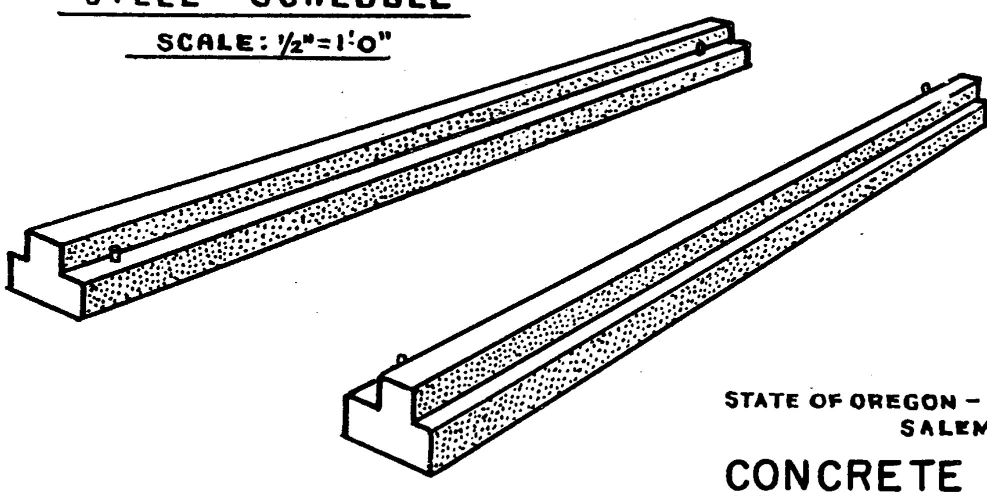
STEEL SCHEDULE

SCALE: 1/2" = 1'-0"

FORM MATERIAL LIST

ESTIMATED CONCRETE 3 CUBIC YARDS

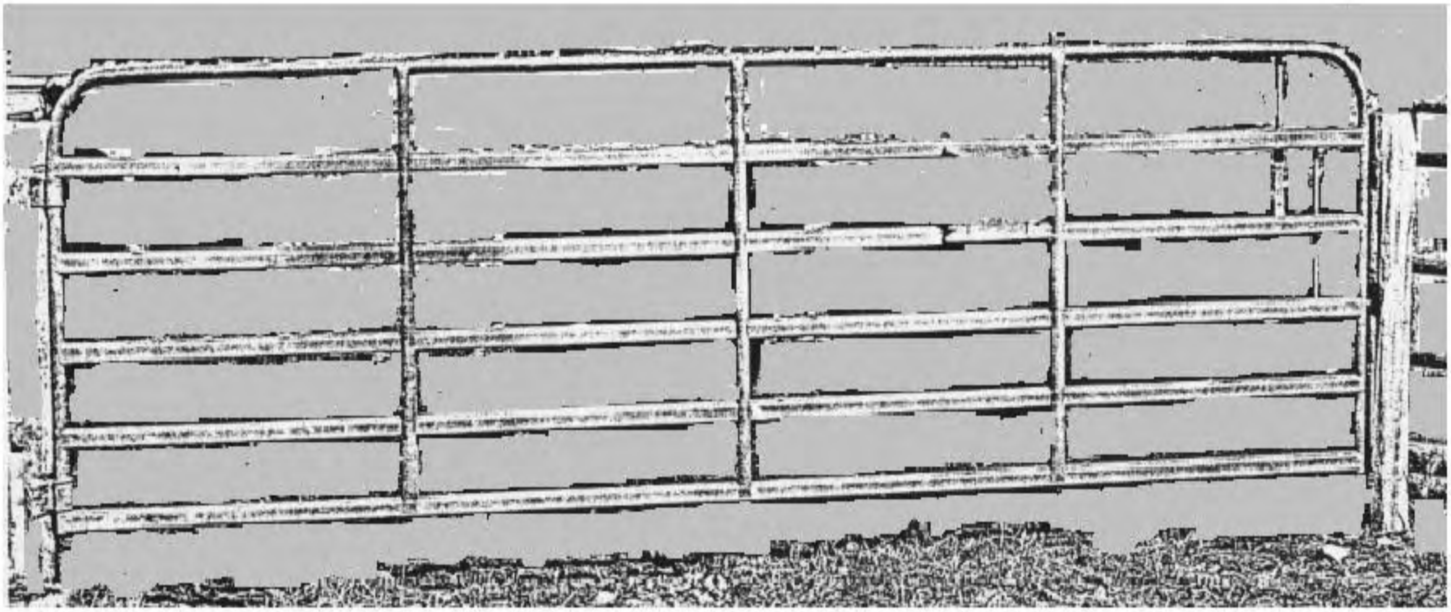
4 PCS. OF 2" x 12" x 16'-0" ——— S4S
2 PCS. OF 2" x 12" x 16'-0" ——— S4S END TIES
4 PCS. OF 2" x 10" x 16'-0" ——— S4S
2 PCS. OF 2" x 8" x 18'-0" ——— S4S
2 PCS. OF 2" x 4" x 16'-0" ——— S4S
6 PCS. OF #4 - 1/2"ø RE-BAR 15'-0" LONG
30 PCS. OF #3 - 3/8"ø RE-BAR 1'-4" LONG
4 PCS OF 3/4"ø x 9" DOWEL PINS (STEEL)



PERSPECTIVE

STATE OF OREGON – DEPARTMENT OF FORESTRY
SALEM, OREGON

CONCRETE FOUNDATION
FOR:
METAL CATTLE GUARD



52-IN. AND 60-IN. CLASSIC GATES

Chain latch price

Heavy Duty "Classic" Gates are famous for their strength. Use them with confidence for your toughest corraling job. The heavy duty steel horizontal rails, with their exclusive pentagonal design, will take an amazing amount of abuse from crowding cattle, then spring back to their original shape. The heavy duty 180° swing hinges are the best in the industry, and standard equipment on all gates. They are made of ¼-in. x 3-in. steel, and are easily adaptable to round and square wooden posts, or welded to steel posts. Two latches are available: a double-pin slide with lever for maximum gate strength, or a 24-in. chain with keeper. Vertical stays are welded to each side of the gate, at each rail, for added strength.

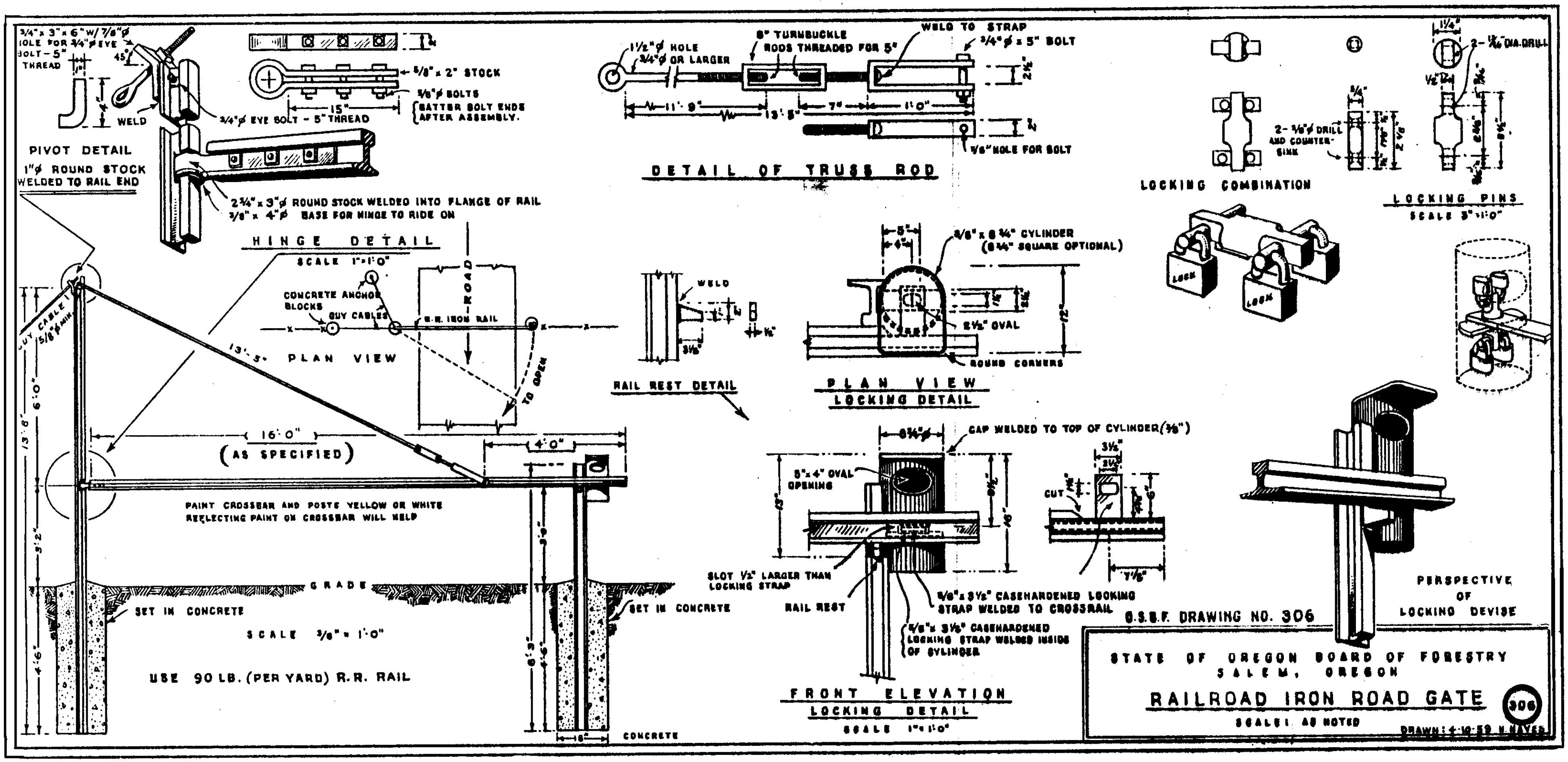
SPECIFICATIONS

- Height — 52 in.
- Frame — 1.66-in. O.D. Tube
- Horizontal Rails — 5 Pentagonal
- Hinges — ¼-in. x 3-in. - 180° Swing
- Latch — Double-Pin Slide with Lever, or 24-in. Chain with Keeper
- Stays — 1-8 ft. & 10 ft., 2-12 ft. & 14 ft., 3-16 ft., 4-18 ft. & 20 ft.

LEVER LATCH		WEIGHTS	
52" Order No.	**LENGTH**	**52 in.**	**60 in.**
32-003	3'	52 lbs.	-
32-004	4'	61	63 lbs.
32-006	6'	77	79
32-008	8'	101	104
32-010	10'	118	121
32-012	12'	142 $139.00	146
32-014	14'	158 $153.00	162
32-016	16'	182 $172.00	187
32-018	18'	202 $212.00	-
32-020	20'	220 $229.00	-

Refer to Price Sheet for order numbers of Chain Latch & 60 in. Gates.

60 IN. CLASSIC GATES



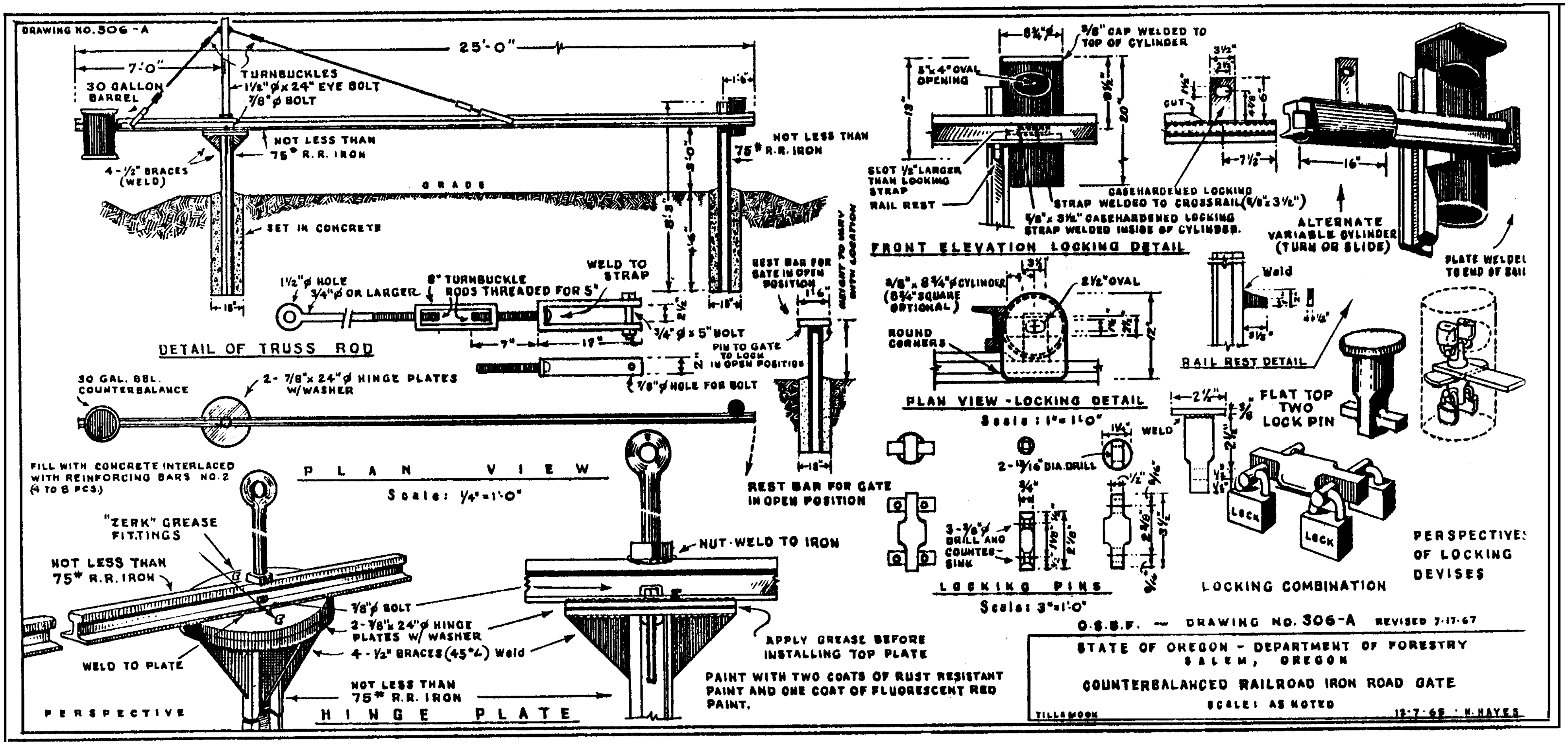
STATE OF OREGON BOARD OF FORESTRY
SALEM, OREGON

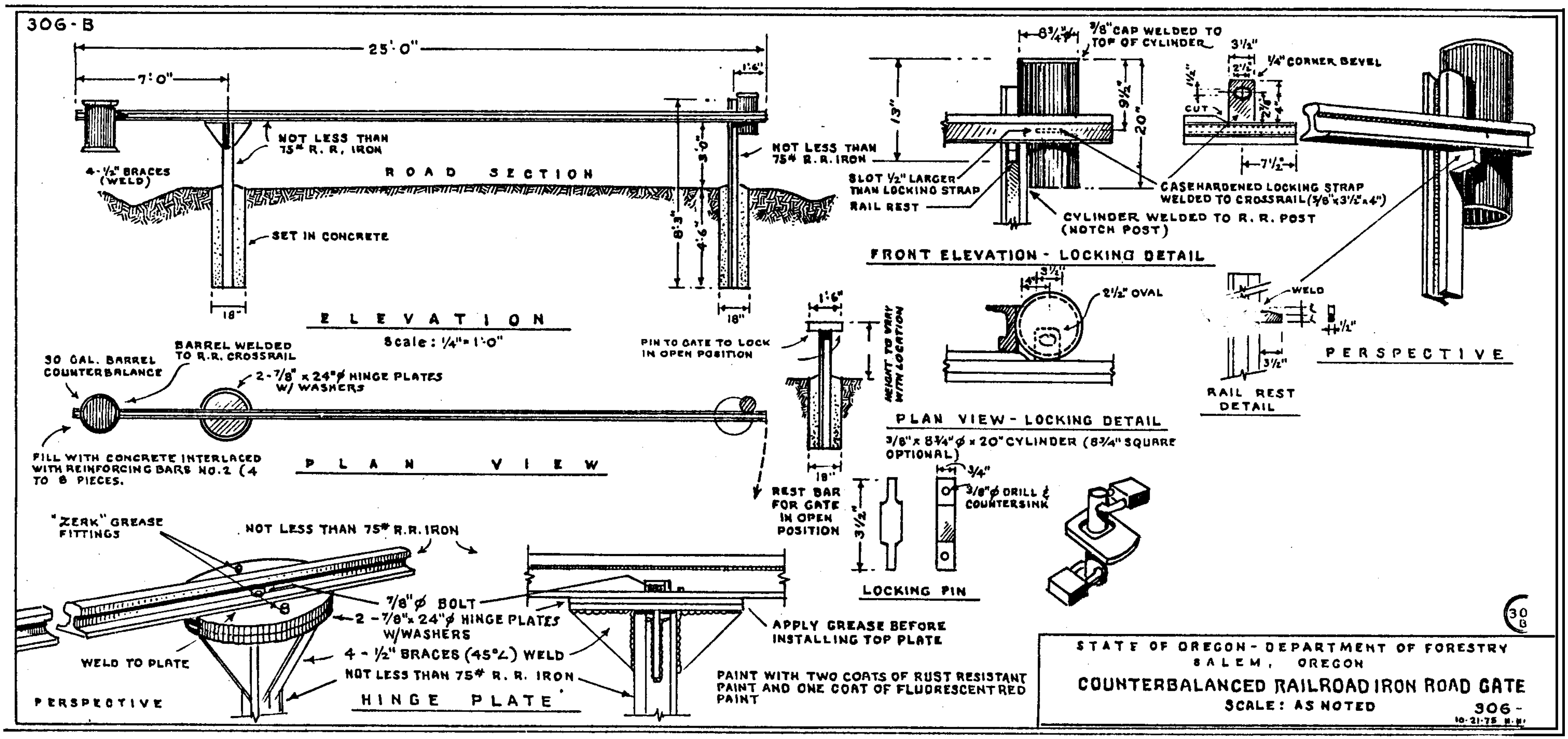
RAILROAD IRON ROAD GATE

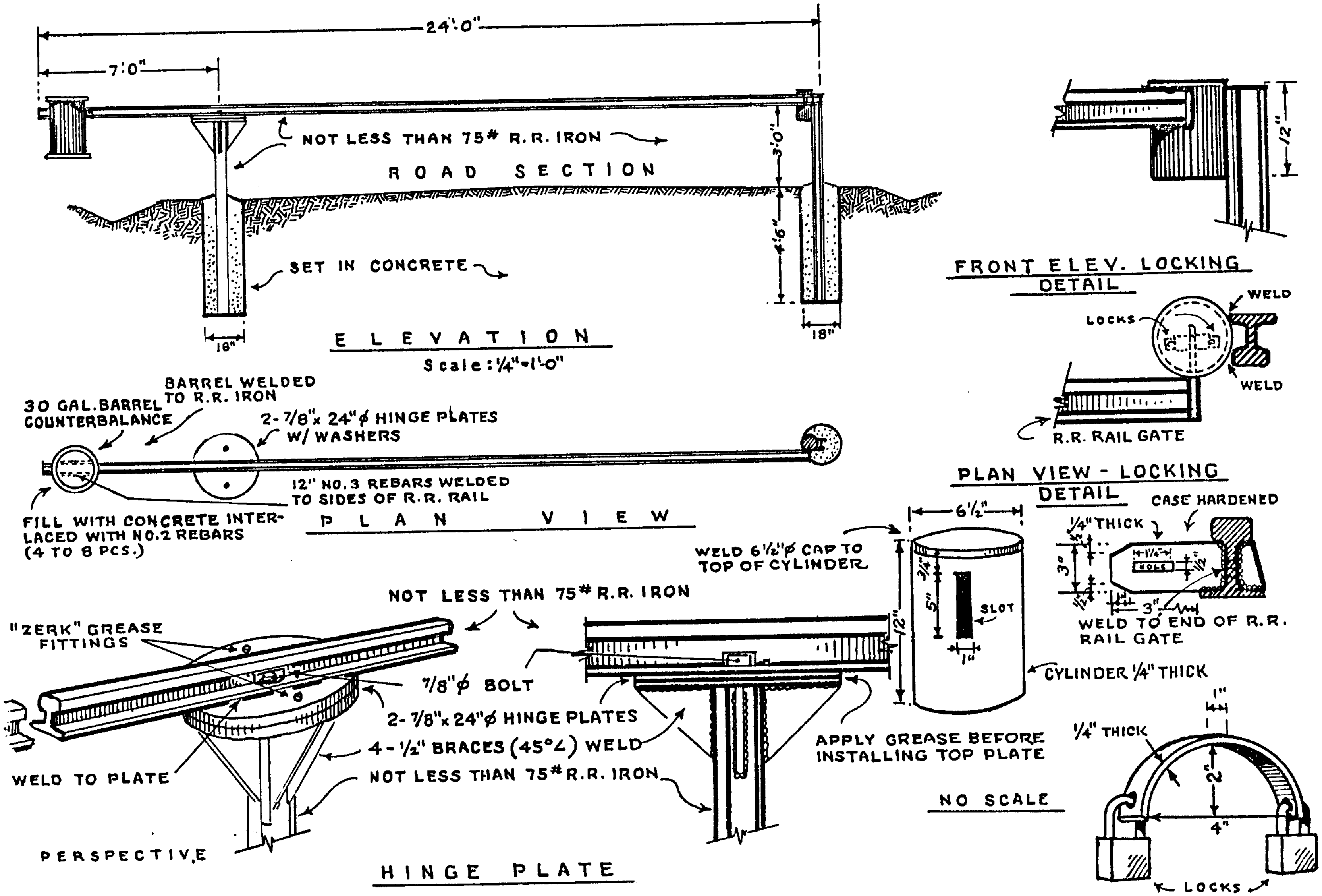
SCALE: AS NOTED

DRAWN: 4-10-59 H. HAYES

306


DRAWING NO. 306-A
25'-0"
7'-0"
TURNBUCKLES
30 GALLON BARREL
1½" ø x 24" EYE BOLT
7/8" ø BOLT
NOT LESS THAN 75# R.R. IRON
4-½" BRACES (WELD)
GRADE
SET IN CONCRETE
NOT LESS THAN 75# R.R. IRON
18"
1½" ø HOLE
3/4" ø OR LARGER
8" TURNBUCKLE RODS THREADED FOR 5"
WELD TO STRAP
3/4" ø x 5" BOLT
7/8" ø HOLE FOR BOLT
DETAIL OF TRUSS ROD
REST BAR FOR GATE IN OPEN POSITION
PIN TO GATE TO LOCK IN OPEN POSITION
HEIGHT TO VARY WITH LOCATION
30 GAL. BBL. COUNTERBALANCE
2- 7/8" x 24" ø HINGE PLATES W/WASHER
FILL WITH CONCRETE INTERLACED WITH REINFORCING BARS NO. 2 (4 TO 6 PCS.)
PLAN VIEW
Scale: ¼" = 1'-0"
REST BAR FOR GATE IN OPEN POSITION
"ZERK" GREASE FITTINGS
NOT LESS THAN 75# R.R. IRON
7/8" ø BOLT
2- 7/8" x 24" ø HINGE PLATES W/ WASHER
4-½" BRACES (45°∠) Weld
WELD TO PLATE
NOT LESS THAN 75# R.R. IRON
PERSPECTIVE
HINGE PLATE
NUT-WELD TO IRON
APPLY GREASE BEFORE INSTALLING TOP PLATE
PAINT WITH TWO COATS OF RUST RESISTANT PAINT AND ONE COAT OF FLUORESCENT RED PAINT.
5/8" CAP WELDED TO TOP OF CYLINDER
5" x 4" OVAL OPENING
SLOT ½" LARGER THAN LOCKING STRAP
RAIL REST
STRAP WELDED TO CROSSRAIL (5/8" x 3½")
5/8" x 3½" CASEHARDENED LOCKING STRAP WELDED INSIDE OF CYLINDER.
CASEHARDENED LOCKING
CUT
FRONT ELEVATION LOCKING DETAIL
ALTERNATE VARIABLE CYLINDER (TURN OR SLIDE)
PLATE WELDED TO END OF RAIL
3/8" x 8¾" ø CYLINDER (8¾" SQUARE OPTIONAL)
2½" OVAL
ROUND CORNERS
PLAN VIEW - LOCKING DETAIL
Scale: 1" = 1'-0"
Weld
RAIL REST DETAIL
FLAT TOP TWO LOCK PIN
2-11/16" DIA. DRILL
3-3/8" ø DRILL AND COUNTERSINK
LOCKING PINS
Scale: 3" = 1'-0"
LOCK
LOCK
LOCKING COMBINATION
PERSPECTIVES OF LOCKING DEVISES
O.S.B.F. — DRAWING NO. 306-A REVISED 7-17-67
STATE OF OREGON - DEPARTMENT OF FORESTRY
SALEM, OREGON
COUNTERBALANCED RAILROAD IRON ROAD GATE
SCALE: AS NOTED
TILLAMOOK
12-7-65 · H. HAYES


306-B
25'-0"
7'-0"
1'-6"
NOT LESS THAN 75# R. R. IRON
NOT LESS THAN 75# R. R. IRON
4-½" BRACES (WELD)
ROAD SECTION
SET IN CONCRETE
18"
18"
ELEVATION
Scale: ¼"=1'-0"
30 GAL. BARREL COUNTERBALANCE
BARREL WELDED TO R.R. CROSSRAIL
2-⅞" x 24"ϕ HINGE PLATES W/ WASHERS
FILL WITH CONCRETE INTERLACED WITH REINFORCING BARS NO.2 (4 TO 8 PIECES.
PLAN VIEW
PIN TO GATE TO LOCK IN OPEN POSITION
HEIGHT TO VARY WITH LOCATION
REST BAR FOR GATE IN OPEN POSITION
"ZERK" GREASE FITTINGS
NOT LESS THAN 75# R.R. IRON
⅞"ϕ BOLT
2-⅞"x 24"ϕ HINGE PLATES W/WASHERS
WELD TO PLATE
4-½" BRACES (45°∠) WELD
NOT LESS THAN 75# R. R. IRON
PERSPECTIVE
HINGE PLATE
APPLY GREASE BEFORE INSTALLING TOP PLATE
PAINT WITH TWO COATS OF RUST RESISTANT PAINT AND ONE COAT OF FLUORESCENT RED PAINT
⅜" CAP WELDED TO TOP OF CYLINDER
8¾"ϕ
13"
9½"
20"
SLOT ½" LARGER THAN LOCKING STRAP
RAIL REST
CYLINDER WELDED TO R. R. POST (NOTCH POST)
CASEHARDENED LOCKING STRAP WELDED TO CROSSRAIL (⅜"x3½"x4")
FRONT ELEVATION - LOCKING DETAIL
3½"
¼" CORNER BEVEL
CUT
7½"
2½" OVAL
PLAN VIEW - LOCKING DETAIL
⅜" x 8¾"ϕ x 20" CYLINDER (8¾" SQUARE OPTIONAL)
¾"
⅜"ϕ DRILL & COUNTERSINK
3½"
LOCKING PIN
WELD
RAIL REST DETAIL
PERSPECTIVE
30 B
STATE OF OREGON - DEPARTMENT OF FORESTRY
SALEM, OREGON
COUNTERBALANCED RAILROAD IRON ROAD GATE
SCALE: AS NOTED
306-
10-21-75



PAINT WITH TWO COATS OF RUST RESISTANT PAINT AND ONE COAT OF FLUORESCENT RED PAINT.

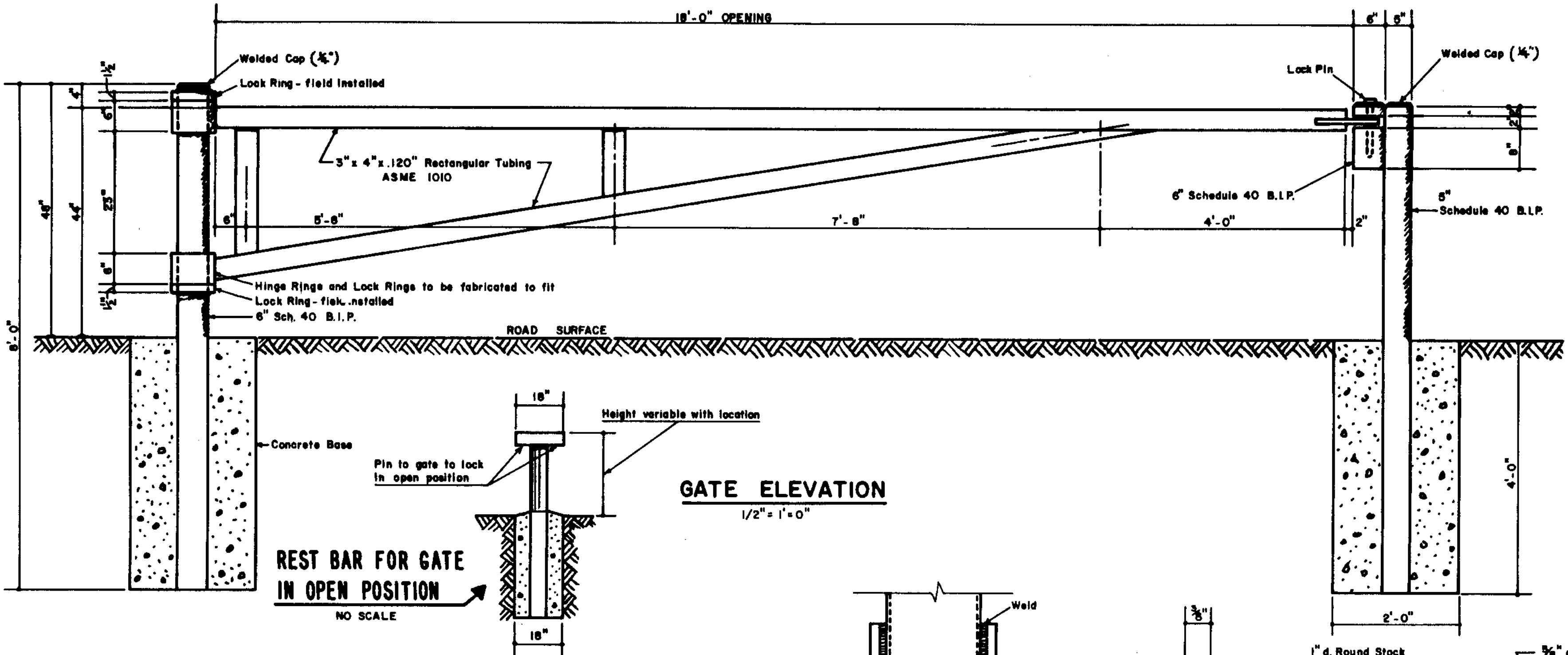
STATE OF OREGON - DEPARTMENT OF FORESTRY
SALEM, OREGON

COUNTERBALANCED RAILROAD IRON ROAD GATE

SCALES: AS NOTED

OSBF DRAWING NO. 306-C 10-29-75 H. HAYES

306 C

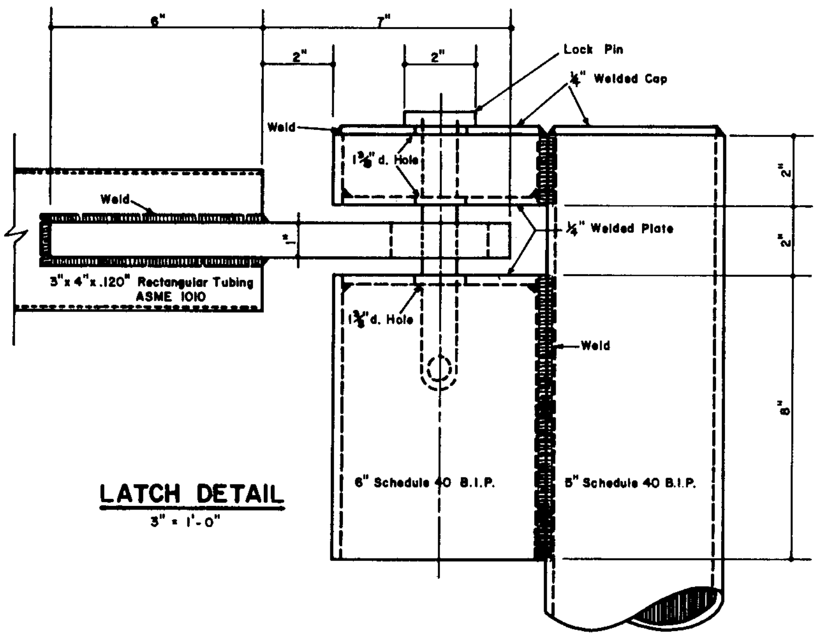


GATE ELEVATION

1/2" = 1'-0"

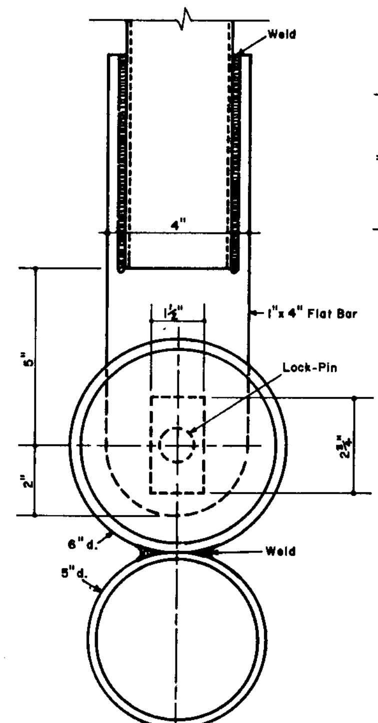
REST BAR FOR GATE IN OPEN POSITION

NO SCALE



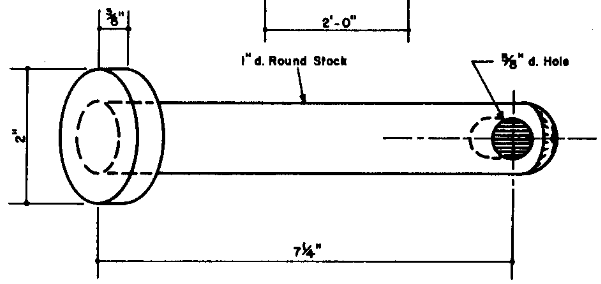
LATCH DETAIL

3" = 1'-0"



LATCH PLAN

3" = 1'-0"



LOCK-PIN

No Scale

STATE OF OREGON — DEPARTMENT OF FORESTRY
SALEM OREGON

RECTANGULAR TUBING IRON GATE

DESIGN: Courtesy of Murphy Timber Co. and Lucas Welding & Machine Works, Powers, Oregon

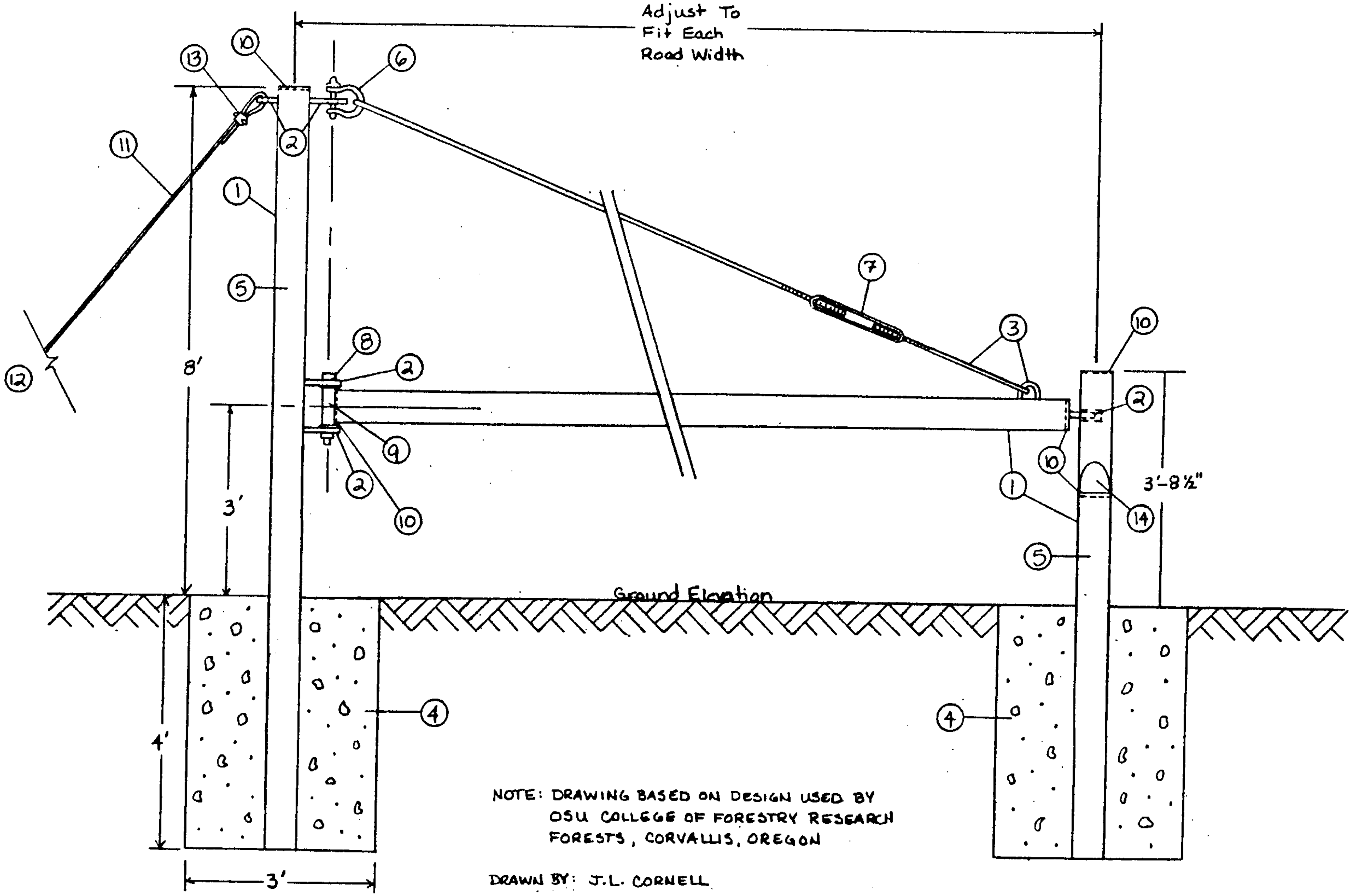
SCALE: NOTED

DATE: 12/29/77 FB

DRAWING NO.
306-D

STEEL TUBE GATE

SCALE: AS NOTED   DATE: 6-1-89

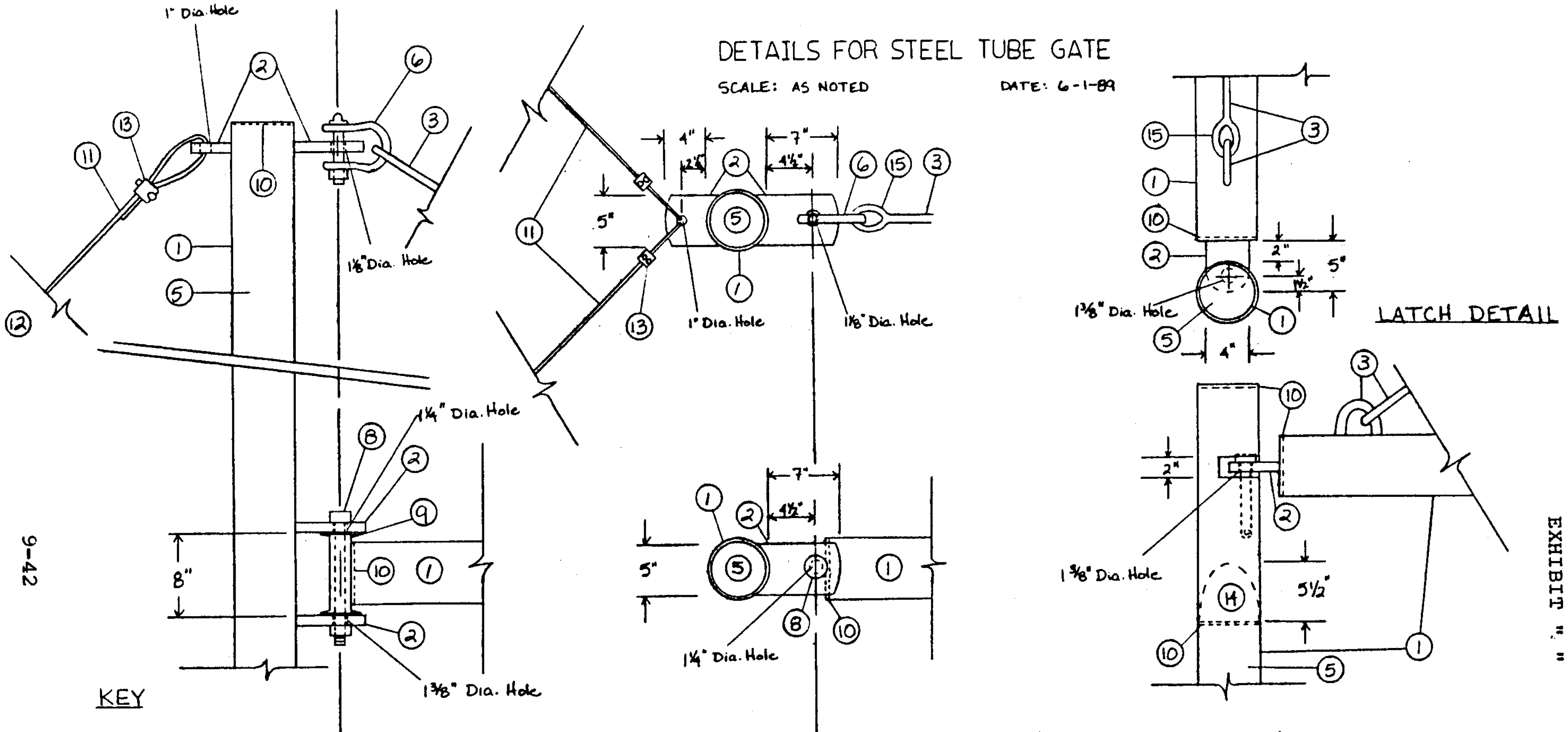


NOTE: DRAWING BASED ON DESIGN USED BY OSU COLLEGE OF FORESTRY RESEARCH FORESTS, CORVALLIS, OREGON

DRAWN BY: J.L. CORNELL

DETAILS FOR STEEL TUBE GATE

SCALE: AS NOTED DATE: 6-1-89



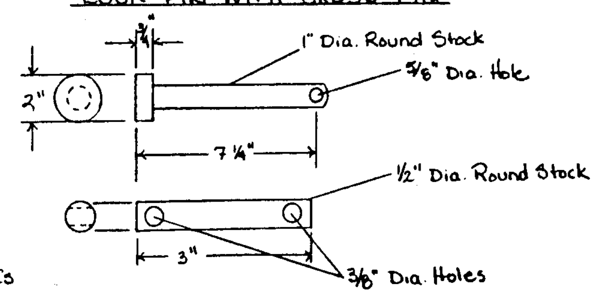
HINGE DETAIL

LATCH DETAIL

KEY

1 - 6" Dia. Steel Well Casing
2 - 1" Thick Steel Flat Stock
3 - ¾" Steel Round Stock
4 - Concrete Base
5 - Concrete-Filled Post
6 - ¾" Shackle With Welded On Nut/Pin
7 - Turnbuckle
8 - 1" Dia. x 13" Steel Bolt With Welded On Nut
9 - 2" Dia. x 7½" Steel Tube With A 3" Dia. Washer Welded On Each End; The Tube Is Welded On To The End Of The Cross Member
10 - ¼" Steel Flat Stock Welded On Ends Of Well Casing As A Cap/Plate
11 - Guylines: Min. ⅜" Dia. Wire Rope; Ends Secured With Welded On Line Clamps
12 - Guyline Anchors: Guylines Are To Be Secured To Something Solid And Permanent; Trees Greater Than 6" In Dia Are Acceptable
14 - Opening To Access Lock-Pin
15 - Welded Eye

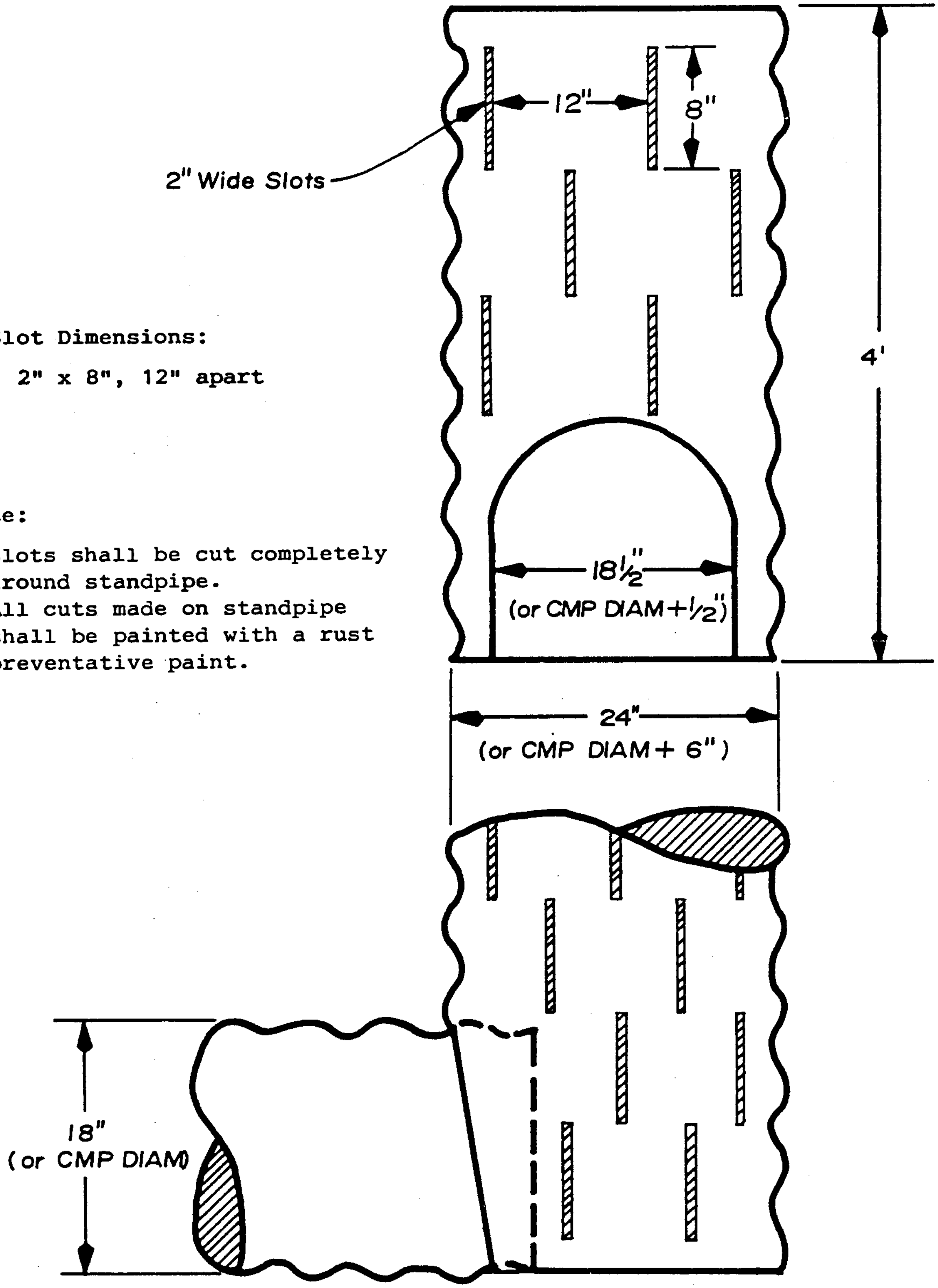
LOCK-PIN WITH CROSS-PIN



9-42

EXHIBIT " "

Typical Culvert Slotted Standpipe Detail

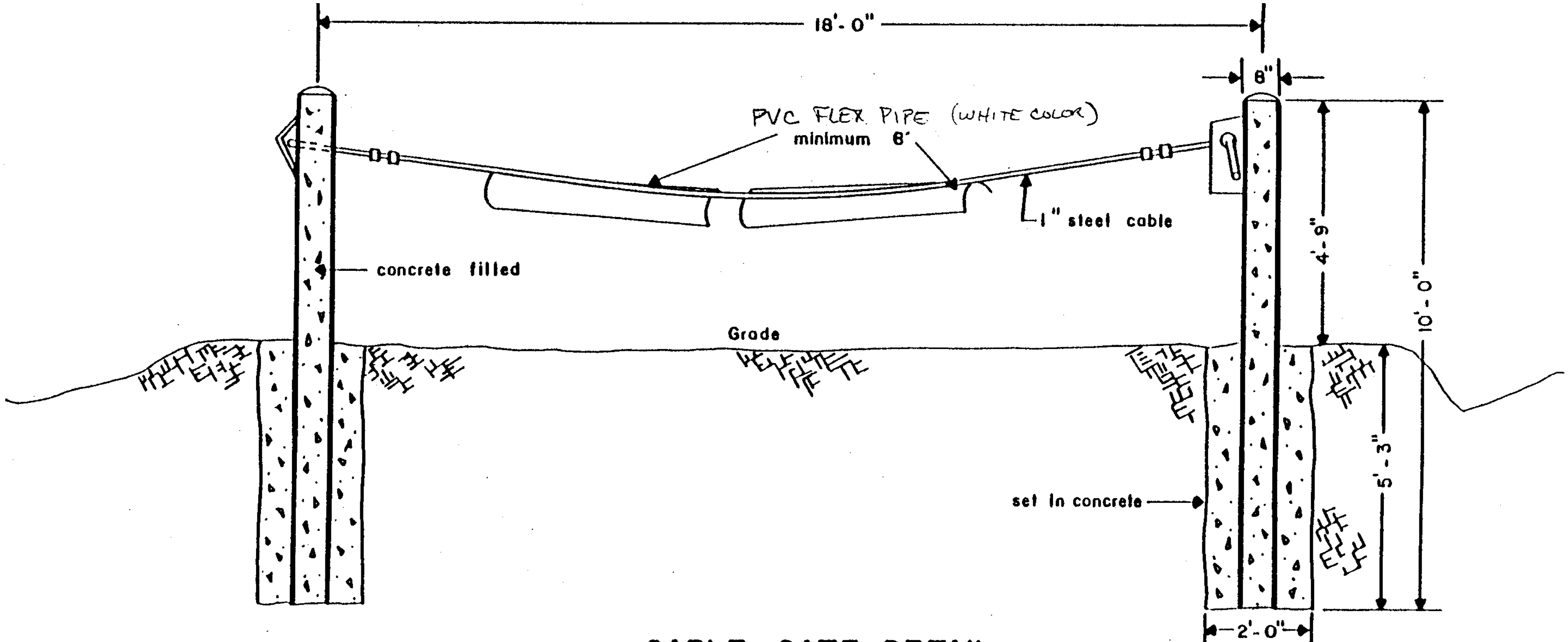


Slot Dimensions:

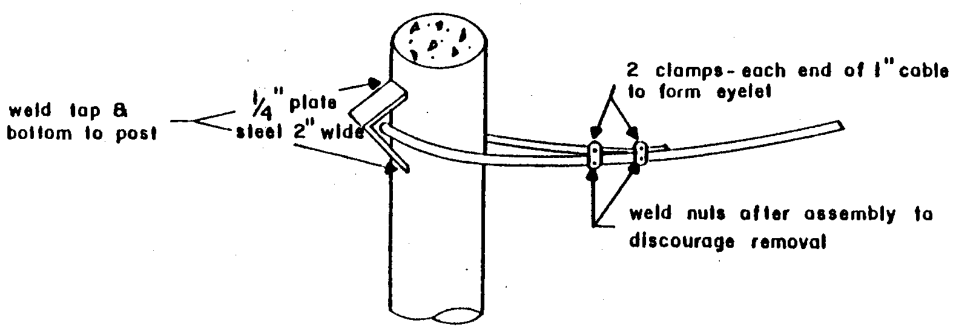
2" x 8", 12" apart

Note:

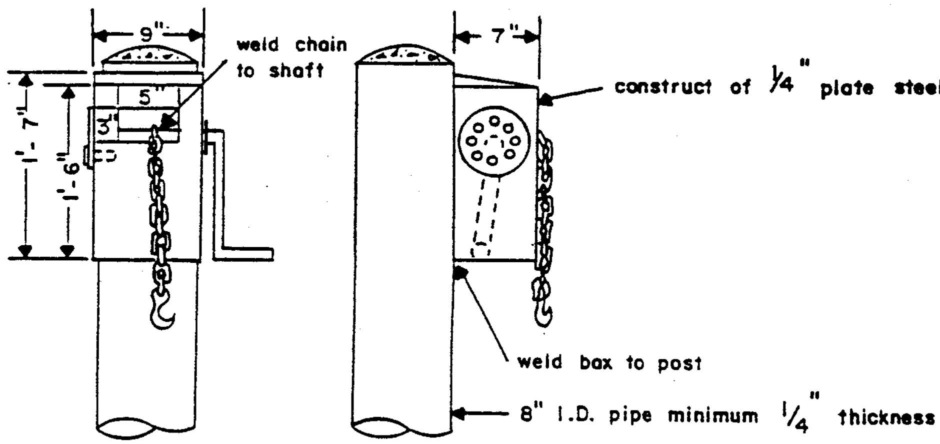
- Slots shall be cut completely around standpipe.
-- All cuts made on standpipe shall be painted with a rust preventative paint.



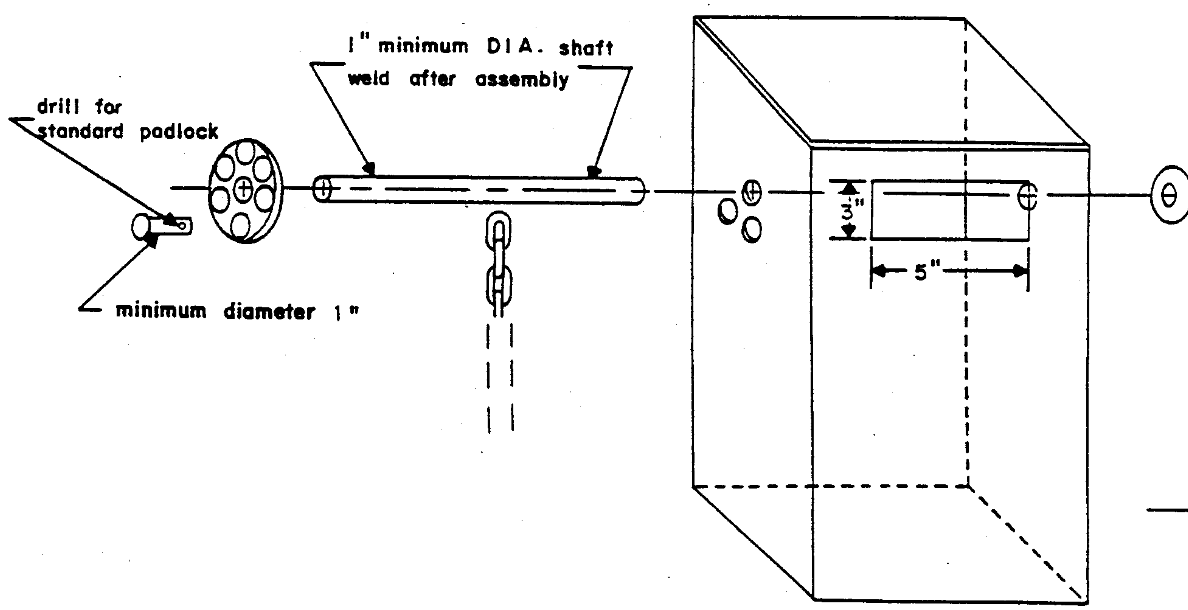
CABLE GATE DETAIL



GATE PLAN



LOCK DETAIL



Appendix 3. Costs Related to Road Construction/Improvement

APPRAISAL POLICY STATEMENT

The cost appraisal policy in this section shall be concerned only with road construction items.

The appraisals shall be made as fairly and impartially as possible with due consideration for prevailing rates for equipment and labor; size and quantity of equipment available; terrain and material types in which equipment will be working.

Unless otherwise stated, all costs and factors include 17% for profit, risk, overhead, and bonding; and 18% for the labor surcharge.

Cost Establishment Procedure

Direct cost items are provided which are up to date as nearly as practicable. Because of outdating and possible wide variation of conditions from the average, basic rates of time and quantity are supplied which will enable said cost items to be updated or modified with a minimum of effort.

Instructions on the use of tables and cost rate items are included with said tables and rates to facilitate their use.

Where the appraiser needs to know the cost of ownership of equipment or structures he/she should refer to textbooks on computation of Average Annual Investment.

No attempt has been made at this time to break down certain contract items, such as fencing, into detailed unit costs.

For the purposes of estimating costs, the appraiser must assume an operation of average efficiency undertaken by a prudent contractor who operates in the following manner:

1. Understands the project(s) prior to signing the contract.

2. Hires trained, competent persons.

3. Supervises and communicates with his crew closely.

2. Plans seasonal operations to take advantage of weather conditions.

3. Plans to have the road construction equipment and supplies necessary for forest road construction which are of correct size to do the job efficiently, and are maintained properly to minimize time lost for repair.

