Elliott State Research Forest
Final Habitat Conservation Plan

December 2024

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of State Lands

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Final

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Acronyms and Abbreviations

°C	degrees Celsius
°F	degrees Fahrenheit
BLM	Bureau of Land Management
CCAA	Candidate Conservation Agreement with Assurances
cfs	cubic feet per second
CRW	conservation research watershed
CWA	Clean Water Act
dbh	diameter at breast height
DEQ	Oregon Department of Environmental Quality
DSL	Oregon Department of State Lands
EFH	essential fish habitat
EIS	environmental impact statement
ELZ	equipment limitation zone
ESA	federal Endangered Species Act
ESU	evolutionarily significant unit
ESRF	Elliott State Research Forest
FR	*Federal Register*
FWS	U.S. Fish and Wildlife Service
HCP	Habitat Conservation Plan
HLDP	high landslide delivery potential
HSI	Habitat Suitability Index
HUC	Hydrologic Unit Code
ITP	incidental take permit
Magnuson-Stevens Act	Magnuson-Stevens Fishery Conservation and Management Act
MBTA	Migratory Bird Treaty Act
MMBF	million board feet
MRW	management research watershed
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
OAR	Oregon Administrative Rules
ODF	Oregon Department of Forestry
ODFW	Oregon Department of Fish and Wildlife
OHV	off-highway vehicle
Oregon ESA	Oregon Endangered Species Act
Oregon FPA	Oregon Forest Practices Act
OSU	Oregon State University
PNFB	perennial non-fish bearing
RCA	riparian conservation area
RMP	resource management plan
SB	Senate Bill
School Lands	Common School Fund Lands

State Land Board	Oregon State Land Board
USC	United States Code
XNFB	non-fish-bearing non-perennial streams that are not HLDP streams

Chapter 1
Introduction

1.1 Overview

The Oregon Department of State Lands (DSL) (Permittee) has prepared this multi-species Habitat Conservation Plan (HCP) to support the issuance of incidental take permits (ITPs) under the federal Endangered Species Act (ESA) on the Elliott State Forest. DSL is the administrative arm of the Oregon State Land Board (State Land Board), which has jurisdiction over the forest. The State Land Board is composed of the state of Oregon's Governor, the Secretary of State, and the Treasurer.

In December 2020, the State Land Board voted that future management of the Elliott State Forest be conducted to support scientific research and, in turn, directed the Permittee to transition the forest into management as the Elliott State Research Forest (ESRF), where forest management activities will create a managed landscape where experimentation can occur. The direction and framework for creation of the ESRF subsequently received broad and bipartisan support from the State Legislature in 2022 and was recently reaffirmed by the State Land Board in December 2023.

The goal of research on the ESRF is to advance more sustainable forest management practices through the application of a systems-based approach investigating the integration of intensively managed forests, forest reserves, dynamically managed complex forests, and the aquatic and riparian ecosystems that flow within them. Forestry will be studied on an appropriate temporal and spatial scale while assimilating wood fiber production with other values and services that address the wellbeing of terrestrial, riparian, and aquatic ecosystems, as well as human communities. Research topics may include, but will not be limited to, the following.

- Conservation of biodiversity and at-risk species dependent on forest landscapes.
- Climate adaptation of forests and carbon sequestration.
- Economics and technology of sustainable timber production.[1]
- Integration of western science and Indigenous Knowledge related to forest management, ecosystem dynamics, and outcomes for human and non-human communities.
- Implications of fire and other forest disturbances on the long-term health of forested landscapes.

Historically, the focus of forestry and forest research has drifted toward the extremes of forest conditions—plantations and protected areas—without investigating new approaches or traditional ecological knowledge for meeting sustainability goals. Forest research related to optimization of wood production generally centers on plantations created by repetitive, intense disturbances through clearcutting and rapid tree establishment. On the other hand, researchers study unlogged, naturally regenerated, young, mature, and old-growth forests at the other end of the spectrum to better understand processes and functions such as carbon sequestration, water quality, biodiversity,

[1] *Sustainable timber production* means not harvesting more wood than you are growing on the forest. In the context of the HCP, it also is a reference to research topics including, but not limited to, new harvest methods and "climate smart" forestry.

and *human dimensions*.[2] Between these endpoints exists an opportunity to further explore and better understand how to manage forests to meet resource demands in a manner that supports natural forest ecosystem function, biodiversity, and forest products for human economic and cultural use. The Permittee proposes to fill this knowledge gap by researching and integrating a suite of social and biophysical objectives and attributes such as carbon sequestration, timber production, recreation, and habitat for imperiled species. This would occur across the ESRF over multiple generations.

The ESRF will be managed in accordance with a framework based on the research platform described in Oregon State University (OSU) proposal for the ESRF (Appendix C, *Proposal: Elliott State Research Forest*). This research proposal outlines allocations, harvest treatment types, and a research platform that takes a landscape-scale approach to long-term sustainable forestry research. The platform is designed to be climate-adaptive, dynamic, and flexible. Over the course of advancing the framework for the ESRF's creation and this associated HCP, the Permittee has made some modifications to the framework of the OSU research proposal, which are captured in this HCP's commitments. The flexibility of the resulting HCP framework is intended to facilitate collaboration with research partners at OSU, as well as other universities and institutions inside and outside of Oregon, Tribal governments, and stakeholders and interests at the local and broader levels. The results obtained from ESRF research, whether advanced by OSU or other research entities, will inform future policy and decision-making in state, federal, Indigenous, and private forest landscapes throughout the Pacific Northwest, the nation, and globally.

A key element of the research design sets allocations in the permit area that allow the Permittee to maintain operational management constant over time. While some degree of management flexibility exists within the allocations, the allocations will create an important level of certainty for researchers and the public by facilitating long-term studies essential to understanding long-lived forests. Subwatersheds in the ESRF will be divided into the conservation research watersheds (CRW) and management research watersheds (MRW). The CRW will be maintained as a conservation area that combines aquatic and terrestrial habitat protection to benefit the covered species, while the MRW lands will be allocated to reconcile conservation, production, and other objectives on forestlands.

The Permittee's future timber management of the forest has the potential to cause *incidental take*[3] of fish and wildlife species listed under the ESA as threatened or endangered. Therefore, in accordance with Section 10 of the ESA, DSL has applied to the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) (together, the Services) for ITPs that will allow specified levels of incidental take of listed species. This plan is called the ESRF HCP and is intended to be implemented by the Permittee as part of a research forest program that transforms the Elliott State Forest and minimizes and mitigates the impacts of the authorized incidental take.

[2] *Human dimensions* means the relationship between people and wildlife/habitat.

[3] *Incidental take* means any taking otherwise prohibited by ESA Section 9 (including any of the forms of "take" defined in the ESA), if such taking is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Among the forms of take, HCPs generally involve "harm" and "harass" situations.

1.2 Background

Indigenous people have lived along the southern Oregon Coast and Coast Range for thousands of years. Physical evidence of this occupation has likely been mostly erased by changes in sea level and periodic major earthquakes, but humans are thought to have arrived in the region from eastern Asia at least 10,000 and perhaps as long as 20,000 years ago.

The Hanis (Coos) and Quuiich (Lower Umpqua) people are the original people and stewards of the lands that we now refer to as the Elliott State Forest. The Hanis people spoke Hanis, a language closely related to miluk in the Coosan branch of the Coastal Oregon Penutian language family. The Quuiich people spoke another Coastal Oregon Penutian language, the quuiich dialect of sha'yuushtɫ'a uɫ quuiich, which is also known as the Siuslaw language. Tenmile Creek was the general dividing line between the Hanis and Quuiich people. Large village sites were primarily located on solid ground above rivers and estuaries and some smaller villages were located along creeks and lakes. There were seasonal fish camps along many rivers and creeks, and seasonal hunting and plant gathering camps were numerous in the Coast Range.

The Hanis and Quuiich people managed and stewarded the Elliott State Forest to provide the natural resources that supported their communities and their culture. They gathered and cultivated culturally important plants such as hazel (*Corylus avellana*), huckleberries (*Vaccinium spp.*), blackberries (*Rubus spp.*), and blackcaps (*Sylvia atricapilla*). They managed and harvested trees to provide logs for canoes and planks for houses. They hunted deer (*Cervidae*) and elk (*Cervus canadensis*) for food and hides, and the antlers and bones were used to make tools. To manage these resources and to create a resilient and diverse landscape with a full spectrum of habitat conditions, the Hanis and Quuiich people actively managed lands that comprise the Elliott State Forest. They routinely utilized trimming, harvesting, and fire to keep large portions of the forest clear of trees and brush. This use of fire maintained large areas of early-seral conditions, which benefited deer and elk populations, benefited the soil, kept pathogens in check, and also promoted the light-loving plants that sustained their communities and their culture.

Today, many of the descendants of these original stewards of the Elliott State Forest landscape are enrolled in the Confederated Tribes of Coos, Lower Umpqua, and Siuslaw Indians. Despite the forest's recent history of clearcutting and conversion to timber plantations, and related lower quality and lack of abundance across much of the forest, the present-day members of these Tribes continue to rely on the Elliott State Forest as a source of traditional foods and medicines. They continue to practice their culture and lifeways on these lands as best they can. They continue to possess and work to actively apply valuable Indigenous Knowledge related to the management of the Elliott State Forest that is built on millennia of experience practicing ecologically sustainable stewardship of these lands.

The Elliott State Forest of today is composed primarily of Common School Fund Lands (School Lands) associated with the federal government's contribution to the Oregon public school system upon recognition of statehood. Through the Oregon Admission Act in 1859, the federal government granted School Lands to the state with the condition that these lands be used for schools. The State Land Board, acting through DSL as its administrative agency, oversees these lands and manages the Common School Fund. The Oregon Constitution dedicates all revenues (including mineral, timber, and other resource extraction revenue) of School Lands to the Common School Fund.

The Oregon Constitution (Article VIII, Section 5) authorizes the State Land Board to manage School Lands, including those on the Elliott State Forest, "with the object of obtaining the greatest benefit for the people of this state, consistent with conservation of this resource under sound techniques of land management." Since its establishment in 1930 as the first state forest, the Elliott State Forest has contributed nearly $617 million in timber sales to the Common School Fund.

In its management role, the State Land Board establishes policies that provide for the stewardship of the Elliott State Forest, including setting harvest levels. Early forest management plans focused on managing the forest for timber and building a road system that would provide access for management, fire control, and the removal of forest products. Subsequent plans included water quality and fish and wildlife habitat as key plan elements. From 1930 to 2017 (87 years), Elliott State Forest was managed by the Oregon Department of Forestry (ODF) on behalf of the State Land Board through a contract with DSL. In 2017, the State Land Board terminated the management contract with ODF for the Elliott State Forest. Currently, the Elliott State Forest is managed by DSL.

In 1995, endangered species concerns led to the development of a new Elliott State Forest Management Plan and the first HCP for the site. The 1995 Elliott State Forest HCP provided incidental take coverage for 60 years for one species, the northern spotted owl (*Strix occidentalis*). The 1995 HCP also provided take coverage for one other species, the marbled murrelet (*Brachyramphus marmoratus*), but only for 6 years because insufficient information was available on the species at the time.[4] Part of the 1995 HCP strategy called for research about the marbled murrelet, which would then be used to revise strategies to support a longer-term ITP for the species. New information on the marbled murrelet gathered from this research, as well as from research conducted elsewhere, was used in subsequent draft HCP revisions. The 1995 HCP and related take permits are no longer in effect.

In the early 2000s, ODF began preparing a long-term HCP to replace the 1995 HCP. A draft HCP and environmental impact statement (EIS) were released to the public by ODF in 2010. That draft HCP proposed to cover three threatened species (northern spotted owl, marbled murrelet, and Oregon Coast coho [*Oncorhynchus kisutch*]) and several nonlisted native vertebrate species. The 2010 draft HCP was not finalized because the State of Oregon decided not to pursue further revisions through the HCP development process, and no ITPs were issued by USFWS or NMFS. In 2011, DSL and ODF released the Elliott State Forest Management Plan, which has guided forest practices since then.

As a consequence of a lawsuit in 2013, timber harvest on the Elliott State Forest has been severely limited due to the presence of ESA-listed species and their habitat and the need to comply with the ESA by avoiding adverse effects on the species in the absence of ITPs. This harvest limitation dramatically reduced timber revenue to the point where the cost of managing the Elliott State Forest in 2013 far exceeded the forest's revenue. Following the 2013 lawsuit, the State Land Board and DSL pursued solutions for meeting ESA obligations and revenue requirements of the Common School Fund.

In May 2014, DSL initiated the Elliott Alternatives Project to develop a range of feasible business models for future ownership and management of the forest. In August 2015, the State Land Board undertook an effort to evaluate options to sell the Elliott State Forest. In May 2017, the State Land Board shifted its efforts away from a possible sale to a private owner after the public expressed

[4] The 1995 Elliott State Forest HCP did not cover Oregon Coast coho (*Oncorhynchus kisutch*) because it had not yet been listed. Listing occurred in 2011.

strong interest in retaining the Elliott State Forest in public ownership. At the same meeting, the State Land Board directed DSL to develop an HCP for the School Lands of the Elliott State Forest.

In December 2018, the State Land Board directed DSL to engage with OSU and begin exploring the Elliott State Forest's potential to become a publicly owned research forest. DSL advanced an assessment, collaborative process, and an advisory committee to do so through an agreement with Oregon Consensus, who advanced this work as a third-party, independent collaborative process manager. In December 2020, based on broad support from the advisory committee and others, the State Land Board endorsed OSU's ESRF research design.

In April 2022, Oregon Governor Kate Brown signed Senate Bill (SB) 1546, which advanced the underlying collaborative agreement and implemented the State Land Board's vision to keep the Elliott State Forest in public ownership and provide benefits for future generations through conservation, economic and cultural advancement, recreation, education, and forest research. The bill established the ESRF with a mission to create an enduring, publicly owned, world-class research forest that advances and supports conservation of imperiled species, as well as forest health, climate resilience, carbon sequestration, biodiversity, water quality and quantity, recreational opportunities, and local economies.

The bill also established ten management policy directives, one of which is that the ESRF be managed to promote collaboration, partnerships, and inclusive public processes and equity, consistent with an applicable HCP, as approved by the Services as well as a forest management plan, to be approved by the State Land Board.

At its December 2022 meeting, and based on SB 1546's direction, the State Land Board moved closer to the ESRF's official creation by voting to decouple the forest from its Common School Fund obligations (made possible through legislatively provided revenue that compensated the fund and intended to secure nontimber benefits on the forest) and prospectively appointing members of an ESRF governing board.

However, because SB 1546 required that six enabling actions be collectively met by December 31, 2023, and because those provisions were not met by this date,[5] the statute's major provisions did not take legal effect. In light of this event, the State Land Board again clarified direction for the ESRF at its December 2023 meeting, recommitting to the ESRF's creation, underscoring work and commitments advanced to date, and directing DSL to advance a management structure with the DSL managing the research forest. This most recent State Land Board direction for the ESRF's continued creation is consistent with its previous foundational commitments as well as the fundamental policy direction advanced by bipartisan vote of the Legislature in SB 1546. Related to this, the State Land Board directed DSL to complete this HCP; advance a forest management plan based on DSL management; identify the lead research partner or partners for the research forest, looking to OSU first; finalize partnership conversations with Tribes and other entities; and advance this work through an advisory body while creating a structure for a public ESRF.

[5] A vote to participate in management of the ESRF by OSU's Board of Trustees was one SB 1546 action required by December 31, 2023. In November 2023, OSU's president issued a letter indicating the university was not prepared to take a vote at that time. As a result, this SB 1546 enabling action was not met. Further, although OSU completed and advanced an ESRF Forest Management Plan for the State Land Board's review and approval prior to December 31, 2023, the State Land Board did not vote on approval of the plan as required by SB 1546 because OSU's Board of Trustees had not authorized the university to engage in management as contemplated by the OSU Forest Management Plan.

1.3 Purpose

Section 9 of the ESA prohibits the taking of species listed as endangered, with *take* defined 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 [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 17.3). The Services may by regulation extend those prohibitions to threatened species as well. In the course of research activities, including timber harvest, there is potential to take three species listed as threatened under the ESA that carry the Section 9 take prohibitions: northern spotted owl, marbled murrelet, and Oregon Coast coho. Protection of the northern spotted owl and marbled murrelet falls under USFWS jurisdiction; protection of the Oregon Coast coho falls under NMFS jurisdiction.

Lawful forestry research activities cannot be conducted without removing or altering habitat or handling[6] the three listed species. To the extent this alteration injures or kills one or more of these three species via "significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding or sheltering" it amounts to take under Section 9 of the ESA.

1.4 Scope of the HCP

This section describes the scope of the HCP, including the plan area and permit area, permit term, covered activities, and covered species.

1.4.1 Plan Area and Permit Area

The plan area (92,504 acres) encompasses the Elliott State Forest and several small privately owned parcels adjacent to the Elliott State Forest (Figures 1-1 and 1-2, Table 1-1). The Elliott State Forest comprises state lands with different oversight, management, and mandates. Most of the Elliott State Forest is School Lands (83,450 acres) overseen by the State Land Board. DSL manages most of these lands (83,326 acres); ODF manages the other 124 acres. The remainder of the plan area (8,893 acres) consists of Board of Forestry Lands managed by ODF. The privately owned parcels are located in the southern part of the plan area and total 161 acres.

The permit area (83,326 acres), where all covered activities and conservation actions will occur, includes all DSL-managed lands within the plan area (Table 1-1, Figure 1-2). Lands within the plan area but outside the permit area are included in the plan area to inform any future potential land exchanges or other potential agreements between the Permittee and adjacent landowners.[7] Because DSL does not yet own or manage these areas, they are not part of the permit area but could be incorporated into the permit area through the process outlined in Chapter 7, Section 7.6.2, *Permit Amendments*.

[6] Handling is specific to Oregon Coast coho.

[7] For example, DSL may exchange a limited amount of School Lands with Board of Forestry Lands to consolidate land ownership and improve management consistency across contiguous parcels.

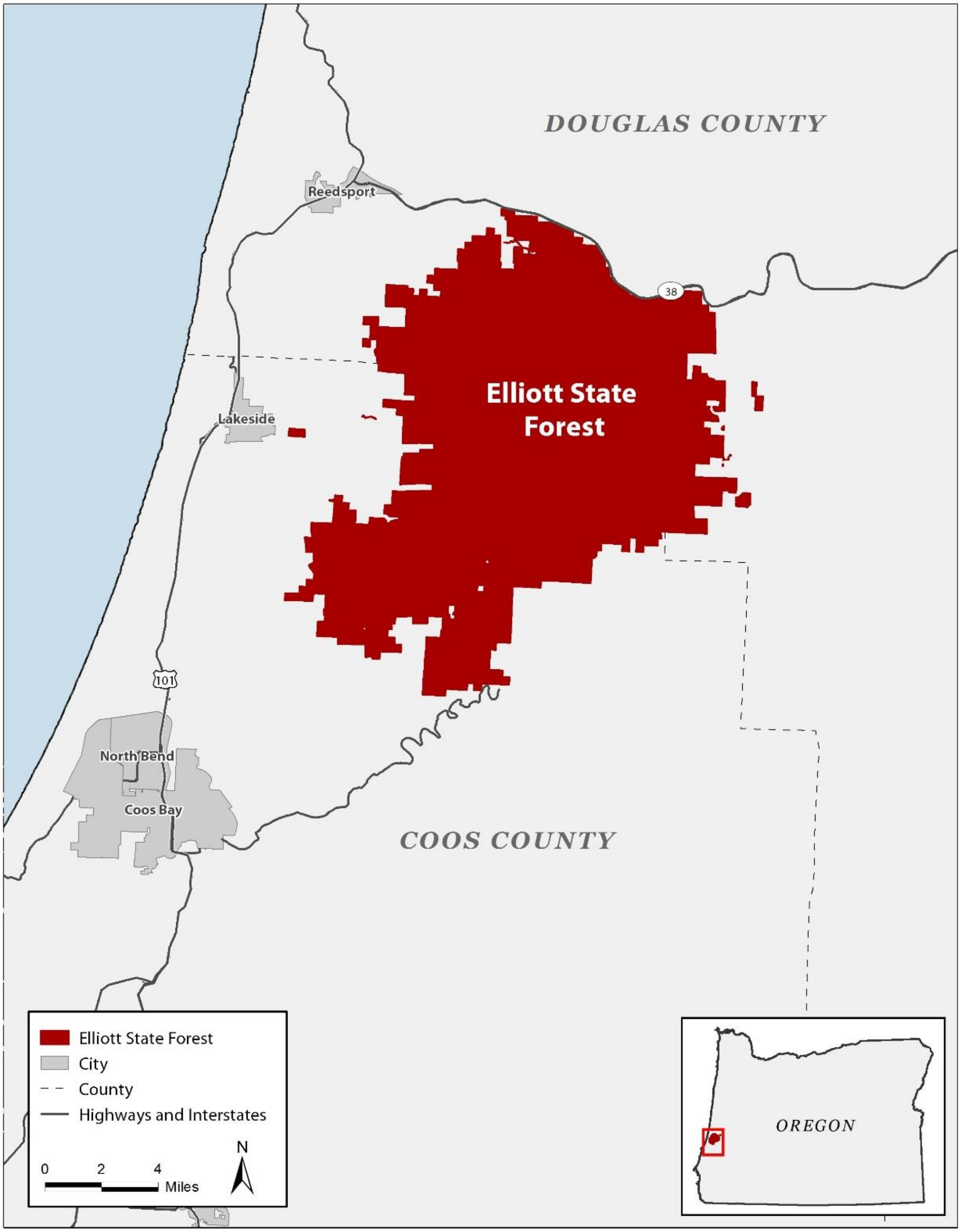

Figure 1-1. Vicinity Map

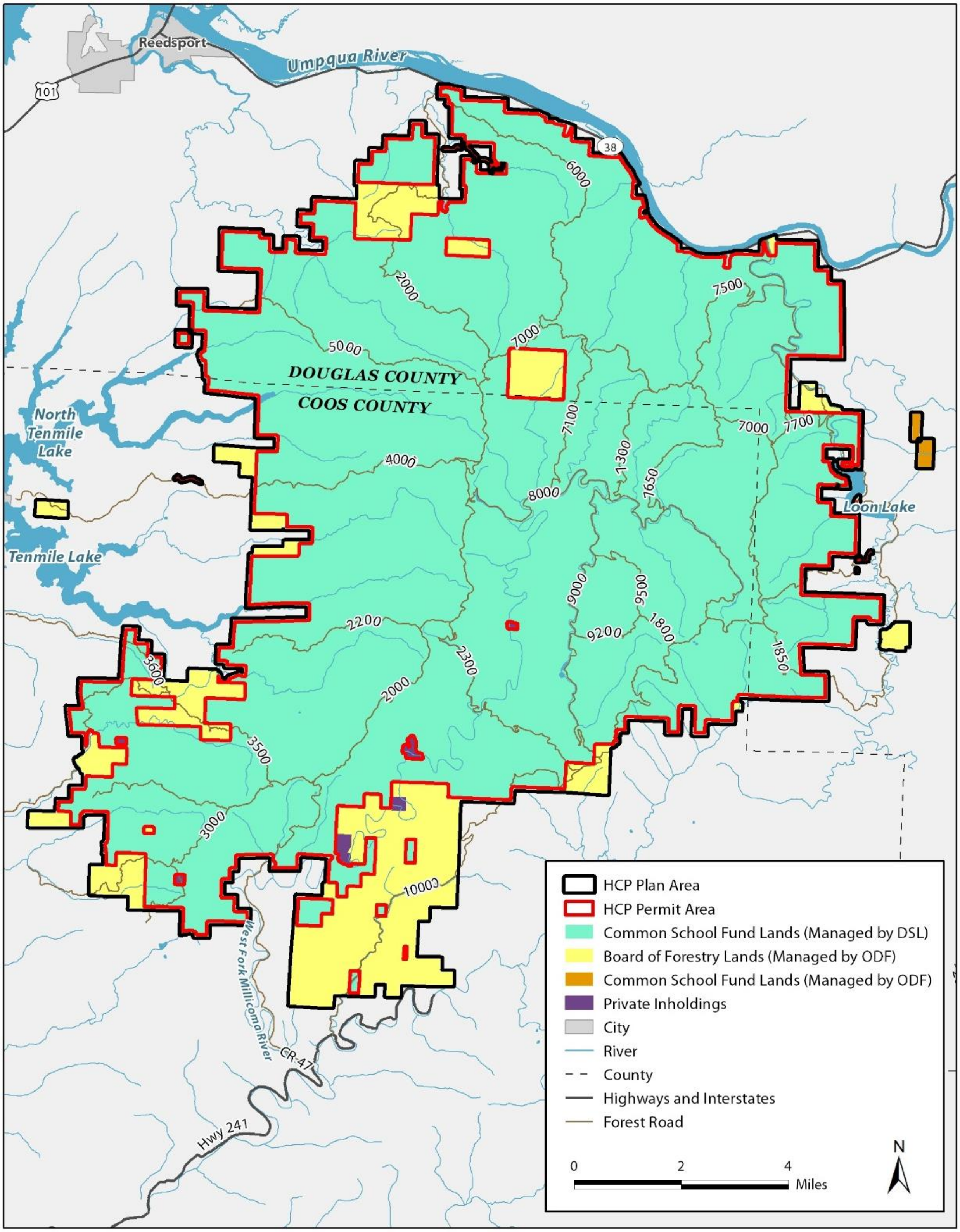

Figure 1-2. Plan Area

Table 1-1. Ownership and Management of Lands in the Plan Area and Permit Area

Land Type	Land Ownership	Land Management	Acres	In HCP Plan Area?	Covered by this HCP (in Permit Area)?
DSL Lands, CSF Decoupled	State Land Board	DSL	83,326 [a]	Yes	Yes
DSL Lands, CSF	State Land Board	ODF	124	Yes	No [b]
Board of Forestry Lands	Board of Forestry	ODF	8,893	Yes	No [b]
Private Inholdings	Private	Private	161	Yes	No [b]

[a] Permit area values may vary slightly throughout document due to nuances including some small parcels outside of the main permit not being assigned specific treatment allocations.

[b] Lands could be incorporated into the permit area and covered by the HCP if they were transferred, exchanged, or sold in the future, or otherwise subject to an agreement between the Permittee and the relevant landowner or manager, through the process outlined in Chapter 7, Section 7.6.2, *Permit Amendments*.

CSF = Common School Fund; DSL = Oregon Department of State Lands; ODF = Oregon Department of Forestry

1.4.2 Permit Term

The ESRF HCP and associated ITPs will have concurrent terms of 80 years. The 80-year term was selected to balance the risks associated with shorter and longer terms. A term of less than 80 years would substantially reduce the Permittee's regulatory certainty to conduct long-term forest management practices and research activities that are intended to run for many decades. The research vision for the forest is measured in hundreds of years rather than decades. Long-term research designs will need predictability in the types and pace of research and timber harvest activities that can be conducted. Additionally, an 80-year permit term was selected to support a successful conservation strategy. A conservation strategy in a managed forested landscape relies on gradual improvement of species' habitat over time, which is only realized as the forest grows older over many decades to develop a complex forest structure that provides optimal habitat for the covered species. Therefore, an 80-year permit term is needed to realize the full benefits of the conservation strategy. A term of 80 years was balanced with the increasing scientific uncertainty of longer permit durations. A term of more than 80 years would increase the risk that unpredictable ecological changes could adversely affect the status of the covered species in the plan area and compromise the success of the conservation strategy.

1.4.3 Covered Activities

This HCP supports the Permittee's application for incidental take authorization for activities in the permit area (Figure 1-2), as well as the activities needed to carry out the conservation strategy as described in Chapter 5, *Conservation Strategy*. This section lists the general categories of covered activities. Detailed descriptions of the selection process and all covered activities, including stand-level treatments, are provided in Chapter 3, *Covered Activities*.

- **Stand-level treatments.** Stand-level treatments are harvest and restoration treatments arrayed in various spatial and temporal configurations.
- **Supporting management activities.** Supporting management activities may be implemented to manage stands (e.g., mechanical vegetation control, prescribed burning, tree planting).

- **Supporting infrastructure.** Supporting infrastructure is needed to facilitate implementation of the HCP, including roads, landings, drainage structures, and quarries.
- **HCP implementation activities**. HCP implementation activities are identified in the conservation strategy and monitoring program and may result in effects on covered species.

1.4.4 Covered Species

Covered species are those species for which the Permittee is seeking incidental take authorization from USFWS and NMFS. The permit area provides habitat for a variety of species, including species listed under state and federal endangered species protection laws. The Permittee selected the covered species for the HCP based on review of all species of conservation concern known or expected to occur in the permit area during the permit term. These species were then screened for coverage based on four selection criteria developed by the Permittee (Section 1.4.4.1, *Covered Species Selection Criteria*). The criteria were applied to each species of conservation concern with potential to occur in the permit area (Appendix B, *Species Considered for Coverage*). The HCP seeks coverage for species that meet all four criteria.

1.4.4.1 Covered Species Selection Criteria

Range

Species should be known or expected to occur in the permit area based on a review of species locality and range data, a review of species literature, and professional expertise. In addition, species that are not currently known in the permit area but are expected to move into the permit area during the permit term (e.g., through range expansion) were considered to meet this criterion.

Status

The species should be listed under the federal ESA as threatened or endangered, or be proposed for listing (candidate), 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; interaction with experts and USFWS, NMFS, and 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 would potentially be adversely affected by covered activities in a manner likely to result in incidental take as defined by the ESA.

Data

Sufficient scientific data exist on the species' life history, habitat requirements, and occurrence in the permit area to adequately evaluate potential effects of covered activities on the species, and to develop conservation measures to mitigate those impacts.

1.4.4.2 Proposed Covered Species

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

Table 1-2. Proposed Covered Species

Species	Status [a] State	Status [a] Federal	Federal Jurisdiction
Fish			
Oregon Coast coho (*Oncorhynchus kisutch*)	--	FT	NMFS
Birds			
Northern spotted owl (*Strix occidentalis*)	ST	FT	USFWS
Marbled murrelet (*Brachyramphus marmoratus*)	SE	FT	USFWS

USFWS = U.S. Fish and Wildlife Service; NMFS = National Marine Fisheries Service
[a] Status
SE = State-listed as endangered
ST = State-listed as threatened
FT = Federally listed as threatened

1.5 Regulatory Setting

1.5.1 Federal and State Endangered Species Laws

1.5.1.1 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 the conservation and protection of threatened and endangered species under the ESA. NMFS is responsible for administering and enforcing the provisions of the ESA for most marine and anadromous species. USFWS is responsible for administering and enforcing the ESA for all other terrestrial and aquatic species.

Section 10

Under Section 10(a)(2)(A), a nonfederal party (such as DSL) may apply to USFWS or NMFS for an ITP providing authorization to incidentally take listed species. The application must include an HCP. That HCP must describe 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, and the funding that will be available to implement such steps. In addition, the HCP must include a discussion of alternative actions the applicant has considered that would reduce or avoid take of covered species, and the reasons these alternative actions are not being used. Finally, the HCP must include "such other measures that the Secretary may require as being necessary or appropriate for the purpose of the plan." Each issuance of an ITP by the Services pursuant to Section 10 is, in turn, subject to an intra-agency Section 7 consultation, because issuance of a federal permit is a federal action; 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.

1.5.1.2 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 NMFS 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. Per the Magnuson-Stevens Act, 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 EFH. Federal activities that occur outside of an EFH but that may, nonetheless, have an impact on EFH waters and substrate must also be considered.

1.5.1.3 Oregon Endangered Species Act

Under the Oregon Endangered Species Act (Oregon ESA), DSL must coordinate with ODFW and the Oregon Department of Agriculture in developing plans that comply with the Oregon ESA, and that are consistent with the constitutional mandate for School Lands.

The Oregon ESA, adopted in 1987, includes both plant and animal species. The act was amended in 1995 to outline listed species protection requirements.

For threatened or endangered species listed after 1995, 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, spawning grounds).

The northern spotted owl was listed as threatened under the Oregon ESA in 1988. Because the northern spotted owl and marbled murrelet were listed prior to 1995, state survival guidelines were not developed for these species. In 2021, the Oregon Fish and Wildlife Commission voted to "uplist" marbled murrelet to state endangered status. As part of that process survival guidelines were developed and approved by the commission. Those survival guidelines are obligatory on state lands, and DSL has an endangered species management plan for marbled murrelet (Oregon Department of State Lands 2023). Once approved and permitted, this HCP may satisfy that state requirement.

1.5.2 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 generally must evaluate the environmental effects of their proposed actions, solicit and consider public input, and complete environmental documents describing their analysis 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 will significantly affect the human environment is required to prepare an EIS.

Issuance by USFWS and NMFS of ITPs under 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, USFWS as the lead agency and NMFS as a cooperating agency, have prepared draft and final EISs addressing the proposed issuance of ITPs based on this HCP.

1.5.3 Other Relevant Federal and State Laws

1.5.3.1 Federal Migratory Bird Treaty Act

The Migratory Bird Treaty Act (MBTA) prohibits the take (including killing, capturing, and transport) of protected migratory bird species without prior authorization by USFWS. The requested ITP will not provide take coverage for MBTA-protected species, and DSL will continue to implement best management practices to avoid and minimize impacts on migratory birds. Of particular relevance to this HCP, barred owl (*Strix varia*) is protected under the MBTA. As discussed in Chapter 2, *Environmental Setting*, Chapter 4, *Effects Analysis*, and Chapter 5, *Conservation Strategy*, barred owls are believed to be a primary stressor causing population declines in northern spotted owls, and USFWS has formally experimented with lethal removal of barred owls to determine the efficacy of such measures in stopping population declines in the northern spotted owl. Based in part on the results of past experimental removals, USFWS developed a barred owl management strategy (Strategy) to address the threat of barred owls to northern spotted owls (U.S. Fish and Wildlife Service 2024a). USFWS completed an EIS (U.S. Fish and Wildlife Service 2024b) and Record of Decision (U.S. Fish and Wildlife Service 2024c) adopting the Strategy and issued an MBTA Special Purpose permit for the removal of barred owls in accordance with the Strategy.

This HCP does not include a request for take authorization for barred owls. As described in Chapter 5 (Conservation Measure 6, Barred Owl Research), the conservation strategy includes a commitment that the Permittee will collaborate with USFWS, as well as other federal and state management agencies to design and implement appropriate barred owl management on the ESRF in support of federal management strategies for northern spotted owl recovery, consistent with the requirements of the MBTA and the results of the Strategy.

1.5.3.2 Oregon Forest Practices Act

The Oregon Forest Practices Act and its associated rules[8] set standards for all commercial activities involving the establishment, management, or harvesting of trees in Oregon forests. The Oregon 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…" (Oregon Revised Statutes 527.630(1)). The Board of Forestry is granted the exclusive authority to develop and enforce rules protecting forest resources and to coordinate with other agencies concerned with forests.

1.5.3.3 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 of the Oregon Plan was added.

[8] Chapter 527 of the Oregon Revised Statutes and the Oregon Administrative Rules pursuant to these statutes.

The purposes of the Oregon Plan for Salmon and Watersheds are 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 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.

1.5.3.4 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 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 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 in-channel work for scour protection or grade control.

1.5.3.5 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 federal 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 U.S. Environmental Protection Agency for approval.

The HCP provides protection for species and their critical habitat to comply with the ESA, not CWA. However, water temperature and turbidity (caused by sediment and other matter suspended in the water column) are key water quality are key water quality parameters for the suitability of aquatic habitat and are important limiting factor for the covered species. Therefore, achieving the water quality standard for temperature and turbidity 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.

1.5.3.6 Oregon Department of Fish and Wildlife Scientific Take Permit

Additional ODFW scientific take permits may be required to implement certain conservation measures, research, and monitoring for this HCP (e.g., barred owl control). Those permits are not part of the federal ITPs issued under this HCP. The Permittee or scientists working on Permittee land will obtain these state scientific take permits separately as needed to conduct their research or monitoring activities.

1.6 Other Conservation Plans in the Region

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

1.6.1 Federal Lands and the Northwest Forest Plan

Management actions on U.S. Forest Service lands are guided and directed by the 1994 Northwest Forest Plan (U.S. Department of Agriculture and Bureau of Land Management 1994) and the associated land and resource management plans of National Forests. Management actions on Bureau of Land Management (BLM) lands were formerly guided and directed by the 1994 Northwest Forest Plan. However, in 2016, the Deputy Director of the BLM signed the Records of Decision for the resource management plans (RMPs) for western Oregon (Bureau of Land Management 2016a, 2016b), providing updated management direction on BLM lands within the Northwest Forest Plan area.

The Northwest Forest Plan, associated land and resource management plans, and the BLM RMPs outline conservation for a wide range of terrestrial and aquatic species, including those covered under this HCP. Management and conservation under these plans include a combination of land allocations, standards and guidelines or management direction, and associated review procedures. Central to the Northwest Forest Plan and the BLM RMPs is a network of conservation reserves intended to support the recovery of the northern spotted owl and other species associated with late-successional and aquatic habitats. BLM lands occur adjacent to the plan area.

Plans for National Forests are currently being revised under the 2012 Planning Rule (77 FR 21162), with current management and species conservation tiering to the Northwest Forest Plan and existing forest plans, as amended (see U.S. Forest Service 2021a, 2021b, and 2021c for forest planning on the Siuslaw, Umpqua, and Rogue River-Siskiyou National Forests, respectively).

1.6.2 Habitat Conservation Plans

1.6.2.1 Western Oregon State Forests HCP

ODF is currently preparing the Western Oregon State Forests HCP.[9] The goals of the Western Oregon State Forests HCP include ensuring that 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.

The Western Oregon State Forests HCP permit area includes all state forest lands west of the crest of the Cascade Range that are owned by the Board of Forestry and managed by ODF (613,663 acres). Most of these state forest lands are in northwestern Oregon in the Tillamook, Clatsop, and Santiam State Forests. In southwest Oregon, state forest lands are found in Coos, southern Douglas, and northern Josephine Counties. 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 the Western Oregon State Forests HCP.

The Western Oregon State Forests HCP permit area also includes 25,826 acres of School Lands owned by DSL but managed by ODF. In total, the Western Oregon State Forests HCP permit area is 639,489 acres. The plan area is 733,695 acres to accommodate future potential land exchanges adjacent to the permit area.

The plan area of the ESRF HCP overlaps with the permit area of the Western Oregon State Forests HCP. The overlap is in the 8,893 acres that are Board of Forestry Lands inside the Elliott State Forest boundary and the 124 acres of other DSL lands adjacent to the ESRF that are managed by ODF (Figure 1-2). These lands are currently in the Western Oregon State Forests HCP plan area. However, if management of any of the Board of Forestry Lands were transferred to DSL, they could be incorporated into the ESRF HCP permit area through the process outlined in Chapter 7, Section 7.6.2, *Permit Amendments*.

The Western Oregon State Forests HCP proposes to cover 17 species (including all three species covered under the ESRF HCP) for which ODF is seeking take authorization from USFWS and NMFS to conduct covered activities. The difference in species covered between the Western Oregon State Forests HCP and ESRF HCP is due to a larger geographic scope under the Western Oregon State Forests HCP. The three federally listed species that occur in the ESRF are covered under both plans. 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.

[9] Public drafts of the HCP and EIS were released in April 2022, with public comments accepted through June 1, 2022. The final HCP and EIS are expected in 2025.

1.6.2.2 Weyerhaeuser-Millicoma Tree Farm HCP

The Weyerhaeuser-Millicoma Tree Farm HCP covers 208,000 acres of land located in Coos and Douglas Counties. This HCP was completed in February 1995 and issued a 50-year permit by USFWS. 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 tree harvest in the 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 more land being maintained in spotted owl dispersal habitat. This plan protects existing northern spotted owl nesting sites and dispersal habitats over a large landscape.

The primary biological goal of the Millicoma HCP is to support dispersal of juvenile spotted owls. The tree farm is located between the ESRF and two blocks of federal land administered by BLM. According to the Millicoma HCP, the plan will contribute to the survival and recovery of the northern spotted owl by linking the three small population areas into what can effectively become one larger interacting population. The Millicoma HCP does not include any conservation actions or credits for lands within the ESRF permit area, although the 1.5-mile-radius home ranges of three northern spotted owl activity centers located in the southern portion of the plan area do overlap with the Millicoma Tree Farm (Chapter 4, *Effects Analysis*).

1.6.3 Safe Harbor Agreements and Candidate Conservation Agreements with Assurances

The following sections summarize other conservation-related planning efforts that are relevant to this HCP process.

1.6.3.1 Oregon Department of Forestry Safe Harbor Agreement for Northern Spotted Owl for Barred Owl Removal

The ODF Safe Harbor Agreement for Northern Spotted Owl for Barred Owl Removal is an agreement made in September 2016. ODF agreed to grant land access to USFWS to conduct the Barred Owl Removal Experiment (Experiment) on two study areas in Oregon: one in the Oregon Coast Ranges west of Eugene, Oregon, and one in the forest lands around Canyonville, Oregon. The Experiment) implemented Recovery Action 29 of the Northern Spotted Owl Recovery Plan: “Design and implement large-scale control experiments to assess the effects of barred owl removal on spotted owl site occupancy, reproduction, and survival.” The closest area where removals were conducted is approximately 25 miles north of the ESRF (Wiens et al. 2021).

The goal of the Experiment was to test the feasibility of barred owl removal to determine whether it improves conditions for spotted owls, and USFWS has concluded that the goals of the Experiment have been completed, although take coverage for any northern spotted owls that may colonize areas where barred owls have been removed extends for the ODF-managed lands until 2029. The Experiment has demonstrated success in the removal of barred owls, resulting in reduced and declining barred owl populations in the removal areas. Across all study areas, removal of barred owls had a strong positive effect on survival of spotted owls and a weaker, but positive effect on spotted owl dispersal and recruitment. Spotted owl populations stabilized in the areas with removals but continued to decline at a rate of 12% in the areas without removals (Wiens et al. 2021).

While the Experiment was focused on federal lands, the Oregon Coast Ranges study area contains interspersed state and private land, including lands managed by ODF. The purpose of ODF participation is to cooperate with USFWS regarding this recovery action without significantly affecting ODF ongoing and future management operations by maintaining a reasonable level of certainty regarding regulatory requirements. This Safe Harbor Agreement permit is valid until August 31, 2029.

1.6.3.2 Weyerhaeuser Company Safe Harbor Agreement for Northern Spotted Owl

The Weyerhaeuser Company has agreed to grant land access to USFWS to support USFWS with conducting their barred owl Experiment on lands throughout the Oregon Coast and near the Canyonville region. No sites were selected for barred owl removal in portions of the Millicoma Tree Farm adjacent to the ESRF (located on the southern boundary), so the direct effects of the removal study are not believed to have any substantive effects on barred owl populations on the ESRF. The purpose of the barred owl experiment is to determine the effects of barred owl on northern spotted owl ecology. The Weyerhaeuser Company's participation demonstrates good faith cooperation with USFWS regarding this recovery action, while being held harmless by USFWS and the ESA from an anticipated biological response during and after the experiment period. This Safe Harbor Agreement was established in June 2016; the permit is active through August 31, 2026.

1.6.3.3 Candidate Conservation Agreement with Assurances for the Fisher in Oregon

In April 2017, USFWS made available a programmatic/template Candidate Conservation Agreement with Assurances (CCAA) for the fisher (*Pekania pennanti*) in western Oregon that could be used by any nonfederal landowners or managers. The enrollment area is the West Coast distinct population segment of fisher in Oregon. The CCAA can be used over a 30-year permit term that ends in June 2048. 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. To date, seven timber companies and ODF have enrolled in the CCAA for fisher. In 2019, ODF enrolled approximately 183,932 acres of Board of Forestry Lands within the fisher's range, although none of the permit area is located within enrolled lands.

1.7 Document Organization

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

- *Executive Summary* presents an overview of this HCP.
- 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 descriptions of covered species.
- Chapter 3, *Covered Activities*, describes the activities covered under the HCP.

- Chapter 4, *Effects Analysis*, presents the impacts of the covered activities.
- Chapter 5, *Conservation Strategy*, summarizes the conservation strategy and describes the specific avoidance and minimization actions to reduce impacts and the mitigation actions to mitigate the impacts of the covered activities.
- Chapter 6, *Monitoring and Adaptive Management*, describes the monitoring and adaptive management program.
- Chapter 7, *Implementation and Assurances*, details the administrative requirements associated with HCP implementation and the roles and responsibilities of the Permittee and the Services. This chapter also describes the regulatory assurances provided to the Permittee and the procedures for modifying or amending the HCP.
- Chapter 8, *Cost and Funding*, reviews the costs associated with HCP implementation and the funding sources proposed to pay those costs.
- Chapter 9, *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.
- Chapter 10, *References*, includes a comprehensive bibliography of references cited in the text.
- Chapter 11, *List of Preparers*, lists those individuals and organizations that participated in producing this HCP.
- Appendix A, *Active Management of Riparian Conservation Areas*, provides more detail on how thinning treatments in riparian conservation areas will benefit covered species.
- Appendix B, *Species Considered for Coverage*, lists the species considered for coverage under this HCP.
- Appendix C, *Proposal: Elliott State Research Forest*, presents OSU's proposal for transforming the Elliott State Forest into a state research forest managed by the university and its College of Forestry.
- Appendix D, *Marbled Murrelet Habitat Suitability Index Approach,* provides an overview of habitat suitability index modeling done in support of this HCP.
- Appendix E, *Wood Modeling,* is a methods paper to support modeling done for this HCP.
- Appendix F, *Glossary*, provides key terms and definitions used in this HCP.

Chapter 2
Environmental Setting

This chapter describes the environmental setting of the plan area for the Elliott State Research Forest (ESRF) Habitat Conservation Plan (HCP), its forest types, and relevant biological details of each of the three covered species. This includes the physical setting and disturbance history that has shaped the ecological landscape of the plan area.

2.1 Physical Setting

2.1.1 Location

The plan area is located in Coos and Douglas Counties, in the south Oregon Coast region, which is defined as the geographic area in the southern one-third of the Oregon Coast Range physiographic province (Franklin and Dyrness 1988). Nearby cities include Coos Bay and North Bend to the southwest, Lakeside to the west, and Reedsport to the northwest (Figure 1-1). The plan area is a nearly contiguous block of land approximately 18 miles north to south and 16 miles west to east. The plan area is described further in Chapter 1, Section 1.4.1, *Plan Area and Permit Area*.

2.1.2 Topography

The topography of the plan area is generally rugged and highly dissected with steep, narrow canyons, although the southeast part of the forest is less steep (Figure 2-1). Across the forest, slopes face in all directions, with no predominant aspect. Elevations range from near sea level to 2,100 feet above sea level.

The major rivers and streams are in narrow valleys, bordered by steep side slopes. The gradients on the side slopes commonly exceed 65%.[1] The valley bottoms were formed by alluvial deposits and are gently sloping. Steep colluvial[2] basins are common. The colluvial materials include soil and debris that have been moved downslope by gravity and biological activity.

The streams draining the plan area flow into one of three major waterbodies. About 47% of the plan area drains southwest into Coos Bay, 30% drains north to the Umpqua River, and 23% drains west to the Tenmile Lakes (North and South). The Umpqua River borders the northeast part, and the West Fork Millicoma River flows through the south and southeastern parts of the plan area. Loon Lake is on the eastern border and Tenmile Lake is west of the plan area (Figure 2-2).

[1] The Oregon Forest Practices Act (Oregon FPA) defines high landslide hazard locations as "the presence, as measured on site, of any headwall or draw in Western Oregon steeper than 70 percent, except in the Tyee Core Area, where it is any headwall or draw steeper than 65 percent" (Oregon Administrative Rules 629-600-0100(69)(b)).

[2] *Colluvium* is material that accumulates at the base of slopes.

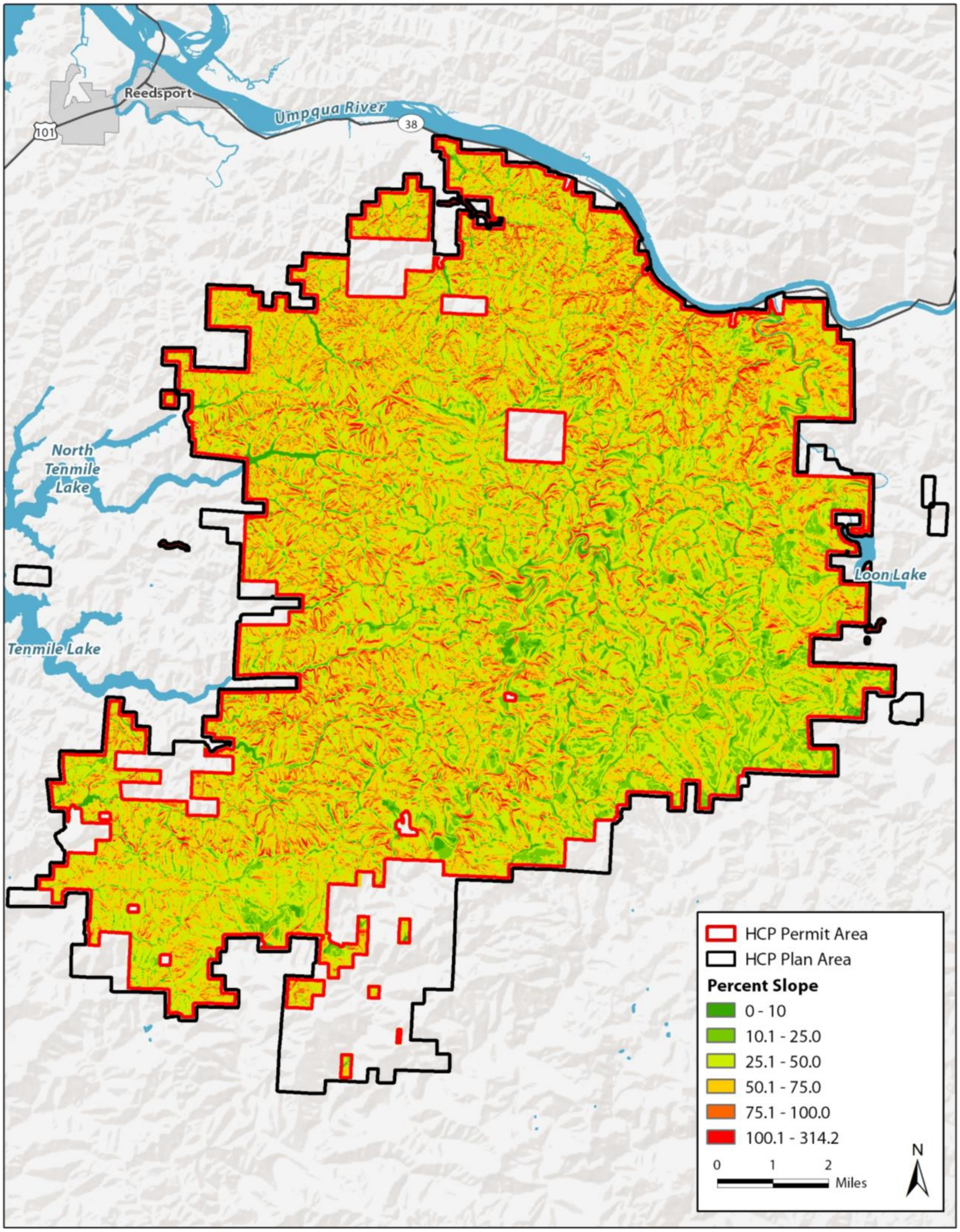

Figure 2-1. Topography in the Permit Area

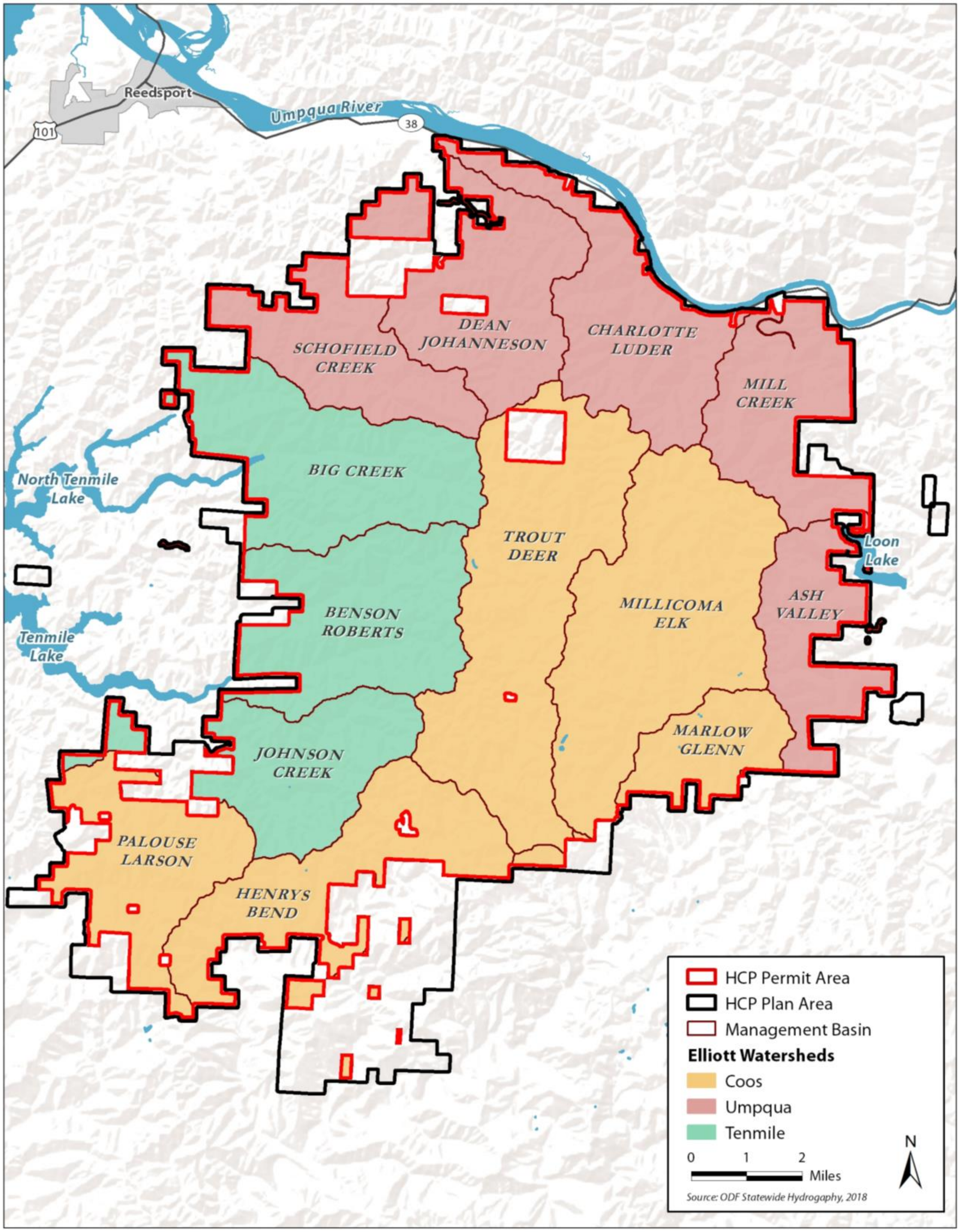

Figure 2-2. Watersheds in the Permit Area

These three waterbodies in the plan area differ in physical characteristics and environmental setting and support three independent populations of coho salmon (*Oncorhynchus kisutch*) (Table 2-1). The Coos region is approximately 67.9 square miles and is more moderately sloped than the other regions. The Coos region has 73.4 miles of large and medium streams, which are important for anadromous fish. The relatively large West Fork Millicoma River is particularly important for supporting coho salmon in the Coos region. The Umpqua region is approximately 44.1 square miles and has 36.8 miles of large and medium stream classes. The Tenmile region is approximately 33.6 square miles and has 24 miles of large and medium stream classes.

The permit area has been divided into 13 watersheds based on hydrologic boundaries aggregated up to fifth level (field) hydrologic unit boundaries from the Watershed Boundary Dataset layer for Oregon (U.S. Geological Survey 2020) (Figure 2-2, Table 2-1).

Table 2-1. Watersheds in the Permit Area [a]

Watershed Name	Acres in Plan Area	Acres in Permit Area	Independent Population
1 - Mill Creek	5,100	4,944	Umpqua
2 - Charlotte Luder	6,252	6,252	
3 - Dean Johanneson	7,320	6,654	
4 - Schofield Creek	5,002	4,772	
13 - Ash Valley	3,911	3,911	
5 - Big Creek	7,648	7,490	Tenmile
6 - Benson Roberts	7,146	6,971	
7 - Johnson Creek	5,981	5,496	
8 - Palouse Larson	6,507	5,428	Coos
9 - Henrys Bend	8,476	6,578	
10 - Marlow Glenn	6,530	3,151	
11 - Millicoma Elk	10,927	10,879	
12 - Trout Deer	11,348	10,789	
Outlying Parcels	344	1	
Total [b]	92,492	83,315	

[a] Disjunct permit area lands not within one of the listed basins.
[b] Total exceeds permit area because some basins include lands outside of permit area.

2.1.3 Geology

The Tyee sandstone/siltstone formation underlies most of the plan area. Sandstone beds may be more than 50 feet thick, alternating with siltstones and mudstones up to several feet thick. The Tyee Formation in the plan area generally has low primary porosity, meaning that it does not hold much water. However, the formation is moderately jointed and fractured, which provides some space for groundwater, but at levels generally insufficient to produce well water (Oregon Department of State Lands and Oregon Department of Forestry 2011). Tyee Formation rocks tend to weather and decompose rapidly when exposed to air and water and, therefore, have extremely limited utility as road gravel or structural aggregate. Fratkin et al. (2020) examined two streams on the Oregon Coast with differing rock types and found that sandstone streams can lose all of its gravel-sized sediments and expose bedrock, while basalt streams can maintain a gravel bed over a longer period of time. The study suggests that this difference is largely due to rock strength and erosion rates. The findings from Fratkin et al. (2020) help explain how the sandstone formations contribute to the lack of gravel-sized sediments in streams in the permit area.

2.1.4 Soils

The soils in the plan area are composed of several different types: approximately 83% of the forest soils are residual soils, approximately 16% are alluvial soils found in valley bottoms, and the remaining 1% includes agricultural land, rock outcroppings, lakes, ponds, and rivers. Most of the plan area is Site class II or III,[3] indicating that trees reach heights of 94 to 134 feet at the age of 50 years (Oregon Department of State Lands and Oregon Department of Forestry 2011).

On steeper slopes, away from channels and colluvial basins, soil depth typically varies from 1 to 3 feet. These soils tend to be gravel and sand dominated, contain less silt and clay-sized particles than other locations, and are usually well drained. In colluvial pockets, soil depth typically varies from 3 to 8 feet. These soils are poorly sorted, contain more silt and clay than other soils on steep slopes, and are often relatively poorly drained (Oregon Department of State Lands and Oregon Department of Forestry 2011).

Along streams, alluvial deposits are common. These deposits are typically well-sorted sands, gravels, or coarse silts; drainage characteristics are highly variable. Clays are uncommon (Oregon Department of State Lands and Oregon Department of Forestry 2011).

2.1.5 Climate

The plan area has a strong maritime influence from the nearby Pacific Ocean. As a result, temperature fluctuations are moderate and rainfall is high. The mean minimum January temperature in the plan area is approximately 32 degrees Fahrenheit (°F) and the mean maximum August temperature is 79°F. Rainfall varies from about 65 inches per year at lower elevations on the western edge of the forest to 115 inches per year on the high, interior ridges. Rainfall declines slightly on the eastern side of the plan area, to 90 inches per year. Snowfall in the forest is normally light to moderate, both in amount and duration of the snow. There is no residual snowpack (Oregon Department of State Lands and Oregon Department of Forestry 2011).

The west side of the plan area is most strongly influenced by the proximity of the ocean. This influence is seen in the moderate temperatures and the frequent summertime fog on the west side. During the dry summer period, the fog contributes a significant amount of moisture to vegetation through fog drip (condensation), which reduces fire risk and moisture stress on vegetation (Oregon Department of State Lands and Oregon Department of Forestry 2011).

Based on a synthesis report regarding climate change and forest health in the Pacific Northwest (Reilly et al. 2018), the following climate trends are projected to occur in the vicinity of the permit area over the next several decades.

- Increased summer temperatures and decreased summer humidity and rainfall.
- Increased frequency, severity, and duration of summer heat waves and drought.

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[3] 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, which is 50 years (King 1966, as cited in Oregon Department of State Lands and Oregon Department of Forestry 2011). Site class II is 115 to 134 feet. Site class III is 94 to 114 feet.

- Increased winter rain and frequency and severity of winter storms and associated high wind events.

Projected climate effects on stream and physical forest conditions are described in Chapter 2, Section 2.1.6, *Hydrology and Water Quality*, and Section 2.2.5, *Climate and Forest Types*.

2.1.6 Hydrology and Water Quality

Hydrologic data for the plan area can be inferred from a U.S. Geological Survey gauge station on the West Fork Millicoma River, which was active from 1955 to 1981. The entire 30,000-acre basin sampled by this gauge is within the permit area and represents slightly more than a third of the entire plan area. This gauge is the most representative monitoring location in the permit area. Gauging stations in the more northern and eastern drainages of the plan area have not been maintained and are, therefore, not available to further categorize the hydrologic conditions in those areas. However, given the proximity of the West Fork Millicoma River gauge and its drainage area overlap with the plan area, the gauge likely represents the best available data to generally categorize hydrologic conditions present in the plan area.

During the period of record, average annual flows varied from 155 to 385 cubic feet per second (cfs), with mean monthly discharges ranging from 10 cfs in the driest month (August) to 630 cfs in the wettest month (December), a pattern typical of rainfall-dominated watersheds in the Oregon Coast Range. During the period of record, the peak flow of 8,100 cfs was recorded on November 24, 1960 (U.S. Geological Survey 2018).

For the purposes of this HCP, the hydrography was based on a 1-meter Light Detection and Ranging Digital Elevation Model (LiDAR DEM) developed by Oregon State University (OSU) (Oregon State University 2020). The complete modeled stream network that is being used in this HCP is 2,099 miles, which is approximately three times the length of the stream network defined by the Oregon Department of Forestry (ODF) (702 miles) and by the National Hydrography Dataset (747 miles). Table 2-2 provides the stream lengths by stream types, which are defined as follows.

- **Fish-bearing streams** (streams with fish use, which may or may not also be domestic water use). Fish-bearing streams are identified using the regulatory definition (Oregon Administrative Rules 629-600-0100), which encompasses the upper limit of coastal cutthroat trout (*O. clarkia*) in stream networks. Cutthroat trout presence generally extends farther into the headwaters of stream networks than any other fish species, often even higher than non-game fish such as sculpin (*Chordata*). Fish-bearing streams are defined as having a gradient of 20% or less, which is based on maximum gradient threshold determined from resident cutthroat trout data (Fransen et al. 2006). This yields a more accurate map, resulting in a fish-bearing stream network that is approximately 20% longer than that employed by ODF on the Elliott State Forest.
- **Non-fish-bearing streams** (streams with neither game fish nor domestic water use). Non-fish-bearing streams are the most abundant portion of the riverine network in the permit area, comprising more than 80% of the total stream miles. Reeves et al. (2018) documents the latest research highlighting the importance of small non-fish-bearing streams at both a landscape and local scale. These streams are critical to maintaining the aquatic ecosystem's productivity by providing cool water, wood, gravels, sediment, fish prey, and nutrients to fish-bearing streams (Reeves et al. 2018). These streams may make up more than 70% of the stream network in the Coast Range and are important contributors of large wood and sediment. Maintaining riparian

protection areas of at least 50 feet on streams in managed forests provides habitat and dispersal corridors for amphibians (Reeves et al. 2018).

- **Perennial streams** (streams that flow year-round and are considered permanent features). The modeled stream network classifies perennial streams as those with contributing area greater than 0.062 square kilometer, which should account for more than 80% of streams that actually sustain perennial flow on the ground (Clarke et al. 2008).
- **Seasonal streams** (streams that have a contributing area less than 0.062 square kilometer [Clarke et al. 2008]).
- **Key debris flow torrent intermittent streams** (streams with a high potential to deliver wood to fish-bearing streams). These streams are typically steep, with few gradient breaks and with approximately 90-degree angle of entry into fish-bearing streams (Miller and Burnett 2007).

Table 2-2. Length of Streams in the Permit Area by Management Watershed (miles)

	Fish-Bearing	Non-Fish-Bearing				
Management Watershed	**Perennial**	**XNFP: (seasonal or intermittent)**	**PNFB: Perennial**	**HLDP: (perennial or non-perennial)**	**Grand Total**	**Independent Population**
Mill Creek	13	110	11	6	140	Lower Umpqua
Charlotte Luder	11	128	14	11	164	
Dean Johanneson	17	128	14	10	168	
Schofield Creek	13	99	9	6	126	
Ash Valley	4	79	17	1	102	
Big Creek	22	154	14	9	200	Tenmile
Benson Roberts	18	136	15	8	177	
Johnson Creek	16	103	11	6	136	
Palouse Larson	13	108	15	5	140	Coos
Henrys Bend	18	125	18	4	165	
Marlow Glenn	8	66	7	0	82	
Millicoma Elk	44	191	16	5	256	
Trout Deer	40	184	21	6	251	
Grand Total	237	1,611	182	77	2,107	

XNFB = other non-fish-bearing; PNFB = perennial non-fish-bearing; HLDP = wood-delivery non-fish-bearing

Wetlands are often near streams or contain trees, but they are ecologically distinct from streams and forests. The Oregon Forest Practices Act (Oregon FPA) identifies three major types of wetlands: significant wetlands, stream-associated wetlands, and other wetlands. Significant wetlands are defined as bogs, estuaries, and both forested and nonforested wetlands larger than 8 acres. Stream-associated wetlands are those less than 8 acres and classified according to the stream to which they are connected. Other wetlands include seeps and springs. Wetlands can be especially valuable in providing refuge for juvenile salmonids during high water events. Wetlands also provide habitat for wildlife, improve water quality, and contribute surface water and groundwater.

2.1.6.1 Stream Use and Water Quality

Water that flows through state forest lands sustains ecosystems and also provides for out-of-stream uses such as irrigation, domestic use, and municipal use. The Coos District keeps records of all registered water users withdrawing water from state forest lands. The Oregon Water Resources Department monitors stream flows, issues permits for water withdrawals from streams and regulates water rights. Several adjacent landowners draw surface water from sources that are in or close to the plan area. No municipal water systems are in the plan area. In the past, ODF has occasionally drawn water from Elliott State Forest streams for firefighting, pesticide applications, road construction, and dust abatement. ODF has generally drawn water from small pools behind culverts and artificial ponds. 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.

Water quality is measured by chemical, physical, and biological properties of water. Aquatic species such as salmonids need high-quality water, as well as suitable habitat. In forests, the water quality parameters most likely to be affected by management activities are sediment and temperature. Chemicals are not usually a water quality concern in forests, but could be if any chemical contamination occurred, such as a fuel spill or improper use of herbicides.

High temperatures have been linked to reduced coho salmon parr abundance (Ebersole et al. 2006), increase disease susceptibility (Cairns et al. 2005), and reduced freshwater production (Lawson et al. 2004) in the Oregon Coast Coho evolutionarily significant unit (ESU). For most Oregon Coast coho populations poor water quality, including high summer water temperatures and excess fine sediments, are secondary limiting factors. This is true for the populations in the permit area. Analysis of water temperatures presented in the Oregon Department of Fish and Wildlife (ODFW) 2019 12-Year Assessment of the Oregon Coast Coho Conservation Plan suggests that baseline summer temperatures are high and often exceed coho thermal tolerances, particularly in the Lower Umpqua Independent Population area (Oregon Department of Fish and Wildlife 2019a: Figure 2-9). Currently, 23 miles of streams in the permit area are listed as 303(d) impaired or threatened for dissolved oxygen, water temperature, and sedimentation by Oregon Department of Environmental Quality (DEQ), meaning they do not meet the standards set by DEQ for native cold-water aquatic communities (Table 2-3). Seventy percent of these streams are in the Lower West Fork Millicoma River within the Coos Independent Population area and are 303(d) listed for water temperatures. A small portion of the listed streams occur in the Lower Umpqua and Tenmile coho populations; these are listed for dissolved oxygen and sedimentation. Water temperature conditions and coho are discussed in more detail in Chapter 4, Section 4.6.1.1, *Habitat Modification*.

Climate change is increasing temperatures, lengthening the summer dry season, and changing precipitation patterns in the Pacific Northwest. These trends are expected to continue and intensify in the coming decades (Mote et al. 2014) and, therefore, over the permit term. Stream temperatures in the permit area are expected to increase due to changing climate conditions over the course of the permit term. NorWeST temperature predictions suggest that much of the mainstem streams in the permit area will exceed 15 degrees Celsius (°C) by 2040 (Figure 2-3) and 18°C by 2080 (Figure 2-4) suggesting that conditions may exceed optimal ranges for coho in the middle to end of the permit term. ODFW predicts, based on NorWeST temperature database, that stream temperatures within the ESU are likely to increase between 1°C to 2.5°C by 2080, with the highest increases most likely in the southern extent of the ESU, which includes the permit area.

Table 2-3. Miles of Streams Listed as 303(d) for Dissolved Oxygen, Temperature, and Sedimentation in the Permit Area Summarized by Coho Independent Population

	Stream Miles			
Coho Independent Populations	**Dissolved Oxygen**	**Temperature**	**Sedimentation**	**Grand Total**
Coos				
Millicoma River	0	17.3	--	17.3
Lower Umpqua				
Lower Umpqua River	1.6	0	--	1.6
Mill Creek	0	0.0	--	0.0
Tenmile				
Tenmile Creek-Frontal Pacific Ocean	2.7	1.3	1.3	5.3
Grand Total	4.3	18.7	1.3	24.3

2.1.7 Mass-Wasting Processes and Stream Channels

Mass wasting, which includes landslides, debris flows, and related movements of rock and soil, is the predominant landform-altering agent in the Oregon Coast Range. *Mass wasting* is the movement of rock and soil downslope under the influence of gravity, often stimulated by rainfall or seismic activity, and may occur rapidly. Debris flows are an important link between the hillslope and stream channel and contribute large amounts of sediment, woody debris, channel scour, bank erosion, and undercutting over a short period of time (Schuster and Highland 2007). The addition of large wood and sediment derived from debris flows and landslides are key drivers to maintaining channel complexity and forming habitat features important to aquatic organisms such as salmonids. Mass wasting as shallow, rapid events in the steep terrain of the plan area most often takes the form of *debris flows*. These debris flows of water-saturated soil, rocks, and vegetation often start in or enter steep V-shaped channels characteristic of the forest, at which point they are called *debris torrents.*

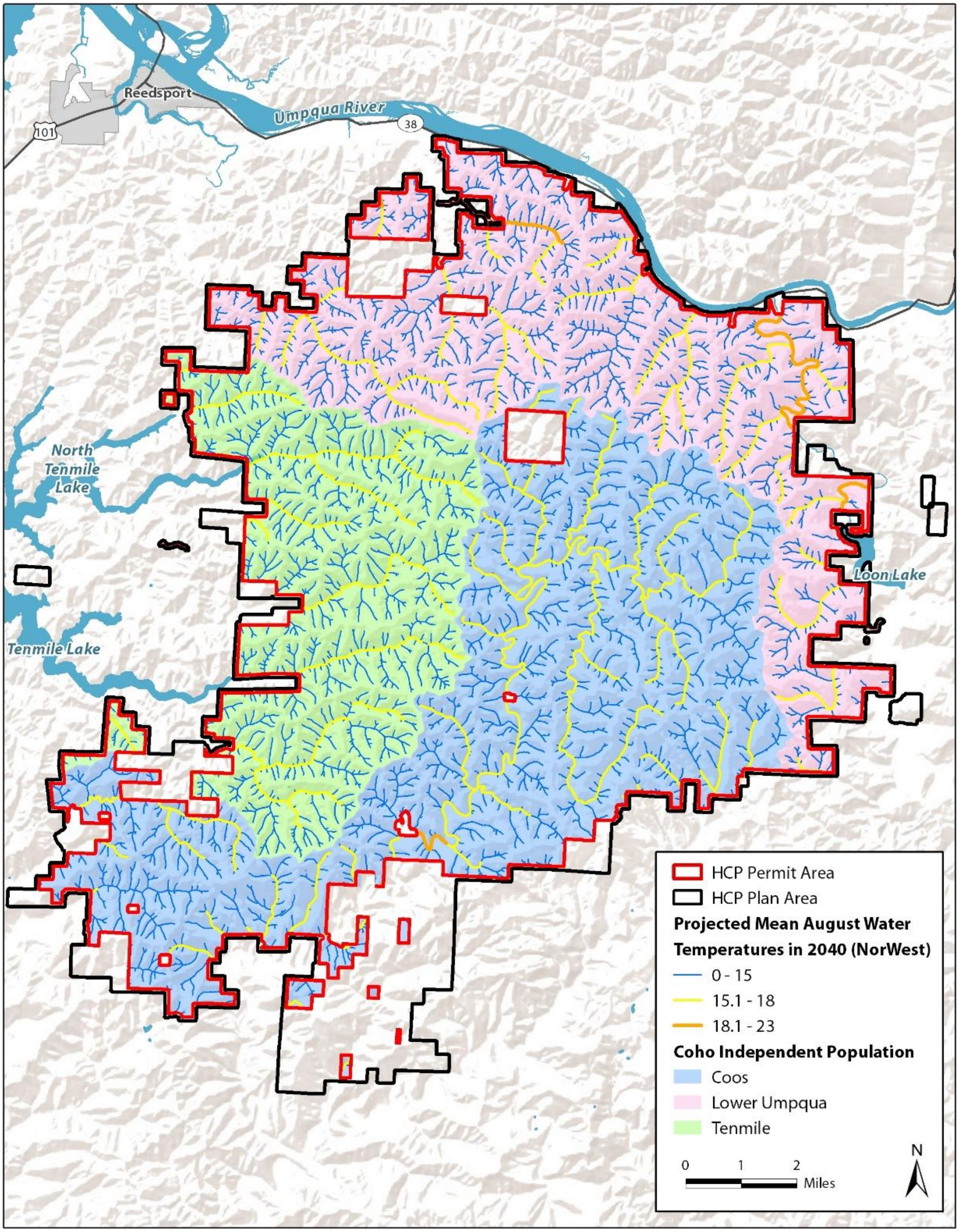


Figure 2-3. Projected Mean August Water Temperatures (°C) in 2040 (NorWest)

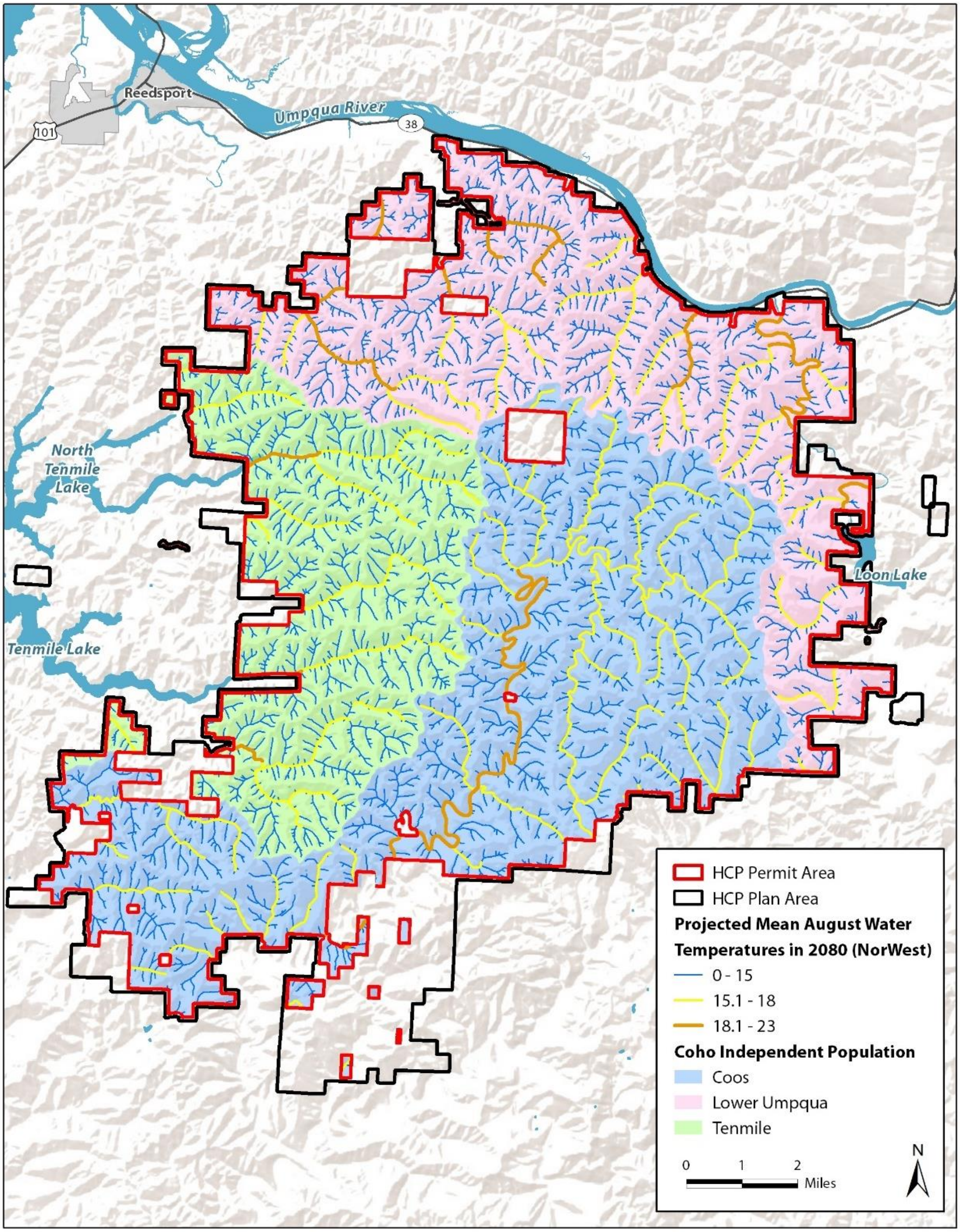


Figure 2-4. Projected Mean August Water Temperatures (°C) in 2080 (NorWest)

Debris flows are dominant processes shaping stream habitats in mountainous regions of Oregon and have been most studied in western Oregon (Dietrich and Dunne 1978; Swanson et al. 1982; Benda and Dunne 1997; Bigelow et al. 2007; Miller and Burnett 2008). Benda and Dunne (1997) described the prevalence of shallow-rapid landslides and debris flows as a landscape-altering process in the Oregon Coast Range:

> The central Oregon Coast Range is formed within massive beds of mechanically weak, marine sedimentary rocks. Hillslopes have relief of up to several hundred meters. Colluvium, 0.1 to 0.5 meters [0.33 to 1.64 feet] deep, mantles the planar portions of the 30° to 40° hillslopes and migrates downhill into stream channels or into convergent areas of hillslopes called bedrock hollows or zero-order basins. In these hollows, colluvium, stabilized by tree roots, accumulates over millennia to depths in excess of 2 meters [6 feet] until root strength is no longer capable of stabilizing it when the pore pressure within it is elevated by large rainstorms. Wedges of colluvium are then evacuated as shallow landslides, the average frequency of which is controlled by the rate of colluvium production. Most shallow landslides in the Oregon Coast Range evolve into debris flows and scour other sediment that has accumulated in first- and second-order channels[4], depositing it at tributary junctions or in high-order reaches. Because first- and second-order channels comprise approximately 90% of all channel length in the central Oregon Coast Range, debris flows in them are important to the sedimentation regime of higher-order channels.

The adjacent riparian forest along debris-flow runout out paths through small, non-fish-bearing first- and second-order streams are important to the stream ecosystem, providing root strength to stabilize stream banks and large wood that maintains desirable channel characteristics as well as shade that moderates water temperatures and organic material inputs (e.g., leaves, terrestrial insects) that support the stream food web (Gregory et al. 1991; Forest Ecosystem Management Team 1993; Meehan 1996). Reeves et al. (2003) studied the sources of large wood in Cummins Creek, a fourth-order fish-bearing stream in the Oregon Coast Range. They found that 65% of the number of pieces, and 46% of the estimated volume, of wood in fish-bearing reaches of Cummins Creek originated from upstream sources delivered by landslides or debris flows more than 300 feet from the fish-bearing channel. The remainder of the wood originated in streamside forest sources immediately adjacent to the fish-bearing channel. Wood from upstream areas constituted the majority of wood found between the bank-full channel width and below the surface level of water at bank-full flow. Reeves et al. (2003) also state that 25% of the wood was in aggregates (log-jams), which were formed mostly from wood originating in the upstream areas.

2.2 Forest Types

This section describes forest conditions in the plan area, including species composition, age, and structural classes. The 2011 Forest Management Plan (Oregon Department of State Lands and Oregon Department of Forestry 2011) describes forest conditions in the Elliott State Forest and served as the basis of much of the following discussion, except as otherwise cited. Disturbance from fire, windstorm, and timber harvest in the plan area has created a patchwork of forest stands of contrasting tree age, size, and density across the landscape.

[4] First-order streams are the smallest perennial streams that flow into and "feed" larger streams but do not normally have any water flowing into them. When two first-order streams come together, they form a second-order stream.

2.2.1 Overview of Oregon Coast Range Forests

The Oregon Coast Range forests are some of the most productive forest ecosystems in the world, due to the moist and moderate maritime climate, relatively low elevations, and productive soils (Spies et al. 2003). This productivity is reflected in rapid tree growth that generates high timber returns as well as nontimber values, including fish and wildlife habitat. Rapid tree growth (matter of decades) in the Oregon Coast Range forests also provides opportunities to restore mature forest conditions in less time than almost anywhere else in the Pacific Northwest (Spies et al. 2003).

The plan area is within the western hemlock (*Tsuga heterophylla*) vegetation zone of the Oregon Coast Range, as defined by Franklin and Dyrness (1988). However, hemlock (*Tsuga heterophylla*) does not typically become the dominant tree species until sometimes hundreds of years after stand-initiating disturbance by fire.

2.2.2 Land Ownership and Forest Cover

Forest cover in the Oregon Coast Range is closely associated with land ownership (Figure 2-5). Most private lands are maintained as commercial timberlands dominated by plantations composed of relatively young, uniform Douglas-fir (*Pseudotsuga menziesii*) forest. Lands adjacent to the permit area in the private Millicoma Tree Farm are managed under an HCP for northern spotted owl (*Strix occidentalis*) (Weyerhaeuser Company 1995). Federal lands adjacent to the permit area contain young forest as well as much of the late-successional forest remaining in coastal Oregon. Much of the federal land is managed for conservation pursuant to the Northwest Forest Plan (U.S. Forest Service and Bureau of Land Management 1994) and associated resource management plans (for Bureau of Land Management [BLM] lands) and land management plans (for U.S. Forest Service lands). Major conservation elements of these plans include conservation of late-successional reserves and riparian reserves, much of which contain older forest cover. Other state lands, including the plan area, have a mix of older and recently harvested forests. Two federally recognized Indian Tribes, the Confederated Tribes of Coos, Lower Umpqua, and Siuslaw Indians and the Confederated Tribes of Siletz Indians, hold Tribal forestlands near the plan area that are actively managed to provide for a balance of economic, ecological, and cultural functions.

Based on these generalities, the plan area is surrounded by young forests (<50 years) on private lands to the west, south, and southeast, and a patchwork of young and older forests to the north and northeast. The Devil's Staircase Wilderness, established in 2019, is directly north of the plan area separated by State Route 38, the Umpqua River, and some private lands.

2.2.3 Tree Species

More than 90% of the plan area is dominated by conifer forest types. Douglas-fir is by far the most common species (Oregon Department of State Lands and Oregon Department of Forestry 2011). Other conifers present in lower abundance are western hemlock, western redcedar (*Thuja plicata*), Sitka spruce (*Picea sitchensis*), and grand fir (*Abies grandis*). Hardwood stands in the plan area are most common along lower slopes and stream corridors but occur in patches and along roads throughout the forest (Oregon Department of State Lands and Oregon Department of Forestry 2011). Most hardwood stands are dominated by red alder (*Alnus rubra*) and bigleaf maple (*Acer macrophyllum*).

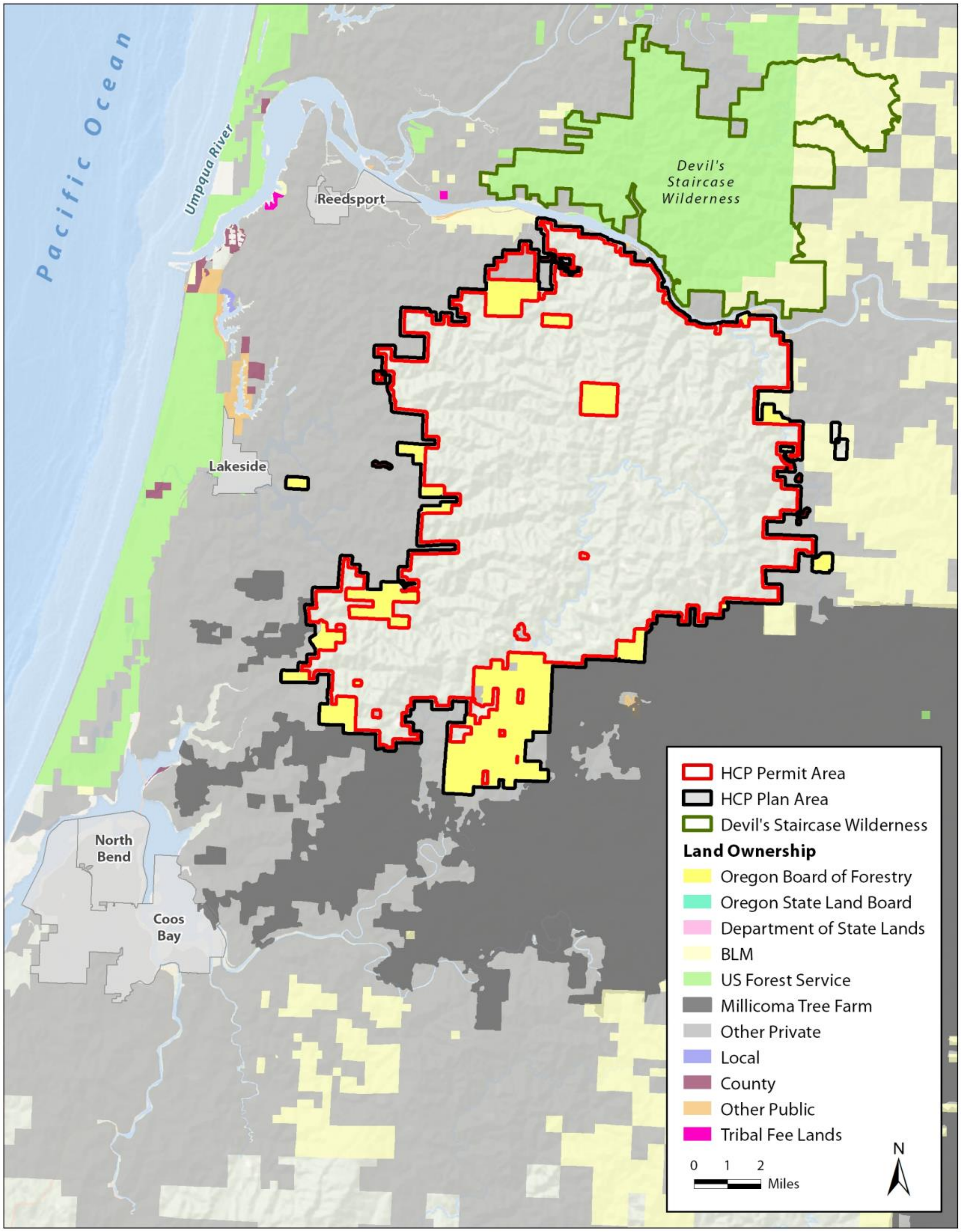


Figure 2-5. Land Ownership in and Near the Plan Area

2.2.4 Ecological Disturbance and Forest and Stream Health

Forests are shaped by biotic and abiotic disturbances that reduce the dominance of overstory trees and initiate regeneration of younger stands. In the historic era, major agents of disturbance on the plan area have been fire, wind, and timber harvest. Natural disturbances are necessary processes of the forest ecosystem and provide many important components of fish and wildlife habitat. Neither fire nor wind completely remove the forest overstory; both tend to leave patches of trees or individual large dominant trees (residuals) that survive, along with standing dead and fallen trees, which end up on the forest floor or in streams from the prior forest cohort. This “legacy” structure may provide habitat used by fish and wildlife until and after forest cover returns throughout the disturbed area. However, when disturbances are more severe, frequent, or widespread than considered normal or acceptable, forest resiliency and resistance decline (Campbell and Liegel 1996). Resilience and resistance are broad concepts that reflect the capacities of systems to regain and retain their fundamental structure, organization, and processes when affected by stresses or disturbances (Hessburg et al. 2019).

Key indicators of forest resilience include impacts from biotic agents such as insects, diseases, and animals, as well as outcomes from abiotic stressors such as fire, weather extremes, and air pollutants. These disturbance agents kill trees or parts of trees, reduce tree growth, and may predispose trees to damage by other agents. The effects of these various disturbance agents are usually described in terms of number of acres affected, number of trees killed, degree of damage, or reduction in tree growth rates, all of which can be measured through various survey techniques. Evaluations must determine what level of change indicates a significant forest decline in resilience and resistance within the context of normal and historical variability. Restoring or maintaining forest health can sometimes be accomplished through silvicultural manipulation of the forest at the stand or landscape level. Such manipulations can help sustain individual tree productivity and thereby limit damage from native pests. Nonnative or invasive species often require special measures such as eradication, quarantine, or direct suppression (Oregon Department of State Lands and Oregon Department of Forestry 2011).

2.2.4.1 Disturbance Agents: Fires

Oregon Coast Range forests are generally subject to infrequent, high-severity fires (DeMeo et al. 2018), resulting in historic patterns of large areas growing into late-successional forests, followed by wide-ranging, stand-replacing fires. The principal wildfire event was the Coos Bay fire of 1868. This fire began a few miles northeast of Scottsburg, Oregon, and burned to the coast, from Lakeside to south of Coos Bay (Phillips 1997:7; Oregon Department of State Lands and Oregon Department of Forestry 2011:1–4). Approximately 90% of the plan area was burned during this fire (Figure 2-6), most of it at high intensity, leaving few residual living trees. Many of the residual snags were felled as a fire prevention measure. Stumps from this fire may be still locally abundant and contribute to forest structure in the post-1868 stands.

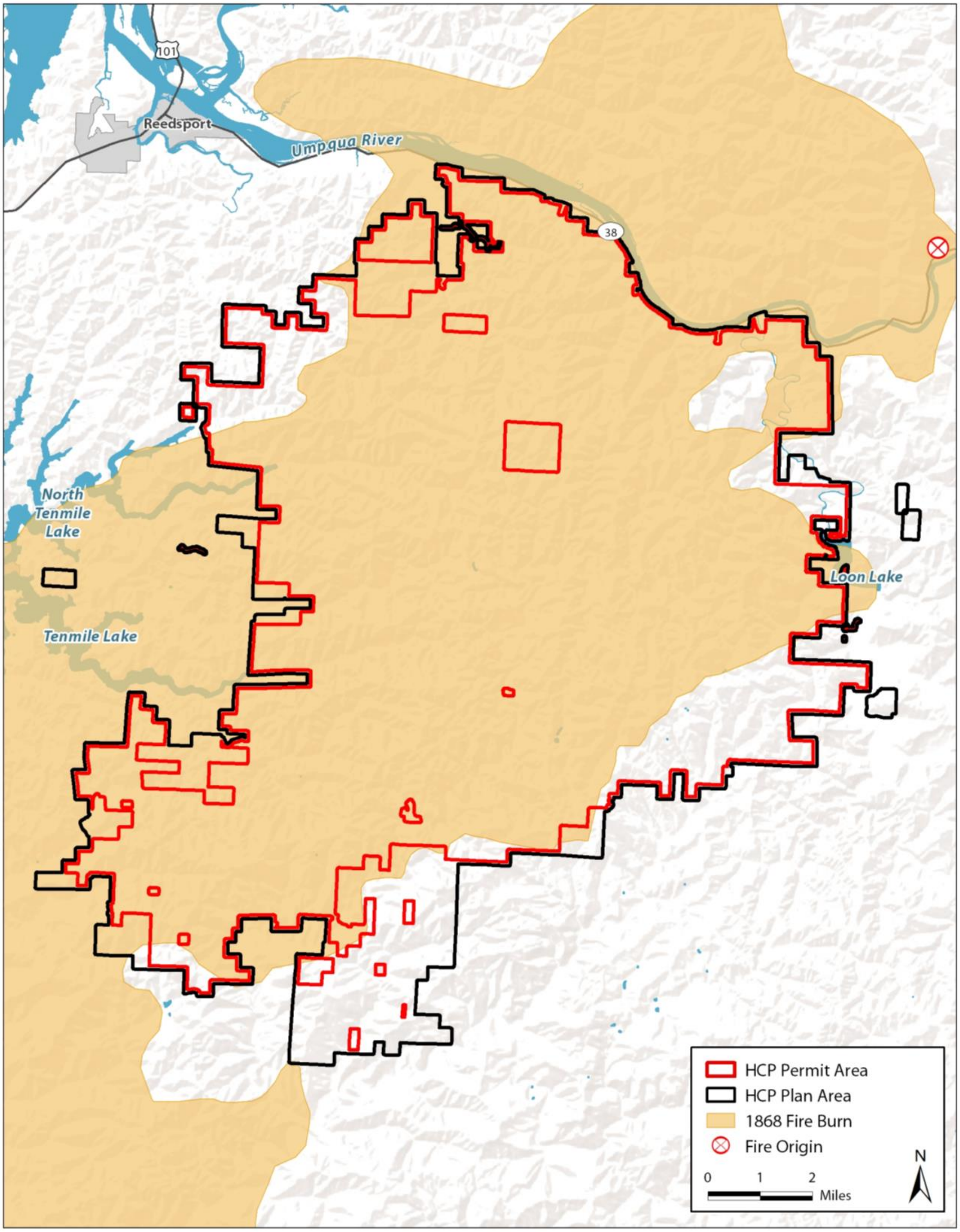


Figure 2-6. Extent of the 1868 Fire on the Elliott State Forest

Contemporary and emerging science also indicates that fire occurrence and severity may have been more frequent and mixed-severity than the general paradigm for Oregon Coast Range forests may suggest. Ongoing fire history reconstruction on the Elliott State Forest and other relevant forests by OSU researchers is contributing to this evidence. Anecdotal and other accounts of periodic and relatively frequent historic indigenous burning in these forests is a contributing factor to this evolving understanding of fire behavior. Depending on the severity and scale, wildfires can have a substantial impact on the stream environment, including increasing the density of large wood; increasing runoff, erosion, and peak flows; and increasing stream temperatures because of the loss of streamside trees and vegetation.

2.2.4.2 Disturbance Agents: Storms

Severe storms are relatively common in the plan area (Robison et al. 1999). The principal storm that has shaped the Elliott State Forest was the Columbus Day storm of 1962. This single event is estimated to have felled approximately 17 billion board feet of timber in western Washington and Oregon, of which approximately 100 million board feet was blown down on the Elliott State Forest. The most severe blowdown was on the windward western slopes. Extensive salvage harvest of the blowdown occurred in over 250 units over the following 3 years (Phillips 1997). No comparable storm has been recorded in western Washington or Oregon, either before or since.

More common examples are the storms of February and November 1996, which remain the most recent severe storm events in the plan area (Robison et al. 1999). Both storms were “atmospheric river” events that produced very heavy precipitation over a multi-day period and were accompanied by shallow and rapid landsliding and debris torrents. Similar events of this kind have been recorded in many other areas of western Washington and Oregon. Such events may be expected to occur more frequently and with greater severity in the future due to climate change (Mahoney et al. 2018).

Storms, particularly severe or large storms, contribute to many processes that can reshape the stream channel and as mentioned previously, trigger landslides that are important ecological drivers of forming complex stream channels. Landslides, debris flows, and debris torrents triggered by severe storms can reshape the stream environment over a short period of time by contributing large amounts of sediment and wood and provide the basis for maintaining stream complexity over time. Severe storms can also increase stream flow significantly, causing increased channel erosion, bank undercutting, and sediment and debris transport. Storm flows reaching or exceeding peak conditions (floods) provide an important connection between the floodplain and the stream channel depositing fine sediment on the floodplain and carving out side channels, alcoves, or backwaters that can serve as important refuge habitats for juvenile salmonids, including coho.

2.2.4.3 Disturbance Agents: Insects and Disease

A comprehensive inventory of pest and disease agents active in the region that may affect the plan area is presented in the 2011 Forest Management Plan for the Elliott State Forest (Oregon Department of State Lands and Oregon Department of Forestry 2011:2-36). Swiss needle cast (*Phaeocryptopus gaeumannii*), the highly visible native foliage disease of Douglas-fir, is causing serious growth decline over a large area along the west slope of the Oregon Coast Range. In northwest Oregon, growth reduction of Douglas-fir is severe enough on some sites that the future of those stands remaining productive for timber harvest is uncertain. In the plan area, though Swiss needle cast affects some stands, it has not become severe enough to require major modification of silvicultural activities yet.

Laminated root rot (*Phellinus weirii*), a native disease of conifers, has damaged Douglas-fir on some sites, but current management practices are expected to stabilize or reduce unwanted effects of this disease. Black stain root disease (*Leptographium wageneri*) has reached epidemic proportions in some locations in southwest Oregon but is currently found infrequently in Douglas-fir in the plan area.

Aerial and ground surveys conducted during the past 60 years show little evidence of major pest outbreaks in the plan area. Currently, few insect problems occur in the mid- to late-successional Douglas-fir stands. The most significant pest is the Douglas-fir bark beetle (*Dendroctonus pseudotsugae*), whose outbreaks follow major windthrow events. The Sitka spruce weevil (*Pissodes strobi*) continues to limit Sitka spruce management. Continued monitoring through aerial and ground surveys will provide early warnings of new problems, and gradually improve the ability to maintain a healthy forest.

Most insect damage on the Oregon Coast is caused by the Douglas-fir bark beetle, which tends to affect low-vigor trees weakened by other factors. Beetle population buildup after significant disturbance events can cause damage to healthy trees. Increases in beetle populations tend to be short lived unless continued disturbance provides new habitat.

2.2.5 Climate and Forest Types

The moderate, moist coastal climate generates high amounts of rainfall in the plan area. This contributes to productive growing conditions for conifers as well as hardwood and ground vegetation, such as sword fern (*Polystichum munitum*) and salal (*Gaultheria shallon*). Dense fog is also common, creating lush moss growth within forested canopies (a habitat feature that is used by marbled murrelets [*Brachyramphus marmoratus*] for nesting). The forest exhibits a general drying (lower precipitation) from west to east, though the entire forest is relatively wet, compared to the valleys between the Oregon Coast Range and the Cascades.

The high moisture levels in the plan area reduce the risk of frequent wildfire. However, because fires are rare, dense forests can build up large fuel loads that produce the potential for stand-replacing fires during drought conditions. With hotter, longer, and drier summers projected to occur in the future, climate-related fire is a potential future agent of disturbance for all forests within the Oregon Coast Range (Agne et al. 2018). Other risks that are at least partly subject to climate controls include insects, disease, and drought-related mortality.

Based on a synthesis report of climate change (Reilly et al. 2018), the relatively moist forests in the vicinity of the plan area may experience decreased growth and productivity due to climate change, although the northern portion of the Coast Range along the Pacific Ocean, which includes the plan area, was projected to have the lowest amount of climate change effects among Pacific Northwest forest regions.

2.2.6 Forest Age

Management of the permit will emphasize key ecological areas ranging from early seral to late-successional forest structure in the context of the greater landscape. The future growth of the forest should encompass diverse objectives of biological quality and resilience for future adaptability.

The Elliott State Forest has a bi-modal age class distribution that can be explained by two general stand histories: (1) stands approximately 65 years old or younger (as of 2020), and (2) stands older than approximately 65 years old (Figures 2-7 and 2-8). These classes may not represent the stand history of every single stand, but the primary activities in the recent past. Stands 65 years of age or younger are forest stands that regenerated following a clearcut. Stands over 65 years of age regenerated naturally, primarily following fire.

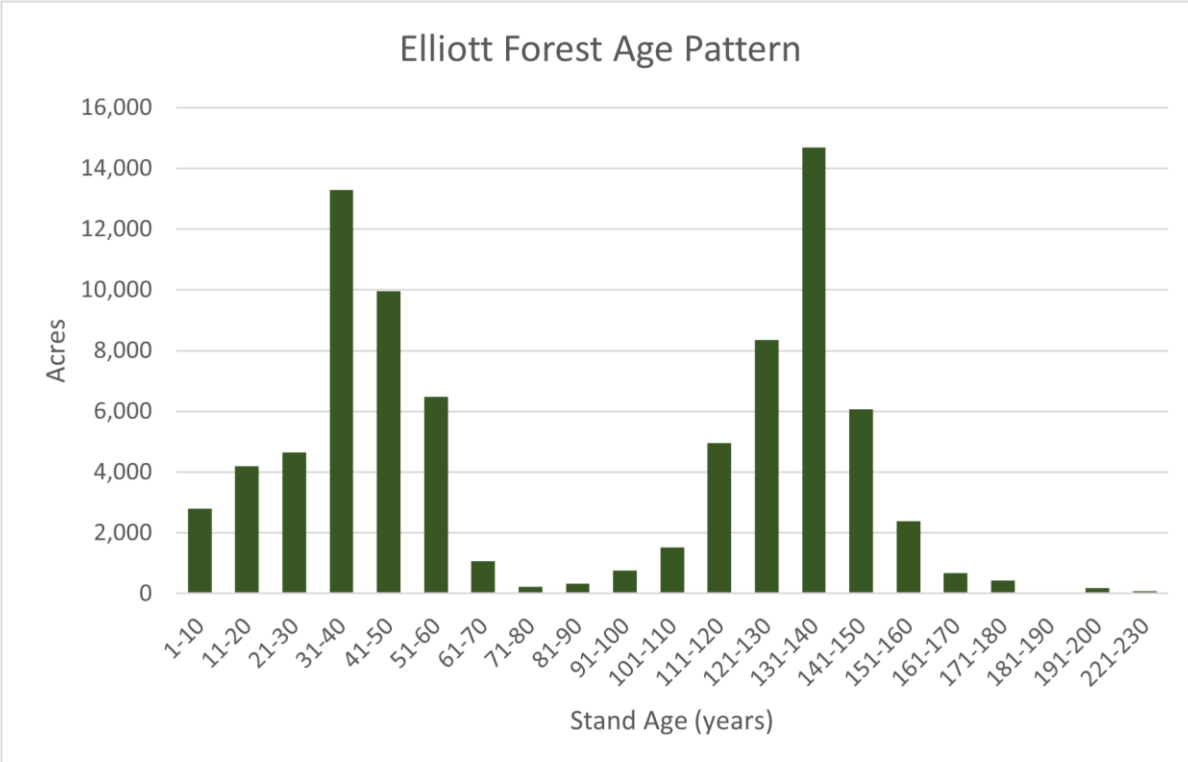


Figure 2-7. Tree Age Distribution on the Elliott State Forest by Age Class as of 2020 (LiDAR)

2.2.6.1 Forests 65 Years Old or Younger (as of 2020)

Overall, about 50% of the permit area has been clearcut in the past 65 years (as of 2020). These forests regenerated naturally following fire, wind events, landslides or regenerated following clearcut harvests that began in 1955 (aside from one early harvest in 1945). Some of these young stands may also have had a pre-commercial or commercial thinning. Regeneration methods varied over this period, starting with a reliance on natural regeneration, followed by aerial seeding, and then hand planting starting around 1970 with the Oregon FPA. These practices resulted in approximately 42,000 acres of young forest in the plan area (approximately 50% of the Elliott State Forest), consisting primarily of Douglas-fir with some alder, western hemlock, and western redcedar. Understory diversity is limited in young forests.

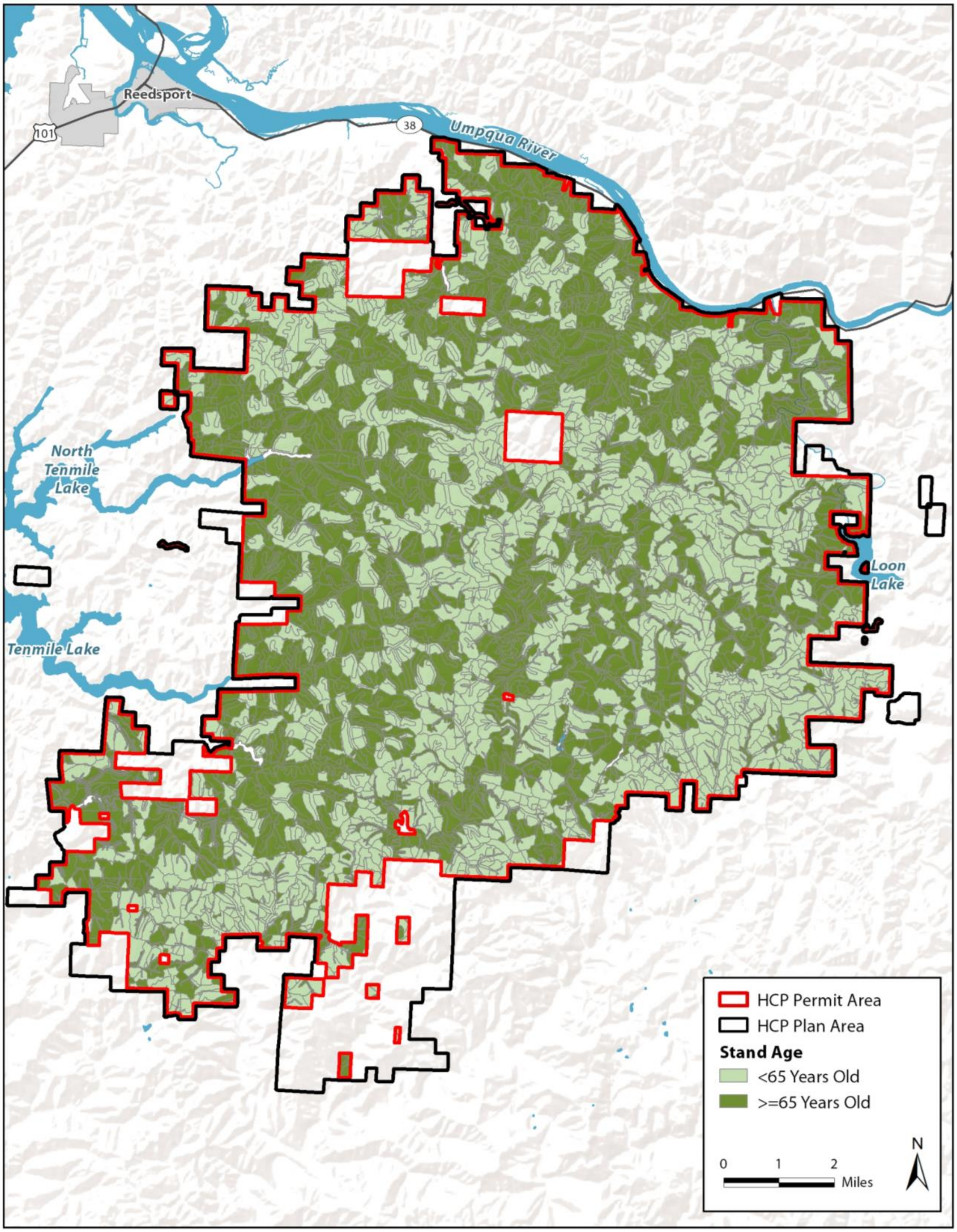


Figure 2-8. Age Class Distribution in the Permit Area

2.2.6.2 Forests Older than 65 Years Old (as of 2020)

Forests in the permit area that are older than 65 years fall into two general categories: those that were thinned prior to 1955 and those that were not.

Approximately 50% of the Elliott State Forest supports forests that regenerated naturally following fire, wind, or landslide events prior to 1955. While records are incomplete, somewhere between 5,000 and 10,000 acres of forests that were primarily 100 to 160 years in 2020 have been partially harvested (Phillips 1997). The purpose of the thinning was to remove approximately 30% of the volume to improve the growth of remaining trees and generate revenue. Several of the thinned stands have subsequently been clearcut and converted to Douglas-fir plantations.

There are a little over 38,000 acres of naturally regenerated forests, but it is uncertain how many acres were partially logged due to incomplete historical records. The primary stand-replacing fire occurred in 1868, but other more localized fires and other disturbances may have happened. It was estimated that 5,000 acres of the plan area survived the 1868 fire, mostly to the southwest. However, most of this area was clearcut and reforested in the 1950s and 1960s (Phillips 1997), so there are very few acres of old-growth forests (more than 200 years old) currently in the Elliott State Forest (Figure 2-7). There may be individual trees older than 200 years old as scattered remnants in younger stands. Using the partial harvest estimates of Phillips (1997), the permit area contains approximately 30,000 to 35,000 acres of unmanaged forests. The age range of these forests is from 80 to 230 years, with 71% of this forest type between 130 and 160 years. Snags from the 1868 and other fires and other disturbances were systematically felled and sometimes removed from the Elliott State Forest to reduce fire danger. These activities occurred in areas that may not have been logged otherwise. Therefore, even the unlogged forests may not be an accurate baseline for the level of standing and down deadwood.

2.2.7 Riparian Forest

Riparian areas are lands adjacent to streams with soils and vegetation that are influenced by proximity to water. In turn, riparian areas influence streams in ecologically important ways, such as by affecting microclimate. In the plan area, hardwoods are the most dominant stand type found within 100 feet of a stream for all stream size classes, composed primarily of red alder and bigleaf maple. Conifer and hardwood stands occupy the majority of the area at distances of 100 to 200 feet from the stream (Biosystems et al. 2003). Riparian forests can affect the types of disturbance characteristic of stream channels, filter sediment from uplands, provide root reinforcement that affects the geometry of the stream channel, affect stream exposure to sunlight and wind, and deliver terrestrial insects and plant material into the stream (Everest and Reeves 2007).

One of the most important forms of plant material—large-diameter wood—is especially important to coho and other fish species because it provides instream cover, store spawning gravels, and a substrate and nutrient source that influence the structure and productivity of stream food webs (Bilby and Ward 1991; Chen et al. 1995; Gregory et al. 1991; Naiman et al. 1998).

In the Elliott State Forest, riparian forests with a mature forest condition represent from 13% to 52% of each major river basin (Biosystems et al. 2003). Riparian areas furthest from streams tend to have a higher percentage of area with mature forest because those stands are subject to fewer disturbances of flood events and debris flows than stands closer to river channels. Based on vegetation surveys (Biosystems et al. 2003), large streams generally have the highest percentage of mature forest. The Umpqua Basin tends to have the highest percentage of riparian area in mature forest condition (stand age older than 90 years), followed by Coos, then Tenmile. On average, forest-wide, 31% of streams have mature forest within 150 feet of the channel (Biosystems et al. 2003).

See Section 2.1.6, *Hydrology and Water Quality,* for a description of stream types in the permit area.

2.3 Northern Spotted Owl

The U.S. Fish and Wildlife Service (USFWS) designated the northern spotted owl in 1990 as threatened throughout its range in Washington, Oregon, and California by the loss and adverse modification of suitable habitat as the result of timber harvesting and other disturbances such as fire (55 *Federal Register* [FR] 26114). In 2020, USFWS found that reclassification of the northern spotted owl from a threatened species to an endangered species was warranted but precluded by higher priority actions to amend the Lists of Endangered and Threatened Wildlife and Plants (85 FR 241). In the finding, USFWS stated that:

> based on our review of the best available scientific and commercial information pertaining to the factors affecting the northern spotted owl, we find that the stressors acting on the subspecies and its habitat, particularly rangewide competition from the nonnative barred owl and high-severity wildfire, are of such imminence, intensity, and magnitude to indicate that the northern spotted owl is now in danger of extinction throughout all of its range

USFWS will develop a proposed rule to reclassify the northern spotted owl as priorities allow.

Since 1994, the Northwest Forest Plan (U.S. Department of Agriculture and Bureau of Land Management 1994) has served as the foundational plan for conservation of the northern spotted owl and late-successional forest habitat on federal lands across the range of the species (Thomas et al. 2006). Additional site-specific conservation actions, standards, and guidelines are defined in associated resource management plans (for BLM lands) and land management plans (for U.S. Forest Service lands). On state and private lands, USFWS has worked with state and private land managers to develop HCPs and Safe Harbor Agreements for northern spotted owl to allow timber harvest and other land management activities to continue consistent with the requirements of the federal Endangered Species Act (ESA).

USFWS revised critical habitat for the northern spotted owl in 2021 by excluding certain areas, which revised the previous 2012 rule (77 FR 71875; 86 FR 62606). Critical habitat for the northern spotted owl now includes approximately 4.3 million acres in Oregon, including 38,745 acres (approximately 42%) of the plan area and (described in more detail in Section 2.3.2, *Population and Habitat Status*). The lands in the plan area were not part of the exclusions identified in the 2021 rule, so critical habitat in the plan area is not affected by the rule revision.

2.3.1 Biology and Ecology

This section provides a summary of key aspects of northern spotted owl biology and ecology, including habitat requirements. Additional information on the biology and ecology of northern spotted owl can be found in the Northern Spotted Owl Recovery Plan (U.S. Fish and Wildlife Service 2011), the final rules designating critical habitat for northern spotted owl (77 FR 71875–72068), and the Notice of 12-Month Finding on a petition to list the northern spotted owl as an endangered (85 FR 81144). The most recent and comprehensive review of the scientific literature regarding northern spotted owl can be found in the 2018 Forest Service Science Synthesis Report (Lesmeister et al. 2018) and in the supporting materials submitted for the 12-Month Finding.

Northern spotted owls are primarily nocturnal hunters that feed on a relatively narrow range of species, with northern flying squirrels (*Glaucomys sabrinus*) being the primary prey species in Douglas-fir/western hemlock forests, such as occur in the plan area (Forsman et al. 1984). Northern spotted owl locations have been found to be closely correlated with prey availability (Lesmeister et al. 2018).

Northern spotted owls are territorial and, as adults, often occur as mated pairs that share a core territorial nesting area and overlapping foraging territories (Forsman et al. 1984). Mated pairs may maintain a territory for many years, although adult movements and mate changes (including replacements if a mate is lost) are common. Single owls may also establish territories and such owls are referred to as resident singles.

For management purposes, northern spotted owl territories are defined as *activity centers* centered on nest sites or daytime roost locations. Single owls may also adopt transient (non-territorial) behavior and move across the landscape; such owls are referred to as floaters. Young spotted owls are also highly mobile as they disperse from the pair nesting territory (Forsman et al. 2002), as described in Section 2.3.1.3, *Dispersal Habitat*. While nesting pairs are the most important component of the population due to their ability to increase it, resident singles, floaters, and dispersing juveniles are important for population maintenance and increase by filling vacancies following mortality of territorial individuals (Courtney et al. 2004) and by colonizing (or recolonizing) unoccupied habitat.

Northern spotted owl habitat requirements are commonly ascribed to the specific essential behaviors of nesting and roosting, foraging, and dispersal (77 FR 71875–72068). Habitat associations for each of these essential behaviors are described in the following sections.

2.3.1.1 Nesting and Roosting Habitat

Northern spotted owls do not construct nests, but rather rely on existing nest structures 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 require very large snags or very large, decadent live trees with broken tops or large cavities. These features are typically found in late-successional forests or younger forests that retain residual patches of large trees and snags.

Nesting and roosting habitat provides structural features for nesting, protection from adverse weather conditions (particularly heat and rain), and cover to reduce predation risks for adults and young (77 FR 71875–72068).

USFWS considers the following components important to nesting and roosting habitat (77 FR 71875–72068).

- 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, and other evidence of decadence).
- Large snags and large accumulations of fallen trees and other woody debris on the ground.
- Sufficient open space below the canopy for northern spotted owls to fly.

2.3.1.2 Foraging Habitat

In addition to nesting and roosting habitat, spotted owls need relatively large amounts of foraging habitat to support survival and reproduction. Foraging habitat is the most variable of all habitats used by territorial spotted owls and is closely tied to the prey base. Also, nesting and roosting habitat always provides foraging habitat, but foraging habitat does not always provide nesting habitat. Owls may forage in younger and more open and fragmented forests if adequate prey is available (77 FR 71875–72068).

Northern spotted owls forage by moving from perch to perch through the forest (Courtney et al. 2004). Once on a perch they sit, look and listen for prey activity, and then attack the located prey (Forsman et al. 1984; Gutiérrez et al. 1995). This essential foraging strategy requires open forests that allow the owls to fly beneath the canopy combined with available perches for hunting.

Foraging habitat varies widely across the northern spotted owl's range. Within the West Cascades/Coast Ranges of Oregon and Washington, USFWS defines foraging habitat as follows (this definition shares some but not all of the habitat characteristics of nesting/roosting habitat).

- Stands of nesting and roosting habitat.
- 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.

2.3.1.3 Dispersal Habitat

Dispersal habitat is essential to spotted owl populations because it allows non-territorial adults and young-of-the-year owls to survive and eventually establish territories, find and pair with a mate, and reproduce. Young northern spotted owls tend to disperse widely, often in a series of steps, where dispersing juveniles take up temporary home ranges for up to several months (Forsman et al. 2002). Dispersal distances have been reported to be in the range of 8 to 17 miles from natal areas (nest sites) to eventual home territories (Courtney et al. 2004).

USFWS defines dispersal habitat as follows (77 FR 71875–72068).

- 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 temporary resting and feeding during the transience phase.
- Habitat supporting the colonization phase of dispersal, which is generally equivalent to nesting, roosting and foraging habitat, but may be smaller in area than that needed to support nesting pairs.

2.3.2 Population and Habitat Status

This section describes trends in population and habitat extent for northern spotted owl throughout its range and within the plan area.

2.3.2.1 Rangewide Status

Populations Rangewide

When the Northwest Forest Plan was published in 1994, the northern spotted owl population was estimated to be declining at about 4.5% per year due primarily to habitat loss and degradation. Current estimates are in the range of a 3.8% annual decline, although there is wide geographic variation (Table 2-4).

Table 2-4. Estimated Mean Annual Rate of Population Decline of Northern Spotted Owls in 11 Study Areas in Washington, Oregon, and California (Annual Average, 1985–2013) [a]

State	Area	Average Annual Percent Decline
Washington	Cle Elum	8.4%
	Rainier	4.7%
	Olympic	3.9%
Oregon	Oregon Coast (including HCP plan area)	5.1%
	H.J. Andrews	3.5%
	Tyee	2.4%
	Klamath	2.8%
	South Cascades	3.7%
California	Northwest California	3.0%
	Hoopa	2.3%
	Green Diamond Resources Area 1	1.2%
	Green Diamond Resources Area 2	3.9%
Average Rangewide		3.8%

Source: Dugger et al. 2016.

[a] A more recent review by Franklin et al. (2021) found annual declines in the Oregon Coast Range up to 9% per year from 1995 through 2017.

Lesmeister et al. (2018) found that the Oregon Coast Range population has been declining at approximately 5% per year, the highest rate of decline in Oregon and the second highest rate of decline in all of the 12 study areas evaluated. A more recent review by Franklin et al. (2021) reported that the Oregon population of northern spotted owls declined statewide by more than 60% from 1995 through 2017, with the Oregon Coast Range and Klamath areas declining by more than 75% over the same time, with up to a 9% decline in population per year. Should these rates continue, the northern spotted owl population along the Oregon Coast would be extirpated by approximately the end of the century.

Current population declines are believed to be primarily due to widespread expansion of the barred owl (*Strix varia*), an invasive species that often displaces northern spotted owl, rather than habitat loss (Dugger et al. 2016). The barred owl expanded its range westward in North America over much of the later part of the last century and now entirely overlaps the historic range of the northern spotted owl (Gutiérrez et al. 2004). In the western United States, barred owl expanded from north to south. They were first detected in Washington in 1965, Oregon in 1974, and California in 1981 (Gutiérrez et al. 2004). Since those first detections, barred owl populations have increased rapidly and have displaced northern spotted owls throughout much of the historic range, including many places on the Elliott State Forest. The number of barred owl detections during annual northern spotted owl surveys conducted on the Elliott State Forest went from 8 in 2003 to 57 in 2016 (Kingfisher Ecological, Inc. 2016).

Dunk et al. (2019) concluded that barred owls are the primary cause of current declines in spotted owl populations, but also noted that retaining unoccupied suitable habitat remains essential for recovery should barred owl populations be reduced through active control. USFWS led experimental removal of barred owls starting in 2013 (U.S. Fish and Wildlife Service 2013a), with more than 1,000 barred owls removed from the Oregon Coast Ranges since 2013 (U.S. Fish and Wildlife Service 2020a). This was shown to have a positive effect on northern spotted owls (Wiens et al. 2021).

Habitat Rangewide

The amount of mature, structurally complex forest required by northern spotted owls has been in decline since early logging (and associated fires) began around 1850. Much of the logging of habitat took place in the latter part of the past century, when nearly all remaining mature forest was removed on private lands, leaving the only large blocks of habitat remaining on federal lands (Thomas et al. 1990). This led to the development of the Northwest Forest Plan (U.S. Department of Agriculture and Bureau of Land Management 1994) in an attempt to manage federal lands to avoid the extinction of the species and associated plant and animal communities. Suitable habitat for northern spotted owl nesting and roosting habitat has continued to decline after completion of the Northwest Forest Plan, with net decreases of approximately 1.5% on federal lands, primarily caused by wildfire, and a net decrease of 8.3% on nonfederal lands, primarily caused by timber harvest (Davis et al. 2016; Lesmeister et al. 2018).

2.3.2.2 Plan Area Status

Population in Plan Area

Initial formal surveys for northern spotted owl on the Elliott State Forest began in 1990. Complete surveys of all suitable habitat were conducted from 1992 to 1996, in 2003, and from 2010 through 2016 (Kingfisher Ecological, Inc. 2016). Additional surveys were conducted from 2005 through 2009, although not all sites were surveyed and surveys were not conducted according to formal protocols. During complete survey years, all potential owl habitat (forest with trees greater than or equal to 11 inches dbh) on the Elliott State Forest was surveyed using a modified survey approach incorporating aspects of both the density survey protocol (Forsman 1995) and the standard survey protocol for spotted owls (U.S. Fish and Wildlife Service 2012).

Based on the survey results, the overall population and density of northern spotted owls across the Elliott State Forest have declined over time, reflecting the rangewide population decline reported in the literature (Lesmeister et al. 2018). In 1991, the northern spotted owl population on the Elliott State Forest was estimated to be 51 individual owls in 25 activity centers. By 2016 (the last year that full surveys were completed) the population was estimated to be 23 individuals,[5] including eight territorial pairs (this includes one pair in a site centered on adjacent federal lands), five resident (territorial) singles at historic pair activity centers, and two non-territorial single owls (floaters).

This decline was accompanied by a corresponding increase in barred owl detections. In 2003, barred owls were detected in only eight sites where northern spotted owls had been previously found. By 2016, barred owls were detected at 57 such sites (Kingfisher Ecological, Inc. 2016).

When considering the survey data as a whole, certain sites have been consistently occupied by northern spotted owls over multiple years. As of 2016, 20 northern spotted owl pair sites, one unconfirmed pair site, and two resident single sites centered on the Elliott State Forest have been consistently occupied over several years and have had at least one northern spotted owl detection between 2011 and 2016 (within 5 years of the last full survey conducted in 2016). In addition, five northern spotted owl pair sites centered on lands adjacent to the Elliott State Forest (i.e., within 1.5 miles) have been consistently occupied over several years and have had at least one northern spotted owl detection between 2011 and 2016. As of 2023, a historic northern spotted owl pair site (46) in the Elliott State Forest was removed from the list of recent owl sites. The site was first documented in 1991 but the last year any owls were detected at this site was 2003; furthermore, this site is multi-ownership, much of which occurs outside the permit area. Table 2-5 lists the details for these sites and Figure 2-9 shows their locations, as well as the 0.5-mile core area and 1.5-mile home range provincial radii centered around the activity center. *Provincial radii* are used to evaluate effects on core nesting areas as well as extended foraging range. Provincial radii are described more as part of the effects analysis presented in Chapter 4, *Effects Analysis*.

[5] This number is based on survey data contained in the Kingfisher (2016) report. The report also evaluated the data using the "density survey protocol" of Forsman (1995), which resulted in a 2016 population estimate on the Elliott State Forest of 14 owls on 8 activity centers.

Table 2-5. Consistent and Recent Northern Spotted Owl Activity Centers in and Adjacent to the Plan Area

ID	Site Name	Highest Status [a]	Years Since Highest Status Last Confirmed (as of 2016)	Year First Documented	2016 Survey Results	Number of Years with Confirmed Pair	Last Year any Owls Detected (as of 2016)	Years with Nest but No Young Fledged	Years with Young Fledged
14	Lower Camp Creek	PR	6	1991	Absent	5	2011	N/A	N/A
36	Murphy Creek	PR	20	1991	Absent	6	2012	N/A	N/A
37	Wind Creek	PR	13	1990	Single	9	2016	1	3
38	Roberts Creek	PR	13	1991	Absent	9	2011		5
42	Dean Creek	PR	13	1990	Absent	10	2015	4	2
45	Alder Creek	PR	5	1991	Absent	8	2011	N/A	2
50	Benson Creek	PR	8	1991	Absent	8	2013	1	1
53	Scholfield Creek	PR	6	1990	Absent	1	2011	N/A	N/A
54	Johanneson Creek	PR	0	1991	Pair	6	2016	N/A	N/A
55	Upper Millicoma	PR	6	1991	Single	1	2016	N/A	N/A
56	Charlotte Creek	PR	6	1991	Single	3	2016	N/A	N/A
57	Cougar Creek	PR	6	1999	Single	2	2016	1	N/A
59	Luder Creek	PR	0	1991	Pair	8	2016	N/A	N/A
61	Upper Elk	RS	3	2013	Absent	1RS	2013	N/A	N/A
62	Footlog Creek	PR	0	2010	Pair	5	2016	N/A	2
63	Lower Mill Creek	PR	0	1986	Pair	21	2016	2	6
64	Marlow Ridge	PR	0	1991	Pair	7	2016	1	N/A
65	West Glenn Creek	PR	0	2003	Pair	3	2016	N/A	N/A
66	Johnson Creek	PR	0	1991	Pair	8	2016	N/A	4
68	Upper Roberts Creek	PU	5	2011	Absent	1 PU	2014	N/A	N/A
69	Panther Creek	RS	6	2003	Absent	2RS	2011	N/A	N/A
70	Salander Creek	PR	25	1991	Absent	7	2015	1	5
2176	Upper Mill Creek [b] (BLM)	PR	1	1991	Single	5	2016	N/A	N/A
2938	Marlow Creek [b] (Weyerhaeuser)	PR	0	1991	Pair	18	2016	1	3

ID	Site Name	Highest Status [a]	Years Since Highest Status Last Confirmed (as of 2016)	Year First Documented	2016 Survey Results	Number of Years with Confirmed Pair	Last Year any Owls Detected (as of 2016)	Years with Nest but No Young Fledged	Years with Young Fledged
3159	Tom Fool Creek [b] (BLM)	PR	8	1992	Absent	11	2012	1	2
3531	Lockhart Road [b] (Weyerhaeuser)	PR	1	1986	Single	9	2016	N/A	N/A
4166	Lower West Fork Millicoma [b] (Weyerhaeuser)	PR	4	1992	Absent	14	2014	2	2

Source: Kingfisher Ecological, Inc. 2016.

[a] PR = Pair, PU = Unconfirmed Pair, RS = Resident Single

[b] Adjacent lands (centered outside permit area or plan area, ownership in parentheses; BLM = Bureau of Land Management)

N/A = not available

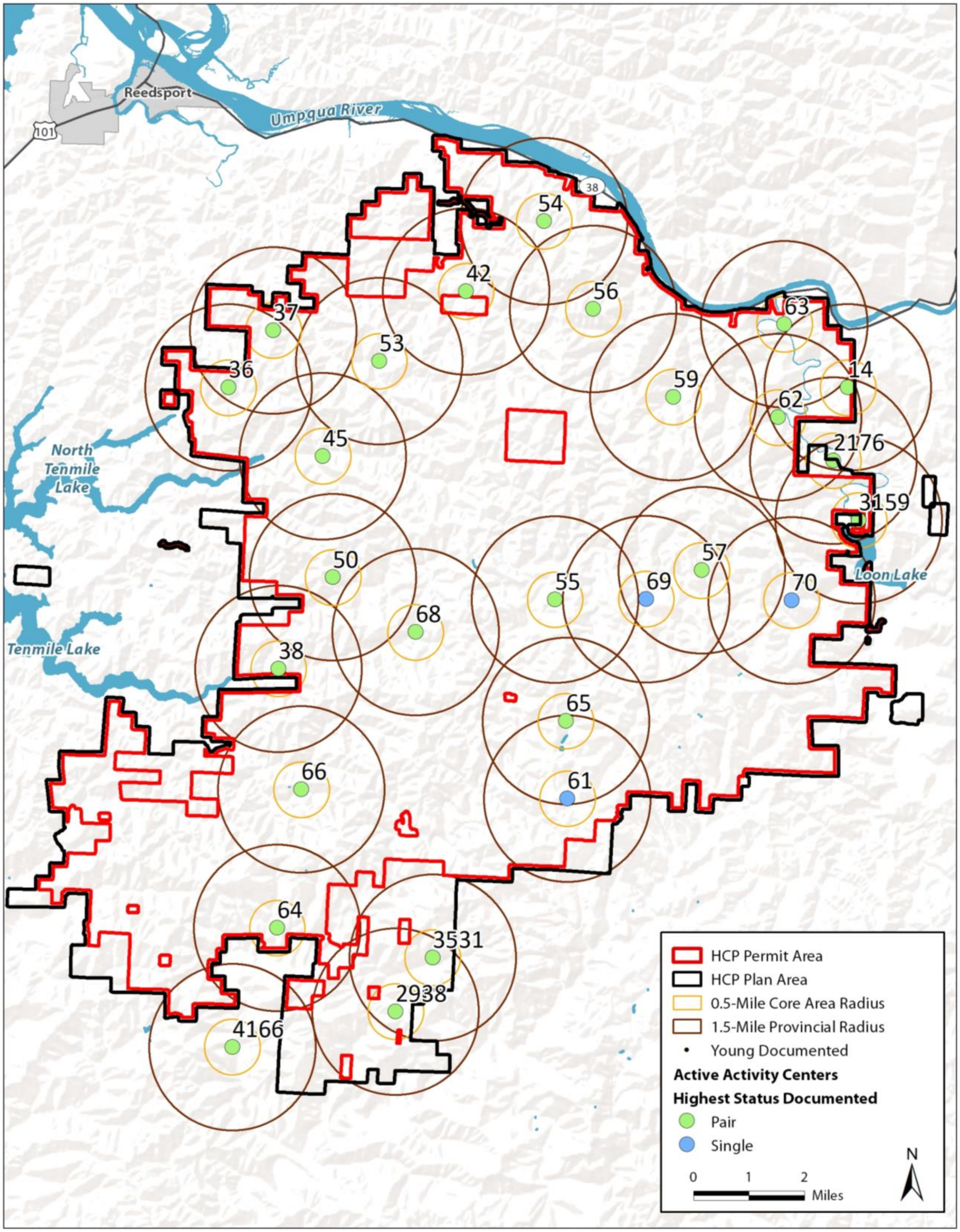


Figure 2-9. Active Northern Spotted Owl Activity Centers in and Adjacent to the Plan Area

Due to declining population trends and the continued expansion of barred owls, it is likely that some—if not most—of the activity centers listed in Table 2-5 are no longer occupied by reproductive pairs of northern spotted owls. However, the historic occupancy of these areas indicates that in addition to potentially harboring the remnant population of northern spotted owls within the permit area, they are provide some of the most likely locations for future reproductive pairs to become reestablished within the permit area.

In addition to occupancy surveys, the surveys included site visits to determine reproductive success. The cumulative results show that of 19 pair sites summarized above and in Table 2-5, 12 (63%) have been determined to have fledged young. No young or nesting attempts were found during the 2016 survey (Kingfisher Ecological, Inc. 2016).

Habitat in the Plan Area

Northern spotted owls in the central Oregon Coast Range prefer a mixture of older forests with younger forest and nonforested areas (Glenn et al. 2004; 77 FR 71875–72068). It may be that while large patches of older forest are needed to support northern spotted owls, home ranges composed predominantly of old forest may not be optimal for the owls in the Oregon Coast Ranges province (Courtney et al. 2004). Hardwood forest appears to provide some of the habitat attributes needed to sustain northern spotted owls in the plan area (Glenn et al. 2004). An analysis of habitat edge types showed that northern spotted owls also select the edge (or ecotone) between hardwood and conifer stands. This includes hardwood trees with relatively complex canopies, such as bigleaf maple and Oregon myrtle (*Umbellularia californica*). These results suggest that hardwood/conifer edge habitat may promote a healthy prey base or enhance access to prey (Anthony et al. 2000).

Tappeiner et al. (2000) found that nesting and foraging areas used by northern spotted owls in the Elliott State Forest have a greater abundance of large trees than do areas receiving little or no use by the owls. They also found that the number and size of snags is greater in nest areas than in forage and low-use areas in the Elliott State Forest. Within nest areas, nest trees tend to be larger than the mean tree and snag size. The results of this work indicate that initial stocking densities likely were low in some stands in the plan area. The investigators also noted that 10 to 15% of the plots where foraging occurred had been thinned 15 to 40 years prior to the study.

One indication of the potential availability of habitat for northern spotted owl is the federal designation of critical habitat. In 2012, USFWS designated 40,381 acres of the plan area (38,745 acres in permit area) as critical habitat for northern spotted owl (77 FR 71875–72068; Figure 2-10).

Using the habitat suitability model developed by Davis et al. (2016), approximately 26,600 acres of the plan area (32%) is rated as highly suitable northern spotted owl nesting and roosting habitat (Table 2-6). Combined with the approximately 8,544 acres (10%) of the plan area rated as suitable nesting and roosting habitat, up to 42% of the plan area is suitable habitat for northern spotted owl nesting and roosting. The model outputs mapped habitat within 30-meter square “pixels,” classified as highly suitable, suitable, marginal, or unsuitable habitat for nesting and roosting. This pixelated coverage adds a layer of potential inaccuracies in the model. The Davis et al. model is based on multiple sources of measurements from field plots, mapped environmental data, and Landsat imagery. It is intended for use in long-term regional habitat monitoring and is not an exact mapping of habitat. Rather, it provides a general indication of where habitat is most likely to be present, based on the most currently available published model outputs. Data sources included data from 1993 and 2012, so some inaccuracies are expected due to changed conditions on the ground, particularly timber harvest that has occurred since the baseline imagery was taken.

Table 2-6. Modeled Northern Spotted Owl Habitat in the Plan Area and Permit Area [a]

Modeled Value	Permit Area (acres)	%	Plan Area Outside of Permit Area (acres)	%	Total Plan Area (acres)	%
Highly Suitable	26,600	32%	1,946	21%	28,546	31%
Suitable	8,544	10%	807	9%	9,351	10%
Marginal	18,788	23%	2,993	33%	21,780	24%
Modeled Habitat (Highly Suitable + Suitable + Marginal)	53,932	65%	5,746	63%	59,677	64%
Unsuitable	29,231	35%	3,427	37%	32,657	35%
Total [b]	83,162	100%	9,172	100%	92,334	100%

Source: Based on Davis et al. 2016; see also Figure 2-11.

[a] For this assessment, areas rated and mapped as highly suitable and suitable by Davis et al. (2016) were considered suitable nesting and roosting habitat; areas rated and mapped as marginal were considered suitable foraging habitat; and areas rated and mapped as highly suitable, suitable, marginal, and unsuitable were are all considered suitable dispersal habitat. Numbers differ slightly from those presented in Chapter 4 due to some areas in the permit area being unallocated under Oregon State University's research proposal (Appendix C, *Proposal: Elliott State Research Forest*).

[b] Acreages do not match exactly with permit area and plan area acreages due to differences in how the models were calculated. All numbers are approximate but are of sufficient accuracy to provide context for overall habitat conditions in the permit area.

Table 2-6 and Figure 2-11 present the results of the Davis et al. (2016) model applied to the plan area. For the purposes of this HCP, all categories defined by Davis et al. are considered under the umbrella of "modeled habitat." This includes the previously termed "marginal" habitat, now recognized as contributing to the overall modeled habitat for northern spotted owl foraging. The "unsuitable" category in this model is also acknowledged as potentially serving dispersal functions for northern spotted owls; however, this is unlikely in stands under 40 years of age. While marginal habitat defined by Davis et al. contains smaller tree stands lacking the large dead or decaying trees needed for nesting, some stands may retain sufficient larger trees and forest structure for Davis et al. to consider such habitat potential nesting sites.

When using these rating frameworks to categorize habitat types and assess the value of habitat, it is important to acknowledge that northern spotted owls use a diverse range of habitats, and the value of a particular type of habitat for any specific pair or individual varies significantly with multiple site-specific factors that defy easy classification. Nonetheless, the method outlined above was employed to represent the best available and most accepted northern spotted owl habitat model into meaningful categories that account for varying habitat quality and value in the permit area.

Because of inherent uncertainty in the modeling data and habitat classification systems, it is best considered collectively with survey and site-level forest inventory data to determine habitat suitability and overall conservation value. As discussed in Chapter 4, *Effects Analysis*, much of the northern spotted owl habitat that will be subject to harvest under the HCP occurs in stands that are on average younger, smaller, and more fragmented (isolated) than the stands in reserves. Factors such as age, patch size, and connectivity have been incorporated in the impact of the taking analysis and determinations presented in Chapter 4.

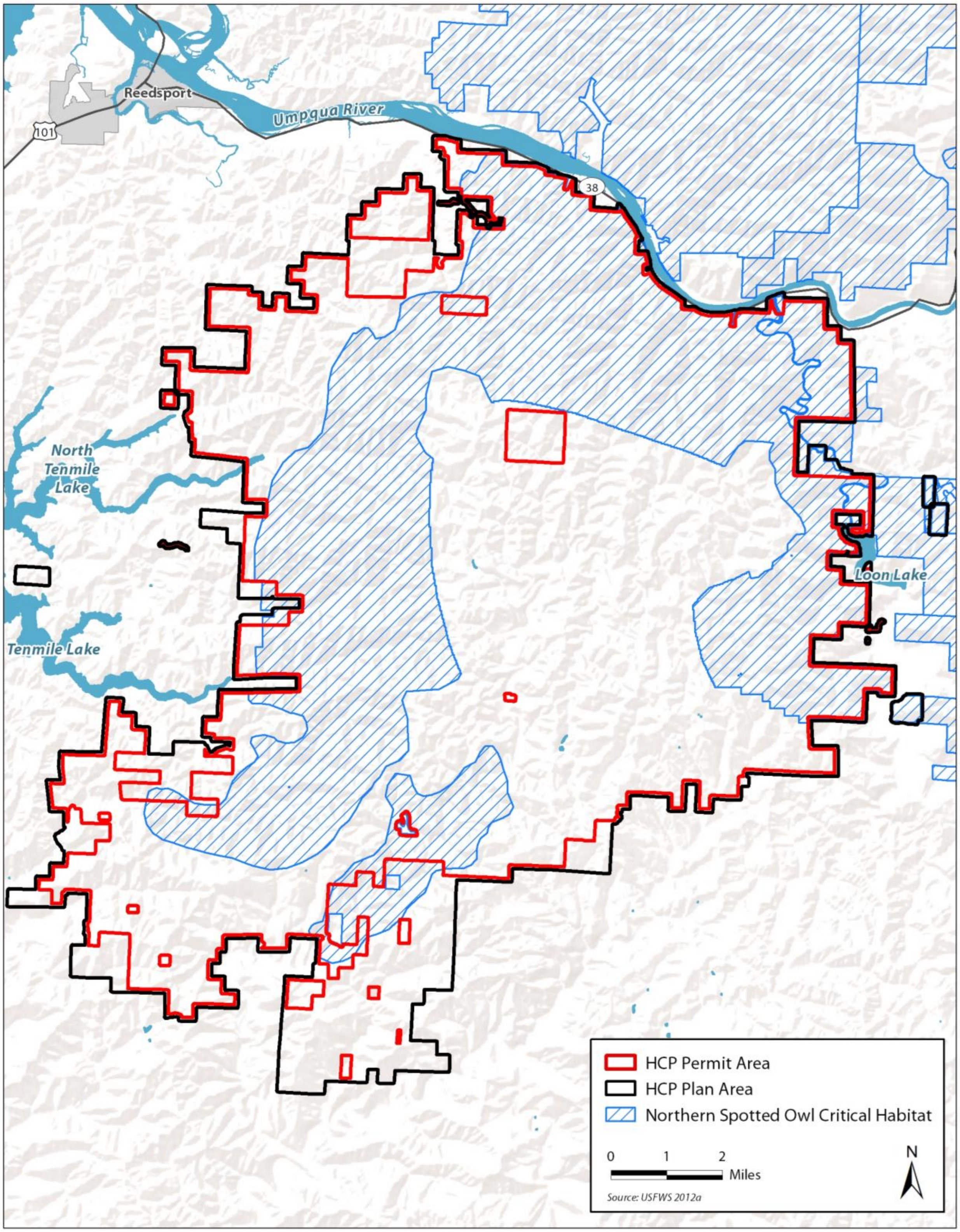


Figure 2-10. Northern Spotted Owl Critical Habitat in and Adjacent to the Plan Area

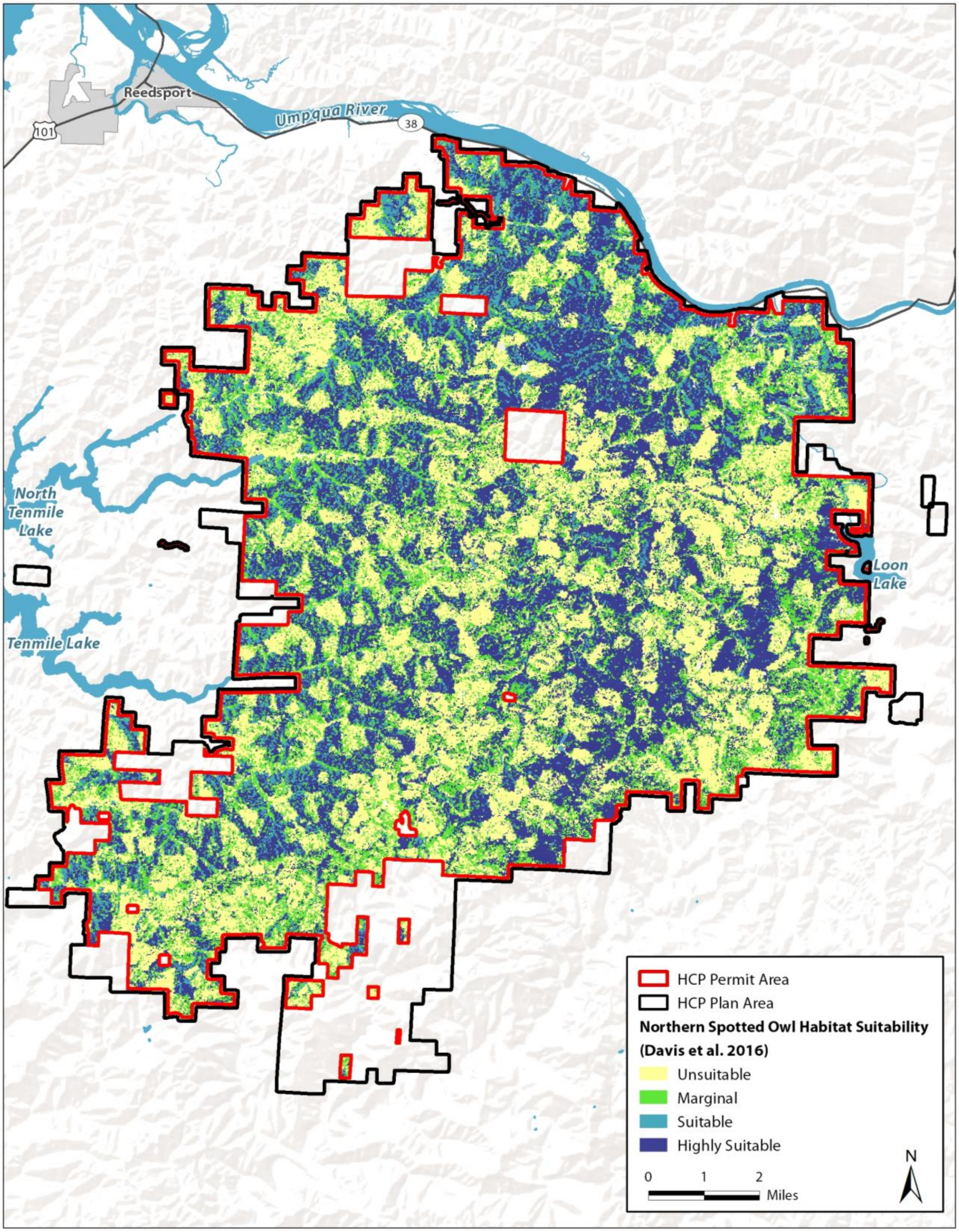


Figure 2-11. Northern Spotted Owl Habitat Suitability (Davis et al. 2016) in the Permit Area

2.4 Marbled Murrelet

USFWS listed the marbled murrelet as threatened on October 1, 1992 (57 FR 45328). A recovery plan was published in 1997 (U.S. Fish and Wildlife Service 1997). Critical habitat was designated in 2016 (81 FR 51348) and includes lands in the plan area. In 2021, the Oregon Fish and Wildlife Commission voted 4-3 to reclassify the marbled murrelet from Threatened to Endangered under the Oregon Endangered Species Act (Oregon ESA).

2.4.1 Biology and Ecology

This section provides a summary of key aspects of marbled murrelet biology and ecology, with an emphasis on inland (forest) habitat requirements. Additional information on the biology and ecology of marbled murrelet can be found in the Marbled Murrelet Recovery Plan (U.S. Fish and Wildlife Service 1997), the final rule for designation of critical habitat for marbled murrelet (U.S. Fish and Wildlife Service 2016), the Marbled Murrelet Technical Report prepared by ODFW (2019b), and the Biological Assessment prepared by ODFW to reevaluate the appropriate listing status for marbled murrelet under the Oregon ESA (Oregon Department of Fish and Wildlife 2021). A recent, comprehensive review of the scientific literature regarding marbled murrelet can be found in the 2018 Forest Service Science Synthesis Report (Raphael et al. 2018).

The marbled murrelet is a seabird that spends most of its life in nearshore marine waters but nests in mature and older forests up to 50 miles inland from marine waters (U.S. Fish and Wildlife Service 1997). Inland nesting habitat is, therefore, the primary focus of habitat management for this species in the plan area.

Marbled murrelets nest on platforms formed on large or deformed branches with moss covering. Platforms usually are found on mature or old trees greater than 30 inches dbh—in Oregon, usually Douglas-fir, western hemlock, or Sitka spruce.

In his review of existing literature, Burger (2002) noted that most nest trees were found to have 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) studied the characteristics of marbled murrelet nesting habitat on state lands, including 11 nests in the Elliott State Forest. This research confirmed that marbled murrelets select large conifer trees with numerous platforms for nesting. A key finding is that nests are predominantly found in trees more than 200 years old (two or three nests were found in 140- to 170-year-old trees).

Marbled murrelet nest sites are vulnerable to habitat fragmentation, with concern for hard edges created by clearcuts adjacent to nesting areas. 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 successional processes.

In addition to nesting in forests, marbled murrelets may use other forest types for courtship (Nelson 1997). Murrelets have been observed landing in young trees contiguous with or near suitable nesting habitat (Evans Mack et al. 2003). Such observed landings have included more than one murrelet landing in the same area at the same time. Such sites may be important habitat components for breeding, including pair bonding and nest site selection, and are considered occupied sites by USFWS.

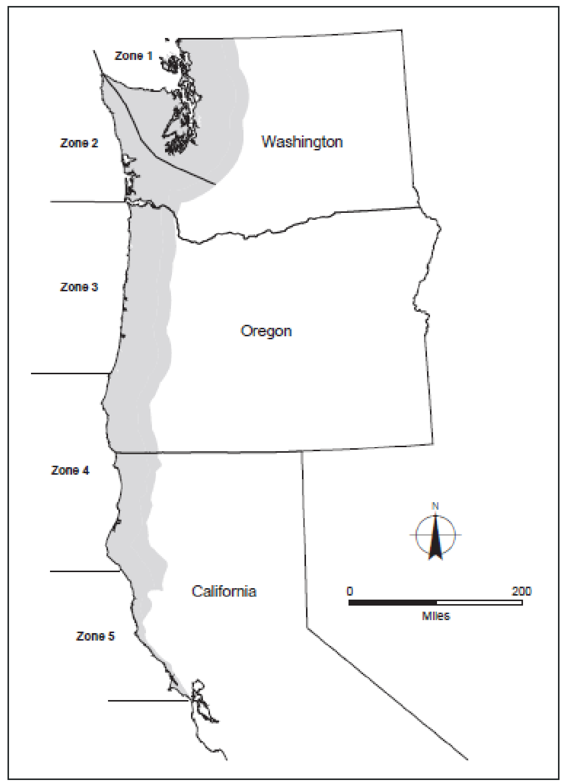
2.4.2 Population and Habitat Status

2.4.2.1 Rangewide Status

Populations

USFWS has designated six recovery zones for marbled murrelet, ranging from San Francisco Bay to the Canada border with Washington State (Figure 2-12). Falxa and Raphael (2016) reported marbled murrelet population estimates in five of these zones 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 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).



Source: Falxa and Raphael 2016.

Figure 2-12. Marbled Murrelet Recovery Zones

At the state scale, Falxa and Raphael (2016) found populations to be declining in Washington (4.6% decline per year), but no evidence of a trend in Oregon or California. A more recent report (McIver et al. 2021) found a steep negative trend in Washington but a slightly positive trend in Oregon.

Based on at-sea data, marbled murrelet populations in Oregon are highest near the Elliott State Forest and the Siuslaw National Forest, corresponding closely to the amount of habitat available inland from these at-sea foraging areas (McIver et al. 2024).

Habitat

Rangewide, the amount of murrelet nesting habitat has declined over time, but this trend has not been seen on U.S. Forest Service lands in the Oregon Coast Range province, where a net gain of about 1% was observed over a 20-year analysis (Falxa and Raphael 2016).

Current and historical loss of marbled murrelet nesting habitat is generally attributed to timber harvest and land conversion, although forest fires have also caused losses (Falxa and Raphael 2016). Timber harvest loss has been greatest on lower-elevation sites and throughout the Oregon Coast Ranges (Thomas et al. 1990). An analysis of 20 years of data consisting of 70,700 marbled murrelet surveys at 19,837 sites across the Oregon Coast Range indicates that landscapes that contained more old forest and were closer to the ocean showed reduced rates of local extinction (Betts et al. 2020a). A reduction in local murrelet colonization rates was also linked to years with warmer ocean conditions with low prey availability (Betts et al. 2020a).

As reported in the status review of the marbled murrelet in Oregon (Oregon Department of Fish and Wildlife 2018a), most remaining marbled murrelet nesting habitat in the state is on federal lands, including the Siuslaw and Rogue River-Siskiyou National Forests and land managed by BLM. The extent of suitable habitat on state lands is mostly restricted to the Elliott, Clatsop, and Tillamook State Forests. While private lands cover roughly 3.4 million acres of potential forest habitat within the range of the marbled murrelet in Oregon, less than 3% is thought to contain higher-suitability habitat.

2.4.2.2 Plan Area Status

Populations

The Elliott State Forest has a relatively large population of nesting marbled murrelets, and the area is considered important to the distribution of marbled murrelet on the Oregon Coast (U.S. Fish and Wildlife Service 1997).

ODF has conducted surveys within potentially suitable marbled murrelet habitat since at least 1992. Surveys were conducted primarily as part of operational planning for thinning and harvest units, following the standard USFWS-accepted survey protocol (Evans Mack et al. 2003). The survey data do not represent a complete inventory of the Elliott State Forest. In addition, very few nest sites have been monitored over time. Surveys typically were stopped in a marbled murrelet management area once sites were determined to be occupied. However, collectively, the data show that the Elliott State Forest contains a relatively high concentration of marbled murrelets, with 120 survey sites with significant observations (313 total observations, with multiple observations on some sites) indicating marbled murrelet likely nesting based on behavior (Figure 2-13).

Survey sites consist of a single fixed survey point from which observers seek to detect marbled murrelets either visually or audibly (Evans Mack et al. 2003). Survey sites are selected to cover all potentially suitable habitat within 0.25 mile of proposed activities (Evans Mack et al. 2003). Multiple surveys are conducted. Based on the defined station effective area, each survey station can cover approximately a 200-meter-radius (656-foot) circle (approximately 13 acres) under ideal circumstances. In practice, stations typically cover less area due to topography and other limitations. Of the 6,965 survey sites completed on the Elliott State Forest since 1992, no murrelets were detected in 79% of the survey sites (5,479), presence was detected in 17% of the sites (1,172), and significant observations indicating nesting were detected in 4% (313) of the survey sites.

The data include multiple surveys of the same stations, and multiple birds may be observed in a single visit. Therefore, the survey data do not represent a count of murrelets nesting on the Elliott State Forest, but rather a cumulative count of activity. In addition, it is possible that some locations, where occupancy was assumed in the past based on survey data, have since been harvested and no longer provide suitable habitat. Because murrelet surveys have not been systematically conducted across the plan area, all modeled habitat is considered for this HCP to be potentially occupied by nesting marbled murrelets.

In addition, Kim Nelson, Senior Faculty Research Assistant at OSU, has conducted surveys in the Elliott State Forest using similar protocols as those conducted by ODF biologists. Based on the ODF and Nelson survey efforts, 15,151 acres met the definition of occupied marbled murrelet habitat. There was overlap between the areas determined to be occupied by Kim Nelson and those determined to be occupied by ODF. Dr. Matt Betts and others at OSU combined Kim Nelson's data with other ODF data in a process described in Appendix 11 of the OSU proposal (Appendix C, *Proposal: Elliott State Research Forest*). The combined areas where marbled murrelet significant (below-canopy) behaviors were observed were categorized as a designated occupied data layer amounting to 21,475 acres in 2020.

In 2021, new LiDAR data became available that found that approximately 2,600 acres of the previously modeled occupied habitat had been intensively harvested at some time between 2009 and 2020 and should no longer be considered occupied. The revised areas were combined into an "occupied" data layer shown in Figure 2-13. This area is referred to as designated occupied marbled murrelet habitat throughout this HCP. This LiDAR interpretation identified another approximately 4,300 acres of older forest that should be included as modeled potential murrelet habitat, and this is discussed below.

Habitat

The most recent designation of marbled murrelet critical habitat by USFWS only included a few acres (<5) in the HCP plan area (U.S. Fish and Wildlife Service 2016). However, at the site-specific level of planning, such as this HCP, site-specific habitat conditions and survey results are the most important consideration when evaluating habitat values.

In 2020, Betts et al. (2020b) created an updated marbled murrelet habitat model, using a Maxtent modeling package that relies on positive occurrence data to train the model to find other similar habitat types within the modeled area, more accurately representing habitat based on actual use in the plan area. The availability of new 2021 LiDAR data further refined these efforts and, when combined with an improved Betts/Yang model (Betts and Yang unpublished data 2023), resulted in approximately 4,300 more acres of modeled potential murrelet habitat than believed to be in the permit area in 2021. Stringers and small patches/stands of older trees identified by the model as mid- to high-suitability habitat (typically riparian stringers through recently harvested areas), and that had little interior habitat, were determined to contain no interior habitat and were not included as modeled potential habitat. The amount of modeled habitat in the permit area is presented in Table 2-7. Figure 2-13 illustrates the spatial distribution of modeled habitat. The modeling data, as with all models, carry some uncertainty and are best considered collectively with survey and site-level forest inventory data to determine habitat suitability and overall conservation value.

Table 2-7. Designated Occupied and Modeled Potential Marbled Murrelet Habitat in the Permit Area

Habitat Type	Acres in Permit Area	Percent of Total Permit Area
Designated Occupied	18,855	23%
Modeled Potential	20,904	25%
Non-Habitat	43,569	52%
Total Permit Area [a]	83,326	100%

Source: Based on Betts and Yang unpublished data 2023.

[a] Acreages do not match exactly with permit area and plan area acreages due to differences in how the models were calculated. All numbers are approximate but are of sufficient accuracy to provide context for overall habitat conditions of the Elliott State Forest.

2.5 Coho Salmon

The Oregon Coast coho salmon (*Oncorhynchus kisutch*) 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 ESA; the Oregon Coast coho salmon ESU is currently listed as threatened. The National Marine Fisheries Service (NMFS) determined that the depressed status of the ESU is the result of habitat degradation, water diversions, harvest, and hatchery production. 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 NMFS found that risks posed by hatcheries and fisheries had been greatly remedied (Stout et al. 2012). A recent assessment of the vulnerability of ESA-listed salmonid species to climate change indicated that Oregon Coast coho salmon had high overall vulnerability, high biological sensitivity and climate exposure, but only moderate adaptive capacity (Crozier et al. 2019). Because young coho spend a full year in freshwater before ocean entry, the juvenile freshwater stage was considered to be highly vulnerable. The ESU also scored high in sensitivity at the marine stage due to expected changes due to ocean acidification. Overall, the Oregon Coast coho salmon ESU is at moderate to low risk of extinction, with viability largely unchanged from the prior status review (National Marine Fisheries Service 2022a).

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 habitat-related threats identified in the recovery plan are loss of habitat are loss of habitat, reduced habitat complexity, and degraded water quality. The recovery plan also expressed concerns that existing voluntary and regulatory mechanisms are inadequate to protect and recover Oregon Coast coho salmon (National Marine Fisheries Service 2016).

Critical habitat was designated for Oregon coast coho salmon on February 11, 2008 (National Marine Fisheries Service 2016). As part of this designation, spawning and juvenile rearing areas, juvenile migration corridors, areas for growth and development to adulthood, and adult migration corridors were identified as essential for conservation of the ESU. Critical habitat exists throughout the permit area and overlaps with Lower Umpqua, Coos, and Tenmile independent coho populations.

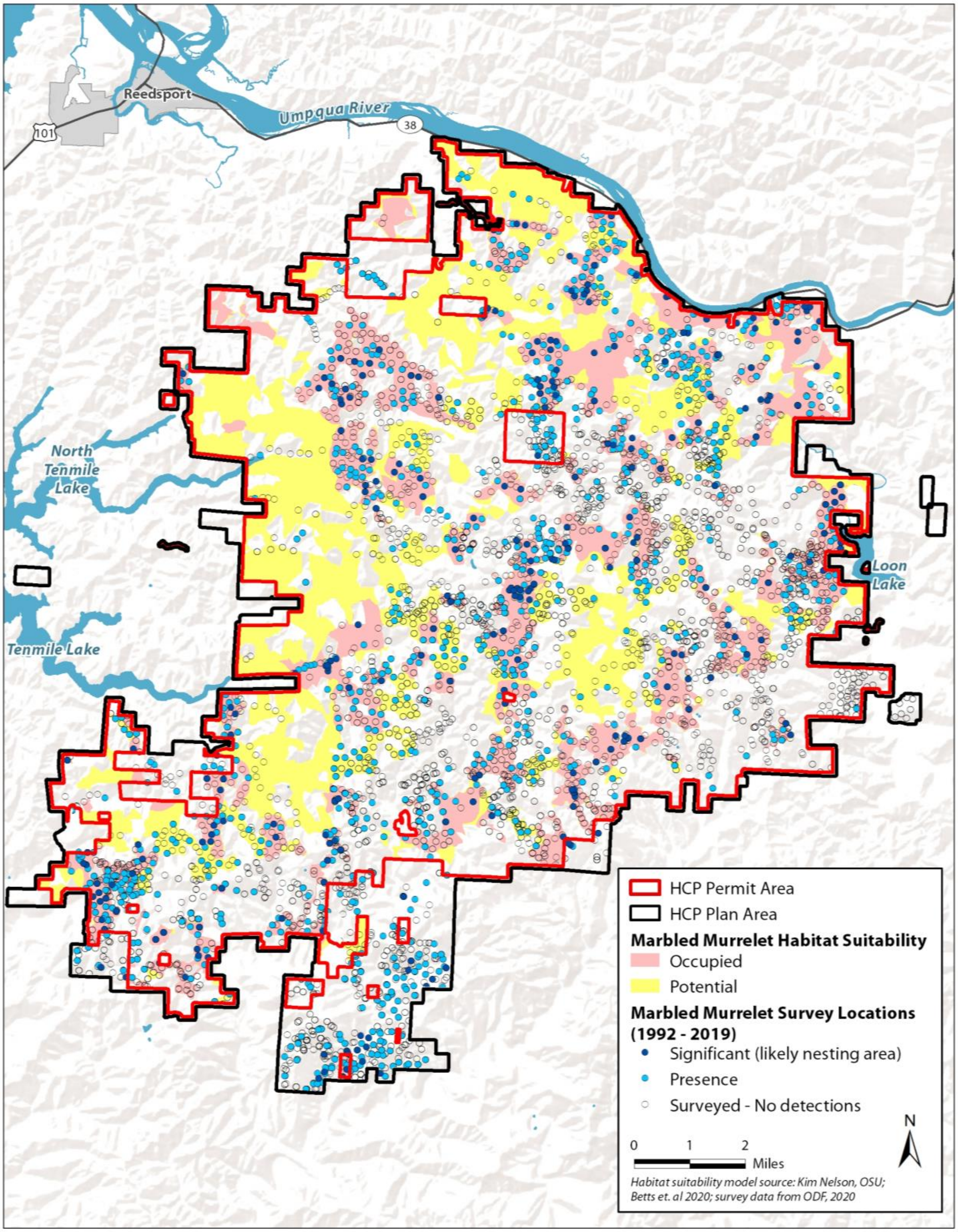


Figure 2-13. Marbled Murrelet Survey Results from 1994 to 2022 and Modeled Habitat in the Plan Area

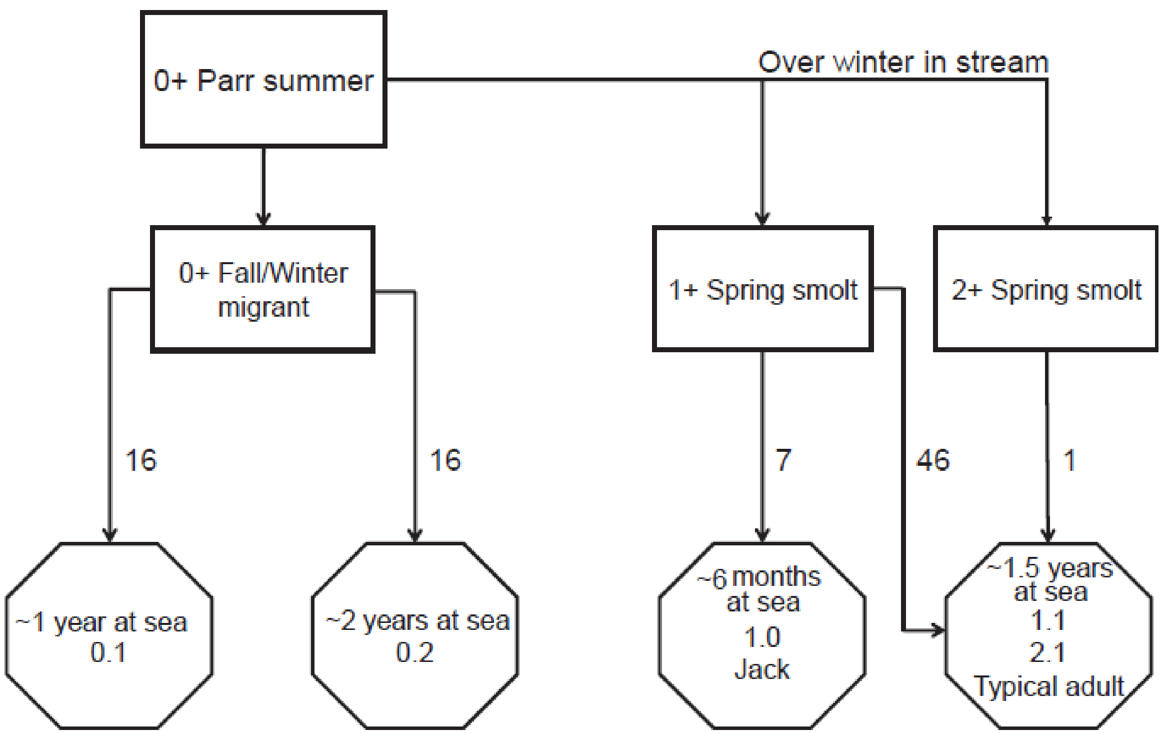
Note: As described in Appendix 11 of OSU's Research Proposal (Appendix C, *Proposal: Elliott State Research Forest*), historically occupied stands were determined based on marbled murrelet occupancy surveys conducted by S.K. Nelson and ODF. These values were then adjusted in 2023 using 2021 LiDAR data.

The Oregon State Coast Coho Conservation Plan (Oregon Coho Plan) was approved by the Oregon Fish and Wildlife Commission in 2007 (Oregon Department of Fish and Wildlife 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.

The Oregon Coho Plan describes the population status and conservation plan for 56 coho salmon populations in multiple Oregon Coast watersheds, including the following three watersheds that partially originate from the plan area: (1) Lower Umpqua, (2) Tenmile, and (3) Coos. Implementation of the Oregon Coho Plan has been monitored annually since its adoption and the first 12-year assessment was recently published (Oregon Department of Fish and Wildlife 2019a).

2.5.1 Freshwater Habitats

Coho salmon in North America inhabit small coastal streams as well as the largest rivers and are most abundant in coastal areas from Alaska to central Oregon. 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, low-gradient rivers and streams in lower-elevation areas (Behnke 2002; National Marine Fisheries Service 2016). Detailed descriptions of the species life history and habitat requirements can be found in Oregon Coast Coho Recovery Plan (National Marine Fisheries Service 2016). This section and Figure 2-14 provide a summary of their juvenile life history and freshwater rearing requirements.



Source: Bennett et al. 2015.