4. Proceeds with various phases of road construction in a safe and workmanlike manner.

5. Allows sufficient time to do the job.

CLEARING AND GRUBBING COSTS

Base Costs/Acre In Dollars For Clearing And Grubbing

Method		Tops & Limbs	Logs	Stumps	Total
1. Side cast	273	30		210	564
2. Scattering	419	48		323	869
3. Piling	465	54		358	965
4. Pile & Burn	671	77		710	1604

Load and Haul to the designated waste area shall be appraised on an individual basis using time and equipment estimates.

____ X _______ = $ ____ /acre
(Base cost) (Adjustment factor) Cost per acre.

For explanation of Adjustment factor see "Clear And Grub" sectionand photos series.

Terrain	Adjustment Constants
Moderate- slopes up to 45%	(1)
Steep- slopes steeper than 45%	(1.1)
Cover types	
Light cover	(.8)
Medium cover	(1)
Heavy cover	(1.3)
(see photo series for guidance)	

Terrain constant__ (X) Cover constant__ = __Adjustment factor

The clearing and grubbing costs shown above represent the total per acre cost for disposal of nonmerchantable material and stumps.

Make sure that you use the correct cost for the type of method that is actually being required in the field. For example sidecast of Clear and Grub debris is one of the most common methods in use on State Forests and should not be confused with Scattering which is sometimes specified but is not actually being done. The appraiser should be familiar with the definitions and differences of these methods.

EXCAVATION COSTS

1.Basic Excavation Costs: (basic cost includes haul to 200') (Slopes over 50% may need add on cost for end hauling)

Classification	% Sideslope	Base Cost
A. Common (soil and loose rock 2' in diameter)	0-20	55.49 $/sta
	0-50	1.09 $/cy
	over 50	1.41 $/cy
B. Boulders (rocks greater than 2' in diameter)	0-20	89.63 $/sta
	0-50	1.73 $/cy
	over 50	1.84 $/cy
C. Loose Rock (Talus Material 2' in diameter with minor amounts of soil)	0-20	60.53 $/sta
	0-50	1.21 $/cy
	over 50	1.59 $/cy
D. Rippable Rock	0-20	161.33 $/sta
	0-50	2.24 $/cy
	over 50	3.19 $/cy
E. Solid Rock	0-20	249.48 $/sta
	0-50	3.84 $/cy
	over 50	5.66 $/cy

2. Basic Add-on Costs

a. Embankment Placement Method	Common	Rippable
1. Side casting and end dumping.	0.00	0.00
2. Layer placement.	.15	.15
3. Layer placement (Roller Compaction).	.31	.29

b. End Haul

Cost on a time and equipment basis

2. Loading cost only

a. Excavator (w/dozer excavation) $1.46/cy

b. Front end loader $ .83/cy

(or use the production computation sheets for excavators or loaders)

3. Truck haul (use "haul cost computation sheet")

c. Slope Rounding $ .17/L.F. (Consider any additional grubbing requirements)

d. Subgrade Finishing ($/Mile)

BRUSH CUTTING

Costs for brush cutters should be based on current estimates from contractors in your local area. Typical mechanical brush cutters have the following characteristics:

a. Specifications - The average reaches for a brush cutter are:

Uphill @ 45^{o} <	Level	Downhill @ 45^{o} <	Height
11 ft.	15 ft.	9 ft.	16 ft.

b. Production rates - average 3/4 to 1 mile per day brushing both sides of road.

c. Equipment and manpower
   1. Brushcutter and operator
   2. Pickup and laborer

d. A tractor mounted flail mower setup should run between $45 to $65 per hour for rough estimating.

SUBGRADE TREATMENTS

Grading ($/Mile)	Surfaced		Unsurfaced	
	common	rocky	common	rocky
1. Single lane without ditch	422	641	492	693
2. Single lane with ditch	586	731	774	949
3. Double lane with ditch	821	1128	1044	1283
4. Grid roll only	233			
5. Dips				
a. Drain Dips	138.00 $/ea			
b. Rolling Dips	69.00 $/ea			

Geotextiles ($/S.Y.)	Material only	Installed
1. Woven 500x (stabilization)	1.71	1.86
2. Nonwoven 140n (separation)	.71	.86

EQUIPMENT/OPERATOR RATES

rev. 12-91

Division Equipment (Make - Model)	---- Equipment Rates ---- $/HR. Average	 Standby	 Operator(s)
BRUSH CHIPPERS			
Brush Mower 8'	89.26		35.90
COMPACTION EQUIPMENT			
Vibratory Roller	36.33	8.60	34.94
Grid Roller	9.00	1.70	
Sheeps Foot	6.12	2.00	
Hand Held Tamper	1.68	.22	34.94
4" DRILL & COMPRESSO	45.0	12.05	(2) 70.36
EXCAVATORS, CRAWLER MOUNTED (BACKHOES)			
1.00 CY (225)	40.54	12.71	36.04
1.50 CY (235)	73.75	23.27	36.04
GRADERS			
12-G	26.26	8.32	35.90
14-G	37.35	11.75	35.90
16-G	53.93	17.0	35.90
LOADERS - FRONT END/BACKHOES			
1.00 CY/24" HOE	13.09	3.56	35.26
1.25 CY/30" HOE	20.06	5.67	35.26
LOADERS - FRONT END			
3.00 CY (950B)	35.77	5.49	35.16
4.00 CY (966D)	48.55	13.56	35.60
5.25 CY (980C)	58.96	15.36	36.68
7.00 CY (988B)	83.28	22.08	37.05
SCRAPERS			
11 CY (613B)	40.74	10.67	35.60
14 - 20 CY (TS14B)	76.21	21.35	35.60
TRACTORS			
D4	19.71	4.72	35.60
D6	35.14	8.35	35.60
D7 WINCH	59.78	15.59	35.60
D8 WINCH	91.44	25.73	35.60
D8 RIPPER	94.71	26.71	35.60

Division Equipment (Make - Model)	---Equipment Rates Average	 Standby		$/HR. Operator(s)
TRUCKS				
Distributor Truck	45.43			33.21
Dump: 10 CY	15.32	3.59		33.21
: 12 CY	24.46	5.23		33.21
: 20 CY (Belly)	40.11	9.48		33.51
Water: 2000 Gal.	14.77	3.48		33.29
: 3000 Gal.	23.95	5.14		33.29
Lowboy	38.33	8.92		33.29
1/2 Ton P.U.	5.80	.92		33.07
3/4 Ton P.U. (Crew Cab)	6.70	1.19		33.07
1 Ton Stake	14.89	2.04		33.07
CRUSHING EQUIPMENT (typical 3 stage equipment)				
Jaw 22" X 36"	29.98			35.60
Cone 45" Standard	42.03			
Rolls 30" X 18" standard	21.79			
Belt 24" X 60'	12.03			
Screen 5' X 12' Triple Deck	10.34			
Apron 48" X 14' - Heavy Duty	17.39			
Grizzly 52" X 27' Vibrating feeder	21.13			
Typical cost for entire setup includes feeding equipment				
1 stage	$312.31/hr			
2 stage	$422.05/hr			
3 stage	$466.21/hr			
MISCELLANEOUS				
CHAIN SAW: BRUSH CUTTERS	3.14			27.65
: FALL AND BUCK	3.14			28.07
ELECTRIC MOTOR 200 HP	14.66			
GENERATOR: 250 KW	21.84	2.78		35.47
: 355 KW	31.34	4.44		35.47
HYDRO-MULCHER	42.75		(2)	70.94
LOG SKIDDER - CAT 518	41.06			35.60
WATER PUMPS				
4" - 600 GPM	2.69	.22		34.64
- 1100 GPM	13.12	1.00		34.64
Welder, 200 AMP	8.50	.49		35.60

CULVERT COSTS PER FOOT rev. 12-91

The following costs were derived from the USFS Cost Estimating Guide. For large projects where a full load of culverts (truck and trailer) will be ordered these costs may be reduced 20%. For small projects where only a few culverts will be needed these costs may be increased by 20%.

The cost shown is an average cost and can be used for culvert estimating without regard for culvert order size and should be within a reasonable range of the true cost.

Costs include bands and delivery

2-2/3" X 1/2 " Thickness	Diameter(in)	Material Price	Material+ installation	Coated corrugations Material Price	Material+ installation
	18	7.59	13.48	8.85	14.74
	21	8.86	14.75	10.33	16.22
	24	10.12	16.01	11.80	17.69
16 Gage	30	12.65	19.13	14.75	21.23
	36	15.18	26.90	17.70	29.42
	42	17.71	31.61	20.65	34.55
	48	20.25	37.50	23.61	40.86

corrugations

2-2/3" X 1/2" Thickness	Diameter(in)	Material Price	Material+ installation	Material Price	Material+ installation
	18	9.45	15.34	10.71	16.63
	21	11.02	16.91	12.49	18.38
	24	12.60	18.49	14.28	20.17
14 Gage	30	15.75	22.23	17.85	24.33
	36	18.90	30.62	21.42	33.14
	42	22.05	35.95	24.99	38.89
	48	25.20	42.45	28.56	45.81
	54	38.35	48.44	32.13	52.22
	60	31.50	53.94	35.70	58.14

corrugations

3" X 1" Thickness	Diameter(in)	Material Price	Material+ installation	Material Price	Material+ installation
	48	28.19	46.30	31.55	49.66
	54	31.72	52.81	35.50	56.59
	60	35.24	58.80	39.44	63.00
14 Gage	66	38.77	65.40	43.39	70.02
	72	42.29	71.41	47.33	76.45
	78	45.81	78.52	51.27	83.98

CORRUGATED POLYETHYLENE PIPE

18	7.02	11.93
24	8.77	14.98

For pipe arches - find the cost for equivalent round pipe & add 10%

MOVE IN AND SET-UP COSTS

Equipment Allowances

Equipment Description	Move-in (dollars)	Move within Project area ____________ ($/mile)
Fire Equipment	120	N/A
Powder House	241	N/A
Drill and Compressor	241	N/A
Cranes - 20 tons	241	N/A
- 60 tons	533	N/A
Graders - all sizes	241	7.05
Loader - 1 1/2 - 2 1/2 cy	241	6.83
- 3 cy and over	387	8.15
Roller and Compactors	241	13.73
Scrapers - 11 cy and under	241	4.91
- over 11 cy	533	7.21
Excavators, large backhoes, etc.	533	21.42
Backhoes 24/30" Bucket (rubber tired)	241	3.52
Tractors - D5 -7	387	18.47
- D8	533	25.53
Dump trucks : under 10 cy	121	2.30
: over 10 cy	144	2.76
Water Truck	158	3.03
Rock Crusher (setup not included)		
1 stage	1066	
2 stage	1597	
3 stage	2489	
Screening Plant	387	

Crusher setup	1 stage	733	COSTS are
	2 stage	1598	complete per
	3 stage	2520	stage, don't
cost to change gradation:		207	add together
Screening Plant:		395	

THE COST TO MOVE THE EQUIPMENT TO THE PROJECT AREA WITH OR WITHOUT A LOWBOY, AS APPLICABLE, IS BASED UPON 50 MILES (ONE WAY). ADJUST COSTS, AS SHOWN ON EXHIBIT 15.

COST TO MOVE THE EQUIPMENT WITHIN THE PROJECT ARE WITHOUT THE USE OF A LOWBOY. IF THE USE OF A LOWBOY IS NECESSARY WITHIN THE PROJECT AREA, USE THE COSTS FROM THE MOVE IN COLUMN.

EXHIBIT 15
MILEAGE FACTORS
(ONE WAY MILES)

Apply to $ / each costs obtained from move in chart

DISTANCE	FACTOR
0 - 25	0.58
30	0.66
35	0.74
40	0.82
45	0.91
50	1.00
55	1.07
60	1.15
65	1.23
70	1.31
75	1.40
80	1.48
85	1.56
90	1.64
95	1.72
100	1.80
110	1.97
120	2.13
130	2.29
140	2.46
150	2.62
160	2.78
170	2.95
180	3.11
190	3.27
200	3.44
210	3.60
220	3.76
230	3.93
240	4.09
250	4.25

GATES

Railroad Iron Gates

These gates are extensively used in many areas and many designs are available.

Four designs are shown, the rock filled barrel counterweight being very popular.

The cost is $450-650, the 95-125 lb. rails being more expensive.

Add $200 for installation.

Because of short sight distances on mountain roads, gates must be placed so as to allow sufficient stopping distance for traffic. If this is impossible, warning signs must be placed alongside the road 500 to 1000 feet away on one or both approaches. In addition, gates must be painted a light or fluorescent color that is highly visible. Do not use white where snow is encountered.

Quite often an information sign hung from the center of the gate can also serve to make the gate more easily detected.

Powder River Gates		dollors	
	52" X 12'	139.00	add 11% for delivery
heavy duty with	52" X 14'	153.00	
chain latch,	52" X 16'	176.00	
no installation	52" X 18'	212.00	

Steel tube Gate (see exhibit)
These are custom made gates, the approximate cost is $1000

(see exhibit section for picture)

Cable gates will not be used on State land.

Appendix 4. Work Forms

Excavator Endhaul Production Computation - CAT 235

Cycle Time Estimating Chart

Hauling Cost Computation Sheet

Hauling Costs Instructions

Loading Cost Computation Sheet

Loading Costs Instructions

Pusher Production Sheet (For Assisting Scraper)

Pusher Production Sheet Instructions

Scraper End Haul Production Sheet

Scraper End Haul Production Instructions

Scraper Travel Time Table

Rock Pit Development And Crushing Cost Summary

Rocking Cost Computation Sheet

Summary Of All Project Codes

Summary Of Construction Cost

Volume Computation Sheet

EXCAVATOR ENDHAUL PRODUCTION COMPUTATION - CAT 235

Sale Name________________________________ Date____________________

Road Name_______________________________

BUCKET PAYLOAD COMPUTATION

Average Bucket Payload = (heaped bucket capacity) x (bucket fill factor)
Heaped bucket capacity for a 48" cutting width = 1.5 cy. for rock and
1.88 cy for soil (1)__________________

Bucket Fill Factor:

Material	Fill Factor Range	
Moist Loam or Sandy Clay	1 to 1.1	
Sand and Gravel	.95 to 1	
Hard, tough clay	.80 to .9	
Rock-Well Blasted	.60 to .7	
Rock-Poorly Blasted	.40 to .50	(2)__________________

Average Bucket Payload = Line (1) x Line (2) (3)__________________

CYCLE TIME COMPUTATION

Cycle time Estimate from Chart (4)________________ sec.

LINE (4) / 60 = CYCLE TIME (100% EFFICIENCY) (5)______________ MIN.

Operator Efficiency Correction = Line (5)/____ (6)______________ MIN.

Job Efficiency Correction = Line (6)/____ (7)______________ MIN.

Swell Factor = Line 7/.80 (if bank yards are used) (8)______________ MIN.

Time (min.) per cubic yard = Line (8)/Line (3) (9)______________ MIN.

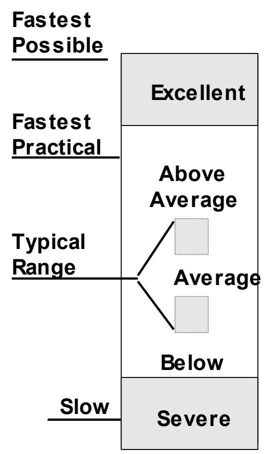
COST PER CUBIC YARD COMPUTATION

Cost of Excavator and Operator per Hr./60 (10)____________ $/MIN.

Cost per cu. yd. = Line (9) x line (10) (11)______________ $/cy.

CYCLE TIME ESTIMATING CHART

CYCLE TIME ESTIMATING CHART					
	MACHINE SIZE CLASS				
CYCLE TIME	215 & 215 SA	225	235	245	CYCLE TIME
10 SEC.					10 SEC.
15					15
20 SEC.					20 SEC.
25					25
30 SEC.					30 SEC.
35					35
40 SEC.					40 SEC.
45					45
50 SEC.					50 SEC.
55					55
60 SEC.					60 SEC.



CYCLE TIME vs
JOB CONDITION DESCRIPTION

- Easy digging (unpacked earth, sand gravel, ditch cleaning, etc.). Digging to less than 40% of machine's maximum depth capability. Swing angle less than 30°. Dump onto spoil pile or truck in excavation. No obstructions. Good operator.
- Medium digging (packed earth, tough dry clay, soil with less than 25% rock content). Depth to 50% of machine's maximum capability. Swing angle to 60°. Large dump target. Few obstructions.
- Medium to hard digging (hard packed soil with up to 50% rock content). Depth to 70% of machine's maximum capability. Swing angle to 90°. Loading trucks with truck spotted close to excavator.
- Hard digging (shot rock or tough soil with up to 75% rock content). Depth to 90% of machine's maximum capability. Swing angle to 120°. Shored trench. Small dump target. Working over pipe crew.
- Toughest digging (sandstone, caliche, shale, certain limestones, hard frost). Over 90% of machine's maximum depth capability. Swing over 120°. Loading bucket in man box. Dump into small target requiring maximum excavator reach. People and obstructions in the work area.

HAULING COST COMPUTATION SHEET

Sale Name________________________________ Date____________________

Road Name_______________________________

Time Computation

Basic haul cycle time per RT* for this job = 2.4 min. X _______ MRT	(1)__________	minutes

Road speed time factors:

1.	40 MPH (-0.90 X___ MRT)	(2)__________	minutes
2.	35 MPH (-0.69 X___ MRT)	(3)__________	minutes
3.	25 MPH	(4) 0.00	minutes
4.	17 MPH (+1.13 X___ MRT)	(5)__________	minutes
5.	10 MPH (+3.60 X___ MRT)	(6)__________	minutes
6.	5 MPH (+9.60 X___ MRT)	(7)__________	minutes

Dump or spread time per RT	(8)__________	minutes
Total hauling cycle time for this setting 100% efficiency	(9)__________	minutes
Operator efficiency correction = line 9/____	(10)__________	minutes
Job efficiency correction = line 10/____	(11)__________	minutes

TIME per cubic yard:

Hauling only, per cubic yard = line 11/____ cubic yard capacity of truck)	(12)__________	minutes
Delay time/cy for loading, line 10 from loading comp. form	(13)__________	minutes
TOTAL TIME per cu. yd. = line 12 + 13	(14)__________	minutes

Cost per cu. yd. Computation

Cost of truck & operator per minute (cost/hour divided by 60) cost /hr. ____	(15)_________	$/minute
Total cost per cy. yd. = line 15 X line 14 $/cy	(16)__________	

RT* = round trip
MRT = MILES PER ROUND TRIP

HAULING COSTS

The following figures assume a basic haul cycle time with 100% efficiency. They must be modified to conform to the variables on any particular project.

The basic time cycle in minutes required for a dump truck travelling at an average 25 MPH to make a round trip of 2 miles is 4.8 minutes or 2.4 minutes per mile.

The variables listed below show the time factors in minutes by which the basic cycle is to be increased or decreased. Numbers in parentheses coincide with those on the work sheet.

TIME Computations

(1) Haul distance on this setting or project multiplied by the basic time cycle of 2.4 minutes per mile from above.

	Road speed time factors (2-7)	Time (minutes)
(2)	Highway (State or Federal) paved, up to 4%, good alignment, up to 50 MPH., Av. 40 MPH.	-0.90
(3)	Highway (County) paved with steep grades, poor alignment, up to 45 MPH., Av. 40 MPH.	-0.69
(4)	Rocked State Forest mainline or Co. road, grades up to 8%, fair alignment, up to 35 MPH. Av. 25 MPH.	0.00
(5)	State Forest, new or rough surface up to	+1.13
(6)	10%, 17 MPH AND 10 MPH respectively	+3.6
(7)	a. State Forest road spur, with some grades over 10%, up to 10 MPH. Av. 5 MPH.	+9.6
	b. Backing (usually end hauling) Av. 5 MPH	+9.6

(8) Dump or spread time can vary from 0.2 to 0.5 minutes. Use least time for pile dumping, or spreading of rock, and the greater time where excessive maneuvering is needed to dump end haul material over a bank.

(9) Add above figures algebraically to obtain 100% efficiency total haul time.

(10-11) Corrections to obtain true haul time:
Operator efficiency - average .75
Job efficiency - average .75 to .83

LOADING COST COMPUTATION SHEET

Sale Name________________________________ Date____________________

Road Name_______________________________

TIME Computation

Basic loading cycle time	(1)__________	min.
Materials time factor (plus or minus)	(2)__________	min.
Pile type time factor	(3)__________	min.
Miscellaneous items time factor	(4)__________	min.
Travel distance time factor	(5)__________	min.
Total loading cycle time for this setting (100% efficiency)	(6)__________	min.
Operator efficiency correction = line 6 ÷ .75	(7)__________	min.
Job efficiency correction = line 7 ÷ .75	(8)__________	min.
TIME (minutes) per cubic yard = line 8 ÷ ____ (CY capacity of loader)	(9)__________	min.

COST PER CU. YD. Computation

Cost of loader and operator per hour	(10)__________	/hr.
Operating cost per minute = line 10 ÷ 60	(11)_________	/min.
Cost per cu. yd. = line 9 X line 11	(12) $_________	/cy

LOADING COSTS

The following instructions are compiled from information in a publication by Caterpillar Tractor Co. entitled Caterpillar Performance Handbook, Edition 3. These figures assume 100% efficiency and must be modified to conform to the variables on any particular project.

A basic loading time cycle in minutes is the time it takes for a loader to load, dump, go through four reversals of direction, a minimum cycle travel distance of loading and dumping within its turning area, and the complete hydraulics needed to accomplish the cycle. Numbers in parentheses coincide with those on the work sheet.

TIME Computations

(1) Basic cycles are 0.40 minutes (24 seconds) for a wheel loader and 0.33 minutes (20 seconds) for a track type or an articulating type loader

Variables and the time factors in minutes by which the basic cycle is to be increased or decreased are listed below.

		Time (decimal of a minute)
(2)	Material type	
	Mixed	+ 0.02
(3)	Pile type	
	Piled 10' and up	0.00
	Piled 10' or less	+ 0.01
	Dumped by truck	+ 0.02
(4)	Miscellaneous	
	Restricted maneuvering area	+ 0.00 to 0.04
	Small Target (small hopper or truck)	+ 0.00 to 0.04
	Fragile target (loading large stone)	+ 0.00 to 0.05
	Normal or average digging	+ 0.06
	Retaining material on road width or retrieving	+ 0.02

(5) Loader travel distance in addition to basic cycle travel distance

Loader travel distance in addition to basic cycle travel distance	Wheel Loader	Track Loader
0 - 25 ft. + 0.10	+ 0.15	
25 - 75 ft. + 0.25	+ 0.28	
50 - 100 ft.+ 0.45	+ 0.33	
75 - 100 ft.+ 0.55	+ 0.45	
100 - 125 ft.+ 0.75	+ 0.53	
125 - 150 ft.+ 0.80	+ 0.70	

(6) Add above figures algebraically to obtain 100% efficiency total loading time.

(7-8) Corrections to obtain true loading time (self explanatory)

(9) Time per cu. yd. to be used below in (12).

COST PER CU. YD. Computation

(10) See equipment & labor rates

(11-12) Self explanatory.

PUSHER PRODUCTION SHEET (For Assisting Scraper)

Sale Name________________________________ Date____________________

Road Name________________________________

Equipment________________________________

TIME COMPUTATION

Basic pusher cycle time*	(1) 1.09	min.
Operator efficiency correction = line 1 _____	(2)____________	min.
Job efficiency correction = line 2 _____	(3)____________	min.
Time (minutes) per cubic yard = line 3 ÷ 16 (CY capacity of scraper)	(4)____________	min.

COST PER CU. YD. COMPUTATION

Cost of tractor per hour $___________
Cost of operator per hour $___________

Total operating cost per hour	(5) $__________	hr.
Operating cost per minute = line 5 ÷ 60	(6) $__________	min.
Cost per cu. yd. = line 4 X line 6	(7) $__________	cy.

*Pusher cycle time = 140% of basic load time from line 1 Scraper Endhaul Production Sheet + 0.25 minute.

INSTRUCTIONS FOR PUSHER PRODUCTION SHEET

The following figures assume a basic pusher cycle time with 100% efficiency. They must be modified to conform to the variables on any particular project

The basic pusher cycle time consists of load, boost, return and maneuver time. Numbers in parentheses coincide with those on the work sheet.

TIME COMPUTATION

(1) Basic pusher cycle time = 140% of basic load time + 0.25 minute.

(2-3) Corrections to obtain true loading time (.75 = the average operator efficiency and the job efficiency range is .75 to .83).

(4) Time per cu. yd. to be used below in line (7).

COST PER CU. YD. COMPUTATION

(5) See equipment and labor rates section.

(6-7) Self-explanatory.

SCRAPER END HAUL PRODUCTION SHEET

Sale Name________________________________ Date____________________

Road Name_______________________________

Equipment cu. yd.____________________________

TIME COMPUTATION

Basic load cycle time	(1)_____.06______	min.
Materials time factor	(2)______________	min.
Miscellaneous items time factor	(3)______________	min.
Basic haul cycle time per *RT	(4)______________	min.
Dump or spread time	(5)_____.07______	min.
Total loading and hauling cycle time for this setting (100% efficiency)	(6)______________	min.
Operator efficiency = line 6 ÷ .75	(7)______________	min.
Job efficiency correction = line 7 ÷ .75	(8)______________	min.
Load factor (swell) = line 8 ÷ ____	(9)______________	min.
Time (minutes) per cubic yard = line 9 ÷ ____ (cy capacity of scraper)	(10)_____________	min./cy

COST PER CU. YD. Computation

Cost of scraper and operator / hour	(11) $____________	hour
Operating cost per minute = line 11 ÷ 60	(12) $____________	min.
Cost per cu. yd. = line 10 x line 12	(13) $____________	/cy

Total cost per cu. yd. for end haul project
line 13 from above + line 7 (from Pusher
Production Sheet) (14) $_____________ /cy

*RT - Round Trip

INSTRUCTIONS FOR SCRAPER END HAUL PRODUCTION

The following instructions are compiled from information in a publication by Caterpillar Tractor Co. entitled Caterpillar Performance Handbook, Edition 5. These figures assume 100% efficiency and Bank Cubic Yards. They must be modified to conform to the variables on any particular project.

A basic cycle time in minutes is the time it takes for a scraper to load, haul, maneuver and spread or maneuver and dump, and return. Numbers in parentheses coincide with those on the work sheet.

TIME COMPUTATION

(1) Basic load cycle is 0.60 minutes (36 seconds) for a 621B scraper.

Variables and the time factors in minutes by which the basic cycle is to be increased are listed below.

(2)

Material type	Time (decimal of a minute)
Bank or broken average	+0.04 and up (.10 normal or for Elliott State Forest)

(3)

Miscellaneous	
Restricted maneuvering area	+0.00 to 0.04
Normal or average digging	+0.06

(4) Basic haul cycle time per round trip is obtained from the scraper travel time table in this section.

(5) Dump or spread time is 0.7 minutes (42 seconds) for a 621B scraper.

(6) Add above figures algebraically to obtain 100% efficiency total cycle time.

(7-8) Corrections to obtain true loading time.

(9) Load factor considers material which has been disturbed and has swelled as a result of loading.

(10) Time per cu. yd. to be used below in (13).

SCRAPER TRAVEL TIME IN MINUTES

#621B-16 CY

Haul distances Round trip in feet	Scraper Grade 2%	4%	6%	8%	10%
500	.49	.55	.60	.67	.73
1000	.69	.76	.86	.98	1.14
2000	.83	1.11	1.21	1.44	1.64
3000	1.54	1.82	2.22	2.78	3.30
4000	1.91	2.32	2.91	3.67	4.34
5000	2.26	2.75	3.55	4.49	5.37
6000	2.59	3.20	4.18	5.35	6.42
7000	2.94	3.66	4.80	6.21	7.47
8000	3.29	4.12	5.45	7.07	8.49
9000	3.66	4.56	6.06	7.91	9.49
10,000	3.98	5.01	6.89	8.25	10.66
12,000	4.67	5.90	8.00	10.56	12.80

The Caterpillar performance handbook may also be used for different sizes of scrapers and steeper grades than those listed above.

ROCK PIT DEVELOPMENT AND CRUSHING COST SUMMARY

Pit: ____________________ Location: ____________________ County: ____________________

Type and Size Rock: __________________________ Cubic Yards: __________________________
__________________________ __________________________

Scalp and Clear Overburden.. ____________________

Drill and Shoot	$_____/CU.YD. X __________CU.YDS. =		____________________
Strip Rock Loose	$_____/CU.YD. X __________CU.YDS. =		____________________
Load Crusher	$_____/CU.YD. X __________CU.YDS. =		____________________
Crushing	$_____/CU.YD. X __________CU.YDS. =		____________________
Load Dump Truck	$_____/CU.YD. X __________CU.YDS. =		____________________
Msc. (haul, spread, process, stockpile)	$_____/CU.YD. X __________CU.YDS. =		____________________
_____________	$_____/CU.YD. X __________CU.YDS. =		____________________

Move in and Setup Crusher .... ____________________

Sub Total ____________________

Sub total ÷ Cu. Yd. = __________ Base Cost/Cu.Yd.

Rd. Segment	Haul Cost Rock Cost	+	Processing Cost	+	Base Cost	=	Cost/Yd.	No. Yds.
________	$_____/YD. $_______		$_____/YD.		$_____/YD.		$_____/YD	____YDS
________	$_____/YD. $_______		$_____/YD.		$_____/YD.		$_____/YD	____YDS
________	$_____/YD. $_______		$_____/YD.		$_____/YD.		$_____/YD	____YDS
________	$_____/YD. $_______		$_____/YD.		$_____/YD.		$_____/YD	____YDS
________	$_____/YD. $_______		$_____/YD.		$_____/YD.		$_____/YD	____YDS
________	$_____/YD. $_______		$_____/YD.		$_____/YD.		$_____/YD	____YDS

_________	$_____/YD. $________	$_____/YD.	$_____/YD.	$_____/YD	____YDS
_________	$_____/YD. $________	$_____/YD.	$_____/YD.	$_____/YD	____YDS
STOCKPILE	Haul Cost + Total Cost	Pile shaping cost +	Base Cost =	Cost/Yd.	
_________	$_____/YD. $________	$_____/YD.	$_____/YD.	$_____/YD	

TOTAL ALL ROCKING COSTS = ____________________

ROCKING COST COMPUTATION SHEET

Sale Name_____________________________________ Date_______________________

Road Name____________________________________

HAULING TIME COMPUTATION

1. 50 MPH (1.20 x ______ MRT)* ______________ Minutes
2. 40 MPH (1.50 x ______ MRT) ______________ Minutes
3. 35 MPH (1.71 x ______ MRT) ______________ Minutes
4. 30 MPH (2.00 x ______ MRT) ______________ Minutes
5. 25 MPH (2.40 x ______ MRT) ______________ Minutes
6. 20 MPH (3.00 x ______ MRT) ______________ Minutes
7. 15 MPH (4.00 x ______ MRT) ______________ Minutes
8. 10 MPH (6.00 x ______ MRT) ______________ Minutes
9. 5 MPH (12.00 x ______ MRT) ______________ Minutes

Dump or spread time per RT ______________ Minutes

Total hauling cycle time for this setting ______________ Minutes
(100% efficiency)

Operator efficiency correction = line 11 ÷ .75 ______________ Minutes

Job efficiency correction = line 12 ÷ .75 ______________ Minutes

Time per Cubic Yard:

Hauling only - per cubic yard = line 13 ÷ 12 ______________ Minutes /cy
(CY capacity of truck)

Delay time (while loading = loading time per cubic yard) ______________ Minutes /cy

Total Time per Cubic Yard = line 14 + line 15 ______________ Minutes /cy

HAULING COST PER CUBIC YARD COMPUTATION

Cost of truck per hour (A) $______/Hr.

Cost of Operator per hour (B) $______/Hr.
Total Operating Cost per hour = A + B $____________ Hour
Operating Cost per minute = line 17 ÷ 60 $____________
Minute
Cost per cubic yard = line 16 x line 18 $____________ cy

LOADING COST PER CUBIC YARD $____________ cy

SPREADING COST PER CUBIC YARD
Cost of Grader or Cat per hour $______/Hr.
Cost of Operator per hour $______/Hr.
Total Operating Cost per hour $______/Hr.
Cost per cubic yard = Cost per hour - 150 CY/Hr. $____________/cy

ROCK COST (From Summary of Rock Crushing Costs, or quote) $____________ /cy

Total Rock Cost = lines 19 + 20 + 21 + 22 $____________ /cy

_________________________* MRT = Mile per Round Trip

SUMMARY OF ALL PROJECT CODES

Sale Name______________________________________ Date________________________

New Construction Road Segment	Length	Cost

TOTAL S __________________ ____________________

Improvements Road Segment	Length	Cost

TOTAL S __________________ ____________________

Special Projects

____
____
____
____
____
____

TOTAL ______________________

Move In

____
____
____
____
____
____
____

TOTAL ______________________

GRAND TOTAL __________________

Compiled By____ Date______________________________

SUMMARY OF CONSTRUCTION COST

SALE____________________________ LENGTH const___________ sta____________ miles
ROAD____________________________ impr____________ sta____________ miles

CLEARING AND GRUBBING

_________ acres @ $_________ /acre = $ ____________________________
_________ acres @ $_________ /acre = $ ____________________________
_________ acres @ $_________ /acre = $ ____________________________
TOTAL CLEARING AND GRUBBING $________________________

EXCAVATION

Unclassified	______________	cy	@ $______________	/cy =	$_____________
Other:	______________	cy	@ $______________	/cy =	$_____________
______________	______________	cy	@ $______________	/cy =	$_____________
______________	______________	hrs	@ $______________	/hr =	$_____________
______________	______________	sta	@ $______________	/sta =	$_____________
______________	______________		@ $______________	/cy =	$_____________

TOTAL EXCAVATION $________________________

CULVERT MATERIALS AND INSTALLATION Bands

Culverts	Size	No.		
_____ LF of _______" @ $______/LF = $________________	_______	_______	@ $_________/bnd	= $_________
_____ LF of _______" @ $______/LF = $________________	_______	_______	@ $_________/bnd	= $_________
_____ LF of _______" @ $______/LF = $________________	_______	_______	@ $_________/bnd	= $_________
_____ LF of _______" @ $______/LF = $________________	_______	_______	@ $_________/bnd	= $_________
_____ LF of _______" @ $______/LF = $________________	_______	_______	@ $_________/bnd	= $_________
_____ LF of _______" @ $______/LF = $________________	_______	_______	@ $_________/bnd	= $_________

Culvert Stakes
Base cost/stake $______________ + Install $___________ = $____________ installed cost/stake
No. of stakes ____________ @ $_________/STK = $______________
TOTAL CULVERT MATERIAL AND INSTALLATION $__________________________

SURFACING

		Size			
Subgrade	__________ cy of	___________	@	__________/cy =	$___________
	__________ cy of	___________	@	__________/cy =	$___________
Turnouts	__________ cy of	___________	@	__________/cy =	$___________
	__________ cy of	___________	@	__________/cy =	$___________
Landings & other	__________ cy of	___________	@	__________/cy =	$___________
	__________ cy of	___________	@	__________/cy =	$___________

TOTAL ROCK COST $________________________

SPECIAL PROJECTS, Miscellaneous Material, Installation (not move in)

____ ____________________________
____ ____________________________
____ ____________________________
____ ____________________________
____ ____________________________
____ ____________________________

TOTAL SPECIAL PROJECTS $________________________

GRAND TOTAL $______________________

Compiled By____ Date___________________________

VOLUME COMPUTATION SHEET

PROJECT______________

	END AREA		DOUBLE END AREA		CUBIC YARDS				PAGE
STATION	CUT	FILL	CUT	FILL	CUT	FILL	%ROCK	ROCK	UNCLASS

NOTES OR CALCULATIONS

SHRINK / SWELL FACTOR ______________________

TOTAL UNCLASS ________________________

TOTAL ROCK _______________

Appendix 5. List of Useful References

1. **Oregon Forest Practices Rules and Statutes**. Oregon Department of Forestry, Forest Practices Program. January 2000 (or later version if available).

This is a complete listing of the forest practices rules and statutes that apply to state owned forestland. It provides the regulatory requirements for all forest operations including regulation for road construction, road improvement, road maintenance, and the vacating of forest roads. These regulatory requirements are the minimum standard for forest roads on state-owned forestland.

2. **Forest Practices Field Guide**. Oregon Department of Forestry. 1999

This notebook provides guidance on complying with the regulatory requirements of the Oregon Forest Practices Rules and Statues. It is a useful field reference.

3. **Forest Road Management Guidebook**. Oregon Department of Forestry, Forest Practices Program. January 2000

This guidebook provides helpful checklists, ideas and suggestions, related to road improvement, road maintenance, and vacation of forest roads. It is useful reference when planning the repair and maintenance of forest roads.

4. **Oregon Road/Stream Crossing Restoration Guide:** Advanced Fish Passage Training Version. Oregon Department of Forestry, Spring 1999 (or later version if available)

The primary purpose of this document is to provide guidlines to mangers that are assessing, planning, designing., or installing repairs or replacements for road/stream crossings that will provide for optimum fish passage. It provides useful information on the biological elements of fish passage, fish passage hydrology and hydraulics, steps in restoring fish passage, and background on culvert/bridge sizing methods. This is an important reference when repairing or replacing stream crossing that are partially or totally blocking fish passage or when installing stream crossings on new road construction.

5. **Handbook of Steel Drainage & Highway Construction Products**: Prepared under direction of the HIGHWAY TASK FORCE for Committee of Galvanized Sheet Producers Committee of Hot Rolled and Cold Rolled Sheet and Strip Producers.

This reference book provides design information on steel culverts and other drainage products as well as some other construction products. There is useful information on fill heights, pipe gages, arch pipes, structural plate culverts, coupling bands, and hydraulic formulas.

6. **Standard Specifications for Highway Construction**: ODOT State Highway Division 1996 or newer.

This reference contains useful specifications for various types of crushed rock, rip rap, drain rock, rock tests, Bridge specifications, various drainage structures, concrete specification, geotextiles and slope protection. Be careful in the use of highway specifications used for forest roads, many of these need to be altered slightly to fit forest road uses.

7. **AASHTO/ASTM testing methods:** Available from Oregon State Highway Division testing lab.

Test methods are described for various crushed rock products to test for durability, unit weight, and specific gravity, sieve analysis of fine and coarse aggregates and many other tests. These may be useful in analyzing rock sources and rock products to produce from quarries.

8. **Road Design Handbook: A** handbook prepared principally for the design of secondary roads. This 1971 book was sponsored by federal agencies such as the USFS and BLM.

This book provides instruction on some of the road design procedures and calculations. Although the book is several decades, old it still contains good information on the basics of designing a forest road. Many of the hand calculations can now be done by computer, but by knowing how the hand calculations are done the reader will get a better appreciation for what goes on inside the computer program.

9. A Road Design Process for Low Volume Recreation and Resource Development Roads: Written by Brian Kramer an Oregon State University Forest Engineering Instructor. Available from the OSU book store.

This is much like the 1971 **Road Design Handbook** only much newer material is presented.

APPENDIX 6. ROAD TERMINOLOGY

This document includes basic road definitions needed for State Forest management. There are five different categories (classification, status, model need, surfacing, and use), as defined and categorized below, with a few additional definitions at the end of the document. These terms are used in the Roads Manual, and will also be used in the Road Information Management System currently under development. All planning and design documents should now use these terms consistently.

Classification: Existing ODF roads are classified as **mainlines, collectors, spurs** and **administrative roads**. These are the ODF roads that should be shown on road system maps. **Vacated roads and abandoned roads may be included in classification.** If planned and vacated/abandoned roads are shown on maps they must be distinguished from actual roads on all data layers and maps produced from those data layers. A long road may change classification along its length, although the vast majority of roads should have only one classification.

No fee - A public road not owned by ODF and open for highway-legal traffic. The road may be a county road or state highway.

Mainline
- Principal haul route for at least 5,000 acres (typically more) and includes all roads accessing over 20,000 (40,000 Klamath) acres (combined ODF and other landowners)
- Outlets onto a state or county public road (may pass through other landowner)
- Is surfaced with durable aggregate
- The desired running surface = 18 feet (1.5 lanes), the minimum width is 14 feet and if width is under 18 feet road must have intervisible turnouts
- The maximum grade is 18%, target under 10%
- Minimum horizontal curve radius is 70 feet with widening

Collector
- Principal haul route for at least 500 acres, over 1,000 acres in Klamath and Southwest
- Maximum of 20,000 acres accessed (over 20,000 must be a mainline)
- Maximum loads per day = 50 (can occasionally exceed this amount)
- Is surfaced with aggregate, except an option for Klamath and Southwest
- The desired running surface = 12–14 feet with turnouts at 750 feet maximum spacing
- The maximum grade is 20%, target under 13%
- Minimum horizontal curve radius is 60 feet with widening

Spur
- Maximum length of 2.5 miles until collector, mainline or off State Forests
- Access to no more than 1,000 acres
- Maximum loads per day = 40 (infrequently)
- Surfaced if expected to increase in timber sale value by more than surfacing cost, or to allow hauling that is restricted due to proximity of certain bird species.
- Target running surface is 12 feet with occasional turnouts

- Target maximum grade is 20% however grades **up to 35% are acceptable for end spur with no other alternative access (assists required, status is constrained use)**
- Minimum horizontal curve radius is 50 feet with widening

Administrative
This classification includes all other existing roads that are not essential for timber haul, those not classified as mainline, collector or spur. Examples include power-line roads, campground roads, and old fire roads that cannot be upgraded for haul. This classification **does not include vacated or abandoned roads.**

Abandoned road
A linear feature that used to be a road, but has not been used for forest management after 1973 and is currently not useable due to tree growth and/or old washouts or failures. Some trees on road surface are over 6 inches diameter. Maintenance is not required. **These roads may or may not be kept on the GIS layer at the districts' discretion, but should not be shown on maps or exhibits as roads**.

Vacated road
A linear feature that used to be a road, but has been permanently obliterated and meets forest practices vacated road standards. It needs no maintenance and should only be inspected if there is evidence of erosion in streams below the road, or a change in long term plans requiring reopening of the road. Vacating requires removal of all stream crossing fills to re-establish the original channel grade and active channel width, frequent cross ditching, and removal of fill with landslide risk. Depending on area in non-forested condition, some parts of the road should be ripped and reforested (at minimum, cross ditched locations). **Vacated roads may or may not be kept on the GIS layer at the Districts discretion, but should not be shown on maps or exhibits as roads**.

<u>Status:</u> Current overall road condition as it affects vehicular access

Open - A road that can now be used safely by trucks and maintenance equipment.

Constrained - Roads that are too steep or with too sharp curves, or too narrow in many locations for safe log truck use. These roads can be negotiated by pick up, at least after maintenance. Some reconstruction is needed to allow efficient log transport (contain extreme grades or extreme switchbacks) and often significant road relocation.

Blocked - Is a closed road that cannot be driven by a pick-up because of a tank trap, boulders or debris on the road, or by vegetation growing on the road. These roads should be routinely inspected if they include any stream crossings or steep fills/sidecast. They may be used as trails. Construction equipment is required to remove the blockage.

Dormant - Is blocked to motorized vehicles and stabilized in self draining condition. It contains extra waterbars and has dips near or fords at stream crossings to handle high flow events. It can be re-opened for fires or other emergencies. Dormant roads do not need routine inspections unless there is evidence of a problem or use by vehicles. ***In the roads manual this has been labeled "partial vacation" that will no longer be used.*** *Vacated roads should not be classified as dormant, as they should have no future use.*

Unknown - Nothing is known about status as there have been no recent inspections.

Designed - Is a planned road that has been designed for construction as project work in a timber sale or for construction by other funds. *Roads in this status, and the two that follow, should be kept as linework for transportation planning, but should not be used for publishing road maps. They may be used for exhibits, but must be labeled accordingly.*

Verified - Are planned roads that have been ground verified that a road meeting grade requirements and avoiding the most critical locations can be constructed. This includes flagging a preliminary location on-site. These are changed to a specific classification upon construction.

Unverified - A planned road that has been planned as part of the Harvest & Habitat (H & H) Model or through the district planning process for transportation planning. The road has not been field verified and there is a possibility that the road cannot be built at the location shown. Planned new roads may be relocated at any time, and are deleted as soon as a road is designed on the ground.

Model need: Is the road used in the H & H model, there are only 2 choices.

Yes - The road is used in the H & H model.
No - The road is not used in the H & H model. It may be an in unit spur or an administrative road.

Surfacing: Is the material directly supporting traffic

Dirt - A road with native soil surface that cannot be used in rainy periods by pick-ups.
Rock - A road with an aggregate surface that allows use during wet weather.
Paved - Any road with an asphalt, concrete, or chip-seal surface.
Unknown - Nothing is known about the road surfacing.
Not applicable - Applies to planned roads.

Use: When and how the road can be used

All-season - A road surfaced with durable aggregate (normally crushed rock) of sufficient depth and quality to allow use during most of the wet season without causing visible turbidity in Type F of D streams, or a paved road.
Intermediate - An aggregate surfaced road that allows wet weather use by pick-ups or occasional use by log trucks
Dry-season - Default dirt surfaced road with open or constrained status

Trail - Blocked, dormant or abandoned road that is being used as a recreational trail
None - Planned and vacated roads, or abandoned roads that are not being used as official trails.
Unknown - There is insufficient information to make a use determination.

Road Work Activities: All road work should fall into one and only one of the three categories below. This is not a road classification.

Construction - Includes both new construction, building a road in a location that did not previously have a road, and reconstruction. Reconstruction includes relocation of a pre-existing road for a distance of greater than 1,000 feet, and re-opening any abandoned road (with trees greater than 6 inches on the surface).

Improvement - Is road work necessary to bring an existing (not abandoned), older road up to current use standards. Specific improvement activities include widening; minor relocation of the road away from streams or slide areas; replacing stream crossings to current standards; adding cross drains or fill protection where needed to disconnect streams or prevent on-going erosion of the road prism, and rocking un-rocked or lightly rocked roads. Note that improvement requires filling out a notification for Forest Practices and standard filing of this document. ***Replacing surfacing lost by wear is not improvement, it is maintenance.***

Maintenance - includes grading, brushing, ditch and culvert cleaning, removing recent bank slough, replacing existing cross drainage culverts, and replacing aggregate lost to wear. Maintenance requires no forest practices paperwork.

Road Definitions: (may fit into one, two or all three categories)

A ***forest road*** is used principally for forest management activities includes any road used by truck or pick-up since 1972 and that has not been formally vacated. It does not include abandoned roads, vacated roads, planned roads, or designed roads that have not yet been constructed. Vacated roads, abandoned, planned roads and designed roads may be kept in the roads database, but shall only be displayed as needed and clearly described as vacated, abandoned, planned or designed.

A ***public road*** has a rock or paved surface and is open to the public, except during essential maintenance or severe weather. It is not closed by yarding or to prevent wildlife disturbance, nor is it blocked or gated. It must be passable by a 2-wheel drive sedan.

State forest roads include all roads on state forest lands except those requiring ODF to get a permit from another landowner for haul. State forest roads include roads on another ownership if the district has an easement for use with ODF primary maintenance responsibility. These two conditions describe the roads that should be summarized in any reports and used for determining state forest road mileage. Roads on ODF lands where an exclusive agreement for the roads has been given to another party, where that party is meets their responsible for maintenance are not considered state forests roads.

APPENDIX 7. ANNUAL REPORTING

These are sorted by annual reporting needs, and by longer term internal needs for determining road performance and spending efficiency. Annual reports are needed for reporting to the counties, the Land Board, and to meet Government Accounting standards (GASB34). Thus the reason to track rocked and dirt roads separately, as only rocked roads are reported as assets. These needs all met with the same information.

Annual Roads Report by District and County (needed by accounting, counties, DSL)

BOF Lands - Every Fiscal year (completed between July 1 and June 30)
Road Construction aggregate/paved - miles and cost
Road Construction dirt - miles and cost
Road Improvement (rock only) - miles and cost
Roads Vacated - miles and cost
New bridges built - number and cost
Bridges replaced - number and cost
Bridges removed- number
CSL Lands - Every Fiscal year (completed between July 1 and June 30)
Road Construction aggregate/paved - miles and cost
Road Construction dirt - miles and cost
Road Improvement (rock only) - miles and cost
Roads Vacated - miles and cost
New bridges built - number and cost
Bridges replaced - number and cost
Bridges removed- number

Reporting Table

FY **State Forests Road Accomplishments** District County
Land Type BOF or CSL submit two tables if road work on both land types

	Aggregate/Paved Surface		Dirt Surface	
Constructed	mi.	$	mi.	$
Improved	mi.	$		
Vacated	mi.	$	mi.	$

	New		Replaced		Removed
Bridges	#	$	#	$	#

APPENDIX 8. ROCKING STATE FOREST ROADS

Issue: Road surfacing is often the most expensive item associated with road management (over half of all project costs on many Districts). Surfacing is a non-renewable resource. Current formal engineering procedures for road surfacing types and depths are impractical to use for low-volume roads, thus the need for guidance consistent with state forests plans and objectives.

Objective: To present an empirical system for management of low-volume road gravel road surfacing that integrates planning, design, construction, production, maintenance and repair.

Northwest Oregon State Forests Forest Management Plan Direction (January 2001):
ACCESS—Main access roads are surfaced with rock to provide for all-weather use and to minimize impacts from rainfall and runoff. Secondary spur roads are built to the same maintenance standards but may have lesser specifications for width and surfacing. FMP p. 2–58
ENERGY AND MINERALS—Survey, evaluate, and identify aggregate rock sources important for the long-term management needs of northwest Oregon state forests. FMP p. 4–94
LAND BASE—Minimize the amount of forest land used for roads, road corridor clearings, landings, and mineral extractions by ensuring that construction and development specifications are designed to efficiently meet management activity objectives. FMP p. 4–96

Forest Practices Rules—OAR 629-625-0700

Wet Weather Road Use

1. *The purpose of this rule is to reduce delivery of fine sediment to streams caused by the use of forest roads during wet periods that may adversely affect downstream water quality in Type F or Type D streams.*
2. *Operators shall use durable surfacing or other effective measures that resist deep rutting or development of a layer of mud on top of the road surface on road segments that drain directly to streams on active roads that will be used for log hauling during wet periods.*
3. *Operators shall cease active road use where the surface is deeply rutted or covered by a layer of mud and where runoff from that road segment is causing a visible increase in the turbidity of Type F or Type D streams as measured above and below the effects of the road.*

SUMMARY PROCEDURES: This guidance includes information on design, construction, aggregate production and maintenance and repair. Guidance is summarized on the following two pages, with the rest of the guidance providing more detail. Since aggregate is so expensive and there is also high aquatic risk from inadequate surfacing near streams, review of aggregate design work by the Engineering Supervisor and/or Unit Forester is essential.

A. Aggregate Surfacing Design

1) Determine road classification and/or near term use
2) Segment road and classify subgrade material and any existing aggregate
3) Categorize in-place subgrade material strength(s) using Table 1 *(pg. 4)*
4) Identify drainage conditions and drainage effectiveness, rated 0, 1 or 2 *(pg. 4-5)*
5) Determine construction period and compaction level, also rated 0, 1 or 2 *(pg. 5)*
6) Start with initial strength value, and add drainage or compaction effectiveness factors (each 0, 1, or 2) to get constructed subgrade strength (as constructed) from Table 2

7) Consider available aggregate surfacing materials (hardness, durability, gradation)
8) Determine aggregate depth for spur roads.
9) Consider use of sub-base and base reinforcement.
10) Consider use of geosynthetics for separation, drainage and/or reinforcement.
11) Add depth (to base course) for collector and mainline road classifications.
12) Use two-layer road rocking (base plus surface) new collector and mainline roads.
13) Add a 5 to 20 percent aggregate reserve to stockpiles for unexpected conditions.

B. Aggregate properties and production

1) Determine available quarries or rock sources.
2) Use the Unified Rock Classification System (URCS) to classify rock source materials and where necessary evaluate testing information.
3) For ODF quarries, prepare a quarry management plan and track reserve stockpiles.
4) Use gradation specifications based on aggregate durability and surfacing type.
5) Monitor rock production by visual observations. Routinely test gradation with sieve analysis, and where necessary conduct other aggregate tests.

C. Construction Practices

1) Verify subgrade materials used for surfacing design and identify any changed conditions after initial excavation begins and make local adjustments for aggregate depth.
2) Monitor moisture conditions. Avoid working when too wet or dry to effectively compact.
3) Grade, shape, drain and compact subgrade for maximum strength
4) Modify surfacing requirements when actual subgrade materials or construction practices are different from the design.
5) Use appropriate compaction equipment and methods for subgrade and road surfacing.
6) Apply aggregate in uniform depths and widths.
7) Process (uniformly mix and compact) aggregate in lifts not exceeding 6 inches in depth at time of placement. Avoid separation of materials.
8) Monitor aggregate processing and compaction. Make any corrections by loosening and processing until visual deformities cease.
9) Apply water during extended drying periods where necessary (most commonly used for surfacing courses and for rock products produced during dry periods and hauled directly to construction sites).
10) Consider use of aggregate stabilizing agents for dust abatement or improved surface course performance.

D. Maintenance and Repair

1) Inspect roads during heavy use and commercial operations (more frequently during wet-season periods). Maintain and inspect highest use roads more frequently.
2) Use reserve aggregate for corrective maintenance during initial heavy uses.
3) Perform maintenance only as needed – frequent grading wears out rock and may release fines.
4) Rutting is normal for gravel roads, so grade only when needed to protect water and the road. Remove ruts over 1½” deep and provide a safe running surface.
5) Plan to add rock by use (for logging **plus** rock hauling)

6) Use correct materials for road maintenance and repair (original aggregate or open graded repair aggregate).
7) High impact areas (landings, severe pumping) may require removal of deteriorated materials and replacement.
8) Perform highest level work for high traffic roads or where needed for resource protection.
9) Limit use of dirt roads to appropriate moisture conditions, and stop use prior to wet season.
10) Cease heavy-hauling during rapid thawing cycles, significant snowmelt, flooding and/or conditions when soils are saturated (uncommon on well drained roads).
11) Preserve unused reserve aggregate for uses on other roads.

Determining roads to rock by road functional use/classification
A) Mainlines should be surfaced for all-season weather use, and should be resurfaced in part based on actual traffic and resource protection.
B) Collectors should normally be surfaced for all weather use unless there is a compelling reason for not surfacing, and should be resurfaced in part based on actual traffic.
C) Spurs should be surfaced where surfacing is likely to increase timber sale value by more than the cost of the rock, as necessary for planned future forest management activity, or for timing restrictions. In addition, purchasers should also have this option (at their discretion). Spurs should be surfaced with the minimum rock necessary for the immediate use. Very steep spurs (sustained grades over 18%) have marginal traction when rocked, if rocking is essential use a 3/4 inch minus traction lift for these roads.
D) Administrative roads should be lightly surfaced or unsurfaced.

AGGREGATE SURFACING DESIGN: Surfacing depth is based on: 1) road strength, 2) traffic types and road use, and 3) current condition of existing roads. This design method considers effective road drainage (and compaction) as the primary factors affecting road strength. **For new roads, the design starts with initial soil strength, then adjusted for drainage and compaction effectiveness to determine the surfacing depth for spur roads**. **Design for summer (dry) building conditions unless there is a sound resource management reason for not doing so.** The aggregate depth is increased for higher use based on road classification (collectors or mainlines) and based on actual traffic if possible.

Properties of the roadbed: The properties that effect performance of the road subgrade include soil strength and drainage (moisture content), and on existing roads, the thickness and quality of the existing aggregate. These properties often vary along the road. Important properties and how they vary along the road should be evaluated during layout or design work. Break roads into segments based on significant differences in either subgrade material or drainage conditions. Short spurs often have a single segment. Longer roads typically have segments that vary between 200 and 2000 feet. Remember, two compacted inches of rock saved per station is about 12 yards. For a one mile road, this is a savings of $5,000 to $15,000. Also, surfacing designs are based upon the worst-case conditions that are anticipated during active road use. High traffic continual use roads require more design information than roads planned for seasonal-controlled use only.

Subgrade Material is most simply characterized by Unified Soil Classification System (USCS) and Unified Rock Classification System (URCS), at least for engineering properties**.** Existing soil surveys are a source of information that may be used for initial planning. The final soil evaluation should be made in the field during design processes. Examine exposed soils in nearby road cuts and by local landforms and recognize how they change over the length of the road by landscape position. Also, it is important to use local knowledge of past performance.

Landforms with typically higher strength materials include ridgetops, and full-bench road sections. Old roads that have been modified by previous uses may also have higher strength values. Weaker soils are often found on benches and flats next to streams, with the weakest materials in wetlands. During field layout, identify seeps, wetlands, saturated soils and other wet areas. Soil strength evaluation is performed for the bearing surface only (upper 12" depth). Initial material strength is summarized in Table 1.

TABLE 1. Initial Subgrade Soil Strength (wet season in place)

Unconfined Compressive Strength (*t/ft2*)	Strength Category	Description	Unified Soil Classification
4	Strong	full bench in rock well graded gravels	GW, GM
3	High	other gravels	GP, GC
2	Average	well graded sands and typical forest soils	SW, SM
1	Low	poorly graded sands, normal clays	SP, SC, CL*
0.5	Weak (pumping)	silts and soft clays	CH*, ML, MH*
0.25	Very Weak	organic, wetland soils	OL*, OH*

* Effective drainage and compaction difficult, use 0 or 1 for condition ratings

Drainage effectiveness is categorized by three categories and is determined by drainage of the road as it will be constructed. When evaluating drainage, also identify stream crossings and segments that will drain to streams versus draining onto the forest floor. Some conditions can be well drained, others cannot. These are noted during segmenting of the road as described below:

<u>Well drained (+2)</u> Used for roads that are effectively drained. This means that there can be no seeps, springs or wetlands in the segment. In addition, positive road drainage is accomplished by:

A. Road grades, ditch lines (ditch bottom at least 2 feet below road surface), cross drainage relief and/or cross slopes of at least 4%.
B. Subgrades are well shaped and compacted. Cross slopes are uniform with ruts removed and concentrations of organic materials are removed.