Figure 2-14. Coho Life History Pathways

Coho typically have a 3-year life cycle. During the freshwater life cycle in Oregon Coast streams adults spawn from November to January and eggs remain in spawning nests (redds) for 1.5 to 4 months, depending on water temperatures, before hatching. Juveniles spend 1 year in freshwater before migrating to sea in the spring. Studies have found evidence for multiple life history patterns for coho during freshwater residence that include the use of estuarine habitat or direct seaward migration by juvenile coho after only 6 months in freshwater (Figure 2-14). Koski (2009) reviewed several studies to better understand the role that these "nomadic" coho play in population resiliency and suggests that estuarine habitats may have a significant role in the recovery of depressed coho populations. For example, Miller and Sadro (2003) reported spring movement of juvenile coho to downstream estuarine habitats for a coastal Oregon stream, where most fry resided through the summer and returned upstream to freshwater to overwinter. Roni et al. (2012) reported juvenile coho 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). These studies demonstrate the importance of estuarine habitats in the growth and development of juvenile coho salmon. It is unclear what proportion of juvenile coho take advantage of estuary rearing in the permit area.

Throughout their freshwater residence juvenile coho salmon are strongly associated with slow water and areas with high channel complexity and physical cover (i.e., in-channel wood, vegetated banks, and side channels). Newly emergent coho 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 coho fry densities in calm backwater pools in small streams on the Oregon Coast.

The fall movement of coho fingerlings is variable across the stream network as they move to their preferred winter habitat, which includes deep pools with large wood and areas of low water velocity. Movement to these nearby habitats is thought to be opportunistic based on both the fishes' perceptual range[6] and/or the onset of fall rains. If overwinter habitat is not available nearby, fish may be passively transported downstream with the current (Hance et al. 2016), causing mortality due to displacement from appropriate habitats (Wainwright and Weitkamp 2013). These overwinter habitats provide low-velocity areas that are slightly warmer than the main channel and support accelerated growth of juvenile coho (Reeves et al. 2011). Ebersole et al. (2006) found that maintaining connectivity between mainstem and tributary habitats provides a range of rearing habitats, which increases survival and productivity. Flitcroft et al. (2012) further supports the importance of connectivity by showing juvenile density is higher in subbasins where seasonal habitats are close to each other. However, given the steep topography of the permit area, the availability of off-channel rearing habitats that are not in the main channel is limited.

During the summer, juvenile coho reside in a wide variety of stream types and sizes, including connected lakes where present (i.e., Tenmile Lake). The highest densities are found in natal streams, although a higher proportion of fry move from higher-gradient streams (Lestelle et al. 1993) to calm, low-velocity habitats. Juvenile coho are more closely associated with the shoreline or dense cover of woody debris than other salmonids. Juvenile coho are most often found in pools (Nickelson et al. 1992). In addition, density can be strongly affected by stream productivity (i.e., amount of food available, water temperature) (Mason 1976; Ptolemy 1993; Ward et al. 2003). More productive streams tend to support higher densities of juvenile salmon.

[6] Perceptual range is the ability to sense the presence of a tributary using olfactory, temperature, or velocity gradients.

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 severely affect survival and limit population abundance. For example, May and Lee (2004) reported a correlation between available salmon rearing habitat during the dry season, in-channel sediment storage between three pool types, and coho survival. Their results indicate that fish density in remnant pools was higher in gravel bed pools and gravel pools with bedrock contact than in bedrock pool types, which created substantial juvenile coho crowding conditions. This translated to much higher summer fish mortality and desiccation in gravel bed pool types due to reduced pool depths. May and Lee (2004) determined the factors influencing water availability in these remnant pools are gravel depth, bedrock topography, and subsurface flow paths through fractured bedrock. Pool-drying effects in different channel morphologies are an important indicator of juvenile coho salmon production in the summer dry season and are an additional mechanism to understand the implications of coho survival beyond overwintering conditions. The effect of summer low flow habitat on survival and freshwater smolt abundance may become increasingly important in a warming, drying climate to the point that the quantity of favorable overwinter habitat may no longer limit coho salmon production.

However, overwinter survival of juvenile coho is a major factor found to influence coho abundance in Oregon Coast streams. Limited overwinter habitat has been shown to create a population bottleneck during coho freshwater residence (Solazzi et al. 2000). Solazzi et al. (2000) reported a substantial increase in coho smolt abundance following habitat modifications to increase the quantity of winter rearing habitat for coho. 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. Moyle (2002) suggests that the availability of overwintering habitat is one of the most important factors influencing the survival of juvenile coho in streams. Improvements to overwintering habitat in locations with good connectivity to all life history requirements has been found to have a greater benefit to coho than a reach-focused approach that does not account for surrounding habitat availability (Flitcroft et al. 2012).

2.5.1.1 Large Wood in Streams

Large wood promotes instream channel complexity by facilitating the creation of vital hydrologic features including pools, gravel bars, and off-channel areas like side channels and backwaters, all of which provide essential habitats for coho salmon. Large wood is especially important for the formation of pool habitats. For example, Reeves et al. (2016) found that large wood formed roughly 65% of pool habitat in a study on an Oregon Coast stream. Large woody material also influences the storage and movement of sediments through the aquatic environment. Hydrologic features created by large wood increase the capacity of a stream or river to store fine sediments and gravels by slowing bedload movement and promoting deposition across the floodplain. Tree roots and large wood can also improve streambank stability by slowing water velocity, reducing or preventing channelization and bed and bank scour. Moreover, the presence of instream wood has been shown to improve habitat conditions for coho salmon by stabilizing streambed substrate and reducing velocities (Bair et al. 2019) and creating important summer and winter rearing habitats. Large wood creates refuge areas where coho can avoid predators and warm temperatures during the summer. Similarly, pools with large wood have been shown to be important refuge habitat for juvenile salmonids during the winter when high flows and flooding occurs (Bustard and Naver 1975). Studies have also consistently found that higher densities of large wood lead to improved habitat complexity and higher densities of rearing salmonids. For example, Jones et al. (2014) found coho salmon rearing densities increased by 32% 6 years following large wood augmentation in western Oregon streams. Finally, juvenile salmonids residing in areas with abundant and complex large wood features have been observed moving shorter distances and less frequently than those residing in wood-deprived areas (Roni and Quinn 2001). Higher densities of large wood increase habitat complexity, improve channel stability, increase nutrient input, and increase aquatic invertebrate habitat, meaning rearing juveniles do not need to migrate to locate food or refuge when large wood is abundant.

The presence of wood in streams is loosely correlated to the number of coho. Wood may have a more important role in pool formation and the quantity of pool habitat favorable for coho and 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). Peters found that juvenile coho 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.

2.5.1.2 Beaver-Created Habitats

Beavers are often referred to as “engineers” because they physically modify stream environments by building dams, lodges, and canals (Naiman et al. 1986). These structures transform hydrologic, geomorphic, and ecological processes (Nash et al. 2021) and significantly influence stream- and riparian-dependent species. Beaver-created habitat such as ponds provide important rearing habitat for juvenile coho. Widespread commercial trapping in the 19th century resulted in dramatic declines in the beaver population throughout North America, from estimates as high as 400 million to approximately 1.1 million by the mid-20th century (Seton 1929; Denney 1952). Today, beaver populations have rebounded to an estimated 10 to 50 million animals. In the Coast Range, most population estimates are based on historic translocations and trapping counts, but the state does not census beaver and no estimate of current populations is available (Baldwin 2017). Re-establishment of beavers through translocation has historically occurred in Oregon. Between 1939 and 1951, 732 beavers were translocated into the Coast Range as part of a program intended to provide optimal distribution across the state (Hiller 2011). It is unknown whether those beaver founded successful populations, were displaced or interbred with resident beaver, or were excluded by resident beaver. During the 2010–2011 trapping season, a minimum estimate of 3,200 beavers were harvested, with 85% occurring west of the Cascade crest (Hiller 2011). More recent data from the 2016 Oregon furtaker annual report estimate 1,268 beavers across the state were taken (Oregon Department of Fish and Wildlife 2018b). Estimates specific to the permit area are not available.

Beavers can strongly influence salmon populations in large alluvial rivers by building dams in off-channel areas that create pond complexes (Malison et al. 2016). Pollock et al. (2004) found that smolt production increases significantly in systems where beavers are present. Habitat created by beavers is especially important for juvenile summer rearing and overwintering periods due to its low velocity, variable depths, complexity, and cover (Pollock et al. 2015). Studies have demonstrated increased juvenile coho salmon rearing densities and growth (Bustard and Naver 1975; Murphy et al. 1989; Pollock et al. 2004; Malison et al. 2016), increased survival (Quinn and Peterson 1996), and increased production (Nickelson et al. 1992; Bouwes et al. 2016) associated with beaver ponds. In coastal Oregon streams, reaches with beaver ponds and alcoves account for 9% of all salmonid habitat, but were found to support 88% of the coho salmon in the system (Nickelson et al. 1992).

Contemporary stream restoration practices rely on large wood to create salmon-rearing habitat. A more cost-effective measure to create the same types of pool habitat required by juvenile coho may be to introduce or promote new or existing populations of beaver (Pollock et al. 2004). However, the survival of translocated beavers is typically less than 50%, with 35 to 57% of predator-related mortality occurring within the first week after release (Petro et al. 2015). Additionally, not all surviving beavers build dams, and many dams do not persist through high winter discharges (Petro et al. 2015). Other beaver-related restoration tactics beyond beaver translocation include the use of artificial structures and riparian vegetation restoration (Nash et al. 2021). Beaver-related restoration is likely to be most successful in landscapes where human objectives align with beavers' survival needs. However, this may not always be the case when beavers do not need dams for their survival or to maintain healthy populations in streams where conditions remain undesirable to human objectives (Nash et al. 2021). Where beaver needs do align with restoration objectives, increasing the number of beaver dams in key areas could create high-quality winter rearing habitat that promotes stream complexity and increases smolt capacity (Oregon Department of Fish and Wildlife 2007). Beaver ponds can also improve habitat quality for salmon by reducing average water temperatures in streams via the creation of deep pools. Deep-pool habitats have greater thermal stratification in the water column than shallow water habitat (Castro et al. 2017), giving fish a wider temperature range to inhabit. The increased water volume in beaver ponds also regulates and maintains cooler water temperatures during the summer by reducing the impact of temperature fluctuations in streams. However, at least one study (Stevenson et al. 2022) found some beaver dams may have increased warming and lower dissolved oxygen with negative effects on coho.

2.5.1.3 Water Temperature

Lestelle (2007) summarized several studies on effects of water temperature on juvenile coho. A study of the Mattole River (Northern California) reported coho were not found in streams warmer than a maximum weekly temperature of 18°C (Welsh et al. 2001). 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). As noted in Stenhouse et al. (2012) optimal temperature ranges for salmonids, including coho, ranged between 10°C and 16°C. Temperatures exceeding 16°C generally result in numerous compensatory behavioral and physiological responses to mitigate the thermal stressors (Stenhouse et al. 2012). Temperatures above 21°C are generally accepted as detrimental and studies have documented depressed feeding rates at these conditions (Stenhouse et al. 2012; Richter and Kolmes 2005).

Juvenile coho may seek sites of thermal refuge to avoid warm water temperatures (National Marine Fisheries Service 2016). These sites may be at the confluence of cool-water tributaries entering a stream, springs, or side channels, or at smaller scales of thermally stratified pools (Torgerson et al. 2012). 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.

While maintaining hospitable stream temperatures is important for coho, thermal variability within a reach may not be as important as once thought for juvenile production where temperatures are unlikely to exceed growth optima. Campbell et al. (2020) found that juvenile growth in the Copper River Delta of south-central Alaska is similar between colder groundwater-fed streams and warmer surface-water streams. This is likely attributed to increased productivity of macroinvertebrates in groundwater streams that provides a larger prey base with higher nutritional and energetic quality compared to what is available in warmer surface-water streams (Campbell et al. 2020), but could also be attributed to local adaptation.

2.5.1.4 Sediment

Salmonids have evolved adaptations to natural disturbances characteristic of watersheds in the Pacific Northwest, including landslides, debris flows, floods, wildfires, and others. Sediment delivered by landslides and associated debris flows can create pools and provide gravel usable for spawning but can also adversely affect fish habitat and macroinvertebrates if the frequency and magnitude of inputs are too high or large wood delivery is low (Hartman et al. 1996; Jensen et al. 2009; Kobayashi et al. 2010). The topography within the permit area is steep with a large proportion of slopes greater than 65% (Figure 2-15). This suggests that sediment delivery to streams in the permit area is high, particularly in the northeast area near the Umpqua River. However, bedrock is the dominant substrate for much of the permit area stream network, indicative of insufficient sediment storage, possibly due to the lack of large in-channel wood. Additionally, given the underlying sandstone geology, gravel-sized substrates are limited (Fratkin et al. 2020). Therefore, the lack of gravels in the permit area is due to a limited supply and insufficient storage features. Consistent delivery of coarse sediments (gravels, cobbles, and boulders) is important for maintaining complex habitats for rearing juvenile coho and for spawning adults. High concentrations of fine sediments (silt or sand) can degrade water quality and habitat conditions by filling in the interstitial spaces between gravels and cobbles, reducing spawning habitat quality. Additionally, high concentrations of suspended sediments or accumulated sediments on the stream bottom can reduce survival and growth of rearing juveniles (Newcombe and Jensen 1996). Araujo et al. (2015) demonstrated that the abundance of a coho salmon population may decrease with forestry-associated increases of fine sediment. Johnson and Big Creeks in the Tenmile independent coho populations are 303(d) listed by DEQ for dissolved oxygen and sedimentation.

2.5.2 Population and Habitat Status

2.5.2.1 Rangewide Status

Botkin et al. (1995) estimated that coho has been extirpated from approximately 46% of its historic range in North America and 3.5% of its original range in western Oregon and Northern California. In western Oregon and northern California, extinctions have mostly occurred in populations that spawned in areas inland from the coast and coastal mountain range (Botkin et al. 1995). Meengs and Lackey (2005) estimated that the abundance of coho salmon from the 1990s to the early 2000s were between 3 and 19% of the estimated historical size (early 1800s and 1900s). However, there is uncertainty among scientists on the magnitude of decline across Oregon and California populations (Cramer and Caldwell 2020).

Since 1994, coho salmon spawner abundance to streams within the Oregon Coast coho ESU has ranged from 23,661 to 359,692 coho salmon (Oregon Department of Fish and Wildlife n.d.). Abundance during the early period was low, averaging 52,240 fish from 1994 to 2000. Coho spawner abundance increased considerably from 2001 to 2014, due mostly to improved marine survival, combined with substantially reduced harvest on returning adults (National Marine Fisheries Service 2022a; Ford 2022). Since 2001, the number of adult coho spawners averaged 177,920 fish.

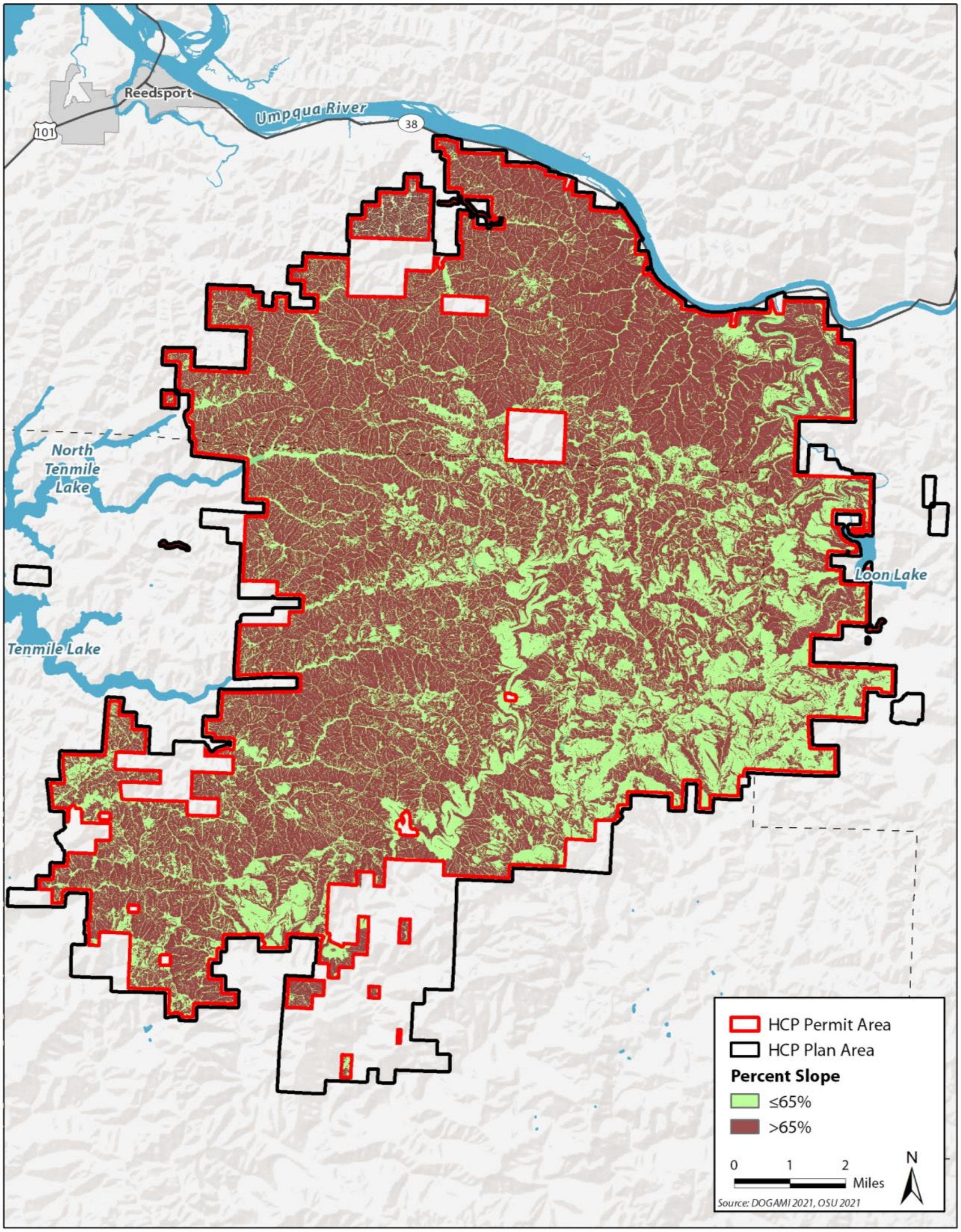
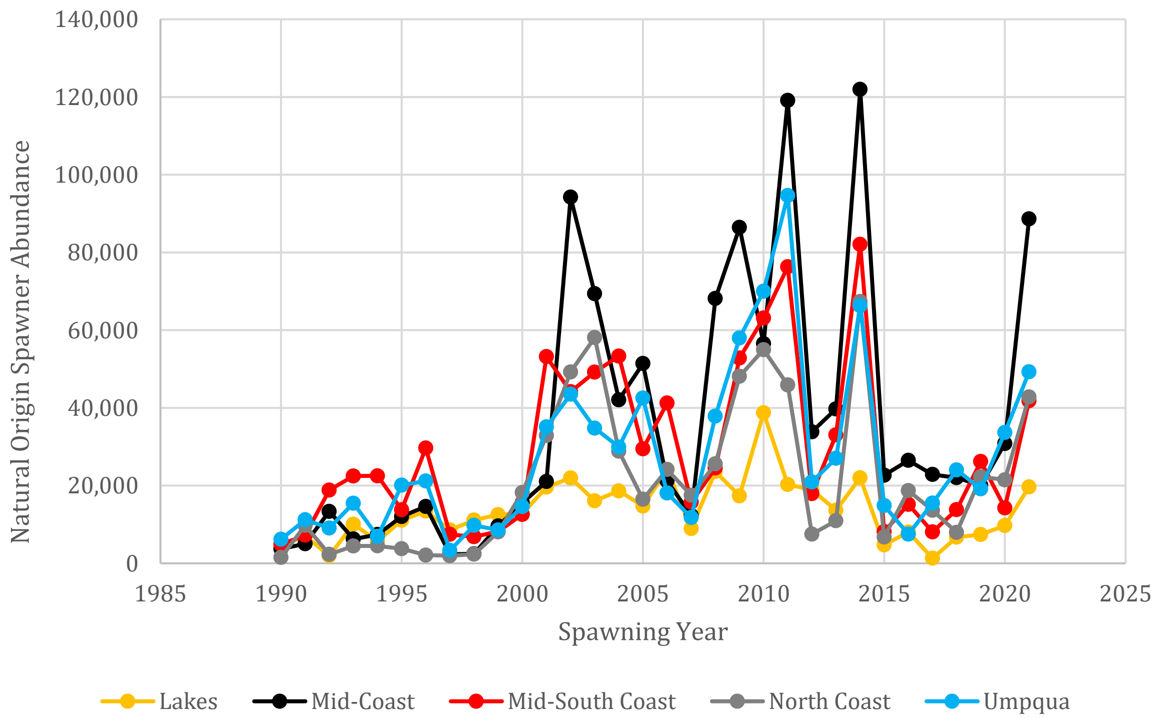


Figure 2-15. Hillslopes Greater than 65 Percent and Less than or Equal to 65 Percent in the Permit Area

Abundance has declined since 2015; from 2015 to 2017 the number of coho salmon spawners across the ESU has been less than 100,000 fish (56,000 fish in 2015). This decline is likely because of low ocean survival and possibly freshwater conditions during egg incubation and juvenile residence (National Marine Fisheries Service 2016; Ford 2022). From 2017 to 2021, improvements to coho salmon abundance have occurred for the entire Oregon Coast coho ESU, consistent with the 12-year assessment of the Oregon Coho Plan and the Ford (2022) assessment (Oregon Department of Fish and Wildlife 2019a; Figure 2-16), although Ford's evaluation found recent declines in spawner abundance between 2015 and 2019. These assessments also note the strong influence that ocean conditions play on adult returns to the ESU, including recent low abundances associated with strong marine heatwaves.



Source: Oregon Department of Fish and Wildlife n.d.

Figure 2-16. Trends in Abundance of Adult Spawning Coho Salmon from 1990 to 2021

Habitat trends analysis conducted by ODFW for the ESU's stratums concluded that the ESU's streams are generally pool rich but structurally simple, there are few off-channel subunit habitats such as alcoves or beaver pools, and most streams have low volumes of wood and high fine sediment concentrations in riffle habitat (Oregon Department of Fish and Wildlife 2019a). Primary limiting factors of concern across the ESU are the loss of stream complexity, including lack of large wood debris and disconnected floodplains affecting juvenile survival, with special concern for overwinter habitat for juvenile coho (National Marine Fisheries Service 2016, 2022a). Also of concern are issues of degraded water quality and high water temperatures (Section 2.1.6.1, *Stream Use and Water Quality*) at specific locations and fish passage barriers limiting access to freshwater and estuarine habitats (National Marine Fisheries Service 2022a).

Given the ongoing habitat concern regarding lack of fish passage and access for all populations in the ESU (National Marine Fisheries Service 2022a), an evaluation of fish passage barriers is necessary to understand the status of coho salmon in the permit area. There are currently 5 impassable fish barriers and 17 partial barriers identified in the permit area, with most of the barriers overlapping the Coos independent population (Oregon Department of Fish and Wildlife 2019c; Table 2-8; Figure 2-17). Additionally, approximately 16 miles of additional modeled fish habitat is available in the permit area upstream of impassable culverts (Table 2-9). The conservation actions to improve fish passage in the permit area are described in Chapter 5, *Conservation Strategy*.

Table 2-8. Fish Passage Barriers in the Permit Area by Independent Population

Independent Populations	Bridges	Culvert					Other			Total
		Blocked	Partial	Passable	Unknown Anadromous	Total	Blocked	Partial	Total	
Coos	11	2	0	2	1	5	2	9	11	27
Lower Umpqua	3	1	2	1	1	5	0	1	1	9
Tenmile	0	0	0	0	0	0	0	5	5	5
Total	14	3	2	3	2	10	2	15	17	41

Source: Oregon Department of Fish and Wildlife 2019c.

Table 2-9. Total Miles of Modeled Fish Habitat Located Upstream of Barriers within the Three Independent Coho Population Watersheds

Independent Populations	Culverts			Other		Total
	Blocked	Partial	Unknown Anadromous	Blocked	Partial	
Coos	0.47	0.00	0.98	1.56	2.37	5.37
Lower Umpqua	1.30	3.38	0.72	0.00	1.81	7.21
Tenmile	0.00	0.00	0.00	0.00	3.31	3.31
Total	1.77	3.38	1.70	1.56	7.49	15.89

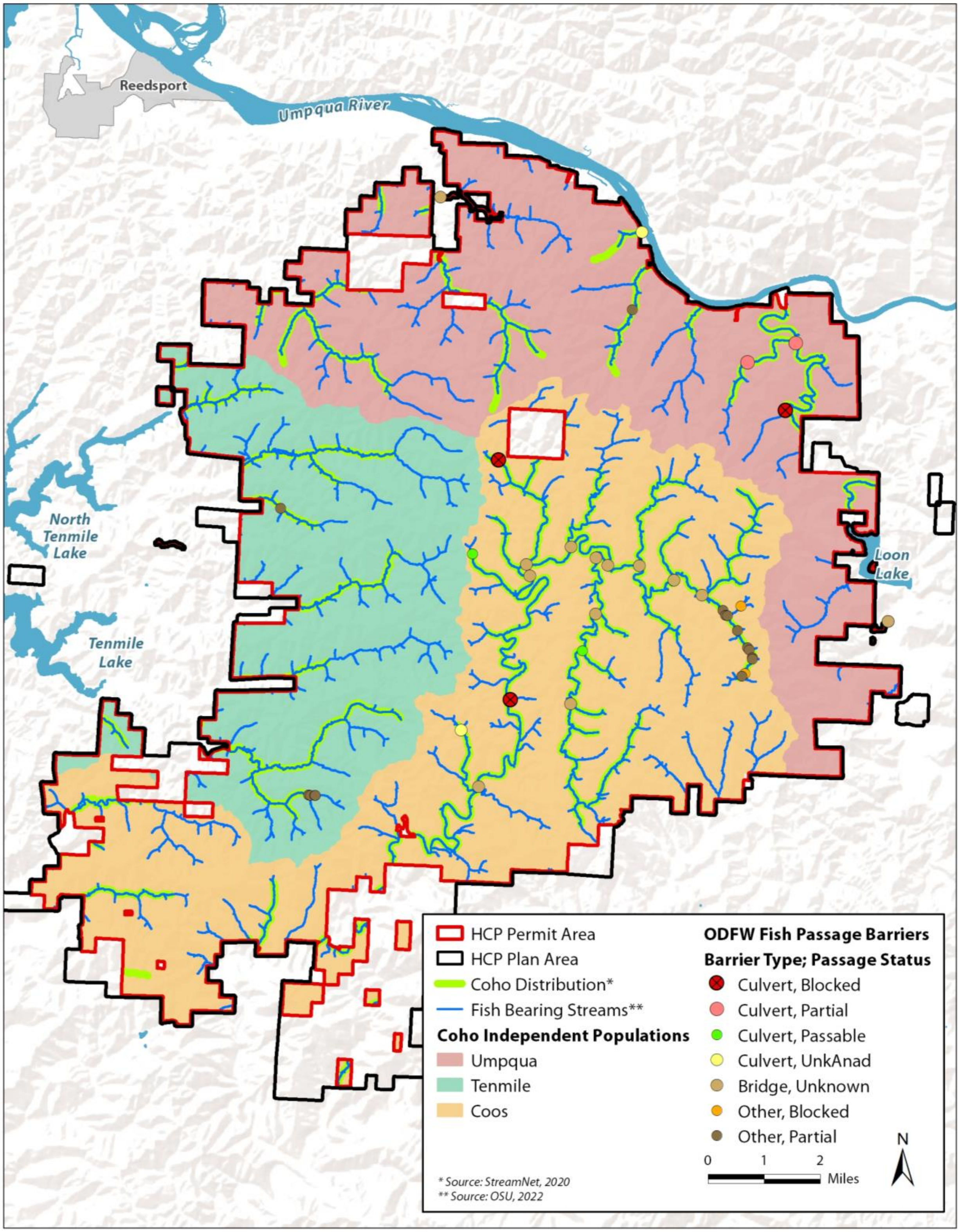


Figure 2-17. Fish Passage Barriers in the Permit Area

2.5.2.2 Independent Populations in the Permit Area

The permit area includes portions of three coho strata within the Oregon Coast coho ESU: Lakes, Umpqua, and Mid-South Coast (Figure 2-18). Miles of streams with ODFW documented or assumed coho salmon presence in the permit area, by independent population, are summarized in Table 2-10. Lewis (2020) calculated population scores for all five stratums within the Oregon Coast coho ESU using the Decision Support System to evaluate current levels of ESU persistence and sustainability. Each stratum was evaluated based on several criteria, including distribution, abundance, and productivity and population sustainability scores. For the three strata reviewed in the permit area (Lakes, Mid-South Coast, and Umpqua), population sustainability scores were highest in the Tenmile, Lower Umpqua and Coos populations across all independent populations (Lewis 2020; Ford 2022).

The condition of each stratum, as it relates to the overall recovery of the ESU, is described below.

- The Lakes stratum consists of three independent coho populations. The Tenmile population is the only population in this stratum that includes portions of the permit area. Approximately 17 stream miles are in the permit area in the Tenmile population (Big Creek, Benson Roberts, and Johnson Creek management basins). The Tenmile Lake systems provide a unique winter rearing habitat and are one of the most productive complexes on the Oregon Coast (National Marine Fisheries Service 2016). The permit area encompasses approximately 19% of the range of the Tenmile population (Table 2-10), contributing coho from the permit area to the overall Tenmile population important for the persistence of this population.
- The Umpqua stratum is a large basin that extends into the Cascade Range and consists of four independent coho populations organized from the Lower Umpqua to the upper watershed and the forks of the Umpqua. The Lower Umpqua population is the only population within this stratum that includes portions of the permit area. Approximately 22 stream miles are in the permit area in the Lower Umpqua population (Mill Creek, Charlotte Luder, Dean Johanneson, and Schofield Creek management basins). While the contribution of coho from the permit area to the Lower Umpqua population is relatively small (4%; Table 2-10), production of coho in the permit area will benefit the Lower Umpqua population and overall ESU.
- The Mid-South Coast stratum consists of four independent coho populations. The Coos population is the only population within this stratum that includes portions of the permit area. Approximately 54 stream miles are in the permit area in the Coos population (Palouse Larson, Henry's Bend, Marlow Glenn, Millicoma Elk, and Trout Deer management basins). The permit area represents approximately 11% of the range of the Coos independent population; production of coho in the permit area will benefit the Coos population and overall ESU.

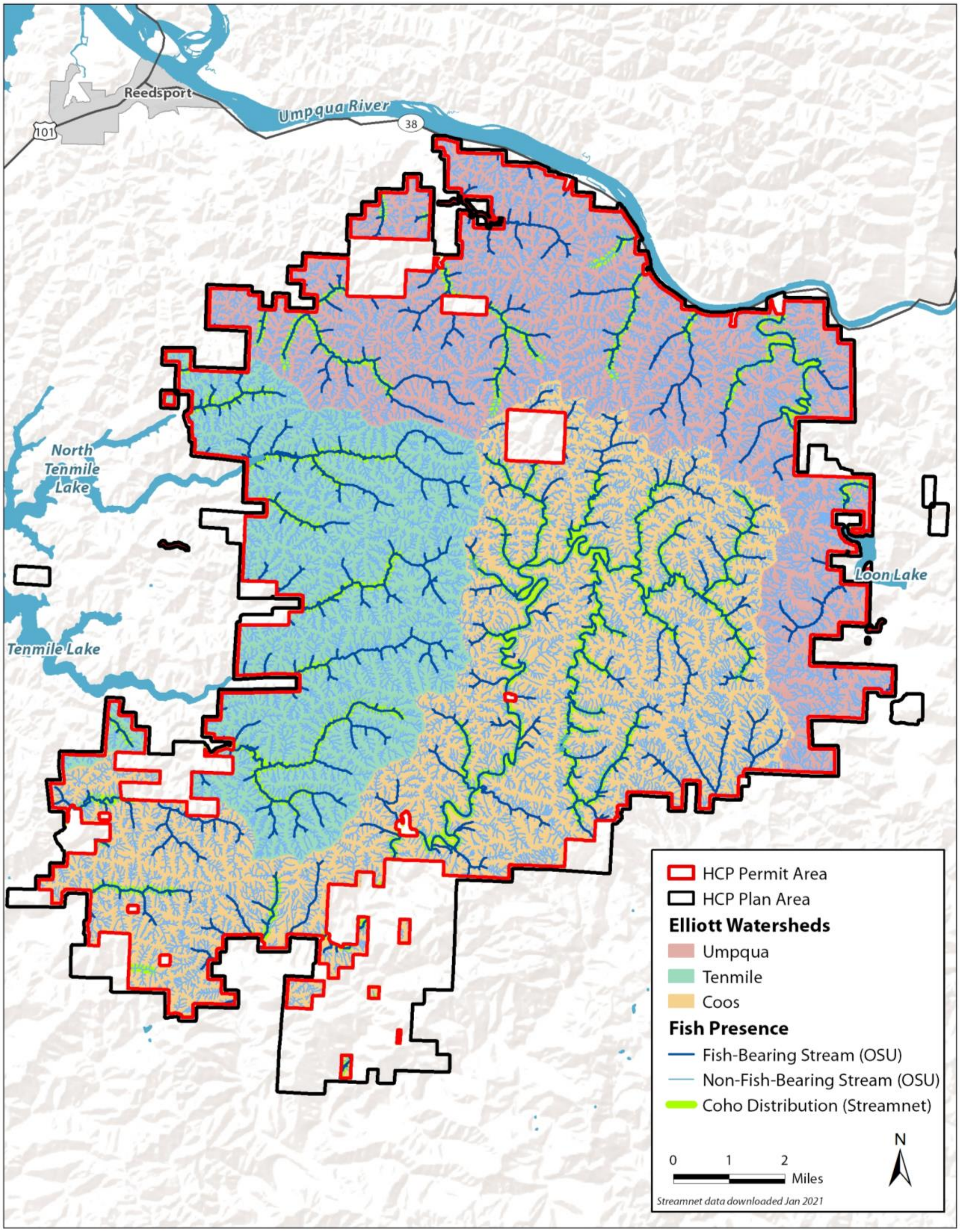


Figure 2-18. Coho Distribution in the Permit Area

Table 2-10. Miles of Coho Salmon Known or Presumed Coho Salmon Presence in the Permit Area

	Stream Miles with Known or Presumed Coho Salmon Presence		
Biogeographic Stratum and Population	**Total Stream Miles in Independent Population**	**Miles in Permit Area**	**Percent of Total Independent Population Stream Miles in Permit Area**
Lakes Stratum			
Tenmile Lake	90	17	19%
Umpqua Stratum			
Lower Umpqua River	618	22	4%
Mid-South Coast Stratum			
Coos River	489	56	11%
Total	1,196	95	8%

Source: Oregon Department of Fish and Wildlife 2019c.

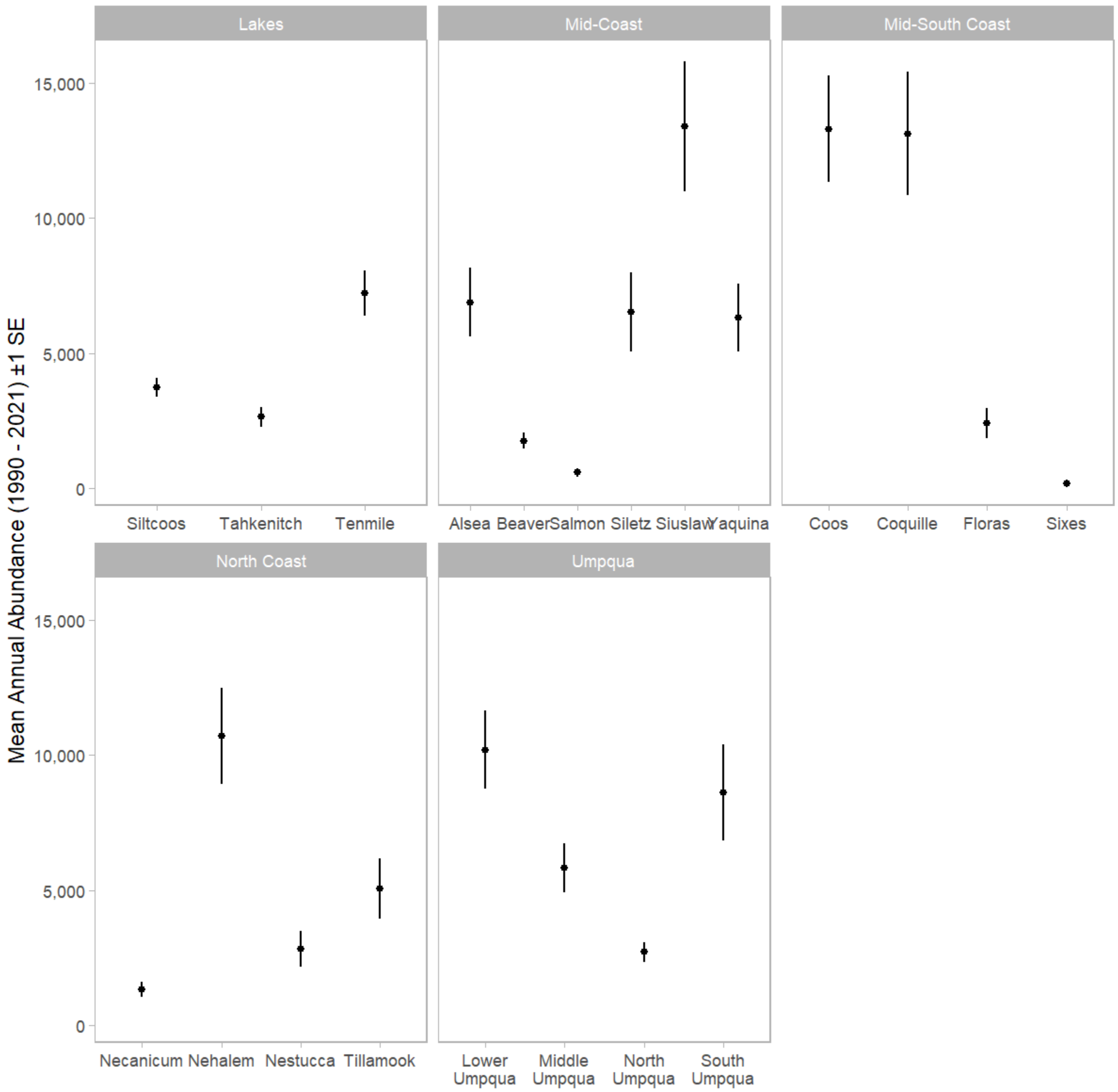
2.5.2.3 Contributions of the Permit Area

The three independent populations associated with the permit area have ranged from 1 to 21% of the total ESU spawner abundance by population. Combined, the three populations have ranged from 14 to 44% of the total ESU spawner abundance. Annual abundances within each independent population have accounted for a significant proportion of their respective coastal stratum abundance (Figure 2-19). Tenmile Lake populations are generally more abundant than their other two populations in the Lakes stratum. The Lower Umpqua River has also typically contained a higher proportion of spawners. The Coos and Coquille Rivers, on average, supported similar numbers of spawners between 1990 and 2021. Overall, the populations in the permit area contribute substantially to the overall abundance of the ESU and individual strata.

Average densities of coho by management basin and independent population have also been measured in the permit area. Table 2-11 summarizes the average number of coho spawners per mile and range of estimates for the 10 annual 1-mile survey reaches in the permit area.[7] The area-under-the-curve technique is used to estimate the total number of adult coho in the survey reach during the spawning season divided by the miles surveyed (Jacobs et al. 2002). Data were summarized for the annual survey panel and not the other panels to reduce the possibility of bias in the estimates as sites surveyed less frequently may not reflect the long-term average because of inter-annual variation in coho abundance. Not all years were surveyed for some reaches. The most consistent surveys were in management basins that were part of the Coos coho population.

From 1998 to 2017 average densities for the four surveyed reaches in management basins that are part of the Coos population ranged from 16 to 135 coho per mile (Table 2-11). Average densities for the last 10 years (2008–2017) ranged from 11 to 151 coho per mile in the same survey reaches. Reach surveys were less frequent in management basins that are part of the Tenmile coho population. Average densities for the five surveyed reaches in these management basins for the last 10 years when surveys were more frequent (most years surveyed were 2008 to 2017) ranged from 43 to 300 coho per mile.

[7] Estimates of coho spawner abundance by stream originating from within the plan area include stream reaches downstream of the forest. Spawner abundance estimates cannot be broken out to a finer scale to report coho just in in the plan area portion of the streams.



Source: Oregon Department of Fish and Wildlife n.d.
Vertical bars indicate +/- 1 standard error.

Figure 2-19. Mean Annual Abundance of Oregon Coast Coho across Five Biogeographic Strata between 1990 and 2021

Table 2-11. Coho Spawner Survey Fish per Mile by Survey Reach in the Permit Area

		Annual Surveys (1998–2017) [a]		Annual Surveys (2008–2017) [a]	
Management Basin	**Coho Population**	**Number of Surveys**	**Coho per Mile (range)**	**Number of Surveys**	**Coho per Mile (range)**
Mill Creek	Lower Umpqua	No Surveys			
Charlotte Luder	Lower Umpqua	No Surveys			
Dean Johanneson	Lower Umpqua	No Surveys			
Schofield Creek	Lower Umpqua	9	44 (0–117)	2	18 (12–24)

Management Basin	Coho Population	Annual Surveys (1998–2017) [a]		Annual Surveys (2008–2017) [a]	
		Number of Surveys	Coho per Mile (range)	Number of Surveys	Coho per Mile (range)
Big Creek	Tenmile	4	300 (167–557)	4	300 (167–557)
Benson Roberts	Tenmile	8	152 (71–314)	6	160 (75–314)
Johnson Creek	Tenmile	6	48 (2–113)	5	57 (2–113)
Johnson Creek	Tenmile	6	43 (0–110)	6	43 (0–110)
Johnson Creek	Tenmile	5	147 (89–294)	5	147 (89–294)
Palouse Larson	Coos	No Surveys			
Henrys Bend	Coos	No Surveys			
Marlow Glenn	Coos	15	29 (0–154)	7	11 (0–51)
Millicoma Elk	Coos	18	16 (0–51)	9	20 (2–51)
Millicoma Elk	Coos	16	26 (0–112)	8	24 (0–71)
Trout Deer	Coos	9	135 (4–338)	8	151 (24–338)

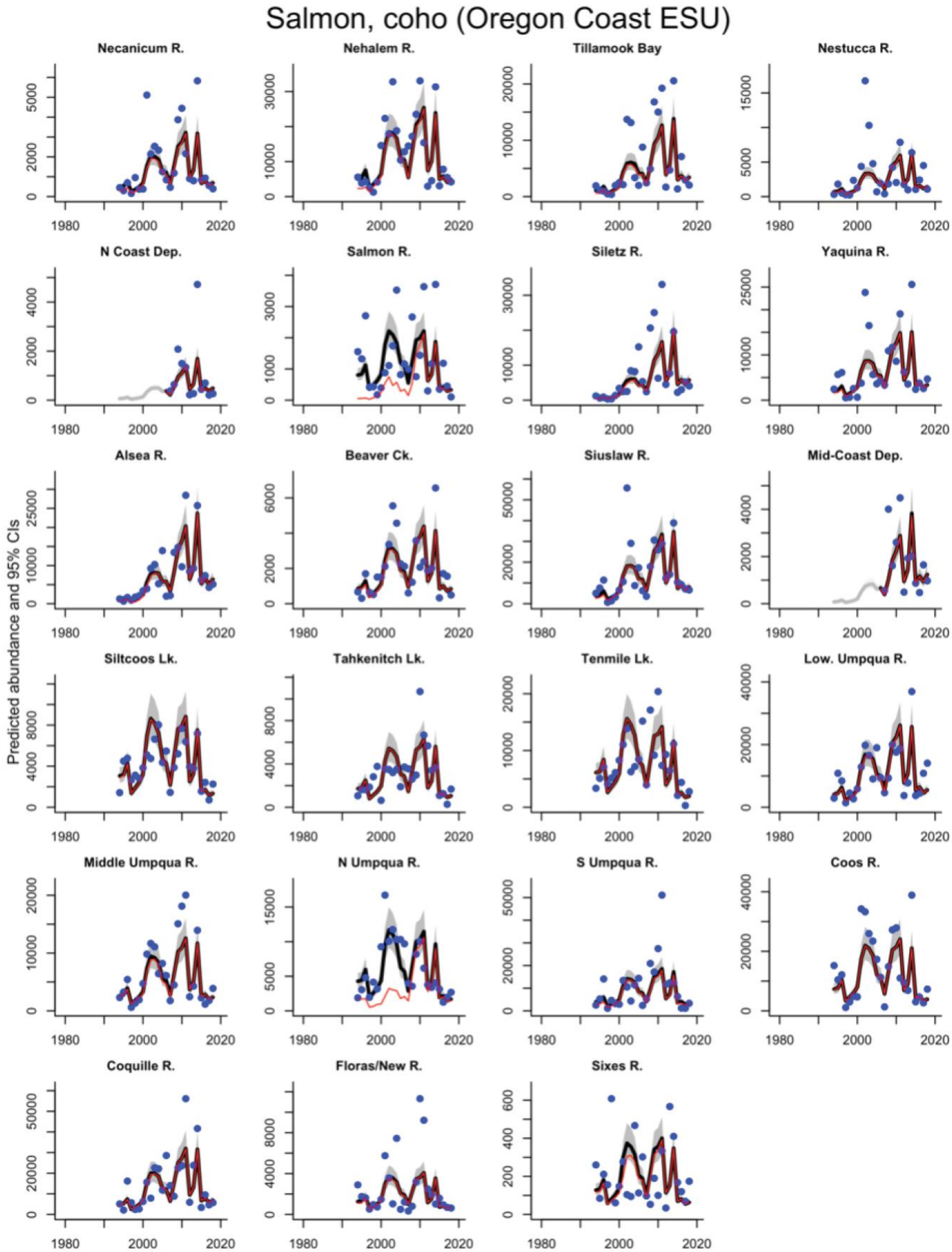
Source: Sounhein pers. comm.

[a] The average and range (minimum and maximum) were summarized for survey reaches originating from the plan area. In some cases, survey reaches extended downstream outside of the plan area. Data were summarized from annual coho survey data provided by ODFW.

Only one management basin that is part of the Lower Umpqua Basin has annual surveys in the plan area. The density for this reach was 44 coho per mile for all years and 18 in the 2 years surveyed from 2008 to 2017. Coho densities for surveyed reaches were compared to population-level densities for recent years (2008–2017) as reported in Sounhein et al. (2017). Reach-level coho densities in management basins that are part of the Tenmile population are high relative to other coastal Oregon management basins. Reach-level densities in management basins that are part of the Coos and Lower Umpqua populations are approximately the same as reported for other coastal populations. Moreover, reach-level spawner densities in the Coos population are similar to those observed in the Coquille and Floras River populations, but higher than observed in the Sixes population by Sounhein et al. (2017).

A recent evaluation by Ford (2022) found recent declines in spawner abundance across the Oregon Coastal Coho ESU (Figure 2-20). Annual abundance estimates have declined in the Tenmile Lake and Coos River populations since 2017, while the Lower Umpqua River population has experienced recent trends of growth in coho abundance and is generally more abundant in population compared with the other strata in the permit area.

The permit area is dominated by steep streams and narrow valleys. Such settings can have a limited potential to provide productive habitat for coho salmon. However, there are some areas in the permit area that have geomorphic conditions where coho salmon numbers are relatively strong (e.g., Coos). The contribution of these local populations may be important for the associated independent populations (Lower Umpqua, Tenmile, and Coos). The plan area also has the potential to contribute wood, gravel, high-quality water, nutrients, and food to the lower portions of watersheds outside of the permit area, where the potential for productive habitats and increases in fish numbers are greatest. HCP implementation will support the recovery and conservation efforts for the three independent coho populations that occur in the permit area.



Source: Ford 2022.

Points show annual raw abundance estimates.

Figure 2-20. Predicted Total (black line) and Natural Spawning (red line) Abundance of Major Oregon Coast Coho Rivers between 1990 and 2020

2.5.2.4 Summary of Limiting Factors

Limiting factors for Oregon Coast coho within the Elliott State Forest have been modeled in a variety of ways over time. One species habitat model for coho salmon is based on a fish habitat assessment study completed by ODFW (Kavanagh et al. 2005) and referenced in the Oregon Coho Plan (Oregon Department of Fish and Wildlife 2007). In addition, Burnett et al. (2007) completed an analysis of habitat intrinsic potential for Oregon coastal watersheds. The intrinsic potential analysis is an estimate of relative suitability of stream reaches for juvenile coho salmon and considers landscape characteristics that provide suitable rearing habitats for coho, such as stream flow, stream gradient, and valley confinement (Burnett et al. 2007). ODFW developed and applied two additional coho models to characterize existing habitat conditions in Oregon Coast streams, including the Elliott State Forest (Kavanagh et al. 2005). These models are based on habitat surveys within the forest that are conducted on wadable streams (1st–3rd order streams).

A coho Habitat Limiting Factors Model (Nickelson et al. 1992, Nickelson 1998) was used to evaluate potential carrying capacity of streams. The Habitat Limiting Factors Model evaluates the quality of habitat available to coho based on the number of pools in a stream reach, including beaver ponds and off-channel ponds, and provides an estimate of juvenile carrying capacity potential for a stream reach (Kavanagh et al. 2005). The third model is the HabRate model, which is used to evaluate the quality of habitat for coho (Burke et al. 2010). The HabRate model is based on published habitat requirements for coho salmon spawning, egg incubation, summer rearing, and overwinter rearing. The model compares habitat requirement of the species to observed conditions for factors related to habitat quality, such as substrate composition, instream cover and structure (wood and bank condition), and stream gradient.

Habitat capacity indices from the Habitat Limiting Factors Model were moderate to high in streams in the Tenmile and Coos watersheds and low to high in streams in the Lower Umpqua watershed in the Elliott State Forest (Kavanagh et al. 2005). Results from the HabRate model indicated stream quality during summer rearing varied across the forest. In the Coos watershed, pool complexity was moderate, with some streams characterized as high and some low. The capacity and quality of streams for winter juvenile rearing was rated as low in all three watersheds. An exception was Joes Creek in the Coos watershed (a tributary of the W.F. Millicoma River in the Trout Deer Management Basin), which rated high for quality of winter habitat. In addition, structural complexity was moderate to high in a few other reaches in upper W.F. Millicoma and Palouse Creek (Palouse Larson Management Basin).

Overall, stream reaches in the Elliott State Forest tend to rate moderate to high for spawning, egg incubation, and summer rearing (Kavanagh et al. 2005). However, areas of high intrinsic value for coho are limited, occurring primarily along the borders of the permit area (Kavanagh et al. 2005). The availability of abundant, high-quality overwinter habitat was the most limiting. These models suggest that for streams in the plan area to support large numbers of coho, a portion of the juvenile coho must redistribute to downstream mainstem rivers and upper estuary habitats for overwinter rearing. Findings from these models in the Elliott State Forest are consistent with other studies that found overwinter habitat to be the primary limiting factor for coho in Oregon Coast streams (Solazzi et al. 2000).

Kavanagh et al. (2005) reported results of percent fine sediment by stream reach across the forest from ODFW stream surveys between 1993 and 2004. Average percent fine sediment within riffles was approximately 12% forest-wide. Thirty surveyed reaches covering 40 kilometers (~25 miles) in the Tenmile Lakes region averaged 18% fine sediment in riffles, indicating moderate impairment of spawning gravels by fine sediment. In the Umpqua Basin, 31 reaches were surveyed, covering 43 kilometers with an average of 8% fine sediment, and the Coos Basin averaged 13% fine sediment in 117 reaches over 206 kilometers. Jensen et al. (2009) reported that based on proposed mechanisms of how sediment affects egg-to-fry survival (i.e., suffocation or entrapment), the odds of survival are proportional to the percent of fine sediments in riffles. The odds of survival lowered and decreased faster when fines sediments were <0.85 millimeter (mm) versus larger size classes. Establishing a threshold effect showed survival dropping rapidly when percent fine sediment <0.85 mm was greater than 10%. The combined data for all species from the study estimated, on average, that a 1% increase in percent fines <0.85 mm will result in about a 17% reduction in the odds of survival over all species.

In the most recent Oregon Coho Plan (Oregon Department of Fish and Wildlife 2019a), ODFW biologists reviewed the limiting factors from the 2005 Oregon Coast Coho Assessment (Chilcote et al. 2005) for each independent population to incorporate changes that may have occurred since 2005. During this review, few changes in current limiting factors were identified, and no new emerging limiting factors were found. Stream complexity and water quality continue to be the primary and secondary limiting factors for most of the populations in the ESU (Oregon Department of Fish and Wildlife 2019a). Notably, exotic fish species are the primary limiting factor for the Tenmile population.

Chapter 3
Covered Activities

3.1 Introduction

This chapter describes the covered activities for which the Oregon Department of State Lands (DSL, the Permittee) is requesting take coverage. 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).

Under the screening criteria developed by DSL, 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 as a project or activity it implements directly; implements through contracts, agreements or leases; or controls through regulation or other means (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.

The covered activities described in this chapter broadly correspond to activities regulated through the Oregon Forest Practices Act (Oregon FPA) (Oregon Revised Statutes 527 and Oregon Administrative Rules [OAR] 629). In addition, the covered activities include HCP implementation actions, such as habitat restoration (Chapter 5, *Conservation Strategy*) and covered species monitoring (Chapter 6, *Monitoring and Adaptive Management*), that have a reasonable likelihood of resulting in take of one or more covered species.

The Oregon FPA attempts to promote environmentally sound forestry while allowing for economically viable forest management, recognizing both the economic and ecological importance of Oregon's forestlands. A key goal of the Oregon FPA is to protect water quality and aquatic habitats by mandating forested buffers along streams, wetlands, and lakes, as well as standards for road design and maintenance to reduce sediment runoff. The Oregon FPA sets standards for all commercial activities involving the establishment, management, or harvesting of trees on Oregon's nonfederal forestlands that are not already or otherwise covered by an Endangered Species Act (ESA) Incidental Take Permit (ITP) pursuant to an HCP such as this one. Adherence to all Oregon FPA rules is not a requirement for compliance with the ESA or the issuance of an ITP.

Like the Oregon FPA, this HCP has similar measures designed to protect species and their habitats on the DSL-owned lands within the HCP permit area. At the overarching level, commitments contained in this HCP as well as DSL's Forest Management Plan, which contains broader direction for values beyond the ESA, will govern management on the Elliott State Research Forest (ESRF). Where specifically identified in Chapters 3 and 5, operations and actions will be managed in accordance with Oregon FPA rules. Additionally, DSL will engage with the Oregon Department of Forestry (ODF) to develop and adopt stewardship agreements and/or plans for alternative compliance where necessary for management actions that deviate from the Oregon FPA rules, as provided by the Oregon FPA in contexts relevant to research and the ESRF. These ODF and Oregon FPA-based arrangements will not result in changes to the covered activities and conservations strategy in HCP but will outline agreements between the agencies regarding how ESRF public lands will be managed relative to the Oregon FPA. DSL will be in compliance with the ESA via the HCP and associated ITPs.

The covered activities described in this chapter are intended to be as inclusive as possible. This chapter describes the activities that are expected to occur in the ESRF in enough detail so that they can be analyzed in Chapter 4, *Effects Analysis*. For projects or activities not described in the HCP, a plan amendment may be necessary if the Permittee wants coverage under the HCP and permits; see Chapter 7, Section 7.6, *Modifications to the Habitat Conservation Plan*, for details on the amendment process. The Permittee would also have the option of conducting those activities under a take avoidance strategy or under a separate permit under the ESA. The Permittee will be responsible for ensuring covered activities are implemented in alignment with the HCP and associated permits, and the Permittee will make all final decisions regarding the management and operation of the ESRF consistent with the HCP and ITPs.

Covered activities have been defined to allow research to occur based on the framework identified by Oregon State University (OSU) (Appendix C, *Proposal: Elliott State Research Forest*) through DSL's original advisory committee process for the ESRF and as revised over time as reflected in this HCP. Covered activity provisions would be applicable to any entity carrying out research under agreement with the Permittee. In turn, research would not occur in a manner inconsistent with HCP commitments. The Permittee will extend its ESA compliance coverage to entities implementing forest management operations and research in the permit area as long as actions are consistent with HCP requirements. If DSL continues to own and manage the ESRF but does not wish to manage it as a research forest consistent with these covered activities, an HCP and permit amendment may be necessary (Chapter 7, Section 7.5, *Adjustments to Stay-Ahead*). Covered activities are described in the remaining sections of this chapter.

3.2 Foundational Research Design of the Elliott State Research Forest

3.2.1 Overview of Research Platform and Relationship to Covered Activities

As described in Chapter 1, *Introduction*, the permit area will be managed based on a research platform framework described in OSU's research proposal for the ESRF (Appendix C, *Proposal: Elliott State Research Forest*), as revised over time and reflected in this HCP. This research proposal outlines allocations, harvest treatment types, and a research platform that takes a landscape approach to long-term sustainable forestry research. The platform is designed to be climate-adaptive, dynamic, and flexible. Over the course of advancing the framework for the ESRF's creation and this associated HCP through an advisory committee process, the Permittee has made some modifications and adjustments to the framework, which are captured in this HCP's commitments. The flexibility within this HCP is intended to facilitate collaboration with research partners at OSU, as well as other universities and institutions inside and outside of Oregon. The results obtained from ESRF research, whether advanced by OSU or other research entities, are intended to inform future policy and decision-making in state, federal, Indigenous, and private forest landscapes throughout the Pacific Northwest, the nation, and globally.

A key element of the underlying research platform and HCP framework is the allocation of lands for operational consistency (Section 3.2.2, *Establishment of Conservation and Management Research Watersheds*). While some degree of management flexibility exists within the allocations, as described in this chapter, these allocations will create an important level of certainty for researchers and the public by facilitating long-term studies essential to understanding long-lived forests. The treatments and associated operations standards (including tree retention standards) prescribed for each allocation (Section 3.3, *Stand-Level Treatments and Operations Standards, by Allocation*) will guide forest stand condition and future growth trajectories in those allocations regardless of the identity of research partners.

3.2.2 Establishment of Conservation and Management Research Watersheds

The permit area is divided into two broader groups: the conservation research watersheds (CRW) and management research watersheds (MRW).

The CRW (33,571 acres) anchors the conservation strategy by establishing a contiguous conservation block that combines aquatic and terrestrial habitat protection to benefit the covered species. Within the CRW, 23,866 acres are in upland reserves and 9,705 acres (29% of the total CRW) are in riparian conservation areas (RCAs) assuming the RCA buffering strategy described in Section 3.3.7, *Riparian Conservation Areas*. The CRW will be managed for long-term ecological functions and cultural practices compatible with restoring and conserving terrestrial, riparian, and aquatic habitat conditions. Within the CRW, site-disturbing research and management activity will focus on projects and methods intended to benefit the long-term conservation of native biota (e.g., restoration thinning to enhance forest habitat structure and complexity, stream restoration projects, meadow restoration and maintenance, road vacating).

The MRW (49,735 acres) is divided into the "triad" allocations, other allocations, and RCAs. Stand-level treatments and operations standards that would be employed within each allocation are summarized below and described in detail in Section 3.3, *Stand-Level Treatments and Operations Standards, by Allocation*. The MRW's triad allocations include Intensive (9,912 acres), Extensive (10,870 acres), and Reserve (11,986 acres) allocations. The three allocations attempt to reconcile conservation, production, and other objectives on forestlands, as follows.

- **Reserve allocations**. Reserve allocations are managed for biodiversity conservation, which means silvicultural treatments or interventions that are limited only to that which improves biodiversity and related attributes, such as restoration thinning.
- **Extensive forestry allocations**. Extensive forestry allocations are typically characterized by partial retention, more time between harvests, and advancement of natural tree regeneration.

- **Intensive forestry allocations**. Intensive forestry allocations are those of traditional production forestry (i.e., clearcutting) commonly applied on private timber lands. Intensive forestry is typically characterized by plantation-based timber production, with shorter time between harvests. Intensive forestry under the HCP includes tree planting and thinning.

The triad design provides a framework for exploring the complex tradeoffs and synergies between commercial forest production and other public values, including endangered species conservation. The experimental units for the triad design are full subwatersheds between 400 and 2,000 acres in size, follow U.S. Geological Survey (USGS) technical specifications for the delineation of Hydrologic Unit Code (HUC)-14 watersheds, and nest within USGS HUC-12 watershed boundaries, that will be assigned to one of the four following research categories.

- Extensive subwatersheds will be 100% Extensive allocations.
- Triad-E subwatersheds will be 60% Extensive, 20% Intensive, and 20% Reserve allocations.
- Triad-I subwatersheds will be 20% Extensive, 40% Intensive, and 40% Reserve allocations.
- Reserves with intensive subwatersheds will be 50% Intensive and 50% Reserve allocations.

To account for the possibility that, over the permit term, harvest in Extensive allocations could be restricted due to marbled murrelet (*Brachyramphus marmoratus*) occupancy in designated modeled potential habitat that has expanded since the initial draft HCP, a portion of the MRW (943 acres) is designated as Volume Replacement allocations. Volume Replacement allocations will be treated as described in Section 3.3.4, *Volume Replacement Allocations*.

MRW RCAs comprise 6,319 acres[1] and would be managed to address riparian habitat protection, conservation, and research. Approximately 10,000 acres of the MRW are in partial subwatersheds that are either less than 400 acres or not fully contained within the permit area boundaries. These areas are not included in the triad design and are designated as either Flexible or Flexible Extensive allocations. Within these partial subwatersheds, 8,887 acres are designated as Flexible allocations. Outside of restrictions for covered species habitat, Flexible allocations will be treated as described in Section 3.3.5, *Flexible Allocations*. The remainder of the partial subwatersheds are designated as Flexible Extensive allocations (819 acres), which will be treated as described in Section 3.3.6, *Flexible Extensive Allocations*. Figure 3-1 illustrates the distribution of allocations across the permit area; the percentage of each is shown in Figure 3-2a for both the CRW and MRW and in Figure 3-2b for the MRW only.

[1] Includes acres associated with Conservation Measure 2, which expands RCAs in certain locations.

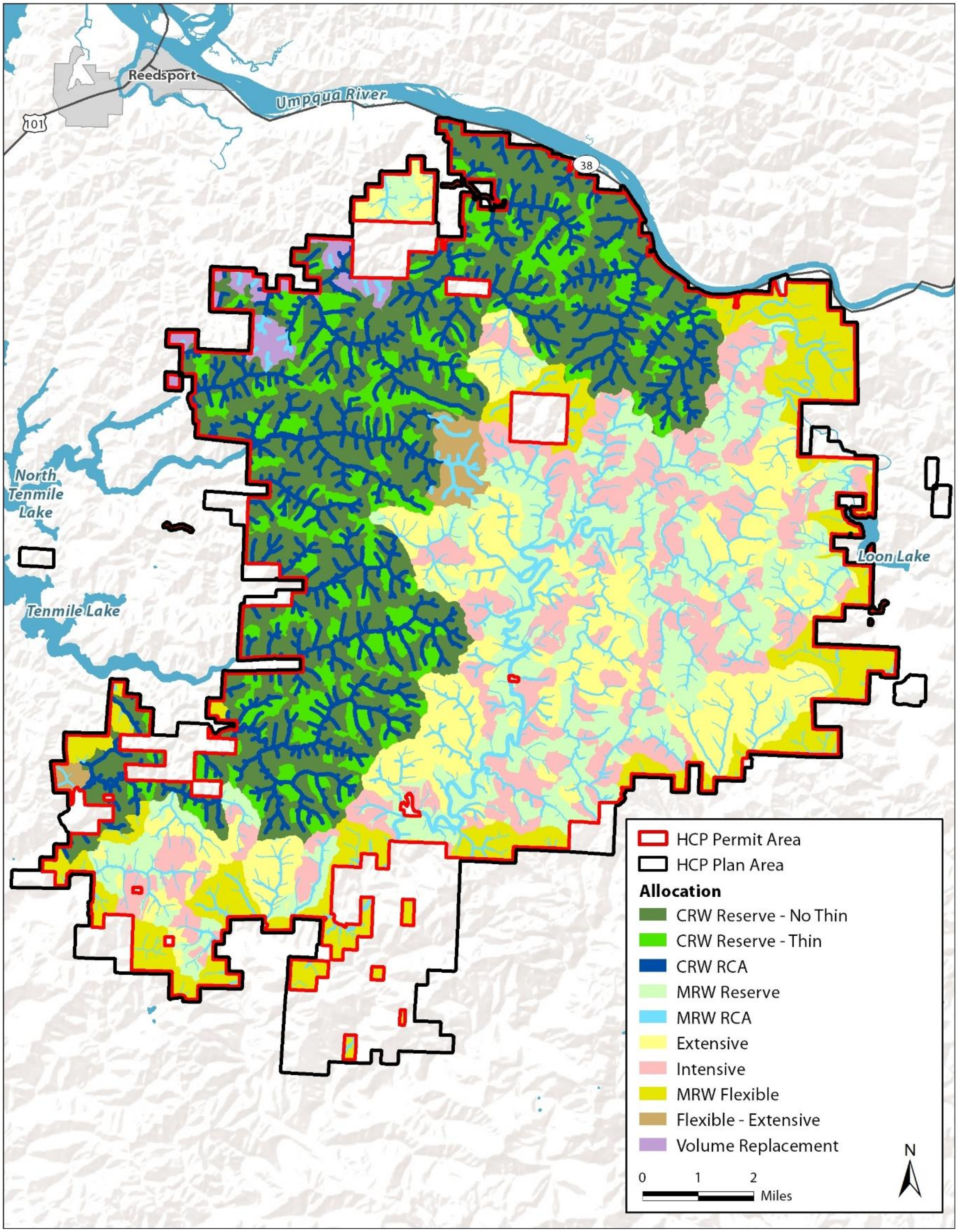


Figure 3-1. Allocations in the Permit Area

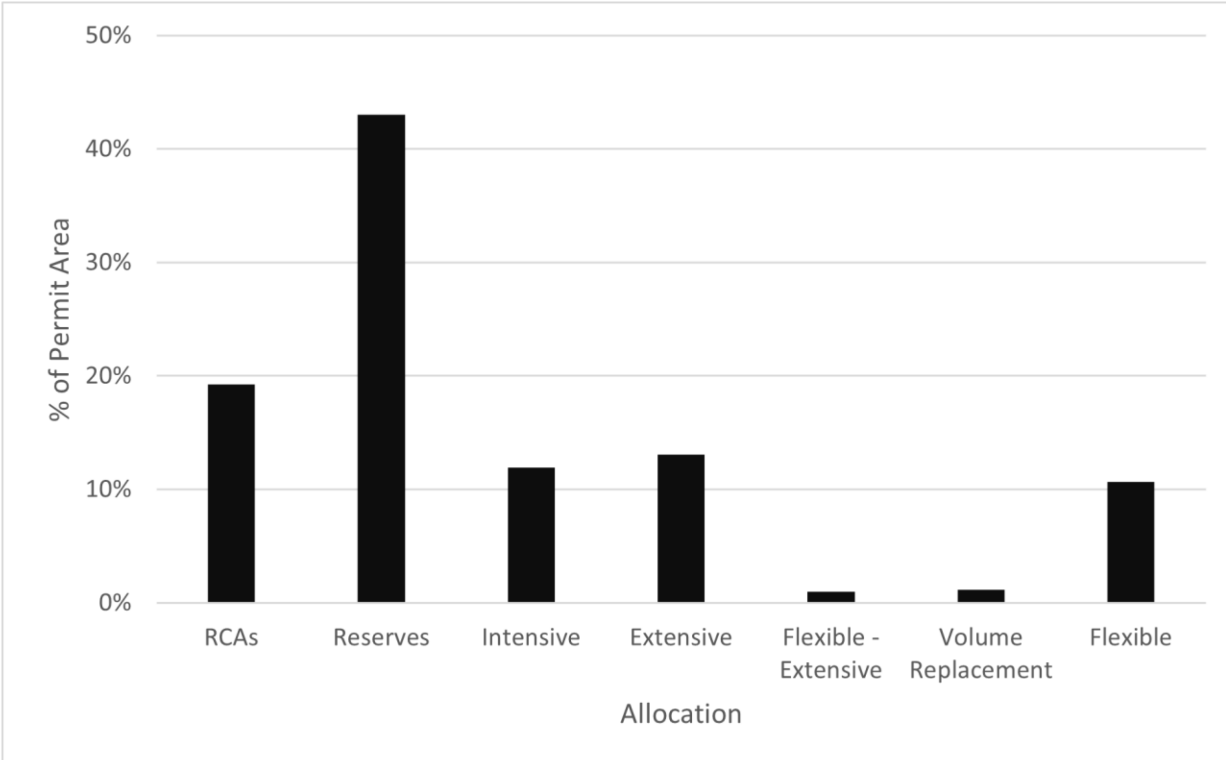


Figure 3-2a. Percentage of Each Allocation in the Permit Area

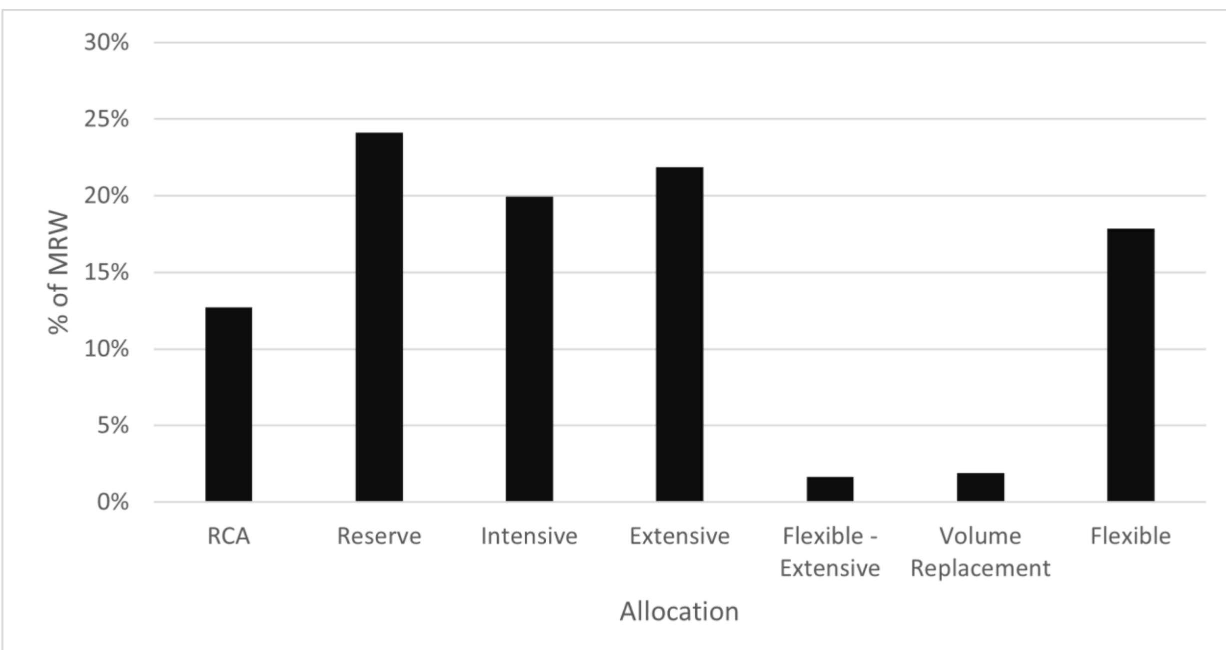


Figure 3-2b. Percentage of Each Allocation in the Management Research Watershed Only

3.3 Stand-Level Treatments and Operations Standards, by Allocation

The stand-level treatments that will be implemented in the permit area include the intensive, extensive, and restoration thinning described here. Table 3-1 summarizes which treatments are allowed by allocation. In some allocations, only one type of treatment would be applied throughout. For example, only intensive treatments are applied in Intensive allocations and only extensive treatments are applied in Extensive and Flexible Extensive allocations. Similarly, only restoration thinnings are allowed in CRW and MRW Reserves and RCA allocations which, as described below, are limited to certain stands (as opposed to across the entire allocations). For Flexible and Volume Replacement allocations, treatments vary within the allocation as described below.

Table 3-1. Treatment Type(s) Allowed by Allocation

	Treatments		
Allocation	**Intensive**	**Extensive**	**Restoration Thinning**
Intensive	X		
Extensive		X	
RCA			X [a]
Reserve			X [a]
Volume Replacement		X [b]	
Flexible [c]	X [d]	X	
Flexible Extensive		X	

[a] Treatment only allowed in stands 65 years old or younger (as of 2020).
[b] Treatment only allowed if stands in Extensive allocation become unavailable due to species occupancy.
[c] Treatment type in this allocation is dependent on stand age and covered species habitat.
[d] Harvest rotation differs from intensive treatments in Intensive allocations.
RCA = riparian conservation area

3.3.1 Conservation Research Watersheds and Management Research Watersheds Reserve Allocations

Treatments in the CRW and MRW Reserve allocations are limited to restoration thinnings in stands 65 years old or younger (as of 2020). These allocations contain a mix of primarily unlogged, naturally regenerated stands, as well as previously harvested stands. Stand-level treatments in these allocations are not based on harvest-driven or financial objectives or objectives other than conservation, restoration of ecosystem services, and compatible cultural practices.

The CRW and MRW Reserve allocations include former plantation stands 65 years old or younger (as of 2020) that are currently dense and homogenous in species diversity and habitat structure. There are also several thousand acres of mature forests that were commercially thinned 40 to 60 years ago or have other legacy effects of past management and natural disturbance (e.g., road systems construction, wildfire, blowdown, fire suppression). Existing mature forests and other functioning complex habitats in the CRW and MRW Reserve allocations will be conserved and not managed with intensive or extensive forestry. However, there is a need for a focused restoration effort to increase forest resilience, address legacy effects (e.g., road sedimentation, invasives or reduced native plant diversity), and support disturbance dynamics that would normally result in multi-aged stands and greater habitat complexity. In addition to the supporting management activities (Section 3.5), treatments in the CRW and MRW Reserve allocations will consist of a range of restoration thinning treatments in stands 65 years old or younger (as of 2020) to alter the trajectory of these established young plantations toward habitat with more complex structure. These treatments are intended to be applied within the context of research with varying replicated treatments across subwatersheds but will be carried out regardless of research as needed to meet HCP commitments.

These conservation-focused CRW and MRW Reserve allocations are ideal for researching and monitoring ecosystem services such as biodiversity, recreation, carbon cycling, and water dynamics in the absence of a timber harvest–driven focus. Examples of research concepts and outcomes associated with Reserve allocations are described in Appendices 2 and 3 of OSU's research proposal (Appendix C, *Proposal: Elliott State Research Forest*). Existing healthy functioning old or mature forests in the conservation-focused CRW and MRW Reserves can serve as benchmarks for research. Treatments are intended to support cultural practices compatible with conservation and restoration efforts, as well as eco-cultural research and stewardship partnerships with tribes and conservation-oriented partners.

CRW and MRW Reserve allocations have the following standards.

1. Retain the CRW as a contiguous[2] conservation area in the southern Coast Range.
2. Assess plantations (forest stands 65 years old and younger as of 2020) in the CRW and MRW Reserves for conservation, restoration, and compatible cultural practice potential in the initial phase of HCP implementation so that restoration thinning treatments can be completed in the first 30 years of the permit term (as further detailed below).
3. Design and implement restoration thinning treatments in plantations 65 years old or younger (as of 2020) that will increase the likelihood of accelerating, achieving, and maintaining resilient complex mature forest structure and other valuable habitat conditions over the permit term. The restoration thinning treatments should result in higher quality habitat ingrowth for covered species, greater overall native species diversity, and a greater range of habitat complexity and ecosystem services than maintaining the current trajectory of dense single-species plantations.
    a. Depending on conditions, thinning treatments could be composed of one or several of the following treatments: variable density thinning, including skips and gaps; creation of snags and downed wood; retaining unique tree forms and structures; retaining and/or encouraging the variety of tree sizes and species; protecting or restoring desirable understory vegetation, complex habitats, or meadows; planting in gaps or in the understory to encourage species diversity; or removal of invasive species. Thinning may occur in combination with other supporting management activities covered by this HCP (Section 3.5, *Supporting Management Activities*).
    b. The intent of thinning is to set an existing plantation stand on a trajectory to meet the objectives of the restoration thinning, between 20 and 80% of the pre-harvest stand density may be removed, depending on the starting conditions and thinning goal.
    c. Restoration thinnings, while intended to occur as part of research efforts within ESRF's broader research design, may be implemented by the Permittee in the absence of a research partner to meet habitat goals of this HCP. Thinning design and related research will draw

[2] *Contiguous* means areas sharing a common border or touching.

from, take advantage of, and expand upon research and findings from various studies that investigate the possibility of accelerating development of late-successional stand structures and compositions (e.g., Poage and Anderson 2007; Bauhus et al. 2009), including Demonstration of Ecosystem Management, Density Management, Young Stand Thinning and Diversity, and others. For a summary of studies, see Monserud (2002), and Poage and Anderson (2007).

   d. Indigenous Knowledge related to prescribed fire, native planting, and invasive species removal (Section 3.5, *Supporting Management Activities*) may be used in combination with thinning techniques to create and maintain habitat conditions consistent with restoration, cultural, and HCP goals. Following an initial thinning treatment, use of supporting activities may occur (e.g., prescribed fire, native planting, invasive species treatments) whether planned in coordination with the thinning or separately.

4. Treatments are implemented over a range of forest ages (up to 65 years old as of 2020). Age class prioritization is incorporated into the timing of restoration treatments to advance thinning during the biological window relevant to achieving growth of desired habitat structure. The stands closest to age 65 (as of 2020) will be subject to thinning treatment in the first 20 years of the HCP term. The Permittee will also strive to advance restoration thinning in younger stands in this initial 20-year period, but these younger stands could be subject to thinning treatments later in the 30-year CRW thinning timeframe, depending on the silvicultural needs for advancing desired habitat and ecosystem services as well as operational limitations. Any plantation stand that reaches 80 years old prior to an initial thinning would only be thinned with concurrence from the Services.

5. Restoration thinning mostly consists of single-entry restoration treatments in the first 20 years of the permit term's 30-year CRW thinning window. Following the initial 20 years of thinning entries, but still within the 30-year period, 3,500 acres of additional thinning treatments (first or second entry) may occur to allow flexibility in research design or to meet restoration objectives that were not achieved during the initial 20 years. Thinning in the MRW Reserves may take longer, depending on how the stepwise implementation corresponds to the original OSU research design or some other design; therefore, it is not subject to the 30-year thinning window. That said, as in the CRW Reserves, any plantation stand that reaches 80 years old in the MRW Reserves prior to thinning would only be thinned with concurrence from the Services and the relevant provisions outlined in Chapter 7, Section 7.6, *Modifications to the Habitat Conservation Plan,* and Section 7.2.4, *Implementation and Adaptive Management Committee*.

6. Following the initial 20 years of thinning entries, but still within the 30-year period, thinning treatments beyond 3,500 acres is permitted contingent on the Permittee collaborating with the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) (together, the Services) and the relevant provisions outlined in Chapter 7, Section 7.6, *Modifications to the Habitat Conservation Plan,* and Section 7.2.4, *Implementation and Adaptive Management Committee.*

7. Management in the CRW and MRW Reserves is for the purposes of conservation research, habitat conservation and restoration, promoting ecosystem services, related and compatible cultural practices, and partnership development. It is not to be driven by timber harvest or financial or revenue demands. Timber-related forest products volume generated from thinning may be sold for revenue, but as a byproduct of restoration thinning treatments (not as the driver of these treatments). Nontimber forest products produced as a result of habitat restoration and

conservation activities are anticipated to support indigenous cultural practices and uses, as well as broader public values and uses.

Salvage harvest will not occur in CRW and MRW Reserve stands, except for the exceptions described in Section 3.4.2.3, *Salvage Harvest*.

3.3.2 Intensive Allocations

Currently, about 42,000 acres of the forest are Douglas-fir (*Pseudotsuga menziesii*) plantations that were established following clearcutting between 1955 and 2015 occur in the permit area. These stands reflect conventional even-age forestry practices over the past six decades. Intensive (production-oriented) stand-level treatments will continue in about 23% of these forests as part of the triad research design. In Intensive allocations treatments emphasize wood fiber production at rotations of 60 years or longer. At the same time, methods can be assessed to lessen this harvest regime's impact on other attributes such as biodiversity, habitat, carbon cycling, recreation, and rural wellbeing. Examples of research concepts associated with Intensive allocations are described in Appendices 2 and 3 of OSU's research proposal (Appendix C, *Proposal: Elliott State Research Forest*).

Intensive allocations have the following standards.

1. Harvesting only in stands 65 years old or younger (as of 2020) that are primarily Douglas-fir plantations. Although unlikely to occur in these younger stands, no harvest of any tree that predates the 1868 fire would occur in the permit area (Section 3.3.3, *Extensive Allocations*, general standard number 4).
2. Even-age management using regeneration harvesting techniques suitable for the terrain. Regeneration harvest rotation age is a minimum of 60 years, with possibly one to two commercial thinnings between 25 and 50 years to maintain stand densities at levels that provide vigorous tree growth and maintain high wood production.
3. Retention standards for intensive treatments meet or exceed the Oregon FPA.
4. Post-harvest application of site preparation and vegetation control practices as described in Section 3.5 to ensure seedling establishment and initial growth.
5. Animal control (e.g., mountain beaver [*Aplodontia rufa*]) techniques following Oregon Department of Fish and Wildlife (ODFW) standards and guidelines but not involving use of rodenticides.
6. Plantations established at densities at or above Oregon FPA requirements that ensure relatively quick canopy closure using species and seed sources best suited for future predicted climate conditions (e.g., ranges of temperature and precipitation expected).
7. Regeneration harvest and commercial thinning determined by growth patterns (mean annual increment), vulnerability to disturbances, and markets, with a minimum rotation age of 60 years.
8. In most of these allocations, no more than 7,000 acres would be thinned to the maximum percentage thinned (80% of the original pre-harvest stand density). Thinning would not exceed 80% of the original pre-harvest stand density without concurrence from the Services and in accordance with Chapter 7, Section 7.6, *Modifications to the Habitat Conservation Plan*.

9. Salvage may occur in stands affected by natural disturbances such as fire, drought, disease, wind, and insects as described in Section 3.4.2.3, *Salvage Harvest*.

3.3.3 Extensive Allocations

The primary goal of extensive management is to maintain continuity of forest structure, function, and composition through time to benefit multiple resource values. This type of silviculture, also referred to as ecological forestry (Franklin et al. 2018a), is recognized as a viable option for conserving biodiversity at the landscape scale (Franklin et al. 1997, 2018b). Treatments in Extensive allocations use ecological forestry approaches to forest management reflecting varying social values, needs, and ecosystem function. While treatments in Reserve and Intensive allocations provide opportunities to evaluate opposite ends of the management spectrum, research in extensive treatments provides an opportunity to study methods to achieve integrated biodiversity and timber objectives at the stand and landscape scale. Extensive treatments also provide opportunity for integration of Indigenous Knowledge, including research partnerships and other Indigenous and non-Indigenous collaborations consistent with the covered activities and other HCP provisions.

Extensive treatments maintain new tree growth, promote the development of a multi-layered canopy structure, accelerate the development of large-diameter trees, foster understory vegetation development as well as complex early seral habitat, and delay crown recession. Accelerating the development of large-diameter branches enhances diverse forest characteristics and better integrates them with riparian areas to meet a broad set of objectives and values for the stand.

Approximately 10,000 acres of stands less than 65 years old (as of 2020) and approximately 3,000 acres of stands between 65 and 150 years old (as of 2020) are allocated to and analyzed in this HCP as subject to extensive treatments. Stand entries could consist of a combination of thinning for timber production purposes or other stand management objectives, as well as a variable retention regeneration harvest over the permit term. Return intervals for harvest depend on monitoring growth and achieving a desired range of conditions, including complex early seral to older forests, with an expected longer rotation age within individual forest stands (analyzed at an average 100-year rotation).

Retention ranges from 20 to 80% of pre-harvest stand density and should occur in a variety of spatial and age-class patterns. Retention occurs through a combination of dispersed and aggregated retention approaches. Dispersed retention areas include uniform and irregular distribution of leave trees within the stand's boundaries. Aggregate retention areas retain trees grouped in patches of the stand boundary and are coupled with patches of regeneration harvest. Extensive treatments will maintain a minimum 20% retention at the subwatershed level excluding RCA allocations. At the stand level, a 20% minimum retention level that includes RCA buffer allocations is allowed.

Planning of extensive harvest units is based on landscape-scale patterns, underlying allocations, the location and arrangement of RCAs, and any related research objectives. Examples of research concepts that may be associated with Extensive allocations are described in Appendices 2 and 3 of OSU's research proposal (Appendix C, *Proposal: Elliott State Research Forest*). The size of the extensive harvest units reflects the allocations within the MRW and includes aggregated or dispersed patterns found in natural disturbance events, including a mix of clumps, open patches, snags, and downed wood. Harvest unit sizes are determined by operational constraints and treatment objectives. The number of entries and nature of treatments for each stand will be developed as part of biennial operations plans in a manner consistent with this HCP and the applicable Forest Management Plan. Figure 3-3 depicts examples of extensive forestry and various retention approaches.

Source: Reprinted from Franklin et al. (2018a) with author permission.

Figure 3-3. Example Photos of Variable-Retention Harvest Stands in Ecological Forestry

Approaches to variable retention regeneration harvest involved in extensive forestry allows potential opportunities to research questions such as the effect of reduced fragmentation on biodiversity and other attributes such as harvest efficacy and safety. In addition, extensive treatments allow individual research projects to be designed to assess and monitor the spatial pattern of retention and regeneration areas based on a combination of factors including, but not limited to, population dynamics of at-risk species, maximizing opportunity for biodiversity, aesthetics, promoting wildlife habitat favoring complex early seral conditions or indigenous cultural uses and practices, retention of hardwood trees, wood production, harvest methods, landslide initiation, wood recruitment, and harvest unit size.

The following standards apply to stand-level approaches within Extensive allocations.

1. **Stands aged 65 to 150 years (as of 2020):** A single variable retention regeneration harvest is allowed, where a portion of the stand is converted into openings to promote new stand establishment. The remaining portion of the stand is retained in dispersion or aggregates. There is an overall 3,200-acre limit on extensive harvest of stands aged 65 to 150 years (as of 2020) during the permit term (Section 3.4.1, *Projected Timing and Amount of Harvest*, and Chapter 5, Section 5.3.2, *Management Research Watershed*).

   Regeneration Harvest Portion:

   a. Variable retention regeneration harvest, when combined with any thinning treatment before or after that harvest, would (a) not reduce a given stand below 20% retention of the original pre-harvest stand density,[3] and (b) maintain an average of at least 50% retention (ranging from 20 to 80%) of original pre-harvest stand density across the totality of extensively managed stands aged 65 to 150 (as of 2020) over the permit term. The 20%

[3] Original pre-harvest stand density = stand density prior to initial thinning or harvest under this HCP.

minimum (inclusive of any RCA buffer allocations adjacent to the stand) and 50% average commitments are "not to exceed" values, absent concurrence from the Services.

b. Up to three entries could be permitted across the regeneration portion of the stand. Thinning treatments occur either prior to variable retention regeneration entry or following such harvest in the newly established stand later in the permit term. Thinning treatments promote the development of complex forest structure, function, and composition associated with extensive forestry. Once the extensive forestry objective is met, subsequent thinning treatments will not occur.

c. The thinning treatments, particularly those taking place later in the permit term to thin new ingrowth, are not subject to the 3,200-acre limit on variable retention regeneration harvest as long as they are occurring on the same acres as that harvest but remain subject to meeting the retention commitments stated in (a) and (b).

Retention Portion (range of aggregate and dispersion):

d. The stand area that was left as dispersed retention or unharvested aggregates is not eligible for variable retention regeneration harvest and would generally be grown forward *in situ* but is eligible for up to three entries in order to achieve extensive forestry objectives (described at the outset of Section 3.3.3, *Extensive Allocations*), subject to meeting retention commitments (a–c).

e. The intent is a minimum of 25% of the retention portion in the form of aggregates.

2. **Stands 65 years or younger (as of 2020):** Up to three entries may occur (prior to or following variable retention regeneration harvest) to promote increased tree size diversity, accelerate the development of large-diameter trees, or to maintain complex early seral or other desired conditions associated with extensive forestry objectives.

    a. At the stand level, up to four entries, including variable retention regeneration harvest, and thinning may occur during the permit term (based on an average 100-year rotation for extensively managed stands across the permit area; longer rotation ages are expected within individual forest stands). Retention ranges from 20 to 80% pre-harvest density (inclusive of any RCA buffer allocations adjacent to the stand).

3. **Stands over 150 years (as of 2020):** No treatment during the permit term.

In addition to the stand-specific standards above, the following general standards are part of extensive allocation management action planning and implementation.

1. Extensive stand treatments are limited to stands that were established following the 1868 fire or regeneration harvests that have occurred primarily since the 1950s. If there are obvious discrete stands and individual trees within younger stands that clearly predate the 1868 fire, they will be protected within Extensive allocations and elsewhere in the permit area. Those stands or individual trees will be identified when stands are surveyed for harvest or for research experiments where harvest activities are laid out. It is recognized that due to safety issues in camp sites, logging operations, and other circumstances trees that predate the 1868 fire may need to be removed on rare occasions. When these circumstances occur, the Permittee is committed to the protection of the oldest forests and individual trees as part of further planning and project-level implementation.

2. Aggregated retention areas focus on conserving existing multi-layered mature or old growth forests already functioning according to extensive forestry objectives, or advancement of these conditions. Retention aggregates in Extensive allocations are likely to remain static over the permit term because of the 100-year average rotation age (with an expected longer rotation age within individual forest stands) and because the features or forest conditions that are being protected (or operational constraints) will remain at those locations. Retention preference (in aggregates or dispersed retention) is prioritized and advanced consistent with the following.
    a. Retention of large, mature (complex canopy structures) trees prioritized based on a combination of factors, including diameter at breast height, bole and bark characteristics, tree height, and crown and branching characteristics that are underrepresented across the stand or that typically support covered species.
    b. The development of riparian forests that emulate their critical roles in natural disturbance, fully integrate with upland management, and maintain critical ecological processes that benefit Oregon Coast coho (*Oncorhynchus kisutch*).
3. At the subwatershed level, retention maintains a minimum of 20% pre-harvest density, exclusive of (i.e., in addition to) any RCA buffer allocations already present in the subwatershed.
4. Salvage may occur in stands affected by natural disturbances such as fire, drought, disease, wind, and insects as described in Section 3.4.2.3, *Salvage Harvest*.

The following examples of attributes would **not** characterize extensive treatments.

- Conversion of a forest from a diverse to a less-diverse condition by not retaining key existing biological legacies (e.g., older trees, structure).
- A selective harvest without accounting for whether the objective of regeneration has been accomplished so that the long-term desired characteristics of the stand are not sustained.
- Establishing merchantable volume as the primary or dominant management objective.

3.3.4 Volume Replacement Allocations

Volume Replacement allocations are treated as Reserves (Section 3.3.1, *Conservation Research Watersheds and Management Research Watersheds Reserve Allocations*) unless certain portions of updated modeled potential marbled murrelet habitat (i.e., acres identified since the Draft HCP habitat modeled potential habitat layer) in the Extensive allocation are found to be ineligible for harvest due to occupancy by marbled murrelet. In these cases, acreage that produces an equivalent amount of timber volume as the Extensive allocation acreage found to be ineligible would become available for extensive harvest in the Volume Replacement allocations up to a total of 943 acres. Volume Replacement acreage available for extensive treatment is limited to stands age 65 years or younger (as of 2020) and restricted to areas outside of covered species habitat. The total amount of Volume Replacement acreage available for extensive harvest that offsets Extensive allocation acreage rendered ineligible for harvest due to murrelet occupancy in modeled potential murrelet habitat is described in Chapter 4, Table 4-1.

Should extensive harvest activity in the Volume Replacement allocation become eligible based on reasons stated previously, the extensive treatments will generally follow the operation standards described in Section 3.3.3, *Extensive Allocations*. This nontriad allocation provides opportunities to explore different approaches to extensive or ecological forestry, including in partnership with tribes or other entities. Salvage may occur in stands affected by natural disturbances such as fire, drought, disease, wind, and insects as described in Section 3.4.2.3, *Salvage Harvest*.

3.3.5 Flexible Allocations

Harvest treatments in Flexible allocations would vary depending on stand age outside of areas restricted for covered species habitat or other reasons (Chapter 5, Section 5.3.2, *Management Research Watershed*). Stands 65 years old and younger (as of 2020) in Flexible allocations are available for intensive or extensive treatments, tribal holistic or longer rotation forestry, or other treatment types. Stands greater than 65 years old (as of 2020), outside of areas restricted for covered species or other reasons, are only available for extensive treatments, tribal holistic, or longer-rotation forestry. Harvest in Flexible allocation stands greater than 65 years old (as of 2020) counts toward the 3,200-acre HCP upper limit commitment to minimize harvest of older stands (Chapter 5, Section 5.3, *Avoidance and Minimization Measures Integrated into the Covered Activities*). No harvest in stands that are designated occupied marbled murrelet habitat or within 100-acre northern spotted owl (*Strix occidentalis*) nesting core areas. The areas available for intensive harvest are subject to the same operation standards described in Section 3.3.2, *Intensive Allocations*, except that minimum rotation age will be 50 years instead of 60 years. The areas available for extensive treatments generally follow the standards described in Section 3.3.3, *Extensive Allocations*.

The Flexible allocations are not part of the triad design and thus are intended to provide opportunities to explore different approaches to extensive, ecological forestry, or longer-rotation forestry, including in partnership with tribes or other entities. Salvage may occur in Flexible allocation stands affected by natural disturbances such as fire, drought, disease, wind, and insects as described in Section 3.4.2.3, *Salvage Harvest*.

3.3.6 Flexible Extensive Allocations

Flexible Extensive allocations follow the same operation standards described in Section 3.3.3, *Extensive Allocations,* except that rotation ages may exceed 100 years on average. There are approximately 819 acres in the Flexible Extensive allocation. This nontriad allocation provides opportunities to explore different approaches to extensive or ecological forestry, including in partnership with tribes or other entities. Salvage may occur in Flexible Extensive allocation stands affected by natural disturbances such as fire, drought, disease, wind, and insects as described in Section 3.4.2.3, *Salvage Harvest*.

3.3.7 Riparian Conservation Areas

The focus of RCAs is restoring and maintaining key ecological processes that influence the productivity of aquatic ecosystems and associated resources. The research associated with the HCP intends to move beyond examining the degree that RCAs protect aquatic systems from wood fiber extraction by implementing RCA restoration actions designed to improve the ecological functions of streams and riparian forests. Thus, monitoring of RCA restoration actions and other ESRF treatments will characterize improvement to ecological function, and research will consider the size, extent, and arrangement of RCAs and adjacent treatments to optimize wood production, aquatic protections, restoration potential, and other important values. Further, research in the permit area will be approached from a whole-system perspective, and the intent is to focus riparian and aquatic components on road restoration and vacating, harvest on steep slopes, earth movement (e.g., landslides, debris flows), and natural disturbances. Because of the close ties with the research program implementation of RCA restoration thinning would only occur as part of the approved research studies. Management activities include components to preserve the integrity of upslope areas and understand the resilience and resistance of associated aquatic ecosystems that are adjacent to reserves, and intensively and extensively managed forests. Salvage harvest will not occur in RCAs, except for the exceptions described in Section 3.4.2.3, *Salvage Harvest*.

An integrated combination of RCAs, land use allocation, and outcome-based wood delivery potential will be applied across a range of stream types such as fish-bearing, non-fish-bearing, perennial, and nonperennial to protect and conserve key ecological processes essential for aquatic ecosystems and coho salmon.

3.3.7.1 Designating Riparian Conservation Areas

The permit area creates a unique opportunity to measure the long-term effects of varying levels of integration of RCAs with managed and unmanaged upland forests on species recovery. In particular, RCAs play a key conservation role adjacent to areas available for intensive and extensive treatments in the MRW. Over time, in RCAs adjacent to areas subject to intensive treatments, the older, more diverse designated RCAs will be less well integrated with the young upslope homogenous plantations, resulting in a sharp delineation between riparian and upslope conditions (in essence, creating a linear reserve). In contrast, integration between RCAs and upslope forests will be more evident in areas subject to extensive treatments due to the higher retention standards. This continuous tree cover and presence of an ever-aging cohort will create very different conditions than areas subjected to intensive treatments.

RCAs vary in size and configuration according to stream type and upslope allocation (Table 3-2). RCA widths are delineated as the horizontal distance from the outer edge of the channel migration zone[4] and in reference to a site potential tree height[5] of 240 feet, per local Bureau of Land Management data. All fish-bearing streams will have RCAs based on their location in the permit area and the adjacent allocation (Table 3-2). All perennial non-fish-bearing (PNFB) streams and high landslide delivery potential (HLDP) streams[6] have a designated RCA. HLDP streams were identified using TerrainWorks 2021 based on Benda and Dunne (1997) and Miller and Burnett (2008) (Figure 3-4). The TerrainWorks Slope Stability Analysis tool (TerrainWorks 2021) was used to identify hillslopes with the potential to initiate shallow, rapid landslides that can deliver sediments and wood to fish-bearing streams and the streams through which these sediments are likely to travel before reaching fish-bearing channels. HLDP streams will receive an RCA to ensure that wood is available for delivery (Section 3.3.7.1, *Designating Riparian Conservation Areas*, and Table 3-2). This modeling tool was run using 2-meter LiDAR-derived digital elevation models. Modeling identified the non-fish-bearing streams that comprise 25% of the total non-fish-bearing channel wood delivery budget to fish-bearing streams.

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[4] Channel migration zones are areas in a floodplain where a stream or river channel can be expected to move naturally over time in response to gravity and topography.

[5] The average maximum tree height for a given site measured in horizontal distance.

[6] Non-fish-bearing streams that comprise 25% of the total non-fish bearing channel wood delivery budget to fish-bearing streams.

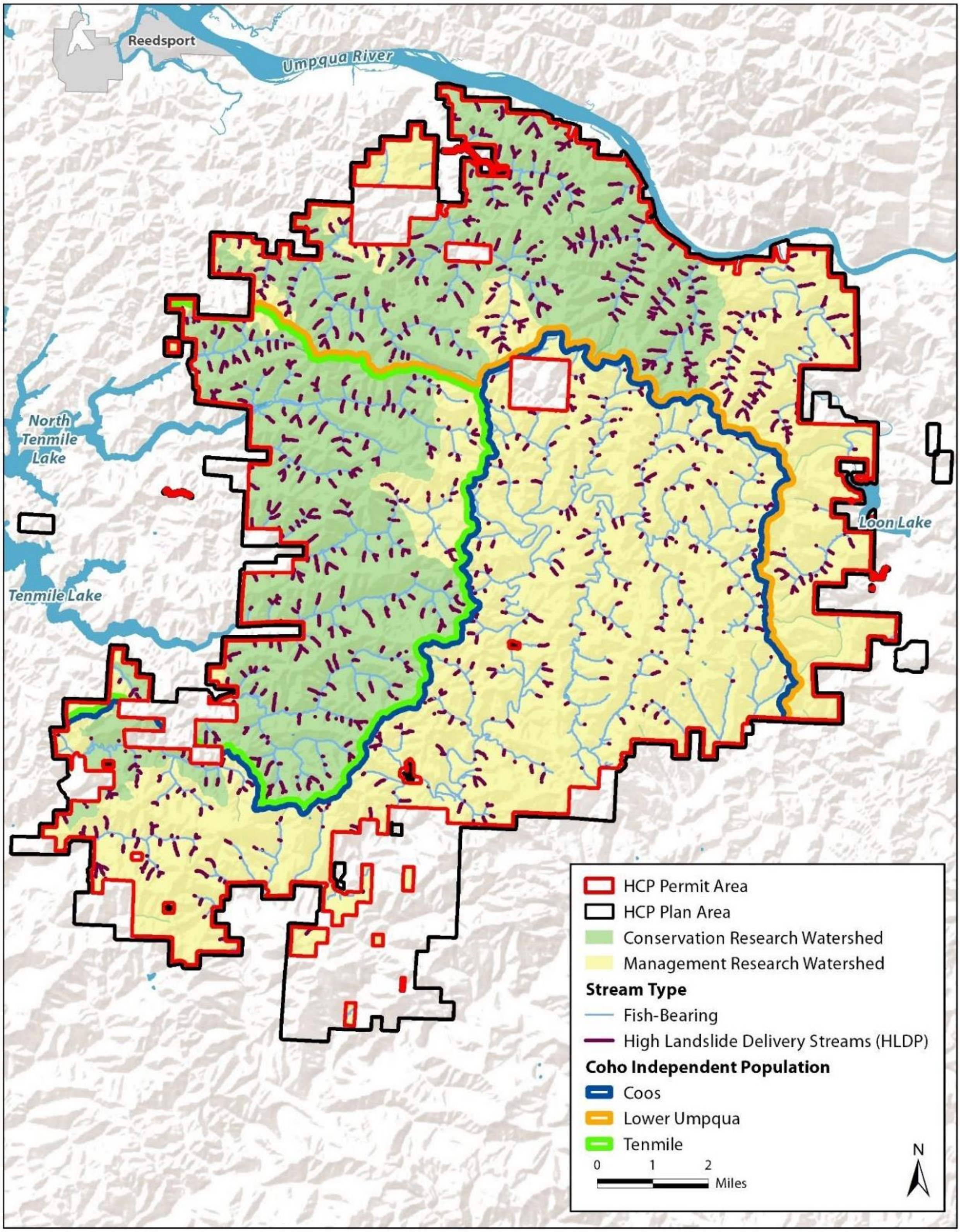


Figure 3-4. High Landslide Delivery Streams with the Potential to Deliver to Fish-Bearing Streams in the Permit Area

Should landslides deliver to HLDP streams, the RCAs are intended to reduce the speed and distance the slide travels downslope and will ensure large wood is available to be transported to fish-bearing streams. RCAs surrounding HLDP streams are intended to ensure landslides provide an ecological benefit and impacts on Oregon Coast coho are reduced as described in Chapter 4, Section 4.6, *Effects Analysis for Oregon Coast Coho*. Non-fish-bearing non-perennial streams that are not HLDP streams—referred to as XNFB streams—do not have designated RCAs; rather, equipment limitation zones (ELZs) apply to a portion of XNFB streams meeting Oregon FPA stream type definitions (Section 3.3.7.3, *Equipment Limitation Zone*, provides more information on ELZs). Stream model output (TerrainWorks 2021) will be used during harvest layout planning; however, siting of the actual RCAs will be determined through field verification.

3.3.7.2 Variation in Widths of Riparian Conservation Areas

The size and configuration of the RCAs are intended to maintain and enhance ecological process in the RCAs. In the CRW and MRW Reserves, except for the restoration thinning that is allowed, there is significant protection of the aquatic ecosystems specifically coho-bearing streams and their associated ecological processes (Appendix E, *Wood Modeling*). The RCA widths presented in Table 3-2 reflect the described wood recruitment strategy.

Table 3-2. Widths of Riparian Conservation Areas by Stream Type and Adjacent Allocation

Stream Type [a]	Adjacent Allocation	Width (feet) [b]
Fish-bearing (FB)	CRW MRW Volume Replacement, Flexible Extensive (in Big Creek subwatershed), and all allocations along the Lower Millicoma River mainstem	200
	MRW Flexible, Flexible Extensive (outside of Big Creek subwatershed), and Reserves, Extensive, and Intensive in the MRW Lower Millicoma River subwatershed (nonmainstem)	120
	MRW Reserves, Extensive, and Intensive (outside of the Lower Millicoma subwatershed)	100
Perennial non-fish-bearing (PNFB)	CRW Reserves MRW Volume Replacement, and Flexible Extensive (in Big Creek subwatershed)	200
	All Other MRW Allocations	50
High landslide delivery potential (HLDP) [c]	CRW Reserves MRW Volume Replacement, and Flexible Extensive (in Big Creek subwatershed)	200
	All MRW Allocations in the Lower Millicoma subwatershed	120
	All Other MRW Allocations	50
Non-fish-bearing non-perennial (XNFB) [d]	All allocations	0

[a] Stream types are defined based on fish presence, perenniality, and susceptibility to landslide-associated debris flows that deliver wood and sediment to fish-bearing streams.

[b] All RCA widths are horizontal distance.

[c] Non-fish-bearing streams that comprise 25% of the total non-fish-bearing channel wood delivery budget to fish-bearing streams.

[d] Non-fish-bearing non-perennial streams that are not HLDP.

3.3.7.3 Equipment Limitation Zone

ELZs along Oregon FPA–designated stream types (OAR 629-600-0100; Type F, SSBT, N, Np, and Ns streams) are intended to protect ecological functionality by limiting ground disturbance from ground-based and cable yarding equipment operation, tethered equipment, shovel-logging, ground-skidding, or similar equipment directly within these zones.[7] This limits equipment operations but does not exclude the direct cutting and removal of trees from this zone. ELZs cover the areas within 35 feet (measured horizontally from the stream channel edge) of the stream types and will be maintained on both sides.

ELZs will comply with the following measures to minimize ground disturbance and associated impact on coho.

- Operators will minimize disturbance from cable yarding and ground-based equipment operations near Oregon FPA–defined streams. When soil disturbances from cabled logging and ground-based operations exceed 20% and 10%, respectively, of the total area in any ELZ associated with an Oregon FPA–defined stream in an operational unit, operators will take corrective actions.
- Disturbed areas will be visually estimated in the field by operators or foresters; a specific monitoring or reporting protocol will not be required for disturbances in ELZs requiring corrective actions. However, disturbance exceedances will be reported as part of annual monitoring efforts and recorded during general compliance monitoring efforts.
- Corrective restoration actions to address disturbance exceedances will be designed to replace the equivalent of lost ecological functions and implemented in a timely manner. Examples include, but are not limited to, water bars, grass seeding, logging slash, mulching, and downed log placement. Onsite materials will be used whenever possible.

ELZ protections will be applied in addition to the protections described for RCAs and steep slopes. Stream model outputs (TerrainWorks 2021) will be used during harvest layout planning; however, siting of the actual ELZs will be determined through field verification.

3.3.7.4 Operational Standards for Restoration Thinning in Riparian Conservation Areas

Vegetative conditions in many parts of the RCAs in the permit area have been altered as a result of past management. Plantings of Douglas-fir plantations following historical timber harvest in the permit area have created dense plantation stands in some areas, including in riparian zones. In other areas, hardwoods are the dominant trees, resulting in a low occurrence of conifers. Restoration thinning treatments in RCAs in the CRW and MRW will be applied on up to 1,200 acres of these dense plantations 65 years old or younger (as of 2020) as part of a research effort designed to support and enhance the long-term ecological functions of the RCAs. During treatment, the RCA widths presented in Table 3-2 will be maintained. Existing older (greater than 65 years as of 2020), mature riparian stands will not be treated but rather conserved as they move through natural successional processes. No intensive stand replacement management will be conducted within RCAs.

[7] ELZs are not required on XNFB segments that do not meet the Oregon FPA–defined stream type definitions for Type F, SSBT, N, Np, and Ns streams.

Up to two restoration thinning entries per stand may occur on up to 50% of the 1,200 acres of RCAs over the course of the permit term. The remaining 50% would be single-entry thins. The second round of thinning, where needed, will be part of moving the research forward using what was learned in the first round of experiments. Varying densities of thinning may occur, with the requirement to maintain a minimum density of 40 square feet of conifer basal area per acre, focusing retention on the largest of existing trees on the site or those with the greatest likelihood to enhance the long-term ecological functions of the RCAs.

RCA thinning in the CRW is subject to the 30-year standard described in Section 3.3.1, *Conservation Research Watersheds and Management Research Watersheds Reserve Allocations*. That said, it is expected that 60 to 70% of the potential sites, concentrated in the CRW, will be treated in the first 20 years of the permit term. RCA stands older than 80 years (at the time of any considered thinning) are not eligible for thinning without prior discussion with and concurrence of the Services pursuant to Chapter 7, Section 7.6, *Modifications to the Habitat Conservation Plan*. Thinning of RCAs in the MRW are not subject to the 30-year limitation (Section 3.4.2.2, *Riparian Conservation Areas*) but would adhere to the limitation on number of entries and 80-year stand age limit.

RCA thinning on slopes greater than 40% will be completed predominantly with hand felling methods; this represents approximately 63% of all RCAs in the permit area. Ground-based equipment may be used on slopes less than 40%, but hand felling will be used whenever possible. There will be no removal of thinned trees from RCAs[8] on HLDP streams (as defined by OSU modeling). Yarding of trees in RCAs may be accomplished by cable yarding, using tethered equipment, shovel-logging, ground- skidding, or similar equipment as described in Section 3.3.7.3, *Equipment Limitation Zone*. Any cable yarding across fish-bearing, large or medium non-fish-bearing streams, lakes, or significant wetlands would be accomplished by swinging yarded materials free of the ground in aquatic and riparian areas per OAR 629-630-0700(4).

Chapter 5, Section 5.4.1, *Conservation Measure 1, Targeted Restoration and Stream Enhancement,* provides additional details and limits on restoration thinning in RCAs. RCA thinning and related research would be coordinated through review by the Implementation and Adaptive Management Committee (Chapter 7, Section 7.2.4, *U.S. Fish and Wildlife Service and National Marine Fisheries Service*), and deviation from limits described under this covered activity or Conservation Measure 1 would be permitted only based on Implementation and Adaptive Management Committee adaptive management review and concurrence by NMFS in accordance with Chapter 7, Section 7.6, *Modifications to the Habitat Conservation Plan*.

The objective of restoration thinning in RCAs is to support the development of key ecological processes for coho that are associated with healthy riparian forests. OAR 340-041-0004(5)(a), outlines exemptions from the antidegradation rule (340-041-0004) for certain activities that may cause temporary water quality degradation but also provide environmental benefits, which applies to RCA thinning projects.

[8] An exception to this is a limited opportunity for selective removal of cedar trees greater than 65 years old (as of 2020) for Indigenous cultural practice, as permitted by the Permittee under certain circumstances for Tribes with ancestral connections to the ESRF (Section 3.8, *Indigenous Cultural Use of Cedar Trees*).

3.4 Harvest Timing, Types, and Methods

Harvest types and methods include the full suite of thinning and harvest techniques used in contemporary forestry. In addition, new techniques may be established, even on an experimental basis, as part of implementing a research program. In general, the HCP covers a variety of harvest types including precommercial and commercial thinning, retention harvests, and regeneration harvest. Stand age described in this HCP is based on the 2021 LiDAR data, which represents best available science. However, there is the potential that some stands ages are incorrect. Field-verified stand ages, when collected, will be used during implementation and data layers will be updated to reflect actual age.

3.4.1 Projected Timing and Amount of Harvest

The following limits apply to acres sold (contracted) for commercial harvest by treatment type and timeframe. These limits are approximations that do not account for changing habitat conditions due to naturally occurring events (e.g., fire, insect infestation). Timber sales from all treatments (Section 3.3, *Stand-Level Treatments and Operations Standards, by Allocation*) may not exceed 1,000 acres per year based on a 4-year rolling average of contracted sales. Of the 1,000-acre cap, no more than 480 acres per year may be from regeneration harvests as part of intensive treatments (Section 3.4.2.1, *Regeneration Harvest*) in Intensive and Flexible allocations (Sections 3.3.2, *Intensive Allocations,* and 3.3.4, *Flexible Allocations*). It is intended that a mix of treatment types (i.e., intensive, extensive, and restoration treatments) occur annually within this 1,000-acre cap as part of operations planning. This 1,000-acre overall limit would apply unless otherwise agreed upon with the Services, pursuant to adaptive management, described in Chapter 6, *Monitoring and Adaptive Management,* in accordance with Chapter 7, Section 7.6, *Modifications to the Habitat Conservation Plan,* and in consultation with the Implementation and Adaptive Management Committee (Chapter 7, Section 7.2.4, *U.S. Fish and Wildlife Service and National Marine Fisheries Service*), in the context of the ESRF Forest Management Plan and biennial operations planning process.

In addition, there is a demonstrated need to implement ecological-based restoration thinning of plantation stands 65 years old or younger (as of 2020) in the CRW and MRW Reserves and RCAs to facilitate the development of mature, complex forest stands to enhance covered species habitat and ecosystem services. Addressing this restoration need is especially relevant in the early decades of the permit term, and while restoration treatments are intended to be part of the overall treatments advanced within the 1,000-acre annual cap, the scale of the restoration need may be greater. To address this habitat improvement objective, up to 300 additional acres per year of restoration thinnings may be allowed during the first 20 years of the permit term and 200 acres per year of restoration thinnings may be allowed during years 21 through 30. Restoration thinnings beyond this acreage may only occur with approval of the Permittee, concurrence of the Services in accordance with Chapter 7, Section 7.6, *Modifications to the Habitat Conservation Plan,* and consultation with the HCP Implementation and Adaptive Management Committee (Chapter 7, Section 7.2.4, *U.S. Fish and Wildlife Service and National Marine Fisheries Service*).

This provision allows potential additional acres of restoration thinning above the overall 1,000-acre limit set forth for all treatments during the first 30 years of the permit term. The 200- to 300-acre additional restoration thinning provision and the base 1,000-acre cap are intended to not only address restoration objectives on the forest but also to allow commercial thinning in intensive allocations as well as advancement of extensive treatments in a manner that relieves pressure to advance regeneration harvest without thinning, as well as lower-retention extensive treatments. While this additional restoration thinning allowance beyond the 1000-acre cap will expire after the initial 30 years of the permit term, it should be noted that restoration thinnings outside the CRW (i.e., MRW Reserves and MRW RCAs) are not subject to the 30-year time limit, as noted in Section 3.3.1, *Conservation Research Watersheds and Management Research Watersheds Reserves*. However, as also noted in Section 3.3.1 and elsewhere in this HCP, restoration thinnings will not occur in stands that have reached 80 years old (at the time of any contemplated thinning) unless prior concurrence of the Services occurs.

Additional harvest caps are included for restoration thinning within RCAs. RCA thinning will occur in up to 1,200 acres across the permit area over the course of the permit term. At the start of the permit term (5 to 7 years), initial RCA restoration thinning of up to 160 acres will occur in the MRW. Outcomes will be monitored and evaluated (as described in Chapter 6, Section 6.3.4, *Riparian Restoration Monitoring*) to ensure objectives are being achieved and adverse effects on covered species are minimized. The remaining 1,040 acres will be thinned applying knowledge gained from prior restoration thins within the initial 160 acres to ensure the multiple resource objectives for riparian and aquatic habitats can be met.

This use of acres sold (contracted) recognizes that timber sale contracts routinely allow actual harvest to occur over a 3-year period following the sale, at the discretion of the contractor. This standard practice can (and often does) result in a variable number of acres harvested in any given year of a contract. Extension of this 3-year period for contract execution may be sought by the Permittee in concurrence with the Services when unforeseen circumstances arise related to contractor operations. In addition, the research forest design is based on the assumption that the covered activities in the allocations would result in a timber volume outcome of approximately 17 million board feet (MMBF) per year over the permit term (Appendix C, *Proposal: Elliott State Research Forest*). While this may vary annually, the 17 MMBF will be calculated based on a 4-year rolling average of timber sold, with no more than 20 MMBF each year within that 4-year timeframe.

Trees predating the 1868 stand replacement fire on the Elliott will be protected (Section 3.3.3, *Extensive Allocations,* general standard number 4). No more than 3,200 acres of stands older than 65 years as of 2020[9] may receive extensive treatment over the permit term and these stands are not subject to intensive treatments.

3.4.2 Harvest Types

The harvest types described below will be applied to achieve the stand-level treatments, which follow the operational standards described in Section 3.3, *Stand-Level Treatments and Operations Standards, by Allocation*.

3.4.2.1 Regeneration Harvest

The intent of a *regeneration harvest* is to develop a new age cohort.

Intensive Allocations and Flexible Allocations Subject to Intensive Treatments

In areas subject to intensive treatments, the form of regeneration harvest used will be *clearcuts.* Intensive treatments are described in Section 3.3.2, *Intensive Allocations*. A clearcut removes all (or

[9] There will be no harvest of stands older than 65 as part of restoration thinnings.

nearly all) trees in a stand; however, the Oregon FPA requires that a certain number of live trees be retained in each unit, and the Permittee will meet at least these requirements in intensive allocation harvest areas.

Extensive, Flexible Extensive, and Flexible Allocations Subject to Extensive Treatments

In areas subject to extensive treatments, the form of regeneration harvest used will be *variable retention regeneration harvests* as described in Sections 3.3.3, *Extensive Allocations,* 3.3.5, *Flexible Allocations,* and 3.3.6, *Flexible Extensive Allocations*.

3.4.2.2 Thinning

Thinning is used to manage the growth and density of existing stands. Thinning prescriptions vary by stand objective and may be designed to increase the structural complexity of a stand, maximize volume growth, or capture tree mortality. Thinning prescriptions remove a portion of the trees from a stand in a generally uniform pattern, with the exception of restoration thinning, where variable density thinning is used. Variable density thinning is also used in allocations subject to extensive treatments (Section 3.3.3, *Extensive Allocations*). Precommercial thinning is generally conducted in stands between 10 and 20 years old to manipulate the density, structure, or species composition of dense young forest stands, while commercial thinning is a partial harvest of the stand to improve stand conditions and provide revenue. Restoration thinning is used to promote development of forest structure to benefit the covered species and ecosystem services and is not based on harvest-driven or financial objectives as described in Section 3.3.7.4, *Operational Standards for Restoration Thinning*.

The structure of a stand immediately after a thinning (within 1–3 years) is very dependent on both the harvest prescription and the structure of the stand prior to harvest. Generally, the stand structure becomes more complex relative to a dense, Douglas-fir plantation, although it may reduce habitat suitability for some species.

Thinning will be used in all allocations as described below.

Intensive Allocations and Flexible Allocations Subject to Intensive Treatments

In Intensive allocations (Section 3.3.2, *Intensive Allocations*) and areas in Flexible allocations (Section 3.3.5, *Flexible Allocations*) that are subject to intensive treatments, commercial thinning will maintain stand densities at levels that provide vigorous tree growth and maintain high wood production.

Extensive, Flexible Extensive, and Flexible Allocations Subject to Extensive Treatments

In stands subject to extensive treatments (Section 3.3.3, *Extensive Allocations,* and 3.3.6, *Flexible Extensive Allocations*), thinning for commercial or other stand management objectives will set plantation stands on a trajectory to meet the goals and objectives of extensive treatments. These objectives include providing diverse forest characteristics encompassing a range of stand structures, successional stages, ecosystem services, and wildlife habitat features while producing wood products to provide a diverse array of ecosystem goods and services across the forest.

Conservation and Management Research Watershed Reserves

Operational standards Restoration thinning in the CRW and MRW reserves will follow the operational standards described in Section 3.3.1, *Conservation Research Watersheds and Management Research Watersheds Reserve Allocations*.

Riparian Conservation Areas

Restoration thinnings in the RCAs will follow the operational standards described in Section 3.3.7.4, *Operational Standards for Restoration Thinning in Riparian Conservation Areas*.

3.4.2.3 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. Salvage harvest will not occur in CRW and MRW Reserve stands or RCAs, with the following exceptions.

- Limited roadside tree removal needed to maintain public safety, access, and forest operations.
- Roadside tree removal within RCAs could occur; heavy equipment will be contained to the roadbed. Salvaged trees inside RCAs may be removed. RCA retention standards outlined in Section 3.4.2.2, *Thinning,* will be followed.
- Selective removal of cedar trees for Indigenous cultural practices (Section 3.8, *Indigenous Cultural Use of Cedar Trees*).
- If an introduced, nonnative insect or disease is found and removal of dead trees can help control it, removal will be coordinated with the Services in accordance with Section 7.6, *Modifications to the Habitat Conservation Plan*.

Salvage harvest may occur in Intensive, Extensive, Volume Replacement, Flexible Extensive and Flexible allocations consistent with the treatment standards described in Section 3.3, *Stand-Level Treatments and Operations Standards, by Allocation*. In addition, salvage operations will consider the biological legacy of the stand prior to the disturbance event and follow Oregon FPA requirements.

3.4.3 Harvest Methods

The following harvest methods reflect current options for forest management. As a research forest, new technologies will be evaluated and employed as they arise. Harvest methods include 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 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 generally used to fell and buck trees.

- On steep terrain, contractors fell and sometimes buck trees with handheld chainsaws and use tethered feller bunchers.

- Mechanical felling is done by a feller-buncher. These machines are structurally like trackhoes and use an articulated attachment to grab, fell, and bunch the trees with other trees or logs for subsequent skidding (i.e., 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 steep slopes if tethered) 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 use on steep slopes. Tethered assist equipment and other advances in technology allow for ground-based harvest on steeper terrain.

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 is 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.
- Although there will be limited opportunity for use in the permit area due to steep slopes, ground-based yarding is a common technique on flatter terrain. Ground-based yarding involves tracked or rubber-tired tractors (skidders) skidding logs to the landing. Machines can grasp the log using powered grapple attachments or wire rope winch lines. Ground-based 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 chainsaw 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 onto 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 transporting 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 prevent such sediment delivery.

3.4.4 Harvest Environmental Protections

Unless infeasible for reasons of public safety or operational viability, the Permittee commits to implement techniques during timber harvest and site preparation 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 (e.g., limbs, tops, cull logs) is retained to levels that do not prohibit reforestation and do not create an unacceptable fire hazard.

3.5 Supporting Management Activities

The following activities may be implemented to manage stands in support of the covered activities and are also covered by the HCP. When used, they will be integrated into the research program and done as part of research studies, including where relevant to advance research and stewardship partnerships with tribes or other entities consistent with the covered activities and other HCP provisions.

- **Mechanical vegetation control**. Mechanical vegetation control may be practiced in the permit area, both to control invasive weeds along the road system and in forestlands, and to control invasive species that compete with desired species for water and sunlight. Mechanical vegetation control will be performed in accordance with restrictions placed by the Oregon FPA under OAR 629-615-0000 and may include grading, hand cutting, using a brush hog–type mechanical device, steaming, and other experimental methods.
- **Prescribed burning**. Prescribed burns will follow the Oregon FPA requirements under OAR 629-615-0300. Activities would include single or multiple prescribed burns that incorporate Indigenous Knowledge to manage fuels and increase or maintain suitable conditions for species of cultural value to local tribal communities. Prescribed burning of slash piles on landings following harvest, broadcast burning of harvest units for site preparation prior to planting, and/or use of prescribed fire for maintenance of meadows or other habitat may also occur, where appropriate, as part of the research management program. Prescribed burns will not be conducted inside RCAs.
- **Yard and burn slash**. Slash is the residual woody debris that results from timber harvest and thinning. Methods of slash removal include piling and burning, mastication (chipping), and

scattering. Piles may be gathered using heavy equipment or by hand. Slash burning will not occur in RCAs.

- **Tree and shrub planting**. While natural reseeding is likely to be pursued as part of harvest treatments across significant portions of the permit area, trees or shrubs may be planted as part of intensive treatments or when deemed important to restoring native plant diversity, tribal cultural practices, or habitat resilience in the permit area and will comply with the Oregon FPA.
- **Animal control.** Animal control (e.g., mountain beaver) techniques will follow ODFW standards and guidelines and will not involve use of rodenticides.
- **Precommercial thinning and pruning**. Precommercial thinning involves thinning where the trees cut are not sold commercially. Felled trees are typically left on site, although slash may be burned, as described under yard and burn slash.
- **Landings**. Timber harvest requires landings for log hauling, as described in Section 3.4.3, *Harvest Methods*.
- **Helicopters**. Helicopters are not expected to be regularly required for management in the permit area. However, helicopters may be used as part of riparian restoration projects or other projects in remote locations where movement of heavy objects, such as large wood, is required.
- **Small fixed-wing aircraft (e.g., Cessna 185)**. Fixed-wing aircraft may be used infrequently for a variety of purposes, including collection of remote sensing imagery and related data.
- Heavy equipment for road construction, road repairs, bridge construction, culvert replacements, riparian restoration, and supporting infrastructure. Many covered activities related to infrastructure and restoration require the use of heavy equipment.
- **Tree climbing**. Trees may be climbed as part of research and potentially as part of monitoring.
- **Hazard tree removal**. Hazard trees (or "danger trees") are defined as 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 (29 Code of Federal Regulations 1910.266(c)). Hazard tree removal will be a standard safety measure for maintenance of forested roads, trails, and developments, as well as during harvest and thinning operations, where hazard trees may pose a risk to workers.
- **Chainsaws/tree felling**. Chainsaw use and tree felling will be conducted as part of all treatment types.

3.6 Supporting Infrastructure

3.6.1 Road System Construction and Management

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, culverts, and quarries. This category of covered activities also includes the vacating of such facilities. It is not expected that many new permanent roads will be constructed during the permit term because the permit area has an extensive existing road network. Over the course of the permit term, the Permittee commits to construction of no more than 40 miles of new permanent roads, at a rate of up to 1.0 mile of new permanent road per year. There may be some new road spurs constructed to facilitate stand management activities. Up to 2 miles of temporary roads, including road spurs, may be constructed annually. Temporary roads that have not been vacated after 5 years will be considered part of the permanent road network and count toward the 40-mile limit. There may also be some road relocation to disconnect current roads from aquatic features. If a road relocation project results in a net increase in the amount of road, the net difference will be counted toward the 40 miles of new road construction. Any of the activities summarized below could occur during these limited road construction activities.

Road and landing construction typically involves excavating and depositing soil or rock to form a road prism; establishing ditches, culverts, and waterbars to manage surface water; and installing culverts and bridges across streams. Road construction includes the widening, realignment, or modification of existing roads. Road maintenance activities typically include surfacing, grading, erosion control, brush control, ditch clearing, and drainage structure repair or replacement.

Vacating may include removing stream crossing structures and associated fill materials, ensuring proper drainage, mulching or seeding exposed soil, and blocking road entrances through the use of gates, excavation, boulders, or other means.

All road construction, maintenance, and vacating will be performed in accordance with restrictions placed by the Oregon FPA (OAR 629) and other applicable statutes, except in those instances described in Chapter 5, *Conservation Strategy*.

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 Prism (OAR 629-625-0310)
- Water Crossing Structures (OAR 629-625-0320)
- Drainage (OAR 629-625-0330)
- Disposal of Waste Materials (OAR 629-625-0410)
- Stabilization (OAR 629-625-0440)
- Road Maintenance (OAR 629-625-0600)
- Vacating Forest Roads and Water Crossings (OAR 629-625-0650)
- Wet Weather Road Use (OAR 629-625-0700)
- Construction in Wetlands (OAR 629-625-0800)

3.6.1.1 Road Construction

Roads in the plan 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 tractors or excavators. Road construction also commonly involves construction of watercourse crossings that use culverts, bridges, and occasionally fords. Roads also include vehicle turnouts and log landings. Road construction may also involve surfacing soil roads with rock, lignin, pavement, or other surface treatments.

The extent of the existing road system (Chapter 4, Table 4-11) is shown on Figure 3-5. This system is stable, with nominal mileage added or removed each year. The existing road system consists of pervious surfaced roads. The principal foreseeable additions to the system would comprise construction of temporary spur roads to access new cutting units. Typically, spur 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 16 feet would be needed. The total disturbance area of the road, including cut slopes and fill slopes, depends on the steepness of the terrain as well as the type of construction used. These roads would typically be vacated once the unit was replanted.

Similarly, many existing spur roads that served only to access prior cutting units are expected to be vacated. No *primary road* or *secondary road*[10] construction, relocation, or vacating is currently proposed, but it is possible that up to 1 mile per year of primary or secondary road construction will occur under the HCP, with a total of up to 40 miles of new permanent roads over the permit term. All new roads will be sited in the best locations for carrying out anticipated activities, and the standard for forest roads will be a suitable match for the terrain and type of access needed. In addition, new roads will be constructed in the best locations for minimizing impacts on aquatic and riparian systems. Road development in the RCAs will only occur when other alternatives are not operationally feasible, consistent with Oregon FPA standards. Any expansions will be kept to the minimum needed to achieve forest management objectives. Road crossings will be constructed to meet NMFS and ODFW fish-passage requirements.

3.6.1.2 Road Use

Roads in the permit area are primarily ridgetop and used by utility vehicles accessing parts of the forest, heavy equipment (log trucks and heavy equipment trailers), and recreational users in street-legal vehicles on public roadways, along with off-highway vehicles (OHVs) that are not licensed for public roadways. Road use as part of other covered activities, including timber harvest and research traffic, is a covered activity under this HCP. However, recreational activities and infrastructure, including OHV and other recreational use of roads, is not a covered activity (Section 3.10, *Activities Not Covered*). DSL has not developed transportation volume estimates for covered road use as part of the research proposal implementation. However, assuming an annual harvest of 17 MMBF, approximately 3,400 truckloads of wood would be hauled out of the forest annually. Based on the even pace of harvest projected (Section 3.4.1, *Projected Timing and Amount of Harvest*), intensive road use would be spread out as mostly temporary, localized use during active harvest and hauling operations.

[10] *Primary roads* are main line roads that receive a high degree of use either by the public for recreation access, by fire safety personnel, or for hauling forest products. These roads are primary arterial connectors in and out of the forest and receive routine maintenance. *Secondary roads* are lightly trafficked roads that receive periodic public use and occasional use for hauling of forest products. These are either dead-end roads or serve as connectors between primary roads. These roads receive periodic maintenance on an as-needed basis.

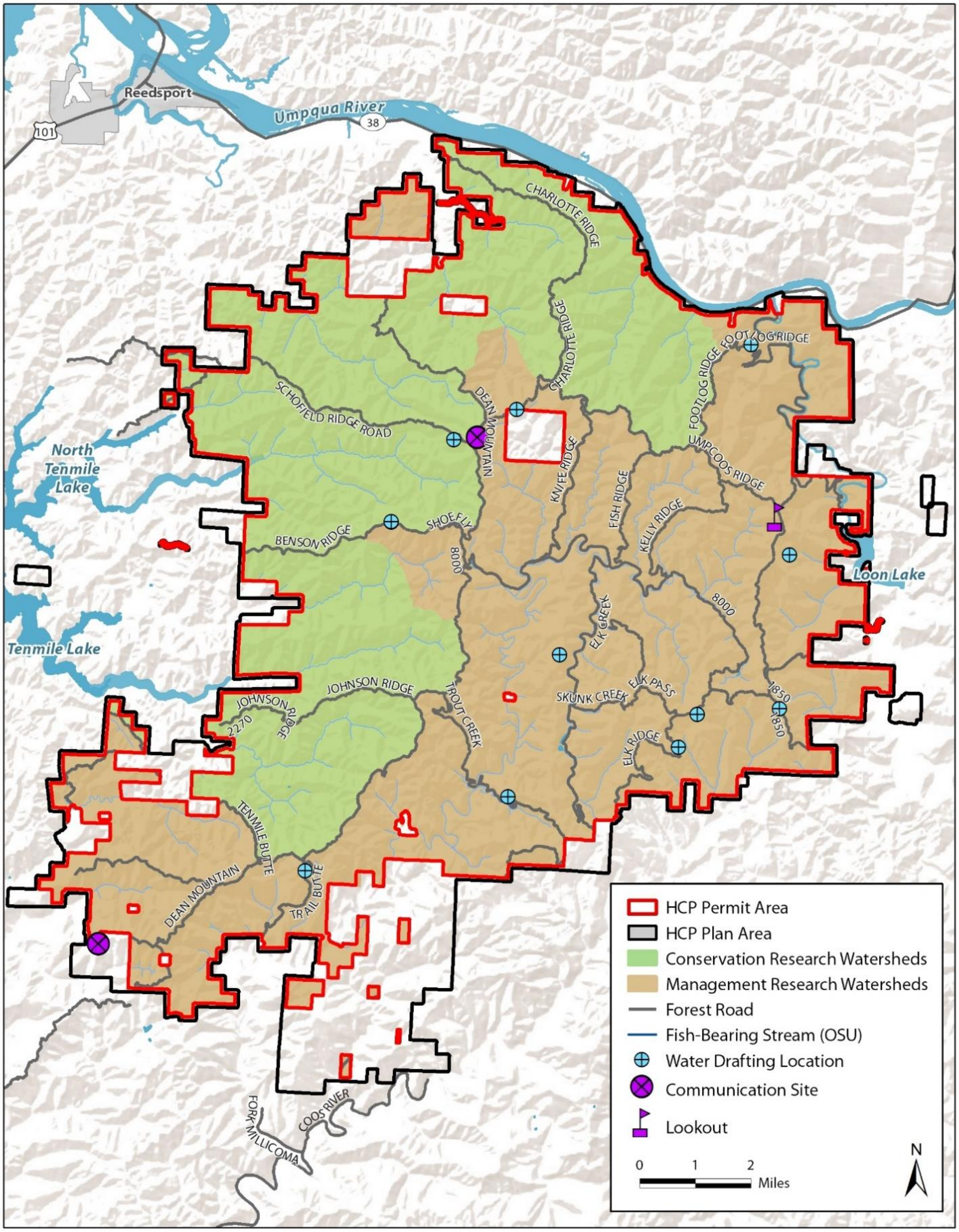


Figure 3-5. Existing Primary Road Network, Water Withdrawal Sites, and Communication and Lookout Sites in and Adjacent to the Permit Area

3.6.1.3 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, repairing slumping or sliding fills, clearing ditches, repairing or replacing culverts and bridges, adding surface material, dust abatement, and installing or replacing surface drainage structures. Road maintenance for fire prevention, public access, safety, and timber management may include mechanical control of roadside vegetation. Mechanical control may include grading, hand or mechanical cutting, using a brush hog–type mechanical device, steaming, and other experimental methods.

3.6.1.4 Road Daylighting

The objective of road "daylighting" is to have sunlight exposure to evaporate moisture from the road so it is less susceptible to erosion and damage from vehicle traffic. The area along a forest road has some trees removed through harvesting, cutting, mulching, or another option available at the site. Daylighting also promotes the establishment of protective vegetative cover on road fill slopes and cut slopes and provides vegetation for wildlife. The open canopy minimizes roadside crown and ladder fuels, reducing wildfire risk and improving line-of-sight visibility for public safety. Existing roads in RCAs are limited, with 0.5% of the existing road network occurring within 100 feet of a fish-bearing stream. Road daylighting will not remove stream-adjacent trees that are providing shade to the stream and therefore protecting the stream against water temperature increase.

3.6.1.5 Road Vacating

Vacating roads refers to the process of making a road impassable and effectively closed, including stabilizing the roadbed surface and removing stream crossing structures and associated fill materials, and may include ensuring proper drainage, mulching or seeding exposed soil, and blocking road entrances through the use of gates, excavation, boulders, or other means.

Roads may be vacated if deemed nonessential to near-term future management plans, where access would cause excessive resource damage, or where existing resource concerns or ecological values including hydrologic connectivity can be improved. The Permittee will use the road study to determine which roads to vacate. Vacated roads are left in a condition that is stable and provides adequate drainage. Vacating roads is a covered activity under this HCP.

3.6.1.6 Drainage Structures

Installation, maintenance, and removal of drainage structures is a covered activity. Such structures are normally associated with roadways and include channel-spanning structures (culverts and bridges), roadside drainage ditches, and cross-slope drainage culverts. All new structures are installed and maintained in accordance with all applicable laws and regulations. Culvert replacements will be carried out according to NMFS fish passage design criteria (National Marine Fisheries Service 2022b). If adhering to fish-passage standards is not feasible due to site-specific constraints, the Permittee will coordinate with NMFS to design an acceptable fish passage solution.

Under certain conditions, natural hazard response may be needed to complete an unplanned, immediate, or short-term repair of a road or culvert. These include in-water repairs that must be made before the next in-water work period to resolve critical conditions that, unless corrected, are likely to cause loss of human life, unacceptable loss of property, or natural resources. Natural hazards in this context may include, but are not limited to, a flood that causes scour erosion and significantly weakens the foundation of a road or bridge; culvert failure due to blockage by fluvial debris, overtopping, or crushing; and ground saturation that causes debris slide, earth flow, or rock fall to cover a road. These actions could be taken outside of ODFW defined in-water work windows to prevent damage to property and life. To the extent practicable, measures will be taken prior to any response to limit impacts on coho and its habitat including, but not limited to, removal and relocation efforts. NMFS will be notified as soon as possible prior to any emergency response and a post-action report will be provided that includes a description of the work performed, as well as an assessment of its effects on coho and its critical habitat. If actions in response to natural hazard conditions do not meet NMFS or ODFW fish-passage design standards or Oregon FPA road design standards at the time of the emergency repair, then follow-up actions will occur so that the structure meets design standards once the appropriate in-water work window is available.

Barrier Upgrade and Removal

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 populations (O'Hanley and Tomberlin 2005). Removing or improving fish passage barriers in the permit area will benefit the covered species by increasing access to previously unavailable or underutilized habitat.

There are currently three blocked culverts and two partially blocked culverts identified in the permit area, with most of these overlapping the Coos independent population (Oregon Department of Fish and Wildlife 2019c; Chapter 2, Table 2-8). There are also two barriers classified as "other" in the Coos population, which could be fords, weirs, debris jam, or an unknown type. Approximately 2 miles of additional modeled fish habitat is available in the permit area upstream of impassable culverts and 3.5 miles upstream of partially blocked culverts; roughly 1.56 miles of stream exists upstream of the "other" passage barriers types (Chapter 2, Table 2-9). Over the course of the permit term artificial barriers will be upgraded or removed to increase the amount of habitat accessible to coho salmon. Over the course of the permit term up to 50 culverts or bridges are expected to be repaired, replaced, or constructed, resulting in in-water work. No more than three bridges or culverts will be installed/upgraded in a single year. Any new and replaced stream crossings will be designed to meet current NMFS and ODFW passage criteria to maintain upstream and downstream fish passage. Culverts will be located and inventoried as part of the roads study and encountered during harvest, riparian, or thinning treatments. By the end of the permit term there will be a net increase in accessible habitat/stream miles that were previously inaccessible due to human-induced barriers in the permit area. The location of barrier improvement(s) will be informed by the road assessment and determined in conjunction with the Services, watershed councils, and Implementation and Adaptive Management Committee (Chapter 7, Section 7.2.4, *U.S. Fish and Wildlife Service and National Marine Fisheries Service*).

3.6.1.7 Landings

Landings are the sites to which felled logs are yarded, processed, and loaded onto trucks. Construction, maintenance, and vacating of landings use the same techniques, are subject to the same regulatory constraints, and typically occur at the same times as those described for road construction, maintenance, use, and vacating. Due to the adjacency of reserves to Extensive and Intensive allocations, landings may be located in reserves in order to conduct harvest in those adjacent harvest units. Typically, a landing area takes up no more than 2% of a given harvest unit.

3.6.1.8 Water Drafting and Storage

There are water developments throughout the forest (Figure 3-5), which provide a water source for firefighting or for filling water trucks that may be on standby during prescribed burning. Some water is used for chemical mixing. The water developments are all located at springs and have been in place for many years. No new water developments are planned or covered as part of this HCP. Maintenance of existing water developments, including brushing for access, maintaining the integrity of the basin, and removal of debris or sediment are covered activities. All water maintenance and abandonment will be performed in accordance with restrictions placed by the Oregon FPA (OAR 629) and other applicable statutes.

3.6.2 Quarries

As noted in Chapter 2, *Environmental Setting*, the only surface rock outcropping in the plan area is Tyee Formation sandstone, which is too soft to be useful in road surfacing. One quarry currently exists in the permit area (Figure 3-5) and is used as a source of rock slope protection material; up to two such quarries could be built and operational during the permit term. New quarries would only be developed in the MRW. Quarry development includes the use of drills, explosives, bulldozers, loading equipment, and trucks. Quarries typically remain active for several years. Quarry siting and operations are compliant with requirements of the Oregon FPA (OAR 629-625-0500) and other applicable statutes. Any new quarries would be constructed outside of CRW and MRW Reserves and RCAs.

3.6.3 Communication Sites and Lookouts

There are two communication sites and one lookout that are leased on the Elliott State Forest to the Oregon Department of Transportation/Oregon State Police and Coos Forest Protective Association (Figure 3-5). These sites periodically need maintenance to remain functional. This maintenance can consist of clearing of vegetation, including trees and shrubs, and will be overseen by the Permittee. To protect against impacts from wildfires and to retain reliable communications in the event of emergencies, there will be 500-foot fire breaks constructed around each of these sites, particularly the Baldy Butte communication site on the southwest end of the forest.

3.7 Potential Research Projects

Types of potential short- and long-term research projects that could occur in the permit area are described by OSU (Appendix C, *Proposal: Elliott State Research Forest*). Research activities are divided into two types: active and passive. Active research would occur within the treatment types and include physical manipulation of the landscape or resources that may result in altering habitat for covered species. It could also include direct contact with covered species. Passive research is not a covered activity (Section 3.10, *Activities Not Covered*).

3.8 Indigenous Cultural Use of Cedar Trees

Cedar trees provide source material for cultural practices, including canoe building, housing or ceremonial space building, and basket weaving. Cedar restoration will be integrated into the priorities for RCA thinning and related riparian habitat restoration (Section 3.4.2, *Harvest Types,* and Section 3.9, *Conservation Strategy and Habitat Conservation Plan Implementation Activities*) through approaches to site selection for RCA thinning, as well as tree replanting and/or retention strategies.

The covered activity is the removal or selective use of individual cedar trees over 65 years of age (as of 2020) over the course of the permit term for indigenous cultural practice. Cedar tree use includes bark peeling and/or tree removal. Uses are limited to cultural purposes such as canoe building, providing material for plank houses and stakes for ceremonies, basket weaving, or other cultural practices specified by an indigenous entity's application to the Permittee.

The following specific restrictions on Indigenous cultural practices involve cedar trees.

- **Permit process.** This activity will be permitted based on receipt (by the Permittee) of an application[11] from an eligible entity demonstrating compliance with the HCP.
- **Eligible entities.** Tribal governments or related indigenous entities with ancestral connections to the permit area.
- **Eligible geography.** All allocations in the permit area.
- Purposes, thresholds and limitations:
    - Cedar use and removal may not be conducted for commercial sale.
    - 80 trees could be removed over the course of the permit term within RCAs; additional individual trees from outside RCAs could also be used if consistent with:
        - Sustainability and forest structure objectives for cedar in the permit area (including cedar inventory data development).
        - Location within areas or instances of:
            - Blowdown/windthrow, tree mortality from wildfire or other factors.
            - Roadside clearing, construction, or maintenance.
            - Management to address human safety protection.
            - Planned research or other treatments in the allocations in the permit area (e.g., extensive, intensive, restoration thinning) where the tree removal would not be inconsistent with retention or other objectives for the planned treatment.
        - Exclusion from removal if a tree is:
            - Within marbled murrelet occupied habitat or northern spotted owl core area, unless, with concurrence from the Services, removal of the tree would not result in take.
            - Situated on a landslide-prone slope, and the Permittee determines removal of the tree would likely destabilize conditions and promote landslide effects.
            - Leaning or situated in a manner that it is likely to become an instream log in the near future.

[11] An application process will be established for receipt of applications through biennial operations planning or other process avenues.

- In order to address the range of potential cultural uses, tree size would not be limited, but tree selection would be limited by compliance with the above criteria.

3.9 Conservation Strategy and Habitat Conservation Plan Implementation Activities

Conservation strategy and HCP implementation activities are activities required as part of the HCP's conservation strategy (including the monitoring and adaptive management program) and that have potential to result in take of one or more of the covered species. Most of the activities related to the conservation strategy involve the same covered activities that have been detailed in previous sections but that are applied for conservation purposes. All operations standards described in Section 3.3, *Stand-Level Treatments and Operations Standards, by Allocation,* apply to covered activities related to conservation strategy and implementation and are not repeated here. Refer to Chapter 5, *Conservation Strategy,* Chapter 6, *Monitoring and Adaptive Management,* and Chapter 7, *Implementation and Assurances*, for additional details.

3.9.1 Riparian Restoration and Stream Enhancement

Riparian restoration and stream enhancement projects will include wood placement, which may involve tree cutting for source wood, and fall and leave trees cut in RCAs (Section 5.4.1.2, *Riparian Vegetation Management in RCAs*). Cutting of source wood for stream enhancement projects will most often be conducted in conjunction with upland harvest projects but may be conducted locally for site-specific needs, following all applicable operations standards.

Riparian restoration and stream enhancement projects will occur directly in stream channels and adjacent floodplains. Equipment such as helicopters, excavators, dump trucks, front-end loaders, full-suspension yarders, and similar equipment may be used to construct projects. Given the novel approach proposed for ELZ restoration, an initial 5-year assessment of short-term impacts will be undertaken as described in Chapter 6, Section 6.3.4, *Riparian Restoration Management,* prior to proceeding with the larger RCA restoration effort.

Beaver habitat projects may also be implemented to improve riparian habitat functioning in the few areas of potential locations for beaver dams present in the permit area. Projects may include installation of a beaver dam analog or habitat enhancement through selective thinning and possibly tree and other plantings. Equipment used may include a wide variety of vehicles, heavy equipment, and powered and nonpowered hand tools. As described in Chapter 5, Section 5.4.1, *Conservation Measure 1, Targeted Restoration and Stream Enhancement,* all beaver habitat projects will be coordinated with regional partners, ODFW, and the Services to ensure beaver management actions fit into the larger context of salmonid recovery and statewide beaver management principles.

Riparian restoration and stream enhancement may also include road vacating, which is described in Section 3.6.1.5, *Road Vacating*. Road work specific to both aquatic and upland restoration is also described in the following section.

3.9.2 Road Restoration and Network Reduction

Road restoration and network reduction efforts described in Chapter 5, *Conservation Strategy,* involve the same activities previously described in Section 3.6.1, *Road System Construction and Management.* This includes road vacating, daylighting, and drainage improvement.

The covered activity for road restoration and network reduction involves activities identical to those described under Section 3.6.1, including use of heavy equipment, soil disturbance, and potentially in-water work. These activities include the following.

- Road relocation/redesign
- Vacating of roads that are degrading the aquatic environment
- Road barrier upgrade and removal
- Reduction of road drainage to stream
- Culvert or stream crossing upgrades (repair unstable crossings)
- Traffic reduction (unpaved roads)
- Increasing surface material thickness or hardness with crushed rock or paving

3.9.3 Research on Oregon Coast Coho Salmon and Their Habitat

The permit area provides excellent opportunities to develop better scientific understanding of the effects and biological response of natural and human-caused disturbances in forest landscapes. Research conducted in the permit area could evaluate the effects of different forest treatments on Oregon Coast coho ESU health, its populations, and habitat parameters important to the species. The coho-related potential research focus in the permit area is described in Appendix C, *Proposal: Elliott State Research Forest,* and may include, but not be limited to, water quality and quantity, and landscape disturbances such as landslides, debris flows, fires, and different types of harvest regimes to determine how these actions affect Oregon Coast coho and its habitat. Most of the specific activities required to conduct such research have already been described in conjunction with the research design.

As described in Section 3.3.7.2, *Variation in Widths of Riparian Conservation Areas*, specific size and configuration of the different RCA components in the respective stream types depends on the level of potential wood delivery needed to attain the outcomes-based wood recruitment objective, by independent coho population. Modeling and monitoring will ensure that the RCAs employed in the MRW are adequate to achieve Objective 3.1 for each independent population of Oregon Coast coho ESU (Chapter 6, *Monitoring and Adaptive Management*). The use of RCAs could allow researchers to test the effectiveness of buffer combinations relative to tradeoffs with other social and ecological attributes, such as habitat, accessibility, and fiber yield on Oregon Coast coho ESU. Several different wood recruitment strategies, all of which meet the biological goals and objectives, could allow experimentation to test buffer effectiveness and tradeoffs with other values, and their effects on and benefits to Oregon Coast coho ESU. Wood recruitment will be tracked as part of the monitoring and adaptive management plan described in Chapter 6.

The Implementation and Adaptive Management Committee, described in Chapter 7, Section 7.2.4, *U.S. Fish and* will participate in research and monitoring planning conversations as they pertain to coho and its habitat.

Monitoring of coho salmon in the permit area will occur as part of the research design to evaluate effects of the various treatments on the population using various demographic measurements. For example, juvenile coho density will be monitored in streams subject to RCA thinning (treatment) as well as untreated streams (controls). These stream reaches would likely be monitored prior to and following treatment for a predetermined amount of time based on the research design. Only reaches with gradients less than 6% would be sampled as coho do not occupy reaches in steeper areas. No more than 10,000 square meters will be sampled annually and will likely be equally split among treatment and control reaches. Sampling for coho will be conducted via electrofishing by qualified and trained biologists, and NMFS (2000) electrofishing guidelines will be adhered to during all sampling activities. Sampling will occur during ODFW designated in-water work windows (Oregon Department of Fish and Wildlife 2023), which ensure juvenile coho are exclusively sampled because other life stages are not present. If sampling needs to occur outside of established work windows, appropriate approvals from ODFW and NMFS will be required. All sampled juveniles will be anesthetized, weighed, and measured before being released back into the sampled stream. All sampled juveniles will be recorded and reported as part of the reporting requirements for this HCP.

3.9.4 Research on Northern Spotted Owls and Marbled Murrelets and Their Habitat

Research on northern spotted owls, marbled murrelets, and their habitat could be conducted to explore methods for increasing the likelihood of achieving old forest structure, increasing species diversity, and creating complex early seral forests from dense, young (65 years old and younger as of 2020), single-species plantations. This approach takes advantage of recent findings from various studies that investigated the possibility of accelerating development of late-successional stand structures and compositions (Bauhus et al. 2009), including demonstration of ecosystem management options, density management studies, young stand thinning diversity studies, and others (for a summary of studies, see Monserud 2002; Poage and Anderson 2007; Puettmann et al. 2016).

This research would be conducted using the covered activities described previously, including thinning and regeneration harvest of plantations and associated experiments to study alternative approaches to accelerating old forest structure and habitat for northern spotted owls and marbled murrelets. Some research on northern spotted owls and marbled murrelets could also involve tree climbing. An Implementation and Adaptive Management Committee will participate in research and monitoring planning conversations as they pertain to northern spotted owls and marbled murrelets and their habitat.

Research that would require handling of individual northern spotted owls or marbled murrelets or other potentially harmful activities are not covered activities because the specific methods, intensity, frequency, and duration of such activities have not yet been defined at the level needed to identify effects and issue take permits. ESA compliance for research that requires handling of northern spotted owls or marbled murrelets will be conducted under an approved scientific collectors' permit; take associated with those activities will be tracked to the collectors permit and not the HCP.

3.9.5 Habitat Enhancement for Northern Spotted Owls and Marbled Murrelets

The research design includes conducting treatments and experiments to restore and enhance conservation value in established plantations by transitioning stands to older, more complex forests, as well as accelerating the development of other stands into habitat for northern spotted owls and marbled murrelets. These treatments may occur in any of the allocations but will be very limited in Intensive allocations and are most likely to occur in CRW and MRW Reserve allocations, with limited use in other allocations. Habitat enhancement would involve covered activities already described—including commercial and precommercial thinning (Section 3.4.2.2, *Thinning,*) and associated temporary roads, landings, and equipment (Section 3.6.1, *Road System Construction and Management*). All stand-level operations standards described previously apply (Section 3.3, *Stand-Level Treatments and Operations Standards, by Allocation*).

The Implementation and Adaptive Management Committee will participate in research and monitoring planning conversations as they pertain to enhancing northern spotted owl and marbled murrelet habitat.

3.9.6 Survey and Monitoring Requirements

Some conservation measures described in Chapter 5, *Conservation Strategy,* require pre-harvest surveys for northern spotted owls and marbled murrelets. In addition, as detailed in Chapter 6, *Monitoring and Adaptive Management,* HCP implementation includes multiple monitoring activities to determine compliance with the HCP and effectiveness of conservation measures. The following provides an overview of survey and monitoring activities covered by this HCP.

- **Turbidity monitoring.** The Permittee will install paired turbidity monitors upstream and downstream of a representative sample of roads that cross a fish-bearing stream and/or RCA thinning units to monitor changes in instream turbidity following the construction of new, and maintenance of existing, haul roads. See Chapter 6, Section 6.3.1, *Turbidity Monitoring*, for more detail.
- **Water temperature monitoring.** Recording thermographs will be placed in key watersheds where data will help address water temperature questions at the coho independent population level. See Chapter 6, Section 6.3.2, *Water Temperature Monitoring*, for more detail.
- **Instream habitat monitoring.** Stream monitoring will be generally consistent with Hankin and Reeves (1988), which is a continuous survey of habitat units along the entire length of the sampled stream. Surveys involve walking in the stream channel and taking measurements using instruments. Monitoring may include insect searches, which may require some movement of substrates. See Chapter 6, Section 6.3.3, *Instream Habitat Monitoring*, for more detail.
- **Riparian restoration monitoring.** The Permittee will assess a limited area of initial RCA thinnings along fish-bearing and non-fish-bearing streams to assess effects of RCA management. Monitoring will be similar to what is described previously for instream habitat monitoring. See Chapter 6, Section 6.3.4, *Riparian Restoration Monitoring,* for more detail.
- **Landslide monitoring.** The Permittee will inventory landslides in the permit area via remote sensing tools (e.g., satellite imagery, LiDAR) and geographic information systems (GIS) and direct reporting. See Chapter 6, Section 6.3.5, *Landslide Monitoring*, for more detail.

- **Terrestrial habitat monitoring.** The terrestrial monitoring methods will rely on the most current scientifically accepted protocols. In general, these will involve a combination of desktop activities such use of remote sensing tools (e.g., satellite imagery, LiDAR) and GIS and stand-level data collection. Stand-level surveys generally involve a surveyor walking through a stand and measuring forest attributes via sample plots or transects. See Chapter 6, Section 6.4.1, *Habitat Monitoring*, for more detail.
- **Northern spotted owl monitoring.** One-third of the 22 northern spotted owl sites in the permit area will be monitored each nesting season; therefore, all of the historic nesting territories will be monitored every 3 years. Searches for new northern spotted owl nest sites will be completed in the same one-third of the forest where nesting activity surveys are being completed in a given year. Northern spotted owl survey methods will follow USFWS-accepted methods, which are currently conducted by trained surveyors playing back recorded calls to elicit responses from northern spotted owls. Automated monitoring units will also be installed as part of the monitoring effort and could be used for monitoring, should that method prove effective. See Chapter 6, Section 6.4.4.1, *Northern Spotted Owl*, for more detail.
- **Marbled murrelet monitoring.** Monitoring of marbled murrelets will be conducted using passive acoustic sampling, as described by Borker et al. (2015). Until it can be established that acoustic sampling accurately detects occupied areas, and until such protocols for such passive surveys are accepted by USFWS, field surveys following standard USFWS-accepted survey protocols (currently Pacific Seabird Group 2024a,b) will be used to verify acoustical surveys or to calibrate automated systems. Monitoring will be prioritized in modeled potential habitat and in stands that are developing into habitat for marbled murrelets, due to either active or passive management. See Chapter 6, Section 6.4.4.2, *Marbled Murrelet*, for more detail.

3.9.7 Barred Owl Management and Research

The Permittee will collaborate with USFWS as well as other federal and state management agencies to design and implement appropriate barred owl management in the permit area in support of federal management strategies for northern spotted owl. In addition, the Permittee will work to coordinate with adjacent and/or nearby landowners and management agencies on a potential broader-scale approach where barred owl management outside the permit area can assist barred owl management in the permit area, and vice-versa.

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.

The Migratory Bird Treaty Act and other state and federal legal compliance associated with barred owl management and research will be obtained separately as needed. Take of barred owl associated with management activities will be tracked to the collectors permit and not the HCP.

3.10 Activities Not Covered

Some activities are not covered under the HCP because they do not meet the criteria described in Section 3.1, *Introduction*, including activities that are outside the control of the Permittee. In addition, for some activities, such as recreational activities and infrastructure, there are insufficient details regarding their intensity, duration, location, and extent, as planning is still underway as part of the Forest Management Plan effort. ESA compliance for activities not covered will be achieved through either take avoidance or through an amendment of the HCP and ITP (Chapter 7, Section 7.6.2, *Permit Amendments*).

The following activities are not covered under this HCP.

- **Recreational activities and infrastructure.** Recreational activities are not a covered activity under this HCP. Recreation use is a year-round activity and is unrestricted except in cases where roads are gated and locked to limit access to capital facilities such as transmission towers. Current information regarding recreational use is limited, but overall use is relatively low due to the remote location and there being no established hiking trails or developed campgrounds. Development of recreational trails and infrastructure has not yet been planned, although recreation is an important aspect of the Forest Management Plan, which will be prepared for consistency with the HCP, and any additional ESA permit coverage would be obtained, as needed through an amendment of the HCP and incidental take permit (Chapter 7, Section 7.6.2, *Permit Amendments*). 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, firewood harvesting, hiking, swimming, and wading. DSL assumes that these activities in the permit area would follow all applicable state regulations (e.g., hunting and fishing licenses, all-terrain vehicle [ATV] permit).
- **Firewood collection.** Firewood collection would occur under a DSL-issued permit. Permits restrict collection to downed trees and roadside debris within 10 feet of road shoulders and landings, or within 25 feet of recent clearcut units. Debris will be kept out of streams, roads, and ditch lines.
- **Grazing permit.** The single grazing lease on the ESRF is 43 acres and 67 Animal Unit Months of riparian meadow in the Big Creek drainage, T23S R 11W Section 6. The lease area is used in conjunction with adjacent private lands and was established to help facilitate winter habitat for elk. It has been under lease since 2007, and the current lease expires in February 2034, and has the option for a 10-year renewal term-putting it out to 2044. The riparian areas in this leased area are fenced, thereby minimizing adverse impacts from cattle or ungulates.
- **Pesticide[12] use.** Pesticide application using either aerial application methods (i.e., fixed-wing airplane, helicopter, unmanned aerial system) or ground-based methods is not a covered activity under this HCP. The Permittee may still apply pesticides in the permit area but will do so in compliance with the ESA through take avoidance.
- **Fire suppression.** Fire suppression is not a covered activity because of the difficulty in defining the extent, location, and intensity of fire and the overall rarity of fire in the moist conditions of

[12] As defined by EPA, a pesticide is any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest, any substance or mixture of substances intended for use as a plant regulator, defoliant, or desiccant, and any nitrogen stabilizer (U.S. Environmental Protection Agency 2024).

the permit area. The last major wildfire in the plan area occurred in 1868 (Coos Bay Fire), which burned approximately 90% of the plan area. Since then, fires in the plan area have been rare and very small (up to several acres), owing to the strong coastal fog and mild maritime climate, low public use (limiting the most common form of ignition), and rapid responses when fires do break out. It is not possible to state the frequency or magnitude of fire suppression activities.

- **Easement use.** Certain parties have easements providing access and use of lands in the plan area. Uses of lands in the plan area by easement holders or other parties who are not representatives of, or contractors to, the Permittee are not covered activities.
- **New water developments.** Water developments for drafting and other uses are all located at springs, have been in place for many years, and are managed by the Coos Forest Protection Association. No additional water developments have been included as covered activities to be accounted for in this HCP.
- **Research involving handling or other disturbance to covered species.** For any research that requires capturing northern spotted owl, marbled murrelet, or other invasive techniques, ESA compliance will be completed separately from this HCP, although specifications may be added to the HCP in consultation with the Services as part of the amendment process described in Chapter 7, *Implementation and Assurances*.
- **Passive research.** Passive research is observational research where the researcher is applying techniques to detect changes in the environment but without physical manipulation of the environment itself. Passive research is not a covered activity because this type of research would not affect covered species in ways that would likely rise to the level of take.
- **Permit coverage.** Use of lands in the permit area by easement holders or other parties who are not Permittee representatives, contractors, or other government or state agencies conducting research or survey activities supporting HCP implementation is not a covered activity.

Chapter 4
Effects Analysis

4.1 Introduction

This chapter presents the analysis of effects of the covered activities on each covered species and their habitat in the permit area. The effects analysis describes 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 covered species that have designated critical habitat in the permit area).

4.2 Regulatory Context

This effects analysis includes mandatory elements of a habitat conservation plan (HCP) and information necessary for the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) (together, the Services) to make their findings for issuance of their permits. Sections of the federal Endangered Species Act (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.*
- Sections 10(a)(2)(B)(ii) and (iv) state that the Services may only issue an incidental take permit (ITP) if, among other requirements, *the applicant will minimize and mitigate impacts 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 *Habitat Conservation Planning and Incidental Take Permit Processing Handbook* (HCP Handbook) (U.S. Fish and Wildlife Service and National Marine Fisheries Service 2016) recommends that an HCP also include information to support the Services' intra-agency consultation process under Section 7 of the ESA. As such, this chapter also includes a cause-and-effect analysis that describes the pathways of how covered activities may affect covered species and associated critical habitat.

4.3 Approach and Methods

4.3.1 Determining and Defining Effects

The effects analysis includes general cause-and-effect analyses to develop habitat-based take estimates to inform the Services' Section 10 process. The approach used in this HCP generally follows the *effects pathway* model described in the HCP Handbook, by which covered activities (Chapter 3, *Covered Activities*) and conservation measures (Chapter 5, *Conservation Strategy*) are subdivided into their individual components that, in total, may be needed to complete the covered activity or conservation measure.

The effects pathway model follows the chain of causation to effects, starting with the covered activities and associated components and stressors to resource needs of the affected species. 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. The effects pathway model is not a quantitative computer model, but rather the HCP Handbook's recommended approach to systematically thinking through effects. Using the effects pathway model helps identify how covered activities may affect species, and this helps determine the source, amount, and type of take.

4.3.2 Methods and Metrics for Calculating Take

The Oregon Department of State Lands (DSL, the Permittee) has determined that proposed covered activities may result in take of one or more of the covered species and, therefore, is applying for ITPs. 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 1532(19)).

The Permittee is seeking an ITP 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 Code of Federal Regulations 17.3).

According to the HCP Handbook, the HCP must include defined units to quantify impacts in terms of taking a number of affected individual animals or acceptable habitat surrogate units in the permit area. These same units are used in the ITP to specify the authorized levels of incidental take.

The Services have found that, in many cases, the biology of the listed species or the nature of the proposed action makes it impractical to detect or monitor take of individuals of the listed species (80 *Federal Register* [FR] 26832). In those situations, evaluating impacts on a surrogate such as habitat, ecological conditions, or similar affected species may be the most reasonable and meaningful measure of assessing take of listed species. A habitat-based approach is a common practice of the Services in biological opinions and in the development of HCPs (U.S. Fish and Wildlife Service and National Marine Fisheries Service 2016). Such is the case for this HCP, where the Permittee has established habitat surrogate units for covered species.

4.3.2.1 Terrestrial Covered Species

For both northern spotted owl (*Strix occidentalis*) and marbled murrelet (*Brachyramphus marmoratus*), surrogate measures of take have been quantified by considering the following categories of effects and associated metrics. Details regarding the assumptions and calculations made to determine these effects and metrics are specified in the *Sources, Types, and Amount of Take* sections for each species.

- **Nest site disturbance.** While known nesting locations would be avoided during critical nesting periods, covered activities could disturb nesting locations of which the Permittee is unaware. The amount of such unintended nest site disturbance is presented in terms of the acres of known or potentially unknown nesting habitat that would be exposed to potentially harmful levels of disturbance during the critical nesting periods, based on USFWS guidelines. This amount is presented in an estimate of total acres per year of adjacent lands that could be exposed to levels that exceed USFWS guidelines.

- **Nest destruction.** As with disturbance, the conservation strategy was developed to avoid or minimize direct destruction of any northern spotted owl or marbled murrelet nest sites, but the potential exists for destruction of nests that the Permittee is unaware of because the monitoring program is not sufficient to provide full "clearance" surveys to document the absence of northern spotted owls. The amount of such unintended destruction of nest sites is presented as the amount of potential nest habitat that could be harvested during the critical nesting period, presented in an estimate of total acres of habitat subject to intensive and extensive harvest over the permit term.
- **Direct mortality.** The Permittee does not anticipate direct mortality due to collisions with vehicles associated with covered activities. However, since such mortality cannot be ruled out over the permit term, the HCP assumes a maximum of such mortality events and includes these elements in the monitoring and adaptive management program.
- **Existing habitat loss.** This metric includes the amount of habitat present, using the habitat definitions described in Chapter 2, *Environmental Setting*, that will be subject to habitat removal or degradation from harvest treatments.
- **Ingrowth habitat loss.** As a long-term plan, the HCP anticipates harvest of habitat that will develop over time. The metric for measuring ingrowth habitat lost is acres, which is presented as maximum amounts of potential habitat that could mature in a model based on 10-year intervals over the permit term.
- **Edge effects (marbled murrelet only).** Edge effects on nesting marbled murrelets (including predation and microhabitat changes) have been measured as a not to exceed limit, using a Habitat Suitability Index (HSI) developed by Oregon State University (OSU).

4.3.2.2 Oregon Coast Coho

For Oregon Coast coho (*Oncorhynchus kisutch*), the take estimate is based on the proportion of each independent population in the permit area and the acres of projected harvest levels and amount of other covered activities in the watersheds that overlap with each independent population in the evolutionarily significant unit (ESU). Habitat effects for each species were evaluated based on the types of treatments allowed in the allocations described in Chapter 3, *Covered Activities*, and shown in Figure 3-1. Across the allocations, there are four categories of treatments and operations standards that can be implemented across the permit area: intensive treatments, extensive treatments, restoration thinning treatments, and no treatment. Within partial subwatersheds, shorter rotations (minimum 50 years) for intensive treatments in Flexible allocations may result in a slight increase in disturbance compared to intensive treatments in Intensive allocations, which would have a minimum rotation of 60 years. Increased effects would be limited and unlikely to notably increase effects compared to intensive treatments in Intensive allocations. Therefore, intensive treatment in Intensive and Flexible allocations are grouped and considered together.

Additionally, there are subwatershed-level retention targets and harvest limits for extensive treatments (20 to 80% of original pre-harvest stand density[1] at the subwatershed level over the permit term) that are consistent across all allocations. Other allocations have more protection,

[1] Stand density prior to initial thinning or harvest under this HCP.

including Flexible Extensive, which could have longer than 100-year harvest rotation, and Flexible, which are considered as subject to intensive treatments. Therefore, extensive treatments in Extensive and Flexible Extensive allocations are grouped and considered together.