Intermediate drainage (+1) applies to roads with drainage and cross slopes of at least 2%, and for roads that must be constructed during wet weather (not the ODF design standard). Ground water concentrations are drained and/or geotextiles membranes are used for wicking, separation and reinforcement.
Poorly drained (0) is used where drainage is ineffective or impossible, often for old roads with grades under 2%.

Compaction is accomplished with construction equipment and 3 ratings are also used, based on the likely relative subgrade density as the road is constructed. Moisture content and use of specialized compaction equipment are critical to achieve high relative density.

Well compacted (+2) means that specialized compaction equipment must be used during periods when soils are near optimum moisture content ***(fine grained soils must be dry to moist, this normally occurs in summer and early fall)***. This is the design standard for new mainlines and collector roads. For fine-grained soils (silts and clays) a tamping compactor and 6 inch lifts must be used. For coarse grained soils without many fines, vibratory equipment is required to obtain the well compacted condition, and moisture content is not as critical. Compaction should continue until there is no visual deflection. During compaction, it is essential that the road cross section be reestablished, with cross slopes ≥ 4%, (crowned, insloped or outsloped). A rating of +2 requires control of construction activity and moisture content. In western Oregon, controlled conditions for soils are limited to drier construction season periods only. **For silts and clays, a lab test must be used to monitor moisture content during compactive efforts if designed with a rating of 2**.
Mid level compaction (+1) includes roads where loaded trucks or tracked equipment are used for compaction. This also includes when work is performed during conditions when soils are moderately wet or dry. Trucks and tracked equipment must be routed over the entire road cross section. Mixing dried ravel material from cut slopes and ditches can be used to improve and dry out wet soils. Note that roads constructed during wet periods or in the winter are not well compacted (the category that follows). Again as with the well compacted condition, it is necessary to insure the road cross slopes are re-established during compaction. This is the design standard for spur roads.
Not well compacted (0) includes all roads in fine grained materials that are constructed during the wet season or wet periods. This also includes any organic (wetland type) soil during any time of the year.

Determining depth of surfacing for spur roads: Spurs should be rocked using the depth indicated in Table 2. **The depth should be just sufficient to allow completion of heavy equipment operations without loss of traction or production of significant turbidity.** Begin with the Soil strength Number (0.25 to 4), and add drainage and compaction factors if appropriate. The drainage and compaction factors are 0, 1, or 2, and for typical conditions are a given a 1. The final strength rating varies from 0.25 to 8, and if less than a whole number round down. This relative strength is related to the unconfined compressive strength. Numbers in this table may be changed as additional field evaluations are conducted. Spurs should be surfaced with a single (base-type) course, though for steep roads (over 12%) should include a traction lift (2 to 3 inches of well graded 3/4 inch minus aggregate).

Determining aggregate depth for mainlines and collectors: Mainline and collector roads require increased base course depths primarily due to heavy traffic. In addition, these roads also require a stable running surface due to the increased loading and higher vehicle speed. Therefore, it is recommended that 2 layer aggregate systems are used for mainline roads and for higher traffic level collector roads. The 2 layer system consists of a base course plus a surface (wearing) course. The surfacing course is typically constructed from finer, well-graded aggregate (Table 5). The surface course provides stability by sealing the road surface. Aggregate depth for mainline roads is increased by at least 4 inches (above spur depth) and is increased by 2 inches (above spur depth) for collector roads.

Table 2. Minimum Aggregate Depth for Low Traffic Road Based on Modified Strength

As-modified Strength	Depth without geotextile	Depth with Geotextile
≥ 7	0	X
6	4	X
5	6	X
4	8	X
3	10	8
2	14	10
≤ 1*	**	***

X - not applicable
*** - indicates likely wetland crossing, evaluate relocation options**
**** - must use on site rock or geotextile for reinforcement**
***** - consult with geotechnical specialist or state forests engineer**

AGGREGATE PROPERTIES AND PRODUCTION: There is a range of useable aggregate specifications based on what the quarry is capable of producing. Ideal aggregate has hard, dense angular fragments with at least 3 sharp edges. It is well graded with a compact (not elongated/arrow) shape. Well-graded aggregate is superior because it can be compacted to a higher density than other materials and keeps water away from the subgrade, both resulting in a higher strength road surface. Single course aggregates should be well-graded and meet the specifications shown in Table 3, unless they are of marginal durability where the open graded (few fines) specifications shown in Table 4 are appropriate. Marginal, lower durability aggregate should not be used as a surface course on segments that drain to streams, but is usually acceptable as a base course, or for spurs that are not draining to streams. Use larger aggregate if the durability is marginal, as it is longer lasting. For this design method, ***durable aggregate*** is defined by strength bearing particles (large and intermediate sizes) with an unconfined compressive strength ≥ 9,000 psi. ***Marginal durability aggregate*** is defined by strength bearing particles with and an unconfined compressive strength ranging from 4,500 to 9,000 psi. These may be estimated by the URCS, as there is no perfect laboratory test to determine these values now. **Durable aggregate road surfacing** must be used for active use roads segments draining into streams. If non-durable aggregate is used on spurs or on other roads with light winter use, traffic must be controlled and the road periodically evaluated for FPA wet weather rule compliance (visible turbidity in Type F or D streams).

Table 3. Standard gradation specifications for a single course well-graded aggregate

Sieve size Percent Passing

	4 inch*	3 inch	2 inch	1.5 inch**
4	95-100	100		
3		95-100	100	
2	70-90		95-100	100
1.5		70-90		95-100
1	50-80		70-90	
3/4		50-80		70-90
1/4 or #4	30-50	35-60	50-80	40-60
#10	20-40	25-50	25-50	30-50
#40	5-15	5-15	5-20	10-20

* Standard for spur if quarry can produce it
* * Standard for l-layer surfacing on higher use roads

Table 4. Standard gradation specifications for marginal durability base or single course aggregate (fewer fines)

Sieve size Percent Passing

	4 inch*	3 inch	2 inch
4	95-100	100	
3		95-100	100
2	70-90		95-100
1.5		70-90	
1	50-70		70-90
3/4		50-70	
1/4 or #4	15-50		20-60
#10	0-30	0-30	0-30
#40	0-10	0-10	0-10

* Standard for spur if quarry can produce it

For the surface course of a higher use road (Table 5), aggregate should contain 8-16 percent plastic fines (not just rock flour) if possible as estimated by examining the percent passing the #40 sieve (should be sticky). Without plastic fines, a surface stabilizer may be needed to prevent loss of fines during heavy summer use. Steep spurs (≥ 12% adverse grades) should receive a thin veneer of aggregate (Table 5 specs.) to increase traction. Finer graded aggregates (1-inch and 3/4-inch minus) are better at sealing the surface and allow higher speeds and easier grading. However, they will break down under traffic more quickly than the coarser materials, so they must be durable quality and obtained from the better rock sources.

Table 5. Standard gradation specifications for durable surface course aggregate

Sieve size — Percent Passing

	1.5 inch	1 inch	3/4 inch*
2	100		
1.5	95-100	100	
1	80-95	95-100	100
3/4	70-90	75-95	90-100
1/4 or #4	40-60	50-75	50-75
#10	25-40	25-50	30-55
#40	8-16***	8-16***	8-16***

*** Use the higher very fine percentage for road grades over 15 percent

Table 6. Gradation specifications for repair aggregate (excess fines in existing aggregate)

Sieve size — Percent Passing

	1.5 inch	1 inch	3/4 inch*
2	100		
1.5	95-100	100	
1	80-95	95-100	100
3/4	60-80	80-95	90-100
1/4 or 4	20-50	20-40	30-60
#10	10-30	10-30	10-30
#40	0-10	0-10	0-10

Aggregate production: There are many ways to produce aggregate and rock products for road construction and maintenance activities. In some cases, rock of sufficient quality can be obtained by excavation into a road cut or other exposure. This can be placed on the road as is, or improved through processes such as blasting, ripping, screening, crushing, sorting and/or mixing. Aggregate production normally requires crushing and screening to produce consistent (reliable products) for road surfacing uses. Procedures for management of major quarries include:

1. Thorough field investigation of the rock source.
2. Classify source materials using the Unified Rock Classification System (URCS) to determine best potential products and uses.
3. Perform topographic surveys of the rock source development area(s).
4. Prepare a geologic model that displays materials distribution, plan and profiles, cross sections and initial volume calculations.
5. Verification of the geologic model by sub-surface testing (excavation, drilling)

6. Develop a quarry management plan, including aggregate/rock specifications and any special development requirements.
7. Test aggregate/rock during production, including visual and sieve analyses.
8. Monitor aggregate performance during uses.

Testing: All tests other than gradation and the URCS have limitations and can be expensive. These other laboratory tests are appropriate only where you have a specific question about the aggregate and feel a specific test can answer your question, or to determine compliance. Other tests are more appropriate for purchased rock, as we do not have control over the quarry. The two most valuable tests are the Oregon Air Degrade (TM-208) and the LA Abrasion (AASHTO T-96). Durable material should have a value under 30 percent for either of these tests. Consult the State Forests Engineer or Area Geotechnical Specialists for advice when needed.

CONSTRUCTION PRACTICES: Aggregate requires compaction after placement on the road. The standard conversion from loose in-truck rock to in place compacted inches by road width is shown in crushed rock Table 7 (compaction factor 1.3)

Table 7. In-truck aggregate required for compacted depth.

Rock Depth inches	Finished Surface Width (feet) 10	12	14	16	18	20
1	5	5	6	7	8	9
2	9	11	12	14	16	17
3	14	16	19	21	23	26
4	18	22	25	28	31	35
5	23	27	31	35	39	43
6	28	33	37	42	47	52
7	32	38	44	49	55	60
8	37	43	50	56	63	69
9	42	49	56	63	70	78
10	46	54	62	70	78	86
11	51	60	68	77	86	95
12	55	65	75	84	94	104
13	60	70	81	91	102	112
14	65	76	87	98	110	121
15	69	81	93	105	117	129
16	74	87	100	112	125	138
17	78	92	106	119	133	147
18	83	98	112	126	141	155
19	88	103	118	133	149	164
20	92	108	124	140	156	173

This volume change during aggregate placement and compaction is due to air space caused by fluffing when loaded and subsequent air space removal due to compaction. The conversion from pit-run rock compacted yardage to truck yardage is 1.3 to 1.4 based on conditions of the particular pit-run source.

It is essential to reevaluate the subgrade and drainage conditions prior to rocking. In addition to the practices described on page 2, ensure that the surface (wearing) course depth for higher use roads is between 4 to 6 inches. The surface course wears out over time and depth should be based upon expected loadings over 3 to 10 year time intervals. Use staged construction methods, applying 2-4 inches lifts in the locations with the highest traffic or that show the most wear first, and then completing the project in later years to get surfacing depths over time when funds are limited. Where minimum surfacing depths are used, it's important to monitor road performance during the initial heavy road use. Aggregate must be held in reserve (stockpiled) and used to correct any problems occurring during road use by adding reserve rock to these soft spots. As a general rule, reserve aggregate should be at least 5% for spur roads and as much as 20% for mainline and collector roads. Reserve rock for mainlines and collectors should be surface course aggregate, for spurs it should be the aggregate used on that road

Geotextiles: Use geotextiles for separation where effective drainage is not possible, including where aggregate is placed on organic soils, in wetlands, flat grades (which we should not have on new roads). Geotextiles should also be used for silts and clays than cannot be effectively compacted. For spurs, use a geotextile if the final strength rating from Table 2 is no greater than 2. Even when well-compacted, silts under mainlines and collectors may pump under wet weather use, so geotextiles should be considered. Another geotextile use is to help recycle aggregate from temporary or unneeded roads. In addition, consider geotextiles when roads must be constructed or repaired outside of normal construction periods (wet periods). Specifications for separation geotextiles are shown in Table 7.

Table 7. Standard Specifications for Separation Geotextiles

High Strength Option - 6 oz/yd2 – Woven Fabric

Grab Tensile Strength	300 lbs.	ASTM D4632
Puncture Strength	110 lbs.	ASTM D4833
Mullen Burst	600 psi	ASTM D3786
Width	12.5 or 16 ft.	

Mid Strength Option - 4½ oz./yd2 – Woven Fabric

Grab Tensile Strength	200 lbs.	ASTM D4632
Puncture Strength	90 lbs.	ASTM D4833
Mullen Burst	400 psi	ASTM D3786
Width	12.5 or 16 ft	

Some geotextiles can improve drainage. In areas with seeps and springs, a drainage geotextile should be used. These are normally non-woven, and have a specification called permittivity. For seeps and small springs, permittivity should also be specified, normally as greater than 0.2 sec^{-1}. A higher value is appropriate for larger springs or seeps. Except for wetlands, use of a drainage geotextile will change the drainage class from 0 to +1. Other geosynthetic products (such as geo-grids and drainage fabrics) may be used for specific reinforcement or drainage applications.

Changed conditions: Determine if subgrade materials used for design are those observed during initial construction. Identify any changed conditions after initial excavation begins and make local adjustments for aggregate depth. This may be a decrease or increase in required aggregate depth, and should be added to or subtracted from the aggregate reserve. Changes due to purchaser action or inaction, including if the purchaser had a dry period in which to construct the road, but instead built it during a wet period are the purchaser's responsibility. The design depth should be recalculated and the purchaser is responsible for any increased aggregate required due to this condition. On the other hand, if the purchaser constructs the road during a dry period and encounters different subgrade conditions, seeps or springs, the increased aggregate required is an ODF responsibility and taken from the design reserve. Purchasers can choose to rock spurs designed for dirt surface at their cost. These spurs must be rocked and used to FPA standards (durable surfacing on those segments connected streams

Application: Aggregate used for road surfacing must be applied in a uniform depth and width. The maximum depth lift that can be processed is 6 inches, 8 inches when applied over geotextiles. This often requires staking the road prior to rock spreading. Aggregate must be uniformly mixed and often requires application of water for processing and compaction. This is especially true for aggregate produced and applied during dry periods. Stockpiled rock retains water and will normally require less applied water for optimum moisture content.

Resurfacing roads: Over time, the road surface weakens while the subgrade increases in strength. Evidence of need for new rock includes 1) excess fines on the surface, *especially fines the color of the subgrade, not just rock flour*; 2) frequent grading required to correct ruts and imperfections; and 3) loss of traction (loss of stability when driven by field rig when surface is wet). Gradation tests can confirm worn surfacing. If over 25 percent of the sample passes the number 40 sieve then additional replacement aggregate is probably needed. Another indicator is the loss of rock to rock contact when observing the aggregate (just below the surface). **If surface runoff discolors Type F or D streams, hauling must cease until the situation is corrected**.

Only roads with active use planned for the current or next year should be resurfaced. Since new surfacing lowers traction during dry periods, resurfacing is best done in the fall after some rain but before the subgrade reaches mid winter moisture levels. Before a major re-rocking project it is essential to estimate the existing useful depth of aggregate. This is best accomplished by digging through the existing rock surfacing (use of road graders or excavators is recommended) and determining the effective rock depth (to aggregate/subgrade contact). Effective rock depth can be zero where the entire road surface has been punched into the subgrade. Use the same subgrade strength and drainage ratings as new roads, and use a compaction rating of +1 unless the subgrade is unusually dense. Existing roads should be resurfaced with surface course material so that the total aggregate depth equals the design depth in Table 2.

When treating a surfacing with too many or too few fines, use gradation as in Table 6. In very limited cases, re-rock segments that have failed (very deep ruts, wet) by removing and replacing contaminated surfacing. Cut out defects and add leveling and reinforcement rock for uniform depth. This requires waiting until it is dry enough to drain and re-compact. If this is not possible, use a geotextile. Do not dump crushed rock into a very soft area (only purchasers can have this option with rock they buy).

Aggregate wear rates: Heavy traffic wears out aggregate. For this design method, wear rates can be used to plan for rock replacement for mainline and collector roads**.** Traffic using mainlines and collectors should be tracked or estimated based on either volume or truck counts. This method is directly related to 18,000 pound equivalent single vehicle axle loads (ESAL). **This includes use by rock trucks.** Each 10 c.y. rock **truck is equivalent to approximately 3 MBF.** Based on past experience, highest quality durable aggregate wears at a rate of 1 compacted inch per 10 MMBF and marginal durability rock wears at a rate of 1 inch per 3.5 MMBF. For each mainline or collector road, rate the durability of the aggregate based on URCS investigations, laboratory tests for durability and/or past experience. For high traffic roads, plan to replace surfacing course materials after 2 to 3 inches of rock wear occurs. Past experiences indicate that surfacing course replacement typically occurs on 1 to 7 year cycles, dependent upon axle loading (heavy traffic).

Tire Pressure: Many studies have shown that aggregate wear is greatly increased by higher tire pressures. This also reduces overall road surface performance. **Tire pressure for trucks using State forests roads should be limited to 75 psi.** This is a safe pressure for operating on paved roads. For rock trucks working only on ODF roads, consider limiting tire pressures to 50 psi (but only if they do not drive on paved roads during the work period.

Aggregate recycling is a technique that Astoria District has used with success. This makes sense for roads with no current wet season uses, and roads that are being vacated, **but only if durable rock was used on that road being closed.** Astoria has found aggregate recovery rates ranging from 75 to 92 percent. Also, recovery and quality of recovered rock was improved when geotextiles were used for subgrade/aggregate separation.

MAINTENANCE AND REPAIR: Work is needed periodically to protect the road investment and minimize environmental impacts. Maintain roads before they are deeply rutted (ruts that keep water from flowing off the road). **The purchaser is also responsible to bring a mainline or collector used for logging back to original condition if logging activity has damaged the surface.** Consider the following items when monitoring and planning for road maintenance operations:

1. Grade only when necessary. Frequent grading wears out aggregate and releases fines.
2. Rutting is a normal occurrence for gravel roads. Ruts and roughness are indicators of maintenance need. If ruts exceed 1½” in depth or direct water down the road, or, surface roughness affects the ability to travel the road it’s time to perform surface maintenance.
3. Re-establish positive road drainage (ditch lines, cross drainage, cross slopes, water-bars).
4. Avoid contamination of aggregate (logging debris, grass and grouser tracks).
5. Cut to depth to correct problems. Most surfacing failures are due to poor quality materials that may require removal or reprocessing to correct.
6. Add patch rock to soft and locally rutted locations.
7. Restrict heavy equipment to staging and landing areas.

8. Avoid working when too wet or too dry. Aggregate must be moist to grade to obtain uniform mix and to process rock. Aggregate processing often requires application of water for optimum moisture content.
9. For mainlines and collectors, compact aggregate for maximum density. Use specialized compaction equipment, such as vibratory rollers where necessary to restore running surfaces.

Winter weather: Snow removal by plowing should be allowed by permission only. Avoid disturbance of road surfacing by leaving a 1 inch layer of snow on the road surface. Provide drainage, avoid berms that direct water down the road surface. Avoid filling in ditch lines, culvert inlets and/or outlets. As a general rule, use of motor graders for snow removal is preferred as opposed to tracked equipment, such as a dozer.

Heavy hauling should be suspended during rapid thawing cycles, significant snowmelt or flooding. ***Ceasing road use*** is essential for all traffic (excluding that necessary to prevent more serious emergencies) during deep thawing period after the aggregate surface has frozen down to the subgrade. Traffic must also be controlled on all roads with marginal durability surfacing that have drainage to streams. This requires careful inspections by contract administrators during periods of moderate rainfall in order to comply with FMP water quality standards and Forest Practices wet season road use rules. All heavy uses must cease except for public safety or more serious resource damage emergencies.

Dry season stabilization: During dry weather, loss of fines as dust will destabilize the surface, affect driving safety, and affect air quality for persons living or recreating near the road. Water, magnesium chloride and lignin sulfate are most commonly used. Where available, water is cheapest in the short term and has the least environmental effects. Use of road water from a stream requires a road watering permit from the Water Resources Department. Magnesium chloride is generally considered to have minimal environmental effects if rainfall does not occur shortly after application. Lignin sulfate needs to be applied during dry periods.

Appendix I
Slope Evaluation Process

Unstable Slopes Riparian Strategy

Introduction

Identification of potentially unstable slopes is an important activity in forest management. Proposed forest road alignments need to be located through terrain that is stable both from a road maintenance perspective and for long-term protection of water resources. Canopy removal from potentially unstable slopes can increase the likelihood of slope failure in some locations and can reduce the availability of large wood recruitment to the aquatic system.

This appendix discusses Oregon Department of Forestry (ODF) slope stability buffering and assessment strategies. The goal of these strategies is to manage and minimize slope instability and potential effects on aquatic resources. Potentially unstable slope classification and identification, as well as mitigation measures, are discussed.

Slope Classification and Management Practices

During timber sale planning and marketing, foresters from the local district offices, planners from the Salem planning unit, and the geotechnical specialist[1] assess the proposed harvest with respect to the slope-related strategies. Aquatic resources are protected by standard stream buffers that relate the width of the adjacent buffer to stream size, flow duration (perennial versus seasonal), and fish presence. In the case of identified slope instability features, these will often add additional buffer width or buffer length, or establish harvest modifications upland not directly adjacent to a Riparian Conservation Area (RCA). There are four types of these additional protections for aquatic resources that are slope stability related: aquatic adjacent unstable slopes, inner gorges, and upland potentially unstable slopes and their associated debris flow tracks (Table 1 and Figure 1).

[1] The geotechnical specialist, or *geotech*, is either a PE (professional engineer) or a CEG (certified engineering geologist), licensed in the state of Oregon. See Oregon Revised Statute (ORS) Chapter 672 Professional Engineers; Land Surveyors; Photogrammetrists; Geologists.

Table 1: Slope Buffers for Protection of Fish-Bearing Streams

Slope Classification	Characteristics	Management Practices	Buffer Above Fish Bearing When:
Inner Gorge (Figure 2)	Obvious slope breaks of >20% from moderate to steeper slopes of ≥70% and ≥15 feet in height. Not to exceed widths of 170 feet from water.	No harvest. Leave trees within one canopy width above the slope break, unless conifer already occupies the inner gorge, in which case leave timber only within the gorge.	Adjacent to: • D.F.T. Ns* • H.E. Ns** • Np • Fish-bearing
Aquatic Adjacent Unstable Slope	Unstable slope immediately adjacent to a channel, where the toe of the unstable slope interacts directly with erosive forces of a stream. Not to exceed widths of 170 feet from water.	No harvest. Buffer to leave trees within one canopy width above the unstable slope, unless conifer already occupies the unstable slope, in which case leave timber only on the unstable portion of the slope.	Adjacent to: • D.F.T. Ns* • H.E. Ns** • Np • Fish-bearing
Upland Potentially Unstable Slopes and Debris Flow Tracks	High Hazard upland slopes: relatively high likelihood of slide initiation.	Buffer potential initiation site and underlying seasonal reaches (debris flow tracks). Buffer to leave trees within one canopy width above the unstable slope, unless stand-age conifer already occupies the site.	Deliverable to: • D.F.T. Ns* • H.E. Ns** • Np, if it forms the lower reach of a D.F.T. • Fish-bearing
	Moderate Hazard upland slopes: may have relatively high likelihood of slide initiation.	Buffer underlying seasonal streams (known as debris flow tracks).	
	Low Hazard upland slopes: do not have a relatively high likelihood of slide initiation.	No upland slope buffers required for potential initiation site or for any underlying seasonal stream.	N/A

*Debris Flow Track is a reach on a seasonal non-fish stream with any likelihood of direct large wood delivery via channelized debris flow to a fish-bearing stream. Deposition in a non-fish stream is not considered.

**High Energy Reach is a stream segment on a seasonal non-fish stream with any likelihood of large wood and gravel delivery to fish-bearing during large flow event. These are independent of potential up-channel initiation sites.

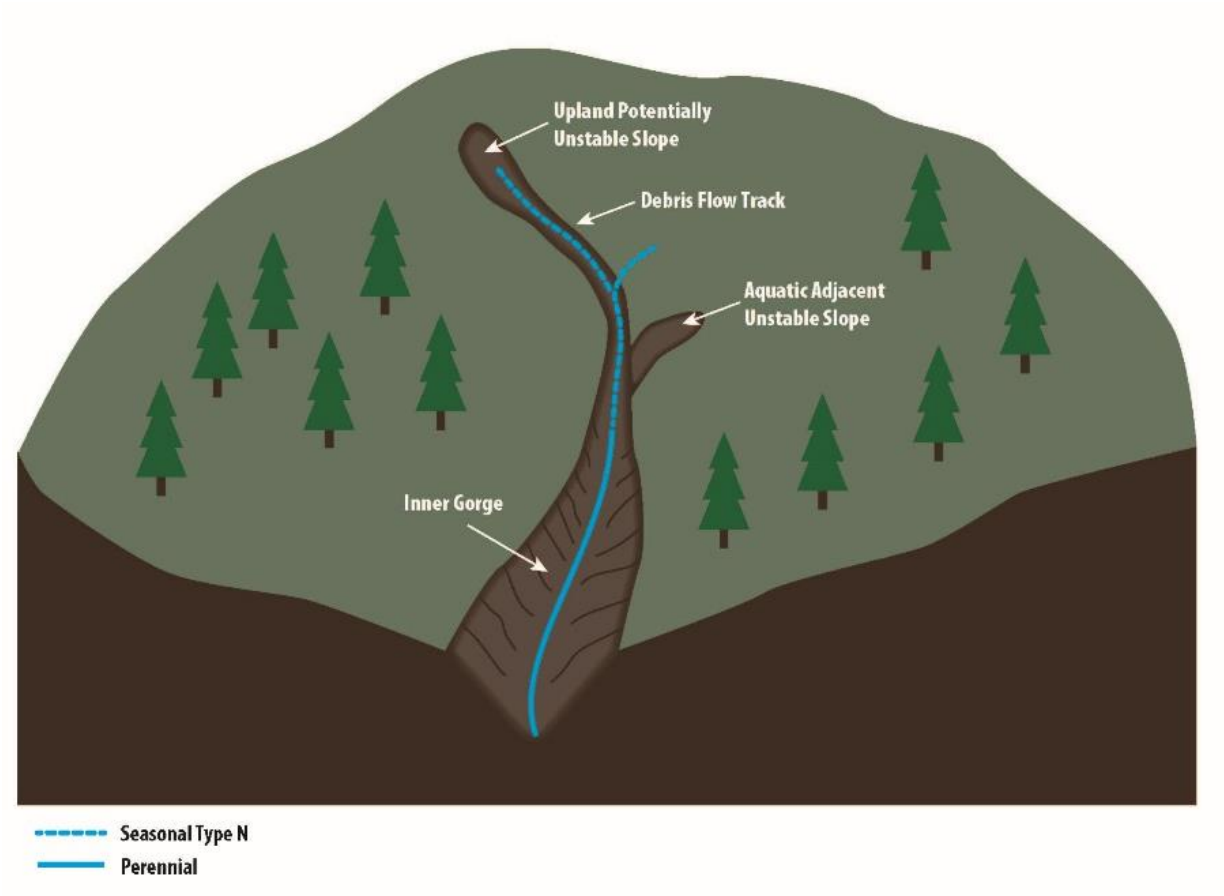
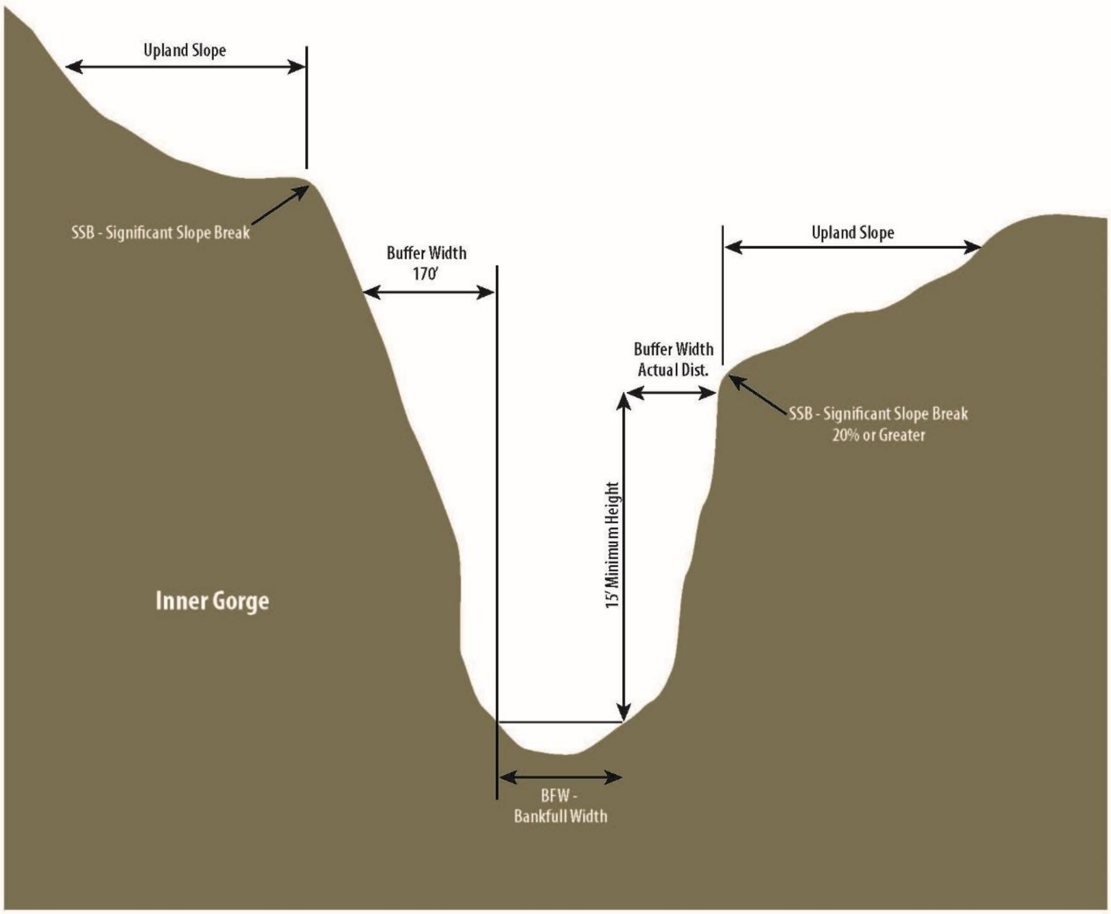


Figure 1. Slope Features

Inner Gorge

An inner gorge is an area next to a stream where the adjacent slope is significantly steeper than the gradient of the surrounding hillsides. It is the result of downcutting of the stream into the surrounding landscape, and the resulting slope is over steepened and reacting to the erosive work of streamflow at its base. When these are identified, they are added to the adjacent stream's RCA (Figure 2).



Limiting Distances to SSB			
Channel Adjacent Slope	Slope Distance	Max. Vertical Distance	Max. Buffer Width Horizontal
70%	207'	119'	170'
80%	219'	138'	170'
90%	229'	153'	170'
100%	240'	170'	170'

Figure 2. Identifying Components of the Inner Gorge

Topographic Expression

This feature is defined as being at least 15 feet deep from stream bottom to top of the slope break (vertical measurement taken perpendicular to the channel bottom). The channel adjacent slope is at least 35 degrees (70%). A well-defined slope break of 20% or greater is present (e.g., if the channel adjacent slope is 70%, the next slope segment as measured at the slope break would be 50%). They are often quite large, extending quite some distance from the aquatic environment, and so are defined at their maximum as extending not more than 170 feet from water's edge (horizontal measurement).

The slope break will be the last significant break prior to reaching the stream. The top of the steep slope defines the top of the inner gorge, and the toe of the slope where it intersects the channel bottom defines the bottom of the inner gorge. This is due to the process of its formation (discussed below). In cases where the inner gorge takes on a more complex expression, the first significant slope break separating the gorge from the upland is also present, but below that there is often a series of very steep slopes/cliffs and small, less steep benches or talus slope sequences. In either case, soils and woody debris fall or migrate down slope in a fairly direct path and will either immediately, or eventually, interact with the stream at its base. Topography located between steep slopes and streams, such as significant benches or steep dry swales that will catch debris or halt their migration toward water, will be an indicator that the steep slopes above do not classify as an inner gorge.

Geo-fluvial Processes

The inner gorge is a slope that is reacting to the erosive work of streamflow at its base. Small slope failures and raveling soils are common in the inner gorge. The slope is steep enough—for the given site soils—that any loose material is not stable on the slope surface and is actively creeping into the active channel, or fails catastrophically to be carried away by the active channel adjacent to the slope base. If soil sluffs off the inner gorge slope, it deposits directly into the active channel, which usually moves most of the soil debris downstream within the first season.

Stream power is not always great enough and water not deep enough, however, to move woody debris downstream in many small and/or seasonal streams adjacent to inner gorges. In those cases, only the passing of a debris flow will entrain woody debris, and this is only possible along streams of steeper gradients with steep uplands that can fail to the stream-course. Sometimes slide debris from a channel adjacent slope failure will remain for a time because water tunnels through woody debris and flows beneath the debris pile, leaving the above material untouched by its erosive power.

Because of these mobile soils, forest characteristics of inner gorges are often different from the adjacent upland stand, due to the more transient nature of the soils. Often the upland stand will transition to hardwoods and underbrush as the inner gorge is encountered.

If the geologic formation is relatively consistent along the stream, the inner gorge can take on a parallel or roughly parallel expression along one or both sides of the stream (Figure 1). In such a case the landscape is reacting to a relatively recent (geologically speaking) adjustment of either a drop in sea-level, tectonic uplift of the area, a change to a wetter climate, or large deep-seated landslide movement. These processes increase the power of the stream, enabling it to notch itself into the pre-existing landscape. This stream-side erosive notching causes the slope break at the top of the inner gorge to progressively move up slope, naturally laying back the slope until a more stable angle is obtained. Given enough time the adjacent slope would reach a stable angle appropriate for the stream power and site soils and geology.

In its more complex form, the inner gorge is controlled by varying hardness of the underlying geologic formation(s). As regional topography is uplifted, harder materials are gradually exposed or uncovered through the erosive force of local hydrology. These harder underlying materials will naturally form streamside cliffs and steep slope sequences. Often, ancient volcanic terrain is exhumed by hydrology, eroding away less resistant marine formations, forming rugged complex terrain like in the Tillamook State Forest.

If forest occupying the flat of an old flood plain at the base of a steep slope is the same age as surrounding forest, it is unlikely that the active channel is influencing the base of the slope and, in this situation, the slope does not meet the definition of an inner gorge. If it is unlikely that the stream will be able to interact with accumulated debris or the base of the slope during the timeframe of the next harvest rotation, then harvest of the steep slope is unlikely to have a significant effect on sediment routing or wood recruitment to the aquatic system.

Steep slopes that fail (or might fail) and deposit debris on topography above the active stream do not make up part of the inner gorge if this material cannot make its way to an active channel. In the case of a flood plain that is wide in comparison to the stream under consideration, soils that could fail from the above slope should be deposited within the width of the normally active floodplain for the slope to be considered part of an inner gorge.

Aquatic Adjacent Unstable Slopes

Aquatic adjacent unstable slopes are, or have recently been, in a state of active shallow landslide failure. Movement may be creeping or catastrophic. They may have a dish or scalloped-shaped curvilinear expression outlining the upper extent of the failure surface, and vertical or horizontal ground surface offsets along the margins of the failure. The ground surface within the boundaries of the unstable slope may be irregular or hummocky. These are slopes where the toe of the unstable portion interacts directly with erosive forces of a stream. This interaction has influence on the stability of the slope. These are sometimes found within an inner gorge delineation and do not require additional protection measures. Aquatic adjacent unstable slopes tend to be small, discontinuous, and more isolated features. When these are identified on the landscape, they are added to the nearby stream’s RCA. Trees on topography representative of ancient deep-seated movement would not be considered candidates for buffering. Large, active, deep-seated, slides whose toes are delineated by a stream can be considered for buffering if the timber in those stream-side locations could deliver within the timeframe of the next rotation.

Upland Potentially Unstable Slopes and Their Associated Debris Flow Tracks

These slopes are potential landslide initiation sites that are above and often not adjacent to a stream. Examples include channel headwalls (otherwise known as “zero-order basins” and “bedrock hollows”). These slopes may also include the over-steepened toes of large deep-seated landslides, or legacy sidecast along old roads. After failure, steep, confined channels below these slopes act as conduits for delivery of large wood, and coarse and fine-grained material to streams below (See Figures 3 through 6). The ability of the site to deliver large wood to a fish-bearing stream via a channel is considered necessary for buffering to occur (see *Determining Delivery* below). If a potential landslide initiation site with a moderate or high risk of failure has the ability to deliver to a fish-bearing stream via a channelized debris flow track, both the site and channelized track will be buffered to ensure that wood is delivered to the stream in the event of a slope failure.

Figure 3. Road Construction Through Headwall Depicts Deeper Soil Contained Within "U"-Shaped Bedrock

Figure 4. Failed Headwall

Figure 5. Channelized Debris Flow Track

Figure 6. Large Wood, Boulders, and Coarse and Fine Grained Sediment Deposited at Confluence of Channelized Debris Flow Track and Fish-Bearing Steam

A hazard-based approach (see *Slope Hazard* below) is taken in determining buffers for upland potentially unstable slopes. When evaluating this feature, the geotechnical specialist makes a determination of high, moderate, or low potential for slide initiation. A high hazard site is a location that has characteristics indicating a relatively high probability of failing. A moderate hazard site may have a relatively high probability of failing. Characteristics of low hazard sites indicate a lack of potential slope instability. While various data sources, models, and other analytic products (e.g., the modeled stream network developed for this Habitat Conservation Plan [HCP] by Terrainworks[2]) are used in this assessment, the final determination of hazard is based on professional experience and field observation.

The determination to buffer includes the likelihood of failure and likelihood of delivering debris to a fish-bearing stream.

If a potential initiation site is deemed “high hazard” and there is any likelihood of delivery to a fish-bearing stream, then harvest modifications are required. These modifications include leaving timber on the high hazard potential initiation site and establishing a 35-foot RCA along both sides of the potential channelized debris flow, where an RCA is not already designated.

In the case of “moderate hazard” initiation sites, harvest modification is required that establishes a 35-foot RCA along both sides of the potential channelized debris flow, but not a buffer of the potential initiation site.

In the case of a “low hazard” initiation site, no harvest modification or establishment of an RCA is required below the potential initiation site.

Slope Hazard and Delivery Assessment Process

The assessment of slope hazard and potential delivery involve both geographic information system (GIS) analysis and field visits, which help in understanding the various factors that could be present at a particular site that contribute to slope stability hazard. Because, to have risk, there must be both a hazard (unstable slope) and a resource at risk (fish-bearing stream), the geotechnical specialist examines the landscape and considers multiple contributing factors and makes a judgment as to the *hazard* (i.e., risk of slope failure) and the d*elivery* (i.e., risk of debris flow reaching fish-bearing water) for the site.

All planned clearcut harvest units will undergo GIS screening during the development of operations plans, which normally take place up to 3 to 5 years in advance of harvest activities. Across much of the permit area, there is a low chance of encountering potential sites that require further analysis; however, some areas of generally steeper terrain will require additional analysis and field work to accurately assess specific sites and designate protections. In addition to areas found during screening, field staff may become aware of additional potential slope issues during harvest unit preparation activities such as road design, stream classification and designation, boundary posting, and timber cruising. Any potential

[2] Terrainworks. 2020. *NetMap and Wood Recruitment Modeling for the Western Oregon State Forest Habitat Conservation Plan*.

slope issues discovered at any point during the planning process or preparation of the harvest unit for auction will be brought to the geotechnical specialist for further review.

A GIS review is conducted on all proposed clearcut harvests and new road alignments using ODF's GIS. Data reviewed include proposed harvest and buffer locations provided from harvest planners, orthophotographs, stream data (location, size, seasonality, fish presence), underlying geology, and digital elevation models (and associated products) derived from lidar. Paramount in the GIS review is the use of lidar topographic data, which exists for all lands west of the Cascades. Various renderings of the data are used to evaluate the steepness, shape, and texture of the ground surface, including: analysis of fine-scaled contours at; multi-directional hillshade models; slope steepness categories (as percent slope); ODF's HLHL model[3]; and slopeshade (a continuous representation of slope steepness, as percent slope). The modeled stream network, developed for this HCP, showing landslide initiation and delivery risk GIS products, will be also be used during this review. The desktop review often identifies locations of the four landforms described above and associated slope buffers. For upland potentially unstable slope features, delivery to fish-bearing streams can sometimes be determined during this stage of review as well. This review often identifies former landslides and areas of higher hazard that could be affected by harvest activities or that may fail in the future.

The GIS review may necessitate a field review to ground-truth a given site. Various indicators of slope hazard are not fully discernable by the desktop review and can be more fully understood in the field.

After determinations are made from either the GIS review and/or field visit, the landform is identified, and the appropriate vegetative buffer is applied. In the case of road alignments, recommendations often involve special best management practices (BMPs) or complete avoidance of an identified location.

Determining Slope Hazard

For activities such as roadbuilding and canopy removal, it is important to understand the slope hazard of the affected landscape. With such understanding, application of additional buffers, or adjusting road location, can reduce impacts on the aquatic environment. Each of the characteristics of the landscape used to make a determination of hazard of slide initiation has a range of effect on the hazard from high to low. Table 2 shows the relative effect of the types of landscape characteristics that can contribute to slope stability. They can be used collectively to determine stability, or if a particular site seems predominantly influenced by just a few characteristics, then the geotechnical specialist can weigh those as more important to inform the decision. In most cases, relative hazard is determined by a smaller set of features that are themselves the net result of multiple factors shown in Table 2, namely slope steepness, topographic and timber indications of instability, and slope shape. Regardless of which factors predominate in any given analysis, the result is a judgment on the potential hazard associated with the potentially unstable slope.

[3] High Landslide Hazard Location GIS model. Created from Lidar DEM. Slopes longer than 30 feet and ≥80% or ≥70% for convergent topography. In forests underlain by the Tyee Formation slope thresholds are 5% less. Thresholds determined from recommendations from ODF's 1996 storm report and issue paper.

Table 2: Hazard Evaluation

Landscape Characteristics Used to Evaluate a Potential Unstable Slope
for the Initiation of a Shallow Rapidly Moving Landslide

Factors Determining Hazard*	Less Hazard		increasing to		More Hazard
Overlying Soil	Gravelly				Fine-grained
Soil Thickness	Thin				Thick
Underlying Geology	Intrusive	Lava flows	Layered volcanics	Sedimentary Beds	Steep outslope-dipping Sedimentary Beds
Slope Steepness	< 70% (volcanic terrain) <60% (sedimentary terrain)			>80% (volcanic terrain) >70% (sedimentary terrain)	
Topographic Indicators of Soil Instability	No slide indicators	Ancient deep-seated movement apparent	Ancient shallow failure but in-place old growth stumps	Recent shallow slide	Open tension cracks
Timber Indicators of Soil Instability	Present conifer stand has straight trunks	Bent trunks near slope surface	Swept trunks	Jack-strawed trees	Former recent failure has removed conifer; bare soil, alder, or salmonberry are dominant
Slope Shape	Ridge top (convex slope)		Open straight slope		Headwall (concave)
Site Drainage	Well-drained soils		Wet soil		Spring/Stream
Headwall Drainage Area (above top of seasonality)		Small area < 0.5 acre		Large area > 3 acres	
Harvest Prescription	No harvest	Partial cut			Clear Cut
Site Preparation for Reforestation		No herbicide use planned		Herbicide planned to control understory	Broadcast burning
Unused Legacy Grade/Trail	Not present	Present without sidecast	Present with sidecast and cutslope	Sidecast has experienced movement	Sidecast has experienced movement and poorly drained grade

* Descriptions within rows are related (comparable) to each other but descriptions within columns are not. For example, a "ridge top" location may have more weight in determining if a slope is stable than "well-drained" soil, even though they lie in the same column.

Determining Delivery

Delivery relates to the likelihood that landslide debris will be transported to a fish-bearing stream. In cases where a slope fails directly into a fish-bearing stream (such as an aquatic adjacent unstable slope), the analysis is straightforward. In other instances, where a slope failure may be distal to the fish-bearing stream, the mobilized debris will have to traverse the stream network by moving around corners, past tributary junctions (requiring tight turns), and traverse downstream along varying gradients. If the debris lodges in the network above fish habitat, it may be moved later by a debris flow from a different tributary. It is in these cases that more analysis is needed to make a delivery determination. A landslide will be determined to deliver if there is <u>any</u> likelihood of large wood debris entering a fish-bearing stream. The possibility of remobilization of debris deposited above fish-use by a subsequent debris flow from a connecting tributary will be considered delivery. As in the hazard evaluation, determining delivery is also informed by various data and observations. Usually the evaluation of delivery is very straightforward in the steeper terrain of northwest Oregon because the water resource is commonly close to the potentially unstable slope, and flow paths are steep and fairly straight to a fish-bearing stream—often existing at the bottom of the proposed harvest unit.

In more subdued topography, or for stream sections with questionable geomorphology, determining delivery can be more challenging. The geotechnical specialist starts the evaluation using various GIS products and information as described above. This information provides a good understanding of the geomorphology of the stream network below the slope in question. Junction angles, stream and slope gradient, and travel distances for stream segments can be discerned easily from lidar data. Once the basic geomorphology is understood the following sources can further inform decisions of the likelihood of delivery:

- ODF guidance on debris flow deposition and transport.[4]
- Deliverability guidance stating the likelihood that a debris flow will stop when one of the following is met (Benda 1990[5]; ODF 2010[6]; Guthrie et al. 2010[7]):
    - The presence of a channel junction that is 70 degrees or more, provided the channel downstream of the junction is <35% gradient, or
    - The presence of a stream reach which is <6% gradient for at least 300 feet, or

---

[4] The *Transport* and *Deposition* sections in Forest Practices Technical Note #6 are helpful in identifying landscape characteristics that have an effect on the likelihood of an unstable slope's ability to deliver to an aquatic resource. The note was prepared to help geotechnical specialists evaluate slopes in the context of *public safety*; however, the principals in these two sections are useful for water resources. See https://www.oregon.gov/odf/Documents/workingforests/LandslideImpactRatingTechNote6.pdf.

[5] Benda, Lee. 1990. The Influence of Debris Flows on Channels and Valley Floors in the Oregon Coast Range, U.S.A. *Earth Surface Processes and Landforms* 15:457–466.

[6] Oregon Department of Forestry. 2010. *Northwest Oregon State Forests Management Plan*. Revised April 2010. 581 pp.

[7] Guthrie, R. H., A. Hockin, L. Colquhoun, T. Nagy, S. G. Evans, and C. Ayles. 2010. An Examination of Controls on Debris Flow Mobility: Evidence from Coastal British Columbia. *Geomorphology* 114(4), 601–613. Available: https://doi.org/10.1016/j.geomorph.2009.09.021.

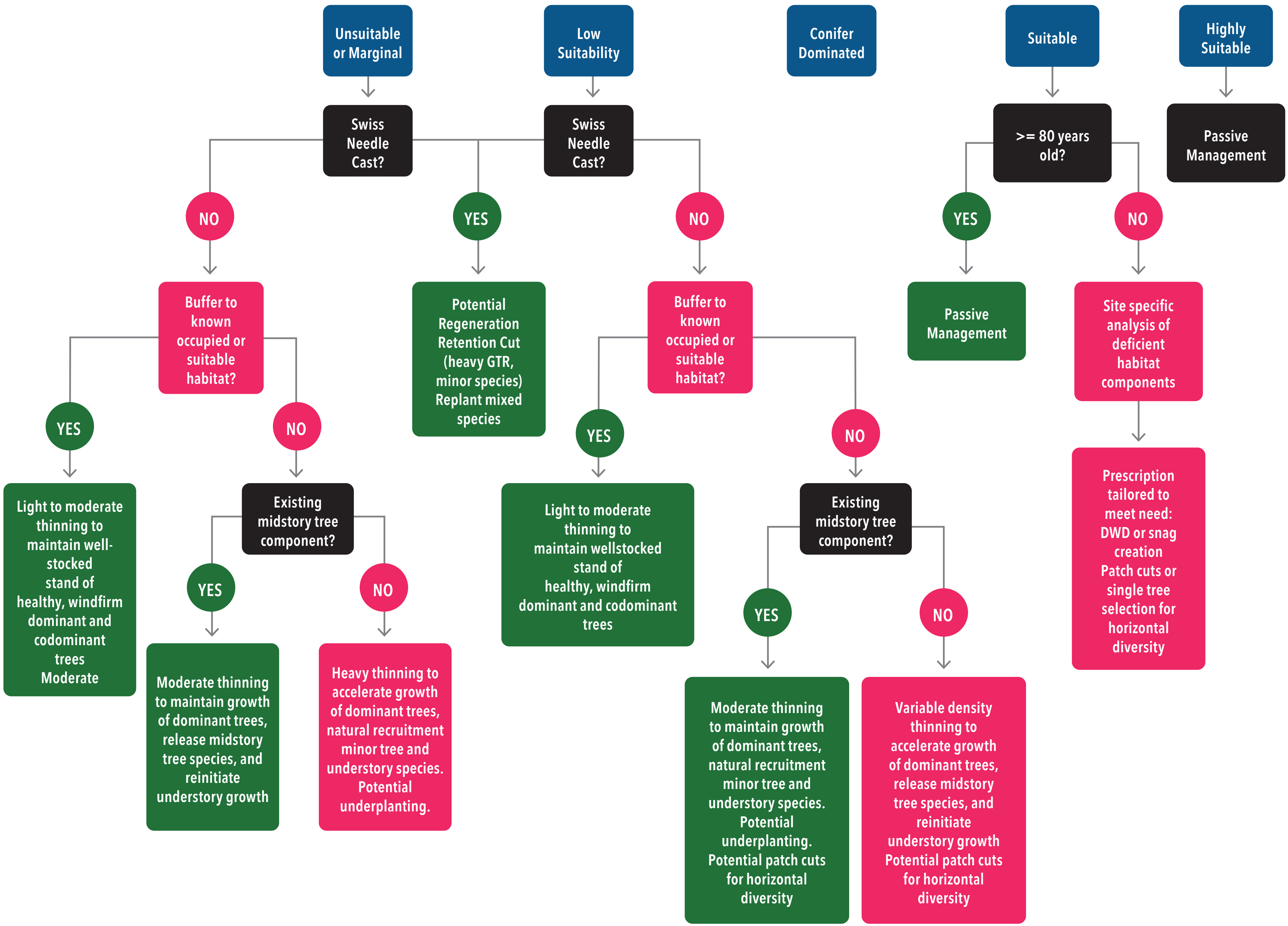
    - The average slope from the initiation site along the potential landslide path to the first stream that is <20%.
- Comparison of the stream network with landslide data from other northwest locations (unpublished debris flow track data collected from two 1996 storms, Robison et al. 1999[8]).
- Field visit to examine existing debris flow deposits in the stream network.

---

[8] Robison, E.G., K.A. Mills, J. Paul, L. Dent, and A. Skaugset. 1999. *Oregon Department of Forestry Storm Impacts and Landslides of 1996: Final Report Oregon Department of Forestry Forest Practices Monitoring Program*. Salem, OR.

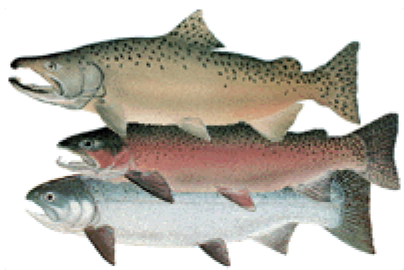
Appendix J
Habitat Conservation Area Management Decision-Making Process

Habitat Conservation Area Management Decision-Making Process



Appendix K
Fish Passage Design Criteria

ANADROMOUS SALMONID
PASSAGE FACILITY DESIGN



NATIONAL MARINE FISHERIES SERVICE
NORTHWEST REGION
www.nwr.noaa.gov

July 2011

ACKNOWLEDGMENTS

Bryan Nordlund, National Marine Fisheries Service (NMFS) Hydraulic Engineer, is the primary author of this document. He was assisted by Larry Swenson, Hydraulic Engineer; Melissa Jundt, Hydraulic Engineer; Ed Meyer, Hydraulic Engineer; Scott Carlon, Fishery Biologist; and John Johnson, Hydraulic Engineer; all with NMFS. In addition, he was assisted by Steve Rainey, GEI Consultants, Inc.

Reviews were provided by Denny Hudson, U.S. Bureau of Reclamation; Pat Powers and Tom Burns, Washington Department of Fish and Wildlife; Ray Hartlerode, Tom Stahl, and Bernie Kepshire, Oregon Department of Fish and Wildlife; Lynn Stratton and Matt Hightree, Idaho Department of Fish and Game; and Ken Bates, Koszmo, Inc.

Suggested changes, additions, or questions should be directed to Bryan Nordlund at Bryan.Nordlund@noaa.gov for consideration in updating this document.

Assistance from NMFS fish passage specialists can be obtained by contacting the NMFS Northwest Region Hydropower Division at 503-230-5414.

Suggested citation:

NMFS (National Marine Fisheries Service). 2011. Anadromous Salmonid Passage Facility Design. NMFS, Northwest Region, Portland, Oregon.

TABLE OF CONTENTS

TABLES AND FIGURES

ACRONYMS AND ABBREVIATIONS

AWS	auxiliary water supply
cfs	cubic feet per second
COE	U.S. Army Corps of Engineers
EPRI	Electric Power Research Institute
ESA	Endangered Species Act
FERC	Federal Energy Regulatory Commission
FPA	Federal Power Act
HGL	hydraulic grade line
HGMP	Hatchery and Genetic Management Plan
MSA	Magnuson-Stevens Fishery Conservation and Management Act
NMFS	National Marine Fisheries Service
NWR	Northwest Region
PESBS	Positive-exclusion screen and bypass systems
PIT	passive integrated transponder
ppm	parts per million
R/D	ratio of bypass pipe center-line radius of curvature to pipe
VBS	Vertical barrier screens
WDFW	Washington Department of Fish and Wildlife

FOREWORD

The National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) is charged by Congress to manage, conserve, and protect living marine resources within the United States Exclusive Economic Zone. NMFS also plays a supportive and advisory role in the management of living marine resources in areas under state jurisdiction. Among these living marine resources are the Pacific anadromous salmonids (salmon and steelhead) which have tremendous economic, cultural, recreational, and symbolic importance to the Pacific Northwest (NRC 1996).

Anadromous fishes reproduce in freshwater and the progeny migrate to the ocean to grow and mature and return to freshwater to reproduce. Salmon and steelhead cross many geographic and human boundaries during their freshwater migration. It is an arduous journey; some species migrate hundreds of miles each way in freshwater and thousands of miles while in the ocean. In addition to the challenge of covering great distances, most species must navigate many barriers during migration. Migration barriers—complete blockages and poorly functioning passage facilities—are a significant factor affecting most salmon populations in the Pacific Northwest.

Any independent Pacific salmonid (genus *Oncorhynchus*) population is considered viable when it can withstand threats and risk of extinction from demographic variation, local environmental variation, and genetic diversity changes over a 100-year timeframe (McElheny et al. 2000). Each viable population needs to exhibit the abundance, productivity, spatial distribution and diversity of natural spawners sufficient to accomplish the following: avoid the loss of genetic and/or life history diversity during short-term losses in abundance that are expected parts of environmental cycles; fulfill key ecological functions that are attributable to the species, such as nutrient cycling and food web roles; and be resilient to environmental and anthropogenic disturbances.

The primary effect of barriers (e.g., hydroelectric dams, water storage projects, irrigation diversions, impassable culverts, etc.) on Pacific salmonids is the reduction in population abundance and productivity through excessive mortality and reduction in habitat quantity and quality. Individuals are lost to the population due to death from passing through turbines, disproportionate predation in reservoirs, entrainment at unscreened or improperly screened diversions, etc. Spatial structure and diversity have also been reduced by the loss of nearly 40% of salmon habitat from dams (NRC 1996), either through complete blockage or inundation.

This document is intended to assist with improving conditions for salmonids that must migrate past barriers to complete their life cycle. The task involved in successfully passing fish upstream or downstream of an in-river impediment is a dynamic integration of fish behavior, physiology, and bio-mechanics with hydraulic analysis, hydrologic study, and engineering. Installing a fish passage structure does not constitute providing satisfactory fish passage unless all of the above components are adequately factored into the design.

The following document provides criteria, rationale, guidelines, and definitions for the purpose of designing proper fish passage facilities for the safe, timely, and efficient upstream and downstream passage of anadromous salmonids at impediments created by artificial structures, natural barriers (where provision of fish passage is consistent with management objectives), or altered instream hydraulic conditions. This document provides fishway facility design standards for the National Marine Fisheries Service, and is to be used for actions pertaining to the various authorities and jurisdictions of NMFS, including Section 18 of the Federal Power Act (FPA), the Endangered Species Act (ESA), and the Magnuson-Stevens Fishery Conservation and Management Act (MSA) in the Northwest Region (NWR). This document intends to provide generic guidance as an alternative to active participation by NMFS engineers in a design process, for the purpose of providing designs that will be acceptable for fishways that fall within NMFS jurisdictions. If passage facilities are designed and constructed in a manner consistent with these criteria, adverse impacts to anadromous fish migration will be minimized.