The coho analysis considered the research design requirement for each acre of intensive harvest to be matched by an acre of reserve at the subwatershed level in full watersheds. While partial watersheds do not have this requirement, due to their limited acreage (Chapter 3, Section 3.2.2, *Intensive Allocations*) and the harvest caps (Chapter 3, Section 3.4.1, *Protected Timing and Amount of Harvest*) the effects of intensive treatments in partial watersheds are expected to be comparable to those described for intensive treatments in full watersheds.

4.3.2.3 Treatment Acreages by Allocation

The effects analyses presented in Sections 4.4 through 4.6 discuss effects by treatment rather than allocation because the same treatment types occur across multiple allocations. Table 4-1 shows the acreage of each treatment by allocation in the permit area.

Table 4-1. Treatment Acreages by Allocation in the Permit Area

Treatment	Allocation	Acres
Intensive	Intensive	9,912
	Flexible	5,899
	RCA	0
	Total	*15,811*
Extensive	Extensive	10,870
	Volume Replacement	943
	Flexible Extensive	819
	Flexible	801
	RCA	0
	Total	*13,433*
Restoration Thinning	CRW Reserve	7,038
	MRW Reserve	2,164
	CRW RCA [a]	3,013
	MRW RCA [a]	2,906
	Total	*15,121*
No Treatment	CRW Reserve	16,828
	CRW RCA	6,692
	MRW Reserve	9,821
	MRW RCA	3,413
	Flexible	2,187
	Total	*38,941*
All Treatments	Grand Total	83,306

[a] Although allocated to restoration thinning, only 1,200 acres of RCAs could undergo such treatment (Chapter 3, Section 3.3.7.4, *Operational Standards for Restoration Thinning in Riparian Conservation Areas*).

CRW = conservation research watersheds; MRW = management research watersheds; RCA = riparian conservation area

In addition to timber harvest, the quantity of acres affected includes all covered activities that would occur within each designation, as described in Chapter 3, *Covered Activities.*

4.3.3 Determining Impact of Taking

The impact of the taking considers effects with avoidance and minimization measures in place. Beneficial and net effects of conservation actions are described in Chapter 5, *Conservation Strategy*. The impact of taking considers the population-level effect. Per the HCP Handbook, determining impacts of take consists of defining the context, intensity, and duration of take identified. *Context* is the setting in which the impact of the take analysis occurs. *Intensity* is the severity of the impact and is defined in this HCP as the percentage of the independent populations of the ESU affected for aquatic covered species and the quantity and degree to which habitat will be affected for both terrestrial and aquatic covered species. The duration of effects is also considered when determining the impact of the take.

4.3.4 Determining Effects on Critical Habitat

Evaluating effects on critical habitat is not a requirement for an HCP, but DSL is providing some quantified descriptions of anticipated effects on designated critical habitat to inform the public and assist the Services in developing the Section 7 biological opinion.

Critical habitat has been designated in the permit area for Oregon Coast coho, northern spotted owl, and marbled murrelet. 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 and their characterization in species habitat value (based on habitat modeling) and known occupancy. Effects on critical habitat for aquatic species are evaluated by quantifying the extent of effects within designated critical habitat units. No formal determinations of adverse modification are made in this HCP, as such determinations will be made by the Services through their biological opinions.

4.4 Effects Analysis for Northern Spotted Owl

4.4.1 Sources, Types, and Amount of Take

4.4.1.1 Nest Site Disturbance

While known northern spotted owl nesting locations (as identified through monitoring or historic records) will be avoided during critical nesting periods, covered activities could disturb nesting locations that the Permittee has not detected as part of the species monitoring commitments described in Chapter 6, Section 6.4.2.1, *Northern Spotted Owl Surveys*. The HCP monitoring program is not sufficient to provide full “clearance” surveys to document the absence of northern spotted owls according USFWS guidance. Sources of such disturbance would include any noise-generating activities, including timber harvest, thinning, and road work (Chapter 5, Table 5-5).

This effects analysis assumes take could occur through disruption of nesting activities at nest sites that the Permittee is unaware of, resulting in harm (reduced fitness) of young or adult northern spotted owls. Such take could occur in areas subject to intensive and extensive treatments or in reserve thinning units when activities are within the distances believed to cause disturbance (Chapter 5, Table 5-5).

The amount of potential unintended nest site disturbance is presented in terms of acres of known or potentially unknown nesting habitat that could be exposed to potentially harmful levels of disturbance during the critical nesting periods, based on USFWS guidelines (Chapter 5, Table 5-5). Many assumptions are required to make any reasonable prediction regarding the amount of inadvertent nest site disruption that may occur over the permit term. One key factor—the population size of spotted owls and of barred owls (*Strix varia*)—cannot be predicted due to the uncertainty of future population trends for these species in areas outside the control of the Permittee. For this assessment, a conservative estimate has been developed by estimating the extent of covered activities conducted within 65 yards of suitable nesting habitat for northern spotted owl because such activities have the potential to disturb nesting owls, including disturbance that rises to the level of take (known as *disruption*).

Due to the lack of a projected harvest schedule and much uncertainty regarding the timing, location, and extent of harvest and other covered activities, this HCP considers a maximum amount of area that would be subjected to potential disruption effects. Based on the annual acreage harvest cap of 1,000 acres, plus an additional maximum of 300 acres allowed for restoration thinning (Section 3.4.1, *Projected Timing and Amount of Harvest*), and assuming an average harvest patch size of 20 acres, a reasonable expected number of harvest patches per year would be 65. The total area outside of these harvest units but within a 65-yard buffer zone would be approximately 1,200 acres of adjacent lands exposed to potentially harmful disturbance per year (assuming a round configuration for calculation purposes; anything other than a circle would result in slightly more disturbance). This represents the area of potential effects, where essential behaviors of nesting northern spotted owls adjacent to the harvest stands could be disrupted if harvest operations occur during the critical nesting period. The proportion of this disturbance zone that contains suitable habitat actually occupied by unknown (unsurveyed) northern spotted owl nest sites is likely to be lower than these estimates, based on the most recently available information on northern spotted owls on the Elliott State Forest.

In addition to timber harvest, slash burning and prescribed burning for site preparation have the potential to disturb nesting owls if such nest sites have not been discovered during monitoring.

4.4.1.2 Nest Site Destruction

Timber harvest and associated road work are the primary risks to nest site destruction. The HCP strategically prioritizes protecting high-quality habitat at the 22 northern spotted owl sites with recent and long-term occupancy, as detailed in Chapter 2, *Environmental Setting*. The Permittee will permanently safeguard these sites and seasonally protect any nests found via monitoring (Conservation Measure 1). However, there is no commitment to protect habitats around new nest sites identified in post-2016 surveys or during the permit's duration.

As described for disturbance of nest sites, the monitoring program is not sufficient to provide full clearance surveys to document the absence of northern spotted owls. Therefore, this effects analysis assumes take could occur through direct removal of a nest site, either during active nesting or outside of the nesting period. Such effects would result in reduced reproduction success, potential direct mortality of eggs or nestlings, and long-term removal of a site selected for nesting by northern spotted owls. Such take could occur in areas subject to intensive and extensive harvest.

The ITP will authorize the incidental take of nest sites outside of the 22 northern spotted owl sites. Based on the commitments outlined in Chapter 3, *Covered Activities,* and Chapter 5, *Conservation Strategy,* and on existing habitat, such take has the potential to occur on approximately 19% of the nesting and roosting habitat (26% total nesting, roosting, and foraging habitat) in the Elliott State Research Forest (ESRF); the remainder is protected by other conservation commitments such as reserves, riparian conservation areas (RCAs), or species commitments (Table 4-2). Areas of ingrowth habitat will also be harvested, particularly in extensive treatment areas that will contain more forest structure due to higher retention and longer growing periods before harvest. Such harvest could result in the inadvertent destruction of nest sites in any of the 13,433 acres where extensive treatments are planned.

New owl nesting locations are expected to be identified through the species monitoring program outlined in Chapter 6, *Monitoring and Adaptive Management*. Direct disturbance of any actively nesting owls that are detected will be avoided through seasonal restrictions described in Chapter 5, *Conservation Strategy*. However, it is possible that new owl nest sites could remain undetected and be harmed either directly through harvest or indirectly through noise disturbance. The conservation strategy has been developed to minimize the likelihood of such taking while not committing the Permittee to conduct project-specific surveys that require multi-year efforts.

As described in Chapter 6, *Monitoring and Adaptive Management,* the Permittee will be conducting ongoing monitoring of northern spotted owls, including use of passive acoustic recording devices. All suitable and highly suitable nesting/roosting habitat in the permit area will be surveyed every 3 years so surveys will cover essentially one-third of all potential nesting, roosting, and foraging habitat each year (Chapter 3, Section 3.9.6, *Survey and Monitoring Requirements*). Distribution of acoustic recording devices in additional locations, beyond known activity centers, will allow the Permittee to determine when northern spotted owl begins to use new locations and to generally track long-term trends in nesting activity in the permit area. This strategy aligns with ecological survey methodologies that emphasize systematic, periodic monitoring to track wildlife populations in large landscapes (Miller et al. 2012; Johnson et al. 2009).

Passive acoustic recording devices, a component of this program, enhance overall detection capabilities. Studies have shown that passive acoustic monitoring, like that employed in this program, can be effective in avian monitoring, offering a more extensive coverage than traditional survey methods alone (Duchac et al. 2020; Furnas and Callas 2015).

While this approach does not strictly conform to USFWS's clearance survey protocols, it represents a rational compromise given the extensive area to be monitored and the practical constraints of long-term monitoring. The selected methodology increases the probability of identifying new nest sites, particularly in areas showing habitat improvement. However, the possibility exists for some newly established, yet undetected, nesting sites to be inadvertently affected. The intent is to minimize this risk through consistent, comprehensive monitoring. This approach is a pragmatic response to the challenges of large-scale ecological monitoring, balancing thoroughness with feasibility, as underscored in wildlife management literature (Thompson et al. 1998).

4.4.1.3 Disturbance and Direct Mortality from Road Use

Road use associated with covered activities (harvest equipment, hauling, research, administrative, forest work crews) could result in direct effects, including noise disturbance from covered activities and direct mortality due to vehicle collisions.

Noise from commercial vehicle traffic could disturb nesting spotted owls, although any nest sites near roads would have been established in the presence of roads because no new roads have been constructed in recent years. The types of reactions that spotted owls could have to vehicle noise are those that USFWS considers to have a negligible impact, and include flapping of wings, turning of a head toward the noise, hiding, and assuming a defensive stance (U.S. Fish and Wildlife Service 2003).

Little information is available in the scientific literature regarding the death or injury of northern spotted owls from collisions with vehicles. Forsman et al. (2002) reported that for 122 cases where researchers were able to infer a cause of death of northern spotted owls, predation accounted for 68% of the mortality (83), followed by starvation at 26% (32) and accidents at 6% (7). Of accidental deaths, vehicle collisions accounted for four of the seven cases. In addition, northern spotted owls are most active at night, when vehicle traffic is significantly lower or nonexistent. In addition, vehicle speeds are likely relatively low on most of the winding gravel roads in the Elliott State Forest, particularly at night.

Therefore, while northern spotted owl collisions with vehicles could occur during the permit term, they are not anticipated to be a significant source of take from covered activities due to the low level of vehicle use, generally low speeds, and rarity of such collisions.

4.4.1.4 Nesting, Roosting, and Foraging Habitat Harvest and Thinning

The covered activities described in Chapter 3, *Covered Activities,* together with conservation measures and conditions on covered activities described in Chapter 5, *Conservation Strategy,* are intended to maintain core area and home range habitat for historic nesting territories and result in a net increase in the quality and quantity of northern spotted owl habitat over the 80-year permit term. However, over the course of the permit term, localized harvest, thinning, road construction and maintenance, and other covered activities will directly remove or otherwise modify northern spotted owl habitat. Of the covered activities described in Chapter 3, the primary source of habitat loss and modification and associated take over the permit term is projected to be the full suite of thinning and timber harvest techniques used in contemporary forestry. Supporting management and infrastructure activities, including construction of access roads and landings, will also affect northern spotted owls. Other sources of northern spotted owl habitat modification include any tree removal associated with covered activities such as road system construction and management, quarry development, landings, temporary roads, maintenance and use of existing water drafting and storage, and hazard tree removal (conducted as part of stand-level treatments or other covered activities).

Modification of habitat by covered activities is anticipated to result in the following stressors on northern spotted owls.

- Remove 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 (reducing prey) and predators (displacing, chasing, killing) that can use habitats modified by timber harvest, including great horned owls (*Bubo virginianus*), barred owls, and corvids.

- Fragment habitat so that habitat patches become inaccessible or require additional effort and predation risk to access for nesting, roosting, foraging, or movement.
- Create habitat that reduces the resilience of spotted owls to barred owl competition, including the ability to find suitable nesting, roosting, and foraging habitat to occupy, and prey to consume.

Behavioral responses to such changes by individual northern spotted owls may include individuals traveling farther to find prey, shifting core use areas, and abandoning nesting territories.

All 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. Take, in the form of 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 degree of habitat modification anticipated to occur is closely associated with the treatments described in Chapter 3, *Covered Activities,* as described in the following sections.

Intensive Treatments

Forest stands meeting the definition of northern spotted owl habitat, as per Davis et al. (2016), will be harvested in intensive treatment areas, which are comprised primarily of existing even-aged Douglas-fir (*Pseudotsuga menziesii*) plantations. This involves clearcut harvesting techniques suitable for the terrain. The overall result of these intensive treatments would be forest stands that lack sufficient forest structure and composition for northern spotted owl nesting, roosting, and foraging.

Intensive treatment in the northern spotted owl habitat is projected to result in harvest of 2,778 acres (8%) of modeled highly suitable and suitable nesting/roosting habitat (as of 2020) (Table 4-2). Additionally, 4,133 acres (22%) of foraging habitat would also be affected by this treatment type. In total, the intensive treatment approach would harvest 6,910 acres (13%) of modeled habitat in the permit area. Intensive treatments are not anticipated to result in nest site destruction as northern spotted owl nesting habitat is not anticipated within stands younger than 65 years (as of 2020). However, disturbance of nests in older stands that are directly adjacent to intensive treatments is possible, as is reduced fitness in northern spotted owls that relied upon these stands for foraging. Therefore, as northern spotted owl occupancy is assumed to be unknown at the time of intensive treatments, the Permittee is disclosing that the 6,910 acres of modeled habitat would be subject to intensive treatments. However, the modeled habitat overlap with the Douglas-fir plantations subject to intensive treatments is acknowledged as an artifact of landscape-level modeling, and these habitats are not considered suitable nesting habitat for the northern spotted owl because they are young and even-aged stands (Chapter 3, Section 3.3.2, *Intensive Allocations*). As such, no stands that are greater than 65 years of age (as of 2020) will be harvested using intensive treatments and the minimum rotation age of 60 years or less suggests little to no ingrowth habitat is expected to be intensively harvested over the permit term.

Table 4-2. Northern Spotted Owl Habitat [a] by Potential Treatment Type and Approximate Amount Available for Harvest

	Nesting/Roosting Habitat		Foraging Only			
	Highly Suitable + Suitable		Marginal		Total Modeled Habitat	
Treatment Type [b]	Acres	Percent of Total	Acres	Percent of Total	Acres	Percent of Total
No Harvest	26,582	76%	7,656	41%	34,238	63%
Restoration Thinning	1,913	5%	3,587	19%	5,500	10%
Extensive ≤65	1,887	5%	2,759	15%	4,647	9%
Extensive >65	1,982	6%	648	3%	2,631	5%
Intensive ≤65	2,778	8%	4,133	22%	6,910	13%
Total	35,142	100%	18,783	100%	53,925	100%
Extensive + Intensive [c]	6,647	19%	7,540	40%	14,187	26%

[a] For this assessment, areas rated and mapped as highly suitable and suitable by Davis et al. (2016) were considered suitable nesting and roosting habitat; areas rated and mapped as marginal were considered suitable foraging habitat; and areas rated and mapped as highly suitable, suitable, and marginal were are all considered suitable dispersal habitat (dispersal habitat also includes unsuitable habitat that is over 40 years of stand origination age). Numbers differ slightly from those presented in Chapter 2, *Environmental Setting,* due to some areas within the permit area being unallocated under OSU's research proposal (Appendix C, *Proposal: Elliott State Research Forest*).

[b] Percent distribution of habitat type among each treatment.

[c] The total habitat available for harvest is likely a slight overestimate given another approximately 400 acres are under species-specific encumbrances associated with Conditions 2, 3, 4, and 8. These are estimates, based on current habitat models. Actual habitats may deviate slightly during HCP implementation and through improved science.

Extensive Treatments

Variable retention regeneration harvest will contain a range of aggregate and dispersed thinning treatments, as well as retention patches. Over the permit term, canopy cover and tree density could fall below that required by northern spotted owls following extensive treatments that reduce stand density down to the minimum of 20% allowed (Chapter 3, Section 3.3.3, *Extensive Allocations*). Habitat values may remain in retention patches or in areas of high-density retention with dispersed thinning, particularly as new ingrowth matures with the overstory cohort, although there is a general lack of research on the effects of thinning on northern spotted owl habitat use (Wan et al. 2018). A case study of a single male spotted owl (Meiman et al. 2003) found that the owl continued to use some areas following thinning, but that overall habitat use shifted away from thinned areas. Thinning has been shown to decrease density of key prey species, including northern flying squirrels (*Glaucomys sabrinus*) and red tree voles (*Arborimus longicaudus*) (Manning et al. 2012; Wilson and Forsman 2013). However, thinning is also believed to be useful for accelerating development of forest structure needed by northern spotted owls, including large trees, multiple canopies, and snags (Spies et al. 2018). Almost all extensive treatments will occur in Douglas-fir plantations, with the intent to increase the landscape-level forest structure needed by northern spotted owls. Those treatments in older forests between 65 and 150 years old (as of 2020) require an average of 50% retention in order to retain habitat values in the modeled highly suitable and suitable habitat subject to extensive treatments.

If all extensive treatments occur immediately after permit issuance in the northern spotted owl habitat in the permit area, this could result in the harvest of 3,869 acres (11%) of modeled highly suitable and suitable nesting and roosting habitat (as of 2020) (Table 4-2). In addition, 3,407 acres of foraging habitat, or 18% of the total foraging habitat (as of 2020) could be affected by this treatment type. Overall, a total of 7,278 acres (14%) of northern spotted owl modeled habitat could be harvested in stands subject to extensive treatments (Table 4-2). However, up to three entries are expected in extensive treatments over the permit term and some of these will be in new habitat ingrowth that could be colonized by northern spotted owl later in the permit term.

Ingrowth Habitat

The management practices associated with extensive treatments are in part age dependent (Chapter 3, Section 3.3.3, *Extensive Allocations*) and the primary goal of extensive management is to maintain continuity of forest structure, function, and composition through time, so harvesting of ingrowth habitat is an expected outcome of extensive management. The emphasis on allowing stands to mature and employing variable retention thinning and regeneration techniques that improve habitat quality means that more areas will transition into suitable habitat for nesting, roosting, or foraging, but also that such stands would be subject to subsequent thinning or harvest entries, with up to three entries into stands more than 65 years old and up to four entries into stands less than 65 years old over the permit term. Therefore, depending on the age and structure of the stand during treatment, modification of northern spotted owl nesting/roosting and foraging habitat could occur in the same stand from one to four times over the permit term.

Because specific harvest plans have not been developed, this HCP makes some conservative estimates to calculate the upper limits of such harvest and borrows from some of the model assumptions made by OSU in its marbled murrelet habitat diminution analysis (Appendix D, *Marbled Murrelet Habitat Suitability Index Approach*) and the standards described in Chapter 3, Section 3.3.3, *Extensive Allocations*. A mock harvest treatment scenario was developed to assist in this analysis that assumes the following scenario.

- Stand ages (as of 2025) and treatment periods are categorized into 10-year intervals where harvest entries could occur.
- 12,425 acres are available for extensive treatments. This value differs from Table 4-1 because it represents the appropriate age classes in Extensive and Flexible Extensive allocations as well as 169 acres of Flexible allocation additional harvest needed up to the 3,200-acre harvest limit in older stands. This value does not include the Volume Replacement allocation, which is available as contingency only (Chapter 3, Section 3.3.4, *Volume Replacement Allocations*).
- Three entries in all stands at roughly 30-year intervals during the permit term.
- Variable retention regeneration harvests reset some portion of the stand (ranging from 35 to 50% of original pre-harvest stand density) at an age of at least 100, that then do not grow forward as northern spotted owl habitat ingrowth during the permit term.
- Stands 70 years old or less will remove up to 80% of the original pre-harvest stand density over the permit term.
- Stands over 70 years old will remove up to 80% of the original pre-harvest stand density (50% on average) and will retain an average of 25% as aggregates.
- Stands that reach 80 years old are considered northern spotted owl nesting habitat.

Based on the conservative assumptions above, harvest of approximately 15,400 acres of existing and new ingrowth of potential northern spotted owl nesting or roosting habitat could occur in the extensive treatments over the permit term. This represents the area of potential effects, where nest site disturbance or destruction could occur if harvest operations take place during the nesting and fledging period. It is not anticipated that all of these acres will result in take. However, harvest in any of the acres could result in take, if a nesting spotted owl is occupying the treatment area, or the treatment compromises the reproductive fitness of a territory. The proportion of this disturbance zone that contains or will contain suitable habitat that is actually occupied by unknown (and unsurveyed) northern spotted owl nest sites is likely to be lower than these estimates, based on the most recently available information on northern spotted owls on the ESRF and the coast range of Oregon.

Restoration Thinning Treatments

Effects from treatments within the conservation research watersheds (CRW) and management research watersheds (MRW) Reserves and CRW and MRW RCAs are expected to have short-term adverse effects on habitat to varying degrees based on site-specific conditions. These short-term adverse effects are expected to be followed by slowly appreciating, long-term beneficial effects as habitat improves through habitat enhancement treatments and natural ingrowth.

Restoration thinning treatments on younger stands in the reserves will explore methods for increasing the likelihood of achieving old forest structure, increasing species diversity, and creating complex early-seral forests from dense single-species plantations. Such treatments could temporarily reduce habitat values in lower-quality foraging habitat, with habitat values improving over the remaining portion of the permit term. The conservation measures and conditions described in Chapter 5, *Conservation Strategy,* such as avoiding activities during the active nesting season and making commitments to nesting, roosting, and foraging habitat retention for the 22 historic northern spotted owl activity centers, will further minimize effects from treatments in reserves.

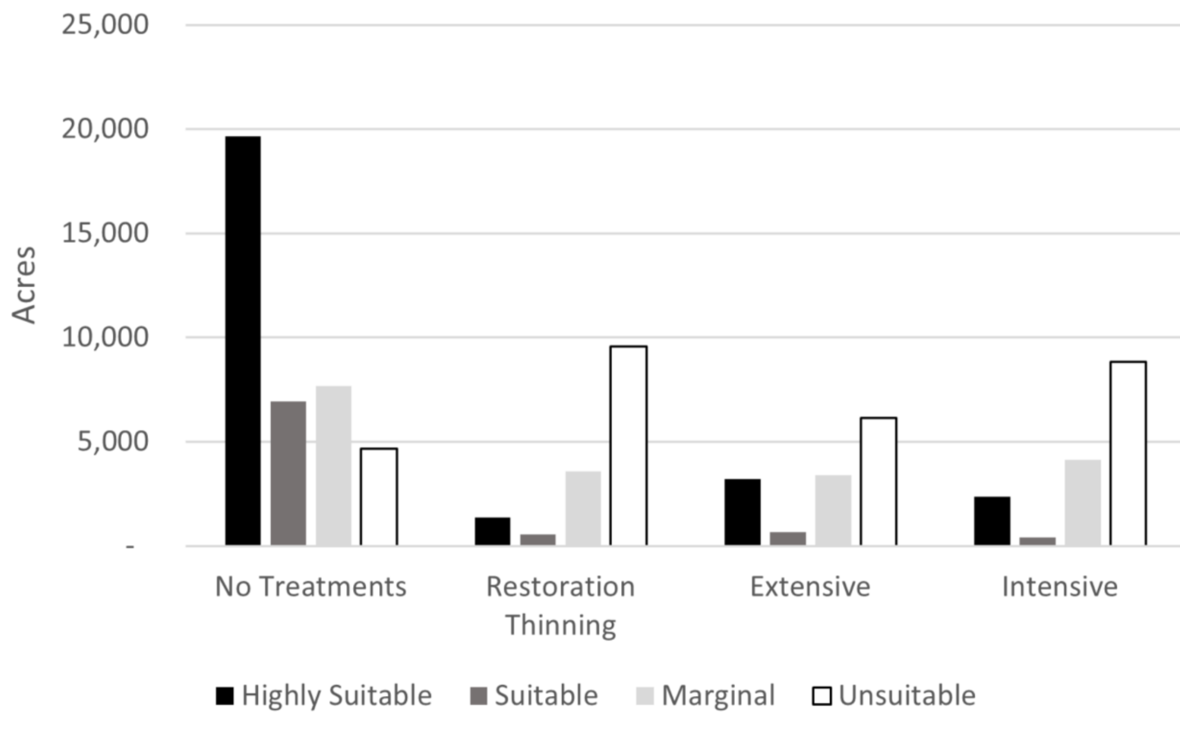
Restoration thinning treatments will occur in portions of the CRW and MRW Reserves, as well as the RCAs and similar operational standards apply to both (Chapter 3, Section 3.3.1, *Conservation Research Watersheds and Management Research Watersheds Reserve Allocations*, and Section 3.3.7.4). However, additional constraints on RCA thinning include the requirement for a 160-acre pilot project necessary for work in the equipment limitation zones (ELZs) (Chapter 3, Section 3.3.7.3, *Equipment Limitation Zone*), and other tree and wood retention requirements.

Most restoration thinning will consist of single-entry restoration treatments within the first 20 years of the permit term's 30-year CRW thinning window. Additional thinning treatments (first or second entry) may occur to allow flexibility in research design or to meet restoration objectives that were not achieved during the initial 20 years. Thinning in the MRW Reserves and MRW RCAs may take longer, depending on how the stepwise implementation corresponds to the original OSU research design or some other design; therefore, it is not subject to the 30-year thinning window (Chapter 3, Sections 3.3.1, *Conservation Research Watersheds and Management Research Watersheds Reserve Allocations*, and 3.3.7.4, *Operational Standards for Restoration Thinning in Riparian Conservation Areas*). As stated in the operational standards in Chapter 3, *Covered Activities,* any plantation stand in the CRW, MRW, or RCAs that reach 80 years old would only be thinned with concurrence from the Services. Therefore, it is not anticipated that habitat loss would occur due to harvest of ingrowth habitat in stands subject to restoration thinning.

Subsequent entries may be permitted contingent on concurrence from the Services (Chapter 7, Section 7.2.5, *Implementation and Adaptive Management Committee*). The focus of all restoration thinning in RCAs is conservation, focused around testing the hypotheses that more rapid development of large trees would occur, so effects may be a temporary reduction in habitat function in lower-quality foraging habitat, with habitat function improving over the remaining portion of the permit term.

The current programmatic level of planning does not provide the specific timing and extent of these treatments. However, it is estimated that 7,038 acres of CRW Reserves and 2,164 acres of MRW Reserves could undergo restoration thinning (Table 4-1). Of the total 5,919 acres potentially subject to restoration thinning in RCAs (Table 4-1), only 1,200 acres could undergo restoration thinning (Chapter 3, Section 3.3.7.4, *Operational Standards for Restoration Thinning in Riparian Conservation Areas*). Most (64%) of the 15,121 acres of forest subject to restoration thinning (Table 4-1) is modeled as unsuitable for northern spotted owl nesting, roosting, or foraging (Table 4-2).

Table 4-2 and Figure 4-1 provide a summary of modeled habitat type across the treatments that could be available for harvest. Figure 4-2 shows the location of the northern spotted owl activity centers within and adjacent to the permit area relative to treatment types described in Chapter 3, *Covered Activities*. Section 4.4.2, *Impact of the Taking,* presents an evaluation of the biological impact of projected habitat modifications and associate implications at the local, regional, and range-wide scales. Beneficial and net effects of the HCP, including the projected offset of these adverse effects through the development of additional habitat, are described in Chapter 5, *Conservation Strategy*.



Source: Davis et al. 2016.

Figure 4-1. Northern Spotted Owl Nesting/Roosting Habitat in the Elliott State Forest by Treatment

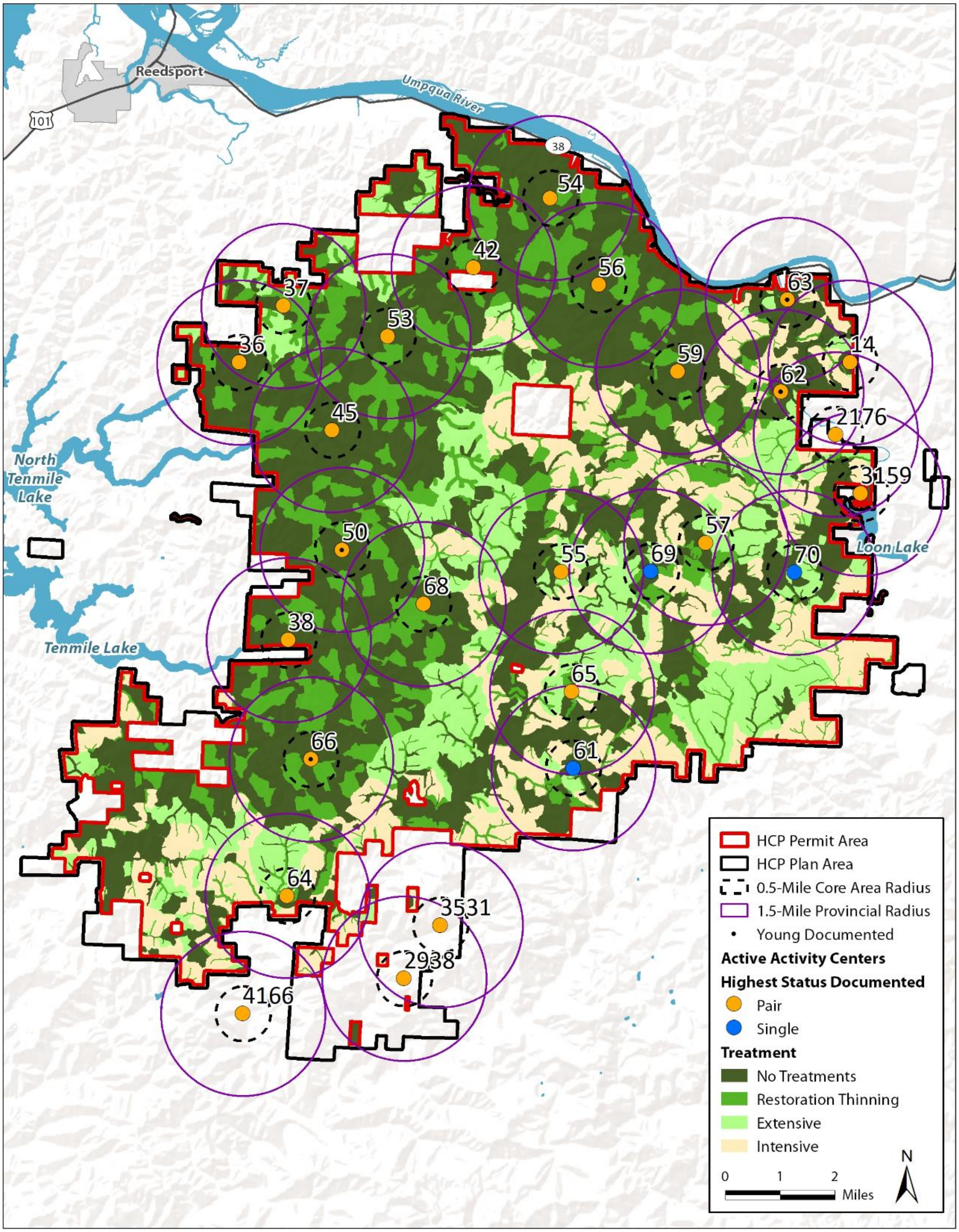


Figure 4-2. Location of the Northern Spotted Owl Activity Centers Within and Adjacent to the Permit Area Relative to Treatment Types

4.4.1.5 Conservation Measures and Conditions

The beneficial effects of conservation measures and conditions have already been described as part of the effects analysis for each treatment. In addition, most adverse effects of conservation measures would occur as part of the previously described treatments, including restoration thinning, in CRW and MRW Reserves and RCAs, and extensive treatments and associated covered activities, such as landings and road construction, maintenance, and use.

In addition to previously described restoration thinning in RCAs, riparian restoration and stream-enhancement projects may include selective tree harvesting beyond 120 feet from the stream channel for ecological purposes only. While unlikely, these harvests could result in localized habitat reductions, although all operations standards for RCAs will be applied to minimize effects, including limiting such harvest to trees 65 years old or younger as of 2020, no thinning entries to stands that have reached 80 years of age, and maintaining the habitat commitments for marbled murrelets and northern spotted owls included in Chapter 5, *Conservation Strategy,* including the 22 northern spotted owl historic nesting territories identified for conservation.

Removal of active or legacy roads would not have adverse habitat effects other than the potential need to remove hazard trees determined to be an unacceptable safety risk for workers or others. Road daylighting will involve cutting trees along roads, which could have some adverse habitat effects, including widening gaps that may be crossed by northern spotted owls. Many of the trees that will be removed are hardwood species, which tend to expand over roadways much more than conifers, and which provide limited habitat values for northern spotted owls. Culvert replacements, fish barrier removals, and other aquatic conservation measures are not anticipated to require modifications of northern spotted owl habitat.

Monitoring and Implementation Activities

Northern spotted owl monitoring efforts (described in Chapter 6, *Monitoring and Adaptive Management*) will follow USFWS-accepted methods, which are currently conducted by trained surveyors playing back recorded calls to elicit responses from northern spotted owls (U.S. Fish and Wildlife Service 2012). Using recorded call playback will likely elicit responses, including altered behavior, of any owls present. Calling surveys can also attract barred owls and result in interactions between northern spotted owls and barred owls, further altering behaviors and potentially placing northern spotted owls at risk of injury or death (although no such events were found to be reported in the scientific literature). The USFWS protocol includes measures to minimize such disturbance, including prohibiting surveys during rain, when calls may result in calling a brooding owl off a nest and exposing eggs or young to rain. The protocol also does not involve climbing nest trees or looking into nest cavity holes to determine the status of young. In addition, the planned use of passive acoustic monitoring devices could be an accepted substitute for using recorded call playbacks in the future, as described in Chapter 3, Section 3.9.6, *Survey and Monitoring Requirements*.

Other Covered Activities

As previously described for the effects of each treatment (intensive, extensive, and restoration thinning), habitat disturbances may occur as the result of supporting management and infrastructure activities (e.g., access roads, landings). All covered activities will follow the operations standards for each treatment described in Chapter 3, *Covered Activities,* as well as the conservation actions and conditions described in Chapter 5, *Conservation Strategy*. This includes avoiding disturbance of nesting northern spotted owls through the seasonal restrictions (Condition 1, Chapter 5). The acres of habitat impacts described in Section 4.4.2, *Impact of Taking*, include acres that will be disturbed from the other covered activities within the framework of the treatments and associated operations standards, conservation measures, and conditions (i.e., habitat effects are counted but not quantified separately).

4.4.1.6 Dispersal Habitat Harvest

The CRW and MRW Reserves and RCAs are expected to continue to develop into nesting, roosting, and foraging habitat over the permit term. These areas will also continue to provide habitat for dispersing northern spotted owls. The Permittee's commitment to retaining at least 40% of the MRW as dispersal habitat (Chapter 5, Objective 1.3) is an acknowledgment that habitat quality will be reduced in areas where intensive treatments occur, and even in some areas where extensive treatments occur, if retention is low. However, overall, the MRW will continue to provide nesting, roosting, and foraging habitat in areas managed with reserve treatments and in RCA habitat throughout the MRW, as well as in some extensive treatment areas. These areas will continue to support dispersing northern spotted owls. The yearly pace of harvest activities is modest (approximately 1% of the permit area), so maintaining this base level of dispersal habitat should not be a challenge. Because dispersal habitat is a landscape goal, the distribution of dispersal habitat across the permit area will change over time. However, due to the mosaic of treatments across the permit area, dispersal habitat will be distributed throughout the MRW, as will be confirmed through monitoring of terrestrial habitats (Chapter 6, Section 6.4.1, *Habitat Monitoring*).

Because dispersal habitat includes young forests, most harvest and thinning will occur within dispersal habitat; therefore, the amount of such habitat loss would be similar to the amount of lands treated. As detailed in Chapter 5, *Conservation Strategy,* the conservation strategy establishes the commitment to retain at least 40% of the MRW as dispersal habitat, which is the amount considered to be sufficient to maintain connectivity and dispersal at the landscape level (Buchanan 2004). The matrix of intensive, extensive, and reserve and RCA allocations across the MRW is expected to maintain dispersal habitat over the permit term.

4.4.1.7 Northern Spotted Owl Activity Centers

Activity Centers in the Permit Area

USFWS (2012) uses three contexts by which to evaluate effects on specific northern spotted owl activity centers. Activity centers are the location or point representing "the best of detections" such as nest stands, stands used by roosting pairs or territorial singles, or concentrated nighttime detections. The three contexts are nest core, core use area, and home range.

- **Nest core.** A contiguous habitat around the activity center, typically at least 70 acres in size. In this HCP the nest core is defined as 100 acres consisting of the "best contiguous habitat."
- **Core use area.** The area of concentrated use within a home range that receives disproportionally high use (Bingham and Noon 1997) 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, but USFWS uses a circle with a radius of 0.5 mile from an activity center to define core use areas of northern spotted owls for the Coast Range physiographic province in which the permit area is located. This results in a 502-acre area around each activity

center. In this HCP the 502-acre area is considered the "highest-quality contiguous habitat" in the core use area.

- **Home range.** The wider area in which a spotted owl conducts nesting, roosting, and foraging activities. Home range sizes vary by geographic location as well as habitat and prey conditions, but USFWS uses a circle with a radius of 1.5 miles from an activity center to define home ranges of northern spotted owls for the Coast Range physiographic province, an area of approximately 4,523 acres.

Based on published studies regarding spotted owl home ranges and core use areas, as summarized in the *Revised Recovery Plan for the Northern Spotted Owl* (U.S. Fish and Wildlife Service 2011), habitat modification is less likely to harm northern spotted owls if nesting, roosting, and foraging habitat is maintained at the following levels.

- ≥40% of the home range (i.e., 40% of area within a 1.5-mile-radius circle centered on the activity center, which equates to ≥1,809 acres of the highest-quality contiguous habitat within the 4,523-acre circle).
- ≥50% of the core use area (i.e., ≥251 acres of the highest-quality contiguous habitat within the 502-acre area). Habitat in core use areas also contributes to home range thresholds because the home range envelops core use areas.

Table 4-3 summarizes the amount of existing habitat in the permit area and in the core area and home range for the 22 activity centers described in Chapter 2, *Environmental Setting,* that are centered in the permit area. Figure 4-2 shows the location of these active activity centers, together with underlying research treatments.

Conditions 1, 2, 3, and 4 (described in Chapter 5, *Conservation Strategy*) provide the following protections for all known northern spotted owl activity centers in the permit area.

- Under Condition 1, seasonal restrictions on covered activities will be followed around nest sites to reduce loud and sustained noise.
- Under Condition 2, a 100-acre no-harvest nesting core area will be maintained around the nest tree.
- Under Condition 3, core use areas of at least 502 acres will be established around the 22 northern spotted owl nest sites, where at least 50% (≥251 acres) of the highest-quality contiguous habitat will be maintained as nesting, roosting, and foraging habitat at all times. For core use areas that are currently below the 50% threshold no harvest will occur until the minimum habitat threshold is met.
- Under Condition 4, at least 40% of the home range will be retained as the highest-quality nesting, roosting, and foraging habitat around the 22 nest core areas. For home range areas that are currently below the 40% threshold no harvest will occur until the minimum habitat threshold is met.

Many of the core use areas and home range territories of the 22 activity centers centered within the permit area include lands outside the permit area. In these cases, Conditions 2, 3, and 4 apply proportionately to the amount of area in the permit area. For example, 38% (1,727 acres) of the home range for the Lower Camp Creek activity center falls within the permit area (Table 4-3). Under Condition 4, a minimum of 40% of that 1,727-acre area (691 acres) will be maintained as nesting, roosting, or foraging habitat. The same proportional protections will apply to core use areas.

Initially, these conditions will apply to the 22 northern spotted owl activity centers described previously and shown in Chapter 2, Figure 2-9. If new owl nest locations are discovered in the future, outside of those shown in Figure 2-9, the Permittee will provide written notice seeking coordination with USFWS (per Chapter 7, Section 7.6, *Modifications to the Habitat Conservation Plan*), prior to removing protections from another (inactive) core use area in favor of the newly discovered (active) nest site. The Permittee may also decide to not retain the new site but will follow the seasonal disturbance restrictions described in Chapter 5, *Conservation Strategy*.

Table 4-3. Northern Spotted Owl Activity Centers and Existing Percent Habitat [a] in Home Range and Core in Permit Area

ID#	Activity Center Name (pairs)	Percent of Home Range in Permit Area [b]	Existing Habitat in Permit Area as Percent of Total Home Range [c]	Percent of Core Use Area in Permit Area	Existing Habitat in Permit Area as Percent of Total Core Use Area
14	Lower Camp Creek	38%	27% [d]	61%	42% [d]
36	Murphy Creek	67%	41%	88%	67%
37	Wind Creek	69%	37% [d]	96%	42% [d]
38	Roberts Creek	72%	51%	74%	61%
42	Dean Creek	82%	57%	76%	54%
45	Alder Creek	99%	71%	99%	79%
50	Benson Creek	94%	65%	100%	82%
53	Scholfield Creek	96%	64%	100%	83%
54	Johanneson Creek	78%	61%	100%	82%
55	Upper Millicoma	100%	67%	100%	76%
56	Charlotte Creek	97%	76%	100%	85%
57	Cougar Creek	100%	55%	100%	61%
59	Luder Creek	100%	74%	99%	81%
61	Upper Elk (Resident Single)	81%	53%	100%	70%
62	Footlog Creek	84%	53%	95%	71%
63	Lower Mill Creek	56%	40%	92%	73%
64	Marlow Ridge	66%	36% [d]	84%	50%
65	West Glenn Creek	100%	68%	100%	52%
66	Johnson Creek	99%	67%	100%	76%
68	Upper Roberts Creek	100%	64%	100%	68%
69	Panther Creek (Resident Single)	100%	64%	100%	61%
70	Salander Creek (Resident Single)	87%	59%	100%	75%
2176	Upper Mill Creek	53%	30%	19%	14% [d]
2938	Marlow Creek	9%	5% [d]	6%	2% [d]
3159	Tom Fool Creek	40%	27%	46%	24% [d]
3531	Lockhart Road	6%	4% [d]	0%	0% [d]

ID#	Activity Center Name (pairs)	Percent of Home Range in Permit Area [b]	Existing Habitat in Permit Area as Percent of Total Home Range [c]	Percent of Core Use Area in Permit Area	Existing Habitat in Permit Area as Percent of Total Core Use Area
4166	Lower West Fork Millicoma	11%	6% [d]	0%	0% [d]

[a] Minimum thresholds based on USFWS (2011), which are a minimum of 50% habitat retained around the core use area (i.e., habitat conserved on at least 50% of lands within a 0.5-mile circle centered on the activity center, which equates to ≥502 acres) and a minimum of 40% of the home range (i.e., a 1.5-mile circle centered on the activity center, which equates to ≥4,523 acres of habitat).

[b] Percent of home range in the permit area is the proportion of the 1.5-mile circle centered on the activity center that is in the permit area.

[c] Existing habitat in permit area as percent of total home range is the amount of habitat in the permit area portion of the 1.5-mile circle that contributes to the total area of the 1.5-mile circle (i.e., in and outside the permit area).

[d] Existing habitat currently below threshold, meaning that the permit area is not sufficient to meet minimum thresholds alone (i.e., habitat on adjacent lands is needed to meet threshold).

4.4.1.8 Effects on Critical Habitat

USFWS has designated critical habitat totaling 38,746 acres for the northern spotted owl in the permit area (77 FR 71875; 86 FR 10). Approximately 50% of designated critical habitat in the permit area was modeled as marginal or unsuitable for nesting and roosting. Approximately 37% was modeled as highly suitable and 13% was modeled as suitable (Davis et al. 2016). Effects on critical habitat are the same as those described previously for modeled northern spotted owl habitat. When harvest occurs, habitat could become less hospitable. If individuals are present, they could be displaced. The degree to which critical habitat could be affected by covered activities relates to the type and quality of the critical habitat when the covered activity occurs. Critical habitat quality is variable. USFWS stated that the justification for designating many of these areas was the need for increased and enhanced habitat and habitat connectivity to support dispersal, population growth, and buffering from competition with the barred owl (77 FR 71875; 86 FR 62606).

In general, designated critical habitat in areas subject to restoration thinning or not available for any treatments is expected to increase in habitat value during the permit term. As described in Chapter 3, *Covered Activities,* treatments in reserves and RCAs will be focused on improving habitat values through management of even-aged Douglas-fir plantations toward more complex, older, and structurally diverse stands with a mix of ages and tree sizes.

Of the 38,745 acres of designated northern spotted owl critical habitat in the permit area, 8% (2,919 acres) is in areas subject to extensive treatments (Table 4-4). Of this, 1,068 acres were modeled as unsuitable habitat for nesting/roosting/foraging, 891 acres as marginal, 183 acres as suitable, and 776 acres as highly suitable. As described in Section 4.4.1.4, subsection *Extensive Treatments*, some stands in areas available for extensive treatments are expected to continue to provide northern spotted owl foraging and dispersal habitat, with nesting and roosting habitat protected in reserves and RCAs. While the covered activities may result in localized and temporary reductions in habitat values to varying degrees, depending on research objectives and stand conditions, live trees will be retained as needed to meet various experimental goals, resulting in patches and blocks of habitat that are expected to remain suitable for northern spotted owl foraging. In addition, Olson et al. (2004) reported that some spotted owls in the Oregon Coast Range were found to use a mixture of forest types, including older forest interspersed with younger forest and nonforest.

Table 4-4. Acres of Designated Critical Habitat for Northern Spotted Owl, by Treatment Type and Modeled Nesting/Roosting Habitat Classification [a]

	Nesting/Roosting Habitat				Foraging Only		Dispersal Only			
	Highly Suitable		Suitable		Marginal		Unsuitable		Total	
Treatment Type	Acres	Percent of Total	Acres	Percent of Total	Acres	Percent of Total	Acres	Percent of Total	Acres	Percent of Total
Restoration Thinning and No Treatment	12,851	90%	4,750	94%	6,514	75%	7,234	67%	31,349	81%
Extensive	776	5%	183	4%	891	10%	1,068	10%	2,919	8%
Intensive	597	4%	144	3%	1,319	15%	2,418	23%	4,478	12%
Total	14,224	100%	5,078	100%	8,724	100%	10,720	100%	38,745	100%

Source: Davis et al. 2016.

[a] For this assessment, areas rated and mapped as highly suitable and suitable by Davis et al. (2016) were considered suitable nesting and roosting habitat; areas rated and mapped as marginal were considered suitable foraging habitat; and areas rated and mapped as highly suitable, suitable, marginal, and unsuitable were are all considered suitable dispersal habitat. Numbers differ slightly from those presented in Chapter 2, *Environmental Setting,* due to some areas in the permit area being unallocated under OSU's 2021 research proposal (Appendix C, *Proposal: Elliott State Research Forest*).

Designated critical habitat in areas subject to intensive treatments is likely to provide little to no habitat value for northern spotted owls for the duration of the permit as the result of habitat modification. A total of 4,478 acres of designated critical habitat for northern spotted owl is in areas subject to intensive treatments (12% of all critical habitat in the permit area). Of this, 2,418 acres is modeled as unsuitable habitat for nesting/roosting/foraging, 1,319 acres as marginal, 144 acres as suitable, and 597 acres as highly suitable (Table 4-4). Table 4-4 and Figure 4-3 summarize the acres of critical habitat by treatment type and modeled habitat category.

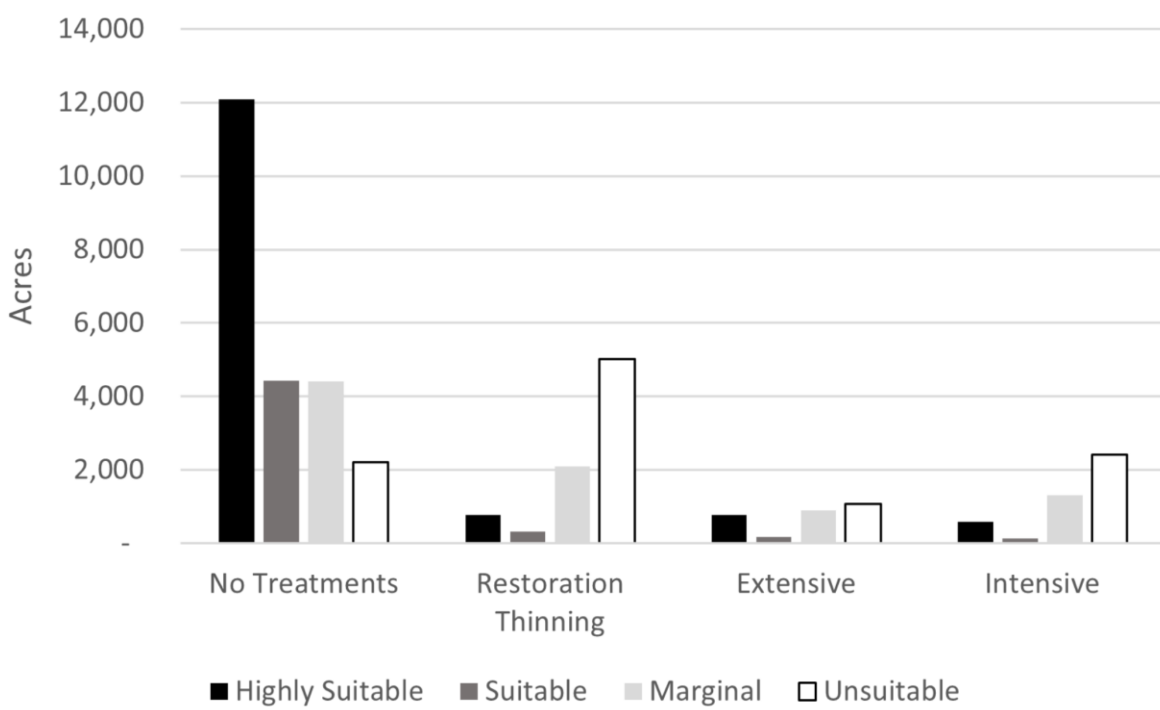


Figure 4-3. Acres of Designated Critical Habitat for Northern Spotted Owl on the Elliott State Forest, by Suitability as Nesting and Roosting Habitat and Treatments

4.4.2 Impact of the Taking

As described in the previous section, covered activities could affect individual northern spotted owls through nest site disturbance and disruption and habitat modification and loss due to harvest, thinning, and road construction. These actions can lead to the take of individuals and, by extension, affect the success of the northern spotted owl population in the plan area.

The impact of the take on local and regional northern spotted owl population levels could be significant in the absence of any offsetting measures. As described in Chapter 2, *Environmental Setting,* the northern spotted owl population has been declining. The primary cause for current declines is identified as competition from the invasive barred owl, rather than habitat loss. In 1991—a time when barred owl populations were still relatively low in Oregon—the Elliott State Forest was estimated to support 51 individual northern spotted owls on 25 activity centers. By 2016 (the last year that comprehensive surveys were completed), the occupancy estimate was 14 owls on 8 activity centers (Kingfisher Ecological, Inc. 2016). Therefore, simply setting aside habitat may not be enough to offset ongoing population declines. For this reason, Conservation Measure 5 was established to actively manage barred owl populations in the permit area. While research into the effectiveness of barred owl removal is ongoing, preliminary results from experiments have shown that removal of barred owls have a positive effect on northern spotted owl survival, dispersal, and recruitment (Wiens et al. 2021).

The impact of habitat harvest has been minimized through conservation of the intact habitat and habitat blocks as part of the reserve strategy and as part of conservation measures to conserve habitat surrounding the 22 historic activities described in Chapter 2 (Table 2-5). As described in Section 4.4.1.4, *Nesting, Roosting, and Foraging Habitat Harvest and Thinning*, approximately 6,647 acres of the total acres of existing suitable northern spotted owl nesting/roosting habitat (combined modeled highly suitable and suitable habitat) are in areas subject to extensive and intensive treatments (Table 4-2). While the Davis et al. (2016) model identified all of these acres as suitable habitat,[2] 70% (4,665 acres) of the 6,647 acres is in plantations that are 65 years old or younger (as of 2020). This plantation habitat tends to be patchy and contains much lower densities of large trees, snags, and downed wood—key features required by northern spotted owls—than occur in unmanaged stands. In addition, northern spotted owl habitat outside of reserve allocations occurs in stands that are on average smaller and more isolated than stands in reserves.

The HCP monitoring program is not sufficient to provide full "clearance" surveys to document the absence of northern spotted owls according USFWS guidance. As described in Section 4.4.1.1, *Nest Site Disturbance,* a conservative estimate has been developed that suggests up to 1,200 acres of adjacent lands could be exposed to disruption from covered activities conducted within 65 yards of suitable nesting habitat for northern spotted owls. The proportion of this disturbance zone that contains suitable habitat that is occupied by unknown (unsurveyed) northern spotted owl nest sites is likely to be lower than this estimate.

[2] The Davis model did not match with age data used by OSU to allocate treatments under the research platform. OSU is confident in the stand age data, so the modeling of young stands as suitable habitat appears to be the result—at least in part—of some inaccuracies that occur when applying the 2016 Davis model at a fine scale. These stands are still considered suitable habitat for the purposes of estimating the amount of take authorization needed, using habitat as a surrogate measure of take. Information regarding known age and past management history of habitat to be lost or modified under the HCP was provided to provide additional context and intensity of effects.

Cumulatively, the harvest of current and ingrowth habitat in the Extensive treatment areas could affect approximately 15,400 acres of existing and new ingrowth of potential northern spotted owl nesting or roosting habitat (80 years or older) over the permit term.

As described in Section 4.4.1.7, *Northern Spotted Owl Activity Centers*, and as detailed further in Chapter 5, impacts on known northern spotted owl nesting territories and associated reproduction are expected to be minimized through Condition 1. In addition, Conditions 2, 3, and 4 provide habitat protections around 22 historic activity centers, many of which are likely currently unoccupied. The strategy is to retain the permit area's capacity to support northern spotted owls by retaining the existing habitat centered around where owls are known to have occurred historically. Under the HCP, the Permittee is committed to retaining habitat around these historic activity centers, while being authorized to take owls that may occur outside of these areas.

As previously mentioned, the generic “provincial radii” from activity centers used in this assessment to identify northern spotted owl territories extends outside the permit area for several of the 22 sites. Conditions 2, 3, and 4 apply proportionately to the amount of area in the permit area, so the core areas of each historic activity center will be protected based on the proportions within the permit area. The strategy is intended to protect habitat at the landscape level based on habitat that is known to have been historically important to northern spotted owls within the permit area. The actual location of nest sites and habitat use is expected to be highly dynamic over the permit term, as forest conditions will be continuously changing through growth, harvest, and disturbances, as will northern spotted owl abundance and distribution throughout the permit area and the region. Considered collectively, habitat to be retained will retain habitat values—and improve such values over time—where spotted owls are most likely to occur over the permit term. As described in Chapter 5, Section 5.6, *Beneficial and Net Effects*, the net effect on northern spotted owl habitat from covered activities would be beneficial, with long-term habitat quality gains that would maintain and increase the capacity of the permit area to support nesting pairs of northern spotted owls. It follows that the impact of the taking 15,400 acres of current and future ingrowth habitat in extensive treatments and the approximately 6,900 acres of young forest subject to intensive treatments, would not likely affect populations in the context of the Oregon Coast Range or range-wide distributions.

However, because of the assumed major influence of barred owls on the distribution and numbers of northern spotted owls, any attempt to offset effects that actually harm remaining northern spotted owls must mitigate the impact of barred owls at the local, regional, and range-wide scales. As described in Chapter 3, *Covered Activities,* and Chapter 5, *Conservation Strategy,* the HCP commits the Permittee to funding and actively participating in barred owl management and research in consultation with USFWS. The success of the HCP to offset incidental take and conserve northern spotted owls on the ESRF likely relies on the effectiveness of barred owl control measures to allow northern spotted owls to reoccupy historic nesting areas.

4.5 Effects Analysis for Marbled Murrelet

4.5.1 Sources, Types, and Amount of Take

4.5.1.1 Nest Site Disturbance

Direct interactions, such as disturbing actively nesting marbled murrelets during harvest treatments, will be avoided in all known occupied habitat and in areas found to be occupied through seasonal restrictions. Harvest treatments will also be minimized in modeled potential habitat through clearance surveys, and in areas adjacent to occupied habitat through conditions described in Chapter 5, *Conservation Strategy*. However, areas adjacent (approximately 110 yards; see Chapter 5, Table 5-5) to modeled potential habitat would be subject to seasonal disturbance, or potentially direct harm (Section 4.5.1.2, *Nest Site Destruction*), through unknowingly harvesting of mature trees in the latter half of the permit term that become occupied without detection. Such disturbances could be generated from covered activities in all allocations that are adjacent to modeled potential habitat not yet surveyed for occupancy, or in areas where forest is too young or incontiguous to have been classified as modeled potential habitat (i.e., isolated patches or stands <80 to 100 years old as of 2020). Areas where this may occur include retention stands in extensive treatments and in areas of the CRW and MRW Reserves or RCAs that will mature throughout the permit term. Areas subject to intensive harvest are managed on a 60-year rotation with no ingrowth potential.

The amount of such disturbance is difficult to estimate because it requires making several assumptions, including future nest densities in areas of ingrowth later in the permit term, as well as the timing and spatial arrangements of future harvest scenarios (Section 4.5.1.5, *Nesting Habitat Harvest and Thinning,* subsection *Ingrowth Habitat*). Due to the lack of a projected harvest schedule and much uncertainty regarding the timing, location, and extent of harvest and other covered activities, this HCP considers a maximum amount of area that would be subjected to potential disruption effects but does not attempt to quantify the number of marbled murrelets disturbed on a future landscape actively managed to promote characteristics of late seral forest.

Based on the annual acreage harvest cap of 1,000 acres, plus an additional maximum of 300 acres allowed for restoration thinning, and assuming an average harvest patch size of 20 acres, a reasonable expected number of harvest patches per year would be 65. The total area outside of these harvest units but within a 110-yard disturbance distance would be approximately 2,100 acres of adjacent lands exposed to potentially harmful disturbance per year (assuming a round configuration with nonoverlapping buffers for calculation purposes; anything other than a circle, would result in slightly more disturbance).

This value represents the maximum area of potential effects, where essential behaviors of nesting marbled murrelets adjacent to the harvest stands could potentially be disrupted if harvest operations occur during the critical nesting period. The proportion of this disturbance zone that contains suitable habitat that is actually occupied by unknown (unsurveyed) marbled murrelet nest sites is likely to be lower than these estimates, based on overall distribution of marbled murrelets on the ESRF.

Under Conservation Measure 5, the Permittee will implement buffering strategies to protect interior occupied marbled murrelet habitats from edge effects due to adjacent harvests within potential habitat, with the intent to maintain habitat connectivity. These actions, detailed in Appendix D, *Marbled Murrelet Habitat Suitability Index Approach,* will complement existing MRW Reserves and occupied habitats. This conservation measure will provide protection for interior murrelet occupied habitat from edge effects potentially caused by extensive harvest within adjacent unoccupied boundaries of modeled potential habitat.

Smoke disturbance from prescribed burning and slash burning will also be avoided through seasonal restrictions within 0.25 mile of occupied murrelet habitat during the critical breeding season (Condition 6). The Marbled Murrelet Recovery Plan (U.S. Fish and Wildlife Service 1997) hypothesized that burning and smoke production may adversely affect marbled murrelets but that research was needed to confirm and understand what effects these disturbances may have on marbled murrelet nesting biology. A review of the scientific literature found that no such research has been published regarding the effects of smoke on nesting marbled murrelets. Because smoke exposure will be minimized through seasonal restrictions, and because smoke has not been reported as a major stressor on nesting marbled murrelets, it is anticipated that some disturbance of nesting marbled murrelets may occur as the result of prescribed burns in the permit area, but the effect is not expected to rise to the level of take.

4.5.1.2 Nest Site Destruction

Timber harvest and associated road work are the primary risks to nest site destruction. The HCP strategically prioritizes protecting marbled murrelet designated occupied habitat. The Permittee will permanently safeguard occupied habitat and seasonally protect any nests found via monitoring (Goal 2 and Condition 9). All modeled potential marbled murrelet stands that are subject to proposed harvest treatments will be examined for presence of marbled murrelet nest sites prior to treatments (Condition 7). Harvest treatments will not occur in habitat determined to be occupied through this process unless it is found later to be unoccupied.

Direct harvest of known marbled murrelet nest trees is not a covered activity. Nor is harvest of mature trees from the CRW and MRW Reserves or RCA buffers. However, the monitoring program is not sufficient to provide full clearance surveys to document the absence of marbled murrelet nest sites in areas not currently designated occupied or modeled potential habitat. This would include ingrowth habitat that becomes subject to harvest in the latter half of the permit term that unknowingly became occupied without detection. Such harvest could be generated from covered activities only in allocations that are subject to harvest and contain stands too young to have been classified as modeled potential habitat (i.e., <90 to 100 years old as of 2020). Areas where this may occur only include retention stands in extensive treatment areas; other areas of ingrowth in the CRW and MRW Reserves or RCAs will mature throughout the permit term, without fear of harvest as no stands over 80 years old (as of 2020) will be subject to restoration thinning.

4.5.1.3 Disturbance and Direct Mortality from Road Use

Road use associated with covered activities (research, administrative, forest work crews) has the potential to disturb nesting murrelets through noise and potentially through direct mortality. Neither effect has been well researched or presented as significant stressors on marbled murrelet populations. Long and Ralph (1998) conducted a review of the literature regarding vehicle noise and found a few reports of minor responses (e.g., chick opening eyes) and other reports of no apparent response. Noise from traffic near marbled murrelet nesting could conceivably disturb nesting murrelets, potentially causing stress and even flushing a brooding adult from the nest, exposing eggs or hatchlings to predation. However, the level of road noise to which marbled murrelets will be exposed in the permit area is expected to be infrequent and at low levels. Based on these considerations, vehicle disturbance may cause minor disturbance or stress to marbled murrelets nesting near roads, but the effects are not anticipated to rise to the level of take.

Road mortality is also a possible effect. Nelson (1997) reported five documented instances of marbled murrelet mortality resulting from vehicular collision and speculated that nesting adults may be susceptible to vehicular traffic risk where nests are located near roads, as birds typically approach nests from below. However, no recent reports of such mortality were found in the literature and accurately predicting risks of such mortality is difficult. Nelson and Peck (1995) reported that murrelets appeared to use open corridors, such as creeks, rivers, ridges, or roads, to approach or leave the nest. However, their reported flight altitudes on approaches were reported to be "as low as 5 m (16 feet) above the ground." This lower range of approach altitude is above the height of most vehicles. However, Manley (1999) reported murrelets flying as low as only 1 to 3 meters (3 to 10 feet) above the ground down logging roads to reach nests. Surveys along the approach route to one nest revealed that the birds were flying along a creek to its junction with a road, then traveling approximately 150 meters (492 feet) from the nest to the road to access the nest.

Based on this limited available information, marbled murrelets could be exposed to risks of vehicle collisions, although the degree of risk may be relatively low due to the low level of road use. In addition, flights to and from nests most often occur very early in the morning, a time when vehicle activity is generally low. However, because this area does contain a large population of marbled murrelets, and covered activities will generate road traffic, such mortality cannot be ruled out.

While mortality from collisions with vehicles is possible, quantifying such take with accuracy is not possible, due to the lack of research data and overall rarity of reported incidents. Based on a review of past consultations. Conservation Measure 3 restricts road development to no more than 40 miles of permanent new roads over the permit term, and states that the current road density will decrease throughout the permit area through vacating in 10-year increments over the permit term, such that a net density reduction (relative to current density) will occur by the end of the permit term.

4.5.1.4 Edge Effects

Edge effects occur when stands are harvested adjacent to marbled murrelet habitat. Timber harvest and thinning are the primary sources of edge effects anticipated over the permit term.

Mortality of marbled murrelet eggs or chicks could occur due to nest site depredation facilitated by intensive treatments or heavy thinning from extensive treatments or reserve treatments adjacent to occupied nesting habitat. Ravens, crows, and jays are known to prey on marbled murrelet eggs and young (Golightly and Schneider 2011; Falxa and Raphael 2016). The Marbled Murrelet Recovery Plan (U.S. Fish and Wildlife Service 1997) recommends minimum buffer widths of 300 to 600 feet to maintain and enhance buffer habitat around occupied nesting habitat. However, based on a review of literature, much of which was published after the recovery plan, Lorenz et al. (2021) reported that nests within 50 to 60 meters (164 to 197 feet) of edge are most susceptible to depredations and nest failure due to edge treatments.

In addition to nest site depredation from corvids that may increase with the creation of edge habitat, clearcut harvest and heavy thinning would expose habitat to windthrow by removing wind protection that was provided by the harvested/thinned stand (Falxa and Raphael 2016). Harvest of adjacent stands can also reduce humidity levels in habitat, reducing the extent and future development of mossy branches required for marbled murrelet nest sites (Van Rooyen et al. 2011).

Some level of "edge effect" could occur at the affected site for up to 40 years until regeneration occurs to create a softer edge and less direct access to nesting stands for predators, with most impacts expected to occur during the first 10 years. Van Rooyen et al. (2011) considered hard edges to be those created by recent clearcuts 5 to 11 years old and soft edges to be those where regenerating stands are 17 to 39 years old. For the purposes of determining the amount of take, this HCP assumes harvested edges will transition from hard edge to soft edge after 20 years, and from soft edge to no edge after 40 years, as modeled in Appendix D, *Marbled Murrelet Habitat Suitability Index Approach*.

Edge creation from covered activities in the permit area would be primarily from intensive treatments adjacent to designated occupied or modeled potential habitat, although similar effects may occur in extensive and reserve treatments where heavy thinning or low-retention harvests are applied in plantations or to create gaps and increase structure. Edge effects will be minimized through Conservation Measure 5, which will provide extra buffering in modeled potential habitat adjacent to designated occupied habitat during treatments to minimize edge effects and provide continuity between existing occupied habitat polygons.

As with road mortality, it is difficult to estimate the amount of such take that will occur. However, the research design included contiguous habitat, where present, adjacent to locations where nesting behavior was detected. In addition, as mentioned in Section 4.5.1.5, under the *Intensive Treatment* subheading, Conservation Measure 5 was added to avoid and minimize edge effects, which will limit depredation.

Based in part on public input received on the public draft HCP, additional measures have been added to the conservation strategy (Chapter 5, *Conservation Strategy*) to avoid and minimize such edge effects. Specifically, Conservation Measure 5 includes a commitment and procedures for establishing buffers to limit the creation of new hard edges and increase habitat connectivity in modeled potential habitat that is adjacent to occupied habitat. In addition, as described in Chapter 5, Objective 2.3 and Condition 9 include commitments to measure and manage edge effects using an HSI (Appendix D, *Marbled Murrelet Habitat Suitability Index Approach*). The Permittee developed the HSI in coordination with USFWS to provide a quantifiable measure of (1) the habitat value of individual forest stands as potential marbled murrelet nesting habitat, (2) the total value of that habitat (expressed as "area-weighted HSI acres"), and (3) the reduction of this habitat value due to edge effects not minimized by Conservation Measure 5.

A generalized HSI score is based on a scale of zero to one, with zero being nonhabitat and one being the best possible habitat. Stand age is the only attribute used to determine the HSI-age function because it is strongly associated with the presence of habitat attributes necessary for marbled murrelet occupancy (Betts and Yang 2023; Hamer et al. 2021). Observational data from the ESRF provide evidence that some stands become occupied by marbled murrelet as early as 100 years. The HSI-age function (Appendix D, Figure 3) captures this dynamic by categorizing a stand as unsuitable while less than approximately 100 years of age, then becoming suitable at 100 years of age, increasing rapidly in suitability to 150 years of age, and then the rate of increase in HSI decreases slowly as stands mature to 300 years of age and older.

The output of area-weighted HSI acres is a way to quantify the overall habitat quality by multiplying HSI scores of individual stands by the corresponding area in acres and summing them up across the entire permit area. As described in Appendix D, *Marbled Murrelet Habitat Suitability Index Approach,* the HSI calculation of edge effects assumes that harvested edges transition from hard edges with low canopy cover to soft edge after 20 years, and from soft edge to no edge after 40 years. Thus, edge effects are accounted for using stand density and canopy cover, not stand age, which would not be reduced by thinning.

Using the HSI, the total modeled area-weighted HSI acres score of the permit area at the beginning of the permit term (2024) is calculated to be 20,098 HSI acres, with a calculated reduction of 7.2% due to existing edge effects (Appendix D, *Marbled Murrelet Habitat Suitability Index Approach*). As specified in Condition 9, maintaining a minimum HSI value and limiting edge effects are intended to ensure the net marbled murrelet habitat value will not drop below that present at the beginning of the permit term. Because marbled murrelet habitat will be developing over the permit term, the projected loss of habitat value due to edge effects is projected to be mitigated by the increase in total habitat value over the permit term.

Figure 4-4 and Table 4-5 present the projected total marbled murrelet habitat value (HSI acres) across the permit area, as adjusted for edge effects over the permit term, by decade.

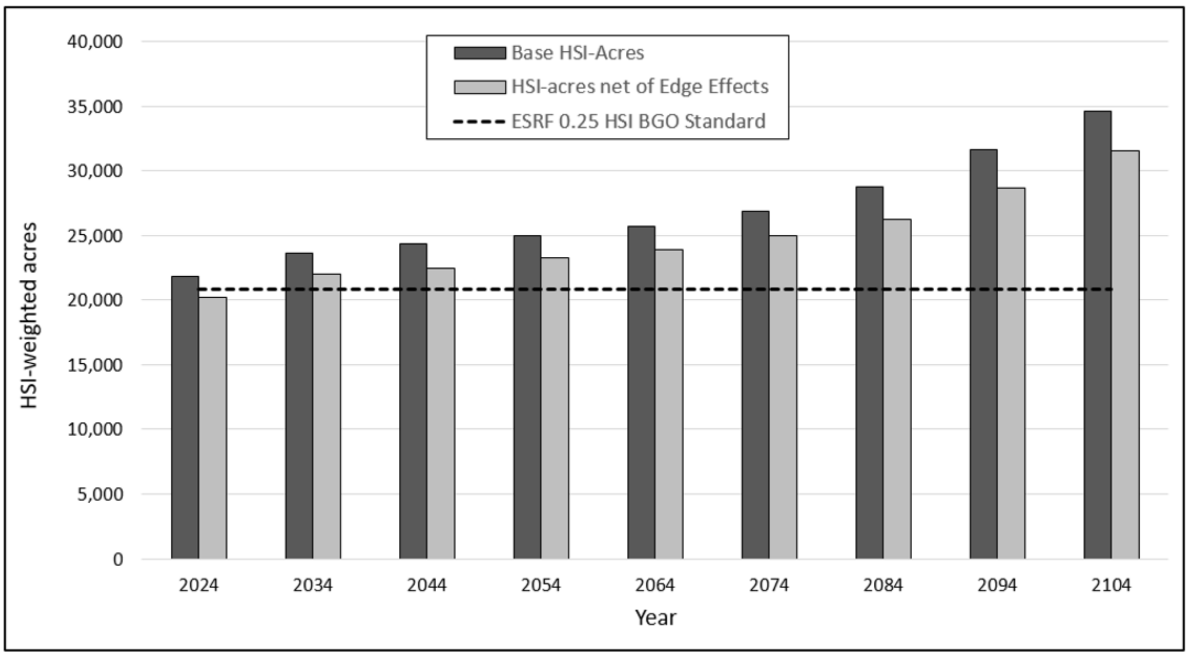


Figure 4-4. Total Area-Weighted HSI Acres and Edge Effects in the Permit Area over the Permit Term

Table 4-5. Projected Edge Effects over the Permit Term, based on Area-Weighted HSI Acres

Year	Gross HSI Acres	HSI Acres net of Edge Effects	Projected Edge Effect (%) [a]
2024	21,831	20,255	7.2%
2034	23,633	22,035	6.8%
2044	24,316	22,424	7.8%
2054	25,024	23,241	7.1%
2064	25,718	23,940	6.9%
2074	26,853	24,978	7.0%
2084	28,785	26,223	8.9%
2094	31,648	28,694	9.3%
2104	34,596	31,560	8.8%

[a] Projected levels of edge effects exceed the 7.2% commitment limit in some decades. Harvest schedules will be developed and/or revised during biennial planning so that forest operations meet all HCP, regulatory, and planning commitments, including the commitment to limit edge effects.

4.5.1.5 Nesting Habitat Harvest and Thinning

The covered activities described in Chapter 3, *Covered Activities*, together with conservation measures and conditions on covered activities described in Chapter 5, *Conservation Strategy*, are intended to avoid or minimize impacts on nesting marbled murrelets and associated habitat and are also projected to result in a net increase in marbled murrelet habitat over the 80-year permit term. However, to achieve research goals, localized harvest, thinning, road construction and maintenance, and other covered activities will occur within or adjacent to marbled murrelet habitat.

Of the covered activities described in Chapter 3, *Covered Activities,* the primary source of habitat loss and modification and associated take over the permit term is projected to be the full suite of thinning and harvest techniques used in contemporary forestry. Supporting management and infrastructure activities, including construction of access roads and landings, could also affect marbled murrelets. Other sources of marbled murrelet habitat modification include tree removal associated with covered activities, such as road system construction and management, quarry development, landings, temporary roads, maintenance and use of existing water drafting and storage areas, and hazard tree removal (conducted as part of research treatments or other covered activities).

Modification of habitat through covered activities is anticipated to result in the following categories of stressors on marbled murrelets (disruption and disturbance considered in previous sections).

- Eliminated large trees with platforms and associated canopy cover and interior habitat required for nesting.
- Interior nesting habitat subjected to forest edge, increasing access to nest sites by predators (primarily corvids).
- Seasonal and temporal disturbance during marbled murrelets nesting season (April 1–September 15).

Behavioral responses to such stressors by individual marbled murrelets may include abandonment of nest sites and searching to establish new nest sites. Such responses may result in individuals not breeding for 1 or more years. These responses may carry high energy costs due to stress from increased time and effort spent traveling to find new nest sites. In addition, new nest sites, if established, may be further from preferred foraging areas, increasing energy demands and influencing forage site selection, prey capture rates, and the number of feeding trips adults can make to the nest (Kuletz 2005; Huff et al. 2006). These energy costs can result in an energy deficit that translates into biological effects, including reduced physical fitness, reproduction, and survival of individual marbled murrelets (Becker et al. 2007). Harm will occur when energy deficits result in reduced nesting successes or mortality of adults through starvation, exposure (e.g., heat, cold, rain), disease, or predation.

The degree of habitat modification anticipated to occur is closely associated with the research treatment described in Chapter 3, *Covered Activities*, as detailed in the following subsections. Table 4-6 summarizes the acres of marbled murrelet habitat across research treatments and Figure 4-5 displays the location of these habitat types relative to treatment types in the permit area.

Table 4-6. Marbled Murrelet Habitat in the Permit Area, by Treatment Type [a]

Treatment Type	Designated Occupied	Modeled Potential
Intensive Total	-	51
Habitat >65 years old (as of 2020)	-	-
Habitat ≤65 years old (as of 2020)	-	51
Extensive Total	-	2,669
Habitat >65 years old (as of 2020)	-	2,597
Habitat ≤65 years old (as of 2020)	-	72
No Treatment	18,783	17,994
Habitat >65 years old (as of 2020)	18,783	17,975
Habitat ≤65 years old (as of 2020)	1	19
Restoration Thinning	71	176
Habitat >65 years old (as of 2020)	-	-
Habitat ≤65 years old (as of 2020)	71	176
Total Existing Habitat in the Permit Area	18,855	20,908

[a] Habitat based on Betts and Yang (2023, unpublished). Reported acreages differ slightly from those presented in OSU's research proposal (Appendix C, *Proposal: Elliott State Research Forest*) because the research proposal was completed before the riparian conservation strategy was finalized. Updated RCA buffer corrections and the removal of a marbled murrelet experiment account for difference in acreages when they occur in occupied or potential marbled murrelet habitat.

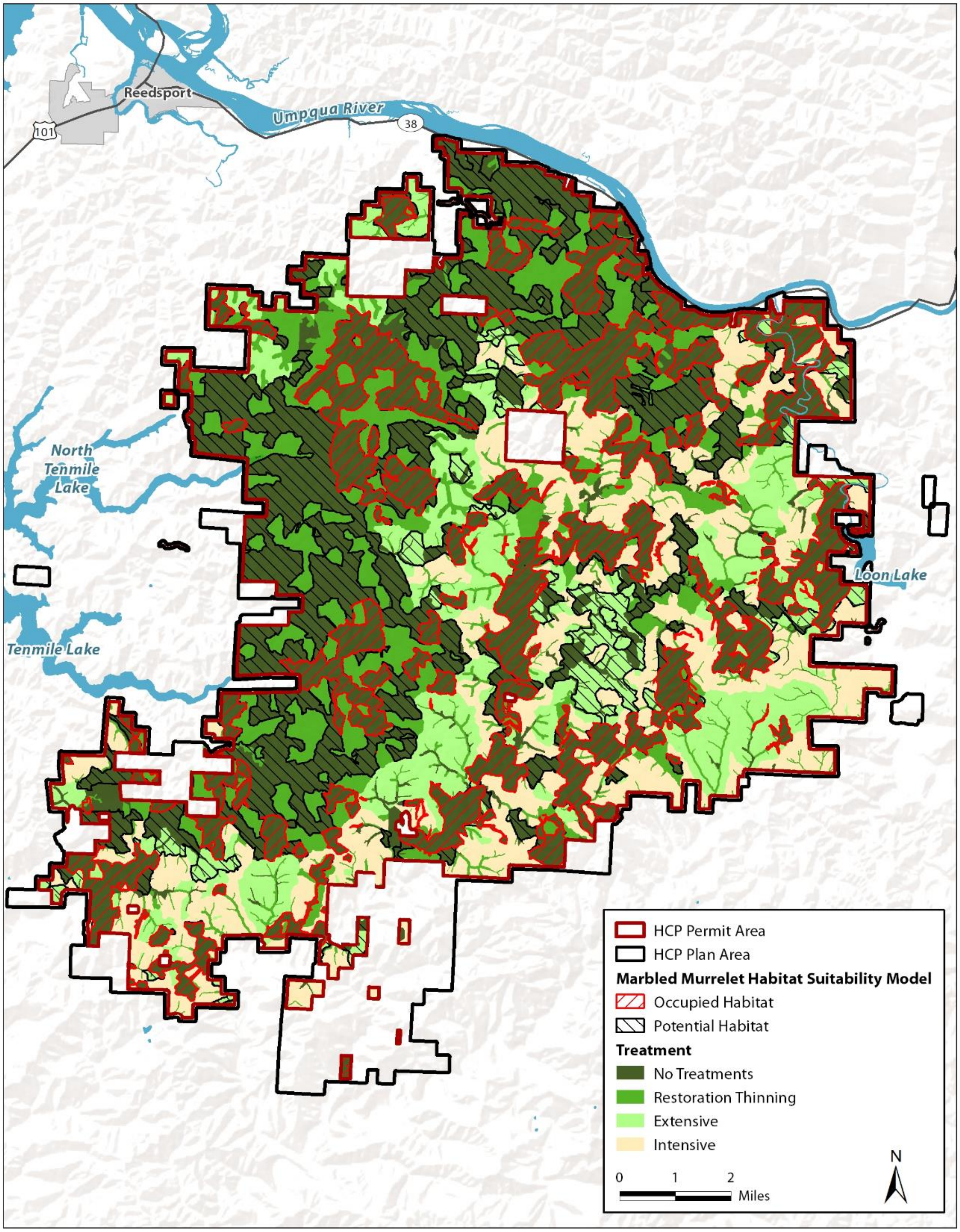


Figure 4-5. Marbled Murrelet Designated Occupied and Modeled Potential Habitat by Treatment Type

Intensive Treatments

Intensive treatments in modeled potential marbled murrelet habitat are prohibited unless they are in areas determined to be unoccupied through the process set forth in Conditions 7 and 8. However, when intensive treatments overlap with modeled potential marbled murrelet habitat, Condition 7 requires an evaluation of the habitat potential in that treatment area and a survey of any remnant habitat patches larger than 5 acres. If remnant patches are 5 acres or larger and are found to be occupied by marbled murrelets, the areas will be designated as an MRW Reserve (or expanded RCA), and the intensive treatment will be reallocated to another part of the subwatershed not occupied by marbled murrelets. Harvest treatments will not occur in habitat determined to be occupied through this process unless it is found later to be unoccupied. Any changes to an occupied stand designation will be handled in accordance with Chapter 7, Section 7.8*, Changed and Unforeseen Circumstances*

Intensive treatments in nonhabitat may still indirectly affect marbled murrelet nesting habitat in adjacent stands. As described in Section 4.5.1.1, *Nest Site Disturbance*, harvest adjacent to marbled murrelet nesting habitat may create a hard edge for up to 20 years and a soft edge for up to 40 years that could subject nesting murrelets to increased risk of nest site predation and reduced physical fitness, reproduction, and survival of individual marbled murrelets.

Conservation Measure 5 commits to procedures for establishing buffers for covered activities to avoid and minimize edge effects in modeled potential habitat adjacent to designated occupied habitat. Edge effects projected to occur are further described and quantified in Section 4.5.2, *Impact of the Taking*.

Approximately 51 acres of young stands modeled as potential habitat (Table 4-6, Figure 4-6) could be subject to intensive treatments. Intensive treatments will occur in existing Douglas-fir plantations 65 years old or younger (as of 2020), so while the model identified these small areas as potential habitat, they are likely to be unoccupied due to stand age, although some higher-quality remnant habitat patches may be occupied.

Condition 7 requires further assessment of modeled potential areas that are allocated to intensive treatments. The condition also requires surveys of any residual habitat patches larger than 5 acres, and any areas found to be occupied by marbled murrelets will be reallocated to reserves. There will be no loss of designated occupied marbled murrelet habitat from intensive treatments.

Because of the harvesting standards of intensive treatments (Chapter 3, Section 3.3.2, *Intensive Allocations*), no stands that are greater than 65 years of age (as of 2020) will be harvested using intensive treatments and the minimum rotation age of 60 years or less means no ingrowth habitat is expected to be intensively harvested over the permit term.

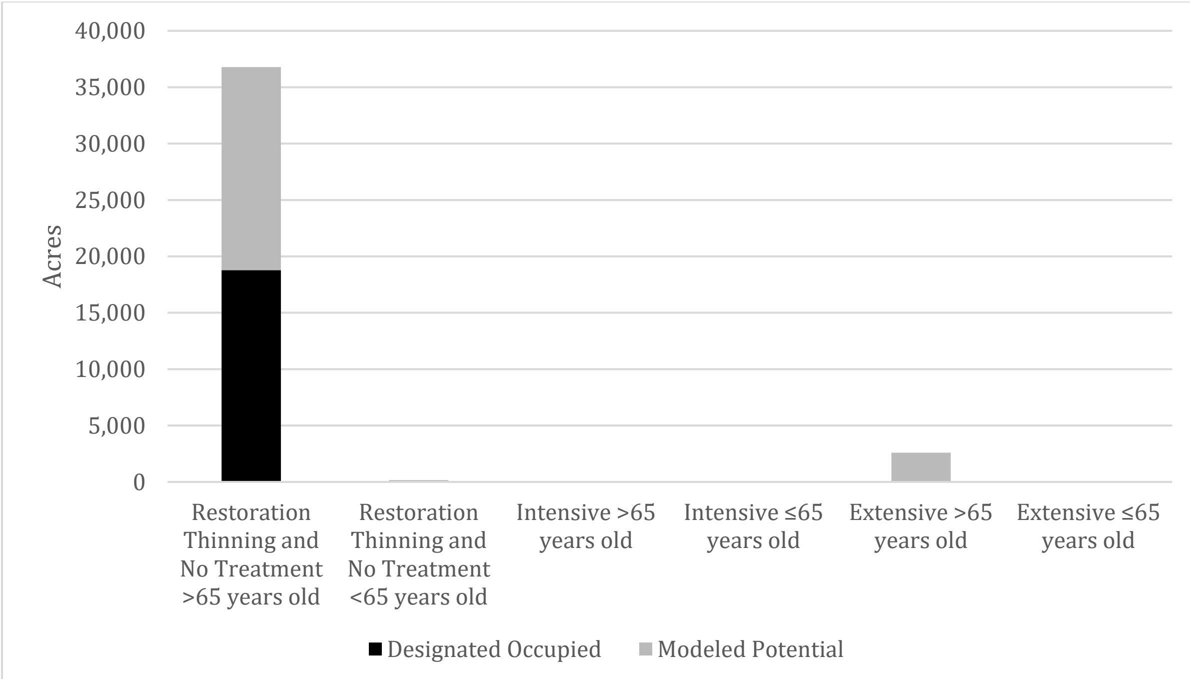


Figure 4-6. Marbled Murrelet Habitat by Treatment Type

Extensive Treatments

Murrelet surveys will be conducted using USFWS-accepted protocols in all modeled potential habitat stands that are intended for harvest (Condition 7). Best management practices will be used and will involve provisions to limit predation by corvids and other impacts on murrelets, as informed by best available science.

As with intensive treatments, extensive treatments could create edge and associated adverse, effects, including increased nest depredation and habitat value reduction through windthrow and altered microclimates and associated moss and nesting habitat. In extensive treatments, leave tree operations standards (Chapter 3, *Covered Activities*) will help to minimize or avoid edge effects and associated risks of predation, but edge effects would still occur. As previously mentioned under *Intensive Treatments*, Conservation Measure 5 was added to avoid and minimize edge effects. Edge effects projected to occur are further described and quantified in Section 4.5.2, *Impact of the Taking*.

This combination of relatively higher tree-retention rates in extensive treatments and the 3,200-acre limit on the total acres of forest older than 65 years (as of 2020) that can be managed with extensive treatments (as described in Chapter 3, Section 3.3.3, *Extensive Allocations*) minimizes some effects from habitat modification on marbled murrelets. Over the permit term, canopy cover and tree density could fall below that required by marbled murrelet following extensive treatments that reduce stand density down to the minimum of 20% allowed and where new edge habitat is created from variable retention regeneration harvests. Habitat values may remain in retention patches or in areas of high-density retention with dispersed thinning.

If all extensive treatments occur immediately after permit issuance this could result in the harvest of a total of 2,669 acres of modeled potential habitat (Table 4-6). However, these acres are required to be evaluated, and if found to contain contiguous potential habitat, surveyed prior to harvest by Condition 7. Any areas found to be occupied by marbled murrelets will be designated as occupied and managed as an aggregate retention area (or otherwise protected) and not subjected to future thinning or harvest, and the extensive treatment activity will be relocated to another part of the subwatershed not occupied by marbled murrelets. There would be no loss of designated occupied marbled murrelet habitat from extensive treatments.

Ingrowth Habitat

The primary goal of extensive management is to maintain continuity of forest structure, function, and composition through time, so harvesting of ingrowth habitat is an expected outcome of extensive management. The emphasis on allowing stands to mature and employing variable retention thinning and regeneration techniques that improve habitat quality means that more areas will transition into suitable habitat for marbled murrelets, but also that such stands would be subject to subsequent thinning or harvest entries, with up to three entries into stands more than 65 years old and up to four entries into stands less than 65 years old over the permit term. Therefore, depending on the age of the stand during treatment, modification of marbled murrelet nesting trees could occur in the same stand from one to four times over the permit term.

Because specific harvest plans have not been developed, this HCP makes some conservative estimates to calculate the upper limits of such harvest and borrows from some of the model assumptions made by OSU in its marbled murrelet habitat diminution analysis (Appendix D, *Marbled Murrelet Habitat Suitability Index Approach*) and the standards described in Chapter 3, Section 3.3.3, *Extensive Allocations*. A mock harvest treatment scenario was developed to assist in this analysis that assumes the following scenario.

- Stand ages (as of 2025[3]) and treatment periods are categorized into 10-year intervals where harvest entries could occur.
- 12,425 acres are available for extensive treatments. This value differs from Table 4-1 because it represents the appropriate age classes in Extensive and Flexible Extensive allocations, as well as 169 acres of Flexible allocation additional harvest needed up to the 3,200-acre harvest limit in older stands. This value does not include the Volume Replacement allocation, which is available as contingency only (Chapter 3, Section 3.3.4, *Volume Replacement Allocations*).
- Three entries in all stands at roughly 30-year intervals during the permit term.
- Variable retention regeneration harvests reset some portion of the stand (ranging from 35 to 50% of original pre-harvest stand density) at an age of at least 100, that then do not grow forward as marbled murrelet habitat ingrowth during the permit term.
- Stands 70 years old or less will remove up to 80% of the original pre-harvest stand density over the permit term.
- Stands over 70 years old will remove up to 80% of the original pre-harvest stand density (50% on average) and will retain an average of 25% as aggregates.
- Stands that reach 100 years old are considered marbled murrelet habitat.

Based on the conservative assumptions above, harvest of approximately 10,669 acres of existing and new ingrowth of marbled murrelet nesting habitat could occur in the extensive treatments over the permit term. This represents the area of potential effects, where nest site disturbance or destruction

[3] Stand age projections used 2020 ages adjusted to 2025 when permit issuance is expected and when habitat tracking will begin.

could occur if harvest operations take place during the nesting and fledging period. The proportion of this disturbance zone that contains or will contain suitable habitat that is actually occupied by unknown (and unsurveyed) marbled murrelet nest sites is likely to be lower than these estimates, particularly if the 2,669 acres of modeled potential habitat (Table 4-6) is found to be occupied and is, thus, allocated to reserve or the occupied habitat protective designation. Given the abundance of marbled murrelets known on the ESRF and their condition in the coast range of Oregon, colonization of stands over 100 years old is expected later in the permit term.

Restoration Thinning Treatments

Restoration thinning treatments will occur in the CRW and MRW Reserves and RCAs to set these stands on a trajectory to develop old forest structure, which will increase the habitat value for marbled murrelets. Most of these stand management activities will occur in the first 20 to 30 years of HCP implementation, although some could take longer in the MRW Reserves and RCAs and will focus on Douglas-fir plantations that are 65 years old or younger (as of 2020). Very little of these stands subject to thinning are designated occupied or modeled potential marbled murrelet habitat.

Because trees older than 65 years (as of 2020) will not be felled during these management activities, the reduced tree density from thinning is not expected to directly remove nesting habitat, but edge effects may occur in areas where designated occupied or modeled potential habitat is present adjacent to thinning treatments in reserves. Conservation Measure 5 was added to avoid and minimize edge effects in modeled potential habitat adjacent to designated occupied habitat. Edge effects projected to occur are further described and quantified in Section 4.5.2, *Impacts of the Taking*.

Restoration thinning treatments in RCAs are expected to be similar to those described for MRW and CRW Reserves, as many of the same operations standards will apply. However, additional constraints on RCA thinning include the requirement for a 160-acre pilot project necessary for work in the ELZs (Chapter 3, Section 3.3.7.3, *Equipment Limitation Zone*), and other tree and wood retention requirements. RCA treatments may result in edge effects in areas where heavy thinning is required to meet RCA objectives. However, thinning is expected to improve habitat value over the remaining portion of the permit term and to not appreciably result in significant edge effects in adjacent habitat.

4.5.1.6 Conservation Measures and Conditions

The beneficial effects of conservation measures and conditions have already been described as part of the effects analysis of research treatment designations. In addition, most adverse effects of conservation measures would occur due to previously described covered activities, including restoration thinning and extensive treatments and associated covered activities, including landings, and road construction, maintenance, and use.

- **Riparian restoration and stream enhancement.** Riparian restoration and stream-enhancement projects will include selective tree harvesting up to stream edges for ecological purposes. This harvesting could result in localized habitat reductions, although all operations standards for RCAs will be applied to minimize effects, including limiting harvest to trees 65 years old or younger (as of 2020), not treating stands that reach 80 years old, and maintaining the habitat commitments for marbled murrelets and northern spotted owls included in Chapter 5, *Conservation Strategy*.

- **Roadwork.** Removal of active or legacy roads would not have adverse habitat effects other than the potential need to remove hazard trees determined to be an unacceptable safety risk for workers or others. Road daylighting involves cutting trees along roads. Many of the trees that will be removed for daylighting are hardwood species, which tend to expand over roadways much more than conifers, and which provide limited habitat values for marbled murrelet. Culvert replacements, fish barrier removals, and other aquatic conservation measures are not anticipated to require modifications of marbled murrelet habitat.

Monitoring and Implementation Activities

Marbled murrelet monitoring efforts (described in Chapter 6, *Monitoring and Adaptive Management*) will follow USFWS-accepted methods, which are currently conducted by trained surveyors intensively watching and listening for marbled murrelets at monitoring stations for 2 consecutive years (Pacific Seabird Group 2024a). This method would have no adverse effects on marbled murrelets. In addition, the planned use of passive acoustic monitoring devices could be an accepted substitute for using recorded call playbacks in the future, as described in Chapter 3, Section 3.9.6, *Survey and Monitoring Requirements*.

Other Covered Activities

As previously described under effects of each treatment (intensive, extensive, restoration thinning), habitat disturbance would occur as the result of supporting management and infrastructure activities (e.g., access roads, landings). All covered activities will follow the operations standards for each research treatment described in Chapter 3, *Covered Activities,* as well as the conservation measures and conditions described in Chapter 5, *Conservation Strategy*. These actions include avoiding disturbance of nesting marbled murrelets through seasonal restrictions in Condition 6, surveying all modeled potential habitat prior to harvest in Conditions 7 and 8, and limits on harvest in Condition 9 and Conservation Measure 5. The acres of habitat impacts described in Section 4.5.2, *Impacts of the Taking,* include acres that would be disturbed from the other covered activities conducted within the framework of the treatment allocations and associated operations standards, conservation measures, and conditions (i.e., habitat effects are counted but not quantified separately).

4.5.1.7 Effects on Critical Habitat

Less than 5 acres of designated marbled murrelet critical habitat overlap with the permit area. These 5 acres will be avoided by covered activities because they are a result of geographic information system (GIS) boundary layers incorrectly overlapping near Loon Lake, resulting in no effect on critical habitat. The HCP is expected to complement these critical habitat areas by providing a large block of high-quality marbled murrelet nesting habitat near high-density marbled murrelet foraging areas along the Oregon Coast.

4.5.2 Impact of the Taking

Incidental take of marbled murrelet through nest site disturbance and possible nest site destruction has been minimized through the habitat protections described in Chapter 3, *Covered Activities,* and through conservation measures and conditions defined in Chapter 5, *Conservation Strategy*. The approximately 2,669 acres of modeled potential habitat present in areas subject to extensive treatments (described in Section 4.5.1.5, *Nesting Habitat Harvest and Thinning,* and Table 4-6) represent 13% of the total modeled potential murrelet habitat in the permit area and just 7% of the total modeled potential and occupied marbled murrelet habitat (2,669 acres of 39,768 acres). In areas subject to Intensive allocations, 51 acres of modeled potential habitat are present, which represents approximately 0.13% of the total designated occupied or modeled potential habitat in the permit area. Collectively, there are 2,720 acres of designated occupied and modeled potential habitat in areas subject to extensive and intensive treatments, representing 7% of the total designated occupied or modeled potential habitat in the permit area.

The HCP monitoring program is not sufficient to provide full "clearance" surveys to document the absence of marbled murrelet from areas adjacent to modeled potential habitat not yet surveyed for occupancy, or in areas where forest is too young or incontiguous to have been classified as modeled potential habitat as of 2020. As described in Section 4.5.1.1, *Nest Site Disturbance,* a conservative estimate suggests up to 2,100 acres of adjacent lands could be exposed to potential disruption effects from covered activities conducted within 110 yards of suitable nesting habitat for marbled murrelet. The proportion of this disturbance zone that contains suitable habitat actually occupied by unknown (unsurveyed) marbled murrelet nests is likely to be lower than this estimate. Cumulatively, the harvest of existing and new ingrowth habitat in the extensive treatment areas could affect approximately 10,669 acres of marbled murrelet nesting habitat (100 years old or older [as of 2025]) over the permit term; 2,669 acres of this habitat is already modeled potential habitat that would need to be surveyed prior to the first entry. If marbled murrelets are found within those stands then they will be designated occupied and afforded those protections. As summarized in Section 4.5.1, *Sources, Types, and Amount of Take*, the conservation strategy includes several conservation measures and conditions to avoid, minimize, and mitigate effects on marbled murrelet, including Conservation Measures 3 and 5 and Conditions 6 through 9. Collectively, these measures are anticipated to result in a demonstrable net increase in marbled murrelet habitat over the permit term, offsetting direct habitat loss, as well as indirect effects related to edge to the maximum extent practicable. In addition, conservation measures will ensure that overall habitat value for the permit area never drops below pre-permit conditions. Therefore, while there would be short-term, localized impacts associated with the covered activities, these would not result in adverse impacts on marbled murrelet populations at the level of the permit area over the course of the permit term. It follows that the impact of the taking would not likely affect marbled murrelet populations in the context of the Oregon Coast Range or range-wide distributions.

4.6 Effects Analysis for Oregon Coast Coho

4.6.1 Sources and Types of Take

The covered activities described in Chapter 3, *Covered Activities,* including upland timber harvest; road construction, maintenance, and vacating; thinning in riparian areas; upgrading or removing passage barriers; supporting activities; and the conservation strategy could result in the following categories of stressors on Oregon Coast coho, each of which has the potential to result in take.

- Changes to ecological processes that result in a reduction or modification of habitat. These include changes in stream habitat features (e.g., pools, off-channel habitat, side channels, spawning and incubation habitat) due to a reduction in large wood available for recruitment and bed alterations due to sedimentation, as well as changes in water quality and quantity, including temperature and suspended sediment.

- Reduced access to suitable habitat due to existing barriers (e.g., undersized culverts, large jump heights).
- Direct disturbance, injury, or mortality of individuals because of in-water work, handling or crushing/entrainment by equipment, management-related debris flows,[4] humans, or felled trees.

These stressors are categorized in this manner to facilitate a meaningful assessment of the effect pathways for Oregon Coast coho. The following sections describe the effects pathways associated with each of the stressors that result from the covered activities. Vulnerability of coho to take by the described activities is dependent on life stage, residence time in the aquatic system, location in the aquatic system, and timing of covered activities. These factors are considered below.

4.6.1.1 Habitat Modification

Management of riparian areas in the permit area is designed to provide the suite of ecological processes needed for a productive aquatic ecosystem, as well as minimize effects on the aquatic environment from the covered activities.

As described in Chapter 3, *Covered Activities,* and Chapter 5, *Conservation Strategy,* RCAs (buffers) in the permit area will be established on fish-bearing streams and some non-fish-bearing streams to protect and promote ecological processes needed to support Oregon Coast coho (Table 4-7). The RCAs were designed to maintain high wood recruitment potential to create and support needed habitat conditions for coho in the permit area and in downstream areas outside the permit area. The RCA strategy is based on relevant science, much of which was reviewed and discussed by Reeves et al. (2018) in the science synthesis for the Northwest Forest Plan. Establishing RCAs will also provide protections against increased water temperatures, regulate sediment transfer, and filter chemicals and other pollutants. However, part of the research design is to determine how various levels of riparian thinning could benefit coho over time, which may cause short-term impacts on coho and its habitat, depending on the magnitude and location of thinning treatments.

Overall, the riparian buffering strategy and upland harvest limits will minimize habitat modifications and are expected to provide a net benefit to coho over the permit term and minimize the likelihood of take. Each of these parameters and the potential effects and benefits under the HCP are discussed below.

[4] *Debris flows* are fast-moving landslides often referred to as mudslides, mudflows, or debris avalanches. Debris flows typically start on steep slopes as shallow landslides that liquefy and quickly pick up speed.

Table 4-7. Widths of Riparian Conservation Areas by Stream Type and Adjacent Allocation

Stream Type [a]	Adjacent Allocation	Width (feet) [b]
Fish-Bearing (FB)	CRW MRW Volume Replacement, Flexible Extensive (in Big Creek subwatershed), and all allocations along Lower West Fork Millicoma River mainstem	200
	MRW Flexible, and Flexible Extensive (outside of Big Creek subwatershed), and Reserves, Extensive, and Intensive in the MRW Lower Millicoma River subwatershed (nonmainstem)	120
	MRW Reserves, Extensive, and Intensive (outside of the Lower Millicoma subwatershed)	100
Perennial Non-Fish-Bearing (PNFB)	CRW Reserves MRW Volume Replacement, and Flexible Extensive (in Big Creek subwatershed)	200
	All Other MRW Allocations	50
High Landslide Delivery Potential (HLDP) [c]	CRW Reserves MRW Volume Replacement, and Flexible Extensive (in Big Creek subwatershed)	200
	All MRW Allocations in the Lower West Fork Millicoma subwatershed	120
	All Other MRW Allocations	50
Non-Fish-Bearing Non-Perennial (XNFB) [d]	All Allocations	0

[a] Stream types are defined based on fish presence, perenniality, and susceptibility to landslide-associated debris flows that deliver wood and sediment to fish-bearing streams.

[b] All RCA widths are horizontal distance.

[c] Non-fish-bearing streams that comprise 25% of the total non-fish-bearing channel wood delivery budget to fish-bearing streams.

[d] Non-fish-bearing non-perennial streams that are not HLDP.

Large Wood Recruitment

A common issue in western Oregon is the lack of instream wood. Reduced instream wood is the result of removing trees in riparian zones around streams and rivers over time for timber harvest, as well as the long-standing practice of clearing debris and logjams from river channels (Stout et al. 2012). NMFS (2016) identifies the loss of stream complexity, which is created through inputs of large woody material, as a primary limiting factor for coho salmon.

Large wood[5] is essential to maintaining natural stream processes and is an important component of high-quality aquatic habitats for coho salmon. The physical and biological roles large wood plays in shaping stream ecosystems have been well studied and documented (e.g., Maser and Sedell 1994; Gurnell et al. 2002; Swanson et al. 2021). Trees that die and fall into and near streams, such as in floodplains and wetlands, regulate sediment delivery, transport, and composition, as well as the inflow of nutrients and water; influence channel complexity and stability, total pool volume and area; and provide refugia and cover for fish (Bisson et al. 1987; Gregory et al. 1991; Hicks et al. 1991; Ralph et al. 1994; Bilby and Bisson 1998; Reeves et al. 2018). Large wood originates from

[5] Large wood is generally defined as logs with a diameter greater than 4 inches and at least 6 feet in length.

trees in streamside forest stands and enters the channel following floods, erosion, windthrow, beaver activity, and disease or natural mortality. Large wood can include whole trees with limbs and intact rootwads or portions of trees with or without limbs or rootwads. Large wood promotes instream channel complexity by facilitating the creation of vital hydrologic features including pools, gravel bars, and off-channel areas like side channels and backwaters, all of which provide essential habitats for Oregon Coast coho. Large wood is especially important for the formation of pool habitats. For example, Reeves et al. (2016) found that large wood formed roughly 65% of pool habitat in a study on an Oregon Coast stream.

Large woody material also influences the storage and movement of sediments through the aquatic environment. Hydrologic features created by large wood increase the capacity of a stream or river to store fine sediments and gravels by slowing bedload movement and promoting deposition across the floodplain. Tree roots and large wood can also improve streambank stability by slowing water velocity, reducing or preventing channelization and bed and bank scour. Moreover, the presence of instream wood has been shown to improve habitat conditions for juvenile coho salmon by stabilizing streambed substrate and reducing velocities (Bair et al. 2019) and creating important summer and winter rearing habitats. Large wood creates refuge areas where fish can avoid predators and warm temperatures during the summer. Similarly, pools with large wood have been shown to be important refuge habitat for juvenile salmonids during the winter when high flows and flooding occurs (Bustard and Naver 1975).

Studies have also consistently found that higher densities of large wood leads to improved habitat complexity and higher densities of rearing salmonids. For example, Jones et al. (2014) found coho salmon rearing densities increased by 32% 6 years following large wood augmentation in western Oregon streams. Finally, juvenile salmonids residing in areas with abundant and complex large wood features have been observed moving shorter distances and less frequently than those residing in wood-deprived areas (Roni and Quinn 2001). Higher densities of large wood increase habitat complexity, improve channel stability, increase nutrient input, and increase aquatic invertebrate habitat (e.g., food for coho), meaning rearing juveniles do not need to move to locate food or refuge when large wood is abundant. Reduction of instream large wood can have negative physiological and behavioral effects on coho salmon by via habitat impacts resulting in reduced growth, survival, and reproduction; increased stress, disease, and predation; altered migration, movement, and distribution; and decreased diversity and resilience (Opperman et al. 2006).

Nearly all sources of wood recruited directly to fish-bearing streams are concentrated within 200 feet of stream edges (Welty et al. 2002). Additional wood is also recruited via upslope processes such as debris flows. However, wood recruited by debris flow processes are widely distributed across the forest and routed through the non-fish-bearing stream network. Despite this dispersed distribution, the densest non-fish-bearing wood sources tend to be concentrated near the fish-bearing streams they are tributary to due to the routing and aggregating effects of the non-fish-bearing stream network. Wood recruitment estimates for the permit area are based on the model *ElliottSFWood*, developed by Dr. Dan Miller of Earth Systems Institute. A brief description of the model is included here, but a full description of the model methods, assumptions, and results is included in Appendix E, *Wood Modeling*. The model estimates the following.

- The relative proportions of total wood recruitment attributable to treefall recruitment directly into fish-bearing streams (i.e., stream-adjacent mortality).
- Shallow transitional landslide recruitment to fish-bearing streams.

- Treefall recruitment that accumulates in non-fish-bearing channels and that is subsequently transported by periodic debris flow to fish-bearing streams.
- Shallow transitional landslide recruitment that is transported forthwith through non-fish-bearing channels to fish-bearing streams, or that is deposited in non-fish-bearing stream channels and is subsequently transported by periodic debris flows to fish-bearing streams (Appendix E, *Wood Modeling*).

This was then integrated with the large wood source-distance relationships described by McDade et al. (1990) in a GIS environment to estimate potential protected wood recruitment, which is the quantity of large wood that could be recruited to fish-bearing streams via adjacent riparian areas and debris flow process (Appendix E, *Wood Modeling*). The model assumes, based on McDade et al. (1990) and a 200-foot site-potential tree height, the following (see Table 4-7 for RCA widths).

- 60% of full-potential wood recruitment is protected by 50-foot RCAs.
- 85% of full-potential wood recruitment is protected by 100-foot RCAs.
- 90% of full-potential wood recruitment is protected by 120-foot RCAs.
- 100% of full-potential wood recruitment is protected by 200-foot RCAs.
- 50% of full-potential wood recruitment is protected outside of RCAs in Extensive allocations.
- 100% of full-potential wood recruitment is protected in reserve allocations.
- 50% of full-potential wood recruitment is protected in non-fish-bearing non-perennial streams that are not high landslide delivery potential (HLDP) streams (XNFB) that fall within RCAs of RCA-protected streams.

Finally, the wood recruitment model does not account for partial harvests including restoration thinning in RCAs and upslope areas. While there is uncertainty associated with the modeled wood recruitment estimates, the model provides a quantitative framework for identifying streams and channels most likely to deliver wood to fish-bearing streams and helps ensure those areas are protected by RCAs. Expected levels of wood recruitment for the entire permit area are expected to be roughly 92% (Table 4-8) and are further discussed by independent coho population in Section 4.6.2, *Impacts of the Taking*.

Table 4-8. Protected Potential Large Wood Recruitment in the Permit Area and in Independent Coho Population Areas

	Protected Potential Wood Recruitment		
Independent Population	**RCAs**	**Non-RCAs**	**Total**
Coos	77.2%	10.3%	87.5%
Lower Umpqua	77.4%	17.3%	94.7%
Tenmile	82.9%	15.4%	98.3%
Permit Area	**78.7%**	**13.6%**	**92.3%**

RCA = riparian conservation area

While timber harvest in riparian areas adjacent to streams can eliminate or reduce the amount of wood available for delivery to streams, RCAs will be maintained to provide a source of large woody material to aquatic ecosystems. RCAs will be applied to all fish-bearing streams, perennial non-fish-bearing (PNFB) streams, and non-fish-bearing streams that were modeled to deliver 25% of the total wood budget to fish-bearing streams (HLDP) (Table 4-7), which should ensure that the input of wood is maintained and keep the productive capacity of instream habitat high, even in the intensively treated watersheds. Moreover, relevant literature (e.g., McDade et al. 1990; Welty et al. 2002) reaffirms that the RCA widths will ensure high wood recruitment over the permit term.

Although thinning will occur in CRW stands meeting the characteristics described in Chapter 3, Section 3.4.2.2, *Thinning* (see also Section 4.6.2, Table 4-12), potential riparian wood delivery is protected along all perennial streams by upland reserves and a 200-foot RCA, which is expected to be wide enough to immediately provide for full (100%) potential wood recruitment to these streams (Welty et al. 2002). The RCA widths on HLDP streams in the CRW will also be 200 feet wide, ensuring high wood recruitment to HLDP and fish-bearing streams. Given the RCA widths in the CRW, thinning in upland areas and in adjacent RCAs is unlikely to reduce wood recruitment to the stream network in the CRW. The likelihood of effects would be further reduced as more time elapses between upland and adjacent thinning actions. However, given the harvest caps described in Chapter 3, Section 3.4.1, *Projected Timing and Amount of Harvest,* the likelihood of this occurring is relatively low; restoration thinning in RCAs will be limited to 1,200 acres in the permit area for the duration of the permit term with roughly 160 acres of RCAs being thinned every 5 to 7 years. Additionally, restoration thinning within the CRW is limited to the first 30-years of the permit term with the majority of thinning occurring during the initial 20.

The level of protection for long-term large wood delivery to coho salmon habitat is also generally expected to be high in the MRW, largely due to RCAs and tree retention requirements in reserve and treatments. Throughout the MRW, RCAs on fish-bearing streams range from 110 to 200 feet and are expected to be wide enough to provide for high (up to 100%) riparian wood delivery (Welty et al. 2002). RCA widths are most divergent in intensively treated subwatersheds; RCAs are 100 to 120 feet where timber harvest occurs upslope and are 200 feet when adjacent to reserve stands. A minimum RCA width of 50 feet in harvested stands of non-fish-bearing streams was calculated as the minimum riparian buffer width necessary to achieve 70% potential wood recruitment in the MRW (Appendix E, *Wood Modeling*). It is possible that thinning may occur in upland slopes, as well as in adjacent RCAs that may temporarily reduce large wood recruitment along fish-bearing, PNFB, and HLDP streams in the MRW.

There are no RCAs along small XNFB streams because these are less likely to deliver large wood via fluvial processes to fish-bearing streams. However, 78% of XNFB streams in the permit area, from headwalls down to fish-bearing streams, are in a protected or increased conservation status (CRW and MRW Reserves, or MRW Extensive) (Chapter 3, Table 3-1). XNFB streams in the CRW and MRW Reserves effectively have a buffer that goes beyond 200 feet, because treatments in these allocations are limited to restoration thinnings; intensive harvest will not occur in the CRW, MRW Reserves, or MRW Extensive. Any negative effects of timber harvest on XNFB streams in areas subject to extensive treatments are expected to be more pronounced in stands younger than 65 years where there is not an average tree-retention requirement and stands can be managed to 20% retention; stands between 65 and 150 years will maintain 50% of pre-harvest retention on average; therefore, effects on large recruitment to XNFB streams will be lower in these stands (Chapter 3, Section 3.3.3, *Extensive Allocations*) (Table 4-9).

Table 4-9. Acres of Extensive and Intensive Treatments and Reserves to Occur in each HUC 12 and Coho Population Area by Stand Age

Coho IP	Size (acres)			Extensive Treatment						
HUC12	Total	Permit Area	Proportion in Permit Area	≤65 Years (min 20% retention)	65 to 150 Years (50% avg. retention)	>150 Years (not treatment)	Intensive Treatment	Total	Proportion to be Harvested	Proportion in Reserves
Tenmile	45,439	19,914	0.44	1,202	251	0	522	1,975	0.10	0.90
North Tenmile Lake	18,669	7,451	0.40	764	85	0	4	853	0.11	0.89
Tenmile Lake-Tenmile Creek	26,770	12,463	0.47	438	166	0	518	1,122	0.09	0.91
Coos	138,926	36,658	0.26	6,507	2,149	23	11,686	20,365	0.56	0.44
Coos Bay	38,667	179	0.00	1	1	0	162	164	0.92	0.08
East Fork Millicoma River	27,599	183	0.01	0	4	0	95	99	0.54	0.46
Glenn Creek	11,290	2,934	0.26	1,394	11	1	779	2,185	0.74	0.26
Haynes Inlet	26,406	5,281	0.20	412	573	22	1,342	2,349	0.44	0.56
West Fork Millicoma River	34,964	28,081	0.80	4,700	1,560	0	9,308	15,568	0.55	0.45
Lower Umpqua—Below Loon	90,788	18,004	0.20	1,430	173	0	395	1,998	0.11	0.89
Dean Creek-Umpqua River	36,339	12,953	0.36	671	166	0	264	1,101	0.08	0.92
Little Mill Creek-Umpqua River	26,770	226	0.01	0	7	0	96	103	0.46	0.54
Scholfield Creek	14,196	4,786	0.34	759	0	0	0	759	0.16	0.84
Lower Camp Creek	13,483	39	0.00	0	0	0	35	35	0.90	0.10
Lower Umpqua—Above Loon	32,329	1,846	0.06	376	53	0	1,274	1,703	0.92	0.08
Lower Lake Creek	32,329	1,846	0.06	376	53	0	1,274	1,703	0.92	0.08
Lower Umpqua—Above/Below Loon	9,860	6,883	0.70	833	414	24	1,933	3,204	0.47	0.53

Coho IP	Size (acres)			Extensive Treatment						
HUC12	Total	Permit Area	Proportion in Permit Area	≤65 Years (min 20% retention)	65 to 150 Years (50% avg. retention)	>150 Years (not treatment)	Intensive Treatment	Total	Proportion to be Harvested	Proportion in Reserves
Loon Lake-Mill Creek	9,860	6,883	0.70	833	414	24	1,933	3,204	0.47	0.53
Total	**317,342**	**83,305**	**0.26**	**10,348**	**3,040**	**47**	**15,810**	**29,245**	**0.35**	**0.65**

Avg = average

However, XNFB streams in these areas are still likely to accumulate large wood to contribute to sediment control and nutrient delivery functions of fish-bearing streams. The remaining 22% of XNFB streams are in Intensive allocations where upslope tree-retention levels will be low and, thus, recruitment will also be low to these streams. However, because XNFB streams are unlikely to deliver large wood to fish-bearing streams due to their size and the low likelihood of traversal by a debris flow, adverse effects on coho habitats in the form of reduced large wood delivery in intensive and extensive areas from XNFB streams are unlikely.

In addition to maintaining RCAs, Conservation Measure 1 will be implemented in RCAs where riparian stand conditions are found to be inconsistent with achieving high-quality aquatic habitat conditions over the course of the permit term. Like other locations along the Oregon Coast that have been harvested and replanted, many riparian forests in the permit area are characterized by a high density of conifers that restrict and lack hardwood trees. Thus, these dense forest plantations can benefit from thinning to promote key aquatic processes (Reeves et al. 2018).

Restoration thinning in RCAs is intended to have the added benefit of accelerating future development of very large-diameter (>40 inches) trees (Spies et al. 2013). Generally, thinning in riparian areas has been limited because of concerns about effects on medium-term wood recruitment, sediment delivery, and water temperatures. However, relevant science indicates that passive management approaches without thinning may actually compromise or slow the recovery of important ecological functions such as the development of the largest trees (Poage and Tappeiner 2002), as well as the availability of high-quality vegetative litter from hardwoods, affecting the structure of the aquatic food web (Bellmore et al. 2013). At locations where riparian stands in RCAs are characterized by young dense plantations (e.g., forests 65 years old and younger as of 2020), silvicultural measures such as restoration thinning (Chapter 3, Section 3.4.2.2, *Thinning*; Appendix A, *Active Management of Riparian Conservation Areas*) will be employed to accelerate development of riparian conditions expected to benefit Oregon Coast coho. Thinning to increase tree growth (Dodson et al. 2012) and the purposeful placement of a proportion of the cut trees in the channel or on the forest floor could immediately reduce deficiencies in dead wood that exist in many streams and riparian areas (Benda et al. 2015; Olson and Burnett 2009; Olson and Kluber 2014).

RCA thinning will follow the approach described in Chapter 3, Section 3.3.7.4, subsection *Riparian Conservation Areas*. Prior to thinning, conditions will be evaluated to confirm that thinning in the stand meets the goal of enhancing forest complexity and habitat by transitioning young, dense plantations to greater compositional, successional, and structural diversity to maintain functional habitat networks for coho salmon. When thinning occurs,[6] all trees thinned within 50 feet of all streams will be retained and either tipped toward or placed into streams or left on the ground. Moreover, thinning actions along all streams may retain up to 20% of the volume of trees cut outside of the first 50 feet of RCAs; these trees will be left on the ground or felled toward the stream channels (Chapter 5, 5.4.1.2, *Riparian Vegetation Management in Riparian Conservation Areas*). Retention and placement of thinned trees in the fish-bearing and non-fish-bearing streams will result in increased instream structure over time when compared to unthinned stands (Benda et al. 2015). The predicted increases in the quantity of instream wood due to retaining portions of thinned trees in RCAs and their instream placement should help mitigate medium-term reductions of instream wood delivery and, depending on the size of placed wood, the near-term impacts on fish habitat resulting from a thinning operation (Beechie et al. 2000; Benda et al. 2015). Additionally,

[6] Thinning in RCAs will not reduce stand density below 40 square feet of conifer basal area per acre.

manual felling increases the amount of instream wood immediately rather than being delayed for 25 to 50 years in an untreated, unmanaged stand, which will benefit coho sooner.

The risk of Douglas-fir beetle (*Dendroctonus pseudotsugae*) infestation from trees felled in riparian areas exists when the predominantly felled tree is Douglas-fir. Ross et al. (2006) concluded that beetle populations increased on sites where downed wood was created for habitat improvements, but the effects of beetle-caused mortality on live trees from this population increase was minimal overall. The study also suggests that felling treatments that maximize the exposure of downed trees to direct sunlight will create the least favorable habitat for Douglas-fir beetles.

The RCAs are sufficient to avoid and minimize negative effects of HCP implementation on large wood recruitment from channel-adjacent covered activities. Effects are expected to be limited spatially and temporally across the permit area and would be offset by Conservation Measure 1, which is a comprehensive stream restoration and enhancement approach that applies both short-term (wood placement) and long-term (RCA thinning) management actions to improve aquatic function and habitats for coho.

When construction of new roads and cable corridors adjacent to streams occurs, the amount of wood available for recruitment will decline. This action will be governed by Conservation Measure 3 and Condition 11, which will limit new and reduce existing roads in the permit area and minimize impacts from road construction and maintenance on large wood recruitment.

Riparian and aquatic research may occur with the goal of developing a better scientific understanding of the effects and biological response of natural and human-caused disturbances in forested landscapes. Several different large wood recruitment strategies, all of which will help ensure biological goals and objectives are met, will allow experimentation to test RCA effectiveness and tradeoffs with other values. Research activities may result in changes to the aquatic ecosystems, as previously described. These effects will be tied to reporting and adaptive management requirements to ensure that the biological goals and objectives are met.

Sediment Delivery

Forest management activities—principally road construction, road maintenance, and timber harvest—affects sediment delivery to coho streams. These activities, if not managed properly, increase the input of fine sediment into the aquatic system and degrade spawning areas for adult salmon, steelhead, and trout by reducing pool volume, decreasing winter refuge areas for juvenile fish, abrading fish gills, and impeding feeding visibility. High concentrations of suspended sediment (20,000 parts per million) can injure fish or alter their behavior patterns (Brown and Krygier 1970).

Intact and functional riparian areas assist in regulating the amount of fine sediment entering the aquatic environment by slowing runoff during storm events and stabilizing stream-adjacent soils, improving the system's capacity to store and regulate transport of fine sediment. When fine sediment delivery rates exceed storage and transport capacity, essential habitat features can be filled in and reduced in quantity, quality, and functionality. Riparian areas can also help maintain water quality by preventing turbidity and suspended sediment levels from exceeding species thresholds. Riparian buffers have the potential to trap and filter sediment in surface erosion resulting from upslope harvest before it enters the aquatic environment (Rachels et al. 2020). Overall, the effectiveness of riparian buffers to prevent sediment inputs into streams is dependent on the terrain (slope), soil characteristics, vegetation, intensity of rainfall events, proper application of best management practices, and several other factors (Broadmeadow and Nisbet 2004; Bywater-

Reyes et al. 2017, 2018). Rashin et al. (2006) suggests that RCAs of 30 feet should be sufficient to protect against most sediment delivery from overland flows. They found that 95% of erosion features at least 30 feet from streams in forested areas in Washington did not deliver sediments.

As described in NMFS (2016), increased mobilization of sediment, which can result from forest management and numerous activities associated with roads (e.g., construction, maintenance, vacating, use) can alter sediment delivery to streams. Consistent with this, Litschert and MacDonald (2009) recommended addressing the potential for surface erosion and mass wasting when designing watershed-scale thinning treatments because thinning can increase the likelihood of sediment delivery. Increased sedimentation can affect coho habitat and production by reducing spawning habitat quality and quantity, smothering redds, decreasing pool depth, reducing abundance of clean gravels for spawning and fry life stages, and degrading water quality. Even so, larger, coarse sediment and gravels are a critical component of high-quality coho salmon spawning and rearing habitat. Currently, large wood and large coarse sediment (larger cobble and boulders) to retain smaller sediments in the permit area is present at low to moderate levels (Oregon Department of Fish and Wildlife 2005) but will be improved through RCAs and the conservation strategy.

Root cohesion, or root strength, on steep slopes can be an important contributing factor to lessening shallow landslide initiation and potential escalation to debris avalanches and flows. Research in the Oregon Coast Range by Schmidt et al. (2001) indicates that there is at least a 100-year legacy of anthropogenic disturbance that decreases root strength in industrial forests, which can increase landslide risk. However, a recent review of slope-stability modeling that incorporates root strength and was primarily conducted in areas of Europe highly prone to landslides, stated that forest thinning can cause a reduction in root strength, but low and intermediate thinning activities cause only small decreases (Masi et al. 2021). Landslides reaching stream channels can provide a source of coarse and fine sediments and woody debris to the channel network. The influence of a single landslide on a watershed scale, without the development of associated debris flows or dam-break floods, is generally localized. RCAs in landslide-prone areas (steep slopes and HLDP streams) should reduce the risk of shallow landslides by maintaining or improving root cohesion. RCAs that are thinned may experience a short-term reduction in root strength, but as the thinned stands mature and trees increase in size root strength should increase as trees grow and the root networks expand.

Aquatic habitats can be either beneficially or adversely influenced, depending on the amount, type, and extent of deposited sediment. Channels need streambed structures such as large boulder clusters or large wood to store and to stabilize the bedload of sediment inputs. In addition, fish spawning habitat is dependent on gravel deposits free of embedded fine sediments. Thick plugs of coarse sediment or high levels of fine sediment are not desirable and can reduce survival of developing fish. For example, Jensen et al. (2009) found that the odds of egg-to-fry survival for coho salmon decrease 18.3% for every 1% increase in fine sediment (grain size less than 0.85 millimeter) and that fry survival drops to about 10% when fine sediments exceed 25% of substrates in spawning nests. Fine sediments in spawning gravels cause mortality by entrapping fry and limiting inflows of oxygen or outflows of metabolic waste products (Beschta and Jackson 1979; Chapman 1988; Bennett et al. 2003). Elevated concentrations of fine sediments resulting from road usage, maintenance, and construction, RCA thinning, placement or tipping of thinned trees into streams, and instream work (i.e., culvert replacement) may intermittently reduce survival and growth of juvenile coho salmon by altering abundances or species composition of their stream-insect prey (Suttle et al. 2004; Cover et al. 2008). Increased concentrations of fine sediment can negatively influence coho salmon at the population level as modeled by Araujo et al. (2015).

The effects of suspended sediment, which contributes to turbidity, on fish have been well documented in research literature and range from beneficial to lethal. Moderate turbidity levels (35–150 nephelometric turbidity units) can provide cover and accelerate foraging rates in juvenile salmonids (Gregory and Northcote 1993). Even moderate levels of suspended sediment exposure not associated with gill damage can affect the respiratory ability of salmonids (Waters 1995) and trigger an acute stress response (Michel et al. 2013). Some sediment-associated stress responses include elevated plasma glucose and plasma cortisol (Redding and Schreck 1984; Servizi and Martens 1992), increased cardiac output (Bunt et al. 2004), and changes in hematologic parameters (Lake and Hinch 1999; Michel et al. 2013). Suspended solids are also known to affect fish's feeding ability (e.g., due to impaired spotting of prey), routine activity, and stress levels (Berg and Northcote 1985; Sweka and Hartman 2001; De Robertis et al. 2003; Robertson et al. 2007; Awata et al. 2011). Behavioral responses (e.g., alarm reaction, avoidance of the plume) can occur with only 6 minutes of exposure (Newcombe and Jensen 1996). Physiological effects (e.g., gill flaring and coughing) may occur with 15 minutes of exposure, temporary reduced feeding rates and success with 1 hour of exposure, and moderate levels of stress with 3 hours of exposure (Newcombe and Jensen 1996). Higher turbidity concentrations can cause physiological stress and inhibit growth and survival. Direct mortality can occur at very high concentrations or extended durations of suspended solids (Newcombe and Jensen 1996).

RCAs have the potential to trap and filter sediment in surface erosion resulting from upslope harvest before it enters the aquatic environment (Rachels et al. 2020). The overall effectiveness of riparian buffers to prevent sediment inputs into streams is dependent on the terrain (slope), soil characteristics, vegetation, intensity of rainfall events, proper application of best management practices, and several other factors (Broadmeadow and Nisbet 2004; Bywater-Reyes et al. 2017, 2018). However, based on the findings of Rashin et al. (2006), the proposed RCAs along all stream types in the permit area are wide enough to trap and filter sediment originating from surface erosion before it enters the aquatic environment. While restoration thinning may reduce sediment trap and filter functions in the short term, effects will be reduced through Conservation Measure 1, which requires all trees cut within the first 50 feet be retained. Conditions will continue to improve over time as stands mature and RCA functions improve. Furthermore, the riparian vegetation maintained inside RCAs will stabilize streambanks, further limiting the potential for introductions of fine sediment into the aquatic environment. In addition, increased wood recruitment into streams, associated with the RCAs, will provide channel complexity that will sort and store fine sediment.

However, due to the steepness of riparian areas, RCA thinning may contribute to localized sediment delivery, particularly when conducted within 30 feet of streambanks (Rashin et al. 2006). As described in Chapter 3, *Covered Activities,* RCA thinning in stands 65 years old or younger (as of 2020) may reduce basal area down to 40 square feet of conifer basal area per acre (Chapter 3, Section 3.3.7.4, *Operational Standards for Restoration Thinning in Riparian Conservation Areas*), which could reduce RCA effectiveness to protect against surface erosion. However, this lower limit will be primarily applied to dense Douglas-fir plantation stands; other thinned areas are expected to maintain higher retention levels. RCA thinning across the entire permit area will be limited to 1,200 acres for the permit term. Thinning within CRW RCAs will occur in the first 30 years of the permit term; if stands reach 80 years old, they will become ineligible for thinning. Thinning of RCAs in the MRW would not be subject to this 30-year limitation but would adhere to the limitation on number of entries and 80-year stand age limit. When thinning does occur, potential for sediment delivery will be minimized by a 35-foot ELZ (Chapter 3, Section 3.3.7.3, *Equipment Limitation Zone*) that will be applied next to all Oregon Forest Practices Act (Oregon FPA)–defined streams, reducing the potential for sediment delivery across the permit area. Outside of the ELZ, ground-based equipment operation in RCAs will be limited to slopes less than 40%. Therefore, the risk of disrupting RCA sediment trapping and filtering functions from thinning will be low and localized. Furthermore, disruption of RCA function from thinning is likely to occur over the short term (a few years). Over the long term, RCA functionality should be enhanced because the stand characteristics will be progressing toward a mature forest structure. Thinned trees in RCAs will be retained per the commitments described in Conservation Measure 1. Trees tipped into fish-bearing streams could cause brief impacts on coho and coho habitat, including sediment loading and disruption of benthic substrate. These effects are expected to be temporary and short lived.

Mass-wasting events, such shallow-rapid landslides, are a natural occurrence in the permit area, given the steep topography and highly dissected channel network. Landslides, other mass-wasting events, and geologic processes can have significant effects on watersheds, including aquatic and riparian areas. The influence of a single landslide on stream habitat, without development of associated debris flows or dam-break floods, is generally localized. However, a substantial high rainfall event, such as the 1996 storm in southwestern Oregon (Yazzie et al. 2023), can generate widespread landsliding (Hofmeister 2000) that can affect much of the channel network simultaneously. Landslides may deliver coarse and fine sediment, as well as large wood directly into streams from adjacent hill slopes or via channelized debris flows to affect coho salmon and their habitat. High landslide hazard locations, as defined here, are specific sites that are subject to initiation of shallow, rapidly moving landslides. Steep slopes present challenges for land managers, particularly regarding timber harvest and road construction. Factors that influence slope stability in the permit area include, but are not limited to, slope steepness, forest cover (i.e., root strength and stand age), road density, and rainfall intensity. Removal of trees can increase the frequency of the landslides and deep-seated earthflows or debris flows (Roering et al. 2003; Schanz and Colee 2022). Concerns are particularly high where infrastructure or human safety may be at risk but also in areas used by salmonids, such as coho salmon. Although the permit area topography is steep and prone to landslides, the CRW and MRW Reserves and RCAs combined comprise 68% of the permit area with hillslope gradients greater than 65% (Table 4-10), reducing landslide risk because treatments are limited to restoration thinning.

If landslides do initiate, the likelihood they will deliver sediment via a debris flow to fish-bearing streams depends on many factors, including channel steepness and the availability of large wood. In addition to being an important driver of coho habitat quality, large wood is also determinative in the distance that debris flows and landslides travel. Debris flows that lack large wood move faster and farther than flows containing no wood (Lancaster et al. 2003). Therefore, debris flows without large wood are likely to travel farther and pose a higher risk to habitat, whereas debris flows with large wood can result in higher sediment storage capacity (Bunn and Montgomery 2004) and creation of persistent terraces (Lancaster and Casebeer 2007; May and Lee 2004). The untreated areas of the CRW and MRW Reserves will protect riparian forests so that landslides or debris flows in the permit area will function as natural ecological disturbances largely benefiting the aquatic environment over time. RCAs along HLDP streams in treated and untreated areas of the CRW and MRW Reserves will provide a source for large wood recruitment that will reduce sediment transport to fish-bearing streams via debris flow tracks. In addition, forest management in the RCAs will be limited to thinning, which will increase the amount and size of large wood and, thus, the associated sediment storage capacity.

Table 4-10. Areas of Steep Slopes in the Permit Area by Treatment Type

	CRW				MRW							
Independent Population	**Restoration Thinning (in RCAs)**	**Restoration Thinning (outside RCAs)**	**No Treatment (in RCAs)**	**No Treatment (outside RCAs)**	**Intensive**	**Extensive**	**Restoration Thinning (in RCAs)**	**Restoration Thinning (outside RCAs)**	**No Treatment (in RCAs)**	**No Treatment (outside RCAs)**	**Total**	**Percent of slopes >65% not in intensive**
Tenmile Total (acres)	1,493	3,829	3,453	8,396	511	1,432	325	20	106	317	19,880	-
Slopes >65% (acres)	1,045	2,852	2,417	6,445	259	935	207	13	67	222	14,462	98%
% Slopes >65%	70%	74%	70%	77%	51%	65%	64%	64%	63%	70%	73%	-
Lower Umpqua Below Loon Lake Total (acres)	1,419	3,064	2,871	7,577	1,897	2,349	467	263	420	2,452	22,779	-
Slopes >65% (acres)	1,080	2,461	2,264	6,300	1,265	1,809	281	205	165	1,887	17,717	93%
% Slopes >65%	76%	80%	79%	83%	67%	77%	60%	78%	39%	77%	78%	-
Lower Umpqua Above Loon Lake Total (acres)	-	-	-	-	1,687	939	172	4	147	960	3,909	-
Slopes >65% (acres)	-	-	-	-	507	395	64	1	59	466	1,492	66%
% Slopes >65%	-	-	-	-	30%	42%	37%	34%	40%	48%	38%	-
Coos Total (acres)	102	145	368	855	11,715	8,713	1,941	1,877	2,740	8,278	36,735	
Slopes >65% (acres)	53	104	225	590	6,513	5,018	1,015	1,196	1,135	4,516	20,364	68%
% Slopes >65%	52%	71%	61%	69%	56%	58%	52%	64%	41%	55%	55%	-
Permit Area Total (acres)	3,013	7,038	6,692	16,828	15,810	13,432	2,905	2,164	3,413	12,007	83,304	-
Slopes >65% (acres)	2,179	5,416	4,906	13,334	8,545	8,156	1,567	1,415	1,426	7,091	54,035	84%
% Slopes >65%	72%	77%	73%	79%	54%	61%	54%	65%	42%	59%	65%	-

Note: Total permit area acreage in this table is less than the actual total due to extent of datasets.

Extensive treatments represent alternative forest management strategies and are intended to transition even-aged Douglas-fir stands toward greater diversity in structural composition and species mixture. The minimum relative density remaining after extensive treatments will be 20% of original pre-harvest stand density in stands 65 years old or younger (as of 2020) that are outside of marbled murrelet and northern spotted owl habitats (Table 4-9). Average retention in stands between 65 and 150 years old would be 50% of pre-harvest density and stand older than 150 years would not be touched. The intent is that these areas will be converted from plantations to low-density stands that will be suitable for a rotation age greater than 100 years while maintaining stand and crown complexity. Due to these minimum retention levels and the annual harvest cap this level of thinning is unlikely to affect the risk of landslide initiation and debris flow runout.

Intensive treatments are expected to represent the highest risk of landslide and debris flow occurrence given the rate and type of harvest to be utilized relative to other treatments (representative of industrial timber production within Oregon FPA requirements and the standards described in Chapter 3, *Covered Activities*). However, given that no more than 50% of any full subwatershed will be intensively treated, the risk of landslides or debris flow occurrence is low. Partial subwatersheds subject to intensive treatments (Chapter 3, Section 3.3.5, *Flexible Allocations*) do not have to retain 50% of the original pre-harvest stand density. However, harvest in these partial watersheds count toward the projected timing and amount of harvest (Chapter 3, Section 3.4.1, *Projected Timing and Amount of Harvest*), which will limit the treatments such that any effects would be spatially and temporally limited.

A majority of the steep slopes will be in areas available only for restoration thinning or off limits to treatments (69%) (Figure 4-7). For the relatively small portion of the permit area's steep slopes that are in areas subject to intensive treatment (16%), some are in locations that will not affect coho salmon habitat (e.g., no anadromy above Loon Lake). Thus, at the scale of the permit area, extensive and reserve treatments provide a high level of protection to steep slopes and headwater streams.

Tools that can be used to assess slope stability in the permit area when available include, but are not limited to, soil type mapping, slope mapping, geologic history, and review of historic slope failures and relevant case studies. Moreover, slope stability and HLDP streams were identified using the Slope Stability Analysis tool (TerrainWorks 2021) based on Benda and Dunne (1997) and Miller and Burnett (2008). RCAs on non-fish-bearing streams integrate shallow translational landslide probabilities and prioritize protection for those slopes and stream channels most likely to initiate and sustain a debris torrent that delivers large wood directly to fish-bearing streams (HLDP streams) (Table 4-8). HLDP streams will receive a 50-foot RCA as well as a 35-foot ELZ. Additionally, any restoration thinning in RCAs on slopes greater than 40% will be completed using predominantly hand-thinning methods (Condition 10). Timber harvest and road construction operations will be assessed for landslide hazard and risk by a geotechnical specialist, when appropriate. Road alternatives will receive site-specific geotechnical evaluations when the forest engineer must compare risk of road location, design, or construction alternatives.

Additionally, roads can exert a strong influence on these types of disturbances by increasing and concentrating overland flow, reducing hydrologic connectivity, and decreasing infiltration (Swanson and Dyrness 1975; Miller and Burnett 2007). Risk-based management principles and best management practices described in Chapter 5, *Conservation Strategy,* will reduce the potential for road-related landslides and chronic erosion that delivers sediment to streams.

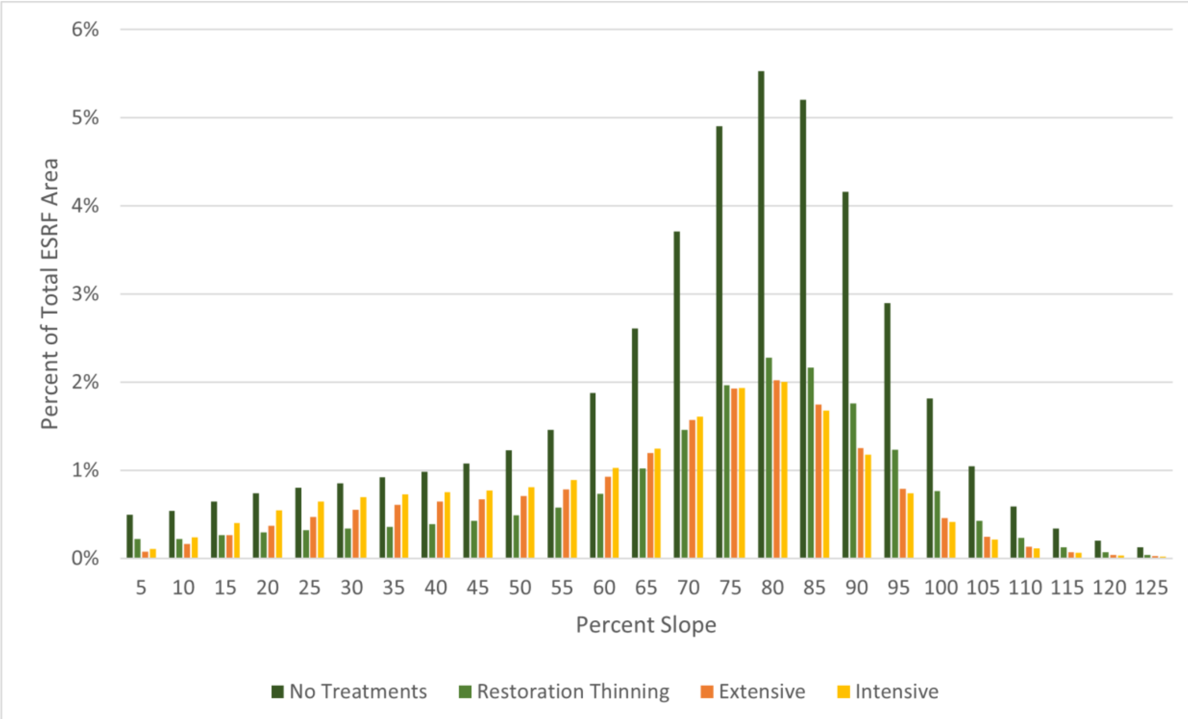


Figure 4-7. Distribution of Classified Hillslope Gradient by Treatments

The road system in the permit area is relatively old, with a road density of 3.79 miles of road per square mile averaged across all subwatersheds (Table 4-11). Sharma and Hilborn (2001) show coho salmon smolt production is uniformly low at road densities exceeding 4 miles of road per square mile, a threshold that may be exceeded in some permit area subwatersheds. Road density is also positively correlated with fine sediments in streams but negatively correlated with the number of pools per mile and the density of large wood in pools (Lee et al. 1997; Burnett et al. 2006), all of which are key indicators of habitat quality for coho salmon. Accordingly, increases in road density were associated with decreases in the number of coho salmon adults in Oregon (Firman et al. 2011) and elsewhere (Bradford and Irvine 2000).

Table 4-11. Summary of the Existing Road System in the Permit Area

Coho Independent Population	Road Length (miles)	Size of Basin (square miles)	Road Density (miles of road/square mile)
Coos	259.6	68.11	3.81
Lower Umpqua	142.0	43.14	3.29
Tenmile	97.5	33.49	2.91
Total	499.2	145.35	3.43

Road density alone is a coarse measure of potential for negative effects on streams; road location relative to streams can provide additional context for considering effects. Therefore, for the purposes of this analysis the existing road network in the permit area was characterized based on location using available spatial data. Roads were characterized as ridgeline roads if they were within 330 feet of ridgelines. Ridgeline roads are generally good locations to minimize fill failure hazards and the hydrologic connectivity between the road system; sediment from upslope roads does not move beyond the road prism (Wemple et al. 2001). Roads characterized as mid-slope were more than 330 feet from ridgelines and more than 200 feet (60 meters) from streams. Wemple et al. (2001) observed that older mid-slope roads dominated the production of sediment during storm events and, thus, can pose significant risk to aquatic environments and the species inhabiting them. Total road miles within 200 feet and 35 feet were also calculated. Roads within 35 feet of a stream represent the highest likelihood of sediment delivery (Rashin et al. 2006).

Within the permit area 58% of the road system is within 330 feet of a major ridgeline (upper slope) and 27% is more than 330 feet from a ridgeline and more than 200 feet from a stream (mid-slope); 14% of the roads are within 200 feet of a stream and roughly 16 miles of fish-bearing streams exist upstream of blocked or partially blocked passage barriers (Chapter 2, Table 2-9). Less than 2% of the existing road system is within 35 feet of a stream. Stream-adjacent roads have the greatest potential to deliver sediment to the aquatic system. To address this, roads in the permit area will be managed in accordance with the provisions included in Chapter 3, Section 3.6, *Supporting Infrastructure*, and Condition 11 to minimize the disruption of natural drainage patterns. Sediment delivery from the existing road system to the aquatic environment is likely to be highest in the areas where roads will be most used (Chapter 3, Section 3.6.1.2, *Road Use*) (i.e., intensive and extensive treatments) and those roads that are closest to streams (Table 4-12). Existing roads that have the potential to deliver sediment to the aquatic system will be included in work plans to rectify issues that allow sediment delivery. Hydrologic connectivity will be evaluated as part of a broader roads study to be conducted during the first 12 years of HCP implementation (Conservation Measure 3). Roads that cannot be fixed will be vacated as described in Conservation Measure 3. In addition, Conservation Measure 3 commits to reducing road density over the course of the permit term by vacating existing roads that are no longer in use or deemed to be nonessential or where access would cause excessive resource damage.

No more than 40 miles of new permanent roads will be built over the permit term to serve new landings or harvest sites (Chapter 3, Section 3.6.1, *Road System Construction and Management*). Construction of new logging roads in RCAs will be limited to up to 1 mile of road a year, and temporary roads will be limited to up to 2 miles of road per year, given the robust existing road network and adherence to the Oregon FPA rules listed in Section 3.6.1. However, if construction does occur it will allow easy public access to areas that were previously less accessible. Increased human activity in and around streams could affect streambank stability (Kaufmann et al. 2009). The indirect effects of new roads could result in increased deposition of fine sediment on the streambed, degrade spawning areas, reduce pool refuge habitat, decrease winter refuge areas for juveniles, and impede feeding visibility. These effects are expected to be limited because new permanent road construction will not exceed 1.0 mile per year and will occur outside of RCAs whenever possible (Oregon Administrative Rules [OAR] 629-625-0200), limiting the creation of new human access points to streams and limiting sediment delivery potential.

Habitat restoration activities under Conservation Measure 1 could result in direct harm to Oregon Coast coho by increasing sediment delivery. Stream restoration projects in the permit area may include placement of logs or whole trees in streams to create pools and to retain spawning gravels, relocation or redesign of improperly located roads, stabilization of sediment sources (i.e., cutbank improvement of road drainage systems), road closure, and/or road vacating. These activities may cause a localized, temporary increase in sedimentation but will ultimately be beneficial and will follow the conditions on covered activities (Conditions 10 and 11) to reduce short-term impacts.

Table 4-12. Total Miles of Existing Permit Area Roads in Riparian Areas (0–200 feet) and Near Major Ridgelines, by Independent Population, Treatment, and Allocation

Independent Population	Treatment	Allocation	Slope Classification					
			0–35	35–200	Mid-Slope [a]	Multiple Zones [b]	Upper Slope [c] (Ridgeline)	Total (miles)
Tenmile	Extensive	Extensive	-	0.2	0.7	-	2.2	3.1
		Flexible Extensive	-	-	1.8	0.0	4.8	6.6
		Volume Replacement	-	-	0.1	-	2.1	2.2
	Intensive	Intensive	0.0	0.3	1.1	0.0	1.7	3.1
		MRW Flexible	-	-	0.3	-	0.8	1.1
	No Treatments	CRW RCA	0.5	4.4	0.2	0.2	0.0	5.3
		CRW Reserve, No Thin	0.0	0.2	6.0	0.1	32.3	38.7
		MRW Reserve	-	-	0.5	-	1.0	1.5
	Restoration Thinning	CRW RCA	0.4	2.9	0.1	0.0	-	3.4
		CRW Reserve, Thin	-	0.0	3.7	0.0	27.3	31.0
		MRW RCA	0.1	0.8	0.0	0.0	-	0.9
		MRW Reserve	-	-	0.1	-	0.6	0.7
Tenmile Total			1.1	8.7	14.7	0.4	72.7	97.5
Coos	Extensive	Extensive	0.1	4.5	21.7	0.4	39.3	65.9
		Flexible Extensive	-	0.2	0.8	-	0.2	1.1
		MRW Flexible	-	0.1	0.3	-	1.2	1.6
	Intensive	Intensive	0.1	4.2	24.1	0.1	41.1	69.5
		MRW Flexible	0.0	0.7	9.0	0.1	18.1	27.9
	No Treatments	CRW RCA	0.0	0.3	-	-	-	0.3
		CRW Reserve, No Thin	-	-	0.4	-	1.9	2.3
		MRW Flexible	-	0.2	1.6	-	2.6	4.4
		MRW RCA	2.4	17.8	0.2	1.3	-	21.7
		MRW Reserve	0.0	3.9	18.9	0.1	18.8	41.7
	Restoration Thinning	CRW RCA	0.1	0.1	-	-	-	0.2
		CRW Reserve, Thin	-	-	0.2	-	0.9	1.0
		MRW RCA	1.5	7.1	0.3	0.3	-	9.2
		MRW Reserve	0.0	0.7	3.6	0.0	8.5	12.8

Independent Population	Treatment	Allocation	Slope Classification					
			0–35	35–200	Mid-Slope [a]	Multiple Zones [b]	Upper Slope [c] (Ridgeline)	Total (miles)
Coos Total			4.2	39.8	80.9	2.3	132.4	259.6
Lower Umpqua Below Loon Lake	Extensive	Extensive	0.0	0.1	4.0	-	3.8	7.9
		MRW Flexible	-	0.0	0.1	-	0.1	0.3
		Volume Replacement	-	-	0.1	-	5.9	6.0
	Intensive	Intensive	0.0	0.2	2.6	0.1	4.5	7.5
		MRW Flexible	0.0	0.3	3.5	0.0	3.7	7.6
	No Treatments	CRW RCA	1.4	2.2	0.0	-	0.0	3.6
		CRW Reserve, No Thin	-	0.0	2.6	-	30.6	33.2
		MRW Flexible	0.0	1.5	1.9	-	0.7	4.2
		MRW RCA	1.0	3.1	0.0	-	-	4.2
		MRW Reserve	0.0	0.6	2.2	-	1.1	3.8
	Restoration Thinning	CRW RCA	0.8	1.9	0.0	-	-	2.6
		CRW Reserve, Thin	-	0.0	1.4	-	21.0	22.3
		MRW RCA	0.4	0.3	0.1	0.0	0.2	1.0
		MRW Reserve	0.0	0.1	1.1	-	0.5	1.7
Lower Umpqua Below Loon Lake Total			3.6	10.5	19.6	0.1	72.0	105.9
Lower Umpqua Above Loon Lake	Extensive	Extensive	0.0	0.5	3.2	0.1	4.1	8.0
		MRW Flexible	0.0	0.1	0.7	-	0.1	0.9
	Intensive	Intensive	0.1	0.6	1.8	-	1.5	4.0
		MRW Flexible	0.0	1.2	9.2	-	5.1	15.5
	No Treatments	MRW Flexible	-	-	0.7	-	0.1	0.8
		MRW RCA	0.2	0.5	0.1	-	-	0.8
		MRW Reserve	0.0	0.8	2.4	0.1	2.4	5.7
	Restoration Thinning	MRW RCA	0.1	0.2	0.1	0.0	-	0.4
		MRW Reserve	-	0.0	-	-	-	0.0
Lower Umpqua Above Loon Lake Total			0.5	3.9	18.3	0.2	13.2	36.1
Grand Total			9.4	62.8	133.5	3.1	290.4	499.2

[a] More than 200 feet from a stream and more than 330 feet from a major ridgeline.
[b] Less than 200 feet from a stream and less than 330 feet from a major ridgeline.
[c] Within 330 feet of a major ridgeline.

RCAs, Conservation Measures 2 and 3, and Conditions 10 and 11 will limit effects on Oregon Coast coho across the permit area to infrequent, localized increases in sedimentation associated with new road construction, existing road and culvert maintenance, road use, and habitat restoration activities. While these conservation measures will minimize management-related erosion and sedimentation, complete elimination of management and public-related inputs (which is not a covered activity) is not possible without prohibiting public access and recreational use of some or all of the permit area.

Water Temperature

Stream temperature directly influences aquatic organisms' physiology, metabolic rates, and life history behaviors and influences aspects of important habitat processes for fish and aquatic species such as nutrient cycling and productivity (Allen 1995). Stream temperature is a function of multiple factors that can be expressed in terms of a *heat budget*. In general, sources of heat input include direct solar radiation and convection. Heat is lost through long-wave radiation, conduction, and evaporation. However, of all these factors, direct solar radiation is the primary contributor to increases in daily maximum stream temperature (Brown and Krygier 1970; Johnson 2004). Therefore, managing riparian vegetation to maintain shade is an effective tool for reducing stream temperature heat flux (Johnson 2004). The actual magnitude of stream temperature increases following removal of riparian vegetation can vary greatly, however, and is determined by factors such as discharge, water depth, width, flow velocity, hyporheic exchange, and groundwater inflows (Janisch et al. 2012; Johnson 2004; Moore et al. 2005). Topographic shading can also influence water temperatures, particularly in small streams flowing in narrow, steep-sided valleys (Zhang et al. 2017). Canopy removal also results in nighttime long-wave radiation loss, leading to lower water temperatures. This effect contributes to increased thermal variability, with poorly understood biological consequences.

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 may also occur on small, PNFB streams that flow into fish-bearing streams. Given the permit area's steep topography and proximity to the coast (Chapter 2, *Environmental Setting*), water temperatures, modeled as a function of air temperature and stream discharge (Isaak et al. 2017), are projected to be relatively favorable to rearing, migration, and smoltification of coho salmon (Tables 4-13 and 4-14). Temperature criteria for coho life stages are presented in Table 4-13 and discussed in Chapter 2, Section 2.5.1.3, *Water Temperature*. Within coho distribution, 76 to 78% of stream miles are projected to remain below 15 degrees Celsius (°C) in much of the permit area over the course of the permit term (Table 4-14; Chapter 2, Figures 2-3 and 2-4). However, there are locations where modeling projects warming may exceed optimal thresholds for coho salmon life stages later in the permit term (Chapter 2, Figure 2-4). By 2080, coho stream miles that exceed 18°C are projected to increase from 9 to 31 miles, making them less than optimal for all life stages of coho (Table 4-13). Additionally, coho stream miles that exceed 15°C (15–23°C) are expected to increase from 149 to 163 stream miles, which may reduce areas of juvenile rearing without cold-water refugia. The designation of RCAs along all perennial streams will help ensure that any projected temperature increases resulting from climate change are not exacerbated by harvest or management actions. Additionally, establishment and management of RCAs will protect streamside forest conditions and provide a high degree of shade throughout the stream network by limiting harvest activities and ensuring riparian stands remain intact. Vegetation and topographic effects specific to each independent population are described in Section 4.6.2, *Impacts of the Taking*.

Table 4-13. General Temperature Criteria for Coho Salmon

Life Stage	7-Day-Average Maximum Daily Temperatures
Spawning and incubation	6–10°C
Juvenile rearing	10–16°C
Adult migration	16.5–18°C
Smoltification	16°C

Sources: Richter and Kolmes 2005; Carter 2005.
°C = degrees Celsius

Table 4-14. Total Perennial Stream Miles of Projected 2040 and 2080 Stream Temperatures in the Permit Area Summarized by Watershed and Independent Coho Populations [a]

Independent Population	2040 Temperature (°C)			2080 Temperature (°C)		
	0–15	15.1–18	18.1–23	0–15	15.1–18	18.1–23
Coos	214	72	1	203	72	13
Lower Umpqua	174	39	8	172	34	16
Tenmile	144	28	0	144	27	2
Total Miles	533	140	9	519	132	31

[a] The values presented here are projections from Isaak et al. (2017) based on expected changes in climate conditions. These modeled values do not include the effects of the covered activities included in this HCP.
°C = degrees Celsius

Data collected during monitoring efforts (described in more detail in Chapter 6, *Monitoring and Adaptive Management*) will be analyzed to test whether riparian thinning to enhance tree growth adequately protects stream temperatures, (Chapter 6, Section 6.3, *Aquatic and Riparian Monitoring,* provides details on the monitoring strategy), while ensuring riparian functions are protected to achieve the desired level of effectiveness needed to meet the ecological, social, and regulatory requirements for the resource protection in fish-bearing and non-fish-bearing streams.

Given the width of RCAs on small and medium fish-bearing streams in the CRW and MRW (100–200 feet), any temperature increases in these streams associated with upslope forest management are expected to remain below 0.3°C (Groom et al. 2018). Likewise, the 200-foot RCAs required on PNFB and HLDP streams in the CRW should limit any temperature increases from upland restoration thinning to less than 0.3°C. In contrast, intensive and extensive treatments upslope of PNFB and HLDP streams with 50-foot RCAs may allow increases in water temperatures up to 1.4°C due to narrower buffer requirements (Groom et al. 2018). Any temperature increases in PNFB and HLDP streams may, depending on proximity, propagate downstream to coho salmon streams. The risk of propagating temperature increases from these streams to fish-bearing streams decreases as distance from fish-bearing streams increases. However, in western Washington, McIntyre et al. (2021) found that statistically significant water temperature increases propagated downstream to the fish/no fish break for the first 2 years following timber harvest with 50-foot buffers on the non-fish-bearing streams. Therefore, it is possible that increased water temperatures in PNFB and HLDP streams up to 1.4°C may propagate and persist into fish-bearing streams for a couple of years following treatments. However, given the expansive RCA strategy, temperature increases are expected to attenuate quickly once reaching fish-bearing streams due to stream size, RCA widths, topography, and the coastal climate. Additionally, placement of large wood from thinning and restoration activities will help keep high temperatures from persisting for long distances downstream into fish-bearing reaches by increasing pool depths and promoting hyporheic exchange.

Considering Groom et al. (2018), upslope harvest in intensive treatments, extensive treatments, or by restoration thinning elsewhere may result in temperature increases exceeding 2°C in XNFB streams, given that these streams will not receive an RCA buffer. However, this is likely limited to intensive treatments given the expansive reserve system and the commitment that intensive areas will be equally matched with reserves. This expectation is consistent with observed water temperature increases in western Oregon from timber harvest along small non-fish-bearing streams lacking riparian buffers (Bladon et al. 2018). Temperature increases in XNFB streams after thinning of riparian forests in extensive treatments or in reserves for restoration are expected to be greater at the lowest tree retention levels (20%). This is consistent with 7-day mean maximum stream temperature increases of 0.5°C, 2.0°C, and up to 3.5°C in headwater streams of western Oregon and Washington associated, respectively, with post-thinning riparian shade of 77%, 61%, and 40% (McCracken et al. 2018). Potential increases in temperature along XNFB streams in thinned areas will be temporary as streamside stands mature and grow, providing more shade relative to pre-thinning conditions.

Much of the water temperature increases from a treated XNFB stream further away than 300 meters (984 feet) is likely to attenuate before reaching a fish-bearing stream, as was observed by Bladon et al. (2018). Consistent with this, Davis et al. (2015) determined in a modeling study of small to medium streams that the average temperature change 300 meters (984 feet) downstream was approximately 50% (1 to 82%) of the temperature change in the harvested reach.

Many XNFB streams are likely highly seasonal, only supporting flowing water when the landscape is fully saturated. Thus, timber harvest or restoration thinning along any XNFB stream that is dry during the summer would have no effect on water temperatures in coho streams. However, harvest along an XNFB stream that retains flow during the summer may contribute to nominal temperature increases downstream, although this is unlikely given that the volume of water entering the fish-bearing network from an XNFB stream likely only represents a very small proportion of the fish-bearing stream water volume.

RCAs interact with stream size to affect key aquatic characteristics and processes such as water temperature. As part of the covered activities, temperature monitoring will be employed in conjunction with upslope harvest activities to determine how the size and vegetative composition of riparian vegetation affects water temperatures in coho salmon habitat (Chapter 6, Section 6.3.2, *Water Temperature Monitoring*). The continued evaluation of the RCAs associated with harvest provides feedback on how buffer configurations influence the aquatic environment. This knowledge will continue to be developed and used over the course of the permit term to meet the biological goals and objectives under the harvest regimes.

As described above, potential effects on water temperature from harvest activities in the permit area will be avoided or minimized by maintaining stream shading via vegetation retention in RCAs during adjacent harvest activities as described in Chapter 3, *Covered Activities*. Absent an unforeseen circumstance such as flooding or fire, vegetation in the RCAs will continue to grow over the course of the permit term, increasing the amount of riparian shade provided, recognizing that events such as fires and storms may rapidly change riparian areas, and temporarily reduce the presence and/or density of riparian forests and their associated temperature protections.

A few studies have examined clearcut harvesting combined with partial harvest of riparian buffers (Kreutzweiser et al. 2009; Macdonald et al. 2003; Mellina et al. 2002; Wilkerson et al. 2006). These studies suggest that the effect of riparian thinning on summer stream temperatures will be correlated positively with the amount of forest canopy removed and inversely with the distance from the stream wherein the activity occurs, and thus the amount of shade lost (Leinenbach et al. 2013). More recent studies have explored the relationship between the intensity of thinning in riparian buffers and the effects on the temperature regime in immediate and downstream stream reaches. Roon et al. (2021a) found that in California coastal redwood forests, thinning activities in a second-growth riparian buffer that caused reductions of shade and corresponding increases in light shifted stream thermal regimes both in thinned reaches and those immediately downstream, particularly in summer months (higher average daily maximum, maximum weekly average of the maximum, average daily mean, maximum weekly average of the mean, cumulative degree days), although some temperature changes were also observed to a lesser degree in fall and spring (higher maximum weekly average of the maximum, daily range, and variance). Downstream effects on temperature can extend 100 to 1,000 meters (328–3,280 feet) from the upstream thinned reaches, depending on the intensity and spacing of upstream thinning activities, and changes were less intense than those observed within the thinned reaches themselves (Roon et al. 2021b).

In general, the amount of shade lost from a given thinning treatment can be highly variable, making it difficult to draw strong generalities. The amount of shade lost can be smaller than the amount of tree basal area removed. For example, in one study, removal of 10 to 20% of basal area had no measurable effect on angular canopy density (Kreutzweiser et al. 2009). In another study, in the year immediately following thinning in a riparian buffer, Roon et al. (2021a, 2021b) found that changes in shade of 5% or less caused minimal changes in temperatures, while decreases in shade ranging between 20 and 30% led to much larger increases in temperature. Similarly, in a study in the Oregon Coast Range, Groom et al. (2011) found a strong association between reductions in shade and increases in maximum stream temperature, observing an average increase of 0.7°C in maximum stream temperatures on managed forest lands that allowed reductions of mean basal area in riparian management zones from 270 square feet per hectare (range 118 to 430 square feet per hectare) to basal areas of 108 square feet per hectare along small streams and 240 square feet per hectare along medium streams with 20-foot-wide harvest-exclusion zones adjacent to the streams. While shade loss from riparian thinning can cause local and downstream temperature increases, the increases are often temporary because riparian forest canopies eventually close after thinning, often within 3 years, although the amount of time is dependent on the level of thinning and can take longer to close completely (more than 8 years) (Chan et al. 2006; Yeung et al. 2017).

The potential magnitude of localized stream temperature increases in response to riparian thinning will be highly dependent on forest attributes outside and within the riparian buffer, the buffer size, the pre-thinned riparian forest attributes (Leinenbach et al. 2013), the thinning prescription (Chapter 3, Section 3.4.1*, Projected Timing and Amount of Harvest*), topography, and the thermal sensitivity of the stream (Janisch et al. 2012). In a study of Oregon Coast Range streams where most sites were in narrow, steep or moderately steep, V-shaped valleys, Allen and Dent (2001) found little relationship between the basal area of riparian forests and stream shade in north-south-draining streams; however, basal area and stream shade were correlated in east-west-draining streams. Thus, such streams in the permit area may be more susceptible to increases in water temperatures from removing riparian trees.

Thinning treatments may reduce tree densities to 40 square feet of basal area per acre in stands younger than 65 years of age as of 2020 with the highest conifer densities, but it is not known how many stands or total acres will be reduced to this level. Streams in east-west-draining orientation in these stands are likely to experience the greatest short-term temperature increases until the stands mature and canopies close, while north-south-draining systems will experience slightly lower short-term temperature increases. However, based on the harvest cap described in Chapter 3, Section 3.4.1, *Projected Timing and Amount of Harvest* (1,200 acres), the amount of annual harvest occurring within RCAs will be minimal (<1% of permit area) and unlikely to occur on large continuous sections of fish-bearing streams or PNFB tributaries and, thus, unlikely to result in temperature increases propagated downstream to coho streams. However, should water temperatures increase because of riparian thinning along non-fish-bearing or fish-bearing streams temperature are expected to ameliorate downstream within 500 to 1,000 meters downstream because the warmed water would pass through forested reaches resulting in cooling back to ambient conditions (Bladon et al. 2018; Davis et al. 2015).

Thinning in RCAs will include the placement of large wood in the stream channel, according to Conservation Measure 1, that can help maintain cool water temperatures. Santelmann et al. (2022) reported that placing wood in stream channels creates habitat complexity and deeper pools thereby increasing thermal variability in the water column in reaches with deeper pools compared to bedrock-dominated reaches. Instream structures can create cool microhabitats, but their influence on mean stream temperatures is not significant; rather, it is the deep pools created from instream structures that create cooler, more localized temperatures with less extremes. Additionally, instream structures can enhance gravel deposition in streams where bedrock was the dominant substrate, which is associated with net cooling in the long term (Crispell and Endreny 2009; Beechie et al. 2013).

The location and density of forest roads can also have a notable impact on stream temperatures. The existing road network in the permit area is primarily within 330 feet of ridgelines (approximately 59%), with approximately 14% of the existing road network occurring within 200 feet of a waterbody (Table 4-12). The existing road network is expansive and new road construction in RCAs is expected to be negligible over the permit term. Less than 0.5 mile of new roads will be constructed per year across the entire permit area, meaning that within RCAs the total miles of roads constructed will be even less. If roads are constructed in proximity to a stream, clearing can permanently remove vegetation in the new road's right-of-way that would eliminate stream shading. Adherence to Oregon FPA restriction pertaining to roads (Chapter 3, Section 3.6.1, *Road System Construction and Management*) and Condition 11 will limit new road construction such that roads will only occur in RCAs when other options are not viable, which will limit temperature effects on adjacent streams. However, some circumstances will require new road construction in the RCAs to enable harvest in areas outside of RCAs. Due to the limited number of roads that are expected to be constructed in the RCAs (Condition 11), impacts on stream shading and temperature are expected to be localized and unlikely to propagate downstream.

Road-vacating activities could require brushing, removal of hazard trees, culvert cleaning, and drainage improvements. These actions could require that trees and brush be removed, with vegetation removal occurring primarily from the understory, while the removal of hazard trees could affect overstory vegetation. These actions would occur infrequently (Chapter 3, *Covered Activities*) and would not affect vegetation composition in one location enough to cause more than a temporary localized impact.

Due to the steep topography of the permit area, designation of RCAs, contribution of large wood through Conservation Measure 1, and limited potential for road construction in RCAs through

Conservation Measure 3, temperature effects across the permit area on Oregon Coast coho are likely to be limited spatially and temporally and result in long-term benefits, including temperature regulation via enhanced stream shading.

Chemical Contaminants

If not sited properly, forest roads can direct and increase the runoff of soils into waterbodies, increasing 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, zinc) and petroleum-related compounds (e.g., 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). However, the permit area roads are pervious, meaning water can infiltrate the road surface, which reduces the risk of chemicals accumulated on the road surface running off directly into the aquatic environment. Runoff associated with forest roads and landings can introduce pesticides and metals to the aquatic environment, which can be toxic to fish at high concentrations and have been shown in laboratories to affect fish behavior even at very low concentrations (McIntyre et al. 2008; Hecht et al. 2007; Linbo et al. 2006; Meador et al. 2006). Accidental introduction of contaminants into streams associated with timber harvest and maintenance activities (e.g., fuel spills from timber harvest equipment) could result in mortality or inhibit normal behaviors of covered species that encounter these contaminants.