Instances will occur where a fish passage facility may not be a viable solution for correcting a passage impediment, due to biological, sociological, or economic constraints. In these situations, removal of the impediment or altering operations may be a suitable surrogate for a constructed fish passage facility. In other situations, accomplishing fish passage may not be an objective of NMFS because of factors such as limited habitat or lack of naturally occurring runs of anadromous fish upstream of the site. To determine whether NMFS will use its various authorities to promote or to prescribe fish passage, NMFS will rely on a collaborative approach, considering the views of other fisheries resource agencies, Native American Tribes, non-government organizations, and citizen groups, and will strive to accomplish the objectives in watershed plans for fisheries restoration and enhancement.

This document does not address aspects of design other than those that provide for safe and timely fish passage, and to some extent, preservation of aquatic habitat. Structural integrity, public safety, and other aspects of facility design are the responsibility of the principal design engineer, who should ensure that the final facility design meets all other requirements in addition to the fish passage criteria and guidelines contained in this document.

Section 11 (Fish Screen and Bypass Facilities) supersedes previous design guidance published by NMFS, including Juvenile Fish Screen Criteria (February 16, 1995) and Juvenile Fish Screen Criteria for Pump Intakes (May 9, 1996).

The fish passage facilities described in this document include various fish ladders; exclusion barriers; trap and haul facilities; fish handling and sorting facilities; instream structures; road crossing structures such as culverts or bridges; juvenile fish screens; tide gates (still under development); infiltration galleries; upstream juvenile passage facilities; and specialized criteria for mainstem Columbia and Snake River passage facilities. Passage facilities for projects under NMFS jurisdiction should be consistent with the details described in this document, with the facility design developed in coordination with NMFS fish passage specialists.

Proponents of new, unproven fish passage designs (i.e., not meeting the criteria and guidelines contained in this document) must provide to NMFS: (1) development of a biological basis for the concept; (2) demonstration of favorable fish behavioral response in a laboratory setting; (3) an acceptable plan for evaluating the prototype installation; and (4) an acceptable alternate plan developed concurrently for a fish passage design satisfying these criteria, should the prototype not adequately protect fish. Section 16 (Experimental Fish Guidance Devices) provides additional information on the NMFS approval process for unproven fish passage devices.

Criteria are specific standards for fishway design, maintenance, or operation that cannot be changed without a written waiver from NMFS. For the purposes of this document, a criterion is preceded by the word “must.” In general, a specific criterion can not be changed unless there is site-specific biological rationale for doing so. An example of biological rationale that could lead to criterion waiver is a determination or confirmation by NMFS biologists that the smallest fry-sized fish will likely not be present at a proposed screen site. Therefore, the juvenile fish screen approach velocity criterion of 0.4 ft/s could be increased to match the smallest life stage expected at the screen site. A guideline is a range of values or a specific value for fishway design, maintenance or operation that may change when site-specific conditions are factored into the conceptual fishway design. For the purposes of this document guidelines are preceded by the word “should.” Guidelines should be followed in the fishway design until site-specific information indicates that a different value would provide better fish passage conditions or solve site-specific issues. An example of site-specific rationale that could lead to a modified guideline is when the maximum river depth at a site is three feet, as compared to the design guideline for a fishway entrance depth of six feet. In this example, safe and timely fish passage could be provided by modifying the guideline to match the depth in the river. It is the responsibility of the applicant to provide compelling evidence in support of any proposed waiver of criteria or modification of a guideline for NMFS approval early in the design process, well in advance of a proposed Federal action.

On occasion, more conservative designs may be required on a project-by-project basis if there is a need to provide additional protection for other species of fish. In addition, there may be instances where NMFS provides written approval for use of alternative passage standards, if NMFS determines that the alternative standards provide equal or superior protection as compared to the guidelines and criteria listed herein, for a particular site or for a set of passage projects within the NWR.

It is possible that part or all of this document, or approved alternate passage standards, could be used to develop programmatic consultation under the ESA. For example, a project developer may choose to use this document as the basis for fish passage design and develop additional detail beyond the scope of this document (e.g., construction management, project implementation scheduling, riparian replacement, project monitoring, etc.) in consultation with NMFS. Programmatic ESA consultation may conclude that an optimal uniform approach to implementing a number of fish passage projects will not pose any threat to ESA-listed species or to critical habitat. With this conclusion, individual ESA consultation on each project could be avoided.

Existing facilities may not adhere to the criteria and guidelines listed in this document. However, that does not mean these facilities must be modified specifically for compliance with this document. The intention of these criteria and guidelines is to ensure future compliance in the context of major upgrades and new designs of fish passage facilities.

The following document is hereby designated as NMFS NWR Fish Passage Design Policy for responsibilities under the ESA, FPA, and MSA, for the purpose of providing project proponents with NMFS' perspective on proper design of fish passage facilities for providing safe, timely, and efficient fish passage. This document was developed by NWR fish passage engineers based on nearly 60 years of agency experience in developing fishway designs, and further refined through a collaborative process with regional fishway design experts. This guidance is considered to be a working document, thus when new or updated information suggests that a different standard (criterion or guideline) provides better fishway passage, simplifies operations, or decreases required maintenance, this document will be periodically updated. Suggested changes, additions, or questions should be directed to Bryan Nordlund at Bryan.Nordlund@noaa.gov for consideration in updating this document. Assistance from NMFS fish passage specialists can be obtained by contacting the NMFS NWR Hydropower Division at (503) 230-5414.

Bruce K. Suzumoto
Assistant Regional Administrator
Hydropower Division

1. DEFINITION OF TERMS

Terms defined in this section are identified in *italics* throughout the document.

Anadromous - fish species that travel upstream to spawn in freshwater.

Active screens - juvenile fish screens equipped with proven cleaning capability and are automatically cleaned as frequently as necessary to keep the screens free of any debris that will restrict flow area. An *active screen* is the required design in most instances.

Approach velocity - the vector component of canal velocity that is perpendicular to and upstream of the vertical projection of the screen face, calculated by dividing the maximum screened flow by the *effective screen area*. An exception to this definition is for end-of-pipe cylindrical screens, where the *approach velocity* is calculated using the entire *effective screen area*. *Approach velocity* should be measured as close as physically possible to the boundary layer turbulence generated by the screen face.

Apron - a flat, usually slightly inclined slab below a flow control structure that provides for erosion protection and produces hydraulic characteristics suitable for energy dissipation or in some cases fish exclusion.

Attraction flow - the flow that emanates from a *fishway entrance* with sufficient velocity and in sufficient quantity and location to attract upstream migrants into the *fishway*. *Attraction flow* consists of gravity flow from the *fish ladder*, plus any *auxiliary water system* flow added at points within the lower *fish ladder*.

Auxiliary water system - a hydraulic system that augments *fish ladder* flow at various points in the *upstream passage facility*. Typically, large amounts of auxiliary water flow are added in the *fishway entrance* pool in order to increase the attraction of the *fishway entrance*.

Backwash - providing debris removal by pressurized wash, opposite to the direction of flow.

Backwater - a condition whereby a *hydraulic drop* is influenced or controlled by a water surface control feature located downstream of the *hydraulic drop*.

Baffles - physical structures placed in the flow path designed to dissipate energy or to re-direct flow for the purpose of achieving more uniform flow conditions.

Bankfull - the bank height inundated by an approximately 1.2 to 1.5 year (maximum) average recurrence interval and may be estimated by morphological features such as the following: (1) a topographic break from vertical bank to flat *floodplain*; (2) a topographic break from steep slope to gentle slope; (3) a change in vegetation from bare to grass, moss to grass, grass to sage, grass to trees, or from no trees to trees; (4) a textural change of depositional sediment; (5) the elevation below which no fine debris (e.g., needles, leaves, cones, seeds) occurs; and (6) a textural change of matrix material between cobbles or rocks.

Bedload - sand, silt, gravel, or soil and rock debris transported by moving water on or near the streambed.

Bifurcation (Trifurcation) pools **-** pools where two or three sections of *fish ladder*s divide into separate routes.

Brail - a device that moves upward (vertically) through the water column, crowding fish into an area for collection.

Bypass flow - in context of screen design, that portion of flow diverted that is specifically used to bypass fish back to the river.

Bypass reach - the portion of the river between the point of flow diversion and the point of flow return to the river.

Bypass system - the component of a downstream passage facility that transports fish from the diverted water back into the body of water from which they originated, usually consisting of a bypass entrance, a bypass conveyance, and a bypass outfall.

Channel bed width - the width of the stream bed under *bankfull* channel conditions.

Conceptual design - an initial design concept based on the site conditions and biological needs of the species intended for passage. This is also sometimes referred to as *preliminary design* or *functional design*.

Crowder - a combination of static and/or movable *picketed* and/or solid leads installed in a *fishway* for the purpose of moving fish into a specific area for sampling, counting, broodstock collection, or other purposes.

Diffuser - typically, a set of horizontal or vertical bars designed to introduce flow into a *fishway* in a nearly uniform fashion. Other means are also available that may accomplish this objective.

Distribution flume - a channel used to route fish to various points in a fish trapping system.

Effective screen area - the total submerged screen area, excluding major structural members, but including the screen face material. For rotating drum screens, *effective screen area* consists only of the submerged area projected onto a vertical plane, excluding major structural members, but including screen face material.

End of pipe screens **-** juvenile fish screening devices attached directly to the intake of a diversion pipe.

Entrainment **-** the unintended diversion of fish into an unsafe passage route.

Exclusion barriers - upstream passage facilities that prevent upstream migrants from entering areas with no upstream egress, or areas that may lead to fish injury.

Exit control section - the upper portion of an *upstream passage facility* that serves to provide suitable passage conditions to accommodate varying *forebay* water surfaces, through means of pool geometry, *weir* design, and the capability to add or remove flow at specific locations.

False weir - a device that adds vertical flow to a upstream fishway, usually used in conjunction with a *distribution flume* that routes fish to a specific area for sorting or to continue upstream passage.

Fish ladder - the structural component of an *upstream passage facility* that dissipates the potential energy into discrete pools, or uniformly dissipates energy with a single *baffled* chute placed between an entrance pool and an exit pool or with a series of *baffled* chutes and resting pools.

Fish lift - a mechanical component of an upstream passage system that provides fish passage by lifting fish in a water-filled *hopper* or other lifting device into a conveyance structure that delivers upstream migrants past the impediment.

Fish lock - a mechanical and hydraulic component of an upstream passage system that provides fish passage by attracting or crowding fish into the lock chamber, activating a closure device to prevent fish from escaping, introducing flow into the enclosed lock, and raising the water surface to *forebay* level, and then opening a gate to allow the fish to exit.

Fish passage season - the range of dates when a species migrates to the site of an existing or proposed *fishway*, based on either available data collected for a site, or consistent with the opinion of an assigned NMFS biologist when no data is available.

Fish weir *(also called picket weir or fish fence)* - a device with closely spaced *pickets* to allow passage of flow, but preclude upstream passage of adult fish. Normally, this term is applied to the device used to guide fish into an adult fish trap or counting window. This device is not a *weir* in the hydraulic sense.

Fishway - the set of facilities, structures, devices, measures, and project operations that together constitute, and are essential to the success of, an upstream or downstream fish passage system.

Fishway entrance - the component of an *upstream passage facility* that discharges *attraction flow* into the *tailrace*, where upstream migrating fish enter (and flow exits) the *fishway*.

Fishway exit - the component of an *upstream passage facility* where flow from the *forebay* enters the *fishway*, and where fish exit into the *forebay* upstream of the passage impediment.

Fishway entrance pool - the pool immediately upstream of the *fishway entrance*(s), where *fish ladder* flow combines with any remaining *auxiliary water system* flow to form the *attraction flow*.

Fishway weir - the partition that passes flow between adjacent pools in a *fishway*.

Flood frequency - the frequency with which a flood of a given river flow has the probability of recurring based on historic flow records. For example, a "100-year" frequency flood refers to a flood flow of a magnitude likely to occur on the average of once every 100 years, or, has a one-percent chance of being exceeded in any year. Although calculation of possible recurrence is often based on historical records, there is no guarantee that a "100-year" flood will occur within the 100-year period or that it will not recur several times.

Floodplain - the area adjacent to the stream that is inundated during periods of flow that exceed stream channel capacity, as established by the stream over time.

Flow control structure - a structure in a water conveyance intended to maintain flow in a predictable fashion.

Flow duration exceedence curve - the plot of the relationship between the magnitude of daily flow and the percentage of the time period for which that flow is likely to be equaled or exceeded. Other time units can be used as well, depending on the intended application of the data.

Flow egress weir - a *weir* used to route excess flow (without fish) from a fish facility.

Forebay - the water body impounded immediately upstream of a dam.

Freeboard - the height of a structure that extends above the maximum water surface elevation.

Fry - for purposes of this document, defined as a young juvenile salmonid with absorbed egg sac, less than 60 mm in length.

Functional design - an initial design concept, based on the site conditions and biological needs of the species intended for passage. This is also sometimes referred to as *preliminary design* or *conceptual design*.

Hatchery supplementation - hatchery propagation usually utilizing the progeny of local wild broodstock.

Head loss - the loss of energy through a hydraulic structure.

Hopper - a device used to lift fish (in water) from a collection or holding area, for release upstream of the impediment.

Hydraulic drop - the energy difference between an upstream and downstream water surface, considering potential (elevation) and kinetic energy (*velocity head*), and pressure head. For *fishway* entrances and *fishway weir*s, the difference in kinetic energy and pressure head is usually negligible and only water surface elevation differences are considered when estimating *hydraulic drop* across the structure. As such, staff gages that indicate *hydraulic drop* over these structures must be suitably located to avoid the drawdown of the water surface due to flow accelerating through the *fishway weir* or *fishway entrance*.

Impingement - the consequence of a situation where flow velocity exceeds the swimming capability of a fish, creating injurious contact with a screen face or bar rack.

Infiltration gallery - a water diversion that provides flow via an excavated gallery beneath the stream bed.

Kelts - an adult steelhead that has completed spawning and is migrating downstream.

Off-ladder trap - a trap for capturing fish located adjacent to a *fish ladder* in an off ladder flow route, separate from the normal *fish ladder* route. This device allows fish to either pass via the ladder, or be routed into the trap depending on management objectives.

Passive screens - juvenile fish screens without an automated cleaning system.

Picket leads or Pickets - a set of vertically inclined flat bars or circular slender columns (*pickets*), designed to exclude fish from a specific point of passage (also, see *fish weir*).

PIT- tag detector - a device that passively scans a fish for the presence of a passive integrated transponder (PIT) tag that is implanted in a fish and read when activated by an electro-magnetic field generated by the detector.

Plunging flow - flow over a *weir* that falls into the receiving pool with a water surface elevation below the *weir* crest elevation. Generally, surface flow in the receiving pool is in the upstream direction, downstream from the point of entry into the receiving pool.

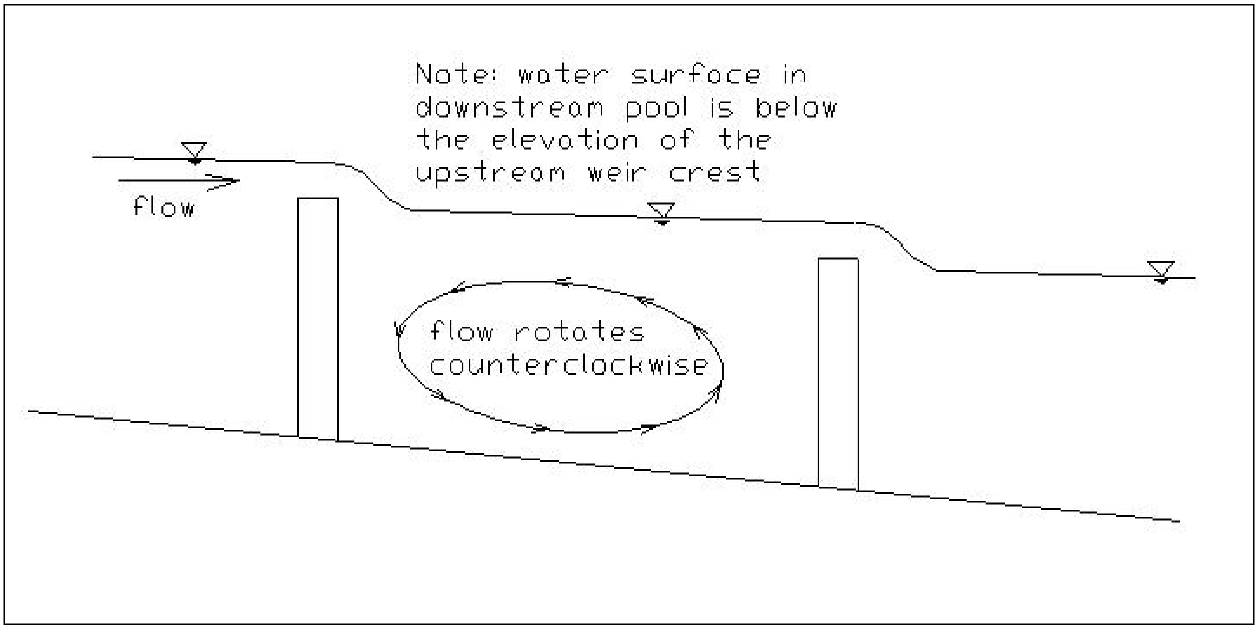


Figure 1-1. Plunging Flow over Fishway Weir

Porosity - the open area of a mesh, screen, rack or other flow area relative to the entire gross area.

Positive-exclusion - a means of excluding fish by providing a barrier which they can not physically pass through.

Preliminary design - an initial design concept, based on the site conditions and biological needs of the species intended for passage. This is also sometimes referred to as *functional design* or *conceptual design*.

Ramping rates - the rate at which (typically inches per hour) a flow is artificially altered to accommodate diversion requirements.

Rating curve - the graphed data depicting the relationship between water surface elevation and flow.

Redd - deposition of fish eggs in a gravel nest, excavated by a spawning female salmonid.

Screen material - the material that provides physical exclusion to reduce the probability of entraining fish. Examples of *screen material* include perforated plate, bar screen, and woven wire mesh.

Scour - erosion of streambed material, resulting in temporary or permanent lowering of streambed profile.

Section 10 and 404 Regulatory Programs - The principal Federal regulatory programs, carried out by the COE, affecting structures and other work below mean high water. The COE, under Section 10 of the River and Harbor Act of 1899, regulates structures in, or affecting, navigable waters of the U.S. as well as excavation or deposition of materials (e.g., dredging or filling) in navigable waters. Under Section 404 of the Federal Water Pollution Control Act Amendments (Clean Water Act of 1977), the COE is also responsible for evaluating application for Department of the Army permits for any activities that involve the placement of dredged or fill material into waters of the United States, including adjacent wetlands.

Smolt - a juvenile salmonid that has completed its fresh water rearing cycle and is proceeding out to sea.

Streaming flow - flow over a *weir* which falls into a receiving pool with water surface elevation above the *weir* crest elevation. Generally, surface flow in the receiving pool is in the downstream direction, downstream from the point of entry into the receiving pool.

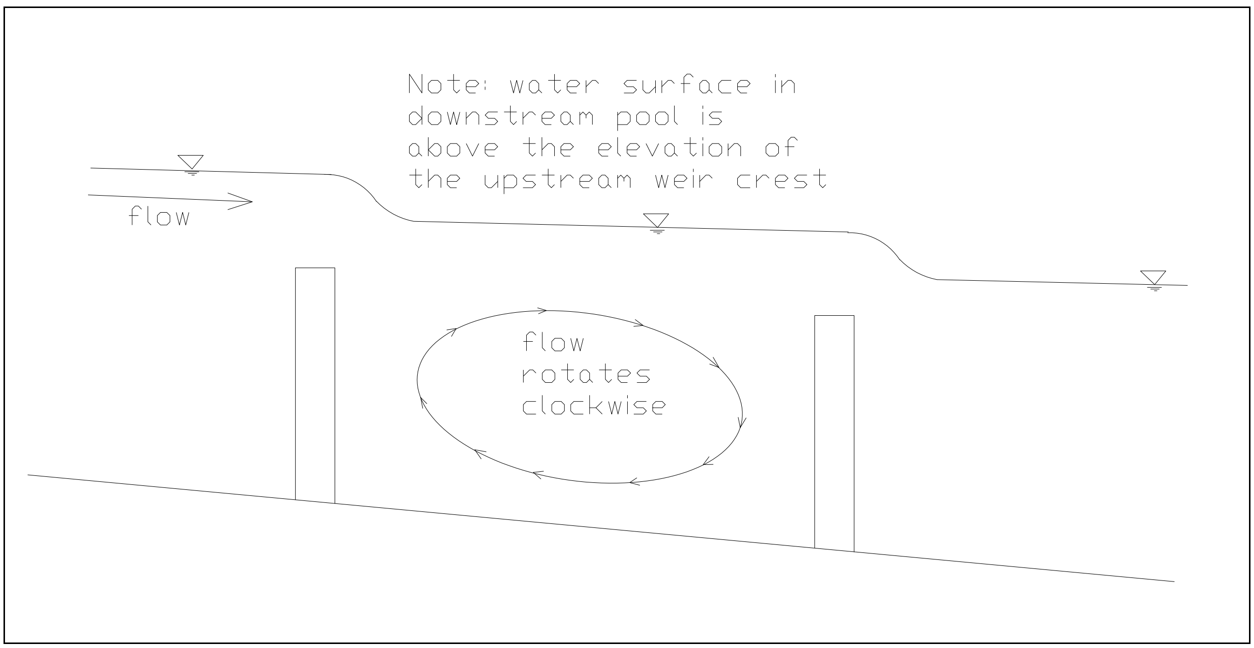


Figure 1-2. Streaming Flow over Fishway Weir

Sweeping velocity - the vector component of canal flow velocity that is parallel and adjacent to the screen face, measured as close as physically possible to the boundary layer turbulence generated by the screen face.

Tailrace - the stream immediately downstream of an instream structure.

Tailwater - the flow through the *tailrace*.

Total project head - the difference in water surface elevation from upstream to downstream of an impediment such as a dam. Normally, *total project head* encompasses a range based on stream flows and/or the operation of flow control devices.

Thalweg - the stream flow path following the deepest parts of a stream channel.

Tide Gate - a gate used in coastal areas to regulate tidal intrusion.

Training wall - a physical structure designed to direct flow to a specific location or in a specific direction.

Transport channel - a hydraulic conveyance designed to pass fish between different sections of a fish passage facility.

Transport velocity - the velocity of flow within the migration corridor of a *fishway*, excluding areas with any *hydraulic drop*s greater than 0.1 feet.

Trap and Haul - a fish passage facility designed to trap fish for upstream or downstream transport to continue their migration.

Trash rack - a rack of vertical bars with spacing designed to catch debris and preclude it from entering the *fishway*, while providing sufficient opening to allow the passage of fish.

Trash rack, coarse - a rack of vertical bars with spacing designed to catch large debris and preclude it from entering the *fishway,* while providing sufficient opening to allow the passage of fish.

Trash rack, fine - a rack of vertical bars designed to catch debris and reduce or eliminate entry of fish into the intake of an *auxiliary water system.*

Turbine intake screens – partial flow screens positioned within the upper portion of turbine intakes, designed to guide fish into a collection system for transport or bypass back to the river.

Upstream fish passage - fish passage relating to upstream migration of adult and/or juvenile fish.

Upstream passage facility - a *fishway* system designed to pass fish upstream of a passage impediment, either by *volitional passage* or non-*volitional passage*.

Vee screen - a pair of juvenile fish screens installed in a vee configuration (i.e., mirrored about a centerline) with the bypass entrance located between the junction of the two screens.

Velocity head **(h_v)** - the kinetic energy of flow contained by the water velocity, calculated by the square of the velocity (V) divided by two times the gravitational constant (g) ($h_v = V^2/2g$).

Vertical barrier screens - vertical screens, usually located in a gatewell of a mainstream hydroproject, that dewater flow from *turbine intake screens*, thereby concentrating fish for passage into a *bypass system*.

Volitional passage - fish passage made continuously available without trap and transport.

Wasteway - a conveyance which returns water originally diverted from an upstream location back to the diverted stream.

Weir - an obstruction over which water flows.

2. PRELIMINARY DESIGN DEVELOPMENT

2.1 Introduction – Preliminary Design Development

In cases such as applications for a FERC license, ESA consultation, ESA Section 9 Enforcement activity, or ESA permit, a *preliminary design* for a fish passage facility must be developed in an interactive process with NMFS NWR Hydropower Division engineering staff. For all fish passage facility projects, the *preliminary design* should be developed based on a synthesis of the required site and biological information listed below. In general, NMFS will review fish passage facility designs in the context of how the required site and the biological information was integrated into the design. Submittal of all information discussed below may not be required in writing for NMFS review. However, the applicant should be prepared to describe how the biological and site information listed below was included in the development of the *preliminary design*. NMFS will be available to discuss these criteria in general or in the context of a specific site. The applicant is encouraged to initiate coordination with NMFS fish passage specialists early in the development of the *preliminary design* to facilitate an iterative, interactive, and cooperative process.

2.2 Site Information

The following site information should be provided for the development of the *preliminary design*.

1. Functional requirements of the proposed fish passage facilities as related to all anticipated operations and river flows. Describe median, maximum, and minimum monthly diverted flow rates, plus any special operations (e.g., use of flash boards) that modify *forebay* or *tailrace* water surface elevations.

2. Site plan drawing showing location and layout of the proposed *fishway* relative to existing project features facilities.

3. Topographic and bathymetric surveys, particularly where they might influence locating *fishway* entrances and exits, and personnel access to the site.

4. Drawings showing elevations and a plan view of existing flow diversion structures, including details showing the intake configuration, location, and capacity of project hydraulic features.

5. Basin hydrology information, including daily and monthly streamflow data and *flow duration exceedence curves* at the proposed fish passage facility site based on the entire period of available record. Where stream gage data is unavailable, or if a short period of record exists, appropriate synthetic methods of generating flow records may be used.

6. Project operational information that may affect fish migration (e.g., powerhouse flow capacity, period of operation, etc.)

7. Project *forebay* and *tailwater rating curve*s encompassing the entire operational range.

8. River morphology trends. If the fish passage facility is proposed at a new or modified diversion, determine the potential for channel degradation or channel migration that may alter stream channel geometry and compromise *fishway* performance. Describe whether the stream channel is stable, conditionally stable, or unstable, and indicate the overall channel pattern as straight, meandering, or braided. Estimate the rate of lateral channel migration and change in stream gradient that has occurred over the last decade. Also, describe what effect the proposed fish passage facility may have on existing stream alignment and gradient and the potential for future channel modification due to either construction of the facility or continuing natural channel instability.

9. Special sediment and/or debris problems. Describe conditions that may influence design of the fish passage facility, or present potential for significant problems.

10. Other information from site-specific biological assessment.

2.3 Biological Information

The following biological information should be provided for the development of the *preliminary design*.

1. Type, life stage, run size, period of migration, and spawning location and timing for each life stage and species present at the site.

2. Other species (including life stage) present at the proposed fish passage site that also require passage.

3. Predatory species that may be present.

4. High and low design passage flow for periods of *upstream fish passage* (see Section 3).

5. Any known fish behavioral aspects that affect salmonid passage. For example, most salmonid species pass readily through properly designed orifices, but other species unable to pass through these orifices may impede salmonid passage.

6. What is known and what needs to be researched about fish migration routes approaching the site.

7. Document, or estimate, minimum streamflow required to allow migration around the impediment during low water periods (based on past site experience).

8. Poaching/illegal trespass - describe the degree of human activity in immediate area and the need for security measures to reduce or eliminate illegal activity.

9. Water quality factors that may affect fish passage at the site. Fish may not migrate if water temperature and quality are marginal, instead seeking holding zones until water quality conditions improve.

2.4 Design Development Phases

A description of steps in the design process is presented here to clarify the *preliminary design* as it contrasts with often-used and related terms in the design development process. The following are commonly used terms (especially in the context of larger facilities) by many public and private design entities. NMFS engineering staff may be consulted for all phases of design; required reviews are described below in Detailed Design Phase.

Reconnaissance study - typically an early investigation of one or more sites for suitability of design and construction of some type of facility.

Conceptual alternatives study - lists types of facilities that may be appropriate for accomplishing objectives at a specific site, and does not entail much on-site investigation. It results in a narrowed list of alternatives that merit additional assessment.

Feasibility study - includes an incrementally greater amount of development of each design concept (including a rough cost estimate), which enables selection of a most-preferred alternative.

Preliminary design - includes additional and more comprehensive investigations and design development of the preferred alternative, and results in a facilities layout (including some section drawings), with identification of size and flow rate for primary project features. Cost estimates are also considered to be more accurate. Completion of the *preliminary design* commonly results in a *preliminary design* document that may be used for budgetary and planning purposes, and as a basis for soliciting (and subsequent collating) design review comments by other reviewing entities. The *preliminary design* is commonly considered to be at the 20% to 30% completion stage of the design process.

Detailed design phase - uses the *preliminary design* as a springboard for preparation of the final design and specifications, in preparation for the bid solicitation (or negotiation) process. Once the detailed design process commences, NMFS must have the opportunity to review and provide comments at the 50% and 90% completion stages. These comments usually entail refinements in the detailed design that will lead to operations, maintenance, and fish safety benefits. Electronic drawings accompanied by 11 x 17 inch paper drawings are the preferred review medium.

3. DESIGN FLOW RANGE

3.1 Introduction – Design Flow Range

The design streamflow range for fish passage, bracketed by the designated fish passage design high and low flows, constitutes the bounds of the fish passage facility design where fish passage facilities must operate within the specified design criteria. Within this range of streamflow, the *fishway* design must allow for safe, timely, and efficient fish passage. Outside of this flow range, fish must either not be present or not be actively migrating, or must be able to pass safely without need of a fish passage facility. Site-specific information is critical to determine the design time period and river flows for the passage facility - local hydrology may require that these design streamflows be modified for a particular site.

Criteria are specific standards for fishway design, maintenance, or operation that cannot be changed without a written waiver from NMFS. For the purposes of this document, a criterion is preceded by the word “must.” In general, a specific criterion can not be changed unless there is site-specific biological rationale for doing so. An example of biological rationale that could lead to criterion waiver is a determination or confirmation by NMFS biologists that the smallest fry-sized fish will likely not be present at a proposed screen site. Therefore, the juvenile fish screen approach velocity criterion of 0.4 ft/s could be increased to match the smallest life stage expected at the screen site. A guideline is a range of values or a specific value for fishway design, maintenance, or operation that may change when site-specific conditions are factored into the conceptual fishway design. For the purposes of this document guidelines are preceded by the word “should.” Guidelines should be followed in the fishway design until site-specific information indicates that a different value would provide better fish passage conditions or solve site-specific issues. An example of site-specific rationale that could lead to a modified guideline is when the maximum river depth at a site is 3 feet, as compared to the design guideline for a fishway entrance depth of 6 feet. In this example, safe and timely fish passage could be provided by modifying the guideline to match the depth in the river. It is the responsibility of the applicant to provide compelling evidence in support of any proposed waiver of criteria or modification of a guideline for NMFS approval early in the design process, well in advance of a proposed Federal action.

3.2 Design Low Flow for Fish Passage

Design low flow for fishways is the mean daily average streamflow that is exceeded 95% of the time during periods when migrating fish are normally present at the site. This is determined by summarizing the previous 25 years of mean daily streamflows occurring during the *fish passage season*, or by an appropriate artificial stream *flow duration* methodology if streamflow records are not available. Shorter data sets of stream flow records may be useable if they encompass a broad range of flow conditions. The fish passage design low flow is the lowest streamflow for which migrants are expected to be present, migrating, and dependent on the proposed facility for safe passage.

3.3 Design High Flow for Fish Passage

Design high flow for fishways is the mean daily average streamflow that is exceeded 5% of the time during periods when migrating fish are normally present at the site. This is determined by summarizing the previous 25 years of mean daily streamflows occurring during the *fish passage season*, or by an appropriate artificial stream *flow duration* methodology if streamflow records are not available. Shorter data sets of stream flow records may be used if they encompass a broad range of flow conditions. The fish passage design high flow is the highest streamflow for which migrants are expected to be present, migrating, and dependent on the proposed facility for safe passage.

3.4 Fish Passage Design for Flood Flows

The general *fishway* design should have sufficient river *freeboard* to minimize overtopping by 50 year flood flows. Above a 50-year flow event, the *fishway* operations may include shutdown of the facility, in order to allow the facility to quickly return to proper operation when the river drops to within the range of fish passage design flows. Other mechanisms to protect *fishway* operations after floods will be considered on a case-by-case basis. A *fishway* must never be inoperable due to high river flows for a period greater than 7 days during the migration period for any anadromous salmonid species. In addition, the fish passage facility should be of sufficient structural integrity to withstand the maximum expected flow. It is beyond the scope of this document to specify structural criteria for this purpose. If the fish passage can not be maintained, the diversion structure should not operate and the impediment should be removed.

4. UPSTREAM ADULT FISH PASSAGE SYSTEMS

4.1 Introduction – Upstream Adult Fish Passage Systems

An upstream passage impediment is defined as any artificial structural feature or project operation that causes adult or juvenile fish to be injured, killed, blocked, or delayed in their upstream migration, to a greater degree than in a natural river setting. Artificial impediments require a fish passage design using conservative criteria, because the natural complexity that usually provides fish passage has been substantially altered.

This definition is provided for the purpose of describing situations in which NMFS will use these criteria in reviewing mitigative measures designed to improve fish passage at an impediment. Any upstream passage impediment requires approved structural and/or operational measures to mitigate, to the maximum extent practicable, for adverse impacts to *upstream fish passage*. These criteria are also applicable where passage over a natural barrier is desired and consistent with watershed, subbasin, or recovery plans.

It is important to note that not every *upstream passage facility* constructed at an upstream passage impediment can fully compensate for an unimpeded natural channel. As such, additional mitigation measures may be required on a case-by-case basis.

The examples listed below do not imply that passage is completely blocked by the impediment. Rather, this list is comprised of situations where fish passage does not readily occur, in comparison to a natural stream system. Examples of passage impediments include, but are not limited to, the following:

- Permanent or intermittent dams.
- *Hydraulic drop* over an artificial instream structure in excess of 1.5 feet.
- *Weirs*, *aprons*, *hydraulic jumps* or other hydraulic features that produce depths of less than 10 inches, or flow velocity greater than 12 ft/s for over 90% of the stream channel cross section.
- Diffused or braided flow that impedes the approach to the impediment.
- Project operations that lead upstream migrants into impassable routes.
- Upstream passage facilities that do not satisfy the guidelines and criteria described below.
- Poorly designed headcut control or bank stabilization measures that create impediments such as listed above.
- Insufficient *bypass reach* flows to allow or induce upstream migrants to move upstream into the *bypass reach* adjacent to a powerhouse or *wasteway* return.
- Degraded water quality in a *bypass reach*, relative to that downstream of the confluence of *bypass reach* and flow return discharges (e.g., at the confluence of a hydroproject *tailrace* that returns flow diverted from the river at some upstream location).
- *Ramping rates* in streams or in *bypass reachs* that delay or strand fish.
- Discharges to or from the stream that may be detected and entered by fish with no certain means of continuing their migration (e.g., poorly designed spillways, cross-basin water transfers, unscreened diversions).

- Discharges to or from the stream that are attractive to migrating fish (e.g., turbine draft tubes, shallow *aprons* and flow discharges) that have the potential to cause injury.
- Water diversions that reduce instream flow.

In addition to describing the configuration and application of the particular styles of *fish ladder*s, this section identifies general criteria and guidelines for use in completion of an upstream adult fish passage facility design. The intent of this section is to identify potential pitfalls and advantages of a particular type of passage system given specific site conditions, and to provide criteria and guidelines for use with a specific type of *fish ladder*. In general, NMFS requires *volitional passage*, as opposed to *trap and haul*, for all passage facilities. This is primarily due to the risks associated with the handling and transport of migrant salmonids, in combination with the long term uncertainty of funding, maintenance, and operation of the trap and haul program including facility failure. However, there are instances in which trap and haul may be the best viable option for upstream and/or downstream fish passage at a particular site, due to height of the dam, temperature issues in a long ladder, passage through multiple projects or other site-specific issues. The design of *trap and haul* facilities is described in Section 6.

The criteria and guidelines listed in this section apply to adult *upstream fish passage* in "moderately-sized" streams. This description is intentionally vague, because the variability of sites and passage needs within the NWR do not lend themselves to a "one size fits all" document specifying stringent criteria for upstream passage systems. Rather, it is expected that for streams with annual average flows between 500 to 5000 cfs, the guidelines listed may be applied in design without significant modification.

Criteria are specific standards for fishway design, maintenance, or operation that cannot be changed without a written waiver from NMFS. For the purposes of this document, a criterion is preceded by the word "must." In general, a specific criterion can not be changed unless there is site-specific biological rationale for doing so. An example of biological rationale that could lead to criterion waiver is a determination or confirmation by NMFS biologists that the smallest fry-sized fish will likely not be present at a proposed screen site. Therefore, the juvenile fish screen approach velocity criterion of 0.4 ft/s could be increased to match the smallest life stage expected at the screen site. A guideline is a range of values or a specific value for fishway design, maintenance or operation that may change when site-specific conditions are factored into the conceptual fishway design. For the purposes of this document guidelines are preceded by the word "should." Guidelines should be followed in the fishway design until site-specific information indicates that a different value would provide better fish passage conditions or solve site-specific issues. An example of site-specific rationale that could lead to a modified guideline is when the maximum river depth at a site is 3 feet, as compared to the design guideline for a fishway entrance depth of 6 feet. In this example, safe and timely fish passage could be provided by modifying the guideline to match the depth in the river. It is the responsibility of the applicant to provide compelling evidence in support of any proposed waiver of criteria or modification of a guideline for NMFS approval early in the design process, well in advance of a proposed Federal action. After a decision to provide passage at a particular site has been made, the following design criteria and guidelines are applicable, in addition to those described throughout Section 3.

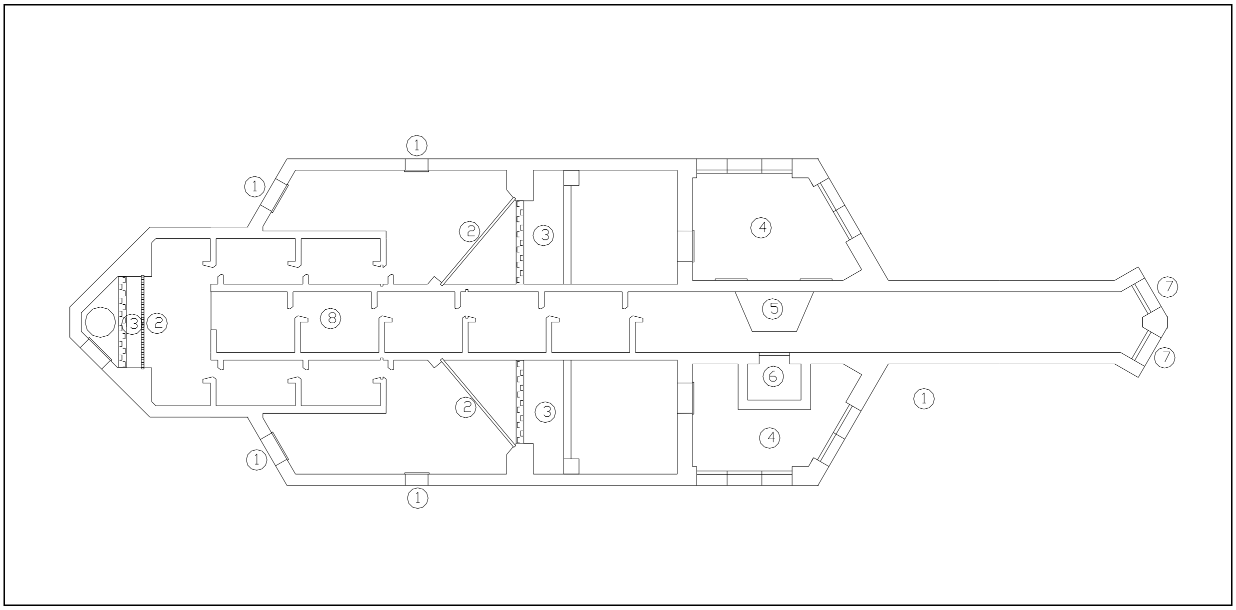


Figure 4-1. Features of an Upstream Passage System Using a Vertical Slot Fishway (flow is from right to left)

1 - Fishway Entrances
2 - Add-in AWS Diffusers
3 - Energy Dissipation Features
4 - AWS Supply Pools
5 - Counting station crowder and picket leads
6 - Counting Station
7 - Fishway Exits
8 - Fishway Pool

4.2 Fishway Entrance

4.2.1 Description and Purpose - Fishway Entrance

The *fishway entrance* is a gate or slot through which *fishway attraction flow* is discharged and through which fish enter the *upstream passage facility*. The *fishway entrance* is possibly the most critical component in the design of an upstream passage system. Placing a *fishway entrance(s)* in the correct location(s) will allow a passage facility to provide a good route of passage throughout the design range of passage flows. The most important aspects of a *fishway entrance* design are: (1) location of the entrance, (2) shape and amount of flow emanating from the entrance, (3) approach channel immediately downstream of the entrance, and (4) flexibility in operating the entrance flow to accommodate variations in *tailrace* elevation, stream flow conditions, and project operations.

4.2.2 Specific Criteria and Guidelines – Fishway Entrance

4.2.2.1 Configuration and Operation: The *fishway entrance* gate configuration and operation may vary based on site-specific project operations and streamflow characteristics. Entrance gates are usually operated in either a fully open or fully closed position, with the operating entrance dependent on *tailrace* flow characteristics. Sites with limited *tailwater* fluctuation may not require an entrance gate to regulate the entrance head. Adjustable *weir* gates that rise and fall with *tailwater* elevation may also be used to regulate the *fishway* entrance head. Other sites may accommodate maintaining proper entrance head by regulating auxiliary water flow through a fixed geometry entrance gate.

4.2.2.2 Location: *Fishway* entrances must be located at points where fish can easily locate the *attraction flow* and enter the *fishway*. When choosing an entrance location, high velocity and turbulent zones in a powerhouse or spillway *tailrace* should be avoided in favor of relatively tranquil zones adjacent to these areas. At locations where the *tailrace* is wide, shallow, and turbulent, excavation to create a deeper, less turbulent holding zone adjacent to the *fishway entrance(s)* may be required.

4.2.2.3 Attraction Flow: *Attraction flow* from the *fishway* entrance should be between 5% and 10% of fish passage design high flow (see Section 3) for streams with mean annual streamflows exceeding 1000 cfs. For smaller streams, when feasible, use larger percentages (up to 100%) of streamflow. Generally speaking, the higher percentages of total river flow used for attraction into the *fishway*, the more effective the facility will be in providing upstream passage. Some situations may require more than 10% of the passage design high flow, if site features obscure approach routes to the passage facility.

4.2.2.4 Hydraulic Drop: The *fishway entrance hydraulic drop* (also called entrance head) must be maintained between 1 and 1.5 feet, depending on the species present at the site, and designed to operate from 0.5 to 2.0 feet of *hydraulic drop*.

4.2.2.5 Dimensions: The minimum *fishway* entrance width should be 4 feet, and the entrance depth should be at least 6 feet, although the shape of the entrance is dependent on *attraction flow* requirements and should be shaped to accommodate site conditions. Also, see requirements for mainstem Columbia and Snake Rivers in Section 9.

4.2.2.6 Additional Entrances: If the site has multiple zones where fish accumulate, each zone must have a minimum of one entrance. For long powerhouses or dams, additional entrances may be required. Since *tailrace* hydraulic conditions usually change with project operations and hydrologic events, it is often necessary to provide two or more *fishway* entrances. Closure gates must be provided to direct flow to the appropriate entrance gate, and gate stems (or other adjustment mechanisms) must not be placed in any potential path of fish migration. Fishway entrances must be equipped with downward-closing slide gates, unless otherwise approved by NMFS.

4.2.2.7 Types of Entrances: *Fishway entrances* may be adjustable submerged *weir*s, vertical slots, orifices, or other shapes, provided that the requirements specified in Section 4.2.2 are achieved. Some salmonid species will avoid using orifices, and at these sites, orifices should not be used.

4.2.2.8 Flow Conditions: The desired flow condition for entrance *weir* and/or slot discharge jet hydraulics is *streaming flow*. *Plunging flow* induces jumping and may cause injuries, and it presents hydraulic condition that some species may not be able to pass. *Streaming flow* may be accomplished by placing the entrance *weir* (or invert of the slot) elevation such that flow over the *weir* falls into a receiving pool with water surface elevation above the *weir* crest elevation (Katapodis 1992).

4.2.2.9 Orientation: Generally, low flow entrances should be oriented nearly perpendicular to streamflow, and high flow entrances should be oriented to be more parallel to streamflow. However, you must conduct site-specific assessments to determine entrance location and entrance jet orientation.

4.2.2.10 Staff Gages: The *fishway entrance* design must include staff gages to allow for a simple determination of whether entrance head criterion (see Section 4.2.2.4) is met. Staff gages must be located in the entrance pool and in the *tailwater* just outside of the *fishway entrance,* in an area visible from an easy point of access. Care should be taken when locating staff gages by avoiding placement in turbulent areas and locations where flow is accelerating toward the *fishway* entrance. Gages should be readily accessible to facilitate in-season cleaning.

4.2.2.11 Entrance Pools: The *fishway entrance* pool is at the lowest elevation of the upstream passage system. It discharges flow into the *tailrace* through the entrance gates for the purpose of attracting upstream migrants. In many *fish ladder* systems, the entrance pool is the largest and most important pool, in terms of providing proper guidance of fish to the ladder section of the *upstream passage facility*. It combines ladder flow with *auxiliary water system (AWS)* flow through *diffuser* gratings to form entrance *attraction flow* (see Section 4.3). The entrance pool must be configured to readily guide fish toward ladder *weir*s or slots.

4.2.2.12 Transport Velocity: Transport velocities between the *fishway* entrance and first *fishway weir*, fishway channels, and over submerged *fishway weir*s must be between 1.5 and 4.0 ft/s.

4.2.2.13 Entrance Pool Geometry: The *fishway* entrance pool geometry must be designed to optimize attraction to the lower *fishway weirs*. This may be accomplished by angling vertical AWS *diffuser*s toward and terminating near the lowest ladder *fishway weir,* or by placing primary *attraction flow*s near the lower *fishway weir.* The pool geometry will normally influence the location of *attraction flow diffuser*s.

4.3 Auxiliary Water Systems

4.3.1 Description and Purpose – Auxiliary Water Systems

*Auxiliary water system*s must be used when *attraction flow*s less than specified by Section 4.2.2.3 are routed from the project *forebay* into the *fish ladder*. AWS flow is usually routed from the *forebay* or pumped from the *tailrace*, through a *fine trash rack* or intake screen, through a back set flow control gate, then an energy dissipation zone consisting of energy *baffles* and/or *diffuser*s, and into the *fishway*. An AWS provides additional *attraction flow* from the entrance pool through the *fishway entrance*, and may also provide flow to an area between *fishway weir*s that on occasion become back-watered and fail to meet the criterion specified in Section 4.2.2.12. In addition, the AWS is used to provide make-up flows to various transition pools in the ladder such as *bifurcation* or *trifurcation* pools, trap pools, *exit control section*s, or counting station pools.

4.3.2 Specific Criteria and Guidelines – AWS Diffusers

Vertical *diffuser*s consist of non-corrosive, vertically-oriented *diffuser* panels of vertically-oriented flat bar stock, and must have a maximum 1-inch clear spacing. Similarly, horizontal *diffuser*s consist of non-corrosive, horizontally-oriented *diffuser* panels of horizontally-oriented flat bar stock, and must have a maximum 1-inch clear spacing. Orientation of flat bar stock must maximize the open area of the *diffuser* panel. If a smaller species or life stage of fish is present, smaller clear spacing may be required.

4.3.2.1 Velocity and Orientation: The maximum AWS *diffuser* velocity must be less than 1.0 ft/s for vertical *diffuser*s and 0.5 ft/s for horizontal *diffuser*s, based on total *diffuser* panel area. Vertical *diffuser*s should only be used in appropriate orientation to assist in guiding fish within the *fishway*. *Diffuser* velocities should be nearly uniform.

4.3.2.2 Debris Removal: The AWS design must include access for debris removal from each *diffuser,* unless the AWS intake is equipped with a juvenile fish screen, as described in Section 11 and if required by Section 4.3.4.

4.3.2.3 Edges: All flat-bar *diffuser* edges and surfaces exposed to fish must be rounded or ground smooth to the touch, with all edges aligning in a single smooth plane to reduce the potential for contact injury.

4.3.2.4 Elevation: Vertical AWS *diffuser*s must have a top elevation at or below the low design entrance pool water surface elevation.

4.3.3 Specific Criteria and Guidelines– AWS Fine Trash Racks

A *fine trash rack* must be provided at the AWS intake with clear space between the vertical flat bars of $^{7}/_{8}$ inch or less, and maximum velocity must be less than 1 ft/s, as calculated by dividing the maximum flow by the entire *fine trash rack* area. The support structure for the *fine trash rack* must not interfere with cleaning requirements and must provide access for debris raking and removal. The *fine trash rack* should be installed at a 1:5 (horizontal:vertical) slope (or flatter) for ease of cleaning. The *fine trash rack* design must allow for easy maintenance, considering access for personnel, travel clearances for manual or automated raking, and removal of debris

4.3.3.1 Staff Gages and Head Differential: Staff gages must be installed to indicate head differential across the AWS intake *fine trash rack*, and must be located to facilitate observation and in-season cleaning. Head differential across the AWS intake must not exceed 0.3 feet.

4.3.3.2 Structural Integrity: AWS intake *fine trash racks* must be of sufficient structural integrity to avoid the permanent deformation associated with maximum occlusion.

4.3.4 Specific Criteria and Guidelines – AWS Screens

In instances where the AWS poses a risk to passage of juvenile salmonids (due to high head systems and convoluted flow paths, for example), during the period of juvenile out-migration(s) the AWS intake must be screened to the standards specified in Section 11. Trip gates or other alternate intakes to the AWS may be included in the design to ensure that AWS flow targets are achieved if the screen reliability is uncertain at higher flows. Debris and sediment issues may preclude the use of juvenile fish screen criteria for AWS intakes at certain sites. Passage risk through an AWS will be assessed by NMFS engineers on a site by site basis to determine whether screening of the AWS is warranted and to determine how to provide the highest reliability possible.

4.3.5 Specific Criteria and Guidelines – AWS Flow Control

AWS flow control may consist of a control gate, turbine intake flow control, or other flow control systems, located sufficiently far away from the AWS intake to ensure uniform flow distribution at the AWS *fine trash rack* for all AWS flows. AWS flow control is necessary to ensure that the correct quantity of AWS flow is discharged at the appropriate location during a full range of *forebay* water surface elevations.

4.3.6 Specific Criteria and Guidelines – AWS Excess Energy Dissipation

Excess energy must be dissipated from AWS flow prior to passage through *diffuser*s (Section 4.3.2). This is necessary to minimize surging and to induce relatively uniform velocity distribution at the *diffuser*s. Surging and non-uniform velocities may cause adult fish jumping and associated injuries or excess migration delay. Examples of methods to dissipate excess AWS flow energy include: (1) routing flow into the pool with adequate volume (Section 4.3.6.1), then through a *baffle* system (*porosity* less than 40%) to reduce surging through entrance pool *diffuser*s; (2) passing AWS flow through a turbine; (3) passing AWS flow through a series of valves, *weir*s or orifices; or (4) passing AWS flow through a pipeline with concentric rings or other hydraulic transitions designed to induce *headloss*.

4.3.6.1 Energy Dissipation Pool Volume: An energy dissipation pool in an AWS should have a minimum water volume established by the following formula:

$$V = \frac{(\gamma)(Q)(H)}{(16\,ft - lbs/s)/\,ft^3}$$

where: V = pool volume, in ft^3
γ = unit weight of water, 62.4 pounds (lb) per ft^3
Q = *fish ladder* flow, in ft^3/s
H = energy head of pool-to-pool flow, in feet

Note that the pool volumes required for AWS pools are smaller than those required for *fishway* pools. This is due to the need to provide resting areas in *fishway* pools, and because AWS systems require additional elements (*diffuser*s, valves, etc.) to dissipate energy, and are not pathways for *upstream fish passage*.

4.3.7 Specific Criteria and Guidelines – AWS Design (General)

4.3.7.1 Cleaning: To facilitate cleaning, the AWS must be valved or gated to provide for easy shutoff during maintenance activities, and subsequent easy reset to proper operation.

4.3.8 Bedload Removal Devices: At locations where *bedload* may cause accumulations at the AWS intake, sluice gates or other simple *bedload* removal devices should be included in the design.

4.4 Transport Channels

4.4.1 Description and Purpose – Transport Channels

A *transport channel* conveys flows between different sectors of the *upstream passage facility*, providing a route for fish to pass.

4.4.2 Specific Criteria and Guidelines – Transport Channels

4.4.2.1 Velocity Range: The *transport channel* velocities must be between 1.5 and 4 ft/s, including flow velocity over or between *fishway weir*s inundated by high *tailwater*.

4.4.2.2 Dimensions: The *transport channel*s should be a minimum of 5-feet deep and a minimum of 4-feet wide.

4.4.2.3 Lighting: Ambient natural lighting should be provided in all *transport channel*s, if possible. Otherwise, acceptable artificial lighting must be used.

4.4.2.4 Design (General):

- The *transport channel*s must be of open channel design.
- Designs must avoid hydraulic transitions or lighting transitions
- *Transport channel*s must not expose fish to any moving parts.
- *Transport channel*s must be free of exposed edges that protrude from channel walls.

4.5 Fish Ladder Design

4.5.1 Description and Purpose – Fish Ladder Design

The purpose of a *fish ladder* is to convert the *total project head* at the passage impediment into passable increments, and to provide suitable conditions for fish to hold, rest, and ultimately pass upstream. The criteria provided in this section have been developed to provide conditions to pass all anadromous salmonid species upstream with minimal delay and injury

4.5.2 Common Types of Fish Ladders

*Fish ladder*s break an impediment into passable discrete steps, by utilizing a series of *fishway weir*s to divide the drop into a series of pools with different water surface elevations. Nearly all of the energy from the upstream pool is dissipated in the downstream pool volume, resulting in a series of relatively calm pools that migrating fish may use to rest, stage and ascend upstream. Examples of *fish ladder*s include the vertical slot ladder, the pool and *weir ladder*, the *weir* and orifice ladder, and the pool-chute *fish ladder*.

4.5.2.1 Vertical Slot Ladder: The vertical slot configuration is a pool type of *fish ladder* widely used for the passage of salmon and steelhead. The passage corridor typically consists of 1.0 to 1.25 foot-wide vertical slots between *fishway* pools. However, narrower slots have been used in applications for other fish species and slots may be wider in designs (or two slots may be used per *fishway weir*) where there is no *auxiliary water system* (Section 4.3). For adult anadromous salmonids, slots should never be less than 1 foot in width. The vertical slot ladder is suitable for passage impediments which have *tailrace* and *forebay* water surface elevations that fluctuate. Maximum head differential (typically associated with lowest river flows) establishes the design water surface profile, which is on average parallel to the *fishway* floor gradient. Vertical slot ladders require fairly intricate forming for concrete placement, so initial construction costs are somewhat higher than for other types of ladders.

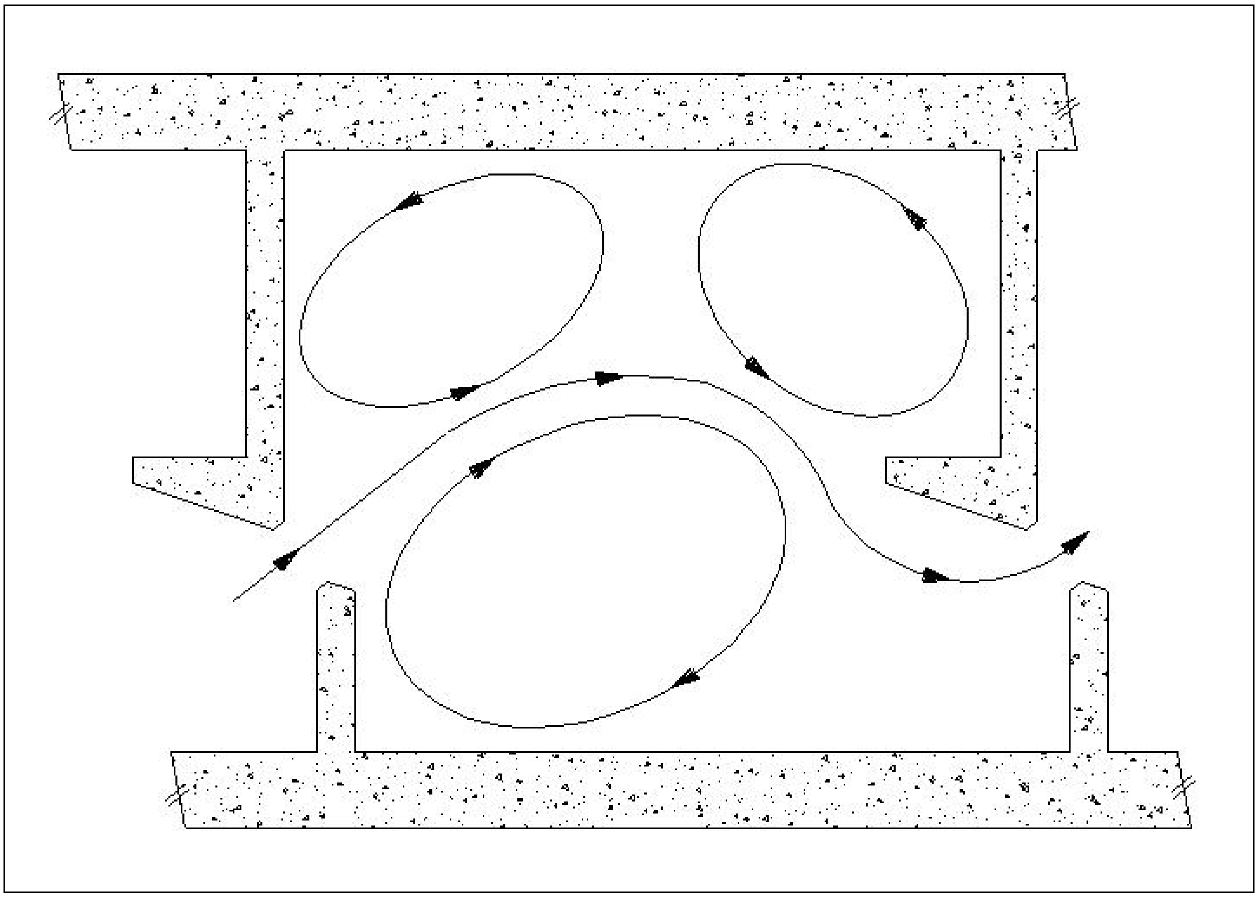


Figure 4-2a. Plan View of Vertical Slot Fishway Showing Generalized Flow Path.