Chemical contaminants may be introduced into streams via existing and newly constructed roads in the permit area. Most of the extant road system in the permit area is on ridgelines (Table 4-12), which are generally good locations to minimize the hydrologic connectivity between roads and streams, reducing the potential for introduction of chemical contaminants into coho salmon habitats. However, use and maintenance of the 41% of roads that are in mid-slope or valley bottom positions (0–200 feet from streams) (Table 4-12) will be more likely sources of chemical-laden runoff that can affect coho salmon habitats. Conservation Measure 3 will reduce the density of the road network, reducing potential inputs of contaminants over the course of the permit term. In addition, Condition 11 focuses on hydrologically disconnecting roads where possible, which will further reduce the potential for chemical contamination to reach streams. Construction of up to 40 miles of new roads over the permit term is expected to occur outside of RCA per the Oregon FPA rules referenced in Chapter 3, Section 3.6.1, *Road System Construction and Management* (OAR 629-625-0200) and Condition 11. However, when new roads are constructed in RCAs, Condition 11 will be followed to ensure they are hydrologically disconnected and unlikely to degrade the aquatic resource. 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 will be at least 150 feet away from any waterbody or wetland to minimize leaks and spills that could enter waters of the state. Should a spill occur, and contaminants reach a waterbody, effects are expected to be localized.

Water Quantity

Forests influence water yield through the interception of precipitation and transpiration by trees. After logging, peak flows can increase due to the removal of the water demand of vegetation (Coble et al. 2020). If more than approximately 20% of a subwatershed is clearcut at any given time, changes in peak flows usually become measurable; with these effects diminishing with increasing watershed area and varying by placement of harvest unit in the catchment (Abdelnour et al. 2011; Grant et al. 2008; Stednick 1996). In an analysis of several experimental and modeling studies across the Pacific Northwest, Grant et al. (2008) found that the change in peak flow increased linearly with increasing harvest area and was undetectable (i.e., relative change in peak flow is less than 10%) for harvested areas of less than 29% in rain-dominated watersheds and 15% for watersheds in the transient snow zone. Given these findings, harvest outside of RCAs is not expected to affect high flows because intensive treatments will be limited. It is unlikely that 20% of any Hydrologic Unit Code (HUC) 12 within the permit area will be in the young forest stage (0–10 years) at any given time, lessening the likelihood of persistent increases in peak flows. Furthermore, the creation of RCAs addresses potential effects on peak flows from harvest activities in the permit area by maintaining riparian forests adjacent to the aquatic zone that will slow overland flow and allow water to infiltrate before entering streams.

As a forest regrows, water demand is expected to increase, particularly during summer months when vegetation is growing rapidly and water supplies are lower, which can cause a reduction in stream flows (Coble et al. 2020). However, much uncertainty surrounds the spatial and temporal scale over which any reductions may manifest. Segura et al. (2020) found that retaining riparian areas partially mitigated the effect of clearcutting, but persistent decreases in summer low flows (i.e., lower low flows) remained detectable in 40- to 53-year-old plantations, even in basins that had only been partially harvested (25% patch cut) (Segura et al. 2020; Perry and Jones 2016). In basins of similar size (<1,000 acres) to those studied in Oregon, Gronsdhal et al. (2019) found that decreases in summer stream flows associated with forest growth after timber harvest were associated with 20 to 50% reductions in the availability of modeled habitat for juvenile trout in British Columbia. Whether harvest-related declines in summer streamflow or available salmonid habitat manifest in larger streams remains unclear (Moore et al. 2020), as does the effect of thinning rather than clearcutting and the duration of effects beyond about 50 years, despite little or no evidence of hydrologic recovery in examined systems (Crampe et al. 2021; Gronsdahl et al. 2019). Even with such uncertainty, flows in some streams in the permit area are undoubtedly already lower than those prior to the start of industrial forest management because logging has been limited over the last decade, leaving the area with few young stands and approximately half in forests 65 years old or younger.

Across the permit area roughly 35% of the landscape is expected to be subject to extensive or intensive treatments (Table 4-9). Restrictions on the acreage of allowable timber harvest over the permit term (approximately 1% of the permit area per year; Chapter 3, Section 3.4.1, *Projected Timing and Amount of Harvest*) may still result in certain watersheds having enough area in the rapidly growing stage to reduce summer flow in some streams. This is most likely in the subwatersheds (HUC 12) with a higher proportion of acres subject to extensive or intensive treatments (Table 4-9). Depending on the spatial distribution of harvest on an annual basis and subsequent plantations in intensively treated areas, findings from previously cited studies indicate that decreases are possible in the amount of summer flow and available habitat for juvenile coho salmon occupying small streams (draining less than 1,000 acres). At a broader spatial resolution, additional reductions in summer flow and habitat availability for larger streams of intensively treated areas are less likely than for small streams (Moore et al. 2020). Risks to reductions in summer flow are further mitigated because it is unlikely that 20% of the forest in any full or partial subwatershed will be intensively treated and subsequently added to the stage of high water use, because of the annual harvest caps (Chapter 3, Section 3.4.1, *Projected Timing and Amount of Harvest*). Furthermore, in full watersheds, each acre of intensive harvest will be matched with an acre of reserves. Extensive treatments are also unlikely to result in reductions in stream flows because retention should be high enough (at least 20% of pre-harvest density) to prevent measurable changes in flows—particularly in stands between 65 and 150 years old where retention levels are higher and stands rely more prominently on natural regeneration (Table 4-9). Similarly, on average, half of the subwatershed areas in the permit area will be retained in reserves; subwatersheds with higher proportions of treatments (intensive and extensive) are generally smaller in total area and represent small portions of the entire subwatershed, meaning the impact on streamflows from the covered activities is likely proportionally smaller (Table 4-9). The subwatersheds that have more area overlapping the permit area are generally more equally distributed between reserves and treatment areas (e.g., West Fork Millicoma). Therefore, considering the annual harvest caps, extensive retention rates, RCAs, and the proportion of treatment areas within subwatersheds (HUC 12), any localized reductions in the extent and area of habitat in small streams from intensive or extensive treatments are not expected to affect the persistence or sustainability of coho salmon in the permit area over the permit term.

Increased delivery of coarse sediment following harvest can increase the effect of low flows by shallowing and widening stream channels (Hicks et al. 1991). Riparian vegetation in RCAs will provide bank stability and prevent the shallowing and widening of a stream that can occur in its absence. Streams in mountainous terrain can over time aggrade or degrade as a function of sediment supply and change fish habitat conditions. Shallow water resulting from aggraded channels during the summer can cause fish to be crowded into a few pools isolated by dry gravel-bed riffles or stranded in intermittent or dry areas (May and Lee 2004). Reduced habitat areas and connectivity can negatively influence survival and prevent fish from reaching thermal refugia, which is important for summer rearing. However, because RCAs will be applied to all fish-bearing streams, the rate of channel aggradation, or shallowing of the channel, is likely to be very low and, thus, stranding or crowding fish during the summer is not likely and unlikely to contribute to reductions in abundance of the ESU.

4.6.1.2 Access to Suitable Habitat

Fish passage for anadromous salmon will be provided for adult and juvenile fish at all new stream-crossing installation or replacement projects conducted in streams historically inhabited by native migratory fish. A number of natural barriers exist in permit area (Chapter 2, Section 2.5.2, *Population and Habitat Status*, and Chapter 3, Section 3.6.1.6, *Drainage Structures, Barrier Upgrade and Removal*) that prevent or delay fish passage.

Stream crossings such as bridges or culverts can be migration barriers that affect Oregon Coast coho. 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 Condition 11, which requires that new and replacement culverts meet the most recent passage criteria (currently NMFS [2014] and OAR 635-412-0035) 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 the end of their expected lifespan or when otherwise due to failure. Culvert replacements will be carried out according to Oregon Department of Fish and Wildlife (ODFW) and NMFS fish passage design criteria (NMFS 2022b, or most recent). If adhering to fish passage standards is not feasible due to site-specific constraints, the Permittee will coordinate with NMFS and ODFW to design an acceptable fish passage solution.

Culvert upgrade or removal will 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 and NMFS if it needs to occur outside appropriate windows. Conservation Measure 3 commits to a net increase in accessible habitat/stream miles that were previously inaccessible due to human-induced barriers in the permit area, resulting in a net benefit to Oregon Coast coho. Short-term effects of instream work associated with a culvert upgrade or removal include vegetation removal and increased sedimentation, which are described in Section 4.6.1.1, *Habitat Modification*, and direct mortality, which is described in Section 4.6.1.3, *Effects on Individuals*.

4.6.1.3 Effects on Individuals

The covered activities could cause unintentional mortality of adult and juvenile Oregon Coast coho, for example, if fish come in contact with equipment, personnel, or chemicals, or if they are present during dewatering associated with the covered activities. In-water activities associated with research, culvert maintenance and installation, stream-crossing construction, and stream-enhancement projects have the potential to affect coho by injuring or killing individual fish. As described in Condition 11, in-water work will follow the established *Oregon Guidelines for Timing of In-Water Work to Protect Fish and Wildlife* (ODFW 2023) or will obtain appropriate approvals from ODFW and NMFS if it needs to occur outside ODFW work windows. The ODFW work windows will minimize impacts on Oregon Coast coho and its habitat by having work occur during times that avoid vulnerable coho life stages, including migration and spawning. However, given that coho salmon typically migrate to the ocean as yearlings, meaning they spend a full year in freshwater before migrating, juveniles may be present in the permit area during in-water work windows. There are currently three fully blocked and two partially blocked culverts in the permit area with approximately 5.5 miles of additional habitat located upstream (Chapter 2, Tables 2-7 and 2-8). These five culverts may be replaced or retrofitted during the permit term to improve passage conditions. In addition, up to 45 culverts or bridges may be replaced, repaired, or constructed during the permit term, resulting in some juvenile coho being harmed during in-water work. Based on data from the Oregon Department of Transportation no more than 50 juvenile coho are expected to be encountered prior to in-water work associated with stream-crossing projects. Annually, based on the limitations described in Chapter 3, *Covered Activities*, no more than 150 juvenile coho would be captured, handled, and relocated because of in-water work associated with crossing projects (Table 4-15). Effects on adult coho would not be encountered outside of emergency actions because in-water work would occur when adults are not present. Some adults may be encountered when actions are taken to address emergency situations as described in Chapter 3.

Table 4-15. Total Number of Adult and Juvenile Coho Expected to be Harmed or Harassed because of Annual Population Monitoring and In-Water Work

	Annual		Permit Term (80 Years)	
Activity	**Adults**	**Juveniles**	**Adults**	**Juveniles**
Population Monitoring				
Electrofishing Handled/Captured	10	2,500	800	200,000
Electrofishing Harassed	10	2,500	800	200,000
In-Water Work—Passage Projects (3/year, 50/Permit Term)				
Captured/Handled/Relocated	0	150	0	12,000

Take in the form of harm and harassment would also occur because of population monitoring efforts to test responses to restoration thinning treatments. For example, following restoration thinning treatments, coho populations may be sampled using electrofishing equipment to estimate population metrics such as density or abundance. Juvenile fish would be collected, anesthetized, and then weighed and measured before being released. Each year, roughly 10 sites may be sampled within treated and untreated (control) reaches. Only reaches with gradients less than 6% would be sampled as coho do not occupy reaches in steeper areas. No more than 2,000 linear meters will be sampled per year, resulting in roughly 5,000 juvenile coho being encountered based on conservative density estimates reported by Nickelson and Lawson (1998) (Table 4-15). Assuming a 50% capture efficiency rate during electrofishing sampling (Peterson et al. 2004) roughly 2,500 fish would be captured, handled, and released each year and another 2,500 unhandled fish would be harmed via harassment and exposure to electrical shock. For the entire extent of the permit term roughly 400,000 juvenile coho may be sampled during research monitoring. While it is unlikely that adults will be encountered during population monitoring activities, because work will primarily occur during ODFW-defined in-water work windows, it is possible over the 80-year permit term that sampling may occur outside of the defined in-water work periods. If this does occur, migrating or spawning adults could be exposed to electrofishing effects. However, as previously stated prior to any work occurring outside of established in-water work windows appropriate approvals from ODFW and NMFS will be obtained, which will likely require that work be delayed if adults are present in the work area. Therefore, the likelihood of adults being exposed to electrofishing effects is low and no more than 10 adults are expected to be encountered.

4.6.2 Impacts of the Taking

The Oregon Coast coho ESU consists of 27 independent and dependent populations distributed across 4.2 million acres. Three independent populations occur in the permit area—Tenmile, Coos, and Lower Umpqua—each of which encompasses only a portion of the overall permit area (Table 4-9). The permit area is dominated by steep streams and narrow valleys, which decreases the intrinsic potential to develop high-quality habitat for coho (Burnett et al. 2007). However, depending on the actual condition of habitat, reaches with low intrinsic potential may still support robust coho rearing and spawning. As previously discussed, the quality of habitat is determined largely by the integrity of processes that create and maintain it. The occurrence of high-quality habitat is supported by observations of relatively high numbers of coho salmon spawners in the permit area (Chapter 2, Table 2-8). Thus, the contribution of reaches that provide high-quality habitat now and into the future are important for the independent populations (Chapter 2, Figure 2-16) in and downstream of the permit area. A significant contribution of the permit area to the recovery of coho is the production and export of wood, sediment, high-quality water, nutrients, and food to the lower portions of watersheds outside of the permit area, where the potential for productive habitats and the increases in fish numbers is greater. Therefore, the permit area can serve as a significant component for recovery and conservation efforts for the three independent coho populations that it supports. Table 4-16 summarizes the stream miles for each independent coho population that occur in the CRW and MRW. The following sections analyze effects based on the types of treatments described in Chapter 3, *Covered Activities*, and presented in Table 4-1.

The following analyses build on the discussions in Section 4.6.1.1, *Habitat Modification*, and apply the concepts to each of the three independent populations within the permit area. A key component of this analysis is the distribution of known coho habitats relative to the modeled fish-bearing streams (Table 4-17; Chapter 2, Figure 2-18) given that modeled fish-bearing streams extend further into the upper portions of the watersheds. Another key component is the total miles of each stream type that occurs in the CRW and MRW given that RCA widths depend on where within the permit area streams occur (Table 4-16). These data are used to evaluate habitat impacts as a function of coho distributions, distribution of stream types in management watersheds, and the extent of riparian and upland treatment types.

Table 4-16. Miles of Fish-Bearing Stream RCAs in the CRW and MRW Available for Restoration Thinning by Independent Coho Population [a]

					Lower Umpqua					
			Tenmile		Below Loon Lake		Above Loon Lake		Coos	
Allocation	**Treatment**	**RCA Width (feet)**	**Miles**	**%**	**Miles**	**%**	**Miles**	**%**	**Miles**	**%**
CRW RCA	No Treatments	200	36	65	23	44	0	0	4	0
	Restoration Thinning	200	14	25	12	22	0	0	1	0
	Subtotal	-	*50*	*90*	*35*	*66*	*0*	*0*	*5*	*4*
MRW RCA	No Treatments	200	2	4	0	0		0	15	12
		120	0	0	6	12	0	1	25	20
		100	0	0	5	9	3	68	35	28
	Restoration Thinning	200	3	5	1	1		0	1	0.8
		120	0	0	2	4	1	20	20	16
		100	0	0	5	8	0	11	22	17.8
	Subtotal	-	*5*	*9*	*19*	*34*	*4*	*100*	*118*	*96*
Total		-	55	-	54	-	4	-	123	-

[a] Stream miles are based on TerrainWorks fish-bearing network (gradient of 20% or less; Chapter 2, Section 2.1.6, *Hydrology and Water Quality*), not representative of all stream miles receiving RCAs in the permit area.

RCA = riparian conservation area; CRW = conservation research watersheds; MRW = management research watersheds

Table 4-17. Miles of Streams Modeled as Fish-Bearing and Designated as Coho Rearing, Spawning, and Migration Habitats by StreamNet

	OSU Modeled	Coho Habitats Designated by StreamNet			
Coho Independent Population	**Fish-Bearing (miles)**	**Rearing (miles)**	**Spawning (miles)**	**Migration (miles)**	**Proportion of OSU Fish-Bearing Layer**
Tenmile	56	2	17	0	34%
Lower Umpqua Below Loon Lake	54	8	15	0	43%
Lower Umpqua Above Loon Lake	4	0	0	0	0%
Coos	123	2	54	0	46%
Total	237	10	85	0	40%

OSU = Oregon State University

4.6.2.1 Tenmile

The permit area comprises approximately 20% of the Tenmile independent coho population's range. In the permit area, 90% (50 miles) of fish-bearing streams within the Tenmile population area are in the CRW and the remaining 10% (5 miles) occur in the MRW (Table 4-16). Within the Tenmile independent coho population, roughly 34% of the modeled fish-bearing network is designated as coho habitat by ODFW (Table 4-17). The majority of coho habitat in the Tenmile population area is designated as spawning (17 miles; 30%) with roughly 4% (2 miles) designated as rearing habitat. Expressed in acres, 86% of the area of the Tenmile population in the permit area is in the CRW and 14 % is in the MRW. Within the Tenmile population area, 511 acres (3%) will be treated intensively (MRW), 1,432 acres (7%) will be treated extensively (MRW), 5,666 acres (29%) will be available for restoration thinning (RCAs, MRW, and CRW), and 12,272 acres (62%) will not be treated (MRW and CRW) (Table 4-10). Approximately 73% of the total area in the Tenmile population occurs on steep slopes (>65 degrees), of which 1.8% is subject to intensive treatments (Table 4-10).

NMFS recognizes that coho salmon in the lake stratum, which includes the Tenmile population, has maintained strong sustainability and persistence despite the presences of nonnative fish (National Marine Fisheries Service 2022a). The rate at which nonnative fish are preying on Oregon Coast coho salmon in the lakes populations and the level of impact nonnative fish predation is having on these populations is unknown (National Marine Fisheries Service 2022a). Nonnative fish do not occur in the permit area, and therefore are not addressed by a conservation measure under this HCP. The covered activities have the potential to affect Tenmile Lakes via downstream effects on sediment, nutrient, wood delivery, and water quality such as temperature. However, Tenmile Lakes are outside of the permit area and therefore effects on coho salmon in the lakes are not fully evaluated in this HCP. Because the areas upstream are almost entirely managed as part of the CRW, downstream effects on Tenmile Lakes are expected to be minimal and mostly beneficial; delivery of fine sediments from the permit area to Tenmile Lakes will likely be low, water temperature inputs to the lakes are expected to remain cool during the summer, and wood delivery may increase over the permit term.

Large Wood Recruitment

The effects on large wood recruitment described in Section 4.6.1.1, *Habitat Modification*, apply to the Tenmile population area. Wood recruitment to fish-bearing streams within the Tenmile population is expected to be 98% of available wood based on RCA widths and modeling results because of the wide RCAs throughout the area. Specifically, 100% of fish-bearing and coho streams in the Tenmile population area will have 200-foot-wide RCAs (Tables 4-8 and 4-16), which exceeds the distance over which wood is expected to be delivered directly from channel-adjacent riparian processes (Welty et al. 2002; McDade et al. 1990). Additionally, because fish-bearing RCAs extend 37 miles further upstream than designated coho habitat (Table 4-17), large wood recruitment to coho streams is unlikely to be affected by the covered activities. Furthermore, all PNFB and HLDP streams will receive RCAs of 200 feet (Tables 4-7 and 4-18), increasing the potential for large wood to reach coho habitats via fluvial processes from riparian and upslope areas. Cumulatively, these actions should avoid impacts on large wood recruitment to coho habitat in the Tenmile population directly from adjacent riparian areas and minimize negative impacts from debris flows (Section 4.6.1.1, *Habitat Modification*).

Table 4-18. Miles of Stream Types in Each Management Watershed (CRW and MRW) and Independent Coho Population

Stream Type	RCA Width	Tenmile			Coos			Umpqua (Below Loon Lake)		
		CRW	MRW	Total	CRW	MRW	Total	CRW	MRW	Total
Coho [a]	200	17	0	17	2	16	18	11	0	12
	120	0	0	0	0	12	12	0	6	6
	100	0	0	0	0	26	26	0	5	5
FB [b]	200	50	2	52	5	16	21	35	1	36
	120	0	0	0	0	45	45	0	8	8
	100	0	3	3	0	58	58	0	9	9
PNFB	200	33	3	36	4	0	4	30	1	32
	50	0	4	4	0	74	74	0	16	16
HLDP	200	22	1	23	1	0	1	24	1	25
	120	0	0	0.00	0	9	9	0	0	0
	50	0	1	1	0	9	9	0	8	8
XNFB	0	340	52	392	30	644	674	297	169	467

[a] Pacific States Marine Fisheries Commission 2023.
[b] Oregon State University 2022.
RCA = riparian conservation area; MRW = management research watersheds; CRW = conservation research watersheds; FB = fish-bearing; PNFB = perennial non-fish-bearing; HLDP = high landslide delivery potential; XNFB = non-fish-bearing non-perennial

Approximately 1, 1,817 acres of fish-bearing and non-fish-bearing RCAs with riparian stands that are 65 years of age or younger (as of 2020) within the CRW and MRW will be available for restoration thinning treatments (Table 4-19), representing roughly 34% of the total RCA area for the Tenmile coho population. The goal of restoration thinning treatments is to achieve properly functioning aquatic habitat conditions in a timely manner. Treatments will maintain conifer basal areas of at least 40 square feet per acre. Restoration thinning in the CRW will occur during the first 30 years of the permit term, while restoration in the MRW may occur over the course of the permit term. All trees cut within the first 50 feet of any stream RCA will be left on the ground or tipped toward or placed in the stream, and no trees will be removed. Outside 50 feet, up to 20% of the trees cut within RCAs may be dropped in the stream or left on the ground to provide coho habitat. This addition of trees, depending on the size relative to the transport capacity of the channel, will immediately improve habitat quality for coho salmon, and help mitigate mid-term decreases in wood delivery from restoration thinning. Furthermore, over the course of the permit term restoration thinning within RCAs will be limited to 1,200 acres in total for the entire permit area; roughly 160 acres are expected to be thinned every 5 to 7 years. The harvest cap (Chapter 3, Section 3.3.7.4, *Operational Standards for Restoration Thinning in Riparian Conservation Areas*) on RCA restoration thinning will help ensure that effects on large wood recruitment do not translate to measurable impacts on coho habitat within the Tenmile population.

Table 4-19. Total Acres of RCAs and Acres of RCAs Eligible for Restoration Thinning by Independent Population

Allocation	RCAs	Coos	Lower Umpqua Below Loon Lake	Lower Umpqua Above Loon Lake	Tenmile	Total
CRW RCAs	Total	470	4,288	-	4,939	9,697
	Available for Restoration Thinning [a]	102	1,412	-	1,490	3,004
	Proportion Available for Thinning	22%	33%	-	30%	31%
MRW RCAs	Total	4,681	888	319	430	6,319
	Available for Restoration Thinning [a]	1,941	467	172	325	2,906
	Proportion Available for Thinning	41%	53%	54%	75%	46%
Permit Area	Total	5,151	5,177	319	5,376	16,024
	Total Available for Restoration Thinning	2,043	1,886	172	1,817	5,919
	Proportion Available for Thinning	40%	36%	54%	34%	37%

[a] Stand age ≤65 and no data.

While XNFB streams will not have RCAs, upslope treatments in the CRW will be limited to restoration thinning (3,829 acres; 31% of the area outside of RCAs) (Table 4-10) during the first 30 years of the permit term in forest stands 65 years old or younger (as of 2020). This, plus the lower wood delivery potential of XNFB streams should greatly minimize, or totally avoid, effects on large wood loading in downslope fish-bearing channels.

A relatively small portion of the Tenmile watershed will be available for intensive treatments (2.6%) and extensive treatments (7%). In extensively treated areas, tree retention would be at least 20% in stands less than or equal to 65 years old (as of 2020), average 50% in stands that are between 65 and 150 years old, and stands 150 years and older will not be treated (Table 4-9). Because of the presence of 200-foot RCAs on all fish-bearing streams, the relatively small proportion of intensively and extensively treated areas, and retention requirements in extensively treated stands, impacts on large wood recruitment to coho streams from channel-adjacent processes are unlikely.

Harvest-related effects on wood loading from debris flows and fluvial processes to coho habitat throughout the Tenmile population area from non-fish-bearing streams are expected to be minimized but not fully avoided. The RCA widths on PNFB and HLDP streams in the MRW (Tables 4-7 and 4-18) are 50 feet, resulting in approximately 65 to 70% of the wood expected to be recruited directly to such streams from a mature or old growth riparian forest (Welty et al. 2002). Less wood being stored in these non-fish-bearing streams may reduce the contribution of wood available for transport downstream to coho habitat. Because RCAs are not required on XNFB streams, wood delivery via debris flows to fish-bearing streams from HLDP streams that are downstream of XNFB streams may be reduced. The delivery of large wood into XNFB streams from riparian areas in the Tenmile population will be minimal in intensive treatments but greater in areas of extensive treatments and restoration thinning, depending on harvest levels. Of the 5,261 upland acres (i.e., outside of RCAs) that could be subject to extensive treatments or restoration thinning in the Tenmile population area (Table 4-10), the lowest potential wood recruitment to XNFB streams is expected in areas with the minimum retention level (20% of original pre-harvest stand density). However, XNFB streams are not anticipated to be important sources of fluvial large wood recruitment directly into coho habitat given their limited hydraulic transport capacity and relatively low modeled probability, when compared to HLDP streams, of delivering a debris flow to a fish-bearing channel. Therefore, any effects would be both spatially and temporally limited.

The recruitment of riparian wood over the course of the permit term will help with pool development and sediment retention, provide cover and store gravels for spawning habitat, potentially increase floodplain connection, and promote nutrient cycling. Any take in the form of reduced large wood recruitment is expected to be spatially and temporally limited.

Sediment Delivery

As described in Section 4.6.1.1, *Habitat Modification*, subsection *Sediment Delivery*, delivery of fine sediments to the aquatic environment is likely from three sources—steep slopes; road construction, maintenance, and use; and RCA restoration thinning. This section discusses effects from these sources that are likely to occur in the Tenmile population area.

Approximately 73% of the total acreage in the Tenmile population area is classified as steep slopes (slopes >65%), with only 2% of these subject to intensive harvest (Table 4-10). The majority of the Tenmile population area is in the CRW, where management will be limited to restoration thinning within established plantations and conserving existing mature forest stands. Intensive harvest will occur in the small portion of the Tenmile population area (2%) in the MRW (Table 4-10). In the Tenmile population area, 15% of the steep slopes in the MRW will be subject to intensive treatment. Fish-bearing streams in these areas will receive 200-foot-wide RCAs and non-fish-bearing perennial (PNFB and HLDP) streams will receive 50-foot-wide RCAs, both of which are wide enough to filter sediments (Table 4-7). Therefore, the risk of adverse impacts on coho from harvest-related increases in sediment delivery from surface runoff is very low in these areas. The remaining 98% of the steep slopes in the entire Tenmile area will be available for extensive treatments, restoration thinning, or will not be treated.

Restoration thinning may occur in 34% of the total RCA acres, reducing overall stand conifer basal area and temporarily contributing to increased sediment delivery (Table 4-10). However, where RCAs on fish-bearing, PNFB, and HLDP streams are untreated, sediment filtration will remain high for the duration of the permit term. This risk will be minimized by ELZs along Oregon FPA–defined streams and the predominant use of hand-felling methods in RCAs on slopes greater than 40% (Condition 10). Sediment filtration functionality will recover in treated RCAs likely to a higher level than pre-treatment conditions. The greatest risk of increasing landslide initiation and debris flow runout to coho habitat in the Tenmile population area from restoration thinning is likely to be where the minimum basal area is retained on steep slopes. The risk of restoration thinning to increase sediment delivery to coho habitat by disrupting RCA functions or altering characteristics of landslides and debris flows will generally be low and isolated to local areas within the Tenmile population over the short term given the RCA restoration thinning cap of 1,200 acres over the permit term. Over the long term, effects on sediment delivery processes will generally be minimized because riparian and upland stand characteristics will progress toward a mature forest structure.

Where forest management and restoration actions occur in the MRW and CRW uplands, the RCAs applied to fish-bearing, PNFB, and HLDP streams will minimize the risk of adverse impacts from sediment delivery via overland flow to the aquatic environment by ensuring that large wood is available to deliver to fish-bearing streams when debris flows, or landslides occur through HLDP streams, which will help regulate sediment transport and storage. Moreover, RCA widths (Table 4-7) are expected to result in protections to the aquatic environment from increases in landslide initiation rates from channel-adjacent unstable slopes while preserving the beneficial function of landslides (e.g., sediment and wood delivery). Moreover, the vast reserve system in the CRW protects the aquatic processes associated with coho streams by reducing the potential that timber harvest will increase rates of landslide initiation.

Additionally, due to the vast reserve system in the CRW watershed and the presence of RCAs on fish-bearing, PNFB, and HLDP streams, abundant large wood will be available for delivery over the long term to the aquatic environment when landslides or debris flows occur and should reduce the distance that debris flows or landslides can travel and thus minimize impacts on the Tenmile coho population while preserving important ecological processes. Furthermore, to the extent possible, equipment use will be limited on slopes greater than 40% to minimize the risk of management-initiated slope failures.

Current road density within the Tenmile population is 3.1 miles per square mile (Table 4-11) and most roads (74%) are near a major ridgeline (upper slope, within 330 feet) (Table 4-12). Fifteen percent (14.7 miles) of the road network exists on mid-slopes meaning more than 200 feet from a stream and more than 330 feet from a major ridgeline. Mid-slope roads represent a higher risk to initiate landslides/debris flows relative to ridgeline or valley bottom roads. Less than 10 miles of roads within the Tenmile population area are within 35 to 200 feet of streams and roughly 1 mile occurs within 35 feet of a stream. Therefore, in its current condition, the road network within the Tenmile population area is unlikely to be a major contributor to instream sediments via surface runoff or as an extension of the drainage network.

Within the first 12 years of HCP implementation, the existing road network will be inventoried and road segments that pose a risk to the aquatic system will be prioritized for upgrade, closure, or to be vacated to reduce anthropogenic inputs of sediment that could degrade coho habitats (Conservation Measure 3). Furthermore, any new roads will be constructed outside of RCAs whenever possible (Condition 11) and will most likely be temporary to facilitate conservation management activities to benefit the covered species. However, new permanent roads may be constructed in areas in MRW watersheds subject to intensive and extensive treatments, which comprises a relatively small portion of the Tenmile population. All road construction, maintenance, and use will be consistent with Condition 11, which includes adherence to Oregon FPA regulations, minimizing the potential for increased sedimentation within coho habitats. The overall road network within the bounds of the Tenmile population is expected to decrease over the permit term and roads that remain will be hydraulically disconnected.

Water Temperature

The discussion surrounding water temperature effects described in Section 4.6.1.1, *Habitat Modification*, subsection *Water Temperature*, applies to the Tenmile population discussion in this section.

The permit area has steep topography that shades much of the stream network. Approximately 73% of the Tenmile watershed is on steep slopes, where the effects of topographic shading are expected to be greater than in gentler terrain. While there are some locations in the Tenmile population where stream temperatures are strongly influenced by riparian vegetation (i.e., east-west-draining streams in areas not dominated by steep slopes; Table 4-10), 86% of the acreage in the Tenmile population is within the CRW, and treatments directly affecting temperatures will be limited to RCA restoration thinning (Conservation Measure 1). The fact that the area is almost entirely in the CRW underpins the expectation of minimal or no increases of stream temperature in coho habitat from timber management over the permit term. Additionally, 90% of fish-bearing streams are in the CRW, ensuring riparian shade will remain intact and protected (Table 4-18).

Individual restoration thinning treatments, which would be allowed in 34% of RCAs in the Tenmile population area, could have effects on stream segments that rely on vegetation for shading by reducing canopy cover, resulting in instream temperature increases until crown closure occurs. In these areas, the time until the canopy closes would depend on the level of thinning and the width of the stream. Upland restoration thinning treatments in the CRW will also occur, potentially reducing shade on XNFB streams, which do not have RCAs. However, due to the relatively small size and extent of thinning (Table 4-1), any single upland thinning is unlikely to increase water temperatures in coho salmon habitat given their location much further downstream in the watershed.

Small portions of the Tenmile population area will be available for intensive treatments (3%) or extensive treatments (8%). However, due to the RCA protections along fish-bearing, PNFB, and HLDP streams, temperature increases in coho habitat are not expected. See Section 4.6.1.1, *Habitat Modification*, subsection *Water Temperature*, for further explanation. Furthermore, the potential effect of any increased water temperatures on Tenmile coho would be limited given that relatively little of the area is within the MRW. Moreover, because coho is only designated in 34% of the fish-bearing stream network (Table 4-15), any increases in stream temperatures in non-fish-bearing reaches will attenuate when passing through shaded fish-bearing stream reaches before reaching coho habitat downstream. Temperature changes as a result of the covered activities may be more impactful in the 1.3 miles of stream reaches listed as 303(d) by the Oregon Department of Environmental Quality (Chapter 2, Table 2-2). However, given that there are limited RCA acres available for thinning along the 1.3 miles of listed streams, the likelihood of persistent effects propagating downstream are low (Figure 4-8). The RCAs available for thinning near the 1.3 miles of 303(d) temperature-listed streams are along small non-fish-bearing streams and are, therefore, less likely to cause effects on the fish-bearing reaches downstream. This, combined with the riparian thinning harvest cap (Chapter 3, Section 3.4.1, *Project Timing and Amount of Harvest*), should prevent persistent long-term effects.

The placement of large wood in channels from restoration thinning treatments in RCAs as part of Conservation Measure 1 can help mitigate any increases in stream temperature from shade loss by increasing pool depths, habitat complexity, and gravel storage. The addition of large wood from restoration thinning treatments is expected to shape instream habitat conditions and promote development of deep pools and ultimately improve thermal heterogeneity. Over time, as large wood is added and riparian canopies expand, close, and mature, thermal conditions in the Tenmile population area are expected to stabilize and remain cooler during low-flow periods.

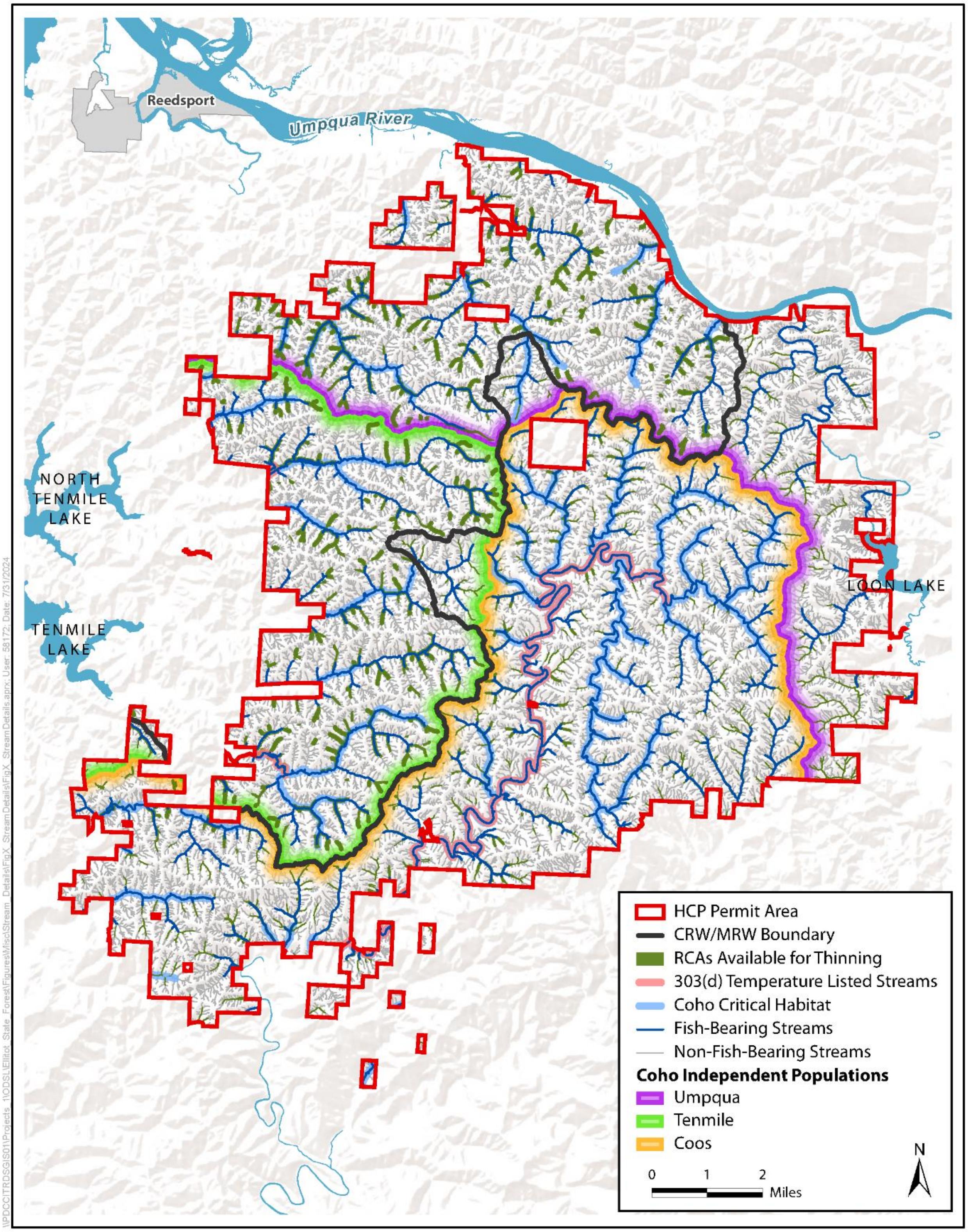


Figure 4-8. Locations of RCAs Available for Thinning in Relation to 303(d)-Listed Stream Reaches and Coho Critical Habitat

Figure 4-8 shows the locations of RCAs available for thinning in relation to 303(d) listed stream reaches and coho critical habitat. Bacteria, stream temperature, algae, dissolved oxygen, pH, biological criteria Total Maximum Daily Loads (TMDL) apply to the Umpqua Population (Oregon Department of Environmental Quality 2006).

Chemical Contaminants

As described in Section 4.6.1.1, *Habitat Modification*, under *Chemical Contaminants,* roads that cannot be disconnected or are unsuitable for wintertime haul will be closed to logging trucks during wet weather. Currently, less than 10 miles of existing roads are within 200 feet of a stream, suggesting that delivery of road-derived chemical contaminants is low. Staging and storage areas associated with construction activities in the RCAs will be at least 150 feet away from any waterbody or wetland to minimize leaks and spills that could enter waters of the state. Therefore, effects from introduced chemical contaminants are expected to be infrequent and limited spatially and temporally.

Water Quantity

Given that the portion of the Tenmile population within the permit area is almost entirely within the CRW, changes to water quantity because of the covered activities are unlikely (Table 4-10). There would be limited silviculture activities associated with restoration thinning treatments (Chapter 3, Section 3.4.2.2, *Thinning*) in CRW and MRW Reserves and RCAs, during the first 30 years of the permit term in the CRW (5,322 acres) and MRW (345 acres) with minimal activities extending further into the permit term (Table 4-10). Based on this low level of silviculture work, large plantations of young forests will not occur, and tree retention in thinned areas will be sufficient to prevent changes in water quantity. Thus, at no point during the permit term will enough acres within the Tenmile population be in the "thirsty stage" of forest growth (10–50 years) (Moore et al. 2004; Perry and Jones 2016; Segura et al. 2020) to cause a decline in water quantity, such that it would negatively affect habitat quality or water temperatures sufficient to affect coho salmon. In addition, hydraulic connections between roads and streams will be corrected wherever possible, road densities will decline over the permit term, and any new roads will be constructed to minimize hydrologic connectivity. Thus, any effects of roads on peak flows are expected to decrease over the permit term. This will reduce the potential for road-related runoff and effects on coho salmon habitats. Moreover, given that fewer than 10 miles of road exist within 200 feet of streams, effects on instream flows from the existing road network are unlikely.

Access to Suitable Habitat

Fish passage will be provided for adult and juvenile fish at all new stream crossings or replacement projects conducted in streams historically inhabited by native migratory fish. Stream crossings that are replaced, installed, or removed under this HCP will be compliant with Condition 11, which requires that new and replacement culverts meet the most recent passage criteria (National Marine Fisheries Service 2022b; Oregon Department of Fish and Wildlife 2015) to maintain hydraulic conditions, including hydrology, velocities, and slopes that pass juvenile and adult fish. Accessible habitat will increase over the permit term because of culvert replacement or improvement projects (Chapter 3, Section 3.6.1.6, *Drainage Structures*). Effects on the Tenmile population from culvert replacement projects will be the same as described in Section 4.6.1.1, *Habitat Modification*.

Effects on Individuals

Effects on individuals can occur as described in Section 4.6.1.3, *Effects on Individuals*. These effects are expected to be limited for the Tenmile population due to nearly 90% of fish-bearing streams being contained within the CRW, where management would be limited to restoration thinning. Currently, there are no bridges or known problematic (partially or completely blocked) culverts in the Tenmile population. However, a portion of the 50 allotted culverts and bridges to be replaced, repaired, or constructed could occur in the Tenmile population area. The total number is expected to be low given that the majority of the Tenmile population is within the CRW.

Additional effects are expected on individual coho because of the research monitoring described in Chapter 3, Section 3.9.3, *Research on Oregon Coast Coho Salmon and Their Habitat*. A research schedule has not yet been defined. However, sampling is expected to occur equally across the independent populations and therefore roughly a third of the totals presented in Table 4-15 would occur in the Tenmile population over the course of the permit term.

4.6.2.2 Coos

The permit area comprises 11% of the Coos independent population's range. In the permit area, 96% (118 miles) of the fish-bearing stream miles within the Coos population are in the MRW and the remaining 4% (5 miles) are in the CRW (Table 4-16). Within the Coos independent population roughly 46% of the modeled fish-bearing stream network is designated as coho habitat by ODFW (Table 4-17). The majority of the coho habitat in the Coos population is designated as suitable for spawning adults (54 miles; 44%), while roughly 2 miles (1.6%) are designated as suitable for rearing juveniles. Within the Coos population, 11,715 acres (32%) will be treated intensively (MRW), 8,713 acres (24%) will be treated extensively (MRW), 4,065 acres (11%) will be available for restoration thinning (including RCAs) (MRW and CRW), and 12,242 acres (33%) will not be treated (MRW and CRW). Approximately 55% of the total area in the Coos population occurs on steep slopes (>65%), of which 32% (6,513 acres) is subject to intensive treatments (Table 4-10).

Large Wood Recruitment

The effects of the covered activities on large wood recruitment described in Section 4.6.1.1, *Habitat Modification*, apply to the Coos independent coho population. Under Conservation Measure 2, RCA widths in the Coos independent population will be expanded along the Lower West Fork Millicoma River and in Volume Replacement allocations. The width of expanded RCAs in these areas will be 200 feet on fish-bearing streams, HLDP streams in the Volume Replacement allocations, and along the mainstem of the Lower West Fork Millicoma River, and 120 feet along HLDP streams and fish-bearing tributaries to the mainstem of the Lower West Fork Millicoma River (Tables 4-7 and 4-18). Therefore, wood recruitment to coho streams within the Coos population is projected to be at least 89% over the permit term based on RCA widths (Welty et al. 2002; McDade et al. 1990) and modeling results (Table 4-8). Additionally, because fish-bearing RCAs extend 67 miles further upstream than designated coho habitat (Table 4-14), large wood recruitment to coho streams is unlikely to be affected by harvest-related activities.

Because a large portion of the Lower West Fork Millicoma River will be bordered by reserves (Chapter 3, Figure 3-1), the RCAs in these locations will exceed 200 feet because adjacent land will not be treated, except by restoration thinning (including RCAs). The potential for adverse impacts on wood delivery in fish-bearing streams in the Lower West Fork Millicoma River is further minimized, because HLDP streams have a larger 120-foot RCA compared to the rest of the permit area (Tables 4-7 and 4-18). Leaving trees along HLDP streams ensures that wood will be available when landslides occur and provides for a different legacy, modifying how a stream responds to future landslides.

Harvest-related effects on wood loading to coho habitat throughout the Coos from non-fish-bearing streams is expected to be minimized but not fully avoided. Although HLDP streams in the Lower West Fork Millicoma require a 120-foot buffer, the 50-foot-wide RCAs on HLDP streams outside the Lower West Fork Millicoma and PNFB streams everywhere in the Coos population (Table 4-16) should provide approximately 65 to 70% of the wood expected to be recruited directly to such streams from a mature or old growth riparian forest (Welty et al. 2002). Less wood being stored in these non-fish-bearing streams may reduce the contribution of wood available for transport downstream to coho habitat, although this is unlikely. Because RCAs are not required on XNFB streams, wood delivery via debris flows to fish-bearing streams from HLDP streams that are downstream of XNFB streams may be slightly reduced. The delivery of large wood into XNFB streams from riparian areas in the Coos population will be minimal in areas subject to intensive treatments but greater in areas subject to extensive treatments, restoration thinning, and areas not available for treatments, depending on harvest levels. Areas subject to extensive treatments thinned to the minimum retention level (20% of original pre-harvest stand density) are expected to have the lowest potential wood recruitment to XNFB streams (Table 4-9). However, XNFB streams are not important sources of large wood recruitment directly into coho habitat, given their limited hydraulic transport capacity and relatively low modeled probability of delivering a debris flow to a fish-bearing channel.

Restoration thinning treatments are aimed at addressing limiting factors (stream complexity) identified by NMFS (2016) by ensuring that wood delivery remains high, and the formation of important habitat features necessary to support Coos coho is promoted. These include pool development and sediment retention, providing cover and spawning habitat, potentially increasing floodplain connection, and promoting nutrient cycling. Restoration thinning in RCAs for the Coos population could occur in 1,941 acres in the MRW and 102 acres in the CRW (Table 4-8). However, not all that area could be thinned, as RCA restoration thinnings are capped at 1,200 acres across the permit area for the duration of the permit; 160 RCA acres are expected to be thinned every 5 to 7 years. In RCAs where restoration thinning occurs, all trees cut in the first 50 feet will be retained and left on the ground or tipped toward or placed in the stream. Similarly, up to 20% of the volume of logs cut outside of 50 feet within RCAs may be felled toward the stream channel or left on the ground. These actions are intended to provide instream structure for Oregon Coast coho, helping to mitigate any short- and mid-term reductions in wood recruitment that may result from thinning. The harvest cap on RCA restoration thinning will ensure that effects on large wood recruitment are minimal within the Coos population.

Sediment Delivery

As described in Section 4.6.1.1, *Habitat Modification*, delivery of sediments to the aquatic environment is likely from three sources—upland timber harvest, RCA restoration thinning, and road construction, maintenance, and use. This section discusses effects from these sources likely to occur within the Coos independent population area.

Approximately 55% of the total acreage in the Coos population area is classified as steep slopes, of which 32% may be subject to intensive treatments (Table 4-10). The remaining 68% of steep slopes in the Coos population area would be subject to extensive treatments (26%), restoration thinning (RCA and Reserves) (12%), or no treatments (32%). Harvest-induced increases in landslide rates are expected to be avoided in untreated areas and depend on tree-retention levels in thinned and extensively treated areas, as described for the Tenmile population in Section 4.6.2.1, *Tenmile*.

While almost all fish-bearing streams in the Coos population area occurs in the MRW (96%) (Table 4-16), intensive treatments will be spread out over space and time and will be limited to 20 to 50% of any full MRW subwatershed (intensive treatments in partial watersheds may be higher). Therefore, intensive treatments are unlikely to affect large contiguous swaths of the Coos population area simultaneously. Intensive, extensive, and restoration thinning treatments will avoid slopes with the highest probability of delivering sediment and debris to fish-bearing streams, further reducing the risk of forest-management-induced landslides. Similarly, ground-based equipment will not be operated on slopes greater than 40% (Condition 10) and ground disturbance will be minimized in these areas during log felling or yarding operations (Chapter 3, Section 3.3.7.4, *Operational Standards for Restoration Thinning in Riparian Conservation Areas*).

The likelihood of harvest contributing to landslide initiation on the steep slopes in areas subject to extensive treatments (31.7% of steep slopes in the population area) will be greatest in areas with the lowest tree-retention rates (20% of original pre-harvest stand density in stands less than or equal to 65 years old) but should be relatively low in stands between 65 and 150 years old due to the targeted average tree-retention rate (50%). The greatest risk of harvest-induced landslide rates will be on the steep slopes in areas subject to intensive treatments (32% of steep slopes). However, the risk is unlikely to translate to a broad spatial scale because of the annual harvest caps on intensive treatments and, in full watersheds, the requirement for each acre of intensive treatments to be matched by an acre of reserves. Thus, site-level landslide risks from timber harvest will be dispersed, which minimizes the overall risk to coho habitat in the Coos population area (Chapter 3, Figure 3-1).

Additionally, the inclusion of RCAs on fish-bearing, PNFB, and HLDP streams is wide enough (ranging from 50–200 feet) (Tables 4-7 and 4-18) to stabilize streambanks and to filter surface runoff from upslope timber management activities before reaching the aquatic environment. RCA thinning will reduce sediment trapping and filtration capabilities until vegetation matures. RCAs on HLDP streams provide large wood that can minimize the risk of landslide or debris flow–derived sediment from reaching coho habitats by reducing the distances these travel. Furthermore, Conservation Measure 2 will ensure that additional protections are provided via expanded RCA widths along the mainstem Lower West Fork Millicoma River (200 feet), fish-bearing tributaries to the mainstem (120 feet), and HLDP streams (120 feet). In the Lower West Fork Millicoma, the 120-foot-wide RCAs on HLDP streams (Table 4-15) should be sufficient to contain all debris flow scour from side slopes along HLDP streams and to provide a full complement of large wood that will facilitate long-term coho habitat creation along with any delivered sediments.

Narrower, 50-foot RCAs on HLDP streams, which are prescribed for the Coos areas outside of the Lower West Fork Millicoma (Tables 4-7 and 4-18), will allow some scour beyond the forested RCA areas, potentially increasing the amount of sediment and limiting the amount of wood in debris flows, which can cause debris flows to travel farther. This is most likely for HLDP streams in areas subject to intensive treatments given more trees will be removed from these areas; however, within RCAs there will be no removal of thinned trees on HLDP streams. XNFB streams have a lower modeled probability than HLDP streams of transporting a debris flow directly to a fish-bearing stream. However, where an XNFB stream occurs upstream of an HLDP stream with a 50-foot RCA, more sediment and less wood may be delivered by debris flows into fish-bearing streams. Thus, RCAs on HLDP streams with 50-foot RCAs are expected to largely minimize, but not totally avoid, the potential for harvest-related sediment pulses from landslides and debris flows to negatively affect coho salmon habitat, particularly in intensive treatment areas.

XNFB streams throughout the permit area do not have RCAs, which increases the potential for sediment to be delivered to these streams via overland flows and, over time, deliver sediment to coho habitat. The potential for sediment delivery to coho streams is expected to be greater from XNFB streams in intensive treatments than in extensive treatments, given the differences in retention requirements (Chapter 3, Section 3.3, *Stand-Level Treatments and Operations Standards, by Allocation*). Within extensive treatments the potential for sediment delivery from XNFB streams to coho habitat will be greater where retention levels are lowest (20% of original pre-harvest stand density), given that less wood will likely have accumulated in these areas to store sediment (Table 4-9). Delivery of sediment to XNFB streams, and ultimately coho habitat, will be minimized and mitigated in both intensive and extensive treatments through 35-foot ELZs adjacent to Oregon FPA–defined stream types, which are aimed at reducing equipment in riparian areas and require corrective actions when soil disturbance exceeds specific thresholds (Chapter 3, Section 3.3.7.4, *Operational Standards for Restoration Thinning in Riparian Conservation Areas*). Estimates of the total XNFB streams that will fall under the Oregon FPA definitions are not possible until field verification.

Roughly 41% (1,941 acres) of MRW RCAs and 22% (102 acres) of CRW RCAs may be treated with restoration thinning in the Coos population area (Table 4-19). As described in Chapter 3, *Covered Activities*, restoration thinning treatments may reduce riparian stands to 40 square feet of conifer basal area per acre (Chapter 3, Section 3.4.2.2, *Thinning*), which could reduce RCA effectiveness to protect against surface erosion and debris flows. The effects on surface erosion are expected to be short term (less than 3 years) as ground litter and understory vegetation recover. The minimum retention threshold is a lower limit that will be primarily applied to dense Douglas-fir plantation stands; other thinned areas are expected to maintain higher retention levels. Additionally, due to the harvest cap on RCA restoration thinning only small portions of RCAs in the Coos population will be affected during any given year. Therefore, the risk of restoration thinning disrupting RCA function will be low and isolated to local areas within the Coos population. Over the long term, RCA functionality should be enhanced because stand characteristics will be progressing toward a mature forest structure.

RCAs and the small area of steep slopes available for intensive treatments will ensure the risk of detrimental effects from landslides to the Coos independent population, and their habitats are minimized while preserving important ecological processes provided by landslides and debris flows.

As described in Section 4.6.1.1, *Habitat Modification*, most roads (>60%) in the permit area are located on or near ridgelines; this is also true in the Coos population area (Table 4-12). Current road density in the Coos population is 4.6 miles per square mile (Table 4-11), which exceeds the density that has been associated with negative effects on coho salmon populations (Sharma and Hillborn 2001). Most roads exist near a major ridgeline (within 330 feet; 52%) or more than 200 feet from a stream and 330 feet from a major ridgeline (mid-slope roads; 31%) (Table 4-12). Mid-slope roads represent a higher risk to initiate landslides/debris flows relative to ridgeline or valley bottom roads. Approximately 15% of roads are within 35 to 200 feet of a stream and less than 2% are within 35 feet of a stream. Of the 81 miles of existing mid-slope roads, which are more likely to be more hydraulically connected to the stream network and have greater potential to initiate landslides than ridgeline (upper slope) roads, 69% are in areas subject to intensive and extensive treatments. These areas are also likely to be where most temporary roads and all permanent roads will be constructed in the Coos population area, potentially leading to increased sediment delivery potential in some subwatersheds.

However, sediment delivery risks will be minimized because the existing road network will be inventoried during the first 12 years of HCP implementation and segments identified to pose a risk to the aquatic system will be upgraded or vacated to reduce anthropogenic inputs of sediment that could affect coho (Conservation Measure 3). Similarly, all newly constructed temporary and permanent roads to facilitate research-related harvest, non-research-related harvest, or conservation management activities will be implemented consistent with Condition 11, which includes adherence to Oregon FPA regulations for all road construction, management, and use, further minimizing the potential for increased sedimentation. Existing and newly constructed roads will be managed consistent with the Oregon FPA, ensuring roads are hydrologically disconnected, road construction in RCAs will be avoided whenever possible (construction of new roads in RCAs is unlikely), and road crossings will be modified or replaced to accommodate high flows and unimpeded sediment and wood transport.

Water Temperature

The discussion surrounding water temperature effects described in Section 4.6.1.1, *Habitat Modification*, applies to the Coos population discussion in this section.

The secondary limiting factor in the Coos population is water quality, specifically water temperature (National Marine Fisheries Service 2016). Reach-scale studies clearly demonstrate that solar radiation is the primary factor affecting stream water temperatures during the summer (e.g., Leinenbach et al. 2013). Within the Coos population area, steep slopes occupy less of the area (55%) than the other two independent populations. Therefore, while topographic shading is an important component to protect stream temperatures, it plays less of a role in the Coos population than for the other two independent populations.

In the Coos independent population, 96% of fish-bearing streams are in the MRW (Table 4-18). RCAs on all fish-bearing streams throughout the Coos population area are wide enough (100 to 120 feet) to provide full shade, protecting against increases in water temperatures (Groom et al. 2011, 2018). This is also true for HLDP streams in the Lower West Fork Millicoma River and in the CRW, which will receive wider RCAs relative to HLDP streams outside of these areas (Table 4-18), which are wide enough to ensure temperature increases are minimal and limited spatially and temporally. For other stream types with narrower RCAs, small, localized increases in temperature may occur. The 50-foot RCAs required on HLDP and PNFB streams in the MRW may allow water temperature increases up to 1.4°C (Groom et al. 2018). Concern about downstream temperature increases is greatest where HLDP and PNFB streams in intensive treatments are directly tributary, or within 984 feet (300 meters) of coho habitat because harvest levels will be highest. However, this occurrence will be limited given that coho streams account for 46% of the total fish-bearing stream network in the Coos population area, meaning that fish-bearing RCAs will extend well upstream of coho-occupied streams. Therefore, any increases in water temperatures in HLDP or PNFB streams are expected to ameliorate to background levels before reaching coho streams after flowing through forested reaches in fish-bearing streams. Additionally, because XNFB streams do not have RCAs, increases in stream temperature exceeding 2°C from upland management are expected in areas subject to intensive treatments. Although warm water may propagate downstream, the effects on summer water temperature in coho habitat should be minimized given that these XNFB streams are small relative to the channel receiving their inputs, many are seasonal and dry during the summer, and their inputs will mix with cooler water delivered from XNFB streams flowing through an equal area of reserves (in full watersheds). Therefore, while harvest activities will occur in the uplands, these are unlikely to cause increases in stream temperature in streams supporting coho salmon.

Individual restoration thinning treatments in 2,043 acres (40%) of RCAs in the Coos coho population area could affect water temperatures in segments that rely more heavily on vegetation for shading (i.e., east-west-flowing or in wider valleys). Such thinning, particularly when conducted to the streambank, will reduce canopy cover, resulting in water temperature increases until crown closure occurs. Increases in average 7-day maximum stream temperature could exceed 2°C where post-thinning shade drops below 60% (McCracken et al. 2018). The rate of crown closure depends on the width of the stream and the level of thinning, but full recovery could take up to a decade (Chan et al. 2006; Yeung et al. 2017). RCA restoration thinning treatments in the Coos population area may reduce riparian stands to 40 square feet of conifer basal area per acre (Chapter 3, Section 3.4.2.2, *Thinning*). According to Groom et al. (2011), thinning within this range (mean 111 ft^2/acre - range 44 - 177 ft^2/acre) led to temperature increases more than 0.7°C. However, the minimum retention threshold is a lower limit that will be primarily applied to dense Douglas-fir plantation stands; other thinned areas are expected to maintain higher retention levels on average. Because RCA restoration thinning treatments will be limited to 1,200 acres across the entire permit area for the duration of the permit term, temperature increases from RCA restoration thinnings should be limited spatially and temporally for the Coos coho population. In the 17.3 miles of the Lower West Fork Millicoma that are listed as 303(d) for temperature (Chapter 2, Table 2-2), any changes in temperature as a result of the covered activities may be more impactful. However, given that there are limited RCA acres available for thinning along the 1.3 miles of listed streams the likelihood of persistent effects propagating downstream is low (Figure 4-8). The quantity of RCAs available for thinning located directly adjacent to the 17.3 miles of 303(d) temperature-listed streams are limited and mainly located along tributary streams, which should further limit effects from propagating along the Lower West Fork Millicoma. This, combined with the riparian thinning harvest cap, should prevent persistent long-term effects. Some short-term effects could still occur but are expected to ameliorate over time and return to or below pre-thinning conditions and are not expected result in basin-wide warming effects.

With proper wood-size-to-stream-width ratios, the placement of large wood in channels from restoration thinning treatments in RCAs as part of Conservation Measure 1 can help mitigate, to some degree, increases in stream temperature from shade loss by increasing pool depths, habitat complexity, and gravel storage. The addition of large wood from RCA restoration thinning treatments is expected to shape instream habitat conditions and promote development of deep pools and ultimately improve thermal heterogeneity. Over time, as large wood is added and riparian canopies expand, close, and mature, thermal conditions in the Coos population area are expected to stabilize and remain cooler during low-flow periods.

Mean August stream temperatures in the Coos independent watershed are expected to increase over the course of the permit term due to expected changes in climate conditions (Table 4-14) (Isaak et al. 2017). Notably, by 2080, streams with temperatures ranging from 18 to 23°C are expected to increase from 1 mile to 13 miles. This is a more pronounced increase relative to the other independent populations and is reflective of the basin's higher susceptibility to temperature increases due to the gentler topography in the Lower West Fork Millicoma River. As noted in Stenhouse et al. (2012) optimal temperature ranges for salmonids, including coho, ranged between

10 and 16°C. Temperatures exceeding 16°C generally result in numerous compensatory behavioral and physiological responses to mitigate the thermal stressors (Stenhouse et al. 2012). Temperatures above 21°C are generally accepted as detrimental and studies have documented depressed feeding rates at these conditions (Stenhouse et al. 2012; Richter and Kolmes 2005). These studies suggest that stream temperatures within portions of the Coos independent population area will be suboptimal during summer low-flow periods during the last quarter of the permit term as a result of changing climatic conditions. This would mainly affect rearing juvenile coho as adults and smolts migrate during the fall when temperatures are cooler. Juveniles would be expected to avoid areas with temperatures exceeding 16°C and may cause increased competition for smaller tributaries where temperatures are more suitable. RCAs are expected to protect streams and mitigate temperature increases resulting from changes in climate conditions.

Chemical Contaminants

As described in Section 4.6.1.1, *Habitat Modification*, under *Chemical Contaminants,* roads that cannot be disconnected, or are unsuitable for wintertime haul, will be closed to logging trucks during wet weather. Currently, roughly 45 miles of existing roads are within 200 feet of a stream in the Coos population (Table 4-12), suggesting that delivery of road-derived chemical contaminants may be high if frequently used during wet weather. However, Conservation Measure 3 will minimize these effects. Staging and storage areas associated with construction activities in the RCAs will 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

The permit area overlaps with roughly 26% of the entire Coos population area with approximately 32% of this area subject to intensive treatments and 24% subject to extensive treatments. Therefore, around 44% of the Coos population area will be in reserves and limited to restoration thinning or no treatments (Table 4-9). Plantations following intensive treatments (Table 4-10) could add enough area to forests already in the stage of high water use (10 to 50 years) that may reduce summer flows and associated available habitat for juvenile coho salmon occupying small streams (draining less than 1,000 acres). Annual allowable harvest is limited to roughly 1% of the permit area per year (Section 3.4.1, *Projected Timing and Amount of Harvest*), so it is unlikely that enough area within the Coos population would be harvested to substantially reduce summer flows and juvenile coho salmon habitat. Additionally, intensive treatments are limited to 480 acres per year, further reducing the risk of causing changes in base flow conditions. Extensive stands are less likely to cause reductions in summer base flows because of the minimum retention levels (20% of original pre-harvest stand density) and reliance on natural regeneration. Additionally, a large proportion of areas subject to extensive treatments will have a higher average retention level; stands between 65 and 150 years old subject to extensive treatments will maintain, on average, 50% retention of pre-harvest densities. Moreover, the presence of RCAs will further reduce the risk of effect related to changes in summer flows, because they will be managed to develop mature forest stands with lower water demands than rapidly growing young plantations.

Based on the low level of harvest, the amount of acres included in reserves, and the presence of expanded RCAs, there is expected to be no point during the permit term when there will be enough acres within the Coos independent population that are in the "thirsty stage" of forest growth (10 to 30 years) (Moore et al. 2004; Perry and Jones 2016) to cause a decline in water quantity such that it would become a limiting factor for the species. Effects on larger streams are less well studied, but reductions in summer flows and coho habitat are also unlikely given the low probability that enough rapidly growing plantations will be added to forests in the stage of high water use, the annual harvest caps, and the presence of RCAs.

In addition, as described above for suspended sediment, hydraulically connected roads will be corrected, including any of the 45 miles of roads within 200 feet of a stream. Roads that cannot be disconnected, or are unsuitable for wintertime haul, will be closed to logging trucks during wet weather. These measures will reduce the potential for road-related runoff and, thus, the contribution of roads to raising peak flows.

Access to Suitable Habitat

Fish passage will be provided for adult and juvenile fish at all new stream crossings or replacement projects conducted in streams historically inhabited by native migratory fish. Stream crossings that are replaced, installed, or removed under this HCP will be compliant with Condition 11, which requires that new and replacement culverts meet the most recent passage criteria (currently National Marine Fisheries Service 2022b; Oregon Department of Fish and Wildlife 2015) to ensure culverts are designed to maintain hydraulic conditions, including hydrology, volume, velocities, and slopes that pass juvenile and adult fish. Accessible habitat will increase over the permit term as a result of culvert replacement or improvement projects (Chapter 3, Section 3.6.1.6, *Drainage Structures*). Effects on the Coos population from culvert replacement projects will be the same as described in Section 4.6.1.1, *Habitat Modification*.

Effects on Individuals

Effects on individuals can occur as described in Section 4.6.1.3, *Effects on Individuals*. The likelihood of effects on individuals in the Coos population area is low, given that ODFW in-water work windows will be followed to minimize impacts on Oregon Coast coho and its habitat by having work occur during times that avoid vulnerable life stages of fish, including migration, spawning, and rearing (Condition 11). Currently, there are 11 bridges or 4 known problematic (partially or completely blocked) culverts in the Coos population. Most of the road crossing work likely to result in take of coho is expected to occur in the Coos population area given that road density is higher and more road crossings exist. Therefore, a larger portion of the individuals likely to be harmed or harassed as a result of in-water work is expected to occur within the Coos population (Table 4-15).

Additional effects are expected to individual coho because of the research monitoring described in Chapter 3, Section 3.9.3, *Research on Oregon Coast Coho Salmon and Their Habitat*. A research schedule has not yet been defined. However, sampling is expected to occur equally across the independent populations; therefore, roughly a third of the totals presented in Table 4-15 would occur in the Coos population over the course of the permit term.

4.6.2.3 Lower Umpqua

The permit area comprises 3% of the Lower Umpqua independent population's range. In the permit area, 66% (35 miles) of the fish-bearing stream miles within the Lower Umpqua population below Loon Lake are in the CRW, and the remaining 34% (19 miles) are in the MRW (Table 4-16). Above Loon Lake, all 4 miles of fish-bearing streams in the permit area are in the MRW (Table 4-17). Of the fish-bearing streams below Loon Lake, 43% (23 miles) have documented occurrence of coho (Table 4-17); 65% of which are designated as spawning habitat and 34% as rearing habitat. Fish-bearing stream miles above Loon Lake do not support coho salmon, given that Loon Lake precludes anadromy. Of the area in the Lower Umpqua population below Loon Lake, 34% is in the MRW and 66% is in the CRW. All of the area in the Lower Umpqua population above Loon Lake is in the MRW. Within the Lower Umpqua population below Loon Lake, where coho are known to occur, 1,897 acres (8.3%) will be available for intensive treatments (MRW), 2,349 acres (10%) will be available for extensive treatments (MRW), 5,214 acres (23%) will be available for restoration thinning (CRW and MRW RCAs and uplands), and 13,320 acres (58%) will not be treated (MRW and CRW). Above Loon Lake, 1,687 acres will be available for intensive treatments, 939 acres will be available for extensive treatments, 176 acres will be available for restoration thinning, and 1,107 acres will not be treated.

Approximately 78% of the total area below Loon Lake occurs on steep slopes, while approximately 38% of the total area above Loon Lake is classified as steep slopes (Table 4-8). Seven percent of the steep slopes below Loon Lake and 34% of the area of steep slopes above Loon Lake will be subject to intensive treatments, respectively.

The following analysis of impacts focuses on the areas of the Lower Umpqua population below Loon Lake, given that coho cannot access the areas upstream of the lake.

Large Wood Recruitment

The effects on large wood recruitment described in Section 4.6.1.1, *Habitat Modification*, apply to the Lower Umpqua independent population. Over the permit term, wood recruitment to fish-bearing streams in the Lower Umpqua is projected to be approximately 95% of available wood based on modeling results (*ElliottSFWood* Model) and RCA widths; this is expected to be sufficient to improve habitat complexity benefiting coho and addressing limiting factors identified by NMFS (2016).

All fish-bearing streams in the portion of the Lower Umpqua population area in the CRW will be 200 feet wide (Table 4-18), which exceeds the distance over which wood is expected to be delivered directly from channel-adjacent riparian processes (Welty et al. 2002). This should avoid any impacts on large wood loading into coho habitat directly from untreated riparian areas. Furthermore, all PNFB and HLDP streams in the CRW will receive RCAs of 200 feet (Table 4-7), increasing the potential for large wood delivery to coho habitat from fluvial processes and debris flows. Although XNFB streams will lack RCAs in the CRW, management will be limited to single-entry restoration thinning in 3,064 acres (29%) during the first 20 years of the permit term in upland forest stands 65 years old or younger (as of 2020). This, plus the lower wood delivery potential of XNFB streams, should minimize or avoid effects on large wood loading for downstream fish-bearing channels in the CRW portion (65%) of the Lower Umpqua population.

Overall wood recruitment to fish-bearing streams in the MRW may be lower than in the CRW. However, the 100- to 120-foot-wide RCAs on fish-bearing streams in the MRW are likely to avoid any upland harvest-related effects on wood recruitment. In contrast, the 50-foot-wide RCAs on HLDP and PNFB streams in the MRW should minimize but not fully avoid harvest-related effects and provide approximately 65 to 70% of the wood expected to be recruited to such streams from mature or old growth riparian forest based on Welty et al. (2002). Because RCAs are not required on XNFB streams, wood delivery to fish-bearing streams from HLDP streams that are downstream of XNFB streams would be minimal in intensive treatments but greater in locations subject to restoration thinning, extensive, or not available for treatments. Of the 2,633 upland acres available for extensive or restoration thinning treatments in the MRW, those with the minimum retention level (20% of original pre-harvest stand density) are expected to have the lowest potential wood storage in XNFB streams. Recruitment will be slightly higher in stand ages 65 to 150 years where retention will average 50% of pre-harvest densities. However, XNFB streams are not anticipated to be important sources of large wood recruitment directly in coho habitat given their limited hydraulic transport capacity and relatively low probability of delivering debris flows to fish-bearing channels. This, coupled with the relatively high level of wood recruitment expected from RCAs on other stream types, suggests that harvest-related effects on coho habitat will be minimized in the MRW. Additionally, because fish-bearing RCAs in the MRW and CRW, collectively, extend 31 miles further upstream than designated coho habitats, large wood recruitment to coho streams is unlikely to be affected by harvest activities.

Restoration thinning in 37% of the total CRW RCAs (1,412 acres) and MRW RCAs (486 acres) could occur over the course of the permit term. Restoration thinning in RCAs would not cause the conifer basal area to be reduced below 40 square feet per acre. In RCAs where restoration thinning occurs, all trees cut will be retained within the first 50 feet of any stream and will be left on the ground or tipped toward or placed in the stream. Outside 50 feet, up to 20% of the trees cut within the RCA will be tipped toward the stream to provide coho habitat; these will consist of the largest cut trees (Conservation Measure 2). All restoration thinning in RCAs will be aimed at achieving properly functioning aquatic habitat conditions. The addition of trees, depending on the size of trees placed relative to the transport capacity of the channel, will immediately improve habitat quality for coho salmon and help mitigate mid-term decreases in wood delivery from thinning. Furthermore, over the course of the permit term, RCA restoration thinning will be limited to 1,200 acres in total in the permit area with roughly 160 acres being thinned every 5 to 7 years. The harvest cap on RCA restoration thinning will ensure that effects on large wood recruitment are minimal on coho habitat within the Lower Umpqua population. The recruitment of riparian wood over the course of the permit term will help pool development and sediment retention, provide cover and spawning habitat, potentially increase floodplain connection, and promote nutrient cycling.

Sediment Delivery

As described in Section 4.6.1.1, *Habitat Modification*, delivery of sediments to the aquatic environment is likely from three sources—upland timber harvest, restoration thinning, and road construction, maintenance, and use. The following discusses effects from these sources likely to occur in the Lower Umpqua independent population area below Loon Lake.

In the Lower Umpqua population area, 78% of the total acreage is classified as steep slopes. Management in the CRW portion of the Lower Umpqua population area will be limited to restoration thinning within established plantations and conserving existing mature forest stands. Timber harvest and active management for timber production will occur in the MRW. Approximately 7% of the steep slopes in the Lower Umpqua population area may be subject to intensive treatments. The remaining 93% of steep slopes may be subject to extensive treatments, restoration thinning, or no treatment. While harvest will occur in the Lower Umpqua, it is unlikely to affect large contiguous swaths of the landscape simultaneously and will be spread out over time. Additionally, all treatments will avoid slopes with the highest probability of delivering sediment and debris to fish-bearing streams, further reducing the risk of forest-management-induced landslides. Similarly, ground-based equipment use will be limited on slopes greater than 40% (Condition 10), and ground disturbance will be minimized in these areas during log felling or yarding operations (Chapter 3, Section 3.3.7.4, *Operational Standards for Restoration Thinning in RCAs*).

Despite steep slopes comprising 78% of the area, the majority (83%) of this area will be treated only with restoration thinning or not treated and, thus, timber harvest is unlikely to increase rates of shallow, rapid landslides that could negatively affect coho habitat. The likelihood of harvest contributing to landslide initiation on the steep slopes in extensive treatments (10% of steep slopes) will be greatest in areas with the lowest tree-retention rates (20% of original pre-harvest stand density) but should be relatively low across stands aged between 65 and 150 years old due to the targeted average tree-retention rate of 50% of original pre-harvest stand density. The greatest risk of harvest-induced increases in landslide rates will be on the steep slopes in intensive treatment areas (8%). However, given the small area to be subject to intensive treatments the risk is unlikely to translate to a broad spatial scale. Furthermore, intensive treatments are capped at 480 acres per year for the entire permit area (<1%). Thus, site-level landslide risks from intensive timber harvest are dispersed, which minimizes the overall risk to coho habitat (Chapter 3, Figure 3-1). Steep-slope modeling will be used to further evaluate the risk of detrimental sediment delivery and to modify harvest plans and treatment allocations to avoid unstable areas (Condition 10).

Additionally, the inclusion of RCAs on fish-bearing, PNFB, and HLDP streams are wide enough (ranging from 50 to 200 feet) (Tables 4-7 and 4-18) when untreated to stabilize streambanks and to filter surface runoff from upslope timber management activities before reaching the aquatic environment. RCAs also minimize the risk of landslides or debris flow–derived sediments from reaching coho habitats (Section 4.6.1.1, *Habitat Modification*, subsection *Sediment Delivery*).

For shallow, rapid landslides that are initiated, in association with harvest or otherwise, RCAs on HLDP streams should provide benefits to and reduce negative impacts on coho habitat. In the CRW, 200-foot-wide RCAs on HLDP streams will be wide enough to contain all debris flow scour from side slopes and to provide a full complement of large wood that can facilitate creation of high-quality coho habitat over time. Narrower, 50-foot RCAs on HLDP streams in the MRW will allow some scour beyond the RCA, potentially increasing the amount of coarse and fine sediments and decreasing the amount of wood in debris flows. This is most likely for HLDP streams in areas subject to intensive treatments and can cause debris flows to travel farther and reduce habitat creation potential. The addition of RCAs along HLDP streams will limit the distance that debris flows, or landslides can travel and will ensure that impacts on Lower Umpqua coho populations are minimized while preserving important ecological functionalities. XNFB streams have a lower modeled probability than HLDP streams of transporting a debris flow directly to a fish-bearing stream. However, where an XNFB stream occurs upstream of an HLDP stream, more sediment and less wood may be delivered by debris flows into fish-bearing streams because XNFB streams do not have RCAs. Thus, RCAs on HLDP streams are expected to largely minimize, but not totally avoid, the potential for harvest-related sediment pulses from landslides and debris flows to negatively affect coho salmon habitat, particularly in intensive treatments.

XNFB streams do not require RCAs. Delivery of fine sediment to coho streams from XNFB streams in the CRW is unlikely given that treatments are limited to restoration thinning. In the MRW, the greatest potential for sediment delivery from overland flow to coho habitat is anticipated from XNFB streams in areas subject to intensive treatments. The potential for sediment delivery from XNFB streams in extensive treatments to downstream coho habitats will be greatest where upland retention levels are lowest (20% of original pre-harvest stand density), given that less wood will likely have accumulated in these channels to store sediment. However, delivery of fine sediment to all XNFB streams, and ultimately to coho habitat, will be minimized in all treatments through 35-foot ELZs adjacent to Oregon FPA–defined stream types. Thus, fine sediment delivery to coho habitat from upland harvest will be minimized through broad treatment allocations, RCAs, and ELZs.

Restoration thinning treatments in the Lower Umpqua MRW RCAs (467 acres) and CRW RCAs (1,419 acres) may reduce overall stand conifer basal area to 40 square feet per acre, which could reduce RCA effectiveness to protect against surface erosion and debris flows. When untreated, the RCAs on fish-bearing, PNFB, and HLDP streams maintained at 50 to 100 feet in the MRW and 200 feet in the CRW (Tables 4-7 and 4-18) will be wide enough to filter sediment from upslope harvest. The harvest cap on RCA restoration thinning will ensure that only small portions of RCAs within the Lower Umpqua population will be thinned during any given year. Additionally, the 40 square feet of conifer basal area is a lower limit that will be primarily applied to dense Douglas-fir plantation stands; other thinned areas are expected to maintain higher retention levels. The risk of surface erosion and landslides will be further reduced because ground-based equipment in RCAs will be restricted, where practicable, to slopes less than 40%. Hand-felling methods will be used when possible on slopes greater than 40% (Condition 10) and minimized inside a 35-foot-wide ELZ starting at the edge of the stream channel. Corrective actions are required in the ELZ if soil disturbance exceeds established thresholds. Taken together, the constraints on where, when, and how restoration thinning in RCAs can occur will minimize delivery of fine sediment to coho salmon habitat.

The risk of restoration thinning to increase sediment delivery to coho habitat by disrupting RCA functions or altering characteristics of landslides and debris flows will be isolated to local areas within the Lower Umpqua population over the permit term. Furthermore, disruption of RCA function is likely only to occur over the short term (a few years). Over the long term, effects on sediment delivery processes will generally be minimized because riparian stand characteristics are expected to progress toward a mature forest structure.

Given the limited acreage of steep slopes subject to intensive treatments and the RCAs applied to fish-bearing, PNFB, and HLDP streams, the risk of adverse impacts from landslides and upland forest management activities to the aquatic environment within the Lower Umpqua watershed is low. Moreover, the RCA widths described in Chapter 3, Table 3-2 are expected to result in numerous protections to the aquatic environment from landslides, as well as preserving the beneficial function of landslides (e.g., sediment and wood delivery). Moreover, the reserve system within the watershed essentially expands RCAs around all coho streams providing further protection from potential landslides while also preserving their ecological function.

The other major source of aquatic sedimentation is forest roads. Current road density in the entire Lower Umpqua area (above and below Loon Lake) is 3.1 miles of road per square mile (Table 4-11). Below Loon Lake, most roads (60%) occur along major ridgelines (within 330 feet)(Table 4-12). Twenty-seven percent (37.9 miles) of the road network exists on mid-slopes, meaning more than 200 feet from a stream and more than 330 feet from a major ridgeline. Mid-slope roads represent a higher risk to initiate landslides/debris flows relative to ridgeline or valley bottom roads. Approximately 4 miles of road are within 35 to 200 feet of a stream and less than 1 mile occurs within 35 feet of a stream. Over half (58%) of all roads in the Lower Umpqua population area below Loon Lake are in the CRW (Table 4-12), where construction of new permanent roads is unlikely. Of the 44.2 miles of existing MRW roads in the Lower Umpqua population area below Loon Lake, 46% are ridgeline (upper slope) and 35% are mid-slope. Mid-slope roads typically have more connections to the stream network and a greater potential to initiate landslides than ridgeline roads. The road network, in its current condition, may be contributing sediments to the aquatic environment. Only 13% of existing roads in the Lower Umpqua (below Loon Lake) are within 200 feet of streams; however, these roads have the greatest sediment delivery potential. To minimize the potential for increased sedimentation in coho habitat, all new roads will be at least 35 feet away from streams except at crossings. This, in combination with RCAs, will provide a forested buffer that will trap sediment before it enters the aquatic environment and stabilize streambanks, limiting the potential for delivery of fine sediment into the aquatic environment.

Additionally, road construction will be consistent with Condition 11, minimizing the potential for increased sedimentation. The existing road network will be inventoried during the first 12 years of HCP implementation and segments of the road network that pose a risk to the aquatic system will be prioritized and upgraded or vacated to reduce road densities and anthropogenic inputs of sediment that could affect coho (Conservation Measure 3). It is expected that the overall road network in the CRW will be reduced, and roads that remain will be hydraulically disconnected. All newly constructed temporary and permanent roads will be consistent with Condition 11, which includes adherence to Oregon FPA regulations for all road construction, management, and use, further minimizing the potential for increased sedimentation. Existing and newly constructed roads will be managed to avoid or minimize sediment inputs consistent with provisions of the Oregon FPA that require roads to be hydrologically disconnected, road construction in RCAs to be avoided, and road crossings to be modified or replaced to accommodate high flows and unimpeded sediment and wood transport. New permanent roads will be limited to 40 miles over the permit area during the permit term. These permanent roads and many of the temporary roads are likely to be concentrated in the MRW to support intensive and extensive treatments. In general, sediment delivery to coho habitat from roads should be minimized for the Lower Umpqua independent population given that most permit area roads are located on ridgelines and new road construction will be limited and occur at least 35 feet away from streams.

Water Temperature

The discussion surrounding water temperature effects described in Section 4.6.1.1, *Habitat Modification*, applies to the Lower Umpqua population discussion in this section.

The secondary limiting factor in the Lower Umpqua is water quality (National Marine Fisheries Service 2016). As described in Section 4.6.1.1, *Habitat Modification*, the permit area has steep topography that shades much of the stream network. However, riparian vegetation may play a stronger role in regulating stream temperatures in east-west-draining segments. Steep slopes comprise roughly 78% of the area below Loon Lake, which enhances the potential for topographic shading and helps protect habitat for the Lower Umpqua population against detrimental increases in summer stream temperature associated with forest management. Additionally, 66% of fish-bearing streams in the Lower Umpqua population area are in the CRW, which contributes to the expectation that long-term increases in stream temperature in coho habitats from management will be avoided or minimized. Treatments in the CRW are limited to restoration thinning of stands 65 years old or younger (as of 2020), which will affect approximately 3,064 acres of upland forests and 1,419 acres of RCAs. RCAs on all stream types in the CRW will be 200 feet and, thus, wide enough to avoid temperature increases more than 0.3°C from any upland restoration thinning (Groom et al. 2011, 2018). The effects of restoration thinning in and outside of RCAs on stream temperatures would be a function of the amount of shade lost from the restoration thinning treatment. In these areas, the time until the canopy closes would depend on the level of thinning and the width of the stream. Upland restoration thinning treatments in the CRW may reduce shade on XNFB streams, which do not have RCAs. However, due to the relatively small size and extent of thinning, any single upland thinning is unlikely to increase water temperatures in coho salmon habitat. Therefore, effects of RCA thinning on stream temperatures are expected to be localized and temporary.

Thirty-four percent of the Lower Umpqua population is in the MRW, where 100- to 120-foot untreated RCAs on fish-bearing streams are expected to avoid significant temperature increases in areas subject to extensive and intensive treatments. The 50-foot RCAs required on HLDP and PNFB streams in the MRW may allow water temperature increases up to 1.4°C. Concern about downstream temperature increases is greatest where HLDP and PNFB streams in intensive treatments are directly tributary to and occur within 984 feet (300 meters) of coho habitat (Davis et al. 2015). However, because coho streams include an additional 31 miles of fish-bearing RCAs upstream, any temperature increases are unlikely to propagate to coho habitat downstream because warm water will pass through fully intact RCAs before reaching coho streams. Restoration thinning is anticipated for 467 acres in MRW RCAs. Such thinning, particularly when conducted in east-west-draining reaches, can reduce canopy cover, resulting in water temperature increases until crown closure occurs. Because of the RCA restoration thinning treatments harvest caps, temperature increases from MRW RCA thinnings should be minimized for the Lower Umpqua coho population.