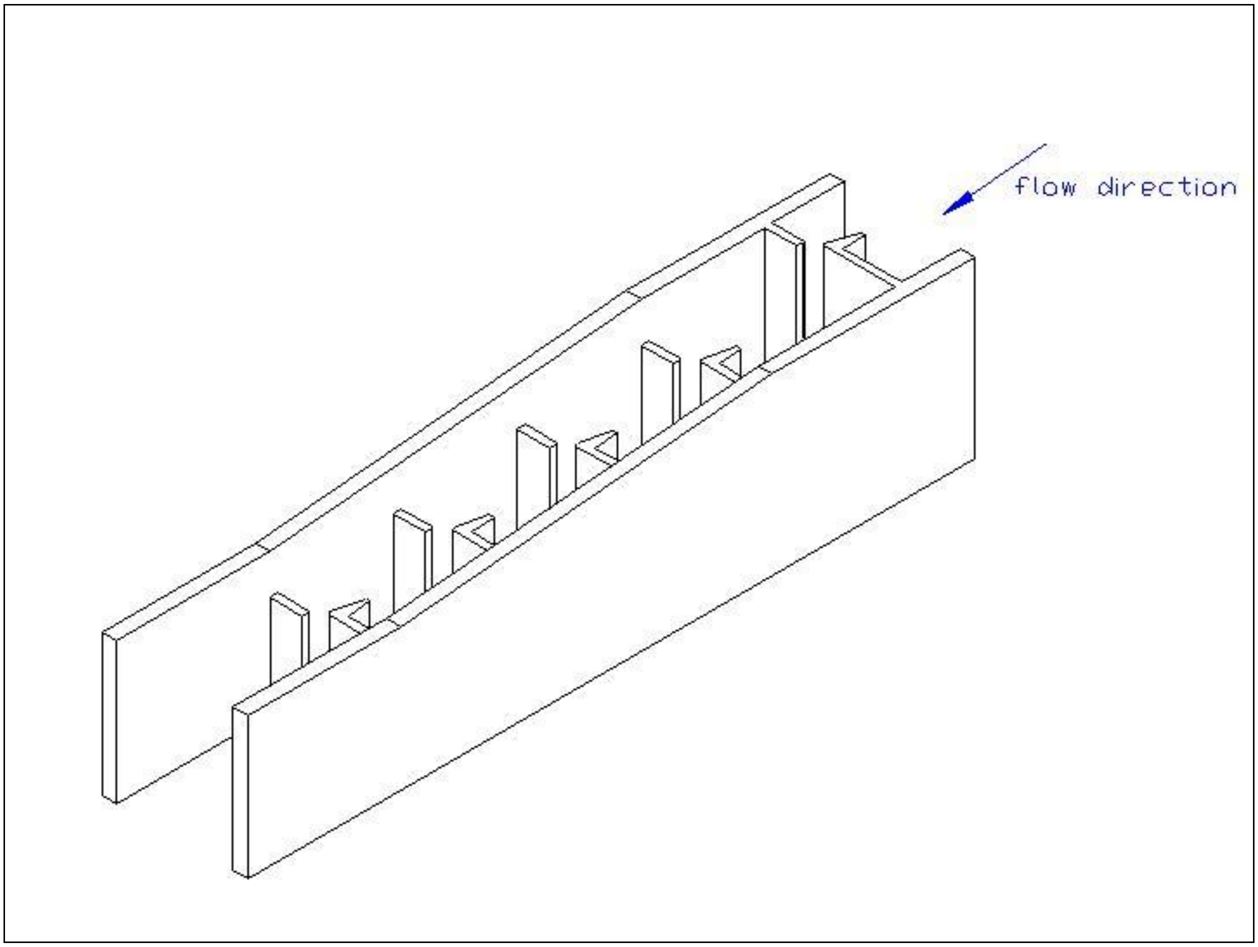


Figure 4-2b. Isometric View of Vertical Slot Fishway.

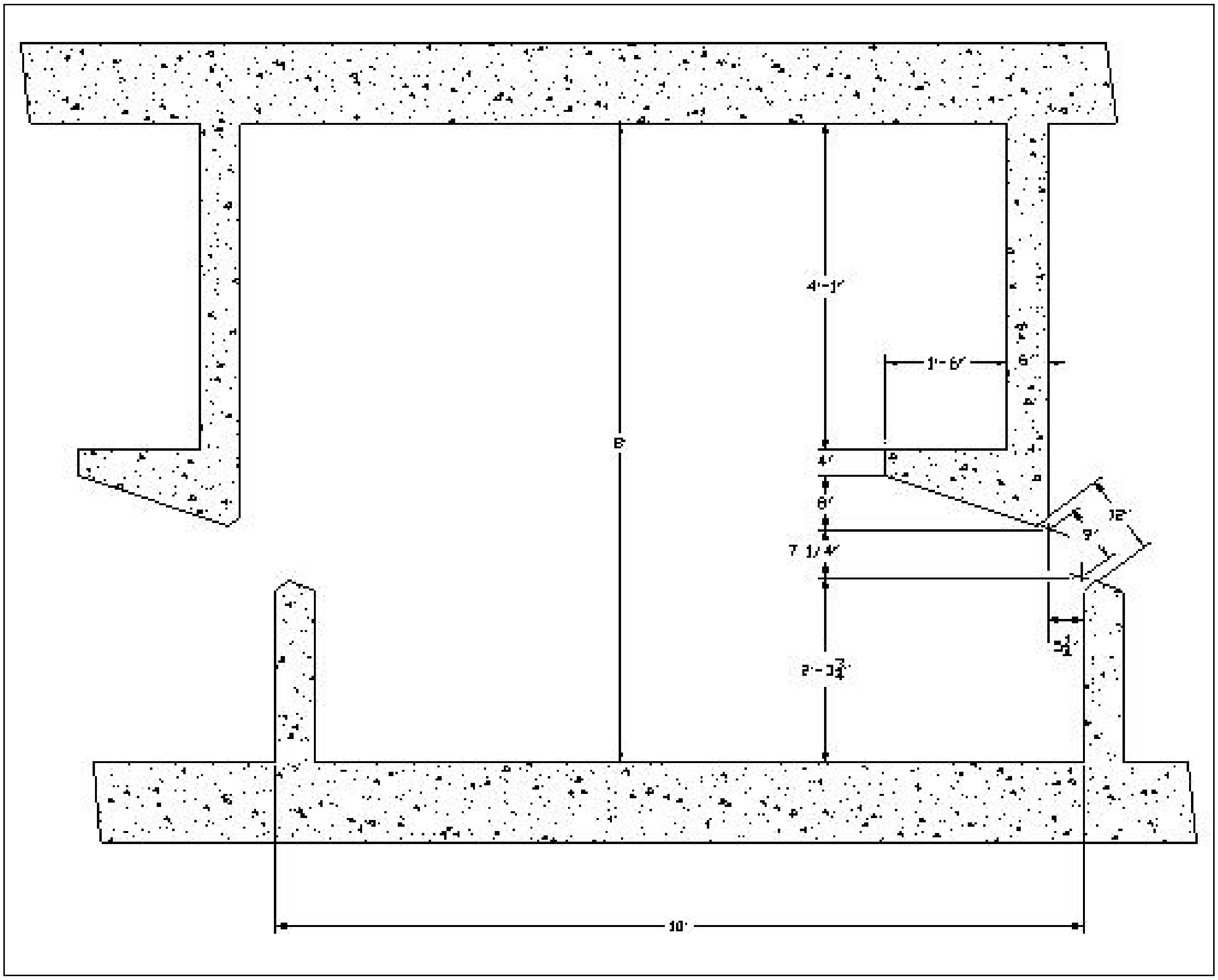


Figure 4-2c. Dimensions of a Typical Vertical Slot.

4.5.2.2 Pool and Weir Ladder: The pool and *weir fish ladder* passes the entire, nearly constant *fishway* flow through successive *fishway* pools separated by overflow *weir*s that break the *total project head* into passable increments. This design allows fish to ascend to a higher elevation by passing over a *weir*, and provides resting zones within each pool. Pools are sufficiently sized to allow for the flow energy to be nearly fully dissipated in the form of turbulence within each receiving pool. Pool and *weir* ladders cannot accommodate much, if any, water surface elevation fluctuation in the *forebay* pool. When fluctuation of water surface elevation outside of the design elevation occurs, too much or too little flow enters the *fishway*. When this happens, this flow fluctuation may lead to operation with *fishway* pools that are excessively turbulent, or provide insufficient flow for adequate upstream passage. To accommodate *forebay* fluctuations, this type of *fish ladder* is often designed with an auxiliary water supply and flow regulation (Section 4.3). To accommodate *tailwater* fluctuations, this type of *fish ladder* is often designed with an adjustable *fishway* entrance (i.e., adjustable geometry and/or *attraction flow*) and additional add-in flow *diffuser*s to meet *transport channel* velocity criterion (Section 4.4).

4.5.2.3 Weir and Orifice Fish Ladder: The *weir* and orifice *fish ladder* passes the *fishway* flow from the *forebay* through successive *fishway* pools connected by overflow *weir*s and orifices, which divide the *total project head* into passable increments.

The Ice Harbor ladder is an example of a *weir* and orifice *fish ladder*. This ladder design was initially developed for use at Ice Harbor Dam (Lower Snake River), in the middle of the 1960's. The Ice Harbor *fishway weir* consists of two orifices, centered and directly below two *weir*s. These orifice and *weir* combinations are located on each side of the longitudinal centerline of the ladder. Between the two *weir*s is a slightly higher non-overflow wall, with an upstream projecting flow *baffle* at each end. An adaptation for lower flow designs is the Half-Ice Harbor ladder design, which consists of one *weir*, one orifice, and a non-overflow wall between *fishway* pools.

Weir and orifice ladders cannot accommodate much, if any, water surface elevation fluctuation in the *forebay* pool. When fluctuation of water surface elevation outside of the design elevation occurs, too much or too little flow enters the *fishway*. When this happens, this flow fluctuation may lead to operation with *fishway* pools that are excessively turbulent, or provide insufficient flow for adequate upstream passage. To accommodate *forebay* fluctuations, this type of *fish ladder* is often designed with an auxiliary water supply and flow regulating section (Sections 4.3). To accommodate *tailwater* fluctuations, this type of *fish ladder* is often designed with an adjustable *fishway* entrance (i.e., adjustable geometry and/or *attraction flow*) and additional add-in flow *diffuser*s to meet *transport channel* velocity criterion (Section 4.4).

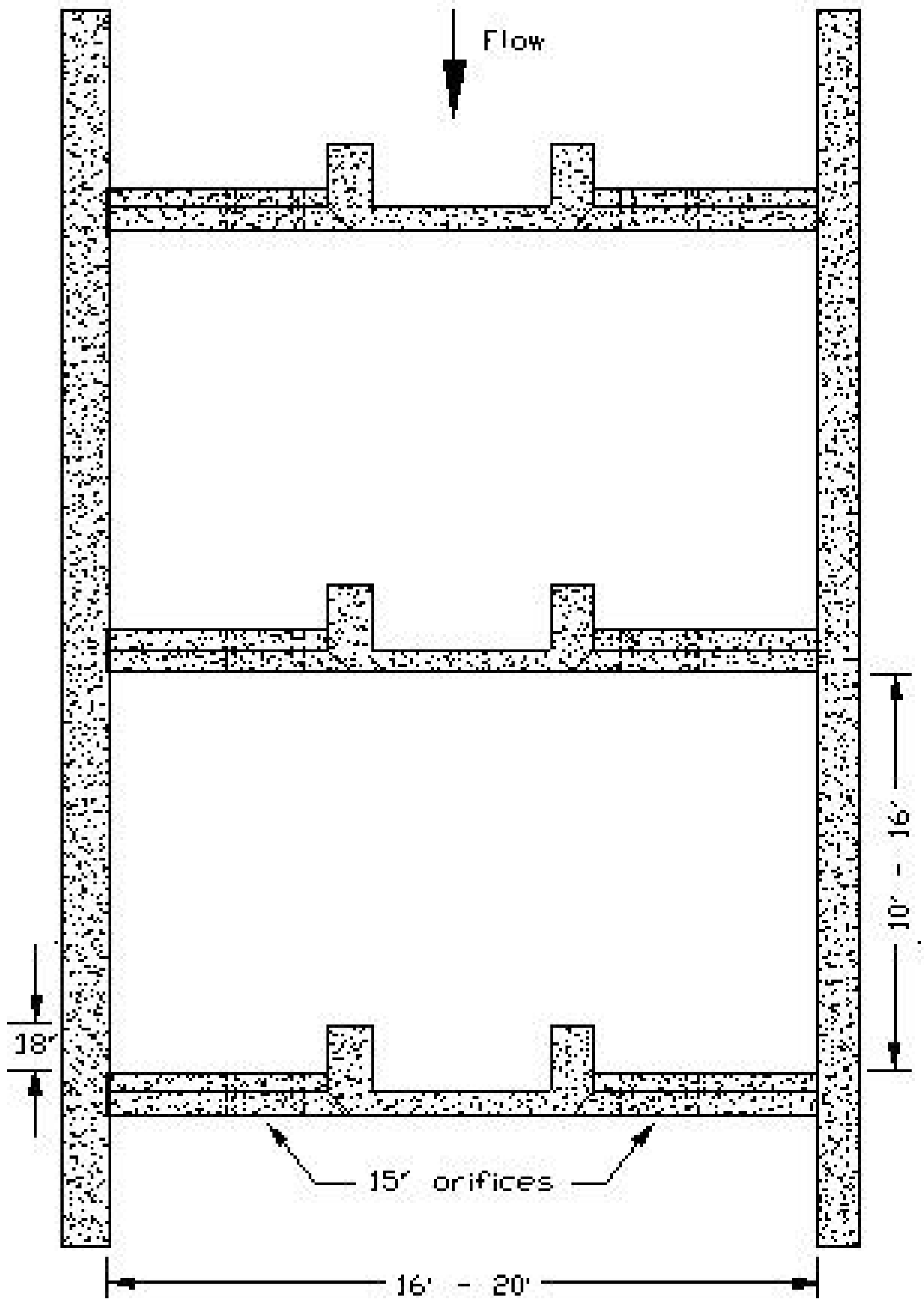


Figure 4-3a. Plan View of an Ice Harbor Type Weir and Orifice Fish Ladder

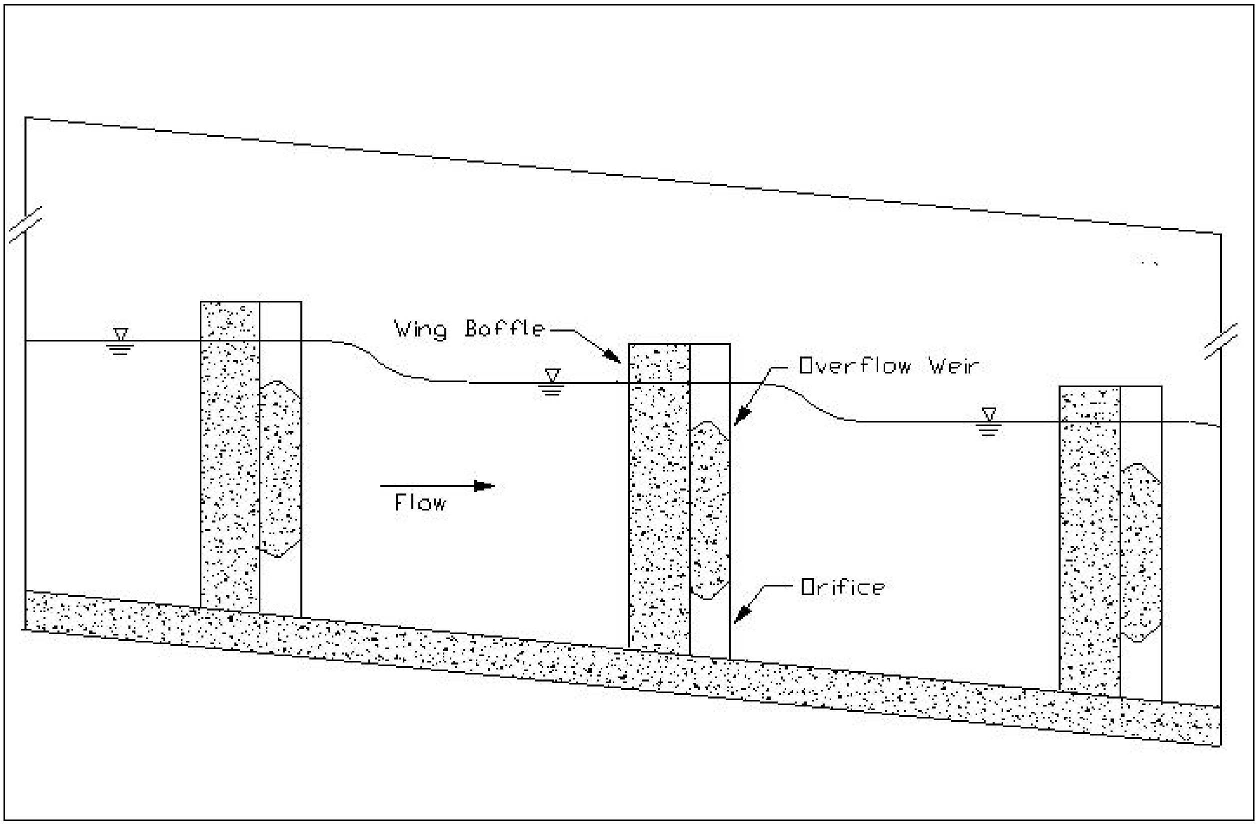


Figure 4-3b. Longitudinal Cross-section of an Ice Harbor Type Weir and Orifice Fish Ladder

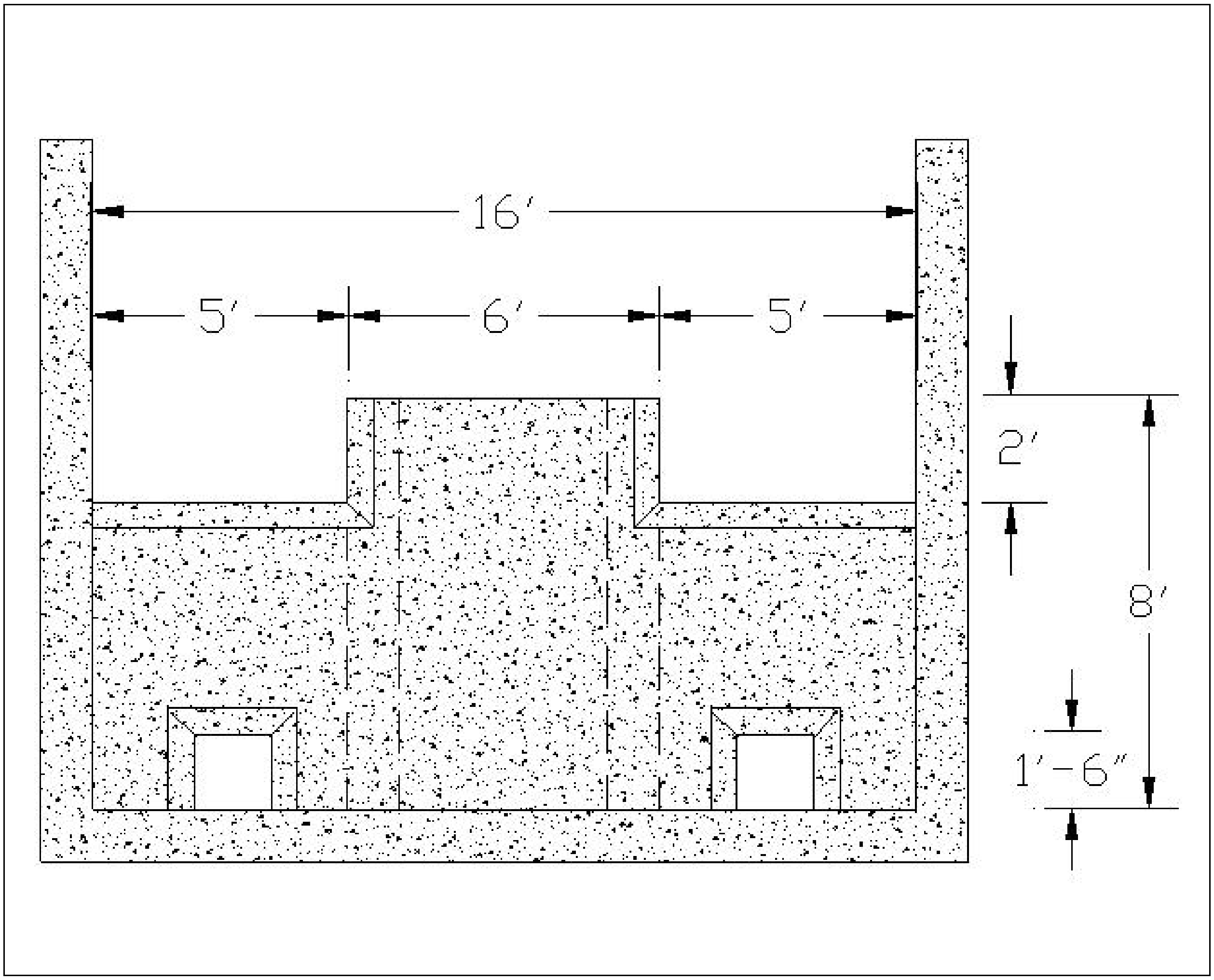


Figure 4-3c. Front View Cross-section of Ice Harbor Fishway Baffle

4.5.2.4 Pool-Chute Fish Ladder: A pool and chute *fishway* is a hybrid type of *fishway* which operates with different flow regimes under different river conditions. This *fishway* is designed to operate as a pool and *weir fishway* at low river flows and a baffled chute *fishway* at higher river flows. This *fishway* offers an alternative for sites that have fairly low *hydraulic drop*, and must pass a wide range of stream flows with a minimum of flow control features. Placement of stoplogs, a cumbersome and potentially hazardous operation, is required to optimize operation. However, once suitable flow regimes are established, the need for additional stoplog placement may not be required. Criteria for this type of *fishway* design are still evolving, and design proposals will be assessed on a site-specific basis.

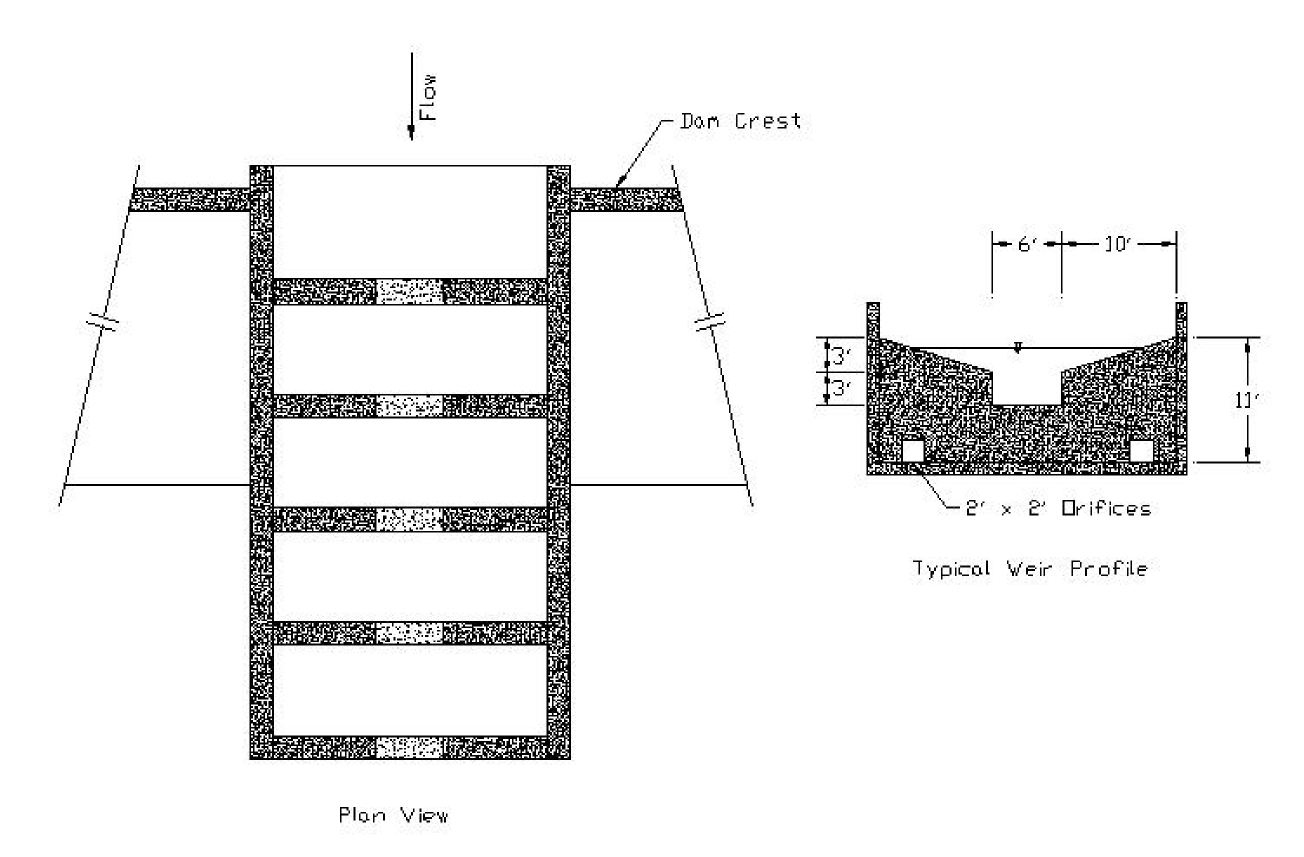


Figure 4-4. Pool and Chute Fishway

4.5.3 Specific Criteria and Guidelines – Fish Ladder Design

4.5.3.1 Hydraulic Drop: The maximum *hydraulic drop* between *fish ladder* pools must be 1 foot or less.

4.5.3.2 Flow Depth: *Fishway* overflow *weir*s should be designed to provide at least 1 foot of flow depth over the *weir* crest. The depth must be indicated by locating a single staff gage (with the zero reading at the overflow *weir* crest elevation) in an observable, hydraulically stable location, representative of flow depth throughout the fishway.

4.5.3.3. Pool Dimensions: The pool dimensions should be a minimum of 8 feet long (upstream to downstream), 6 feet wide, and 5 feet deep. However, specific ladder designs may require pool dimensions that are different than the minimums specified here depending on site conditions and ladder flows.

4.5.3.4 Turning Pools: Turning pools (i.e., where the *fishway* bends more than 90°) should be at least double the length of a standard *fishway* pool, as measured along the centerline of the *fishway* flow path. The orientation of the upstream *weir* to the downstream *weir* must be such that energy from flow over the upstream *weir* does not affect the hydraulics of the downstream *weir*.

4.5.3.5 Pool Volume: The *fishway* pools must be a minimum water volume of:

$$V = \frac{(\gamma)(Q)(H)}{(4\ ft - lbs/s)/ft^3}$$

where: V = pool volume, in ft^3
γ = unit weight of water, 62.4 pounds (lb) per ft^3
Q = *fish ladder* flow, in ft^3/s
H = energy head of pool-to-pool flow, in feet

This pool volume must be provided under every expected design flow condition, with the entire pool volume having active flow and contributing to energy dissipation.

4.5.3.6 Freeboard: The *freeboard* of the ladder pools must be at least 3 feet at high design flow.

4.5.3.7 Orifice Dimensions: The dimensions of orifices should be at least 15 inches high by 12 inches wide, with the top and sides chamfered 0.75 inches on the upstream side, and chamfered 1.5 inches on the downstream side of the orifice.

4.5.3.8 Lighting: Ambient lighting is preferred throughout the *fishway*, and in all cases abrupt lighting changes must be avoided.

4.5.3.9 Change in Flow Direction: At locations where the flow changes direction more than 60°, 45° vertical miters or a 2 foot vertical radius of curvature must be included at the outside corners of *fishway* pools.

4.6 Counting Stations

4.6.1 Description and Purpose – Counting Stations

A counting station provides a location to observe and enumerate fish utilizing the fish passage facility. Although not always required, a typical counting station including a camera or fish count technician, *crowder,* and counting window is often included in a *fishway* design to allow fishery managers to assess fish populations, provide observations on fish health, or conduct scientific research. Other types of counting stations (such as submerged cameras, adult PIT-*tag detectors*, or orifice counting tubes) may be acceptable, but they must not interfere with the normal operation of the ladder or increase fish passage delay.

4.6.2 Specific Criteria and Guidelines – Counting Stations

4.6.2.1 Location: Counting stations must be located in a hydraulically stable, low velocity (i.e., around 1.5 ft/sec), accessible area of the *upstream passage facility*.

4.6.2.2 Downstream/Upstream Pools: The pool downstream of the counting station must extend at least two standard *fishway* pool lengths from the downstream end of the *picket leads*. The pool upstream of the counting station must extend at least one standard *fishway* pool length from the upstream end of the *picket leads*. Both pools must be straight and in line with the counting station.

4.6.3 Specific Criteria and Guidelines – Counting Window

4.6.3.1 Design and Material: The counting window must be designed to allow complete, convenient cleaning with sufficient frequency to ensure sustained window visibility and accurate counts. The counting window material must be of sufficient abrasion resistance to allow frequent cleaning.

4.6.3.2 Orientation: Counting windows must be vertically oriented.

4.6.3.3 Sill: The counting window sill should be positioned to allow full viewing of the passage slot.

4.6.3.4 Lighting: The counting window design must include sufficient indirect artificial lighting to provide satisfactory fish identification at all hours of operation, without causing passage delay.

4.6.3.5 Dimensions: The minimum observable width (i.e., upstream to downstream dimension) of the counting window must be 5 feet, and the minimum height (depth) should be full water depth (also see Section 4.6.3.6).

4.6.3.6 Width: The minimum width of the counting station slot between the counting window and back vertical counting window surface should be 18 inches. The design must include an adjustable *crowder* to move fish closer to the counting window to allow fish counting under turbid water conditions. The counting window slot width should be maximized as water clarity allows, and when not actively counting fish.

4.6.3.7 Picket Lead: To guide fish into the counting window slot, a downstream picket lead must be included in the design. The downstream picket lead must be oriented at a deflection angle of 45° relative to the direction of *fishway* flow. An upstream picket lead oriented 45° to the flow direction must also be provided. Picket orientation, picket clearance, and maximum allowable velocity must conform to specifications for *diffuser*s (Section 4.3.2). *Picket leads* may be comprised of flat stock bars oriented parallel to flow, or other cross-sectional shapes, if approved by NMFS. Combined maximum head differential through both sets of *pickets* must be less than 0.3 feet. Both upstream and downstream *picket leads* must be equipped with "witness marks" to verify correct position when *picket leads* are installed in the *fishway*. A one foot square opening should be provided in the upstream picket lead to allow escape if smaller fish pass through the downstream picket lead.

4.6.3.8 Transition Ramps: To minimize flow separations created by *head loss* that may impede passage and induce fallback behavior at the counting window, transition ramps must be included. These ramps provide gradual transitions between walls, floors and the count window slot. As general guidance, these transitions should be more gradual than 1:8 (vertical:horizontal). A free water surface must exist over a counting window.

4.7 Fishway Exit Section

4.7.1 Description and Purpose – Fishway Exit Section

The *fishway* exit section provides a flow channel for fish to egress through the *fishway* and continue on their upstream migration. The exit section of *upstream fish passage* facilities may include the following features: add-in auxiliary water valves and/or *diffuser*s, exit pools with varied flow, exit channels, *coarse trash rack* (for fish passage), and auxiliary water *fine trash racks* and control gates. One function of the exit section is to attenuate *forebay* water surface elevation fluctuation, thus maintaining hydraulic conditions suitable for fish passage in ladder pools. Other functions should include minimizing the entrainment of debris and sediment into the *fish ladder*. Different types of ladder designs (Section 4.5) require specific *fish ladder* exit design details.

4.7.2 Specific Criteria and Guidelines – Fishway Exit Section

4.7.2.1 Hydraulic Drop: The *exit control section hydraulic drop* per pool should range from 0.25 to 1.0 feet.

4.7.2.2 Length: The length of the exit channel upstream of the *exit control section* should be a minimum of two standard ladder pools.

4.7.2.3 Design Requirements: Exit section design must utilize the requirements for auxiliary water *diffuser*s, channel geometry, and energy dissipation as specified in Sections 4.3, 4.4 and 4.5.

4.7.2.4 Location: In most cases, the ladder exit should be located along a shoreline and in a velocity zone of less than 4 ft/s, sufficiently far enough upstream of a spillway, sluiceway or powerhouse to minimize the risk of fish non-volitionally falling back through these routes. Distance of the ladder exit with respect to the hazards depends on bathymetry near the dam spillway or crest, and associated longitudinal river velocities.

4.7.2.5 Public Access: Public access near the ladder exit should not be allowed.

4.8 Fishway Exit Sediment and Debris Management

4.8.1 Description and Purpose – Fishway Exit Sediment and Debris Management

For large facilities where maintenance is frequently required and provided, *coarse trash racks* should be included at the *fishway* exit, to minimize the entrainment of debris into the *fishway*. Floating debris may partially block passage corridors, potentially creating hazardous passage zones and/or blocking fish passage. Other types of debris, such as sediment transport into the *fishway*, may also adversely affect the operation of the facility.

4.8.2 Specific Criteria and Guidelines – Coarse Trash Rack

4.8.2.1 Velocity: The velocity through the gross area of a clean *coarse trash rack* should be less than 1.5 ft/s.

4.8.2.2 Depth: The depth of flow through a *coarse trash rack* should be equal to the pool depth in the *fishway*.

4.8.2.3 Maintenance: The *coarse trash rack* should be installed at 1:5 (horizontal:vertical) slope (or flatter) for ease of cleaning. The *coarse trash rack* design must allow for easy maintenance, considering access for personnel, travel clearances for manual or automated raking, and removal of debris.

4.8.2.5 Bar Spacing: The *fishway* exit *coarse trash rack* should have a minimum clear space between vertical flat bars of 10 inches if Chinook salmon are present, and 8 inches in all other instances. Lateral support bar spacing must be a minimum of 24 inches, and must be sufficiently back set of the *coarse trash rack* face to allow full trash rake tine penetration. *Coarse trash racks* must extend to the appropriate elevation above water to allow easy removal of raked debris.

4.8.2.6 Orientation: The *fishway* exit *coarse trash rack* must be oriented at a deflection angle greater than 45° relative to the direction of river flow.

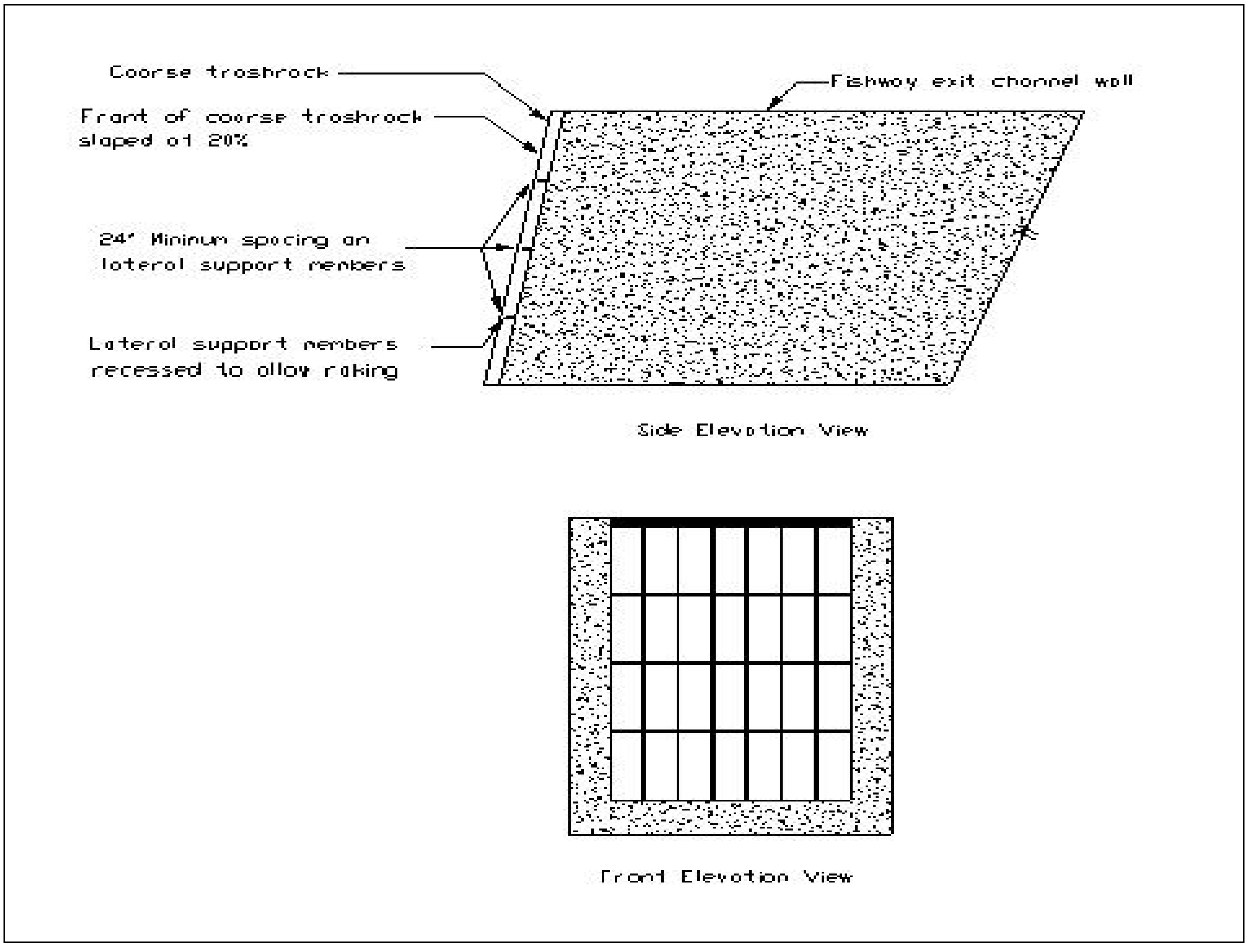


Figure 4-5. Coarse Trashrack

4.8.3 Specific Criteria and Guidelines – Debris and Sediment

4.8.3.1 Coarse Floating Debris: Debris booms, curtain walls, or other provisions must be included in design if coarse floating debris is expected.

4.8.3.2 Debris Accumulation: If debris accumulation is expected to be high, the design should include an automated mechanical debris removal system. If debris accumulation potential is unknown, the design should anticipate the need in the future and include features to allow possible retrofit of an automated mechanical debris removal system.

4.8.3.2 Sediment Entrainment and Accumulation:

- The *fishway* exit should be designed to minimize entrainment of sediment.
- The facility should be designed such that it does not accumulate sediment or debris during normal operation.

4.9 Miscellaneous Considerations

4.9.1 Specific Criteria and Guidelines – Miscellaneous

4.9.1.1 Security: *Fishway*s should be secured to discourage vandalism, preclude poaching opportunity, and to provide public safety.

4.9.1.2 Lighting: Natural lighting should be consistently provided throughout the *fishway*. Where this is not possible (such as in tunnels), artificial lighting should be provided in the blue-green spectral range. Lighting must be designed to operate under all environmental conditions at the installation.

4.9.1.3 Access: Personnel access must be provided to all areas of the *fishway*, to facilitate operational and maintenance requirements. Walkway grating should allow as much ambient lighting into the *fishway* as possible.

4.9.1.4 Edge/Surface Finishes: All metal edges in the flow path used for fish migration must be ground smooth to minimize risk of lacerations. Concrete surfaces must be finished to ensure smooth surfaces, with one-inch wide 45° corner chamfers.

4.9.1.5 Protrusions: Protrusions (such as valve stems, bolts, gate operators, pipe flanges etc.) must not extend into the flow path of the *fishway*.

4.9.1.6 Exposed Control Gates: All control gates exposed to fish (for example, entrances in the fully-open position) must have a shroud or be recessed to minimize or eliminate fish contact.

4.9.1.7 Maintenance Activities: To ensure fish safety during in-season fishway maintenance activities, all *fish ladder*s must be designed to provide a safe egress route or safe holding areas for fish prior to any temporary (i.e., less than 24 hours) dewatering. Longer periods of fishway dewatering for scheduled ladder maintenance must occur outside of the passage season with safeguards in place to allow evacuation of fish in a safe manner.

4.10 Roughened Chutes

4.10.1 Description and Purpose – Roughened Chutes

Another general type of fish passage system is the roughened chute, which consists of a hydraulically roughened channel with near continuous energy dissipation throughout its length. Three examples of a roughened chute passage are a *baffled* chute (including steeppass and Denil *fishway*s) (Section 4.10.2.1), a roughened channels (Section 4.10.2.2) and full width stream *weirs* (Section 4.10.2.3).

4.10.2 Types of Roughened Chutes

4.10.2.1 Baffled Chutes (Denil and Steeppass Fishways): Denil and steeppass *fishway*s are examples of roughened chute *fishway*s and are of similar design philosophy. This type of *fishway* has excellent fish attraction characteristics when properly sited and provides good passage conditions using relatively low flow amounts. Denil and steeppass *fishway*s are used mainly for sites where the fishway can be closely monitored, such as off-ladder fish trap designs or temporary fishways used during construction of permanent passage facilities. Debris accumulation in any fishway, in combination with turbulent flow, may injure fish or render the fishway impassable. Because of their baffle geometry and narrow flow paths, Denil and steeppass *fishway*s are especially susceptible to debris accumulation. As such, they must not be used in areas where downstream passage occurs, or where even minor amounts of debris are expected.

Denil and steeppass *fishway*s are designed with a sloped channel that has a constant discharge for a given normal depth, chute gradient, and *baffle* configuration. Energy is dissipated consistently throughout the length of the *fishway* via channel roughness, and results in an average velocity compatible with the swimming ability of adult salmonids. The passage corridor consists of a chute flow between and through the *baffles*. There are unique aspects of Denil or steeppass *fishway*s that need to be carefully considered. First, there are no resting locations within a given length of Denil and steeppass *fishway*s. Therefore, once a fish starts to ascend a length of a steeppass or Denil, it must pass all the way upstream and exit the fishway, or risk injury when falling back downstream. If the Denil or steeppass *fishway* is long, intermediate resting pools may be included in the design, located at intervals determined by the swimming ability of the weakest target species.

The Denil *fishway* generally is designed with slopes up to 20%, and has higher flow capacity and less roughness than a steeppass *fishway*. Steeppass *fishway*s may be used at slopes up to 28%. For either *fishway*, the average chute design velocity should be less than 5 ft/s. For an *upstream passage facility* utilizing a Denil or a steeppass ladder, the horizontal distance between resting pools should be less than 25 feet. Resting pool volumes must adhere to volume requirements specified in Section 4.5.3.5. The minimum flow depth in a Denil *fishway* should be 2 feet, and in a steeppass *fishway* the minimum flow depth should be 1.5 feet, and depth must be consistent throughout the *fishway* for all ladder flows. Denil and steeppass *fishway*s must be located to minimize the potential for fallback of fish.

4.10.2.2 Roughened Channels: Another general category of *upstream fish passage* is termed a roughened channel, where design involves the selection of appropriately sized streambed material placed in such a way as to mimic the configuration in the natural streambed. These are also referred to as stream or streambed simulation, rock channels, or nature-like *fishway*s. By replicating natural stream conditions, a wide variety of life stages and species of fish may be able to utilize the roughened channel for passage. In addition, roughened channels may provide additional benefits to other species such as insects, mollusks, and crustaceans. Roughened channels may not always be the appropriate design choice. This is a relatively new technology without a developed and proven design methodology, and the effectiveness for passing specific species and life stages over a wide flow range, and the long term durability of a wide range of designs has yet to be established. It is expected that through careful engineering and construction techniques, and through monitoring of design uncertainties over time, especially regarding the durability of the roughened channel structure, future design uncertainty can be reduced. If passage conditions in the constructed roughened channel can be achieved that are similar to the downstream passage conditions in the natural stream, there is reason to expect that a properly constructed roughened channel may pass all life stages and species that arrive at the constructed roughened channel.

Designs of roughened channels vary depending on the specific site conditions. Criteria for this type of passage design are evolving, and proposals for this type of ladder assessed on a site-specific basis. In general, roughened channels should only be used when:

- Channel slope using stream simulation is less than 6%.
- Total length of passage is less than 150 feet.
- An appropriate mix of bed materials (from fines to boulder sized material) are used such that flow depths of at least 1 foot can be maintained for upstream adult salmonid passage.
- Sub-surface flow will be minimized by filling voids between larger materials with finer-sized material. Guidance on the mixture of fill material is still evolving, but general guidance is provided in Washington Department of Fish and Wildlife (WDFW) 2003.

The arrangement of bed materials should demonstrate channel complexity similar to the characteristics of the adjacent stream reaches. To minimize the potential for head-cutting to occur, discrete *hydraulic drop*s across the entire width of the roughened channel should be avoided. It should be demonstrated in the design analysis that any scouring of fines from the constructed channel will be refilled by subsequent *bedload* transport and aggradations. It is noted that if the channel roughness of adjacent stream reaches is heavily influenced by woody debris, it may be difficult to mimic this condition with any sort of constructed roughened channel.

Since this design method is an evolving technology, any site utilizing a constructed roughened channel must include an annual (at a minimum) monitoring plan at least until after a 50-year stream flow event has occurred. Monitoring must include an assessment of passage conditions and/or maintenance of original design conditions, and repaired as necessary to accomplish design passage conditions. The loss of placed bed material after a high flow event will result in loss of flow through the channel substrate, and may render a roughened channel too shallow for fish passage. Criteria for this type of *fishway* design are still evolving, and design proposals will be assessed on a site-specific basis.

4.10.2.3 Full Width Stream Weirs: Full width (i.e., full stream width) *weir*s provide fish passage by incrementally *backwatering* an impassable barrier or impediment. These structures span the entire width of the stream channel and convey the entire stream flow, breaking the *hydraulic drop* into passable increments. This is accomplished by incrementally stepping down the water surface elevation from the barrier to intersect the natural stream gradient downstream.

Unlike many of the *fishway*s described herein, these structures are not designed with auxiliary water supply systems, *trashrack*s, or a great deal of operational complexity. *Weir*s may be constructed from reinforced concrete, or in limited applications, boulders or logs. Since boulders must be large, and usually have unpredictable dimension, a result can be the lack of the desired water surface differential for the range of design streamflows. It is especially difficult to maintain the required water surface elevation differential between *weir*s (maximum of 1.0 feet) when the design must encompass a wide flow range (tens to thousands of cfs) typical in a Northwest stream. In applications that require precision rock placement for maintenance of *hydraulic drop* between *weir*s, for long-term predictability, some applications may require regular maintenance to bring the projects back to design standards. The result is additional instream work that may produce continuing impacts to habitat and fish. These factors must be considered and accommodated before choosing this design for a site.

Design of each *weir* must concentrate flow into the center of the downstream pool, and/or direct flow toward the downstream *thalweg*. This concentration is accomplished by providing a slight *weir* crest elevation decrease from each bank to the center (flow notch). Typically, the flow notch will be designed to pass the minimum instream flow, while higher stream flows pass over the entire *weir* crest. Natural *bedload* movement will fill in pools providing a scour pool area below the flow notch, and shallower fringe areas.

Scour is a critical and often underestimated design issue. If sills and *weir*s are not anchored on bedrock, a means of preventing undermining is required, using embedded anchor boulders or other such means of stabilizing the streambed. If a pool lining technique is selected to prevent undermining of the *fishway*, a minimum of 4 feet of depth should be provided in each pool and in the *tailrace* below the *fishway*. This allows for a fish to stage or hold below each *weir* before proceeding upstream. In addition, the *tailrace* area should be protected from scour to prevent lowering of the streambed, and should be monitored after high flows occur to ensure the facility remains passable. Criteria for this type of *fishway* design are still evolving, and design proposals will be assessed on a site-specific basis.

5. EXCLUSION BARRIERS

5.1 Introduction – Exclusion Barriers

Exclusion barriers are designed to minimize the attraction and stop the migration of upstream migrating fish into an area where there is no upstream egress or suitable spawning area, and to guide fish to an area where upstream migration may continue. *Exclusion barriers* may also be used to restrict movement of undesirable species into habitat. *Exclusion barriers* are designed to minimize the potential for injury of fish that are attracted to impassable routes.

Some examples of the use of *exclusion barriers* include:

- preventing fish from entering return flow from an irrigation ditch
- preventing fish from entering the *tailrace* of a power plant
- guiding fish to a trap facility for upstream transport, research, or broodstock collection
- guiding fish to a counting facility
- preventing fish from entering a channel subject to sudden flow changes
- preventing fish from entering turbine draft tubes
- preventing fish from entering channels with poor spawning gravels, poor water quality or insufficient water quantity.

5.2 Types of Exclusion Barriers

The two primary categories of *exclusion barriers* are picket barriers and velocity barriers. Another type of exclusion barrier is a vertical drop structure, which provides a jump height that exceeds the vertical leaping ability of fish. Other types of barriers, such as electric and acoustic fields, have very limited application because of inconsistent results most often attributed to varying water quality (turbidity, specific conductance).

Criteria are specific standards for fishway design, maintenance, or operation that cannot be changed without a written waiver from NMFS. For the purposes of this document, a criterion is preceded by the word “must.” In general, a specific criterion can not be changed unless there is site-specific biological rationale for doing so. An example of biological rationale that could lead to criterion waiver is a determination or confirmation by NMFS biologists that the smallest fry-sized fish will likely not be present at a proposed screen site. Therefore, the juvenile fish screen approach velocity criterion of 0.4 ft/s could be increased to match the smallest life stage expected at the screen site. A guideline is a range of values or a specific value for fishway design, maintenance or operation that may change when site-specific conditions are factored into the conceptual fishway design. For the purposes of this document guidelines are preceded by the word “should.” Guidelines should be followed in the fishway design until site-specific information indicates that a different value would provide better fish passage conditions or solve site-specific issues. An example of site-specific rationale that could lead to a modified guideline is when the maximum river depth at a site is 3 feet, as compared to the design guideline for a fishway entrance depth of 6 feet. In this example, safe and timely fish passage could be provided by modifying the guideline to match the depth in the river. It is the responsibility of the applicant to provide compelling evidence in support of any proposed waiver of criteria or modification of a guideline for NMFS approval early in the design process, well in advance of a proposed Federal action. After a decision to provide passage at a particular site has been made, the following design criteria and guidelines are applicable, in addition to those described throughout Section 3.

5.3 Picket Barriers

5.3.1 Description and Purpose – Picket Barriers

Picket barriers diffuse nearly the entire streamflow through *pickets* extending the entire width of the impassable route, sufficiently spaced to provide a physical barrier to upstream migrant fish. This category of exclusion barrier includes a fixed bar rack and a variety of hinged floating *picket weir* designs. Picket barriers usually require removal for high flow events, increasing the potential to allow passage into undesirable areas.

In general, since the likelihood of impinging fish is very high, these types of barriers cannot be used in waters containing species listed under the ESA, unless they are continually monitored by personnel on site, and have a sufficient operational plan and facility design in place to allow for timely removal of impinged or stranded fish prior to the occurrence of injury. Since debris and downstream migrant fish must pass through the *pickets*, sites for these types of *exclusion barriers* must be carefully chosen. Picket barriers must be continually monitored for debris accumulations, and debris must be removed before it concentrates flow and violates the criteria established below. As debris accumulates, the potential for the impingement of downstream migrants (e.g., juvenile salmonids, *kelts*, adult salmon, or resident fish) increases to unacceptable levels. Debris accumulations may also concentrate flow through the remainder of the open picket area, increasing the attraction of upstream migrants to these areas and thereby increasing the potential for jumping injury or successful passage into areas without egress.

5.3.2 Specific Criteria and Guidelines - Picket Barriers

5.3.2.1 Openings: The clear opening between *pickets* and between *pickets* and abutments must be less than or equal to 1 inch. A tighter opening may be required if resident species are also to be excluded by the design.

5.3.2.2 Average Design River Velocity: The average design river velocity through *pickets* should be less than 1.0 ft/s for all design flows, with maximum velocity less than 1.25 ft/s, or half the velocity of adjacent passage route flows whichever is lower. The average design velocity is calculated by dividing the flow by the total submerged picket area over the design range of stream flows. When river velocities exceed these criteria, the picket barrier must be removed.

5.3.2.3 Head Differential: The maximum head differential across the *pickets* must never exceed 0.3 feet over the clean picket condition. If this differential is exceeded, the *pickets* must be cleaned as soon as possible.

5.3.2.4 Debris and Sediment: A debris and sediment removal plan must be considered in the design that anticipates the entire range of conditions expected at the site. Debris must be removed before accumulations develop that violate the criteria specified in 5.3.2.2 and 5.3.2.3.

5.3.2.5 Orientation of Picket Barrier: *Pickets* barriers must be designed to lead fish to a safe passage route. This may be achieved by angling the picket barrier toward a safe passage route, providing nearly uniform velocities through the entire length of *pickets*, and providing sufficient *attraction flows* from a safe passage route that minimizes the potential for false attraction to the picket barrier flows.

5.3.2.6 Picket Freeboard: The minimum picket extension above the water surface at high fish passage design flow is 2 feet.

5.3.2.7 Submerged Depth: The minimum submerged depth at the picket barrier at low design discharge must be two feet for at least 10% of the river cross section at the barrier. Picket barriers should be sited where there is a relatively constant depth over the entire stream width.

5.3.2.8 Picket Porosity: The picket array must have a minimum of 40% open area.

5.3.2.9 Picket Construction Material: *Pickets* must be comprised of flat bars aligned with flow, or round columns of steel, aluminum, or durable plastic. Picket panels should be of sufficient structural integrity to withstand high streamflows.

5.3.2.10 Picket Sill: A uniform concrete sill, or an alternative approved by NMFS engineering staff, should be provided to ensure that fish do not pass under the picket barrier.

5.4 Velocity Barriers

5.4.1 Description and Purpose – Velocity Barriers

A velocity barrier consists of a *weir* and concrete *apron* combination that prevents upstream passage by producing a shallow flow depth and high velocity on the *apron*, followed by an impassable vertical jump over the *weir*. A velocity barrier does not have the previously mentioned problems of a *picketed weir* barrier, since flow passes freely over a *weir*, allowing the passage of debris and downstream migrant fish. However, since this type of barrier creates an upstream impoundment, the designer must consider *backwater* effects that may induce loss of power generation or property inundation upstream of the velocity barrier.

5.4.2 Specific Criteria and Guidelines - Velocity Barrier

5.4.2.1 Weir Height: The minimum *weir* height relative to the maximum *apron* elevation is 3.5 feet.

5.4.2.2 Apron Length: The minimum *apron* length (extending downstream from base of *weir*) is 16 feet.

5.4.2.3 Apron Slope: The minimum *apron* downstream slope is 16:1 (horizontal:vertical).

5.4.2.4 Weir Head: The maximum head over the *weir* crest is 2 feet. Other combinations of *weir* height and *weir* crest head may be approved by NMFS Hydropower Division staff on a site-specific basis.

5.4.2.5 Downstream apron elevation: The elevation of the downstream end of the *apron* must be greater than the *tailrace* water surface elevation corresponding to the high design flow.

5.4.2.6 Flow ventilation: The flow over the *weir* must be fully and continuously vented along the entire weir length, to allow a fully aerated flow nappe to develop between the *weir* crest and the *apron*. Full aeration of the flow nappe prevents an increase in water surface behind the nappe, which may allow fish to stage and jump the *weir*.

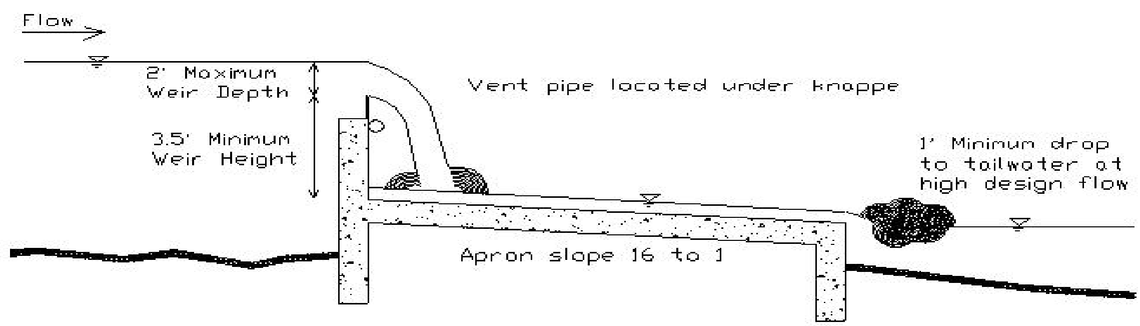


Figure 5-1. Velocity Barrier

5.5 Vertical Drop Structures

5.5.1 Description and Purpose - Vertical Drop Structures

A vertical drop structure can function as an exclusion barrier by providing *head* in excess of the leaping ability of the target fish species. These can be a concrete monolith, rubber dam, bottom-hinged leaf gate or approved alternative.

5.5.2 Specific Criteria and Guidelines – Vertical Drop Structures

5.5.2.1 Minimum Height: The minimum height for vertical drop structure must be 10 feet relative to the high design flow elevation in the *tailrace*.

5.5.2.2 Cantilever: If the potential for leaping injury exists, flow must pass over two feet or more of cantilevered ledge provided over the leaping pool.

5.5.2.3 Minimum Flow Depth: Provision must be made to ensure that fish jumping at the vertical drop structure flow will land in a minimum five foot deep pool, without contacting any solid surface.

5.6 Horizontal Draft Tube Diffusers

5.6.1 Description and Purpose – Horizontal Draft Tube Diffusers

A horizontal draft tube *diffuser* is a device used below a powerhouse at the turbine draft tube outlet to prevent fish from accessing the turbine runners, where injury may occur during start up or shut down of turbine operations, or possibly during normal operations if draft tube velocity is low (generally less than 16 ft/s). If the draft tubes are located in proximity of an upstream passage system, a horizontal draft tube *diffuser* system may be the appropriate choice for an exclusion system.

5.6.2 Specific Criteria and Guidelines – Horizontal Draft Tube Diffusers

5.6.2.1 Flow: Average velocity of flow exiting the horizontal *diffuser* grating must be less than 1.25 ft/s, and distributed as uniformly as possible. Maximum velocity should not exceed 2 ft/s.

5.6.2.2 Bar Spacing: Clear spacing between *diffuser* bars and any other pathway from the *tailrace* to the turbine runner must be less than 1 inch.

5.6.2.3 Placement: *Diffuser*s must be submerged a minimum of 2 feet for all *tailwater* elevations.

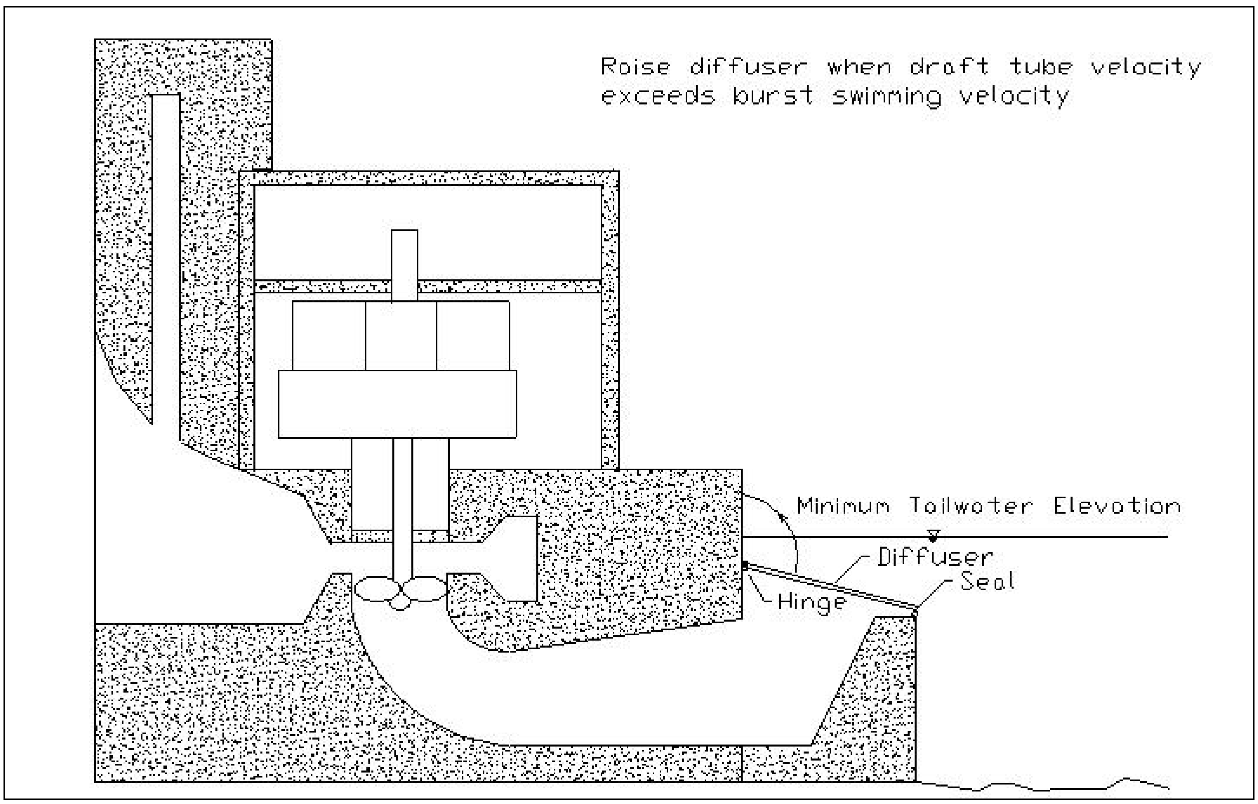


Figure 5-2. Potential Layout of a Horizontal Draft Tube Diffuser

6. ADULT FISH TRAPPING SYSTEMS

6.1 Introduction – Adult Fish Trapping Systems

In general, NMFS requires *volitional passage*, as opposed to trap and haul, for upstream passage facilities. This is primarily due to the risks associated with the handling and transport of adult upstream migrants, in combination with the long term uncertainty of funding, maintenance, and operation of the trap and haul program. Furthermore, trap and haul programs tend to not operate at the beginning and end of migration periods because there are only a few individuals present. This practice truncates the tails of the migration and likely has adverse affects on salmon population diversity. In contrast, a facility that provides for *volitional passage* can operate 24/7, year-round. Nevertheless, there are instances where trap and haul may be the only viable option for a particular site. In particular, at high head dams where thermal stratification occurs in the reservoir, temperature differentials in the *fishway* (as opposed to water temperatures below the dam) may dissuade fish from utilizing *volitional passage* facilities. In any case, NMFS' primary objective in prescribing or requiring the construction and operation of a fish passage facility is to maintain or restore the viability of anadromous fish populations.

This section addresses design aspects of adult fish trapping systems. The operations and design criteria and guidelines are dependent on each other, since the management objectives for trap operation define the facility *functional design* and must be stipulated before the trap design development can proceed.

In many cases, NMFS may not require retrofit of existing facilities to comply with criteria listed herein. It is emphasized that these criteria and guidelines are viewed as a starting point for design development of new, or upgraded, trapping facilities. This section does not directly apply to existing trapping programs/facilities, unless specifically required by NMFS.

Adult fish trapping systems may either be included in the initial design of a proposed *upstream passage facility*, or in some cases may be retro-fitted to an existing *fishway*. Traps should be designed to utilize known or observed fish behavior to benignly route fish into a trap holding pool that precludes volitional exit. From the trap holding pool, fish may be loaded for transport and/or examined for research and management purposes. Traps may be used as the terminus of volitional *upstream fish passage* followed by transport to specific sites, or as a parallel component of a *fish ladder* where fish may either be routed into an adjacent trapping loop or if the trap is closed, allow unimpeded fish passage through the *fishway*.

Criteria are specific standards for fishway design, maintenance, or operation that cannot be changed without a written waiver from NMFS. For the purposes of this document, a criterion is preceded by the word "must." In general, a specific criterion can not be changed unless there is site-specific biological rationale for doing so. An example of biological rationale that could lead to criterion waiver is a determination or confirmation by NMFS biologists that the smallest fry-sized fish will likely not be present at a proposed screen site. Therefore, the juvenile fish screen approach velocity criterion of 0.4 ft/s could be increased to match the smallest life stage expected at the screen site. A guideline is a range of values or a specific value for fishway design, maintenance or operation that may change when site-specific conditions are factored into the conceptual fishway design. For the purposes of this document guidelines are preceded by the word "should." Guidelines should be followed in the fishway design until site-specific information indicates that a different value would provide better fish passage conditions or solve site-specific issues. An example of site-specific rationale that could lead to a modified guideline is when the maximum river depth at a site is 3 feet, as compared to the design guideline for a fishway entrance depth of 6 feet. In this example, safe and timely fish passage could be provided by modifying the guideline to match the depth in the river. It is the responsibility of the applicant to provide compelling evidence in support of any proposed waiver of criteria or modification of a guideline for NMFS approval early in the design process, well in advance of a proposed Federal action. After a decision to provide passage at a particular site has been made, the following design criteria and guidelines are applicable, in addition to those described throughout Section 3.

6.2 Trap Design Scoping

- New trap construction or major upgrade proposals must address and describe the consideration of (at least) the following issues:
- Objective of trapping - count, handle, collect, interrogate for tags, etc.
- Number of fish targeted and total number potentially present
- Target species, included ESA-listed species
- Other species likely to be present at the trap, including ESA-listed species
- Environmental conditions during trap operation such as water and air temperature, flow conditions (lows and peaks), debris load, etc.
- Operation location, duration and scale
- Fish routing and ultimate destination
- Maximum duration of delay or holding within the trapping system for target and non-target fish
- Security mechanisms
- If a Hatchery and Genetic Management Plan (HGMP), 4(d) Limit 7 Scientific Research and Take Authorization application, or Section 10(a)(1)(A) permit application exists, and use these as the basis for design of a trap site. Most trap sites will require at least one of these documents.

6.3 Fish Handling

6.3.1 Specific Criteria and Guidelines – Fish Handling

6.3.1.1 Nets: Use of nets to capture or move fish must be minimized or eliminated. If nets are used they should be sanctuary type nets, with solid bottoms to allow minimal dewatering of fish. Fish must be handled with extreme care.

6.3.1.2 Anesthetization: In most cases, fish should be anesthetized before being handled. The method of anesthetization for ESA-listed anadromous salmonids may be specified by the appropriate ESA permit, which must be received prior to any directed take of listed species. In the design process and prior to permit submittal, the type of anesthetic can be selected by agreement by NMFS staff involved in trap design.

6.3.1.3 Non-Target Fish: New or upgraded trapping facilities must be designed to enable non-target fish to bypass the anesthetic tank.

6.3.1.4 Frequency: Fish must be removed from traps at least daily. When either environmental (e.g., water temperature extremes, low dissolved oxygen or high debris load) or biological conditions (e.g., migration peaks) warrant, fish must be removed more frequently to preclude crowding or adverse water quality (see Section 6.5.1.2 and 6.5.1.3).

6.3.1.5 Personnel: Individuals handling fish must be experienced or trained to ensure fish are handled safely.

6.3.1.6 Fish Ladders: *Fish ladder*s must not be completely dewatered during trapping operations, and should not experience any reduction in *fishway* flow.

6.4 General Trap Design

6.4.1 Specific Criteria and Guidelines – General Trap Design

6.4.1.1 Primary Trapping System: Primary trapping system components usually include:

- in-ladder removable diffusers or gates to block passage within the ladder and guide fish into the trap;
- an off-ladder holding pool including a transition channel or port and trapping mechanism (through which *attraction flow* is discharged via one of the devices described in Section 6.6);
- a gate to prevent fish from entering the trap area during crowding operations;
- a holding pool fish *crowder* (for encouraging adult egress from the off-ladder holding pool to sorting/loading facilities);
- separate holding pool inflow and outflow facilities;
- *distribution flume* (used with *false weir* or steeppass to enable fish entry to and/or egress from the holding pool); and
- a lock or lift for truck-loading fish.

6.4.1.2 Fish Ladders: *Fish ladder*s are the preferred means of upstream passage at impediments, unless site conditions preclude their use. This is due to the preference that fish be allowed to pass at their inclination, rather than that of a human operator. Factors to be considered include the adverse effects of holding trapped fish in a potentially high-density holding pool for an excessive period, the long-term uncertainty of maintaining funding and trained personnel, exposure to poaching or predation in the trap, injuries from jumping, facility failures (e.g., loss of water supply), and cumulative handling and holding stresses.

6.4.1.3 Location: In general, *fish ladder*s should not be designed or retrofitted with either in-ladder traps or loading facilities. Rather, trap/holding and loading facilities should be in an adjacent, off-ladder location where fish targeted for trapping purposes may be routed. This allows operational flexibility to readily switch from passage to trapping operational modes.

6.4.1.4 Distribution Flume: A *distribution flume* must be used when fish are routed to anesthetic tanks, recovery tanks, pre-transport holding tanks, fish ladders or project *forebays*. The flume must have smooth joints, sides, and bottom with no abrupt vertical or horizontal bends and have continuously wetted surfaces. Horizontal and vertical radius of curvature should be at least 5 times flume width to minimize risk of fish strike injuries. The minimum inside width (or diameter) of the *distribution flume* must be 15 inches, and the minimum sidewall height in the *distribution flume* must be 24 inches.

6.4.1.5 Water Quality: Holding pool water quality should equal or exceed that of the ambient waters from which fish are trapped. The water temperature, oxygen content, and pH must provide fish with a safe, healthy environment.

6.4.1.6 Inflow: Trap inflow must be routed through an upstream *diffuser* conforming with Section 4.3.2, with maximum 1.0 ft/s average velocity. Baffling or other energy dissipation means should be used to prevent excessive turbulence and surging, which may induce adult jumping within the trap.

6.4.1.7 Recovery Pool: Anesthetized fish must be routed to a recovery pool to allow monitoring of fish to ensure full recovery from the anesthetic effect prior to release. Fish recovering from anesthesia must not be routed directly back to the river where unobserved mortality may occur. Recovery pool inflow must satisfy the specified water quality guidelines (see Sections 6.4.1.5, 6.5.1.2, and 6.5.1.4). Recovery tank hydraulic conditions must not result in partially or fully anesthetized fish being impinged on an outflow grating or any other hazardous area. A release pool must allow fully recovered fish to volitionally exit.

6.5 Trap Holding Pool

6.5.1 Specific Guidelines and Criteria – Trap Holding Pool

For single-pool traps, refer to Section 6.9. For trap holding pools at multi-pool ladders, criteria and guidelines include:

6.5.1.1 Off-Ladder Trap System: For new or existing *fish ladder*s, fish must not be trapped and held within the ladder for intermittent sampling or truck-loading. Rather, an *off- ladder trap* system is required. This type of system allows unimpeded ladder passage during non-trapping periods, and intermittent trapping of fish for required collection or sampling. The intent is to minimize adverse impacts (such as delay and elevated jumping injury/mortality) of fish trapping by allowing rapid transition from one operational mode to the other.

6.5.1.2 Capacity, Temperature, and Dissolved Oxygen: Trap holding pools (for short term holding in *off ladder trap*s and for trap and haul facilities) must be sized to provide a minimum volume of 0.25 ft^3 per pound of fish based on trap capacity, with water temperatures less than 50° F, dissolved oxygen between 6 to 7 parts per million, and fish held less than 24 hours (Senn 1984). The trap capacity is determined by the maximum daily fish return, or by the number of fish expected to be trapped before the trap catch is transported. The poundage of fish is determined by the weight of an average fish targeted for trapping, times the maximum number of fish. Note that the poundage calculation may entail a number of different fish species. For long term holding at off ladder holding pools, (greater than 72 hours), trap holding pool water volumes should be increased by a factor of three. If water temperatures are greater than 50° F, the poundage of fish held should be reduced by 5% for each degree over 50° F. The trap capacity and average weight of targeted fish to be used in design are subject to approval by a NMFS. Also, see Section 6.3.1.4.

6.5.1.3 Water Supply and Quality: Trap holding pools (for short-term holding in *off ladder trap*s and for trap and haul facilities) must be designed with a separate water supply and drain system. Trap holding pool design water supply capacity must be at least 0.67 gallons per minute per adult fish for the predetermined adult salmon trap holding capacity, with water temperatures less than 50° F, dissolved oxygen between 6 to 7 ppm, and fish held less than 24 hours. For long term holding, (greater than 72 hours), trap holding pool flow rates should be increased by a factor of three (Senn 1984). Also, see Section 6.3.1.4.

6.5.1.4 Minimization of Adult Jumping: Trap holding pool designs must include provisions to minimize adult jumping which may result in injury or mortality. Examples include (but are not limited to): high *freeboard* on holding pool walls (5 feet or more); covering to keep fish in a darkened environment; providing netting over the pool strong enough to prevent adults from breaking through the mesh fabric; or, provision of sprinklers above the holding pool water surface to reduce the ability of fish to detect movement above the trap pool.

6.5.1.5 Pickets:

- Off-ladder holding pools should include intake and exit *pickets* designed to prevent adult egress and to conform with Section 4.3.2, and with an adjustable exit overflow *weir* located upstream of the exit *picket* to control holding pool water surface elevation.
- Removable *pickets* within the ladder (installed to block fish ascent within the ladder when fish are to be routed into an *off-ladder trap*ping pool) must be angled toward the *off ladder trap* entrance location, and must comply with Section 4.3.2. *Pickets* must be completely removed from the ladder when not actively trapping.

6.5.1.6 Crowders: Holding pool *crowder*s should have a maximum clear bar spacing of $^{7}/_{8}$ inch. Side gap tolerances must not exceed 1 inch, with side and bottom seals sufficient to allow *crowder* movement without binding, and to prevent fish movement behind the *crowder* panel.

6.5.1.7 Distribution Flume: Where *false weir*s and steeppass ladders are used to route fish into or out of a trap holding pool, *distribution flume*s or pipes are used as described in Section 6.4.1.4.

6.6 Trapping Mechanism

6.6.1 Description and Purpose – Trapping Mechanism

The trap holding pool trapping mechanism (e.g., *finger weir*, vee-trap, *false weir*, steeppass ladder) allows fish to enter, but not volitionally exit, the holding pool.

6.6.2 Specific Criteria and Guidelines – Trapping Mechanism

6.6.2.1 Design (General):

- All components exposed to fish must have all welds and sharp edges ground smooth to the touch, with other features as required to minimize injuries.
- Bars and spacings must conform to Section 4.3.2.
- Trapping mechanisms must allow temporary closure to avoid spatial conflict with *brail* crowding and loading operations.
- Trapping mechanisms should be designed to safeguard against fish entry into an unsafe area such as behind a *crowder* or under floor *brail*.
- A gravity (i.e., not pumped) water supply should be used for *false-weirs* and steeppass ladders to avoid potential rejection of the trapping mechanism associated with the transmission of pump/motor sounds.

6.7 Lift/Hopper

6.7.1 Description and Purpose – Lift/Hopper

A lift in this context includes a full-sized *hopper* that is capable of collecting/lifting all fish trapped in a holding pool at one time, then either routing fish to the *forebay*, or loading onto a truck for transport.

6.7.2 Specific Criteria and Guidelines – Lift/Hopper

6.7.2.1 Maximum Water Volume: *Hopper* and transport truck loading water volumes should be greater than or equal to 0.15 ft^3 per pound of fish at the maximum fish loading density, to provide *hopper* or transport operations with sufficient volume of water for fish safety.

6.7.2.2 *Hopper freeboard*, from *hopper* water surface to top of *hopper* bucket, should be greater than the water depth within the *hopper*, to reduce risk of fish jumping out during lifting operations.

6.7.2.3 Sump: When a trap design includes a *hopper* sump (into which the *hopper* is lowered during trapping), side clearances between the *hopper* and sump sidewalls should not exceed 1 inch, thereby minimizing fish access below the *hopper*. Flexible side seals must be used to ensure that fish do not pass below the *hopper*.

6.7.2.4 Transport Tanks:

- Truck transport tanks must be compatible with the *hopper* design to minimize handling stress. If an existing vehicle will be used, the *hopper* must be designed to be compatible with existing equipment. If the transport tank's opening is larger than the tube or *hopper* opening, a cap or other device must be designed to prevent fish from jumping at the opening.
- Design should allow *hopper* water surface control to be transferred to the truck transport tank so that water and fish do not plunge abruptly from the *hopper* into the fish transport tank during loading.

6.7.2.5 Fish Egress Opening: The fish egress opening from the *hopper* into the transport tank must have a minimum horizontal cross-sectional area of 3 ft^2, and must have a smooth transition that minimizes the potential for fish injury.

6.7.2.6 Design (General):

- Fail-safe measures must be provided to prevent entry of fish into the holding pool area to be occupied by the *hopper* before the *hopper* is lowered into position.
- The *hopper* interior must be smooth, and be designed to safeguard fish.

6.8 Fish Lock

6.8.1 Description and Purpose – Fish Lock

A *fish lock* allows trapped fish in the trapping system holding pool to be elevated without a *hopper* or *hopper* sump.

The following steps describe the routing of fish from the lock to the *forebay* or transport vehicle:

1. Fish are crowded into the lock.
2. The closure gate is shut.
3. Flow into the lock is introduced through floor *diffuser*s below the floor *brail*.
4. As the water level rises within the lock, it will ultimately reach a control *weir* equilibrium elevation. The floor *brail* should be raised only after the lock water surface elevation is at equilibrium, and should not be used to lift fish out of the water.
5. Overflow passes over a control *weir* and through a dewatering screen, allowing excess flow to be drained off and adult fish to be routed directly into the anesthetic tank, or into a wetted flume for routing to separate sorting/holding pools, or to be loaded into a transport vehicle.

6.8.2 Specific Criteria and Guidelines – Fish Lock

6.8.2.1 Lock Inflow Chamber: The lock inflow chamber (below the lowest floor *brail* level) must be of sufficient depth and volume (see Section 4.5.3.5) to limit turbulence into the fish holding zone when lock inflow is introduced. The inflow sump should be designed so that flow upwells uniformly through add-in floor *diffuser*s (see Section 4.3.2), thereby limiting unstable hydraulic conditions within the lock that may agitate fish.

6.8.2.2 Depth Over Fish Egress Weir: Depth over the *fish egress weir* should be at least 6 inches, to facilitate fish egress from the lock for transport or handling.

6.8.3.2 Floor Brail:

- Floor *brail* should be composed of sufficiently sized *screen material* (based on life stage and species present), to preclude injury or mortality of non-target species. Side gap openings must not exceed 1 inch with seals included to cover all gaps. The floor *brail* panel should be kept in its lowest position until flow passes over the *flow egress weir*.
- The floor *brail* hoist should be designed for manual or automatic operation to allow movement of the *brail* at 2 feet/minute (upward and downward) matching the change in water surface elevation that will minimize stress of fish crowded between the floor *brail* and lock *flow egress weir*. Automated operation is allowed only when the water depth above the *brail* is 4 feet or more.

6.9 Single Holding Pool Traps

6.9.1 Description and Purpose – Single Holding Pool Traps

Single pool traps are often used in tandem with intermittent *exclusion barriers* (see Section 5) for brood-stock collection from small streams. These trapping systems are used to collect, sort, and load adult fish.

6.9.2 Specific Criteria and Guidelines – Single Holding Pool Traps

6.9.2.1 Design (General):

- The trap holding pool water volume must be designed according to Section 4.5.3.5 to achieve relatively stable interior hydraulic conditions and minimize jumping of trapped fish.
- Intakes must conform to Section 4.3.3.
- Sidewall *freeboard* should be a minimum 4 feet above trap pool water surface at high design streamflow.
- The trap holding pool interior surfaces must be smooth to reduce the potential for fish injury.

6.9.2.2 Fish Removal Procedure: A description of the proposed means of removing fish from the trapping pool and loading onto a transport truck must be submitted to NMFS for approval in the ESA incidental take permit application.

7. CULVERTS AND OTHER STREAM CROSSINGS

7.1 Introduction – Culverts and Other Stream Crossings

This section provides criteria and guidelines for the design of stream crossings to aid upstream and downstream movement of anadromous salmonids. For the purpose of fish passage, the distinction between bridge, culvert, and low water crossing is not as important as the effect the structure has on the form and function of the stream. To this end, these criteria conceptually apply to bridges as well as to culverts. In addition to providing fish passage, any road crossing design should include consideration for maintaining the ecological function of the stream - passing woody debris, flood flows and sediment, and other species that may be present at the site. The objective of these criteria and guidelines is to provide the basis for road crossing fish passage designs for all life stages of anadromous salmonids present at the site requiring passage. The design team should be in close contact with all biologists familiar with the site to assess potential impacts on spawning, life stages requiring passage, and to assess bed stability.

Criteria are specific standards for fishway design, maintenance, or operation that cannot be changed without a written waiver from NMFS. For the purposes of this document, a criterion is preceded by the word "must." In general, a specific criterion can not be changed unless there is site-specific biological rationale for doing so. An example of biological rationale that could lead to criterion waiver is a determination or confirmation by NMFS biologists that the smallest fry-sized fish will likely not be present at a proposed screen site. Therefore, the juvenile fish screen approach velocity criterion of 0.4 ft/s could be increased to match the smallest life stage expected at the screen site. A guideline is a range of values or a specific value for fishway design, maintenance or operation that may change when site-specific conditions are factored into the conceptual fishway design. For the purposes of this document guidelines are preceded by the word "should." Guidelines should be followed in the fishway design until site-specific information indicates that a different value would provide better fish passage conditions or solve site-specific issues. An example of site-specific rationale that could lead to a modified guideline is when the maximum river depth at a site is 3 feet, as compared to the design guideline for a fishway entrance depth of 6 feet. In this example, safe and timely fish passage could be provided by modifying the guideline to match the depth in the river. It is the responsibility of the applicant to provide compelling evidence in support of any proposed waiver of criteria or modification of a guideline for NMFS approval early in the design process, well in advance of a proposed Federal action. After a decision to provide passage at a particular site has been made, the following design criteria and guidelines are applicable, in addition to those described throughout Section 3.

7.2 Preferred Alternatives for New, Replacement, or Retrofitted Stream Crossings

All the alternatives listed below have the potential to pass fish, but some may perform better than others at a particular site. Based on the biological significance and ecological risk of a particular site, NMFS may require a specific design alternative to be developed, if feasible, to allow normative physical processes within the stream-*floodplain* corridor by (1) promoting natural sediment transport patterns for the reach, (2) providing unaltered fluvial debris movement, and (3) restoring or maintaining functional longitudinal continuity and connectivity of the stream-*floodplain* system.

The following alternatives and structure types are listed in general order of NMFS' preference:

- Road abandonment and reclamation or road realignment to avoid crossing the stream.
- Bridge or stream simulation spanning the stream flood plain, providing long-term dynamic channel stability, retention of existing spawning areas, maintenance of food (benthic invertebrate) production, and minimized risk of failure. If a stream crossing is proposed in a segment of stream channel that includes a salmonid spawning area, only full-span stream simulation designs (see Section 7.4) are acceptable.
- Embedded pipe culvert, bottomless arch designs or non-floodplain spanning stream simulation (see Sections 7.3 and 7.4).
- Hydraulic design method, associated with more traditional culvert design approaches - limited to low stream gradients (0% to 1%) or for retrofits (Section 7.5).
- Culvert designed with an external *fishway* (including roughened channels) for steeper slopes (see Section 4).
- Baffled culvert or internal weirs - to be used only for when other alternatives are infeasible (see Section 7.6). Many *baffle* designs are untested for anadromous salmonid passage, and *baffles* always reduce the hydraulic capacity of culverts. NMFS may only approve *baffled* culverts on a site by site basis if compelling evidence of successful passage at other sites utilizing a similar design is provided and a suitable monitoring and maintenance plan is developed and followed.

7.3 Embedded Pipe Design Method

7.3.1 Description and Purpose – Embedded Pipe Method

This method provides a simplified design methodology that is intended to provide a culvert of sufficient size and embedment to allow the natural movement of *bedload* and the formation of a stable bed inside the culvert, and is intended for use only in very small streams. Determination of the high and low fish passage design flows, water velocity, and water depth is not required for this method, since the stream hydraulic characteristics within the culvert are intended to mimic the stream conditions upstream and downstream of the crossing. This design method is usually not suitable for stream channels that are greater than 3% in natural slope or for culvert lengths greater than 80 feet. Structures for this design method are typically round, oval, or squashed pipes made of metal or reinforced concrete.

7.3.2 Specific Criteria and Guidelines – Embedded Pipe Design Method

7.3.2.1 Culvert Width: The minimum culvert bed width must be greater than the *bankfull* channel width. Vertical clearance from bed to ceiling must be at least 4 feet to allow for maintenance activities. There are many cases where greater widths may be required, based on the objective of providing a stable structure that will allow ecological function to continue.

7.3.2.2 Culvert Slope: The culvert must be placed level (0% slope).

7.3.2.3 Embedment: The bottom of the culvert should be buried into the streambed not less than 20% of the culvert height at the outlet and not more than 40% of the culvert height at the inlet. The slope of the bed must replicate the natural upstream and downstream stream gradient in the vicinity of the road crossing.

7.3.2.4 Fill Materials: Fill materials should be comprised of material to maximize the probability that fill materials will remain in place for all flows or be replaced as deposition occurs as streamflow recedes. The design must demonstrate the ability (by choosing fill material using size analysis of streambed material in the adjacent stream reaches if stream hydraulics are replacated, or by using guidance provided in WDFW 2003) to maintain the engineered streambed in the design configuration over the life of the project.

7.3.2.5 Water Depth: Water depth and velocity in the culvert must replicate the natural stream depth and water velocity upstream and downstream of the road crossing.

7.4 Streambed Simulation Design Method

7.4.1 Description and Purpose – Streambed Simulation Design Method

This method is a design process that is intended to mimic the natural upstream and downstream processes within a culvert or under a bridge. Fish passage, sediment transport, and debris conveyance within the culvert are designed to function as they would in a natural channel. Determination of the high and low fish passage design flows, design water velocity, and design water depth is not required for this option since the stream hydraulic characteristics within the culvert or beneath the bridge are designed to mimic the stream conditions upstream and downstream of the road crossing. The structures for this design method are typically open-bottomed arches or boxes but could have buried floors in some cases, or a variety of bridges that span the stream channel. This method utilizes streambed materials that are similar to the adjacent stream channel.

Streambed simulation requires a greater level of information on hydrology and geomorphology (topography of the stream channel) and a higher level of engineering expertise than the Embedded Pipe Design method (see Section 7.3). In general, streambed simulation should provide sufficient channel complexity to provide passage conditions similar to that which exists in the adjacent natural stream, including sufficient depth, velocity and resting areas.

7.4.2 Specific Criteria and Guidelines – Streambed Simulation Design Method

7.4.2.1 Channel Width: The minimum culvert bed width must be greater than *bankfull* channel width, and of sufficient vertical clearance to allow ease of maintenance activities. There are many cases where greater widths may be required, based on the objective of providing a stable structure that will allow ecological function to continue. For example, if a channel is not fully entrenched, some allowance for overbank flow may need to be provided. Similarly, for braided or meandering channels or other unconfined channel shapes, the flood plain must be allowed to function as a flow conveyance. If a stream is not fully entrenched, the minimum culvert bed width should be at least 1.3 times the *bankfull* channel width.

7.4.2.2 Channel Vertical Clearance: The minimum vertical clearance between the culvert bed and ceiling should be more than 6 feet, to allow access for debris removal. Smaller vertical clearances may be used if a sufficient inspection and maintenance plan is provided with the design that ensures that the culvert will be free of debris during the passage season.

7.4.2.3 Channel Slope: The slope of the reconstructed streambed within the culvert should approximate the average slope of the adjacent stream from approximately ten channel widths upstream and downstream of the site in which it is being placed, or in a stream reach that represents natural conditions outside the zone of the road crossing influence. For purposes of maintaining streambed integrity within the road crossing, the maximum slope of streambed simulation where closed bottom culverts are used should not exceed 6%. Design detail and/or a long term maintenance plan should be included that reflects how the streambed within the culvert will be maintained in its design condition over time.

7.4.2.4 Embedment: If a culvert is used, the bottom of the culvert should be buried into the streambed not less than 30% and not more than 50% of the culvert height, and a minimum of 3 feet. For bottomless culverts the footings or foundation must be designed for the largest anticipated scour depth. The ability (using size analysis of streambed material in the adjacent stream reaches, or by using guidance provided in WDFW 2003) to maintain the engineered streambed in the design configuration over the life of the project must be demonstrated by the design.

7.4.2.5 Maximum Length of Road Crossing: The length for streambed simulation should be less than 150 feet. If the length is greater than 150 feet, a bridge should be considered.

7.4.2.6 Fill Materials: Fill materials should be comprised of materials of similar size composition to natural bed materials that form the natural stream channels adjacent to the road crossing. The design must demonstrate long term stability of the passage corridor, through assessment of hydraulic conditions through the passage corridor over the fish passage design flow range, and through assessment of the ability of the stream to deliver sufficient transported bed material to maintain the integrity of the streambed over time. Larger material may be used to assist in grade retention and to provide resting areas for migratory fish.

7.4.2.7 Water Depth and Velocity: Water depth and velocity must closely resemble those that exist in the adjacent stream, as described in Section 7.4.2.3, or those listed in Section 7.5.2.6. To provide resting zones, special care should be used to provide areas of greater than average depth and lower than average velocity throughout the length of the streambed simulation, reasonably replicating those found in the adjacent stream. Hydraulic controls to maintain depth at low flows may be required.

7.5 Hydraulic Design Method

7.5.1 Design and Purpose – Hydraulic Design Method

The hydraulic design method is a design process that matches the hydraulic performance of a culvert with the swimming abilities of a target species and age class of fish. It is only suitable in streams with sufficiently low gradient to provide the hydraulic conditions found in Table 8.5. This method targets distinct species of fish and therefore does not account for ecosystem requirements of non-target species. There are significant errors associated with estimation of hydrology and fish swimming speeds that are resolved by making conservative assumptions in the design process. Determination of the high and low fish passage design flows, water velocity, and water depth is required for this option. The hydraulic design method requires hydrologic data analysis, open channel flow hydraulic calculations, and information on the swimming ability and behavior of the target group of fish. This design method may be applied to the design of new and replacement culverts and may be used to evaluate the effectiveness of retrofits of existing culverts.

7.5.2 Specific Criteria and Guidelines – Hydraulic Design Method

7.5.2.1 Culvert Width and Vertical Clearance: The minimum culvert width and vertical clearance between the culvert bed and ceiling should be more than 6 feet, to allow access for debris removal. Smaller vertical clearances may be used if a sufficient inspection and maintenance plan is provided with the design that ensures that the culvert will be free of debris during the passage season.

7.5.2.2 Culvert Slope: The slope of the reconstructed streambed within the culvert should not exceed 125% of the approximate average slope of the adjacent stream from approximately 10 channel widths upstream and downstream of the site in which it is being placed, or in a stream reach that represents natural conditions outside the zone of the road crossing influence. If embedment of the culvert is not possible, the maximum slope should not exceed 0.5%.

7.5.2.3 Embedment: Where physically possible, the bottom of the culvert should be buried into the streambed a minimum of 20% of the height of the culvert below the elevation of the *tailwater* control point downstream of the culvert, and the minimum embedment must be at least 1 foot.

7.5.2.4 Fish Passage Design Velocity: The fish passage design high flow (see Section 3.3) for adult fish passage is used to determine the maximum water velocity within the culvert.

7.5.2.5 Fish Passage Design Depth: The fish passage design low flow (see Section 3.2) for fish passage is used to determine the minimum depth of water within a culvert. Hydraulic controls may be required to maintain depth at low flows.

7.5.2.6 Average Water Velocity: The maximum average water velocity in the culvert refers to the calculated average of velocity within the barrel of the culvert at the fish passage design high flow. In most instances, upstream juvenile fish passage requirements should also be considered in design. Juvenile fish passage analysis should include calculating average water velocity for the 50% exceedence flow for the time period corresponding to juvenile upstream passage. Use Table 7-1 to determine the maximum average water velocity allowed.

Table 7-1. Maximum Allowable Average Culvert Velocity

Culvert Length (ft)	Maximum Average Velocity (ft/s)		
	Chinook, Steelhead, Sockeye, and Coho Adults	Pink and Chum Adults	Juvenile Salmonids
<60	6.0	5.0	1.0
60-100	5.0	4.0	1.0
100-200	4.0	3.0	1.0
200-300	3.0	2.0	1.0
>300	2.0	2.0	1.0

7.5.2.7 Minimum Water Depth: Minimum water depth at the low fish passage design flow should be: 1.0 feet for adult steelhead, Chinook, coho, and sockeye salmon; 0.75 feet for pink and chum salmon; and 0.5 feet for all species of juvenile salmon, as measured in the centerline of the culvert. The minimum depth within the culvert barrel is calculated at fish passage design low flow.

7.5.2.8 Maximum Hydraulic Drop: *Hydraulic drop*s between the water surface in the culvert and the water surface in the adjacent channel should be avoided in all cases. This includes the culvert inlet and outlet. Where physical conditions preclude embedment and the streambed is stable (e.g., culvert installation on bedrock) the *hydraulic drop* at the outlet of a culvert must not exceed the limits specified in Table 10-1 if juvenile fish are present and require upstream passage, or 1 foot if juvenile fish are not present or do not require upstream passage.

7.6 Retrofitting Culverts

7.6.1 Description and Purpose – Retrofitting Culverts

For future planning and budgeting at the state and local government levels, redesign and replacement of substandard stream crossings may contribute substantially to the recovery of salmon stocks throughout the state, if better access to underutilized habitat is provided. Many existing stream crossings can be improved for fish passage by cost-effective means. The decision to replace or improve a crossing should fully consider actions that will result in the greatest net benefit for fish passage. If a particular stream crossing causes substantial fish passage problems that hinder the conservation and recovery of salmon in a watershed, complete redesign and replacement is warranted. The extent of the needed fish passage improvement work depends on the severity of fisheries impacts, the remaining life of the structure, and the status of salmonid stocks in a particular stream or watershed.

For work at any stream crossing, site constraints need to be taken into consideration when selecting options. Some typical site constraints are ease of structure maintenance, construction windows, site access, equipment, and material needs and availability. Consolidation and/or decommissioning of roads and reclamation and restoration of the roadbed can sometimes be the most cost effective option. Consultations with NMFS biologists can aid in selecting priorities and alternatives.

7.6.2 Specific Criteria and Guidelines – Retrofitting Culverts

Where existing culverts are being modified or retrofitted to improve fish passage, the hydraulic requirements specified in Section 7.5 should be the design objective for the improvements. However, it is acknowledged that the conditions that cause an existing culvert to impair fish passage may also limit the remedies for fish passage improvement. Therefore, short of culvert replacement, the Section 7.5 criteria and guidelines should be the goal for improvement but not necessarily the required design threshold. Fish passage through existing non-embedded culverts may be improved through the use of gradient control *weir*s downstream of the culvert, interior *baffles* or *weir*s, or, in some cases, *fish ladder*s. However, these measures are not a substitute for good fish passage design for new or replacement culverts. The following guidelines should be used:

7.6.2.1 Hydraulic Controls: Hydraulic controls in the channel upstream and/or downstream of a culvert may be used to provide a continuous low flow path through the culvert and stream reach. They may be used to facilitate fish passage by accomplishing adequate depth and water velocity within the culvert, to concentrate low flows, to provide resting pools upstream and downstream of the culvert, and to prevent erosion of bed and banks.

7.6.2.2 Approach Pool: An approach pool should be provided that is at least 1.5 times the stream depth, or a minimum of 2 feet deep, which ever is deeper.

7.6.2.3 Baffles: *Baffles* may provide incremental fish passage improvement in culverts (if the culvert has excess hydraulic capacity) that cannot be made passable by other means. However, *baffles* may increase the potential for clogging and debris accumulation within the culvert and require special design considerations specific to the *baffle* type. Culverts that are too long or too high in gradient require resting pools, or other forms of velocity refuge spaced at increments along the culvert length. *Baffle* installations must only be installed after approval by NMFS engineers on a site-specific basis, and generally only for interim use until a permanent passage solution is employed. A suitable inspection and maintenance plan must be provided (i.e., inspected prior to each passage season and after any flood event greater than a 2-year exceedence flow, with subsequent debris removal as needed). The *baffle* design configuration must demonstrate that it can provide successful fish passage over the range of fish passage design flows. If an inspection and maintenance plan is implemented and successful, and good fish passage is documented, *baffles* may be approved for permanent installation.

7.6.2.4 Fishways (see Section 4 and Section 10): *Fishway*s may be required for some situations where excessive drops occur at the culvert outlet, or for some steep stream gradient situations, or to maintain channel integrity if an undersized culvert has been removed. *Fishway*s require specialized site-specific design for each installation and as such, a NMFS fish passage specialist must be contacted prior to ESA consultation.

7.7 Miscellaneous Culverts/Road Crossings

7.7.1 Specific Criteria and Guidelines – Miscellaneous Culverts/Road Crossings

7.7.1.1 Trash Racks: *Trash racks* should not be used near the culvert inlet. Accumulated debris may lead to severely restricted fish passage and potential injuries to fish. Where *trash racks* cannot be avoided in culvert installations, they must only be installed above the water surface indicated by *bankfull* flow. A minimum of 9 inches clear spacing should be provided between *trashrack* vertical members. If *trash racks* are used, a long term maintenance plan must be provided along with the design, to allow for timely clearing of debris.

7.7.1.2 Livestock Fences: Livestock fences should not be used across the culvert inlet. Accumulated debris may lead to severely restricted fish passage and potential injuries to fish. Where fencing cannot be avoided, it should be removed during adult salmon upstream migration periods. Otherwise, a minimum of 9 inches clear spacing should be provided between *pickets*, up to the high flow water surface. If fencing is used, a long term maintenance plan must be provided along with the design, to allow for timely clearing of debris. Cattle fences that rise with increasing flow are highly recommended.

7.7.1.3 Lighting: Natural or artificial supplemental lighting should be considered in new or replacement culverts that are over 150 feet in length. Where supplemental lighting is required, the spacing between light sources should not exceed 75 feet. Available research results indicate that different species of anadromous salmonids respond differently to lighting conditions (COE 1976), and NMFS engineering staff should be specifically contacted if a culvert greater than 150 feet in length is under consideration.

7.7.1.4 In-Stream Work Windows: NMFS and State Fish and Wildlife officials commonly set instream work windows in each watershed. Work in the active stream channel must not be performed outside of the instream work windows.

7.7.1.5 Temporary Crossings: Temporary crossings, placed in salmonid streams for water diversion during construction activities, must meet all of the guidelines in this document. However, if it can be shown that the location of a temporary crossing in the stream network is not a fish passage concern at the time of the project, then the construction activity only needs to minimize erosion, sediment delivery, and impact to surrounding riparian vegetation.

7.7.1.6 Installation: Culverts must be installed only in a dewatered site, with a sediment control and flow routing plan acceptable to NMFS.

7.7.1.7 Riparian Restoration: The work area must be fully restored upon completion of construction with a mix of native, locally adapted, riparian vegetation. Use of species that grow extensive root networks quickly should be emphasized. Sterile, non-native hybrids may be used for erosion control in the short term if planted in conjunction with native species.

7.7.1.8 Construction Disturbances: Construction disturbance to the riparian area must be minimized and the activity must not adversely impact fish migration or spawning.

7.7.1.9 Presence of Salmonids: If salmonid are likely to be present, salvage operations must be conducted by qualified personnel prior to construction. If these salmonids are listed as threatened or endangered under the ESA, consult directly with NMFS biologists to acquire an ESA take permit to gain authorization for these activities. Care should be taken to ensure salmonids are not chased under banks or logs that will be removed or dislocated by construction. Any stranded salmonids are to be returned to a suitable location in a nearby live stream, and as specified in the ESA take permit, if applicable.

7.7.1.10 Pumps: If pumps are used to temporarily divert a stream (to facilitate construction), an acceptable fish screen (see Section 11) must be used to prevent entrainment or impingement of small fish. At no time must construction or construction staging activity disrupt continuous streamflow downstream of the construction site.

7.7.1.11 Wastewater: Unacceptable wastewater associated with project activities must be disposed of off-site in a location that will not drain directly into any stream channel.

7.7.1.12 Flood Capacity: Regardless of the design option used, to minimize the risk of the environmental consequences of structural failure, all road crossings must be designed to withstand the 100-year peak flood flow, including consideration of debris loading likely to be encountered during flooding. Stream crossings or culverts located in areas where there is significant risk of inlet plugging by flood-borne debris should be designed to pass the 100-year peak flood without exceeding the top of the culvert inlet (headwater-to-diameter ratio is less than one). This is to ensure a low risk of channel degradation, stream diversion, and failure over the life span of the crossing. Hydraulic capacity must compensate for expected deposition in the culvert bottom.

7.7.1.13 Other Hydraulic Considerations: Besides the upper and lower flow limit, other hydraulic effects need to be considered, particularly when installing a culvert. Water surface elevations in the stream reach must exhibit gradual flow transitions, both upstream and downstream of the road crossing.

Within the culvert, abrupt changes in water surface and velocity, hydraulic jumps, turbulence, and drawdown at the upstream flow entrance must be avoided in design. A continuous low flow channel must be maintained during construction throughout the entire stream reach affected by the road crossing construction. In addition, especially in retrofits, hydraulic controls may be necessary to provide resting pools, concentrate low flows, prevent erosion of stream bed or banks, and allow passage of *bedload* material. Hydraulic control devices may be required to avoid headcutting. Culverts and other structures should be aligned with the stream, with no abrupt changes in flow direction upstream or downstream of the crossing. This can often be accommodated by changes in road alignment or slight elongation or enlargement of the culvert. Where elongation would be excessive, this must be weighed against better crossing alignment and/or modified transition sections upstream and downstream of the crossing. In crossings that are unusually long compared to streambed width, natural sinuosity of the stream will be lost and sediment transport problems may occur even if the slopes remain constant. Such problems should be anticipated and mitigated in the project design.

8. TIDE GATES (WORK IN PROGRESS)

Design standards for fish passage through tide gates are in the developmental stage. If you are interested in the current status, please call Larry Swenson at 503-230-5448.

9. COLUMBIA AND SNAKE RIVER FISH PASSAGE FACILITIES

9.1 Introduction – Columbia and Snake River Fish Passage Facilities

The following criteria and guidelines are specially adapted to Columbia and Snake River upstream and downstream fish passage facilities. The guidelines and criteria in this section apply at mainstem hydroelectric projects. This section is intended as a starting point for future fish passage facilities designs, and is based on experience at COE mainstem hydroelectric dams on the Lower Columbia and Snake Rivers.

Criteria are specific standards for fishway design, maintenance, or operation that cannot be changed without a written waiver from NMFS. For the purposes of this document, a criterion is preceded by the word “must.” In general, a specific criterion can not be changed unless there is site-specific biological rationale for doing so. An example of biological rationale that could lead to criterion waiver is a determination or confirmation by NMFS biologists that the smallest fry-sized fish will likely not be present at a proposed screen site. Therefore, the juvenile fish screen approach velocity criterion of 0.4 ft/s could be increased to match the smallest life stage expected at the screen site. A guideline is a range of values or a specific value for fishway design, maintenance or operation that may change when site-specific conditions are factored into the conceptual fishway design. For the purposes of this document guidelines are preceded by the word “should.” Guidelines should be followed in the fishway design until site-specific information indicates that a different value would provide better fish passage conditions or solve site-specific issues. An example of site-specific rationale that could lead to a modified guideline is when the maximum river depth at a site is 3 feet, as compared to the design guideline for a fishway entrance depth of 6 feet. In this example, safe and timely fish passage could be provided by modifying the guideline to match the depth in the river. It is the responsibility of the applicant to provide compelling evidence in support of any proposed waiver of criteria or modification of a guideline for NMFS approval early in the design process, well in advance of a proposed Federal action.

9.2 Mainstem Upstream Passage

9.2.1 Description and Purpose – Mainstem Upstream Passage

Each mainstem *fish ladder* system is designed with a specific number (and location) of primary entrances (typically at each shore, and at the powerhouse/spillway interface), a defined hydraulic capacity, and specific operations of auxiliary water, entrance, and exit facilities. For a number of reasons, ladder entrance operations may evolve and not be consistent with that envisioned in the design phase. Ladder entrances are perhaps the most important feature of the adult *fish ladder* system. If entrances are improperly located or designed, excessive *upstream fish passage* delay may occur. While this document primarily focuses on design criteria and guidelines, operations of fish passage facilities are a vital and overlapping link. The criteria and guidelines in this sub-section are intended to reinforce what NMFS believes are appropriate ladder entrance operations.

9.2.2 Specific Criteria and Guidelines – Mainstem Upstream Passage

9.2.2.1 Attraction Flows: Total *attraction flow* discharged from adult *fishway* entrances should be either a minimum of 3% of mean annual river flow, or the *attraction flow* approved in the original design memorandum phase prior to construction. Total ladder *attraction flow* and entrance location are important design parameters to assure safe, efficient, and timely upstream passage.

Unless approved by NMFS, adult ladder total entrance *attraction flow* (gravity ladder flow from *forebay*, plus auxiliary water flow) must not be reduced from original design levels.

9.2.2.2 Ladder Entrances: Unless specifically stated in the original design, all ladder entrances must be designed to be operated continuously during *fish passage season* in accordance with ladder entrance *attraction flow* criteria listed below.

9.2.2.3 Auxiliary Water Systems: *Auxiliary water system*s must include sufficient back-up hydraulic capacity to ensure continued operation consistent with design criteria.

9.2.2.4 Ladder Entrance Attraction Flow Criteria: Adjustable *weir* gate crest elevations at primary entrances must be submerged at a minimum depth of 8 feet (relative to *tailwater* water surface elevation), with a head differential of 1.0 to 2.0 feet. These two parameters have evolved to become the standard for determining whether mainstem hydro project *fish ladder* entrances are discharging at, or above, the minimum satisfactory ladder *attraction flow*. However, if this criteria cannot be satisfied at one or more ladder entrances (as is the case at some mainstem hydro projects), an hydraulic investigation should be initiated to determine whether some entrances are discharging excessive *attraction flow*, while others fail to satisfy minimum *attraction flow* criteria. In these cases, it should be determined whether different ladder entrance combinations of head differential and *weir* submergence can be implemented to provide the minimum equivalent *attraction flow* (e.g., provided by 8-foot *weir* submergence and 1 foot of entrance head) at each ladder entrance. For instance, if the *weir* depth at one entrance is reduced by 25% and the differential is increased to remain within criterion listed above, the equivalent *attraction flow* can still be provided. Analysis findings should be coordinated with all parties before implementation.

All other ladder design and operational features must comply with Section 4.

9.3 Mainstem Juvenile Screen and Bypass

9.3.1 Description and Purpose – Mainstem Juvenile Screen and Bypass

Turbine intake screens and *vertical barrier screen*s at mainstem Columbia and Snake River hydroelectric dams are an exception to design criteria for conventional screens referenced in Section 11. *Turbine intake screens* are considered partial screens, because they do not screen the entire turbine discharge. They are high-velocity screens, meaning approach velocities are much higher than allowed for conventional screens. *Turbine intake screens* were retrofitted at many mainstem Columbia and Snake River powerhouses (which cannot be feasibly screened using conventional screen criteria) to protect fish from turbine entrainment to the extent possible.

9.3.2 Specific Criteria and Guidelines – Mainstem Juvenile Screen and Bypass

Dewatering screen systems must adhere to the criteria and guidelines provided in Section 11. The following turbine intake screen and *vertical barrier screen* design criteria are the product of extensive research and development:

9.3.2.1 Turbine Intake Screens :

- Dimensions/Orientation: Existing intake screens are either 20 or 40 feet long and are located in the bulkhead slot of each turbine. They are lowered into the intake, and then rotated to the correct operating inclination.
- Materials: The turbine intake screen face must be stainless steel bar screen, with maximum clearance between bars equal to1.75 mm.
- Cleaning: The turbine intake screen must have an approved and proven screen cleaning device, which may be adjusted for desired cleaning frequency.
- *Porosity*: Turbine intake screen *porosity* must be determined on the basis of physical hydraulic modeling

9.3.2.2 Maximum Approach Velocity: Maximum approach velocity (normal to the screen face) for *turbine intake screens* must be 2.75 ft/s. Above this velocity threshold, injury rates increase.

9.3.2.3 Stagnation Point: The stagnation point (point where the component of velocity along the turbine intake screen face is 0 ft/s) must be at a location where the submerged screen intercepts between 40% to 43% of turbine intake flow, and must be within 5 feet of the leading edge of the screen.

9.3.2.5 Gatewell Flow: Gatewell flow must be approximately 10% of intercept flow (which is flow above the intake screen stagnation point), and approximately 4% of turbine flow.

9.4 Vertical Barrier Screens

9.4.1 Description and Purpose – Vertical Barrier Screens

Vertical barrier screens (VBS) pass nearly all flow entering the gatewell from the intake screen and intake ceiling apex zone. Fish pass upward along the VBS, then accumulate in the upper gatewell, near an orifice that is designed to pass them safely into the juvenile *bypass system*.

9.4.2 Specific Criteria and Guidelines – Vertical Barrier Screens

9.4.2.1 Velocity Distribution:

- Hydraulic modeling must be used to ensure the greatest possible uniform velocity distribution across the entire VBS. Note that this criterion assumes that operating gate position has a significant influence over VBS velocity flow distribution, and is one of the design issues to be reconciled through use of the physical model.
- Variable-*porosity* stacked panels must be developed through physical hydraulic modeling, to achieve uniform velocity distribution and minimize turbulence in the upper gatewell.

9.4.2.2 Materials and Orientation: Where gatewell flow is increased by a flow vane at the gatewell entrance, VBS should be constructed of stainless steel bar screens with bars oriented horizontally, and a maximum clearance between bars of 1.75 mm.

9.4.2.3 Cleaning/Debris Removal: A screen cleaner and debris removal system must be features of each VBS with a gatewell flow increaser vane. Horizontal orientation of the screen bars facilitates debris removal.

9.4.2.4 Through-Screen Velocity: Average VBS through-screen velocity must be a maximum of 1.0 ft/s, unless field testing is conducted to prove sufficiently low fish descaling/injury rates at a specific site.

10. UPSTREAM JUVENILE FISH PASSAGE

10.1 Introduction – Upstream Juvenile Fish Passage

Upstream juvenile fish passage is necessary at some passage sites, where inadequate conditions exist downstream for rearing fish. In a ladder that uses only a portion of the river flow for *upstream fish passage*, juvenile passage may require special and separate provisions from those designed to optimize adult passage. However, adult fish passage should never be compromised to accommodate juvenile passage.

Criteria are specific standards for fishway design, maintenance, or operation that cannot be changed without a written waiver from NMFS. For the purposes of this document, a criterion is preceded by the word “must.” In general, a specific criterion can not be changed unless there is site-specific biological rationale for doing so. An example of biological rationale that could lead to criterion waiver is a determination or confirmation by NMFS biologists that the smallest fry-sized fish will likely not be present at a proposed screen site. Therefore, the juvenile fish screen approach velocity criterion of 0.4 ft/s could be increased to match the smallest life stage expected at the screen site. A guideline is a range of values or a specific value for fishway design, maintenance or operation that may change when site-specific conditions are factored into the conceptual fishway design. For the purposes of this document guidelines are preceded by the word “should.” Guidelines should be followed in the fishway design until site-specific information indicates that a different value would provide better fish passage conditions or solve site-specific issues. An example of site-specific rationale that could lead to a modified guideline is when the maximum river depth at a site is 3 feet, as compared to the design guideline for a fishway entrance depth of 6 feet. In this example, safe and timely fish passage could be provided by modifying the guideline to match the depth in the river. It is the responsibility of the applicant to provide compelling evidence in support of any proposed waiver of criteria or modification of a guideline for NMFS approval early in the design process, well in advance of a proposed Federal action. After a decision to provide passage at a particular site has been made, the following design criteria and guidelines are applicable, in addition to those described throughout Section 3.

10.2 Design – Upstream Juvenile Fish Passage

As discussed in Section 4.2, it is recommended that a 1.0 to 1.5 foot *hydraulic drop* from entrance pool to *tailwater* is used for *fishway* entrance design. Attraction of adult salmonids to a *fishway* entrance is compromised with decreased head drop at a *fishway* entrance, unless all of the streamflow is passed through the entrance. *Fishway* attraction (i.e., fishes’ ability to locate the *fishway* entrance downstream of the dam) is the critical design parameter for an *upstream passage facility*. Previously, many of the *fishway* entrances on the Columbia River operated with 0.5 foot of *hydraulic drop* (measured from the entrance pool water surface to *tailwater* surface). After extensive laboratory and field studies, it was conclusively determined that higher velocities, which directly relate to the amount of *hydraulic drop* through the entrance, provide better attraction of adult salmonids than did lower velocities. This determination resulted in making hydraulic adjustments to *fishway* entrances so that they operated with 1.0 to 1.5 feet of *hydraulic drop*, instead of 0.5 feet. Subsequent radio telemetry studies verified that passage times decreased as a result. Thus, there is a clear basis for designing entrance pool to *tailwater* differentials between 1.0 to 1.5 feet for adult salmonid passage.

Within the Northwest Region of NMFS (which includes the states of Washington, Oregon, and Idaho), there are varying requirements for juvenile passage. NMFS will consider the appropriate design requirements as applicable. Lower required *hydraulic drop* between pools is not going to provide an obstacle to adult fish, provided that the facility satisfies entrance design requirements of Section 4.2. When juvenile fish passage is required, the *fishway* should meet the guidelines listed in Table 10-1. However, the *fishway* entrance must operate per the guidelines and criteria listed in Section 4.4 when adult salmonids are present.

10.2.1 General Criteria and Guidelines – Upstream Juvenile Passage

Given the reported swimming speeds for juvenile coho salmon and observed leaping capabilities, submerged ports or pipes should be avoided when designing passage facilities for juvenile fish, except for inlet and outlet conditions. *Fishway*s should be designed as pool and chute or roughened channel, with drops not to exceed the criteria listed in Table 10.1. In addition to the *hydraulic drop*, calm water in the pools and a low velocity just upstream of the *weir* crest is important. *Weir*s should be designed as sharp crested, where the head over the *weir* is two times the breadth.

Table 10-1. Juvenile Upstream Fish Passage Guidelines

Upstream Juvenile Fish Passage Guidelines			
Fish Size (mm)	Maximum hydraulic drop over fishway weir (ft)	Maximum hydraulic drop at fishway entrance and exit (ft)	Velocity for swimming distances less than 1 foot, (ft/s)
45 to 65	0.7	0.13	1.5 to 2.5
80 to 100	1	0.33	3 to 4.5

Powers (1993) indicated that pool volume criteria such as described in Section 4.5.3.5 are critical to ensuring appropriate passage conditions. The pool volume criteria described in Section 4.5.3.5 defines a maximum turbulence threshold based on energy dissipation within the volume of a fishway pool. If this threshold is exceeded, a turbulent barrier to adult fish may be created. For optimal juvenile fish passage, this pool volume should be doubled.

Hydraulic design for juvenile upstream passage should be based on representative flows in which juveniles typically migrate. Recent research indicates that providing for juvenile salmon passage up to the 10% annual exceedence flow may cover the majority of flows in which juveniles have been observed moving upstream.

In some situations, it may be feasible to operate a ladder entrance with a decreased *hydraulic drop* at times when adult salmon are not present and at 1 to 1.5 feet during the adult salmon upstream migration. The feasibility of doing this often entails making a judgment call on the timing of adult passage when often little or no information is available, and if it is available, it may change from year to year. In other situations, it may be appropriate to provide multiple *fishway* entrances that operate independently, according to the desired *hydraulic drop*. One entrance may operate to attract adult fish and convey the appropriate volume shape of attraction jet and velocities and another entrance may operate at a lower differential and convey flow over a *weir*.

11. FISH SCREEN AND BYPASS FACILITIES

11.1 Introduction – Fish Screen and Bypass Facilities

This section provides criteria and guidelines to be used in the development of designs of downstream migrant fish screen facilities for hydroelectric, irrigation, and other water withdrawal projects. The design guidance provided in this section applies to *fishway* designs after a decision to provide a passage facility has been made. Unless directly specified herein, this guidance is not intended for use in evaluation of existing facilities, nor does it provide guidance on the application of the design for any particular site. Sections 1, 2, 3, and the Foreword of this document also apply to the guidelines and criteria listed in this section.

In designing an effective fish screen facility, the swimming ability of the fish is a primary consideration. Research has shown that swimming ability of fish varies and may depend upon a number of factors relating to the physiology of the fish, including species, size, duration of swimming time required, behavioral aspects, migrational stage, physical condition and others, in addition to water quality parameters such as dissolved oxygen concentrations, water temperature, lighting conditions, and others. For this reason, screen criteria must be expressed in general terms.

Several categories of screen designs are in use but are still considered as experimental technology by NMFS. These include Eicher screens, modular inclined screens, coanda screens, and horizontal screens. The process to evaluate experimental technology is described in Section 16. Several of these experimental screen types have completed part or all of the experimental technology process, and may be used in specific instances when site conditions allow. Design of these screens, or new conceptual types of experimental screens, may be developed through discussions with NMFS engineers on a case-by-case basis.

Criteria are specific standards for fishway design, maintenance, or operation that cannot be changed without a written waiver from NMFS. For the purposes of this document, a criterion is preceded by the word “must.” In general, a specific criterion can not be changed unless there is site-specific biological rationale for doing so. An example of biological rationale that could lead to criterion waiver is a determination or confirmation by NMFS biologists that the smallest fry-sized fish will likely not be present at a proposed screen site. Therefore, the juvenile fish screen approach velocity criterion of 0.4 ft/s could be increased to match the smallest life stage expected at the screen site. A guideline is a range of values or a specific value for fishway design, maintenance or operation that may change when site-specific conditions are factored into the conceptual fishway design. For the purposes of this document guidelines are preceded by the word “should.” Guidelines should be followed in the fishway design until site-specific information indicates that a different value would provide better fish passage conditions or solve site-specific issues. An example of site-specific rationale that could lead to a modified guideline is when the maximum river depth at a site is 3 feet, as compared to the design guideline for a fishway entrance depth of 6 feet. In this example, safe and timely fish passage could be provided by modifying the guideline to match the depth in the river. It is the responsibility of the applicant to provide compelling evidence in support of any proposed waiver of criteria or modification of a guideline for NMFS approval early in the design process, well in advance of a proposed Federal action. After a decision to provide passage at a particular site has been made, the following design criteria and guidelines are applicable, in addition to those described throughout Section 3.

11.2 Functional Screen Design

A *functional screen design* should be developed that defines type, location, size, hydraulic capacity, method of operation, and other pertinent juvenile fish screen facility characteristics. In the case of applications to be submitted to FERC and for consultations under the ESA, a *functional design* for juvenile (and adult) fish passage facilities must be developed and submitted as part of the FERC License Application or as part of the Biological Assessment for the facility. It must reflect NMFS input and design criteria and be acceptable to NMFS. *Functional design* drawings must show all pertinent hydraulic information, including water surface elevations and flows through various areas of the structures. *Functional design* drawings must show general structural sizes, cross-sectional shapes, and elevations. Types of materials must be identified where they may directly affect fish. The final detailed design must be based on the *functional design*, unless changes are agreed to by NMFS.

11.3 Site Conditions

To minimize risks to anadromous fish at some locations, NMFS may require investigation (by the project sponsors) of important and poorly defined site-specific variables that are deemed critical to development of the screen and bypass design. This investigation may include factors such as fish behavioral response to hydraulic conditions, weather conditions (ice, wind, flooding, etc.), river stage/flow relationships, seasonal operational variability, potential for sediment and debris problems, resident fish populations, potential for creating predation opportunity, and other information. The life stage and size of juvenile salmonids present at a potential screen site usually is not known, and may change from year to year based on flow and temperature conditions. Thus, adequate data to describe the size-time relationship requires substantial sampling efforts over a number of years. For the purpose of designing juvenile fish screens, NMFS will assume that *fry*-sized salmonids and low water temperatures are present at all sites and apply the appropriate criteria listed below, unless adequate biological investigation proves otherwise. The burden-of-proof is the responsibility of the owner of the diversion facility.

11.4 Existing Screens

11.4.1 Acceptance Criteria and Guidelines for Existing Screens

If a fish screen was constructed prior the establishment of these criteria, but constructed to NMFS criteria established August 21, 1989, or later, approval of these screens may be considered providing that all six of the following conditions are met:

11.4.1.1 The entire screen facility must function as designed.

11.4.1.2 The entire screen facility has been maintained and is in good working condition.

11.4.1.3 When the *screen material* wears out, it must be replaced with *screen material* meeting the current criterion stated in this document. To comply with this condition, structural modifications may be required to retrofit an existing facility with new *screen material.*

11.4.1.4 No mortality, injury, entrainment, impingement, migrational delay, or other harm to anadromous fish has been noted that is being caused by the facility;

11.4.1.5 No emergent *fry* are likely to be located in the vicinity of the screen, as agreed to by NMFS biologists familiar with the site.

11.4.1.6 When biological uncertainty exists, access to the diversion site by NMFS is permitted by the diverter for verification of the above criteria.

11.5 Structure Placement

11.5.1 Specific Criteria and Guidelines – Structure Placement: Streams and Rivers

11.5.1.1 Instream Installation: Where physically practical and biologically desirable, the screen should be constructed at the point of diversion with the screen face generally parallel to river flow. However, physical factors may preclude screen construction at the diversion entrance. Among these factors are excess river gradient, potential for damage by large debris, access for maintenance, operation and repair, and potential for heavy sedimentation. For screens constructed at the bankline, the screen face must be aligned with the adjacent bankline and the bankline must be shaped to smoothly match the face of the screen structure to minimize turbulence and eddying in front, upstream, and downstream of the screen. Adverse alterations to riverine habitat must be minimized.

11.5.1.2 Canal Installation: Where installation of fish screens at the diversion entrance is not desirable or impractical, the screens may be installed in the canal downstream of the entrance at a suitable location. All screens installed downstream from the diversion entrance must be provided with an effective *bypass system*, as described in Sections 11.9 through 11.12, designed to collect and transport fish safely back to the river with minimum delay. The screen location must be chosen to minimize the effects of the diversion on instream flows by placing the bypass outfall as close as biologically feasible (i.e., considering minimizing length and optimizing the hydraulics of the bypass pipe) and practically feasible to the point of diversion.

11.5.1.3 Functionality: All screen facilities must be designed to function properly through the full range of stream hydraulic conditions as defined in Section 3 and in the diversion conveyance, and must account for debris and sedimentation conditions which may occur.

11.5.2 Specific Criteria and Guidelines – Structure Placement: Lakes, Reservoirs, and Tidal Areas

11.5.2.1 Intake Locations: Intakes must be located offshore where feasible to minimize fish contact with the facility. When possible, intakes must be located in areas with sufficient ambient velocity to minimize sediment accumulation in or around the screen and to facilitate debris removal and fish movement away from the screen face. Intakes in reservoirs should be as deep as practical, to reduce the numbers of juvenile salmonids that encounter the intake.

11.5.2.2 Surface Outlets: If a reservoir outlet is used to pass fish from a reservoir, the intake must be designed to withdraw water from the most appropriate elevation based on providing the best juvenile fish attraction and appropriate water temperature control downstream of the project. The entire range of *forebay* fluctuation must be accommodated in design. Since surface outlet designs must consider a wide spectrum of site-specific hydraulic and fish behavioral conditions, NMFS engineers and biologists must be involved in developing an acceptable conceptual design for any surface outlet fish passage system before the design proceeds.

11.6 Screen Hydraulics – Rotating Drum Screens, Vertical Screens, and Inclined Screens

11.6.1 Specific Criteria and Guidelines – Screen Hydraulics

11.6.1.1 Approach Velocity: The *approach velocity* must not exceed 0.40 ft/s for *active screens*, or 0.20 ft/s for *passive screens*. Using these approach velocities will minimize screen contact and/or impingement of juvenile fish. For screen design, *approach velocity* is calculated by dividing the maximum screened flow amount by the vertical projection of the *effective screen area*. An exception may be made to this definition of *approach velocity* for screen where a clear egress route minimizes the potential for impingement. If this exception is approved be NMFS, the *approach velocity* is calculated using the entire *effective screen area*, and not a vertical projection. For measurement of approach velocity, see Section 15.2.

11.6.1.2 Effective Screen Area: The minimum *effective screen area* must be calculated by dividing the maximum screened flow by the allowable *approach velocity*.

11.6.1.3 Submergence: For rotating drum screens, the design submergence must not exceed 85%, nor be less than 65% of drum diameter. Submergence over 85% of the screen diameter increases the possibility of entrainment over the top of the screen (if entirely submerged), and increases the chance for impingement with subsequent entrainment if fish are caught in the narrow wedge of water above the 85% submergence mark. Submerging rotating drum screens less than 65% may reduce the self-cleaning capability of the screen. In many cases, stop logs may be installed downstream of the screens to achieve proper submergence. If stop logs are used, they should be located at least two drum diameters downstream of the back of the drum.

11.6.1.4 Flow Distribution: The screen design must provide for nearly uniform flow distribution (see Section 15.2) over the screen surface, thereby minimizing *approach velocity* over the entire screen face. The screen designer must show how uniform flow distribution is to be achieved. Providing adjustable *porosity* control on the downstream side of screens, and/or flow *training wall*s may be required. Large facilities may require hydraulic modeling to identify and correct areas of concern. Uniform flow distribution avoids localized areas of high velocity, which have the potential to impinge fish.

11.6.1.5 Screens Longer Than Six Feet:

- Screens longer than 6 feet must be angled and must have *sweeping velocity* greater than the *approach velocity*. This angle may be dictated by site-specific geometry, hydraulic, and sediment conditions. Optimally, *sweeping velocity* should be at least 0.8 ft/s and less than 3 ft/s.
- For screens longer than 6 feet, *sweeping velocity* must not decrease along the length of the screen.

11.6.1.6 Inclined Screen Face: An inclined screen face must be oriented less than 45° vertically with the screen length (upstream to downstream) oriented parallel to flow, unless the inclined screen is placed in line with riverbank and reasonably matching the slope of the riverbank.

11.6.1.7 Horizontal Screens: Horizontal screens have been evaluated as experimental technology, because they operate fundamentally different than conventional vertically oriented screens. This fundamental difference relates directly to fish safety, because when inadequate flow depth exists with vertically oriented screens, there is no potential for fish to get trapped over the screened surface. In contrast, when water level on horizontal screens drops and most or all diverted flow goes through the screens, there is high likelihood that fish will become impinged and killed on the screened surface. In addition, if depths become shallow and flow rate is high over a horizontal screen, the resulting cross-section velocity may be too high to allow fish to swim away from the horizontal screen surface.

Unless specified differently below, general screen and bypass criteria and guidelines specified in section 11 apply for horizontal screens as well. Horizontal screens are considered biologically equivalent to conventional screens only if the following criteria and guidelines are achieved in design and operation:

11.6.1.7.1 Design Development: Since site-specific design considerations are required, NMFS engineers must be consulted throughout the development of the horizontal screen design.

11.6.1.7.2 Hydrologic and Hydraulic Analysis: The horizontal screen design process must include an analysis to verify that sufficient hydrologic and hydraulic conditions exist in the stream so as not to exacerbate a passage impediment in the stream channel (see Section 4.1), or in the off-stream conveyance, including the screen and bypass. This analysis must conclude that all criteria listed below can be achieved for the entire juvenile outmigration season, as defined by section 3. If the criteria listed below cannot be maintained per this design analysis, a horizontal screen design must not be used at the site. If this analysis concludes that removal of the bypass flow required for a horizontal screen from the stream channel results in inadequate passage conditions or unacceptable loss of riparian habitat, other screen design styles must be considered for the site and installed at the site if adverse effects are appreciably reduced.

11.6.1.7.3 Screen Geometry: Horizontal screens must be set at specific slopes and geometry consistent with prototypes approved by NMFS. The screen design must include reference material for an example prototype that confirms the adequacy of the design.

11.6.1.7.4 Site Limitation: Horizontal screens must not be installed spanning the entire width of stream or river channels, or in stream or river channels where hydraulic conditions on the screen cannot be maintained as specified below, or where the screen cannot be easily accessed for maintenance. Upstream fish passage must not be impeded by installation of a horizontal screen. In general, very few instream sites may be appropriate for installation of a horizontal screen.

11.6.1.7.5 Flow Regulation: For a horizontal screen to be installed, the site must have a good headgate, capable of maintaining sufficiently consistent diversion rates to allow a horizontal screen and bypass to operate within these criteria and guidelines.

11.6.1.7.6 Channel Alignment: Horizontal screens must be installed such that the approaching conveyance channel is completely parallel and in line with the screen channel (no skew) such that uniform flow conditions exist at the upstream edge of the screen. A straight channel should exist for at least twenty feet upstream of the leading edge of the horizontal screen, or up to two screen channel lengths if warranted by approach flow conditions in the conveyance channel. Flow conditions that require a longer approach channel include turbulent flow, supercritical hydraulic conditions, or uneven hydraulic conditions in a channel cross section. Horizontal screens must be installed such that a smooth hydraulic transition occurs from the approach channel to the screen channel (no abrupt expansion, contraction, or flow separation).

11.6.1.7.7 Bypass Flow Depth: For horizontal screens, the bypass flow must pass over the downstream end of the screen at a minimum depth of one foot.

11.6.1.7.8 Bypass Flow Amount: Bypass flow is used for transporting fish and debris across the plane of the screen and through the bypass conveyance back to the stream. Bypass flow amounts must be sufficient to continuously provide the hydraulic conditions specified in this section, and bypass conditions specified in section 11.9. In general, for diversion rates less than 100 cfs, about 15% of the total diverted flow should be used as bypass flow for horizontal screens. For diversion rates more than 100 cfs, about 10% of the total diverted flow should be used for bypass flow for horizontal screens. Small horizontal screens may require up to 50% of the total diverted flow as bypass flow. The amount of bypass flow must be approved by NMFS engineers.

11.6.1.7.9 Diversion Shut-off: If inadequate bypass flow exists at any time (per Sections 11.6.1.7.7 and 11.6.1.7.8), the horizontal screen design must include an automated means to shut off the diversion flow, or a means to route all diverted flow back to the originating stream.

11.6.1.7.10 Sediment Removal: The horizontal screen design must include means to simply and directly remove sediment accumulations under the screen, without compromising the integrity of the screen while water is being diverted.

11.6.1.7.11 Screen Approach Velocity: Screen *approach velocity* is calculated by dividing the maximum flow rate by the *effective screen area,* and must be less than 0.25 ft/s and uniform over the entire screen surface area (see section 15.2). The horizontal screen design must include *approach velocity* and *sweeping velocity* consistent with the prototype example submitted per 11.6.1.7.3. Recent prototype development has demonstrated that better self-cleaning of a horizontal screen is achieved when the ratio of sweeping velocity and approach velocity exceeds 20:1, and *approach velocities* are less than 0.1 ft/s. If equipped with an automated mechanical screen cleaning system, screen *approach velocity* must be less than 0.4 ft/s and uniform over the entire screen surface area (see section 15.2).

11.6.1.7.12 Screen Sweeping Velocity: For horizontal screens, *sweeping velocity* must be maintained or gradually increase for the entire length of screen (see section 11.9.1.8). The design *sweeping velocity* must be consistent with the prototype example submitted per 11.6.1.7.3. Higher *sweeping velocities* may be required to achieve reliable debris removal and to keep sediment mobilized. *Sweeping velocity* should never be less than 2.5 ft/s, or an alternate minimum velocity based on an assessment of sediment load in the water diversion system.

11.6.1.7.13 Screen Cleaning: For passive horizontal screens, *approach velocity* and *sweeping velocity* must work in tandem to allow self cleaning of the entire screen face and to provide good bypass conditions. If the proposed design has not been demonstrated to have cleaning capability and hydraulic characteristics similar to a successful prototype, the screen design must include an automated screen cleaning system.

11.6.1.7.14 Inspection, Maintenance and Monitoring: Daily inspection and maintenance must occur of the screen and bypass to maintain operations consistent with these criteria. Post construction monitoring of the facility must occur for at least the first year of operation. This monitoring must occur whenever water is diverted, and include a inspection log (in table form) of date and time, water depth at the bypass, debris present on screen (including any sediment retained in the screen openings), fish observed over the screen surface, operational adjustments made, maintenance performed and the observer’s name. A copy of the inspection log must be provided annually to the NMFS design reviewer, who will review operations and make recommendations for the next year of operation.

.

11.7 Screen Material

11.7.1 Specific Criteria and Guidelines – Screen Material

11.7.1.1 Circular Screen Openings: Circular screen face openings must not exceed $^{3}/_{32}$ inch in diameter. Perforated plate must be smooth to the touch with openings punched through in the direction of approaching flow.

11.7.1.2 Slotted or Rectangular Screen Openings: Slotted or rectangular screen face openings must not exceed 1.75 mm (approximately $^{1}/_{16}$ inch) in the narrow direction.

11.7.1.3 Square Screen Openings: Square screen face openings must not exceed $^{3}/_{32}$ inch on a side.

11.7.1.4 Material: The *screen material* must be corrosion resistant and sufficiently durable to maintain a smooth uniform surface with long term use.

11.7.1.5 Other Components: Other components of the screen facility (such as seals) must not include gaps greater than the maximum screen opening defined above.

11.7.1.6 Open Area: The percent open area for any *screen material* must be at least 27%.

11.8 Civil Works and Structural Features

11.8.1 Specific Criteria and Guidelines – Civil Works and Structural Features

11.8.1.1 Placement of Screen Surfaces: The face of all screen surfaces must be placed flush (to the extent possible) with any adjacent screen bay, pier noses, and walls to allow fish unimpeded movement parallel to the screen face and ready access to bypass routes.

11.8.1.2 Structural Features: Structural features must be provided to protect the integrity of the fish screens from large debris, and to protect the facility from damage if overtopped by flood flows. A *trash rack*, log boom, sediment sluice, and other measures may be required.

11.8.1.3 Civil Works: The civil works must be designed in a manner that prevents undesirable hydraulic effects (such as eddies and stagnant flow zones) that may delay or injure fish or provide predator habitat or predator access.

11.9 Bypass Facilities

11.9.1 Specific Criteria and Guidelines – Bypass Layout

11.9.1.1 Bypass Location:

- The screen and bypass must work in tandem to move out-migrating salmonids (including downstream migrant adult salmonids such as steelhead *kelts*, if present) to the bypass outfall with a minimum of injury or delay.

- The bypass entrance must be located so that it may easily be located by out-migrants.
- The bypass entrance and all components of the *bypass system* must be of sufficient size and hydraulic capacity to minimize the potential for debris blockage.
- Screens greater than or equal to 6 feet in length must be constructed with the downstream end of the screen terminating at a bypass entrance. Screens less than or equal to 6 feet in length may be constructed perpendicular to flow with a bypass entrance at either or both ends of the screen, or may be constructed at an angle to flow, with the downstream end terminating at the bypass entrance.
- Some screen systems do not require a bypass system. For example, an end of pipe screen located in a river, lake, or reservoir does not require a bypass system because fish are not removed from their habitat. A second example is a river bank screen with sufficient hydraulic conditions to move fish past the screen face.

11.9.1.2 Multiple Entrances: Multiple bypass entrances should be used if the *sweeping velocity* may not move fish to the bypass within 60 seconds, assuming fish are transported along the length of the screen face at a rate equaling *sweeping velocity*.

11.9.1.3 Training Wall: A *training wall* must be located at an angle to the screen face, with the bypass entrance at the apex and downstream-most point. For many facilities, the wall of the civil works opposite to the screen face may serve as a *training wall*. For single or multiple *vee screen* configurations, *training wall*s are not required, unless an intermediate bypass must be used.

11.9.1.4 Secondary Screen: In cases where there is insufficient flow available to satisfy hydraulic requirements at the bypass entrance for the primary screens, a secondary screen may be required within the primary bypass. The secondary *bypass flow* conveys fish to the bypass outfall location or other destination, and returns secondary screened flow for water use.

11.9.1.5 Bypass Access: Access for inspection and debris removal must be provided at locations in the *bypass system* where debris accumulations may occur.

11.9.1.6 Trash Racks: If *trash racks* are used, sufficient hydraulic gradient must be provided to route juvenile fish from between the *trash rack* and screens to the bypass.

11.9.1.7 Canal Dewatering: The floor of the screen civil works must be designed to allow fish to be routed back to the river safely when the canal is dewatered. This may entail using a small gate and drain pipe, or similar provisions, to drain all flow and fish back to the river. If this cannot be accomplished, an acceptable fish salvage plan must be developed in consultation with NMFS and included in the operation and maintenance plan.

11.9.1.8 Bypass Channel Velocity: To ensure that fish move quickly through the bypass channel (i.e., the conveyance from the terminus of the screen to the bypass pipe), the rate of increase in velocity between any two points in the bypass channel should not decrease and should not exceed 0.2 ft/s per foot of travel.

11.9.1.9 Natural Channels: Natural channels may be used as a bypass upon approval by NMFS engineers. A consideration for utilizing natural channels as a bypass is the provision of off-stream habitat. Requirements for natural channels include adequate depth and velocity, sufficient flow volume, protection from predation, and good water quality.

11.9.2 Specific Criteria and Guidelines – Bypass Entrance

11.9.2.1 Flow Control: Each bypass entrance must be provided with independent flow-control capability.

11.9.2.2. Minimum Velocity: The minimum bypass entrance flow velocity should be greater than 110% of the maximum canal velocity upstream of the bypass entrance. At no point must flow decelerate along the screen face or in the bypass channel. *Bypass flow* amounts should be of sufficient quantity to ensure these hydraulic conditions are achieved for all operations throughout the *smolt* out-migration period.

11.9.2.3 Lighting: Ambient lighting conditions must be included upstream of the bypass entrance and should extend to the *bypass flow* control device. Where lighting transitions cannot be avoided, they should be gradual, or should occur at a point in the *bypass system* where fish cannot escape the bypass and return to the canal (i.e., when bypass velocity exceeds swimming ability).

11.9.2.4 Dimensions: For diversions greater than 3 cfs, the bypass entrance must extend from the floor to the canal water surface, and should be a minimum of 18 inches wide. For diversions of 3 cfs or less, the bypass entrance must be a minimum of 12 inches wide. In any case, the bypass entrance must be sized to accommodate the entire range of *bypass flow*, utilizing the criteria and guidelines listed throughout Section 11.9.

11.9.2.5 Weirs: For diversions greater than 25 cfs, *weir*s used in *bypass system*s should maintain a *weir* depth of at least 1 foot throughout the *smolt* out-migration period.

11.9.3 Specific Criteria and Guidelines – Bypass Conduit and System Design

11.9.3.1 General: Bypass pipes and joints must have smooth surfaces to provide conditions that minimize turbulence, the risk of catching debris, and the potential for fish injury. Pipe joints may be subject to inspection and approval by NMFS prior to implementation of the bypass. Every effort should be made to minimize the length of the bypass pipe, while maintaining hydraulic criteria listed below.

11.9.3.2 Bypass Flow Transitions: Fish should not be pumped within the bypass system. Fish must not be allowed to free-fall within a pipe or other enclosed conduit in a bypass system. Downwells must be designed with a free water surface, and designed for safe and timely fish passage by proper consideration of turbulence, geometry, and alignment.

11.9.3.3 Flows and Pressure: In general, *bypass flow*s in any type of conveyance structure should be open channel. If required by site conditions, pressures in the bypass pipe must be equal to or above atmospheric pressures. Pressurized to non-pressurized (or vice-versa) transitions should be avoided within the pipe. Bypass pipes must be designed to allow trapped air to escape.

11.9.3.4 Bends: Bends should be avoided in the layout of bypass pipes due to the potential for debris clogging and turbulence. The ratio of bypass pipe center-line radius of curvature to pipe diameter (R/D) must be greater than or equal to 5. Greater R/D may be required for super-critical velocities (see Section 11.9.3.8).

11.9.3.5 Access: Bypass pipes or open channels must be designed to minimize debris clogging and sediment deposition and to facilitate inspection and cleaning as necessary. Long bypass designs (eg. greater than 150 feet) may include access ports provided at appropriate spacing to allow for detection and removal of debris. Alternate means of providing for bypass pipe inspection and debris removal may be acceptable as well.

11.9.3.6 Diameter/Geometry: The bypass pipe diameter or open channel bypass geometry should generally be a function of the *bypass flow* and slope, and should be chosen based on achieving the velocity and depth criteria in Sections 11.9.3.8 and 11.9.3.9.

Table 11-1 provides examples for selecting the diameter of a bypass pipe based on diverted flow amount, assuming 1) bypass pipe slope of 1.3%; 2) Manning's roughness of 0.009; and 3) other bypass pipe criteria (Section 11.9) are met. Bypass pipe hydraulics should be calculated for a given design to determine a suitable pipe diameter if the design deviates from the assumptions used to calculate pipe diameters in Table 11-1.

Table 11-1. Bypass Design Examples

Diverted Flow (cfs)	***Bypass flow* (cfs)**	**Bypass Pipe Diameter (in)**	***Bypass flow* Depth (in)**
< 6	5% of diverted flow	10	2 ½
6 - 25	5% of diverted flow	10	4
40	2.00	12	4 ¾
75	3.75	15	6
125	6.25	18	7 ¼
175	8.75	21	8 ½
250	12.5	24	9 ½
500	25.0	30	12
750	37.5	36	14
> 1000	design with direct NMFS engineering involvement		

11.9.3.7 Flow: Design *bypass flow* should be about 5% of the total diverted flow amount, unless otherwise approved by NMFS. Regardless of the *bypass flow* amount, hydraulic guidelines and criteria in Sections 11.9.3.8 and 11.9.3.9 apply.

11.9.3.8 Velocity: The design bypass pipe velocity should be between 6 and 12 ft/s for the entire operational range. If higher velocities are approved, special attention to pipe and joint smoothness must be demonstrated by the design. To reduce silt and sand accumulation in the bypass pipe, pipe velocity must not be less than 2 ft/s.

11.9.3.9 Depth: The design minimum depth of free surface flow in a bypass pipe should be at least 40% of the bypass pipe diameter, unless otherwise approved by NMFS.

11.9.3.10 Closure Valves: Closure valves of any type should not be used within the bypass pipe unless specifically approved based on demonstrated fish safety.

11.9.3.11 Sampling Facilities: Sampling facilities installed in the bypass conduit must not in any way impair operation of the facility during non-sampling operations.

11.9.3.12 Hydraulic Jump: There should not be a hydraulic jump within the pipe.

11.9.3.13 Spillways: Spillways upstream of the screen facility also act as a *bypass system*. These facilities should also be designed to provide a safe passage route back to the stream, adhering to the bypass design principles described throughout Section 11.9

11.9.4 Specific Criteria and Guidelines – Bypass Outfall

11.9.4.1 Location:

- Bypass outfalls must be located to minimize predation by selecting an outfall location free of eddies, reverse flow, or known predator habitat. The point of impact for bypass outfalls should be located where ambient river velocities are greater than 4.0 ft/s during the *smolt* out-migration. Predator control systems may be required in areas with high avian predation potential. Bypass outfalls should be located to provide good egress conditions for downstream migrants.
- Bypass outfalls must be located where the receiving water is of sufficient depth (depending on the impact velocity and quantity of *bypass flow*) to ensure that fish injuries are avoided at all river and *bypass flow*s. The *bypass flow* must not impact the river bottom or other physical features at any stage of river flow.

11.9.4.2 Impact Velocity: Maximum bypass outfall impact velocity (i.e., the velocity of *bypass flow* entering the river) including vertical and horizontal velocity components should be less than 25.0 ft/s.

11.9.4.3 Discharge and Attraction of Adult Fish: The bypass outfall discharge into the receiving water must be designed to avoid attraction of adult fish thereby reducing the potential for jumping injuries and false attraction. The bypass outfall design must allow for the potential attraction of adult fish, by provision of a safe landing zone if attraction to the outfall flow can potentially occur.

11.10 Debris Management

11.10.1 Specific Criteria and Guidelines – Debris Management

11.10.1.1 Inspection and Maintenance: A reliable, ongoing inspection, preventative maintenance, and repair program is necessary to ensure facilities are kept free of debris and that screen media, seals, drive units, and other components are functioning correctly during the outmigration period. A written plan should be completed and submitted for approval with the screen design.

11.10.1.2 Screen Cleaning (Active Screens): *Active screens* must be automatically cleaned to prevent accumulation of debris. The screen cleaner design should allow for complete debris removal at least every 5 minutes, and operated as required to prevent accumulation of debris. The head differential to trigger screen cleaning for intermittent type cleaning systems must be a maximum of 0.1 feet over clean screen conditions or as agreed to by NMFS. A variable timing interval trigger must also be used for intermittent type cleaning systems as the primary trigger for a cleaning cycle. The cleaning system and protocol must be effective, reliable, and satisfactory to NMFS.

11.10.1.3 Passive Screens: A *passive screen* should only be used when all of the following criteria are met:

- The site is not suitable for an *active screen*, due to adverse site conditions.
- Uniform approach velocity conditions must exist at the screen face, as demonstrated by laboratory analysis or field verification.
- The debris load must be low.
- The combined rate of flow at the diversion site must be less than 3 cfs.
- Sufficient ambient river velocity must exist to carry debris away from the screen face.
- A maintenance program must be approved by NMFS and implemented by the water user.
- The screen must be frequently inspected with debris accumulations removed, as site conditions dictate.
- Sufficient stream depth must exist at the screen site to provide for a water column of at least one screen radius around the screen face.
- The screen must be designed to allow easy removal for maintenance, and to protect from flooding.

11.10.1.4 Intakes: Intakes must include a *trash rack* in the screen facility design which must be kept free of debris. In certain cases, a satisfactory profile bar screen design may substitute for a *trash rack*. Based on biological requirements at the screen site, *trash rack* spacing may be specified that reduces the probability of entraining adult fish.

11.10.1.5 Inspection: The completed screen and bypass facility must be made available for inspection by NMFS, to verify that the screen is being operated consistent with the design criteria.

11.10.1.6 Evaluation: At some sites, screen and bypass facilities may be evaluated for biological effectiveness and to verify that hydraulic design objectives are achieved. At the discretion of NMFS, this may entail a complete biological evaluation especially if waivers to screen and bypass criteria are granted, or merely a visual inspection of the operation if screen and bypass criteria is met in total.

11.10.1.7 Sediment: Provision must be made to limit the build-up of sediment, where it may impact screen operations.

11.11 End of Pipe Screens (including pump intake screens)

11.11.1 Specific Criteria and Guidelines – End of Pipe Screens

11.11.1.1 Location: *End of pipe screens* must be placed in locations with sufficient ambient velocity to sweep away debris removed from the screen face, or designed in a manner to prevent debris re-impingement and provide for debris removal.

11.11.1.2 Submergence: *End of pipe screens* must be submerged to a depth of at least one screen radius below the minimum water surface, with a minimum of one screen radius clearance between screen surfaces and natural or constructed features. For *approach velocity* calculations, the entire submerged *effective screen area* may be used.

11.11.1.3 Escape Route: A clear escape route should exist for fish that approach the intake volitionally or otherwise. For example, if a pump intake is located off of the river (such as in an intake lagoon), a conventional open channel screen should be placed in the intake channel or at the edge of the river to prevent fish from entering a lagoon.

12. INFILTRATION GALLERIES (EXPERIMENTAL TECHNOLOGY)

12.1 Introduction – Infiltration Galleries

This section discusses the application and suitability for the installation of infiltration galleries. In concept, infiltration galleries may provide suitable fish passage conditions at a diversion site. However, if improperly sited, failure may occur that results in severe adverse habitat impacts and loss of habitat access in addition to the loss of the diversion. As such, any site proposed for an infiltration gallery must follow the experimental process described in Section 16. The following section describes the guidelines and criteria that should be followed in the planning, design, operation, monitoring, and maintenance of infiltration galleries.

The intent of these criteria is to build and operate infiltration galleries that provide at least the same level of fish protection as conventional screen facilities that meet NMFS screen criteria, as presented in Section 11. Accordingly, infiltration galleries have similar design criteria to conventional screens, such as: *screen* dimensions, *approach velocity*, bypass facilities, ability to monitor *head loss*, ability to be self-cleaning, ability to be maintained, and owner agreements to maintain and operate the system within criteria. These aspects are discussed in more detail in the following sections.

Criteria are specific standards for fishway design, maintenance, or operation that cannot be changed without a written waiver from NMFS. For the purposes of this document, a criterion is preceded by the word "must." In general, a specific criterion can not be changed unless there is site-specific biological rationale for doing so. An example of biological rationale that could lead to criterion waiver is a determination or confirmation by NMFS biologists that the smallest fry-sized fish will likely not be present at a proposed screen site. Therefore, the juvenile fish screen approach velocity criterion of 0.4 ft/s could be increased to match the smallest life stage expected at the screen site. A guideline is a range of values or a specific value for fishway design, maintenance or operation that may change when site-specific conditions are factored into the conceptual fishway design. For the purposes of this document guidelines are preceded by the word "should." Guidelines should be followed in the fishway design until site-specific information indicates that a different value would provide better fish passage conditions or solve site-specific issues. An example of site-specific rationale that could lead to a modified guideline is when the maximum river depth at a site is 3 feet, as compared to the design guideline for a fishway entrance depth of 6 feet. In this example, safe and timely fish passage could be provided by modifying the guideline to match the depth in the river. It is the responsibility of the applicant to provide compelling evidence in support of any proposed waiver of criteria or modification of a guideline for NMFS approval early in the design process, well in advance of a proposed Federal action. After a decision to provide passage at a particular site has been made, the following design criteria and guidelines are applicable, in addition to those described throughout Section 3.

12.2 Scope

The term infiltration gallery, in this document, refers to a water collection system that is installed in the zone of surface water influence, for the purpose of conveying water to either a pumped or gravity-fed water distribution network (see Figure 12-1). The infiltration gallery is intended to be a substitute for a surface-based diversion system that is normally installed above the bed of the stream.

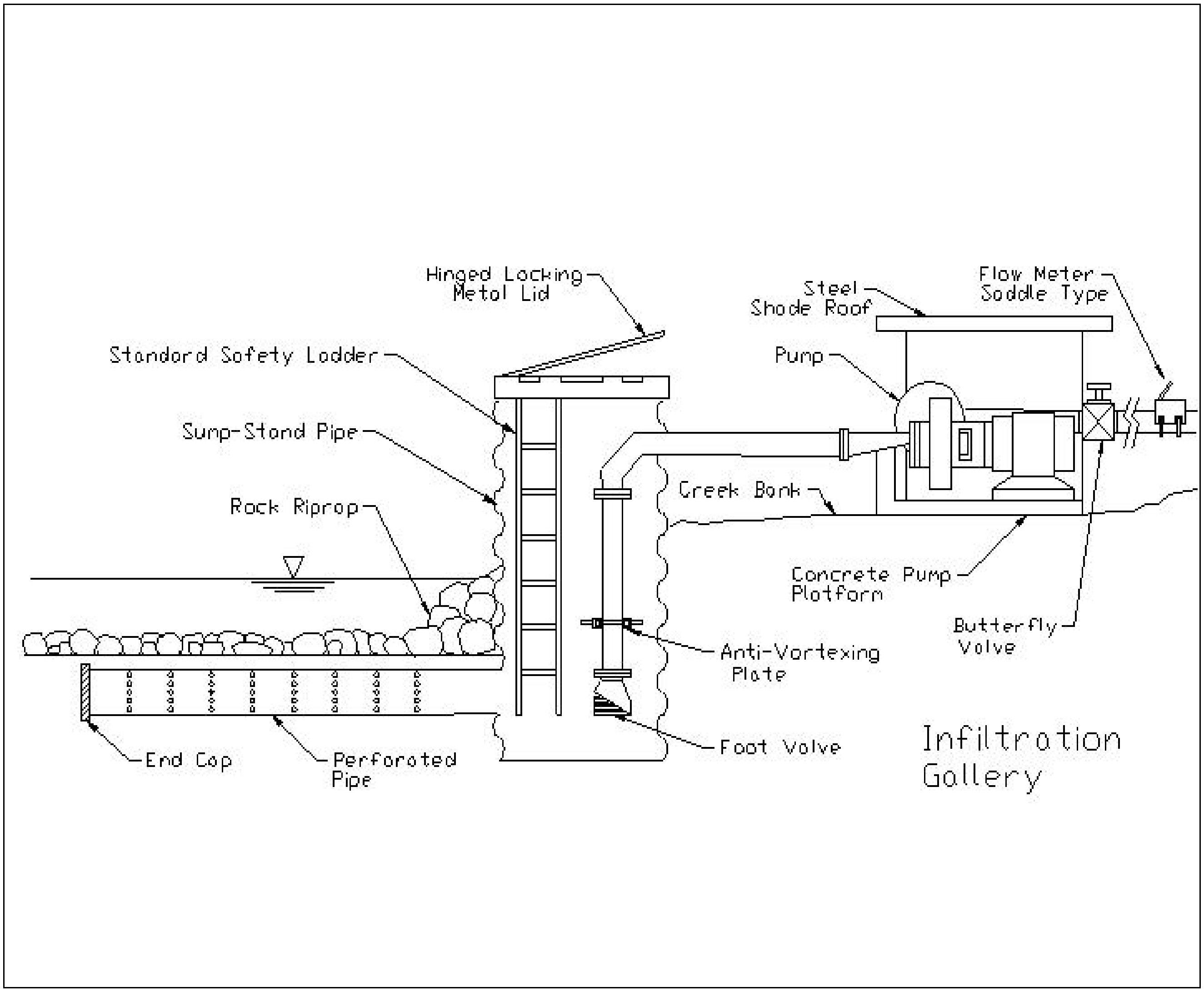


Figure 12-1. Cross Section of an Example Infiltration Gallery

12.3 Selection of Appropriate Screen Technology

Due to their location below the stream bed, infiltration galleries are prone to become ineffective due to plugging by sediments. In addition to reducing the flow capacity of the facility, plugged galleries also increase the risk to small fish due to the creation of velocity hot spots. Since very few existing infiltration galleries include effective self-cleaning systems, it is a common practice to repair plugged galleries by digging them up and rebuilding them. This process may create enormous disruption to the river habitat and to the diverters' ability to divert water. Therefore, the designer should select an infiltration gallery as the preferred diversion method only after a thorough review of the benefits and risks of using conventional screens indicates that an infiltration gallery may create less risk for fish and their habitat.

12.4 Site Selection

NMFS intends to only permit infiltration galleries at stream sites that exhibit sufficient natural fluvial processes to minimize sediment deposition on top of the infiltration gallery to the maximum practical extent. The sealing of infiltration galleries with transported *bedload* sediments seems to be a common mode of failure. Infiltration galleries should not be installed at sites where natural sedimentation occurs that would plug a gallery.

12.5 Design: Infiltration Galleries

12.5.1 Specific Criteria and Guidelines - Design

12.5.1.1 Design Objectives: The infiltration gallery must be designed to:

- Provide the same volume, rate, and timing of water supply that the diverter would be entitled to when using a surface-based diversion;
- Withdraw water primarily from the portion of the stream located directly above the infiltration gallery; and
- Provide at least the same level of fish protection as conventional screens.

12.5.1.2 Minimum Depths and Velocities over Infiltration Galleries: Infiltration galleries should not be operated when the water depth above the river bed over any part of the infiltration gallery is less than 0.5 feet. Use of temporary impoundments such as push-up berms and other dams to raise the water level is not permitted. The minimum stream velocity at low flow should be 2 ft/s.

12.5.1.3 Screen Material Opening: Infiltration galleries installed with less than 24 inches of gravel cover should meet juvenile fish screen criteria, as described in Section 11.

12.5.1.4 Flow Direction: Infiltration galleries should be designed to withdraw flow primarily from the zone directly above the intake screen.

12.5.1.5 Imported Gravels: Rock used to backfill over the infiltration gallery must be designed and approved by the design engineer. The backfill material selection must also be approved by NMFS.

12.5.1.6 Induced Vertical Approach Velocity at the Stream Bed: The maximum vertical interstitial velocity through the substrate, V_s , must not exceed 0.05 ft/s when the substrate is new and/or after *backwashing* (see Figure 12-1).

V_s is defined according to the following calculation:

$$V_s = \frac{Q}{(A_{eff})(\eta)}$$

where: V_s = average vertical interstitial velocity through the gravel substrate

Q = diverted flow rate

A_{eff} = plan view area of gravel substrate through which the flow is assumed to pass

η = *porosity* of gravel substrate

12.5.1.7 Determination of Plugged Gallery: As with conventional screen technology, it is essential to be able to measure the *head loss* through the screening material (Section 11.7). As a minimum, sufficient instrumentation must be installed to measure the hydraulic grade line (HGL) values, as shown schematically in Figure 12-1. The gallery material must be *backwashed* when the *head loss* measurements indicate that V_s is greater than or equal to 0.10 ft/s. If *backwashing* does not reduce V_s below 0.10 ft/s then the gallery must be shut down and repaired.

12.5.1.8 Backwashing: All infiltration galleries must be designed to be capable of being *backwashed*. *Backwashing* may be accomplished using air or water or both. The *backwash* system must be designed to thoroughly clean all of the material in the Effective Cleaning Zone (Figure 12-1). The Effective Cleaning Zone is the volume of filter medium that the designer has assumed contributes about 90% of the diverted flow rate.

12.5.1.9 Limitations/Cessation of Use:

- Infiltration galleries should not be constructed in areas where spawning may occur.
- Should spawning occur within 10 feet of a portion of an infiltration gallery, then use of those portions of the infiltration galleries within 10 feet of the *redd* should be discontinued for 90 days, or as directed by NMFS.
- Instream excavation to repair infiltration galleries is not included in the scope of permitted work beyond 90 days from the date of commencement of initial instream construction, or the end of the approved work period, whichever is earlier, unless performed when there is no flowing water in

the creek. This restriction does not apply to repairs that do not disturb the river bed or banks.

- Failed infiltration galleries must not be replaced until the failure mechanism is identified, and a subsequent design is provided that eliminates future failures due to the identified failure mechanism.
- Excavation for infiltration gallery repair must not be conducted, unless specifically approved by NMFS.

12.5.1.10 Qualifications of Infiltration Gallery Designers: The design of infiltration galleries must be performed by an appropriately qualified engineer or engineering geologist, and the drawings should be signed by the designer and/or stamped with his/her seal. The design of each infiltration gallery must be reviewed and approved by NMFS.

12.5.1.11 Operations and Maintenance: Infiltration galleries must be operated and maintained in accordance with Section 14.

13. TEMPORARY AND INTERIM PASSAGE FACILITIES

Where construction and/or modifications to artificial impediments (e.g., dams) or upstream passage facilities are planned, upstream and downstream passage may be adversely impacted. If possible, these activities should be scheduled for periods when migrating fish are not present, as specified in the in-water work period allowable for construction of facilities in streams. However, this may not always be possible or advisable. In these cases, an interim fish passage plan must be prepared and submitted to NMFS for approval, in advance of work in the field. Criteria listed previously in this document also apply to the interim passage plan. Where this is not possible, project owners must seek NMFS approval of alternate interim fish passage design criteria, and a final interim passage plan.

14. OPERATIONS AND MAINTENANCE RESPONSIBILITIES

Passage facilities at impediments must be operated and maintained properly for optimum, or even marginal, success. The preceding criteria are intended for use in the design of passage facilities; however, failure to operate and maintain these facilities to optimize performance in accordance with design may result in compromised fish passage, and ultimate deterioration of the entire facility. Therefore, NMFS requires facility operators to commit to long-term responsibility for operations, maintenance, and repair of fish facilities described herein, to ensure protection of fish on a sustained basis. This includes immediate restoration of the passage facility (including repair of damage and sediment/gravel removal) after flooding, and prior to the arrival of migratory fish. Where facilities are inadequately operated or maintained, and mortality of listed fish can be documented, the responsible party is liable to enforcement measures as described in Section 9 of the ESA.

An operation and maintenance plan must be drafted and submitted to NMFS for approval. This plan must include a brief summary of operating criteria posted at the passage facility or otherwise made available to the facility operator. Staff gages must be installed and maintained at critical areas throughout the facility in order to allow personnel to easily determine if the facility is being operated within the established design criteria. Comprehensive operation and maintenance plans for a group of projects (e.g., road maintenance plans for culverts, small screen facilities, etc.) will satisfy this criterion, so long as NMFS is in agreement with the operation and maintenance of passage facilities.

15. POST-CONSTRUCTION EVALUATION

15.1 Introduction – Post Construction Evaluation

Post-construction evaluation is important to ensure that the intended results of the *fishway* design are accomplished and to assist in ensuring that mistakes are not repeated elsewhere. If a post-construction evaluation may be required, NMFS will identify that need early in the design process. Large facilities, experimental devices, and facilities that deviate widely from these previous guidelines or criteria are likely candidates for hydraulic and biological evaluation. These evaluations are not intended to cause extensive retrofits of any given project unless the as-built installation does not reasonably conform to the design guidelines, or an obvious fish passage problem continues to exist. Over time, NMFS anticipates that the second and third elements of these evaluations may be abbreviated as commonly used designs are evaluated and fine-tuned to ensure optimal passage conditions.

There are three parts to this evaluation: (1) verify that the fish passage system is installed in accordance with the approved design and that construction procedures are sound; (2) measure hydraulic conditions to ensure that the facility meets these guidelines and criteria, and (3) perform biological assessment to confirm that hydraulic conditions are resulting in successful passage. NMFS technical staff may assist in developing a hydraulic or biological evaluation plan to fit site-specific conditions and species, but in any case, evaluation plans are subject to approval by NMFS.

15.2 Evaluation of Juvenile Fish Screens

Hydraulic evaluations of juvenile fish screens must include confirmation of uniform *approach velocity* and the requisite *sweeping velocity* over the entire screen face. Confirmation of approach and sweeping velocities must consist of a series of velocity measurements encompassing the entire screen face, divided into a grid with each grid section representing no more than 5% of the total diverted flow through the screen (i.e., at least 20 grid points must be measured). The approach and *sweeping velocity* (parallel and perpendicular to the screen face) should be measured at the center point of each grid section, as close as possible to the screen face without entering the boundary layer turbulence at the screen face. Uniformity of *approach velocity* is defined as being achieved when no individual *approach velocity* measurement exceeds 110% of the criteria. In addition, velocities at the entrance to the bypass, *bypass flow* amounts, and total flow should be measured and reported.

15.3 Biological Evaluation

Depending on the site and its potential for adverse biological impacts, detailed biological evaluations and/or monitoring may likely be required and are the responsibility of the project sponsor. The need for and scale of biological evaluation may be identified by NMFS early in the design process. If a passage facility will be encountered by the majority of the fish migration, and if waivers to the criteria are granted, biological evaluation will likely be required.

16. EXPERIMENTAL FISH GUIDANCE DEVICES

16.1 Introduction – Experimental Fish Guidance Devices

NMFS believes that conventional fish passage facilities constructed to the criteria and guidelines described above are most appropriate for utilization in the protection of salmon and steelhead at all impediments. However, the process described below delineates an approach whereby experimental fish passage devices can be evaluated and, if comparable performance is confirmed to the satisfaction of NMFS, installed in lieu of conventional passage facilities.

16.2 Juvenile Fish Entrainment at Intakes

The injury and death of juvenile fish at water diversion intakes have long been identified as a major source of overall fish mortality (Spencer1928; Hatton 1939; Hallock and Woert 1959; Hallock 1987). Fish diverted into power turbines incur up to 40% or more immediate mortality, while also experiencing injury, disorientation, and delay of migration that may increase predation related losses (Bell 1991). Fish entrained into agricultural and municipal water diversions may experience 100% mortality, particularly if no egress route back to the river is provided. Diversion mortality may cause decline in fish populations, especially if instream habitat is unsuitable for any aspect of spawning, incubation, rearing or migration. For the purposes of this document, diversion losses include turbine, irrigation, municipal, and all other potential fish losses related to human water use.

Positive-exclusion barrier screens that screen the entire diversion flow have long been used to prevent or reduce entrainment of juvenile fish for diversions of up to 6000 cfs, and their designs are discussed in Section 11. In recent decades, design improvements have been implemented to increase the biological effectiveness of *positive-exclusion* screen and *bypass system*s by taking advantage of known behavioral responses to hydraulic conditions. Recent evaluations have consistently demonstrated high success rates (typically greater than 98%) at moving juvenile salmonids past intakes with a minimum of delay, loss, or injury. For diversion flows over 6000 cfs, such as at Columbia River mainstem turbine intakes, submerged traveling screens or bar screens are commonly used. These are not considered *positive-exclusion* screens in the context of this position statement. In addition, large reservoirs often involve consideration of a surface outlet for fish passage, and may offer a superior route of passage as compared to a deep outlet with a positive exclusion screen

The past few decades have also seen considerable effort in developing "startle" systems or other behavioral exclusion devices to elicit a taxis (response) by fish, with an ultimate goal of reducing entrainment. This paper addresses research to be performed for types of fish passage devices not included in the preceding chapters of this document in order to prevent losses at intakes and other passage impediments and presents a position statement for reviewing and implementing future fish protection measures.

Entrainment, impingement, and delay/predation are the primary contributors to the mortality of juvenile migrating salmonids. Entrainment occurs when fish are drawn into the diversion canal or turbine intake. Impingement occurs when a fish is not able to avoid contact with a screen surface, *trashrack*, or debris at the intake. This may cause bruising, descaling and other injuries.

Impingement, if prolonged, repeated, or occurring at high velocities, also causes direct mortality. Predation (which is the leading cause of mortality at some diversion sites) occurs when fish are preyed upon by aquatic or avian animals. Delay at intakes increases predation by stressing or disorienting fish and/or by providing habitat for predators.

Design criteria for *Positive-exclusion screen and bypass system*s (PESBS) (Section 11) have been developed, tested, and proven to minimize adverse impacts to fish at diversion sites. Screens with small openings and fish-tight seals are positioned at a slight angle to flow. This orientation allows fish to be guided to safety at the downstream end of the screen, while they resist being impinged on the screen face. These screens are very effective at preventing entrainment (Pearce and Lee 1991). Carefully designed *bypass system*s minimize fish exposure to screens and provide hydraulic conditions that safely return fish to the river, thereby preventing impingement (Rainey 1985). The PESBS are designed to minimize entrainment, impingement, and delay/predation from the point of diversion through the facility to the bypass outfall.

PESBS have been installed and evaluated at numerous facilities (Abernathy et al. 1989, 1990; Rainey 1990; and Johnson 1988). A variety of screen types (e.g., fixed-vertical, drum, fixed-inclined) and *screen material*s (e.g., woven cloth [mesh], perforated plate, profile wire) have proven effective, when used in the context of a satisfactory design for the specific site. Facilities designed to previously referenced criteria consistently resulted in a guidance efficiencies of over 98% (Hosey 1990; Neitzel 1985, 1986,1990a,b,c,d; Neitzel 1991).

The main detriment of PESBS is cost, because of the low velocity requirement and structure complexity. At the headworks, the need to clean the screen, remove trash, control sediment, and provide regular maintenance (e.g., seasonal installation, replacing seals, etc.) also increases costs.

16.3 Behavioral Devices

There has been considerable effort since 1960 to develop less expensive behavioral devices as a substitute for conventional fish protection (EPRI 1986). A behavioral device, as opposed to a conventional passage system, requires volitional taxis on the part of the fish to avoid entrainment. Some devices were investigated with the hope of attracting fish to a desired area while others were designed to repel fish. Most studies focused on soliciting a behavior response, usually noticeable agitation, from the fish.

Investigations of prototype startle-response devices document that fish guidance efficiencies are consistently much lower for these devices than for conventional screens. Experiments show that there may be a large behavioral variation in startle responses between individual fish of the same size and species. Therefore, it cannot be predicted that a fish will always move toward or away from that stimuli. Until shown conclusively in laboratory studies, it should not be assumed that fish can discern where a signal is coming from and what constitutes the clear path to safety.

If juvenile fish respond to a behavioral device, limited size and swimming ability may preclude small fish from avoiding entrainment (even if they have the understanding of where to go and have the desire to get there). Another concern is repeated exposure; fish may no longer react to a signal after an acclimation period. In addition to vagaries in the response of an individual fish, behavior variations due to species, life stage, and water quality conditions can be expected.

Another observation is that past field tests of behavioral devices have been deployed without consideration of how controlled ambient hydraulic conditions (i.e., the use of a *training wall* to create uniform flow conditions, while minimizing stagnant zones or eddies that may increase exposure to predation) may optimize fish guidance and safe passage away from the intake. Failure to consider that hydraulic conditions may play a large role in guiding fish away from the intake is either the result of the desire to minimize costs or the assumption that behavioral devices may overcome the tendency for poor guidance associated with marginal hydraulic conditions. The provision of satisfactory hydraulic conditions is a key element of PESBS designs.

The primary motivation for selection of behavioral devices relates to cost, and possibly to ease maintenance issues with PESBS. However, much of the cost in PESBS is related to construction of physical structures to provide hydraulic conditions that are known to optimize fish guidance. Paradoxically, complementing the behavioral device with hydraulic control structures needed to optimize juvenile passage will compromise much of the cost advantage relative to PESBS.

Currently few behavioral devices are being used for stand-alone fish protection in the field. Those that have been installed and evaluated seldom show consistent guidance efficiencies over 60% (Vogel 1988; EPRI 1986). The louver system is an example of a behavioral device with a poor record, particularly for *fry*-sized salmonids. Entrainment rates were high, even with favorable hydraulic conditions, due to the presence of smaller fish (Vogel 1988; Cramer 1973; Bates 1961). Due to their poor performance, most of these systems were eventually replaced by PESBS.

16.4 Process for Developing Experimental Fish Passage Technology

Development of new passage concepts may have the potential to provide fish passage. In general, the process for developing new upstream adult passage technology and gaining NMFS approval is the same as for downstream juvenile fish passage. Some of these concepts are currently in development (e.g., stream simulation and roughened channel designs), and have existing field prototype installations that have been assessed to some degree.

There is potential for future development of new passage devices that may safely pass fish at a rate comparable with conventional technology. These new concepts are considered "experimental" until they have been through the process described herein and have been proven in a prototype evaluation validated by NMFS. These prototype evaluations should occur over the foreseeable range of adverse hydraulic and water quality conditions (e.g., temperature, dissolved oxygen). NMFS will not discourage research and development on experimental fish protection devices, but the following elements should be addressed during the process of developing experimental juvenile passage protection concepts:

1. **Earlier Research.** A thorough review of similar methods used in the past should be performed. Reasons for substandard performances should be clearly identified.

2. **Study Plan.** A study plan should be developed and presented to NMFS for review and concurrence. It is essential that tests occur over a full range of possible hydraulic, biological, and ecological conditions that the device is expected to experience. Failure to receive study plan endorsement from NMFS may result in disputable results and conclusions.

3. **Laboratory Research.** Laboratory experiments under controlled conditions should be developed using species, size, and life stages intended to be protected. For behavioral devices, special attention must be directed at providing favorable hydraulic conditions and demonstrating that the device clearly induces the planned behavioral response. Studies should be repeated with the same test fish to examine any acclimation to the guidance device.

4. **Prototype Units.** Once laboratory tests show high potential to equal or exceed success rates of conventional passage devices, it is appropriate to further examine the new device as a prototype under real field conditions. Field sites must be appropriate to (1) demonstrate durable performance at all expected operational and natural variables, (2) evaluate the species, or an acceptable surrogate, that would be exposed to the device under full operation, and (3) avoid unacceptable risk to depressed or listed stocks at the prototype locations.

5. **Study Results.** Results of both laboratory tests and field prototype evaluations must demonstrate a level of performance equal to or exceeding that of conventional fish passage devices before NMFS may support permanent installations.

16.5 Conclusions

Proven fish passage and protection facilities designs are available to provide successful passage at most fish passage impediments. Periodically, major initiatives have been advanced to examine the feasibility of experimental passage systems. Results were generally poor or inconclusive, with low guidance efficiencies attributable to the particular device used. Often results were based on a small sample size, or varied with operational conditions. In addition, unforeseen operational and maintenance problems (and safety hazards) were sometimes a byproduct. Nevertheless, some of these passage systems have shown potential for success. To further advance fish protection technology, NMFS will not oppose tests that proceed in accordance with the tiered process outlined above. To ensure no further detriment to any fish resource, including delays in implementation of acceptable passage facilities, experimental field testing should occur simultaneous to design and development of conventional passage design for that site. This conventional system should be scheduled for installation in a reasonable time frame, independent of the experimental efforts. In this manner, if the experimental guidance system once again does not prove to be as effective as proven conventional technology, a conventional passage design may be implemented without additional delay and detriment to the resource.

17. SUGGESTED READING AND REFERENCES

Abernathy, C.S., D.A. Neitzel, and E.W. Lusty. 1989. Velocity Measurements at Six Fish Screening Facilities in the Yakima Basin, Washington, Summer 1988. Annual report to the Bonneville Power Administration.

Abernathy, C.S., D.D. Neitzel, and E.W. Lusty. 1990. Velocity Measurements at Three Fish Screening Facilities in the Yakima River Basin, Summer 1989. U.S. Department of Energy Bonneville Power Administration Division of Fish and Wildlife.

Aisenbrey, A.J., R.B. Hayes, H.J. Warren, D.L. Winsett and R.B. Young, 1974. Design of Small Canal Structures. U.S. Department of Interior Bureau of Reclamation. U.S. Government Printing Office, Denver, CO.

Baker, C.O. and F.E. Votapka. 1990. Fish Passage Through Culverts. Federal Highways Administration & USDA Forest Service. FHWA-FL-90-006. 67 pages. (Available from USDA Forest Service publications, San Dimas Laboratory, CA).

Bates, D.W. and S.G. Jewett, Jr. 1961. Louver Efficiency in Deflecting Downstream Migrant Steelhead Transaction of the American Fisheries Society, Vol. 90., No. 3, p. 336-337.

Bates, K.M. 1988. Screen Criteria for Juvenile Salmon, Washington Department of Fisheries. Olympia, WA.

Bates, K.M. 1992. *Fishway* Design Guidelines for Pacific Salmon. Working paper 1.6. (Available from WDFW. 600 Capitol Way North, Olympia, WA, 98501-1091.)

Bates, K.M and R. Fuller. 1992. Salmon *Fry* Mesh Study. State of Washington Department of Fisheries. Olympia, WA.

Bates, K.M. 1993. Fish passage Policy and Technology - Proceedings of a Symposium Sponsored by the Bioengineering Section of the American Fisheries Society, Portland, OR.

Bell. M. C. 1991. Fisheries handbook of engineering requirements and biological criteria. Fish Passage and Development Evaluation Program, U.S. Army Corps of Engineers, Portland, OR.

Beechie, T., E. Beamer, and L. Wasserman. 1994. Estimating Coho Salmon Rearing Habitat and *Smolt* Production Losses in a Large River Basin, and Implications for Habitat Restoration. North Am. J. Fish. Mgt. 14:797 - 811.

Behlke, C.E., D.L. Kane, R.F. McLean, and M.D. Travis. 1991. Fundamentals of Culvert Design for Passage of Weak-Swimming Fish, Final Report. Alaska DOT&PF and USDT, Federal Highway Administration, FHWA-AK-RD-90-10. 177 pages.

Bell, Milo C., 1991. "Revised Compendium on the Success of Passage of Small Fish Through Turbines." Report for U.S. Army Corps of Engineers, North Pacific Division, Contract No. DACW-57-88-C-0070. Portland, OR. North Pacific Division Army Corps of Engineers (COE). May 1976. Fourth Progress Report on Fisheries Engineering Research Program 1966-1972, Report #32. Portland, Oregon.

Bigelow, J.P. and R.R. Johnson. 1996. Estimates of Survival and Condition of Juvenile Salmonids passing Through the Downstream Migrant Fish Protection Facilities at Red Bluff Diversion Dam on the Sacramento River, Spring and Summer 1994. U.S. Fish and Wildlife Service Annual Report. North Central Valley Fish and Wildlife Office, Red Bluff, California.

Brett, J.R., Hollands, M., and Alderdice, D.F. 1958. "The effect of temperature on the cruising speed of young sockeye and coho salmon" Fisheries Research Board of Canada, Journal 15(4): pp 587-605.

Cada, G. F. 1998. Fish passage mitigation at hydroelectric power projects in the United States, pp. 208–219. In: Fish Migration and Fish Bypasses: Proceedings of the Symposium. (Jungwirth, M., S. Schmutz, and S. Weiss, Eds.). Vienna, Austria: Fishing News Books.

California Department of Fish and Game. 1998. California Salmonid Stream Habitat Restoration Manual, 3rd Edition, Part X Fish Passage Evaluation At Road Crossings (Part X is in preparation, expected fall 2001).

California Department of Fish and Game. 2001. Culvert Criteria for Fish Passage.

Clay, C. H. 1995. Design of *Fishway*s and Other Fish Facilities. Boca Raton, Florida: CRC Press.

Coutant, C. C. (Ed.). 2001. Behavioral technologies for fish guidance. American Fisheries Society, Symposium 26, Bethesda, MD.

Cramer, D.P. 1982. Evaluation of Downstream Migrant *Bypass system* - T.W. Sullivan Plant, Willamette Falls (Progress Report for Fall 1981 and Spring 1982 dtd October 11, 1982) PGE.

Chow, V.T. 1959. Open-channel Hydraulics. McGraw-hill Book Company.

Davis, G.E., J. Foster, C.E. Ward and P. Doudoroff. 1968. The Influence of Oxygen on the Swimming Performance of Juvenile Pacific Salmon at Various Temperatures. Technical Paper No. 1475, Oregon Agricultural Experiment Station, Corvallis, OR.

Darling, D.D. 1991. Evaluation of an Eicher Screen at Elwha Dam. Proceedings of the International Conference on Hydropower, July 1991. Denver, CO.

Electric Power Research Institute. 1988. Proceedings: Fish Protection at Steam and Hydroelectric Power Plants, EPRI CS/EA/AP-5663-SR, Electric Power Research Institute, Palo Alto, CA.

Electric Power Research Institute. 1990. Fish Protection Systems for Hydro Plants, EPRI GS-6712, Electric Power Research Institute, Palo Alto, CA.

Electric Power Research Institute, prepared by Stone & Webster Engineering Corporation. 1994. Biological Evaluation of the Modular Inclined Screen for Protecting Fish at Water Intakes, EPRI TR-104121, Electric Power Research Institute, Palo Alto, CA.

Electric Power Research Institute. 1996. Evaluation of the Modular Inclined Screen (MIS) at the Green Island Hydroelectric Project: 1995 Test Results, EPRI TR-106498, Electric Power Research Institute, Palo Alto, CA.

Electric Power Research Institute, prepared by Stone & Webster Engineering Corporation. 1986. Assessment of downstream migrant fish protection technologies for hydroelectric application. EPRI AP-4711, Electric Power Research Institute, Palo Alto, CA.

Electric Power Research Institute. 1991. Evaluation of an Eicher Screen at Elwah Dam: Spring 1990 test results, EPRI GS/EN-7036, Palo Alto, CA.

Easterbrooks, J.A. 1984. Juvenile Fish Screen Design Criteria: A review of the Objectives and Scientific Data Base. State of Washington Department of Fisheries. Yakima, WA.

EPRI (Electric Power Research Institute). 1986. Assessment of Downstream Migrant Fish Protection technologies for hydroelectric application. EPRI, Palo Alto, CA.

Evans, W.A. and B. Johnston. 1980. Fish Migration and Fish Passage: a Practical Guide to Solving Fish Passage Problems. U.S. Forest Service, EM - 7100 - 2, Washington, D.C.

Federal Energy Regulatory Commission. 2004. Evaluation of mitigation effectiveness at hydropower projects: fish passage. Draft report 2004 1008-0140, Office of Energy Projects, Division of Hydropower Administration and Compliance, Washington D.C.

Fisher, F.W. 1981. Long Term Swimming Performance of American Shad and Chinook Salmon. State of California Department of Fish and Game, Administrative Report No. 81-2, Bay-Delta Fisheries Project, Sacramento, CA.

Francfort, J.E., G.F. Cada, D.D. Dauble,R.T. Hunt, D.W. Jones, B.N. Rinehart, G.L. Summers, and R.J. Costello. 1994. Environmental Mitigation at Hydroelectric Projects. Volume II. Benefits and Costs of Fish Passage and Protection. Idaho National Engineering Laboratory, Idaho Falls, ID.

Furniss, M.J., T.D. Roelofs, and C.S. Yee. 1991. Road Construction and Maintenance. American Fisheries Society Special Publication 19:297-323.

Gebhards, S., and J. Fisher. 1972. Fish Passage and Culvert Installations. Idaho Fish and Game Rep. 12 pages.

Glova, G.J. and F.E. McInerney. 1972. Critical Swimming Speeds of Coho Salmon *Fry* to *Smolt* Stages in Relation to Salinity and Temperature. Journal of the Fisheries Board of Canadian Journal 34:151-154.

Greenland, D.C. and A.E. Thomas. 1972. Swimming Speed of Fall Chinook Salmon *Fry*. Transactions of the American Fisheries Society, 101(4):696-700.

Groot, C., and L. Margolis, editors. 1991. Pacific Salmon Life Histories. Univ. British Columbia Press, Vancouver. 564 pages.

Haro, A., M. Odeh, J. Noreika, and T. Castro-Santos. 1998. Effect of water acceleration on downstream migratory behavior and passage of Atlantic salmon juvenile salmonids and juvenile American shad at surface bypasses. Trans. Am. Fish. Soc., 127: 118–127.

Hallock, R.J., and W.F. Van Woert. October 1959. A Survey of Anadromous Fish Losses in Irrigation Diversions from the Sacramento and San Joaquin Rivers. California Fish and Game. Vol. 45, No. 4, pp. 227-266.

Hallock, R.J. 1977. A Description of the California Department of Fish and Game Management Program and Goals for the Sacramento River System Salmon Resource. California Fish and Game, Anadromous Fisheries Branch Administrative Report. 16 pp.

Hallock, R.J. 1977. A Description of the California Department of Fish and Game Management Program and Goals for the Sacramento River System Salmon Resource. California Fish and Game, Anadromous Fisheries Branch Administrative Report. 16 pp.

Hanson C.H. and H.W. Li, 1983. Behavioral Response of Juvenile Chinook Salmon to *Trash rack* Bar Spacing. California Fish and Game 69(1) 18-22.

Hassler, T.J. 1987. Species Profiles: Life Histories and Environmental Requirements of Coastal
Fishes and Invertebrates (Pacific Southwest) Coho Salmon. U.S. Fish Wildl. Serv. Biol.
Rep. 82(11.70). U.S. Army Corps of Engineers, TR EL-82-4. 19 pages.

Hatton, S. 1940. Progress Report on Central Valley Fish, 1939. California Fish and Game, 26(3) pp. 334-373.

Hosey and Associates and Fish Management Consultants. 1990. Easton Facility Evaluation. Prepared for U.S. Bureau of Reclamation, Contract No. 7-CS-10-07720, Boise, Idaho.

Hosey and Associates and Fish Management Consultants. 1990. Evaluation of the Chandler, Columbia, Roza and Easton Screening Facilities, Completion Report. Prepared for U.S. Bureau of Reclamation, Contract No. 7-CS-10-07720, Boise, Idaho.

Hosey and Associates and Fish Management Consultants. 1988. Chandler Facility Evaluation. Prepared for U.S. Bureau of Reclamation, Contract No. 7-CS-10-07720, Boise, Idaho.

Hosey and Associates and Fish Management Consultants. 1988. Columbia Facility Evaluation. Prepared for U.S. Bureau of Reclamation, Contract No. 7-CS-10-07720, Boise, Idaho.

Johnson, A. and J.F. Orsborn. Undated, circa 1990. Welcome to Culvert College. Washington Trout, Duvall, WA. 67 pages.

Johnson, G. E., B. D. Ebberts, D. D. Dauble, A. E. Giorgi, P. G. Heisey, R. P. Mueller, and D. A. Neitzel. 2003. Effects of jet entry at high flow outfalls on juvenile Pacific salmon. North Am. J. Fish Manage., 23: 441–449.

Johnson, R.C. 1995. Fish Passage Evaluation Tests in the North Shore *Fishway* Hydroelectric Project at The Dalles Dam. Prepared for North Wasco County People=s Utility District, The Dalles, Oregon.

Jones, S.T., G.M. Starke and R.J. Stansell. 1998. Predation by Gulls and Effectiveness of Predation Control Measures at Bonneville, The Dalles and John Day Dams in 1997. U.S. Army Corps of Engineers CENWP-CO-SRF, Cascade Locks, OR.

Johnson, P.L. 1988. Hydraulic Design of Angled Drum Fish Screens. In: Proceedings of the Electric Power Research Institute Conference on Fish Protection at Steam and Hydro Plants, San Francisco, CA., Oct. 28-30, 1987. EPRI CS/EA/AP-5663-SR.

Jungwirth, M. S., Schmutz, and S. Weiss (Eds.). 1998. Fish Migration and Fish Bypasses. Proceedings of a symposium. London: Fishing News Books (1998).

Kano, R.M. 1982. Responses of Juvenile Salmon and American Shad to Long Term Exposure to Two-Vector Velocity Flows. Interagency Ecological Study Program for the Sacramento-San Joaquin Estuary, Technical Report No. 4., Stockton, CA.

Kay, AR., and R.B. Lewis. 1970. Passage of Anadromous Fish Through Highway Drainage
Structures. California Division of Highways, Dist. 01 Res. Rep. 629110. 28 pages.

Knapp, S.M.(editor). 1992. Evaluation of the Juvenile Bypass and Adult Fish Passage Facilities at Water Diversions on the Umatilla River, Annual and Interim Progress Reports October 1990-September 1991. Project No. 89-024-01. Prepared for Bonneville Power Administration, Portland, Oregon.

Knapp, S.M.(editor). 1994. Evaluation of the Juvenile Bypass and Adult Fish Passage Facilities at Water Diversions on the Umatilla River, Annual Report 1993. Project No. 89-024-01. Prepared for Bonneville Power Administration, Portland, Oregon.

Katopodis, C. 1992. Introduction to *fishway* Design. Working Document from Fish Passageways and Diversion Structures Course presented by National Education and Training Center, USFWS.

Lauman, J.E. 1976. Salmonid Passage at Stream-Road Crossings. Oregon Dept. of Fish and Wildlife.

Marquette, M. W. and C. W. Long. 1971. Laboratory studies of screens for diverting juvenile salmon and trout from turbine intakes. Trans. Am. Fish. Soc., 3: 439–447.

McClellan, T.J. 1970. Fish Passage Through Highway Culverts. U.S. Dept. Trans., Federal
Highway Administration and Oregon State Game Comm., Portland OR. 16 pages.

McElhany, P., M.H. Ruckelshaus, M.J. Ford, T.C. Wainwright, and E.P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-42,156 p.

Mueller, R.P., C.S. Abernathy, and D.A. Neitzel. 1995. A Fisheries Evaluation of the Dryden Fish Screening Facility Annual Report 1994. Project No. 85-062. Prepared for Bonneville Power Administration, Portland, Oregon.

Meehan, W.R., editor. 1991. Influences of Forest and Rangeland Management on Salmonid
Fishes and Their Habitats. American Fisheries Society Special Publication 19.

Nigro, A.A.(editor). 1990. Evaluation of the Juvenile Bypass and Adult Fish Passage Facilities at Three Mile Dam, Umatilla River, Annual Progress Report October 1989. Project No. 89-024-01. Prepared for Bonneville Power Administration, Portland, Oregon.

Nietzel, D.A. and C.S. Abernathy. 1995. Movement and Injury Rates for three Life Stages of spring Chinook Salmon: A comparison of Submerged Orifices and an Overflow *Weir* for Fish Bypass in a Modular Rotary Drum Fish Screen. Prepared for Bonneville Power Administration, Portland, Oregon.

Nietzel, D.A., C.S. Abernathy, E.W. Lusty and L.A. Prohammer. 1985. A Fisheries Evaluation of the Sunnyside Canal Fish Screening Facilities Spring 1985 Annual Report. Contract No. DE-AC06-RLO. Prepared for Bonneville Power Administration, Portland, Oregon.

Neitzel, D.A., C.S. Abernathy, and W.W. Lusty. 1986. A Fisheries Evaluation of the Richland and Toppenish/Satus Canal Fish Screening Facilities, Spring 1986. Annual Report to the Bonneville Power Administration.

Neitzel, D.A., C.S. Abernathy, and E.W. Lusty. 1990. A Fisheries Evaluation of the Wapato, Sunnyside and Toppenish Creek Canal Fish Screening Facilities, Spring 1988.

Nietzel, D.A., C.S. Abernathy and E.W. Lusty. 1990. A Fisheries Evaluation of the Westside Ditch and Wapato Canal Fish Screening Facilities Spring 1989 Annual Report. Project No. 85-62. Prepared for Bonneville Power Administration, Portland, Oregon.

Nietzel, D.A. and C.S. Abernathy. 1995. Movement and Injury Rates for three Life Stages of spring Chinook Salmon: A comparison of Submerged Orifices and an Overflow *Weir* for Fish Bypass in a Modular Rotary Drum Fish Screen. Prepared for Bonneville Power Administration, Portland, Oregon.

Neitzel, D.A., C.S. Abernathy, and E.W. Lusty. 1991. Evaluating of Rotating Drum Screen Facilities in the Yakima River Basin, South-Central Washington State. In: Fisheries Bioengineering Symposium. American Fisheries Society Symposium 10. Bethesda, MD.

Neitzel, D.A., C.S. Abernathy, and G.A. Martenson. 1990d. A Fisheries Evaluation of the Westside Ditch and Town Canal Fish Screening Facilities, Spring 1990. Annual Report to the Bonneville Power Administration.

Nietzel, D.A., S.L. Blanton, C.S. Abernathy and D.S. Daly. 1996. Movement of fall Chinook *fry*: A comparison of Approach Angles in a Modular Rotary Drum Fish Screen. Project No. 86-118. Prepared for Bonneville Power Administration, Portland, Oregon.

Neitzel, D.A., T.J. Clune, and C.S. Abernathy. 1990a. Evaluation of Rotary Drum Screens Used to Project Juvenile Salmonids in the Yakima River Basin. In: Proceedings of the International Symposium on *fishway*s '90. Gifu, Japan.

Nordlund, B.D. 1997. Designing Fish Screens for Fish Protection at Water Diversions, in Fish Passageways and Bypass Facilities - West, U.S. Fish and Wildlife Service National Conservation Training Center, Shepardstown, WV.

Normandeau Associates, Inc., Parametrix, Inc., and J. R. Skalski. 1996. Behavior of juvenile salmonids relative to the prototype surface bypass collection channel at Wanapum Dam, Columbia River, Washington. Drumore, PA: Normandeau Associates, Inc.

NRC (National Research Council). 1996. Upstream: salmon and society in the Pacific Northwest. National Academy Press, Washington D.C.

Odeh, M. (Ed.). 1999. Innovations in fish passage technology. Bethesda, MD: American Fisheries Society (1999).

Odeh. M. (Ed.). 2000. Advances in fish passage technology. Bethesda, MD: American Fisheries Society.

ODFW, 1997. Oregon Department of Fish and Wildlife Guidelines and Criteria for Stream-RoadCrossings. 7 pages.

Office of Technology Assessment. Fish passage technologies: protection at hydropower facilities. OTA-ENV-641. Washington, DC: U.S. Government Printing Office.

Ott, R.F. and D.P. Jarrett. Air-Burst Fish Screen Cleaning System for the Twin Falls Hydroelectric Project (unpublished). HDR Engineering, Inc. Bellevue, WA.

Pearce, R.O., J. Ferguson, M. Lindgren and J. Nestler. 1995. Fish Passage and Protection, Chapter 7 in Guidelines for Design of Intakes for Hydroelectric Plants, pp 215-283. American Society of Civil Engineers, New York, NY.

Pearce, R.O., and R.T. Lee. 1991. Some Design Considerations for Approach Velocities at Juvenile Salmonid Screening Facilities. In:Fisheries Bioengineering Symposium. American Fisheries Society Symposium 10. Bethesda, MD.

Poe, T. P., M. G. Mesa, R. S. Shively, and R. D. Peters. 1993. Development of biological criteria for siting and operation of juvenile *bypass system*s: implications for protecting juvenile salmonids from predation, pp. 169–178. In: Fish Passage Policy and Technology (Bates, K., Ed.). Bethesda, MD: American Fisheries Society.

Pearsons, T.N., G.A. McMichael, S.W. Martin, E.L. Bartrand, A. Long, and S.A. Leider. 1996.
Yakima Species Interactions Studies Annual Report 1994. U.S. Department of Energy, Bonneville Power Administration Annual Report 1994. No. DOE/BPB99852-3.

Poulin, V.A., and H.W. Argent. 1997. Stream Crossing Guidebook for Fish Streams, a Working Draft. Prepared for British Columbia Ministry of Forests. 80 pages.

Powers, Pat. 1993. Structures for Passing Juvenile Salmon Into Off-Channel Habitat American Fisheries Society Annual Meeting in Portland in 1993

Rainey, W.S. 1990. Cylindrical Drum Screen Designs for Juvenile Fish Protection at Two Large Diversions. In: Proceedings of the International Symposium on *fishway*s '90 in Gifu. Gifu, Japan.

Rainey, W.S. 1985. Considerations in the Design of Juvenile *Bypass system*s. Paper presented at the Symposium on Small Hydropower and Fisheries. Denver, CO.

Reading, H.H. 1982. Passage of Juvenile Chinook Salmon and American Shad through Various Trashrack Bar Spacings. State of California Department of Fish and Game technical Report 5, Interagency Ecological Study Program for the Sacramento-San Juaquin Estuary. Red Bluff, CA.

Reiser, D. W. and K.T. Oliver. 2002. Review of Projects Employing Conventional Fish Screens - Existing Information Analysis. Prepared for Portland General Electric Company, Portland, OR.

Ruehle, T.E. and C.S. McCutcheon. 1994. PIT-Tag Studies with Juvenile Salmonids at the Chandler Fish Collection Facility, Yakima River, 1990. Project No.90-65. Prepared for Bonneville Power Administration, Portland, Oregon.

Salmonid Restoration Federation Conference. 1996. Culvert Fish Passage Design and Retrofitting Workshop. Fortuna, CA. 30 pages.

Sandercock, F.K. 1991. Life History of Coho Salmon. Pages 397-445 in C. Groot and L. Margolis (eds.), Pacific salmon life histories. Univ. British Columbia Press, Vancouver. 564 pages.

Senn, H., Mack, J. and L. Rothfus. 1984. Compendium of Low-cost Pacific Salmon and Steelhead Trout Production Facilities and Practices in the Pacific Northwest. Project No. 83-353. Prepared for Bonneville Power Administration, Portland, Oregon.

Shirvell, C.S. 1994. Effect of changes in streamflow on the microhabitat use and movement of sympatric juvenile coho salmon (Oncorhynchus kisutch) and chinook salmon (O.tshawytscha) in a natural stream. Can. J. Fish. Aquat. Sci. 51:1644-1652.

Simmons, W.P. 1964. Hydraulic Design of Transitions for Small Canals. U.S. Bureau of Reclamation, Engineering Monograph No. 33, U.S. Government Printing Office, Washington D.C.

Skinner, J.E. 1974. A Functional Evaluation of a Large Louver Screen Installation and Fish Facilities Research on California Water Diversion Projects. In: Proceedings of the Second Workshop on Entrainment and Intake Screening. Johns Hopkins University, Baltimore, MD., February 5-9, 1973.

Smith, L.W. 1982. Clogging, Cleaning, and Corrosion Study of Possible Fish Screens for the Proposed Peripheral Canal. Interagency Ecological Study Program for the Sacramento-San Juaquin Estuary, Sacramento, CA.

Smith, L.S. and L.T. Carpenter. 1987. Salmonid *Fry* Swimming Stamina Data for Diversion Screen Criteria. Final Report. Fisheries Research Institute, University of Washington, Seattle, WA (1987).

Spencer, John. 1928. Fish Screens in California Irrigation Ditches. California Fish and Game, Vol. 14, No. 3, p. 208-210.

Stefan, H. and A. Fu. 1978. Headloss Characteristics of Six Profile-wire Screen Panels Project Report No. 175. St. Anthony Falls Hydraulic Laboratory, Minneapolis, MN.

Stone, J. M. and T. R. Mosey. 2005. Biological evaluation of the Rocky Reach juvenile fish *bypass system* 2004. Chelan County Public Utility District, Wenatchee, WA.

Taft, N. 1994. Fish Passage at Hydroelectric Projects, presented at Hydro's Leading Edge Technology: A Symposium Celebrating ARL's Centennial, Phoenix, AZ.

Taylor, E.B. and J.D. McPhail. 1985. Variation in Burst and Prolonged Swimming Performance Among British Columbia Populations of Coho Salmon. Canadian Journal of Fisheries and Aquatic Sciences, Volume 42.

Thomas, A.E., J.L. Banks and D.C. Greenland. 1969. Effect of Yolk Sac Absorption on the Swimming Ability of Fall Chinook Salmon. Transactions of the American Fisheries Society 98(3):406-410

Tomljanovich, D.A., and J.H. Heuer. 1979. Protection of Fish Larvae using Fine-Mesh Screening. Presented at American Society of Engineers Convention, Atlanta, GA.

Turnpenny, A.W. 1981. An Analysis of Mesh Sizes Required for Screening Fishes at Water Intakes. Estuaries, Volume 4, No. 4

Turnpenny, A.W., H.G. Struthers, and K.P. Hanson. 1998. A UK guide to intake fish-screening regulations, policy and best practice. ETSU H/06/0052/00/00. Report to the Department of Trade and Industry, Energy Technology Support Unit, Harwell, United Kingdom.

U.S. Army Corps of Engineers (COE). 1956. North Pacific Division Corps Of Engineers, Progress Report On Fisheries Engineering Research Program, November 1956. Portland, Oregon.
Contents:

1. A Review of Studies in Guiding Downstream Migrating Salmon with Light. U.S. fish and Wildlife Service.
2. Determination of the Normal Stream Distribution, Size, Time and current Preference of Downstream Migrating Salmon and Steelhead Trout in the Columbia and Snake Rivers. State of Washington Dept. of Fisheries.
3. The Effect of Sound Waves on Young Salmon. U.S. Fish and Wildlife Service.
4. Powerhouse Collection System and Transportation Flows, Bonneville Dam. Portland District, Corps of Engineers.
5. The Status of Field Scale Electrical Fish Guiding Experiments. U.S. Fish and Wildlife Service.
6. Effect of Structures at Main Columbia River Dams on Downstream Migration of Fingerlings. Portland District, Corps of Engineers.
7. Bouyant Submerged Orifice Research. Portland District, Corps of Engineers.
8. Study of the Effect of Magnetic Fields on Salmon. U.S. Fish and Wildlife Service.
9. *Fishway* Attraction Water Supply Study. Walla Walla District, Corps of Engineers.

10. Submerged Orifice Research Powerhouse Fish Collection System, Bonneville Dam. Portland District, Corps of Engineers.
11. The Control of Downstream Migrants by Means of Mechanical Screens. Oregon Game Commission.
12. Research Relating to Mortality of Downstream Migrant Salmon Passing McNary Dam. State of Washington Department of Fisheries.
13. Research Relating to Study of Spawning Grounds in Natural Areas. State of Washington Department of Fisheries.
14. Investigation of the Rate of Passage of Salmon and Steelhead Trout through Bonneville Dam and The Dalles Dam Site as Compared to Unobstructed Sections of the Columbia River. Oregon Fish Commission.
15. Investigations and Field Studies Relating to Numbers and Seasonal Occurrence of Migratory Fish Entering the Columbia River above Bonneville and the Snake River and Their Final Distribution among Principal Tributaries Thereto. Oregon Fish Commission.
16. Enumeration Study – Upper Columbia and Snake Rivers. Idaho Department of Fish and Game.
17. Research on Fishway Problems. U.S. Fish and Wildlife Service.
18. A Study to Investigate the Effects of Fatigue and Current Velocities on Adult Salmon and Steelhead Trout. School of Fisheries, University of Washington.
19. A Study to determine the Effects of Electricity on Salmon and Steelhead Trout. School of Fisheries, University of Washington.
20. Determination of the Vertical and Horizontal Distribution of Seaward Migrants, Baker Dam. State of Washington, Department of Fisheries.
21. Guiding Downstream Migrant Salmon and Steelhead Trout. A Research Summary. School of Fisheries, University of Washington.

U.S. Army Corps of Engineers (COE). 1960. North Pacific Division Corps Of Engineers, Progress Report On Fisheries Engineering Research Program, July, 1960. Portland, Oregon.

Contents:

1. Guiding Downstream Migrant Salmon and Steelhead Trout College of Fisheries. University of Washington.
2. Results of a Tagging Program to Enumerate the Numbers and to Determine the Seasonal Occurrence of Anadromous Fish in the Snake River and its Tributaries Fish Commission of the State of Oregon.
3. Enumeration Study Upper Columbia and Snake Rivers. Idaho Department of Fish and Game.
4. Evaluation of the Ability of an Artificial Outlet to Attract Downstream Migrant Salmonids from the Reservoir of Lookout Point Dam. Fish Commission of the State of Oregon.
5. The Control of Downstream Migrants by Means of Mechanical Screens. Oregon State Game Commission.
6. Fishway Attraction Water Supply Study. Walla Walla District, Corps of Engineers.
7. Effect of Structures at Main Columbia River Dams on Downstream Migration of Fingerlings. Portland District, Corps of Engineers.

8. The Status of Electrical Fish Guiding Experiments. U.S. Fish and Wildlife Service.
9. Research Relating to McNary Supplemental Spawning Channel. State of Washington, Department of Fisheries.
10. Research on *Fishway* Problems. Bureau of Commercial Fisheries, U.S. Fish and Wildlife Service.
11. A Study to Determine the Effects of Electricity on Salmon and Steelhead Trout. College of Fisheries, University of Washington.
12. A Study to Investigate the Effects of Fatigue and Current Velocities on Adult Salmon and Steelhead Trout. College of Fisheries, University of Washington.
13. Research Relating to Mortality of Downstream Migrant Salmon Passing McNary and Big Cliffs Dams. State of Washington, Department of Fisheries.
14. Powerhouse Fish Collection System and Transportation Flow, Bonneville Dam. Portland District, Corps of Engineers.
15. Submerged Orifice Research Powerhouse Fish Collection System, Bonneville Dam. Portland District, Corps of Engineers.
16. Buoyant Submerged Orifice Research. Portland District, Corps of Engineers.
17. An Investigation of the Effect of The Dalles Dam upon Migration Rates of Adult Salmonids, 1956 and 1957. Fish Commission of the State of Oregon.
18. Experimental Studies on the survival of the Early Stages of Chinook Salmon after varying Exposures to Upper Lethal Temperatures. State of Washington, Department of Fisheries.
19. Fish Passage through Turbines. Walla Walla District, Corps of Engineers.

U.S. Army Corps of Engineers (COE). 1966. North Pacific Division Corps Of Engineers, Progress Report On Fisheries Engineering Research Program, November 1966. Portland, Oregon.

Contents:

1. Migrant Salmon Light-Guiding Studies at Columbia River Dams. Paul E. Fields.
2. Juvenile Fish Passage Through Turbines. Raymond C. Oligher.
3. Research on *Fishway* Problems, May 1960 to April 1965. Joseph R. Gauley, Charles R. Weaver, and Clark S. Thompson.
4. Fallback of Adult Chinook Salmon at Ice Harbor Dam Spillway, May 1964. James H. Johnson.
5. Review and Analysis of Fish Counts, Counting Technique and Related Data at Corps of Engineers Dams on the Columbia and Snake Rivers. Louis C. F*redd*.
6. Research Relating to McNary Supplemental Spawning Channel, Five-Year Summary, 1960 through 1964. State of Washington Department of Fisheries.
7. The Accelerated Fish Passage Research Program of the U.S. Bureau of Commercial Fisheries – Summary of Progress through 1964. Gerald B. Collins and Carl H. Elling.

U.S. Army Corps of Engineers (COE). 1972. North Pacific Division Corps Of Engineers, Fourth Progress Report On Fisheries Engineering Research Program, 1966-1972. Portland, Oregon.

Contents:

- Standardization of Spill Patterns at Ice Harbor Dam
- General Guidelines for Adjusting Spill Distributions to Improve Fish Passage with Tentative Spilling Schedule for Bonneville and John Day Dams
- Operational Studies at Dams on the Lower Columbia and Snake Rivers
- I. Operational Studies at Dams on the Lower Columbia River with a Brief Analysis of Adequacy of New Spilling Techniques at Ice Harbor Dam
- II. Fish Passage Problems at Lower Columbia River Dams in 1968
  Effects of Peaking Operations on Passage of Adult Salmonids Over Columbia River Dams
- Evaluation of Upstream Passage of Adult Salmonids through the Navigation Lock at Bonneville Dam during the Summer of 1969
- A Tagging Study to Investigate the Unexplained Loss of Spring and Summer Chinook Salmon Migrating Past Bonneville and The Dalles Dam
- Indications of Loss and Delay to Adult Salmonids below Ice Harbor Dam (1962-66)
- Radio Tracking of Adult Spring Chinook Salmon below Bonneville Dam, 1971
- Sonic Tracking of Adult Steelhead in Ice Harbor Reservoir, 1969
- Sonic Tracking of Steelhead in the Ice Harbor Reservoir, 1967
- Sonic Tracking of Steelhead in the Rocky Reach Reservoir, 1967
- Evaluation of Fish Passage in the Vertical Slot Regulating Section of the South Shore Ladder at John Day Dam
- Propagation of Fall Chinook Salmon in McNary Dam Experimental Spawning Channel, 1957 through 1963
- Effect of Gas Supersaturated Columbia River Water on the Survival of Juvenile Salmonids, April-June 1972, Final Report – Part 1
- A Nitrogen (N2) Model for the Lower Columbia River
- Test of Fingerling Passage at Bonneville Dam, Report No. 1
- A Study to Determine the Value of Using the Ice-Trash Sluiceway for Passing Downstream Migrant Salmonids at Bonneville Dam
- Bonneville and The Dalles Dams Ice-Trash Sluiceway Studies, 1971
- Research on Gatewell-Sluice Method of Bypassing Downstream Migrant Fish Around Low-head Dams
- Fingerling Fish Mortalities at 57.5 fps, Report No. 1
- Fingerling Fish Research Effect of Mortality of 67-fps Velocity, Report No. 2
- Fingerling Fish Research, High-Velocity Flow through Four-Inch Nozzle, Report No. 3
- Fingerling Shad Studies at Bonneville Dam, November and December 1966
- Progress Report on Fish Protective Facilities at Little Goose Dam and Summaries of Other Studies Relating to the Various Measures Taken by the Corps of Engineers to Reduce Losses of Salmon and Steelhead in the Columbia and Snake Rivers
- A Compendium on the Survival of Fish Passing Through Spillways and Conduits
- Special Section on Stilling Basin Hydraulics and Downstream Fish Migration
- A Compendium on the Success of Passage of Small Fish Through Turbines
- Fisheries Handbook of Engineering Requirements and Biological Criteria
- Steelhead Fishing Method Study, Lake Sacajawea, Washington, Ice Harbor Reservoir
- Steelhead Fishing Project, Ice Harbor Reservoir, 1969

- Fish Passage Research at the Fisheries Engineering Research Laboratory, May 1965 to September 1970
  Studies:
  1. Behavior of Juvenile Salmonids in a Simulated Turbine-Intake
  2. Passage of Adult Salmonids through Pipes
  3. Factors Influencing the Passage of Adult Salmonids Through Channels
  4. Factors Influencing the Passage of Fish through Submerged Orifices
  5. Tests of Velocity Barriers
  6. Tests of a Model "A" Alaska Steeppass *Fish ladder*
  7. Research on Shad Passage Problems
  8. Response of Migrating Adult Salmon and Trout to Heated and Cooled Effluents and their Effect on Upstream Passage
- Survival of Fingerlings Passing through a Perforated Bulkhead and Modified Spillway at Lower Monumental Dam, April-May 1972
- Evaluation of Fish Facilities and Passage at Foster and Green Peter Dams on the South Santiam River Drainage in Oregon
- Final Report, Evaluation of Fish Passage Facilities at Cougar Dam on the South Fork McKenzie River in Oregon
- Final Report, Evaluation of Fish Facilities and Passage at Fall Creek Dam on Big Fall Creek in Oregon
- Evaluation of Fish Passage Facilities at the North Fork Project on the Clackamas River in Oregon
- Summary Report on Juvenile Downstream Migrant Fish Passage and Protection Studies at Willamette Falls, Oregon
- Hydraulic Model Studies on a Fish Guidance Screen
- Effects on Hydraulic Shearing Action on Juvenile Salmon (Summary Report)
- The Effect of Small Impoundments on the Behavior of Juvenile Anadromous Salmonids
- The Feasibility of Rearing Sockeye Salmon in Reservoirs, Final Report
- Use of a Hydroelectric Reservoir for the Rearing of Coho Salmon (Oncorhynchus kisutch)
- Effects on Low Flows Below Big Cliff Reservoir, North Santiam River, on Fish and Other Aquatic Organisms
- A Study to Identify the Race of Fall Chinook Whose Spawning Grounds will be Inundated by the John Day Impoundment on the Columbia River
- An Evaluation of the Rocky Reach Chinook Salmon Spawning Channel, 1961-1968
- Fecundity of Fall Chinook Salmon from the Upper Columbia River
- Summary Report, The Operation and Evaluation of the Carmen-Smith Spawning Channel, 1966-67
- Effect of Brownlee Reservoir on Migrations of Anadromous Salmonids

U.S. Army Corps of Engineers (COE). 1978. North Pacific Division Corps Of Engineers, Fifth Progress Report On Fisheries Engineering Research Program1973-1978 . Portland, Oregon.

Contents:

- Radio Tracking Studies of Chinook Salmon and Steelhead to Determine Specific Areas of Loss between Dams
- Studies of the Relationships between Adult Fish Passage and Powerhouse Operations
- Radio-Tracking Studies to Determine the Effects of Peaking on Adult Chinook Salmon and Steelhead
- Radio-Tracking Studies Relating to Fallback at Hydroelectric Dams on the Columbia and Snake Rivers
- Passage Problems of Adult Columbia River Chinook Salmon and Steelhead
- Adult Fish Exposed to a High Velocity Jet
- Radio-Tracking Studies to Determine the Effects of Spillway Deflectors on Adult Salmonids
- The Effects of Altered Flow Regimes, Temperatures, and River Impoundment on Adult Steelhead Trout and Chinook Salmon
- Effects of Reduced Nighttime Flows on Upstream Migration of Adult Chinook Salmon and Steelhead Trout in the Lower Snake River
- Effects of Power Peaking on the Indian Fishery
- Adjusting Spill Distributions to Improve Fish Passage at Corps Dams
- John Day Powerhouse Adult Fish Collection System Studies
- The Dalles Dam Powerhouse Adult Fish Collection System Studies
- Vertical Slot *Fishway* Evaluation at Bonneville Dam
- Evaluation of the Adult Salmonid Trap Installed in the Bradford Island “A” Branch *Fish ladder,* Bonneville Dam
- Studies on Adult Fish Passage over “A” Branch of Bradford Island Fishery at Bonneville Dam
- Bonneville 1st Powerhouse Adult Fish Collection System Studies
- Side Entrance *Fishway* Studies
- Evaluation of Methods for Handling and Artificially Propagating Summer Chinook Salmon
- Ice Harbor Fall Chinook Trapping, 1978
- Effects of Power Peaking on Survival of Juvenile Fish at Lower Columbia and Snake River Dams
- Study of Turbine Operations under Peaking and High River Flow Conditions to Obtain Maximum Fish Passage Survival and Updated 1967 May Compendium
- Fish Passage through Turbines: Tests at Big Cliff Dam
- Effects of Dam Operations and Flow Regulation on Juvenile Salmon and Steelhead Migrations in the Snake and Columbia Rivers
- Effects of Peaking (Stranding) of Columbia River Dams on Juvenile Anadromous Fishes below The Dalles Dam
- Improving the Fingerling Protection System for Low-Head Dams

- Evaluation and Development of the Ice-Trash Sluiceway at The Dalles Dam as a Downstream Migrant Bypass
- Fingerling Passage at Bonneville Powerhouse
- Ejection of Fingerling in High-Velocity Jet
- Fingerling Passage through John Day Spillway
- Effect of Spillway Bucket Roughness on Fingerling
- Transportation of *Smolt*s and Related Studies in the Snake and Columbia Rivers
- Evaluation of the Fingerling *Bypass system* Outfalls at McNary and John Day Dams
- Effects of Atmospheric Gas Supersaturation on Survival of Fish and Evaluation of Proposed Solutions
- Nitrogen Reduction, Fish Barge Water Supply
- Slotted Bulkheads for Skeleton Power Units
- Spillway Deflectors to Reduce Buildup of Nitrogen Saturation
- Equilibrium with Packed Column Degassor
- Feasibility of Using Siphons for Degassing Water
- Special Drought Year Operation for Downstream Fish Migrants

U.S. Army Corps of Engineers (COE). 1984. North Pacific Division Corps Of Engineers. Sixth Progress Report, Fish Passage Development and Evaluation Program. Portland, Oregon.

Contents:

Adult Anadromous Salmonid Passage Effectiveness Research

1. The John Day Powerhouse Adult Fish Collection System Evaluations – 1979-1980
2. Evaluation of Adult Fish Passage At Little Goose and Lower Granite Dams – 1981.
3. Evaluations of Adult Fish Passage At Ice Harbor and Lower Monumental Dams – 1982.
4. Evaluation of Adult Fish Passage At Bonneville Dam 1982.
5. Adult Salmonid Delay at John Day Dam – 1982-1983.

Effects of River Flow and Spill On Juvenile Anadromous Salmonid Migrations.

1. Migrational Characteristics of Juvenile Salmon and Steelhead in the Columbia River System – 1979-1983.
2. Migration Patterns of Salmonid *Smolt*s in the John Day Dam *Forebay*.
3. Hydroacoustic Monitoring of Downstream Migrant Juvenile Salmonids at John Day Dam – 1981.
4. Hydroacoustic Monitoring of Downstream Migrant Juvenile Salmonids at John Day and The Dalles Dam – 1982.
5. Updated Compendium on the Success of Passage of Small Fish Through Turbines

Juvenile Salmonid Transportation
1. Evaluation of Juvenile Fish Transportation and Related Research – 1979-1983.
2. Evaluating the Effects of Stress on the Viability of Chinook Salmon *Smolt*s Transported from the Snake River to the Columbia River Estuary – 1983.
3. Juvenile Salmonid Transport Operations – 1981-1983.

Juvenile Salmonid Bypass Efficiency
1. Research to Develop Passive Bar Screens for Guiding Juvenile Salmonids out of Turbine Intakes at Lower Head Dams on the Columbia and Snake River – 1979.
2. Evaluation of Submersible Traveling Screens, Cycling of Gatewells Orifice Operations, and the Ice-Trash Sluiceway System for Juvenile Fish Protection at the Bonneville First Powerhouse – 1981.
3. Research to Develop an Improved Fingerling Protection System for John Day Dam – 1981-1982.
4. Research to Develop an Improved Fingerling Protection System for Lower Granite Dam – 1981-1983.
5. Effects of the Intermittent Operation of Submersible Traveling Screens on Juvenile Salmonids – 1982.
6. Evaluation of the Juvenile Collection and *Bypass system* at Bonneville Dam – 1983.
7. Research to Develop The Dalles Dam Ice and Trash Sluiceway as a Juvenile Fish *Bypass system* – 1979-1981.
8. Operating Criteria for the Bonneville Dam Ice and Trash Sluiceway when Operated as a *Smolt* Bypass – 1979-1981.
9. A Hydroacoustic Evaluation of Downstream Migrating Salmonids at Ice Harbor Dam – 1982-1983.

U.S. Army Corps of Engineers (COE). 1983. North Pacific Division Corps Of Engineers, Sixth Progress Report On Fisheries Engineering Research Program,1979-1983. Portland, Oregon.

Contents:
1. Evaluations of Adult Fish Passage at Bonneville Lock and Dam and John Day Dam. D.M. Shew, Corps of Engineers, Portland District.
2. Adult Salmonid Delay at John Day Dam (1984). D.M. Damkaer and D.B. Dey.
3. Evaluation of Transportation of Juvenile Salmonids and Related Research on the Columbia and Snake, 1984. G.M. Mathews and D.L. Park, National Marine Fisheries Service.
4. Survival of Chinook Salmon *Smolt*s Passing Dams and Entering Seawater as Related to Stress Level and *Smolt* Quality. T.C. Bjornn et al, Idaho Cooperative Fishery Research Unit.
5. Columbia River Salmonid Outmigration: McNary Dam Passage and Enhanced *Smolt* Quality. C.B. Schreck and H.W. Li, Oregon Cooperative Fish Research Unit.

6. Evaluation of the Juvenile Collection and *Bypass system*s at Bonneville Dam, 1984. Krcma et al, National Marine Fisheries Service.
7. Fish Guiding and Orifice Passage Efficiency Tests with Subyearling Chinook Salmon, McNary Dam, 1984. G.A. Swan and R.F. Krcma, National Marine Fisheries Service.
8. Development of an Improved Fingerling Protection System for Lower Granite Dam, 1984. G.A. Swan and R.F. Krcma.

U.S. Army Corps of Engineers (COE). 1993. North Pacific Division Corps Of Engineers. Seventh Progress Report, Fish Passage Development and Evaluation Program 1984-1990. Portland, Oregon.

Contents:

Annual Progress Report 1985

1. Evaluation of The Juvenile Collection and *Bypass system*s at Bonneville Dam – 1985. M. Gessel et al.
2. Studies to Evaluate Alternative Methods of Bypassing Juvenile Fish at The Dalles Dam – 1985. B. Monk et al.
3. Evaluation of The Rehabilitated Juvenile Fish Collection and Passage System at John Day Dam – 1985. R. Krcma et al.
4. Evaluation of Transportation of Juvenile Salmonids – 1985. D. Park and G. Matthews.
5. Continuing Studies to Improve and Evaluate Juvenile Fish Collection at Lower Granite Dam – 1985. G. Swan and R Krcma.
6. Hydroacoustic Evaluation of Fish Collection Efficiency at Lower Granite Dam in Spring 1985. S. Kuehl and L. Johnson.
7. Survival of Chinook Salmon *Smolt*s Passing Dams and Entering Seawater as Related to Stress Level and *Smolt* Quality. Idaho Cooperative Fish and Wildlife Research Unit.
8. Evaluation of Adult Fish Passage at McNary Dam and John Day Dam. R. Peters et al.
9. Response of Chinook Salmon and Steelhead Trout *Smolt*s to Three Flumes Tested at Lower Granite Dam, 1985. J. Congleton and R. Ringe.

Annual Progress Report 1986

1. Evaluation of the juvenile collection and *bypass system*s at Bonneville Dam – 1986. M Gessel et al.
2. Studies to evaluate alternative methods of bypassing juvenile salmonids at The Dalles Dam – 1986. B. Monk et al.
3. Evaluation of the rehabilitated juvenile fish collection and passage system at John Day Dam – 1986. D. Brege et al.
4. Research to improve subyearling chinook salmon fish guiding efficiency at McNary Dam – 1986. G. Swan and W. Norman.

5. Determine fish guiding efficiency of submersible traveling screens at Lower Monumental Dam – 1986. R. Ledgerwood.
6. Initial study to evaluate existing juvenile fish collection at Little Goose Dam – 1986 G. Swan et al.
7. Hydroacoustic evaluation of fish guiding efficiency at Little Goose Dam – 1986. Parametrix, Inc. and Associated Fisheries Biologists, Inc.
8. Evaluation of juvenile salmonid passage through the *bypass system*, turbine, and spillway at Lower Granite Dam – 1986. D. Park and S. Achord.
9. Evaluation of transportation of juvenile salmonids – 1986. G. Matthews and D. Park.
10. Survival of chinook salmon *smolt*s with stress levels similar to those encountered at dams – 1986. T. Bjornn, and J. Congleton.

Annual Progress Report 1987

1. Evaluation of juvenile salmonid survival through the second powerhouse turbines and downstream migrant *bypass system* at Bonneville Dam. E. Dawley et al.
2. Continuing studies to improve the *bypass system* at Bonneville Dam. M. Gessel et al.
3. Bonneville Dam Second Powerhouse fish guidance research; velocity mapping studies. A. Jensen.
4. Hydroacoustic monitoring at Bonneville Second sluice chute and powerhouse. R. Magne.
5. Research at McNary Dam to improve fish guiding efficiency of yearling and subyearling chinook salmon. D. Brege et al.
6. Evaluate the prototype juvenile *bypass system* at Ice Harbor Dam. D. Brege et al.
7. Hydroacoustic assessment of sluiceway effectiveness at Ice Harbor Dam. Biosonics, Inc.
8. Fish guiding efficiency of submersible traveling screens at Lower Granite and Little Goose Dams. R. Ledgerwood et al.
9. Behavior and physiology studies in relation to yearling chinook salmon guidance at Lower Granite and Little Dams. W. Muir et al.
10. Evaluate improved collection, handling, and transport techniques designed to increase survival of juvenile salmon and steelhead. G. Matthews.
11. Survival of chinook salmon *smolt*s with stress levels encountered at dams. T. Bjornn.

Annual Research Report 1988

1. Update on A Compendium of the Success of Passage of Small Fish Through Turbines. M. Bell.
2. Update on Fisheries Handbook of Engineering Requirements and Biological Criteria. M. Bell.
3. Continuing studies to improve the juvenile *bypass system* at Bonneville Dam. M. Gessel et al.
4. Hydroacoustic development at Bonneville First Powerhouse. Biosonics, Inc.

5. Evaluation of juvenile salmonid survival through downstream migrant *bypass system*s, spillways, and turbines at Bonneville Dam. E. Dawley.
6. Survival of chinook salmon *smolt*s with stress levels encountered at dams. T. Bjornn.
7. Evaluate improved collection, handling, and transport techniques designed to increase survival of juvenile salmon and steelhead. J. Harmon et al.
8. Evaluate causes for decreased survival of transported spring chinook salmon from Lower Granite Dam. R. Pascho and D. Elliott.
9. Hydroacoustic monitoring at Bonneville Second Powerhouse. R. Magne.
10. Measurement of low frequency sound at Bonneville, McNary, and Lower Granite Dams. J. Anderson et al.
11. An assessment of the relationship between *smolt* development and FGE at Bonneville Dam. A. Giorgi et al.

Annual Research Report 1989

1. Continuing studies to improve and evaluate the juvenile *bypass system*s at Bonneville Dam. M. Gessel.
2. Evaluation of juvenile salmonid survival through downstream migrant *bypass system*s, spillways, and turbines at Bonneville Dam. E. Dawley.
3. Hydroacoustics and video monitoring at the Bonneville Dam Second Powerhouse. R. Magne.
4. Continuing studies to improve and evaluate juvenile fish collection at Lower Granite Dam. J. Williams et al.
5. Survival of chinook salmon *smolt*s with stress levels encountered at Dams. T. Bjornn.
6. Evaluate improved collection, handling, and transport techniques designed to increase survival of juvenile salmon and steelhead. G. Matthews.
7. Impact of bacterial kidney disease on survival of spring/summer chinook salmon stocks. R. Pascho and D. Elliott.
8. Hydroacoustic evaluation of fish behavioral response to fixed bar screens at Lower Granite Dam. Biosonics, Inc.
9. Literature review and design criteria of behavioral fish guidance systems. J. Anderson and B. Feist.

U.S.D.A., Forest Service, 1999. Water Road Interaction Series.

U.S. Fish and Wildlife Service. 1983-19__. Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates. U.S. Fish Wildlife Service, Biol. Rep.82(11). U.S. Army Corps of Engineers, TR EL-82-4.

Vinsonhaler R. and D. Sutherland. 1964. Exploratory Tests of Velocity Selection as a Means of Guiding Juvenile Fish. Fish Passage Research Program, U.S. Bureau of Commercial Fisheries, Seattle, WA.

Vogel, D.A., K.R. Marine and J.G. Smith. 1990 or 1988. A Summary of Upstream and Downstream Anadromous Salmonid Passage at Red Bluff Diversion Dam on the Sacramento River, California, U.S.A.. In: Proceedings of the International Symposium on *fishway*s '90 in Gifu. Gifu, Japan.

Waples, R.S. 1991. Definition of "Species" under the ESA: Application to Pacific Salmon. U.S. Dep. Commer., NOAA Tech. Memo., NMFS, F/NWC-194, 29 pages.

Washington Department of Fish and Wildlife, 2000a. *Fishway* Guidelines for Washington State - Draft Report, K. Bates. Olympia, WA. 57 pp.

Washington Department of Fish and Wildlife, 2000b. Fish Protection Screen Guidelines for Washington State - Draft Report. B. Nordlund, K. Bates. Olympia, WA 53 pp.

Washington Department of Fish and Wildlife, 2003. Design of Road Culverts for Fish Passage, K. Bates, B. Barnard, B. Heiner, J.P. Klavas, P.Powers and P. Smith, Olympia, WA 110 pp.

Washington State Department of Transportation. 1998. Juvenile and Resident Salmonid Movement and Passage Through Culverts. Final Report. Rept. No. WA-RD 457.1.
(Available through the National Technical Information Service, Springfield, VA 22616).

Washington State Department of Transportation. 1997. Fish Passage Program Department of
Transportation Inventory Final Report. G. Johnson (Project Leader) and nine others. 58 pages.

Washington State Department of Transportation. 1996. Investigation of Culvert Hydraulics Related to Juvenile Fish Passage. Final Report. Rept. No. WA-RD 388.1. (Available through the National Technical Information Service, Springfield, VA 22616)

Weaver, W.E., and D.K. Hagans. 1994. Handbook for Forest and Ranch Roads. Mendocino County Resource Conservation District. 161 pages.

Webb, P.W. 1978. Fast Start Performance and Body Form in Seven Species of Teleost Fish. Journal of Experimental Biology 74:211-226, Ann Arbor, MI.

Weitkamp, D.E. 1997. Designing a Fish Bypass to Minimize Predation Downstream of Dams. In Hydro Review, Volume XVI, No. 4, pp. 120-127August 1997

Wietkamp, L.A., T.C. Wainwright, G.J. Bryant, G.B. Milner, D.J. Teel, R.G. Kope, and R.S.

Waples. 1995. Status Review of Coho Salmon from Washington, Oregon, and California.

U.S. Dep. Commer., NOAA Tech. Memo., NMFS-NWFSC-24, Northwest Fisheries Science Center, Seattle, Washington. 258 pages.

Whitney, R., L. Calvin, M. Erho, and C. Coutant. 1997. Downstream passage for salmon at hydroelectric projects in the Columbia River basin: development, installation, and evaluation. ISAB 97-15. Northwest Power Planning Council, Portland, OR.

Ziemer, G.L. 1961. Fish Transport in Waterways. Alaska Dept. of Fish and Game. 2 pages.

Appendix L
Forest Matrix

Permit Area - Landscape - Acres by Age Class - HCP Scenario (run 3.1) - 2020-08-05

MGT	year	0-30	31-60	61-90	91-120	121-150	151-180	>180	NA
Inside HCAs	2023	30635	66097	133950	20282	10379	3714	1463	8114
	2033	30516	40161	114875	61837	11878	4989	2264	8114
	2043	21791	40414	76061	103894	13560	6986	3814	8114
	2053	21900	30323	55674	123703	19485	10258	5176	8114
	2063	14600	30484	35681	105492	61375	11635	7253	8114
	2073	7300	21791	38748	71712	102748	13421	10800	8114
	2083	0	21900	30323	55674	123703	19485	15435	8114
	2093	0	14600	30484	35681	105492	61375	18888	8114
Outside HCAs	2023	73713	115567	149426	10862	1413	238	11	12883
	2033	120654	66663	142039	20023	1732	85	34	12883
	2043	139085	76824	91787	40341	2769	394	31	12883
	2053	167840	71253	52595	55134	3601	747	61	12883
	2063	150614	110329	20130	60364	8429	1280	84	12883
	2073	134445	121840	22990	44487	24851	2219	398	12883
	2083	131581	127779	16645	28940	42237	3251	796	12883
	2093	135693	93007	46073	10764	56559	7780	1353	12883