Stream reaches where summer water temperatures are elevated prior to RCA restoration thinning may be more at risk of more significant effects compared to cooler reaches, such as 303(d) stream reaches. While there are no 303(d) streams listed for temperature in the Umpqua portion of the permit area, the Umpqua basin collectively has 180 individual temperature listings that lead to the development of TMDL by the Oregon Department of Environmental Quality in 2006. The TMDL limits cumulative anthropogenic temperature increases to 0.3°C above baseline conditions. This means that water temperatures cannot increase more than 0.3°C in fish-bearing or non-fish-bearing streams contributing to fish-bearing streams as a result of anthropogenic actions. Adherence to the basin TMDL would ensure that fish-bearing and non-fish-bearing streams that contribute to fish-bearing streams do not experience water temperature increases greater than 0.3°C over the long-term. Some short-term increase are possible in the areas where thinning could occur (Figure 4-8). However, per OAR 340-041-0004 (5)(a) exemptions are allowed for activities, such as RCA thinning, that may cause temporary water quality degradation but also provide environmental benefits, meaning that while temperature exceedances may occur, they are permitted under this specific exemption.

Although XNFB streams do not have RCAs, topographic shading will help moderate stream temperatures (Tables 4-7 and 4-18). Upland restoration thinning to the minimum retention (20% of original pre-harvest stand density) will reduce shade on XNFB streams. However, any single upland thinning is unlikely to result in increases to water temperatures in coho salmon habitat. Increases in temperature exceeding 2°C from upland management are expected for XNFB streams in areas subject to intensive treatments. Although warm water from these XNFB streams may flow downstream, effects on water temperature in coho habitat should be minimized, given that XNFB streams are small relative to most channels receiving their inputs, many are seasonal and dry during the summer, and their inputs will mix with cooler water delivered from streams with RCAs or XNFB streams in areas not subject to harvest treatments. Moreover, any warm water from XNFB streams will flow through non-coho fish-bearing streams before reaching coho habitat, which will ensure temperatures attenuate before reaching coho waters. Therefore, while forest management activities will occur in the uplands, stream temperature increases in coho salmon habitat will be largely avoided.

The placement of large wood in channels from restoration thinning treatments in RCAs as part of Conservation Measure 1 can help mitigate any increases in stream temperature from shade loss by increasing pool depths, habitat complexity, and gravel storage. The addition of large wood from restoration thinning treatments are expected to shape instream habitat conditions and promote development of deep pools and ultimately improve thermal heterogeneity. Over time as large wood is added and riparian canopies expand, close, and mature, thermal conditions within the Lower Umpqua are expected to stabilize and remain cooler during low-flow periods.

Chemical Contaminants

As described in Section 4.6.1.1, *Habitat Modification*, under *Chemical Contaminants,* roads that cannot be disconnected, or are unsuitable for wintertime haul, will be closed to logging trucks during wet weather. Currently, roughly 14 miles of existing roads are within 200 feet of a stream suggesting that delivery of road-derived chemical contaminants is low. Staging and storage areas associated with construction activities in the RCAs will 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

The permit area overlaps roughly 20% of the Lower Umpqua Coho population area with roughly 11% of this area subject to intensive and extensive treatments; the other 89% will be in reserve allocations and limited to restoration thinning or no treatments (Table 4-9). Plantations in the 395 acres slated for intensive treatment would not add enough area to forests in the stage of high water use to reduce summer flows in small streams. Extensive stands are even less likely to cause reductions in summer base flows in the Lower Umpqua coho population area because of minimum retention levels (20% of original pre-harvest stand density) and reliance on natural regeneration. Additionally, a large proportion of areas subject to extensive treatments would have a higher average retention level (Table 4-9); stands between 65 and 150 years old subject to extensive treatments will maintain, on average, 50% retention of pre-harvest densities. Finally, only a small portion of the average allowable annual harvest across the permit area (1% of the permit area per year) (Chapter 3, Section 3.4.1, *Projected Timing and Amount of Harvest*) will come from the Lower Umpqua coho population area and is, therefore, unlikely to amount to reduce summer flows. Moreover, the presence of RCAs will further reduce the risk of effects related to changes in summer flows because they will be managed to develop mature forest stands with lower water demands than rapidly growing young plantations.

Based on the low level of harvest, there is expected to be no point during the permit term when there will be enough acres within the Lower Umpqua independent coho population area that are in the "thirsty stage" of forest growth (10–30 years) (Moore et al. 2004; Perry and Jones 2016) to cause a decline in water quantity, such that it would become a limiting factor for the species.

In addition, as described for sediment delivery, the road network is expected to decrease in total miles, and hydraulic connections will be corrected. Roads that cannot be disconnected, or are unsuitable for wintertime haul, will be closed to logging trucks during wet weather, including the 14 miles of roads within 200 feet of a stream, which are most likely to contribute to changes in instream flows if hydraulically connected. These measures will reduce the potential for road-related runoff and, thus, the contribution of roads to increasing peak stream flows.

Access to Suitable Habitat

Fish passage will be provided for adult and juvenile fish at all stream-crossing installation or replacement projects conducted in streams historically inhabited by native migratory fish. Stream crossings that are replaced, installed, or removed under this HCP will be compliant with Condition

11, which requires that new and replacement culverts meet the most recent passage criteria (currently National Marine Fisheries Service 2022b; Oregon Department of Fish and Wildlife 2015) to ensure culverts are designed to maintain hydraulic conditions, including hydrology, water volume, velocities, and slopes that pass juvenile and adult fish. Accessible habitat will increase over the permit term as a result of culvert replacement or improvement projects (Chapter 3, Section 3.6.1.6, *Drainage Structures*). Effects on the Lower Umpqua population from culvert replacement projects will be the same as described in Section 4.6.1.1, *Habitat Modification*.

Effects on Individuals

Effects on individuals can occur as described in Section 4.6.1.3, *Effects on Individuals*. The likelihood of effects on individuals in the Lower Umpqua is low, given that ODFW work windows will be followed to minimize impacts on Oregon Coast coho and its habitat by having work occur during times that avoid vulnerable life stages of fish, including migration, spawning, and rearing (Condition 11). Currently, there are three bridges and five known problematic (partially or completely blocked) culverts in the Lower Umpqua population. A portion of the 50 allotted culverts and bridges to be replaced, repaired, or constructed could occur in the Lower Umpqua population area. The total number is expected to be relatively low given that a large portion of the Lower Umpqua population area is in the CRW (Table 4-15).

Additional effects are expected on individual coho in the Lower Umpqua because of the research monitoring described in Chapter 3, Section 3.9.3, *Research on Oregon Coast Coho Salmon and Their Habitat*. A research schedule has not yet been defined. However, sampling is expected to occur equally across the independent populations and therefore roughly a third of the totals presented in Table 4-15 would occur in the Lower Umpqua population over the course of the permit term.

4.6.3 Effects on Critical Habitat

A small portion (8%) of the designated critical habitat for Oregon Coast coho is in the permit area (Table 4-18). While the covered activities could have limited spatial and temporal effects on critical habitat, the RCAs and conservation measures identified in Chapter 5, *Conservation Strategy*, would protect the physical and biological features that support the life history requirements of Oregon Coast coho in the permit area and are unlikely to destroy or adversely modify critical habitat. The discussions above, which are specific to effects on habitat features, are also relevant to effects on critical habitat but are not repeated here.

Under the HCP, all stream miles designated as critical habitat in the permit area will be protected by RCAs. Buffers on fish-bearing streams designated as critical habitat will range from 100 to 200 feet in portions of the MRW to 200 feet in the CRW and reserves. The RCAs will promote the development of functional riparian forests that will provide shade, contribute to instream habitat, and improve water quality and quantity. Of the 85 miles of critical habitat in the permit area, roughly 30% of RCAs are available for restoration thinning treatments (Table 4-20). 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. If new roads are constructed in the RCA, they will maintain a 35-foot minimum buffer from the edge of the stream to minimize sedimentation (Condition 11). The commitment to reduce the forest road network (Conservation Measure 3), with a focus on segments that are degrading aquatic habitat, will limit potential sediment inputs to critical habitat. Restoration thinning will set riparian forests on a trajectory that will benefit Oregon Coast coho and other aquatic organisms in the permit area.

Table 4-20. Miles of Critical Habitat by Independent Population in the Permit Area

Independent Coho Population	Total Miles of Critical Habitat within OCC ESU	Total Miles of Critical Habitat in the Permit Area		
		Total (%)	No Treatments	RCA Restoration Thinning
Coos	453.2	55.3 (12.2%)	39.6	15.7
Lower Umpqua	532.6	13.5 (2.5%)	7.3	6.1
Tenmile	78.7	16.1 (20.5%)	12.1	4.0
Total	1,064.5	84.9 (7.9%)	59.0	25.9

OCC = Oregon Coast coho; ESU = evolutionary significant unit; RCA = riparian conservation area

Chapter 5
Conservation Strategy

This chapter describes the conservation strategy the Oregon Department of State Lands (DSL, the Permittee) will use to minimize and mitigate impacts of take on listed species as required under Section 10(a)(2)(A) of the federal Endangered Species Act (ESA) and its implementing regulations. Chapter 4, *Effects Analysis*, identifies certain take pathways and impacts that are predicted to occur by carrying out the proposed covered activities (Chapter 3, *Covered Activities*), the net effects following consideration of the avoidance and minimization measures integrated into the covered activities, and the conservation strategy described in this chapter. Chapter 6, *Monitoring and Adaptive Management*, specifies the monitoring and adaptive management program that will be implemented to ensure the intended benefits of the conservation strategy are realized.

This chapter contains the following sections.

- Section 5.1, *Conservation Approach and Methods*, describes the overall conservation approach and the basis for developing proposed conservation measures.
- Section 5.2, *Biological Goals and Objectives*, describes the long-term biological goals and measurable biological objectives for each covered species.
- Section 5.3, *Avoidance and Minimization Measures Integrated into the Covered Activities*, describes the specific components of the covered activities (Chapter 3, *Covered Activities*) that the Permittee will use, in part, to achieve biological goals and objectives.
- Section 5.4, *Conservation Measures*, includes specific conservation measures that will be implemented—in addition to the avoidance and minimization measures integrated into the covered activities—to further avoid, minimize, and mitigate effects from the covered activities and achieve biological goals and objectives.
- Section 5.5, *Conditions on Covered Activities*, includes additional avoidance and minimization measures in the form of specific conditions under which covered activities will be implemented to further avoid, minimize, or mitigate effects from the covered activities on covered species.
- Section 5.6, *Beneficial and Net Effects*, includes a summary of beneficial and net effects on each of the three covered species (northern spotted owl [*Strix occidentalis*], marbled murrelet [*Brachyramphus marmoratus*], and Oregon Coast coho [*Oncorhynchus kisutch*]), considering implementation of the covered activities (as described in Chapter 3) and the conservation strategy described in this chapter.

The following terms are central to the organization of this chapter and the conservation strategy itself.

- **Biological goals.** Biological goals are broad guiding principles based on the conservation needs of the covered species. A biological goal is included for each covered species.
- **Biological objectives.** Biological objectives are 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. There are often multiple biological objectives needed to fully achieve a biological goal.

- **Conservation measures.** Conservation measures are actions that the Permittee will implement to offset the effects of the covered activities on covered species that support the biological goals and objectives of the habitat conservation plan (HCP).
- **Conditions on covered activities.** Conditions on covered activities are rules or standards that will be used when covered activities are implemented. Conditions are included on covered activities to further minimize and sometimes avoid potential effects on covered species. The conditions generally speak to how, when, or where an activity can occur, and are considered a subset of the conservation measures described in this chapter that are intended to achieve the biological goals and objectives.

5.1 Conservation Approach and Methods

The effects analysis presented in Chapter 4, *Effects Analysis*, summarizes the impacts anticipated as a result of habitat modification or effects on covered species from the covered activities presented in Chapter 3, *Covered Activities*. The habitat protections, including the establishment of the conservation research watersheds (CRW) and management research watersheds (MRW) Reserve allocations, and enhancements integrated into the covered activities described in Chapter 3, *Covered Activities.* are considered in the effects analysis. These research forest design–based habitat protections and enhancements limit effects on the three covered species. They are foundational components of the research forest's design rather than commitments negotiated as part of the HCP to offset or mitigate take under the ESA. The conservation strategy in this chapter identifies specific conservation measures and conditions on covered activities that stand as HCP commitments to avoid, minimize, or mitigate any residual impacts of take resulting from covered activities and ensure that those impacts are offset and mitigated to the maximum extent practicable.

5.2 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 *Habitat Conservation Planning and Incidental Take Permit Processing Handbook* (HCP Handbook) (U.S. Fish and Wildlife Service and National Marine Fisheries Service 2016).[1] Biological goals broadly describe the desired future conditions of an HCP in succinct statements. Each goal steps down to one or more objectives that define how to achieve these conditions in measurable terms; each objective clearly states a desired result that collectively will achieve the biological goals and that can be monitored over the permit term.

The biological goals and objectives were developed within the context of covered activities described in Chapter 3, *Covered Activities*, most of which reflect the Elliott State Research Forest (ESRF) goals of exploring management strategies to ensure the conservation of aquatic and terrestrial ecosystems as an integrated system. For clarity, the conservation strategy's biological goals and objectives for each species reflect an outcome based on the integration of the components of the covered activities and habitat protections described in Chapter 3, *Covered Activities,* and the

[1] The requirement for biological goals and objectives in HCPs was first published by USFWS and NMFS in 2001 in what was then called the "5-Point Policy" (65 *Federal Register* 35242).

HCP-negotiated conservation measures and condition commitments described in this chapter (i.e., they are additive).

Biological goals and objectives are provided in the following sections for each species along with an accompanying rationale for each biological objective. The biological goals and objectives are given unique numeric codes to enable easier tracking during implementation.

5.2.1 Northern Spotted Owl

The intent of the northern spotted owl conservation strategy is to (1) retain existing nesting, roosting, and foraging habitat in the permit area; (2) increase the amount of nesting, roosting, and foraging habitat in the permit area; and (3) maintain dispersal habitat in the permit area. This strategy is summarized in the biological goals and objectives.

5.2.1.1 Goal 1: Retain and enhance existing northern spotted owl nesting, roosting, foraging, and dispersal habitat and increase the availability of higher-quality habitat types in the permit area.

Objective 1.1: Retain and enhance 27,000 acres of nesting/roosting habitat, and 11,000 acres of foraging habitat in the permit area.

Rationale

Northern spotted owl was listed in the ESA in 1990 (55 *Federal Register* [FR] 26114) because of widespread habitat loss across the range of the species. Past and current habitat loss and increasing barred owl (*Strix varia*) populations continue to threaten the spotted owl, and populations have continued to decline (Davis et al. 2016; Lesmeister et al. 2018). The permit area and surrounding areas continue to be a stronghold for northern spotted owl on the southern Oregon Coast (Kingfisher 2016), although numbers are likely to have declined since surveys were last completed in 2016. Because the northern spotted owl population along the Oregon Coast continues to decline (U.S. Fish and Wildlife Service 2011; Dugger et al. 2016; Dunk et al. 2019; Franklin et al. 2021), any unmitigated loss of habitat—particularly habitat currently occupied by northern spotted owls—would be significant.

Protecting existing northern spotted owl habitat in the permit area, when combined with barred owl management, will help sustain survival and reproduction of northern spotted owls in currently occupied habitat, support and potentially improve persistent low densities in the central Coast Range, and retain sufficient unoccupied suitable habitat to accommodate potential future recolonization. Additionally, retaining 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 (U.S. Fish and Wildlife Service 2011; Forsman et al. 2011).

There are currently approximately 28,500 acres of habitat that are modeled as highly suitable or suitable nesting/roosting habitat by Davis et al. (2016) that are located in areas available for only restoration thinning or no treatments—and these areas will be retained as highly suitable or suitable nesting/roosting habitat throughout the permit term (Chapter 4, Table 4-2). These habitats are located in stands generally more than 65 years old as of 2020 and will not be treated with thinning for habitat improvement, which is limited to plantations 65 years old or younger as of 2020. The objective was set slighlty below the total available acres to account for uncertainty in both the total amount of modeled habitat and its response to thinning treatments. An additional 11,000 acres in these areas modeled as marginal habitat, which is considered suitable for foraging only (less than 65 years old as of 2020), will also be retained throughout the permit term as foraging habitat initially, with some of the older stands (30 to 60 years old) growing into suitable nesting/roosting habitat. Collectively, there is a commitment to retain and enhance approximately 38,000 acres of nesting, roosting, and foraging habitat in reserve allocations as described in Chapter 3, *Covered Activities*. In addition, Section 5.5, *Conditions on Covered Activities*, outlines additional conditions on covered activities intended to achieve Objective 1.1 (particularly Conditions 2, 3, and 4), including commitments to retain highly suitable or suitable nesting/roosting habitat habitat around the 22 historic northern spotted owl nests centered in the permit area.

Objective 1.2: Increase nesting, roosting, and foraging habitat in the permit area by 14,000 acres by the end of the permit term.

Rationale

The 2011 *Revised Recovery Plan for the Northern Spotted Owl* (U.S. Fish and Wildlife Service 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 naturally over time) 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). These practices will be used in the extensive treatment areas.

In addition to conserving and enhancing 38,000 acres of known nesting, roosting, and foraging habitat (Objective 1.1), the Permittee will increase the amount of nesting, roosting, and foraging habitat that is available by 14,000 acres over the permit term.

The areas that will be managed to enhance the development and maintenance of northern spotted owl habitat will primarily be in the CRW and MRW Reserves, though areas managed under extensive treatments with higher relative retention rates (i.e., 50 to 80%) are also expected to retain some habitat value for northern spotted owls where trees grow older. Management that occurs in the CRW or MRW Reserves in the first 30 years of the permit term will target stands that are overstocked and, thus, currently providing lower-quality habitat. Those stands, once managed, will be on a trajectory to increase in habitat value over time, so any short-term effects on habitat quality will result in long-term habitat improvements. Growth of large trees and the development of snags, multilayered canopies, and other key elements of forest structure take decades, particularly in stands that have little residual legacy structure and lack large trees (Lindenmayer and Franklin 2002; Dodson et al. 2012), which is the case over much of the permit area. This objective is intended to provide benefits during the middle to later periods of the permit term.

Improving the quantity and 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 the species faces. This net increase in owl habitat is intended to result in a wider and less fragmented distribution of the species' habitat across the permit area. In addition, barred owl management in these areas will improve the quality of the habitat through reduced competition.

The rate and extent of new habitat development will depend on site-specific conditions and treatments. Stands that are currently older have the most likelihood of developing from nonhabitat into habitat. Stands with any residual large trees would be particularly likely to develop into habitat.

Approximately 9,400 acres in the CRW (including CRW riparian conservation areas [RCAs]) are between 30 and 60 years old (as of 2020), and these stands are most likely to become nesting and roosting habitat within the permit term either naturally or through treatments intended to accelerate the development of old forest structure. Another approximately 3,900 acres of habitat in the same age range will develop within MRW Reserves and MRW RCAs, either naturally or through treatments intended to accelerate the development of old forest structure and associated habitat values for northern spotted owl (Table 5-1). These approximately 13,300 acres of stands that are between 30 and 60 years old, most of which are modeled as dispersal or foraging habitat (Chapter 4, Table 4-2), support the numerical commitment in this objective. Additional habitat will be retained within the variable density retention stands in extensive treatments and additional unsuitable habitat in reserve allocations could mature into foraging or suitable habitat to meet the overall 14,000-acre objective. Depending on initial stand conditions and treatment access, some of these areas will also provide foraging and dispersal habitat in both the near term and long term.

Table 5-1. Northern Spotted Owl Habitat Recruitment Pool

Acres of 30-to-60 Year-Old-Stands (as of 2020)	
CRW Reserve	6,829
CRW RCA	2,625
CRW total	9,454
MRW Reserve	1,371
MRW RCA	2,506
MRW total	3,877
Grand Total	13,330

Objective 1.3: Maintain at least 40% of the MRW as dispersal habitat at all times.

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 northern spotted owls 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). This is important within the permit area, but also in the region surrounding the permit area.

The U.S. Fish and Wildlife Service (USFWS) defines dispersal habitat as follows (77 FR 71875–72068).

> 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 [diameter at breast height] and have a minimum 40 percent canopy cover.

The majority of the CRW and MRW Reserves is expected to develop into nesting, roosting, and foraging habitat over the permit term. These areas will continue to support dispersing northern spotted owls. The Permittee's commitment to retaining at least 40% of the MRW as dispersal habitat is an acknowledgment that habitat quality will be reduced in areas that are intensively harvested, and in some areas that are extensively harvested. On the whole, however, the MRW will provide some nesting, roosting, and foraging habitat and will provide at least this base level of dispersal habitat. This objective will ensure that that a large portion of the permit area functions as northern spotted owl habitat at some level, at all times.

5.2.2 Marbled Murrelet

The intent of the marbled murrelet conservation strategy is to increase the amount of nesting habitat and, by association, the number of marbled murrelets in the permit area. This strategy is summarized in the following biological goals and objectives.

5.2.2.1 Goal 2: Increase occupied and potential marbled murrelet nesting habitat in the permit area.

Objective 2.1: Retain and enhance 17,000 acres of occupied marbled murrelet habitat in the permit area.

Rationale

Conserving occupied habitat is the most effective method to avoid further declines in marbled murrelet populations (U.S. Fish and Wildlife Service 1997). Past habitat removal in the permit area has limited marbled murrelet nesting habitat and distribution. Conserving and maintaining marbled murrelet nesting habitat in the permit area will help support or increase populations. Some enhancement of potential marbled murrelet habitat in extensive treatments may improve habitat conditions over the long term, and more large-diameter trees are expected on the landscape in response to management practices.

This objective will be achieved primarily through the avoidance and minimization measures already incorporated into and resulting from the covered activities. There are currently 18,855 acres of designated occupied habitat in areas available for only restoration thinning or no treatments and this objective ensures that 17,000 acres of that habitat will be retained and enhanced. These acres of designated occupied habitat will be retained for the duration of the permit term in those areas, as described in the covered activities (however, see Conditions 7 and 8 in Section 5.5, *Conditions on Covered Activities*).

Objective 2.2: Increase suitable marbled murrelet nesting habitat in the permit area by 13,000 acres by the end of the permit term.

Rationale

The intention of this objective is to expand marbled murrelet habitat over time through silvicultural actions that accelerate development of late-seral forest characteristics and, in particular, nest platforms and associated cover (Plissner et al. 2015). This objective will be achieved primarily through the covered activities, such as designation of the CRW and MRW Reserves and operational standards for treatments in these areas, as well as other areas where treatments are limited to restoration thinnings or extensive treatments, including standards intended to increase old forest structure and associated habitat values. Within areas available for only restoration thinning or no treatments, there are approximately 14,000 acres that are not designated occupied or modeled potential habitat for marbled murrelets. It is anticipated that most of those acres will grow into habitat suitable for occupancy by the end of the permit term either naturally or through treatments intended to accelerate the development of old forest structure. Although site-specific conditions and thinning treatments, disturbance, or other factors may result in some of these stands not achieving habitat objectives. As described in Chapter 6, *Monitoring and Adaptive Management*, marbled murrelet monitoring will be prioritized in stands that are developing into habitat for marbled murrelet, either due to active or passive management.

Stand management in the CRW and MRW Reserves will be strategically focused in locations that currently do not support habitat for marbled murrelet (i.e., generally those stands 65 years old or younger as of 2020). Stand management will be aimed at developing nesting habitat faster by reducing stocking levels and removing competition, which will encourage growth of larger trees with structure preferred by marbled murrelets. The general method used will be stand thinning with potential additional thinning around selected individual trees to increase height and stimulate tree branch growth to increase nesting platforms (Raphael et al. 2018). Restoration thinning treatments will also occur in portions of the RCAs and would be similar to those described for reserve treatments, as the same operations standards will apply.

Direct habitat removal will not occur in designated occupied or modeled potential habitat that is verified to be occupied following surveys described under Conditions 7 and 8 in Section 5.5, *Conditions on Covered Activities*.

The anticipated increase in suitable nesting habitat in the permit area will likely allow colonization of new habitat and support expansion of the nesting population in the permit term. It will also improve the value of existing habitat by reducing edge effects through the maturation of larger interior stands of suitable nesting habitat.

Objective 2.3: Maintain an area-weighted mean marbled murrelet Habitat Suitability Index (HSI) value of 0.25 across the permit area (net of all edge effects), and limit reduction of marbled murrelet habitat attributable to harvest-related edge effects to 7.2% of total permit area HSI-weighted acres throughout the permit term.

Rationale

There are approximately 37,000 acres of existing forest over 100 years old that are subject to no treatment in CRW, MRW, and RCA Reserves and inoperable areas of the Flexible allocation in the permit area (Table 5-2). By the end of the permit term, this habitat will be grown forward and joined by another approximately 15,000 acres of forest ingrowth as stands subject to restoration thinning grow older (expecting approximately 49,000 acres of forest over 100 years old in reserve by the end of the permit term) (Table 5-2).

However, current and future edge effects are expected to degrade the quality of some of this habitat during the permit term when adjacent to harvest treatments and hard edges. As such, given the expectation of edge effects, a mechansim for quantifying the quality of the habitat and maintaining it was developed to facilitate the managmenet of marbled murrelet habitat over the permit term. A Habitat Suitability Index (HSI) provides a quantifiable measure of the suitability of individual forest stands in the permit area as potential marbled murrelet nesting habitat, and provides a means of evaluating edge effects caused by timber harvest to this habitat (Appendix D, *Marbled Murrelet Habitat Suitability Index Approach*). The total area of modeled HSI-weighted acres in the permit area is 21,664 HSI-weighted acres at the beginning of the permit term; however, edge effects attributable to timber harvest prior to 2024 reduce the modeled HSI-weighted acres to 20,098 acres, a reduction of 7.2% (Appendix D). As of 2024, the modeled area-weighted mean marbled murrelet HSI of the permit area is 0.243, net of edge effects. This value is expected to increase gradually throughout the permit term, but could conceivably decrease in some years if harvest schedules are accelerated or harvest areas are clustered in areas susceptible to edge effects. Maintaining a minimum area-weighted mean marbled murrelet HSI value of 0.25 and limiting edge-effect habitat reductions to 7.2% of total HSI-weighted acres throughout the permit term ensures that the net marbled murrelet habitat value across the permit area, as measured by HSI-weighted acres, does not drop below the net marbled murrelet habitat value at the beginning of the permit term, and that the percent of marbled murrelet habitat negatively affected by harvest-related edge effects does not exceed the percent of edge present at the beginning of the permit term.

5.2.3 Oregon Coast Coho

5.2.3.1 Goal 3: Contribute to the persistence of the Oregon Coast coho evolutionarily significant unit directly and indirectly by restoring ecological attributes and processes that benefit multiple life histories of the three independent populations in the permit area (Tenmile, Lower Umpqua, and Coos) as well as in downstream reaches outside the permit area.

Riparian forests provide several critical functions, including large wood recruitment, controls on stream temperature, litter input, influencing flow regimes, and reducing stream sediment loads that are important for maintaining native aquatic biota in headwater streams. Research will be used across the permit area to explore how different management strategies affect the functions listed in this goal and will inform future forest policy and management practices concerning riparian forests and aquatic ecosystems.

There are three independent populations of Oregon Coast coho in the permit area: Tenmile, Lower Umpqua, and Coos. The biological goal for Oregon Coast coho in this HCP is to manage for key ecological attributes and processes in the permit area that will benefit fish in the permit area, as well as those in downstream reaches outside the permit area.

The strategy is further guided by the following principles.

- The role of the permit area in supporting the conservation and recovery of Oregon Coast coho was expressly considered and addressed in the development and implementation of research designs and forest management plans on the ESRF.
- The aquatic and riparian strategy is based on the best available scientific information.

- Unless otherwise indicated by credible scientific information, management strategies to benefit Oregon Coast coho will be based on natural ecosystem processes.

Objective 3.1: Improve the complexity and physical structure within streams by recruiting large wood to coho salmon habitat.

Rationale

This objective promotes the development of streamside vegetation and instream structure to improve freshwater habitat conditions for Oregon Coast coho through the contribution of large woody debris, and will be measured by monitoring the density (e.g., number of pieces/mile) of large wood in streams over the entire permit term within each independent population to be able to track long-term trends of instream wood (e.g., baseline levels versus amounts at various monitoring increments). This approach incorporates monitoring at the reach and independent population unit level (Chapter 6, Section 6.3, *Aquatic and Riparian Monitoring*) to allow comparison of areas subject to RCA thinning, various types of upstream active management in upland areas, and areas of no management (controls), and it is suject to triggers relevant to tracking progress (Chapter 6, Table 6-2).

Large woody material has multiple ecosystem benefits for fish and other aquatic species. Its presence in stream systems forms pools and promotes the habitat complexity required by juvenile salmon for successful rearing and emigration. 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 Oregon Coast coho, as well as other aquatic biota.

Landscape characteristics, such as riparian forest conditions, affect large wood recruitment and alter the habitat conditions of Oregon Coast coho (Beechie et al. 2000; Burnett et al. 2007). Riparian forests throughout much of the Pacific Northwest, including coastal Oregon, have been altered by land-use activities over the past century that have reduced the potential to provide large wood to aquatic ecosystems. The forests were harvested extensively, often to the edge of the stream, prior to the advent of current policies (Everest and Reeves 2007). Many of these riparian zones were subsequently planted with commercially valuable conifers, primarily Douglas-fir (*Pseudotsuga menziesii*), resulting in the development of dense, relatively uniform conifer stands and a decrease in relative abundance of hardwoods. In other cases, conifers were not successfully reestablished in logged riparian zones that are now dominated by alder (*Alnus spp.)* with a dense salmonberry (*Rubus spectabilis*) understory (Hibbs and Giordano 1996). Rates of landslides and debris flows have increased in heavily roaded and logged watersheds (Goetz et al. 2015; Guthrie 2002; Jakob 2000), which has also led to systematic changes in riparian vegetation. Consequently, the present-day forests frequently differ in structure and composition from the pre-settlement forests that preceded them (McIntyre et al. 2015; Swanson et al. 2011) and have a reduced potential to provide large wood to aquatic ecosystems. Promoting the development of native riparian vegetation structure and composition by thinning, within 0.6 site potential tree height[2] (Spies et al. 2013), creates material to be recruited as instream large wood. This objective will be accomplished by the end of the permit term via Conservation Measures 1 and 2. Abundance of instream channel wood will be tracked over time to determine long-term trends in wood recruitment for each independent coho population relative to the wood recruitment goals described in Section 5.3.4.3, *Oregon Coast Coho*. See Chapter

[2] Site potential tree height is approximately 200 feet in the permit area.

6, Section 6.3.3, *Instream Habitat Monitoring,* for more details on metrics to be tracked as part of the habitat monitoring.

Objective 3.2: Support improvement in water quality and quantity conditions most important to coho salmon as measured by long-term trends in fine sediments in riffles, summer low flows, and stream temperature in the permit area.

Rationale

Protection of existing functional riparian systems and restoration of degraded systems can address water quality issues. 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).

Degraded water quality, including high temperatures and fine sediments (National Marine Fisheries Service 2016), is a limiting factor for the Coos and Lower Umpqua coho independent populations. The steep topography of the permit area is a significant source of stream shade. In a climate vulnerability assessment for Pacific salmon and steelhead, Crozier et al. (2019) identified Oregon Coast coho to have moderate adaptive capacity to climate change and to be most vulnerable to stream temperature increases during juvenile stages. While the steep topography of the permit area does provide stream shading in the permit area, riparian vegetation also meaningfully contributes to additional shading, and thus designation of and thinning in RCAs will influence the long-term potential to reduce stream temperatures (Beechie et al. 2012). Maintaining stream shade through RCAs will benefit coho across the permit area and provide longer-term climate change resilience. In addition, the research design's focus on wood recruitment and related Objective 3.1 will reduce water temperature concerns over the permit term by accreting sediments reducing thermal loading from exposed bedrock in stream channels (Crispell and Endreny 2009; Beechie et al. 2013; Santelmann et al. 2022).

In forested environments, sediment delivery is often increased through surface erosion on unpaved roads or landslides from roads or clearcuts (Beechie et al. 2012). Approximately 14.6% of the roads in the permit area are within 200 feet of a stream.[3] Most roads (60%) in the permit area are on ridgelines (upper slopes) (Chapter 4, Table 4-12), which are generally the least problematic in regard to fine sediment delivery to aquatic ecosystems because most sediment does not move beyond the road prism (Wemple et al. 2001). Moreover, the size and extent of RCAs will filter sediments that are mobilized via overland flow and minimize sediment transfer to fish-bearing stream channels (Rashin et al. 2006). HCP commitments to reduce road density across the forest over the term of the HCP, improve condition of the existing road network (Conservation Measure 3), as well as limits on new roads in, near, and across streams, will minimize new sources of sediment and rectify existing sources from roads and other infrastructure. As a result, this configuration reduces the potential for roads in the permit area to contribute to chronic sedimentation.

Water quantity in the permit area will be affected by climate change. 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.

[3] Based on the Oregon State University synthetic stream layer developed of Oregon Coast coho.

Downscaled projections[4] for the permit area suggest that the reduction of summer flows will be on the low end of these projections (no more than approximately 7%) (Figure 5-1). In contrast, winter flows are expected to increase by a similar proportion because of increased levels of precipitation (no more than approximately 15%) (Figure 5-2). A climate vulnerability assessment incorporating both exposure and sensitivity evaluations found Oregon Coast coho to have moderate vulnerability to summer water deficit or flooding at any life stage (Crozier et al. 2019).

Reduction in summer low flows can negatively affect Oregon Coast coho by reducing the quantity and quality of rearing habitat (Woelfle-Erskine et al. 2017). Forests affect water yield through the interception of precipitation and transpiration by trees, with younger forests having higher rates than older forests. Perry and Jones (2016) found declining streamflow can result when old growth stands are converted to Douglas-fir plantations, with greater reductions correlated with larger harvested area (old growth stands will not be converted to plantations as part of the covered activities).

In response to this potential, the research design described in Chapter 3, *Covered Activities*, will limit intensive treatments in MRW full subwatersheds to no more than 50% of any subwatershed, with every acre of intensive treatments matched with an acre of reserve. Additionally, there is an annual permit area-wide harvest cap (1,000 acres) and, within this, an annual cap on intensive treatments (480 acres). In addition, extensive treatments are required to have a minimum retention of 20%, in addition to RCAs, within each subwatershed.

Perry and Jones (2016) did not observe effects on streamflows at harvest levels less than 50%. In an analysis of several experimental and modeling studies across the Pacific Northwest, Grant et al. (2008) found that the change in peak flow increased linearly with increasing harvest area and was undetectable (i.e., relative change in peak flow is less than 10%) for harvested areas of less than 29% in rain-dominated watersheds and 15% for watersheds in the transient snow zone.

In rain-dominated hydroregions, increased peak flows appear to be proportional to acreage harvested (i.e., more timber harvest = more water) (Bosch and Hewlett 1982; Keppler and Zeimer 1990). Changes in peak flows in the snow-dominated zone rarely occur until more than 20% of the basin is harvested, with a highly variable response after that threshold is exceeded. Peak flows increased 20 to 90% in study catchments where 20 to 40% of the trees were harvested (Troendle and King 1985; King 1989), while in another study, 100% clearcutting resulted in a 50% change in peak flow (Van Haveren 1988). Grant et al. (2008) also found that the percentage change in peak flow generally decreases with time after harvest (Jones 2000; Jones and Grant 1996; Thomas and Megahan 1998). Peak flow effects seem to diminish over the first 10 to 20 years (as the stand grows).

In addition, only those stands that are 65 years old or younger (as of 2020) will be harvested in intensive treatments, maintaining older forests where they occur and not creating new plantation forests on the landscape, which should produce smaller openings and limit low flow effects (Chapter 3, Figure 3-1). The RCA network across the permit area will reduce the potential of covered activities to affect summer flows. Water quality and quantity will be protected through the designation of RCAs, as described in Chapter 3, *Covered Activities*, as well as the management of RCAs, as described in Conservation Measures 2 and 3, as well as Condition 11.

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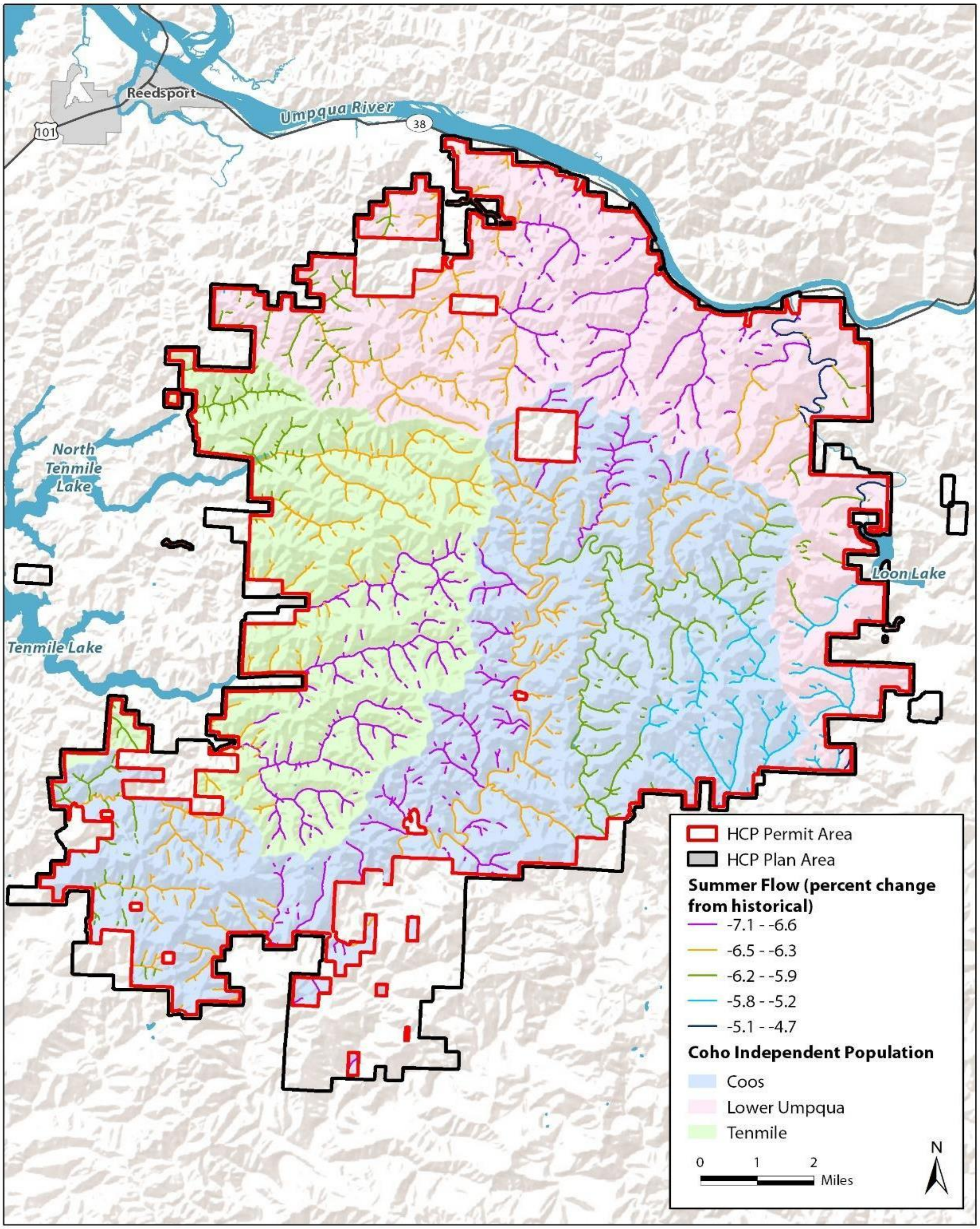
[4] Based on NetMap Climate Change Vulnerability tool: [Topic: 7.2 Climate Change Vulnerability (netmaptools.org).]()



Source: TerrainWorks 2021.

Figure 5-1. Downscale Climate Projections for Reductions in Summer Flow in the Permit Area from Historical Conditions to 2040

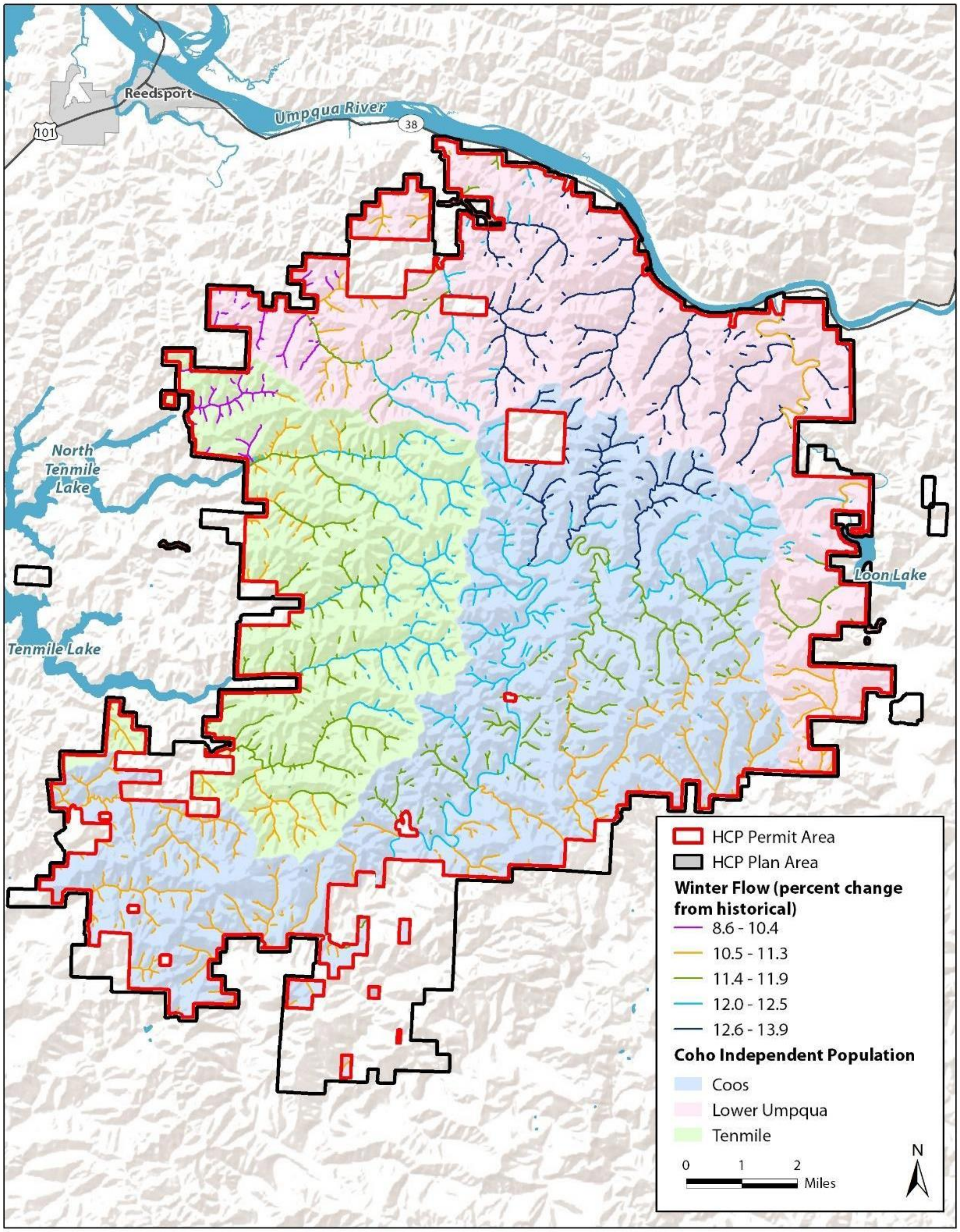


Figure 5-2. Downscale Climate Projections for Increases in Winter Flow in the Permit Area from Historical Conditions to 2040 (TerrainWorks 2021)

5.3 Avoidance and Minimization Measures Integrated into the Covered Activities

The covered activities described in Chapter 3, *Covered Activities*, incorporate stand-level treatments and operations by allocation that are designed, in part, to conserve the covered species and their habitats. These allocations and associated treatments are an integral part of the research forest's design. In other words, the designation and management of the CRW and RCAs, and the subwatershed allocations in the MRW (Chapter 3, Sections 3.2, *Foundational Research Design of the Elliott State Research Forest*, and 3.3, *Stand-Level Treatments and Operations Standards, by Allocation*) are project design features of the proposed research forest and are therefore not described in this chapter as conservation measures. However, the following sections summarize the intent of the avoidance and minimization measures that are integrated into the covered activities described in Chapter 3.

5.3.1 Conservation Research Watersheds

A major component of the avoidance and minimization measures integrated into the covered activities is the establishment of a 33,571-acre contiguous conservation block in the CRW. This CRW will be exclusively managed to promote conservation outcomes, including the restoration and protection of mature, complex forest stands providing significant habitat benefiting all three covered species, and compatible Indigenous and non-Indigenous cultural practices and uses. This contiguous conservation block contains 90 miles of fish-bearing streams in RCAs (Chapter 4, Table 4-12) and will constitute one of the largest dedicated conservation reserves in the Oregon Coast Range.

5.3.2 Management Research Watersheds

The covered activities described in Chapter 3, *Covered Activities*, for the MRW result in an integrated approach relevant to avoidance and minimization in several ways.

Of the 49,735 acres allocated within the MRW, 11,986 acres are designated as Reserves, 2,187 acres of Flexible allocations will be off limits to all treatment, and 6,319 acres will be designated and managed as RCAs buffering approximately 294 miles of stream. These RCAs will provide coho habitat where coho are present while also providing habitat for nesting marbled murrelet and nesting, roosting, and foraging northern spotted owls.

The MRW Reserves will range in size from approximately 10 to 1,000 acres and are specifically intended to protect mature forest habitat with known and projected occupancy of both marbled murrelets and northern spotted owls. When added to the CRW and RCAs, a total of 61% of the entire permit area is being managed exclusively for conservation purposes (Chapter 4, Table 4-1) benefiting the covered species.

The remaining 29,243 acres (or 35%) of the permit area is available for harvest, but with the following operations standards built into the covered activities that provide significant conservation benefits.

- **No harvest of oldest trees.** Trees pre-dating the 1868 stand replacement fire on the Elliott State Forest will be protected (see exception in Chapter 3, Section 3.3.3, *Extensive Allocations*).
- **Minimize harvest of older stands.** No more than 3,200 acres of stands older than 65 years as of 2020[5] will be harvested as part of extensive treatments over the permit term, and these stands will not be subject to intensive treatments.
- **Minimize effects of harvest through ecological forestry (i.e., extensive treatments).** Only extensive treatments, described in Chapter 3, *Covered Activities*, could be applied across 13,433 acres of related allocations (including Extensive, Flexible, Flexible Extensive, and Volume Replacement allocations) to protect and enhance multiple forest values beyond fiber production, including retention and creation of habitat patches, large trees, multiple canopy levels, and downed wood.
- **Limit area of intensive treatments.** While more than 42,000 acres (over 50%) of the permit area are currently characterized by stands 65 years or younger as of 2020, a maximum of 15,810 acres will be subject to intensive treatments. Rotation ages in Intensive allocations (60 years) are longer than the 40-year rotation often used in industrial forest management and would result in additional areas suitable for northern spotted owl foraging and less edge effects. In full subwatersheds, limiting Intensive allocations to 50% of the acres in a subwatershed and matching each acre available for intensive treatments with an acre of Reserve would minimize negative coho habitat quantity and quality effects related to water quality and quantity.
- **Minimize operation of ground-based equipment next to designated streams.** An equipment limitation zone (ELZ) will minimize ground-based equipment and associated disturbance within 35 feet of Oregon Forest Practices Act (Oregon FPA)-defined stream types (Oregon Administrative Rules [OAR] 629-600-0100; Type F, SSBT, N, Np, and Ns streams).[6] This operation standard is discussed further in Chapter 3, Section 3.3.7.4, *Operational Standards for Restoration Thinning in RCAs*.

5.3.3 Forest Maturation Through the Permit Term

As described in Chapter 3, Section 3.2.2, *Establishment of Conservation and Management Research Watersheds*, there are approximately 54,000 acres of forest allocated to CRW, MRW Reserves, or RCAs, which would be subject to no treatment or restoration thinning only in the ESRF. This includes approximately 2,200 acres in MRW Flexible allocation that is subject to no treatment. The majority (37,901 acres) of stands in these allocations will be over 60 years old by the time advancement of management activity is anticipated to begin on the ESRF (estimated 2025, at the soonest) (Table 5-2).

In addition to this substantial amount of habitat allocated to conservation outcomes as part of the research forest design, there are additional measures described in the HCP conservation measures

[5] There will be no harvest of stands older than 65 (as of 2020) as part of restoration thinning. See Chapter 3, Section 3.4.2.2, *Thinning*, for additional details.

[6] ELZs are not required on XNFB segments, which do not meet the Oregon FPA–defined stream type definitions of Type Type F, SSBT, N, Np, and Ns streams.

and conditions that provide more acres of habitat conservation commitment. These include the retention of tree cover in extensive treatments (both aggregates and dispersion), modeled potential marbled murrelet habitat that is found to be occupied during surveys, expanded riparian protections in certain areas, and any areas needed to comply with the protection measures surrounding the 22 northern spotted owl sites.

Table 5-2. Acres in Areas of No Treatment or Restoration Thinning Only, through Time

Age Cohort of Older Forest	Acres Today (2025)	Acres in 40 Years (2065)	Acres in 80 Years (2105)
60–100 yrs old	2,031	14,453	4,755
101–150 yrs old	30,470	2,373	11,630
151–230+ yrs old	6,400	36,528	37,498
Total	38,901	53,354	53,883

Forest conditions in the permit area will continue to mature through the permit term, likely resulting in over 53,000 acres of older forest by 2065, as existing older forest stands get older and as younger stands that were subject to restoration treatment mature (Table 5-2). Apart from the restoration thinning and supporting activities early in the permit term, these stands will be grown forward and subject to supporting activities consistent with conservation and not harvest treatments.

5.3.4 Species-Specific Measures

The following species-specific avoidance and minimization measures have been integrated into the covered activities.

5.3.4.1 Northern Spotted Owls

The following measures incorporated into the covered activities will serve to achieve Goal 1 and Objectives 1.1, 1.2, and 1.3 for northern spotted owls.

- 74% of modeled nesting, roosting, and foraging habitat is located in areas that are available for only restoration thinning or no treatments.
- 13% of modeled nesting, roosting, and foraging habitat is included in areas subject to intensive treatments.
- 13% of modeled nesting, roosting, and foraging habitat is in areas subject to only extensive treatments, where habitat enhancement and retention will occur as part of research objectives for ecological forestry.

Of the 22 known nest locations for northern spotted owl centered in the permit area, 12 are in the CRW and 10 are in the MRW. Of the 10 in the MRW, 5 are in Reserves, and 2 are in RCAs. The 17 owl centers in the CRW and MRW Reserves and RCAs are protected based on their occurrence in reserves. In addition, 1 activity center is in Flexible, and 2 are in Extensive allocations that will also result in varying levels of baseline protections. Collectively, these protections will occur as a result of the covered activities and will help achieve goals and objectives for northern spotted owls (Goal 1 and Objectives 1.1, 1.2, and 1.3).

5.3.4.2 Marbled Murrelets

Inclusion of 100% of designated occupied and 87% of modeled potential marbled murrelet habitat in areas available only for restoration thinning or no treatments as part of the covered activities will help achieve Goal 2 and Objectives 2.1, 2.2, and 2.3 for marbled murrelet.

5.3.4.3 Oregon Coast Coho

The following measures incorporated into the covered activities will help achieve Goal 3 and Objectives 3.1 and 3.2 for coho salmon over the course of the permit term.

- 65% of the permit area is in areas that are available for only restoration thinning or no treatments, which protect and promote aquatic processes.
- 78% of stream miles that are non-fish-bearing, non-perennial, and non-high landslide delivery potential (HLDP) stream (XNFBs) are located in areas that are available for only restoration thinning or no treatments, or areas subject to extensive treatments characterized by ecological forestry principles (Chapter 3, Section 3.3.3, *Extensive Allocations*) that provide significant flexibility when establishing appropriate harvest layouts to reflect site-specific characteristics. This also includes steep slopes and landslide-prone areas. The occurrence of XNFB streams in conservation-dedicated areas (CRW and MRW Reserves) provides inherent protection and promotion of aquatic processes relevant to minimizing and avoiding harvest effects where these XNFB streams occur upstream of occupied coho spawning and rearing habitat.
- 84% of the acres of slopes greater than 65% (steep slopes) are located outside of areas available for intensive treatments (Chapter 4, Table 4-10), which provides inherent protection and promotion of aquatic processes.
- RCAs were designated for the following purposes.
    - To focus on fish-bearing streams (up to 20% gradients) and non-fish-bearing streams, including reaches with a high probability to deliver wood to fish-bearing streams.
    - To incorporate a high proportion of the potential wood recruitment (which is a proxy for the effectiveness to maintain key ecological processes[7]). Based on modeled outcomes (Carlson 2023), wood recruitment targets for the three independent populations of coho is expected at the following levels.
        - 98% for the Tenmile independent population.
        - 95% for the Lower Umpqua independent population.
        - 89% for the Coos independent population.

[7] Key ecological processes that influence the condition and productivity of aquatic ecosystems originate from with the riparian area adjacent to the stream. These processes, which include wood and litter input, and shade (for water temperature), occur at varying distances from the channel (FEMAT 1993). Wood input occurs across the entirety of the riparian area, while the source distance for the others is more limited. Wood input can thus be a surrogate for the condition of the riparian area and the strength of the other key processes.

5.4 Conservation Measures

The conservation strategy includes several conservation measures. Conservation measures, as defined for this HCP, are specific take avoidance, minimization, and mitigation measures that the Permittee has committed to apply to meet permit issuance criteria. They are HCP-negotiated commitments that are distinct from conservation benefits inherent to the ESRF research design embedded in the covered activities described in Chapter 3, *Covered Activities*. These conservation measures will apply throughout the permit term.

5.4.1 Conservation Measure 1, Targeted Restoration and Stream Enhancement

As described by the National Marine Fisheries Service (NMFS) (2016), historical and ongoing land uses have reduced stream complexity in Oregon coastal streams and lakes through disturbance, road building, splash damming, stream cleaning, and other activities. Timber harvest activities have reduced levels of instream large wood, increased fine sediment levels, increased stream temperatures, and altered watershed hydrology. Historical splash damming removed stream roughness elements, such as boulders and large wood, and in many cases scoured streams to bedrock (Miller 2010). Beaver (*Castor canadensis*) removal has also resulted in the loss of instream wood, which has degraded habitat. Restoration and stream enhancement projects in the permit area will include placement of logs or whole trees in streams to create pools and to retain spawning gravels, creation or recreation of beaver habitat, and riparian vegetation management.

5.4.1.1 In-Channel Restoration

The loss of 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 primary limiting factor[8] for the Lower Umpqua and Coos independent populations and a secondary limiting factor for the Tenmile independent population of Oregon Coast coho (National Marine Fisheries Service 2016; Oregon Department of Fish and Wildlife 2005). Complex stream habitat is critical to produce enough juveniles to sustain productivity, particularly during periods of poor ocean conditions. Stream complexity provides a variety of habitat conditions that support adult coho salmon spawning, egg incubation, and juvenile rearing. The loss of habitat capacity and degraded conditions to support overwinter rearing of juvenile coho salmon is especially a concern (National Marine Fisheries Service 2016).

The elements described in this section are intended to offset adverse impacts of the covered activities on desired aquatic habitat conditions and Oregon Coast coho. These elements will promote aquatic habitat conditions that support the short- and long-term survival needs of Oregon Coast coho and other aquatic organisms, strategic enhancement projects will make it more likely that properly functioning aquatic habitat conditions will be attained in a timely manner.

This comprehensive stream restoration and enhancement approach applies both short- and long-term management actions. These elements will improve levels of aquatic function in the short term (to meet the immediate habitat needs of Oregon Coast coho and place aquatic habitats on a pathway

[8] Factors that constrain a population's size and slow or stop population growth.

toward desired conditions), while at the same time creating self-sustaining habitats over the long term. The following actions will be part of the aquatic habitat maintenance or improvement strategy.

The *Elliott State Forest Watershed Analysis (*Biosystems et al. 2003)*, Final ESA Recovery Plan for Oregon Coho Salmon* (National Marine Fisheries Service 2016), and local watershed plans identify recommendations for restoration projects in the permit area that would address limiting factors for the Oregon Coast coho. During HCP implementation, the Permittee will focus on key restoration actions identified in these plans, along with other opportunistic projects, when there is a need, along with existing resources and partnerships, and taking advantage of existing equipment onsite during harvest operations. Instream wood placement projects will occur on fish-bearing streams within or adjacent to all harvest operations when the stream is below the desired level of wood (as identified in Section 5.3.4.3, *Oregon Coast Coho*, and monitored as described in Chapter 6, *Monitoring and Adaptive Management*).

The following guidelines will apply when planning instream restoration and enhancement projects.

- Aquatic habitat improvement projects will be designed with the intent of mimicking natural processes. The use of "engineered" or "constructed habitat" approaches to stream enhancement will be minimized.
- Projects will be selected, designed, and implemented through coordination with the Oregon Department of Fish and Wildlife (ODFW) and in cooperation with local watershed councils.
- Project planning and design will address habitat conditions, stream processes, and the disturbance regime at both the watershed and site-specific scale.
- Projects will be designed and implemented consistent with the natural dynamics and geomorphology of the site, and with the recognition that introduction of materials may cause changes to the stream channel.
- Priority will be placed on projects that supplement natural legacy elements (large wood) that are lacking due to previous disturbance events and/or management activities*.*
- Projects will be designed to create conditions and introduce materials sufficient to enhance or reestablish natural physical and biological processes. An emphasis will be placed on projects that reintroduce large key pieces of wood to stream channels in natural configurations.
- Wood placement activities will use materials that are expected to be relatively stable yet functional in these dynamic stream systems. The intent is to maximize the functional attributes of large wood and minimize potential conflicts with public safety in downstream reaches. Artificial anchoring methods (e.g., cables) will be minimized and will only be used in cases of significant concern for public safety.
- Projects will be implemented in a manner that minimizes the potential for negative effects on riparian areas.

5.4.1.2 Riparian Vegetation Management in Riparian Conservation Areas

The rationale for vegetation management in RCAs is described in Chapter 3, Section 3.3.7, *Riparian Conservation Areas*, and Appendix A, *Active Management of Riparian Conservation Areas*.

Silvicultural projects and related research will be designed to improve aquatic and riparian conditions in RCAs during the permit term. Improvement of riparian forests may also indirectly benefit terrestrial species, including northern spotted owls and marbled murrelets. Vegetation management treatments will be designed to reduce stand densities and increase residual tree growth rates (Roberts and Harrington 2008; Dodson et al. 2012; Newton and Cole 2015), and to promote larger crowns, and more rapid development of large limbs (Maguire et al. 1991; Roberts and Harrington 2008; Dodson et al. 2012) that may be used as nesting habitat for species such as marbled murrelets. Treatments will include planting, natural regeneration, or both in gaps and thinned areas to promote regeneration of diverse vegetative communities (Puettmann and Tappeiner 2014).

RCA restoration thinning and research will occur consistent with the description in Chapter 3, Section 3.3.7.4, *Operational Standards for Restoration Thinning in Riparian Conservation Areas*. The predominant vegetation treatment method will be hand thinning, given the steep terrain of most RCAs. This is further described in Section 5.5.11, *Condition 10: Management on Steep Slopes*.

An initial assessment of RCA thinning inside the ELZ (0 to 35 feet) will occur on up to 160 acres of RCAs along fish-bearing and non-fish-bearing streams prior to thinning in other ELZs. These projects will be monitored and evaluated (as described in Chapter 6, Section 6.3.4, *Riparian Restoration Monitoring*) to determine if outcomes are enhancing ecological function of RCAs while minimizing adverse effects on coho. The knowledge gained will be applied in an adaptive management context so that the multiple resource objectives for riparian and aquatic habitats can be more successfully met with subsequent RCA thinnings.

As part of the RCA restoration thinning treatments, the following vegetation management actions will be applied to help achieve the coho biological goals and objectives.

- All trees cut within the first 50 feet of all RCAs will be left on the ground, tipped toward or placed into the stream; no trees will be removed.
- Outside 50 feet, 0 to 20% of the volume of cut logs within RCAs will be left on the ground or felled toward, or placed in, the stream channel. These will consist of the largest cut trees to provide the greatest ecological benefit to coho.
- Sale of residual logs (trees not left on the ground, tipped toward or felled into streams in compliance with the above bulletted commitments) that are a byproduct of a riparian restoration thinning design may occur to offset cost of treatments.

5.4.1.3 Beaver-Related Habitat Management

Beavers create ponds and other slow-water aquatic areas that provide important habitat for salmonids. Widespread commercial trapping in the nineteenth century resulted in declines in the beaver population. Today, beaver populations have somewhat 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 beavers provide important summer rearing and overwintering habitat (Castro et al. 2017). 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 this habitat (Nickelson et al. 1992). In the permit area, beaver habitat occurs in many areas where coho have been documented. Table 5-3 shows the miles of potential beaver habitat and streams with documented occurrence of coho.

Table 5-3. Miles of Potential Beaver Habitat and Streams with Documented Occurrence of Coho

	MRW (miles)	CRW (miles)
Beaver habitat	58	23
Coho streams [a]	65	30

[a] StreamNet

Beavers generally colonize low-gradient streams that flow through unconfined valleys, with a preference toward the lower-gradient areas. The major rivers and streams in the permit area are in narrow valleys, bordered by steep side slopes with gradients on the side slopes that commonly exceed 65%, thus, resulting in limited potential beaver habitat in the permit area. Potential beaver habitat in the permit area was identified using the following criteria from Suzuki and McComb (1998) and is shown in Figure 5-3.

- Active channel width: between 3 and 6 meters
- Valley floor width: >25 meters
- Channel gradient: <3%

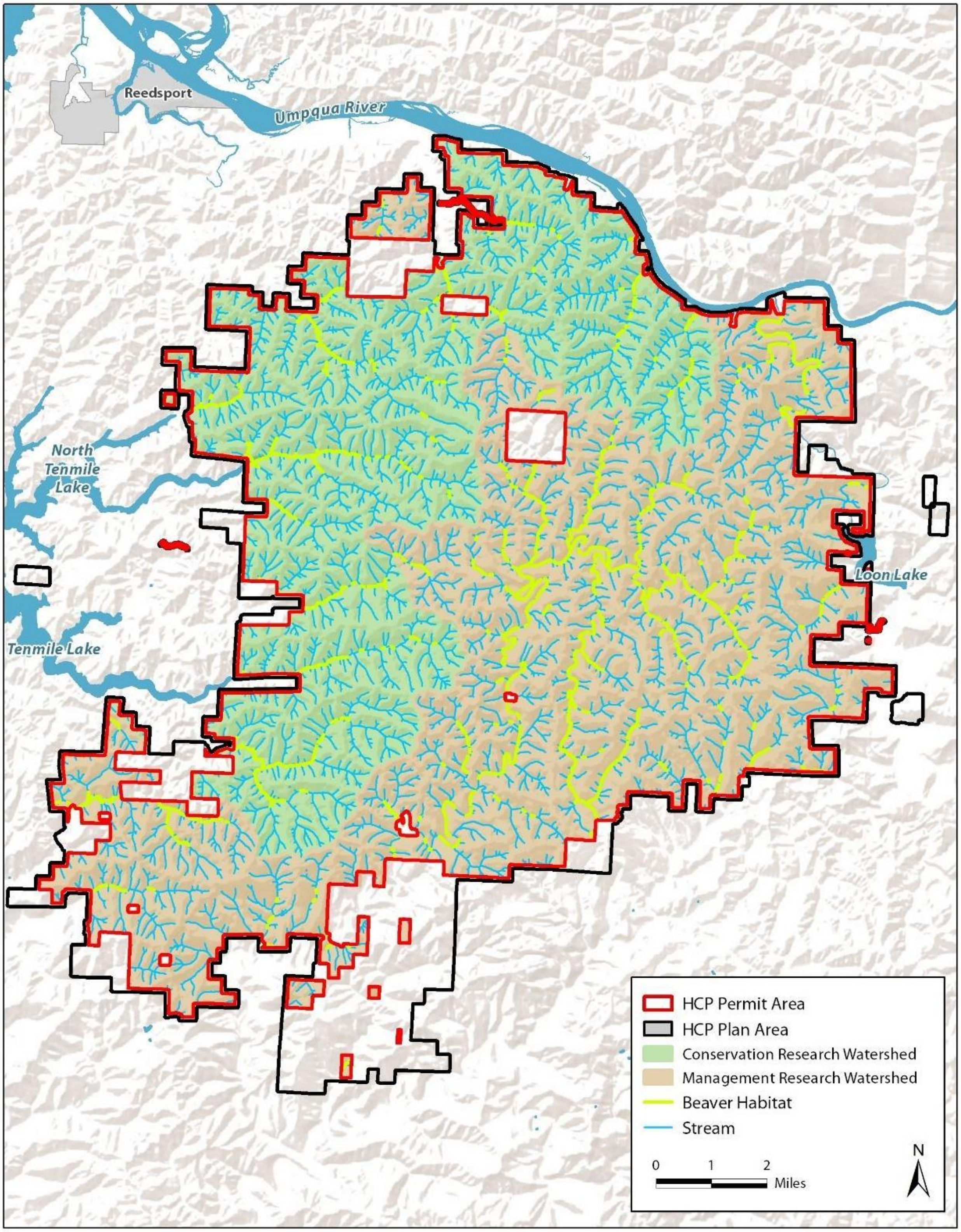
Over the course of implementation, it may be decided that a beaver restoration project (e.g., installation of a beaver dam analog, beaver habitat enhancement) should be implemented to benefit coho. If such a project were proposed, it would follow relevant scientific literature to develop achievable goals, strategies, and objectives that are in line with the HCP's biological goals and objectives and accommodate research goals. Promoting the occurrence of beavers in the permit area will improve floodplain connectivity, stream complexity, and low-velocity rearing habitat that would benefit coho salmon. The Permittee will coordinate this work with regional partners, ODFW, USFWS, and NMFS to ensure beaver management actions fit into the larger context of coho conservation and statewide beaver management principles.

5.4.2 Conservation Measure 2, Expanded Riparian Conservation Areas on Select Management Research Watershed Streams

5.4.2.1 Lower West Fork Millicoma River

The Millicoma system provides distinct relative values to the Coos independent population and the Oregon Coast coho salmon evolutionarily significant unit (ESU). In recognition of this, the designated RCAs for the Lower West Fork Millicoma River will be as follows (refer also to Chapter 3, Table 3-2).

- 200 horizontal feet on each side of the channel migration zone along the mainsteam river from the edge of the permit area boundary to the confluence with Elk Creek (approximately 16 miles).
- 120 feet measured as horizontal distance from each side channel migration zone for all HLDP streams (9 miles) and fish-bearing streams (45 miles) (Miller and Carlson in prep.).



Source: Suzuki and McComb 1998.

Figure 5-3. Modeled Potential Beaver Habitat in the Permit Area

This conservation measure is included to specifically address the lower amount of wood recruitment expected in the Coos independent population, as it is entirely within the MRW and, thus, the West Fork Millicoma River will have more variable RCA widths when compared to rivers on the Tenmile and Lower Umpqua and their independent populations. With the expanded RCAs on the Lower West Fork Millicoma River, wood recruitment within the Coos independent population would be 88% based on model results. The expanded RCAs also ensure that the recruitment occurs in a location where it is most beneficial to coho.

5.4.2.2 Volume Replacement Allocations

As described in Chapter 3, *Covered Activities*, Volume Replacement allocations would be available for extensive treatments if Extensive allocations become restricted from harvest due to marbled murrelet occupancy. In these areas, the designated RCAs will be the same as in the CRW. This will include a 200-foot RCA (measured as the horizontal distance from each side of the channel migration zone) on either side of fish-bearing streams, HLDP streams, and perennial non-fish-bearing (PNFB) streams (Chapter 3, Table 3-2).

5.4.2.3 Flexible Extensive Allocations

Flexible Extensive allocations in the Big Creek and Palouse subwatersheds will have designated RCAs that are the same as in the CRW, including a 200-foot RCA (measured as the horizontal distance from each side of the channel migration zone) on either side of fish-bearing streams, HLDP streams, and PNFB streams (Chapter 3, Table 3-2).

5.4.3 Conservation Measure 3, Reduce Density and Negative Impacts of the Forest Road Network in the Permit Area

The objectives for managing the forest road systems are to keep as much forest land in a natural productive condition as possible, prevent water quality degradation and associated impacts on aquatic and riparian resources, minimize disruption of natural drainage patterns, provide adequate fish passage, and minimize exacerbation of natural mass-wasting processes. In addition, reducing road networks can have direct and indirect positive benefits on northern spotted owls and marbled murrelets, as well as other wildlife species not covered by this HCP.

The construction and use of forest roads are an integral part of actively managing state forest lands. Roads provide essential access for forest management activities, fire protection, and a variety of recreational uses. However, roads can be a major source of habitat removal, fragmentation, disturbance, erosion, and sedimentation. Roads can degrade salmon habitats through increased delivery of fine sediment, increased 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). Proper road system planning, design, construction, and maintenance will prevent or minimize water quality problems and associated impacts on aquatic resources and will significantly extend the useful life of a forest road.

The road network in the permit area will provide effective access for all covered activities taking place in the forest while also being actively managed to address potential negative effects on the functioning condition of at-risk natural resources. In addition to the commitment to not exceed construction of 40 miles of permanent new roads over the course of the permit term (Chapter 3, *Covered Activities*), existing roads will be vacated in 10-year increments to reduce net density (relative to current density) by the end of the permit term.[9] In other words, by the end of the permit term the road density across the permit area will less than the current road density listed in Chapter 4, Table 4-11. The location, method, specific timing, and rate of road density decreases will be based on actions set forth in Biennial Operations Plans consistent with this HCP, the forest management plan, and 10-year planning projections reviewed and adopted by forest managers in coordination with the HCP implementation and adaptive management committee (Chapter 7, Section 7.2.4, *Implementation and Adaptive Management Committee*). The results of these planning efforts will be made available to the public. The first 10-year planning period will begin after completion of the required road assessment discussed below. Thus, activities to decrease road densities should commence in the mid to late 2030s. Decreases will be emphasized in the CRW.

To meet this Conservation Measure commitment, the Permittee will use the road assessment and monitoring to identify roads that are contributing to the degradation of covered species habitat to inform decisions regarding vacating.

All road construction, maintenance, and vacating will be performed in accordance with the Oregon FPA (OAR 629) and other applicable statutes as described in Chapter 3, *Covered Activities*. Surface erosion and delivery of sediment to streams can be substantially reduced through good road design and maintenance (Roni et al. 2002). Stream processes that can be restored through road design and improvement techniques are shown in Table 5-4 and will be implemented when addressing existing road systems identifed in the road assesmment for improvement to benefit the covered salmonids.

Table 5-4. Processes Restored by Various Road Improvement Techniques

		Sediment Delivery	
Road Improvement Technique	**Hydrology**	**Fine (sand and smaller particles)**	**Coarse (gravel and larger particles)**
Removal of roads that are degrading the aquatic environment	X	X	X
Culvert or stream-crossing upgrades (repair unstable crossings)	X	X	X
Sidecast removal or reduction		X	X
Reduced road drainage to stream [a]	X	X	
Increased surface material thickness or hardness with crushed rock or paving		X	
Traffic reduction (unpaved roads)		X	

Source: Roni et al. 2002.
[a] Drainage reduced through increased crossings and by diverting water onto forest floor.

During the first 12 years of HCP implementation, a formal road assessment will be developed to identify the degree of hydrologic connections of current and legacy roads and their primary locations in the permit area. This assessment, in conjunction with monitoring (Chapter 6, *Monitoring and Adaptive Management*), will also identify the location of existing culverts and candidate roads for modification to test methods for reducing hydrologic connections, restoring ecological function, and long-term monitoring of subsequent habitat impacts. In support of this, an inventory of the road networks will be maintained to identify current and legacy roads that present a risk (e.g.,

[9] Spur roads will be temporary and developed so as not to degrade the aquatic environment.

sedimentation, landslide frequency, erosivity, habitat fragmentation) to the aquatic and riparian system and inform modifications to the road system, prioritizing segments that pose the highest risk to aquatic resources. This inventory will also be used to track current and future road density during the permit term. While focused on aquatic resource concerns for purposes of this HCP, the roads assessment may also identify roads that pose considerable concern or benefit to other resources or values (e.g., wildlife security, barred owl removal efforts, human safety, cultural resources).

Roads to be vacated as part of this road density reduction commitment will be selected depending on their relative utility and degree of resource concern or potential benefit. This effort will be mindful of providing access for firefighting and recreation, active forest management operations, and the conservation goals and multiple management objectives associated with this publicly owned forest. The current road density in the CRW and MRW will decrease over the permit term, and new, permanent roads may be constructed as part of a strategy to vacate other road segments. Empahsis on road density decreases in the CRW will consider the future utility of roads or segments in light of the completion of restoraton thinning work and long-term conservation objectives in the CRW, while also considering their relative utility for other uses and values. Any road-vacating strategy must be developed and implemented within the context of a forest management plan.

5.4.4 Conservation Measure 4, Barred Owl Management and Research

Barred owl populations have grown rapidly and achieved particularly high densities in older forests of Washington and western Oregon, which has exacerbated northern spotted owl population declines (U.S. Geological Survey Forest and Rangeland Ecosystem Science Center 2018). In addition to habitat loss, USFWS has identified competition from nonnative and invasive barred owls as one of the two main threats to the northern spotted owl's continued survival (U.S. Fish and Wildlife Service 2011; Lesmeister et al. 2018). Lethal removal of barred owls has been experimentally shown to be an effective management tool to mitigate negative impacts on northern spotted owls (Wiens et al. 2021). Across the four study areas (two in western Oregon), removal of barred owls had a positive effect on survival, dispersal, and recruitment of northern spotted owls that allowed populations to stabilize in the areas with removals (Wiens et al. 2021). These promising results are being incorporated into USFWS' development of a Barred Owl Management Strategy.

The permit area is uniquely suited to explore barred owl management strategies, including its scale, geographic proximity to other land managers where barred owl management work may occur, and an ability to advance experimental approaches and research to better understand barred owl competition with northern spotted owl. The Permittee will collaborate with USFWS, in accordance with the relevant provisions outlined in Chapter 7, Section 7.6, *Modifications to the Habitat Conservation Plan*, as well as other federal and state management agencies to develop a barred owl management and research approach, as described in Chapter 3, Section 3.9.7, *Barred Owl Management and Research*.

This barred owl management and research conservation measure will also integrate into the monitoring and data collection related to northern spotted owl identified in Chapter 8, *Cost and Funding*, to the greatest extent possible—including any monitoring necessary to assess the effectiveness of barred owl management. Management will remove barred owls in amounts intended to facilitate sustained improved conditions for northern spotted owl persistence and recolonization in the ESRF (i.e., lead to areas where barred owl and northern spotted owl competition is substantially reduced and sustained over time). Monitoring of the effectiveness of the removal will be determined through collaboration between USFWS and the Permittee, including the amount, quality, and duration of habitat management for northern spotted owl benefit. The results of removal efforts and subsequent effectiveness monitoring will be included in annual reports. Research associated with barred owl removal could also inform effectiveness monitoring.

The management associated with this conservation measure will be designed, budgeted, and authorization sought under the Migratory Bird Treaty Act (MBTA) within 16 months of incidental take permit issuance and begin no later than the field season of the following year, assuming appropriate federal MBTA take permit(s) are in place and other state and federal legal compliance has been addressed. The success of the program will be evaluated with USFWS during reporting at 6- and 12-year intervals. If barred owl management is found to be ineffective at providing a population benefit to northern spotted owls beyond the control of the Permittee after 15 years of continual barred owl management within the permit area, the Permittee will not be obligated to continue funding it as described in Chapter 6, Section 6.5.2, *Adaptive Management Triggers*. A population benefit would be demonstrated by maintaining or increasing the northern spotted owl population within the permit area coincident with the begnning of active barred owl management.

5.4.5 Conservation Measure 5, Harvest and Thinning Adjacent to Occupied Marbled Murrelet Habitat

This conservation measure will enhance protection for interior murrelet occupied habitat from edge effects potentially caused by extensive harvest within adjacent unoccupied boundaries of modeled potential habitat (Chapter 2, Figure 2-13). Buffering, as described in Appendix D, *Marbled Murrelet Habitat Suitability Index Approach*, and in this section, will also help connect and provide continuity between existing occupied habitat polygons (Pacific Seabird Group 2024b). These protections are meant to build upon continuity provided by existing spatial configurations of MRW Reserves and occupied habitat, and do not limit any additional measures in the modeled potential habitat that may occur during the biennial planning process.

Additional buffering (beyond what is described below), treatment layout and stand-level boundary adjustments, or other protections may occur as part of the biennial planning process where these conservation considerations are balanced with considerations for other resource values and financial and operational viability. Consistency with HCP requirements will be maintained in all instances.

The Permittee will take the following actions in support of achieving Goal 2 and Objective 2.3.

5.4.5.1 Restoration Thinning in Conservation Research Watersheds and Management Research Watersheds

To address potential edge effects associated with restoration thinning in the CRW and MRW Reserves, if thinning is proposed in modeled potential habitat that is adjacent to occupied marbled murrelet habitat, a 164-foot buffer will be placed in the modeled potential habitat to minimize edge effects on the occupied habitat. The buffer will be managed at 100% retention unless the modeled potential habitat is surveyed and a finding of probable absence is determined (per Condition 7), in which case retention could range from 60 to 100% of preharvest density.

5.4.5.2 Harvest in Management Research Watersheds

To enhance interior habitat protection against edge effects and promote habitat connectivity, modeled potential marbled murrelet habitat that exists immediately adjacent to occupied marbled murrelet habitat, and that is outside of MRW Reserves, will be buffered as follows.

- 164-foot harvest buffer extending outwards from the border of occupied habitat polygons.
- 328-foot harvest buffer extending outwards from either side of the borders of adjacent occupied habitat polygons that are 656 feet apart or less.

Buffers will be maintained at 100% retention of original preharvest stand density[10] unless the adjacent modeled potential marbled murrelet habitat is surveyed (per Condition 7) and a finding of probable absence is determined, in which case the buffer will remain but retention can range from 60 to 100% of original preharvest stand density.

5.4.5.3 Exceptions

To support operational needs in stands adjacent to the occupied habitat, the following exceptions apply. Any deviations would be documented and reported following the processes outlined in Chapter 6, *Monitoring and Adaptive Management*.

- **Existing edges**. If a hard edge is already present due to, for example, an existing road, cliff, canyon, ridgeline or other significant edge feature, this edge will form the outer boundary of the area adjacent to occupied habitat for purpose of any harvest buffering.
- **Roads and landings**. Existing roads and landings (as of 2020) may be used for harvest operations and hauling in compliance with Condition 6. All standing trees and snags adjacent to harvest and hauling operations that are not within the harvest area boundaries will be retained, provided they do not present a safety hazard as described in Chapter 3, Section 3.5, *Supporting Management Activities*.
- **Logging systems**. Tailholds and guyline anchors are allowed in occupied habitat, modeled potential habitat, RCAs, and Reserves where necessary to harvest adjacent stands that are outside of these designations or unoccupied stands in modeled potential habitat. Trees with potential marbled murrelet nesting platforms will not be used as tailholds or guyline anchors, and measures will be taken to avoid damage to these trees.
- **Safety considerations.** Consistent with those described in Chapter 3, *Covered Activities*.

5.5 Conditions on Covered Activities

The conservation strategy includes several conditions on covered activities. Conditions, as defined for this HCP, are specific take avoidance and minimization measures that the Permittee has committed to apply to the covered activities described in Chapter 3, *Covered Activities*. These conditions will apply throughout the permit term.

[10] Original preharvest density is the stand density prior to initial thinning or harvest under this HCP.

5.5.1 Definitions Used in Conditions

The following sections define terms used in the conditions related to northern spotted owls and marbled murrelets. These definitions are important when defining the responsibilities of the Permittee during HCP implementation.

5.5.1.1 Northern Spotted Owl Definitions

- **Activity center.** Spotted owls have been characterized as central-place foragers, where individuals forage over a wide area and subsequently return to a nest site or roost location that is often centrally located within the home range. Activity centers are a location or point representing the best of detections such as nest sites, stands used by roosting pairs or territorial singles, concentrated nighttime detections, and other methods defined in USFWS-accepted protocols. Activity centers are in the core use area and are represented by this central location. For this HCP, activity centers (and *historic activity centers*, as defined later in this section) are administrative designations used to determine associated habitat committments and to manage and monitor these committments over the permit term.
- **Historic activity center.** Historic activity center refer to an activity center that has been documented as active in the past but for which subsequently has been determined to no longer be occupied by pairs or for which current status is unknown (due to lack of recent surveys).
- **Active versus inactive activity center.** For this HCP, a northern spotted owl active pair or single activity center is defined as any location where presence of a nesting pair or single owl has been documented, during the period necessary for detecting nesting and reproductive status per USFWS-accepted protocols, in at least 1 year out of the last 6 survey years. If a site is unoccupied every year for 7 consecutive survey years, then it will be deemed inactive. If surveys are not completed every year, presence will be assumed in nonsurvey years. For a nest site to switch from active to inactive status, surveys will have to be completed per USFWS-accepted protocols or as otherwise determined to be inactive by USFWS.
- **Nest site.** The nest site is the nest tree and other trees within 300 feet of the nest tree. Nest sites, where known, are used to demarcate an activity center, but are not required to demarcate an activity center.
- **Nesting core area.** The nesting core area consists of 100 acres of the best contiguous habitat that surrounds a northern spotted owl nest site.
- **Core use area.** The core use area consists of 502 acres of the best contiguous habitat area that surround a northern spotted owl nest site. The edge of the core use area will be no less than 300 feet from the nest location. The nesting core area is inside, and part of, the core use area.
- **Home range area.** The home range area consists of 4,522 acres that surround a northern spotted owl nest site. This area is generated by observing a 1.5-mile buffer from the known nest site. The home range area includes both the core use area and nesting core area.
- **Highest-quality habitat.** For this HCP, the term *highest quality* means the highest ranking among nesting, roosting, and foraging habitat based on the specific habitat model adopted for northern spotted owl by the ESRF.[11] When selecting the highest-quality stands, those stands that

[11] Habitat models may be updated as needed in coordination with the Services to reflect current science.

are modeled as highly suitable habitat would be prefereentially selected over suitable stands, and suitable stands would be selected over marginal stands.

- **Highest-quality contiguous habitat.** Highest-quality contiguous habitat refers to the requirements of Conservation Measures 2 and 3 for retention of at least 251 acres of the highest-quality contiguous habitat within the 22 northern spotted owl core use areas. Upon establishment of these core use areas, the highest-quality habitat arrayed in the most spatially contiguous manner will be selected and allowed to improve through time with passive and active management. The precise locations of the boundaries of the highest-quality contiguous habitat may change through time with improvement of habitat models. Stands of the highest-quality will be preferentially selected over stands of lower-quality habitat and these will be based on age related factors, habitat models, and spatial arrangement so that the maximum benefit within the core use areas can be obtained.
- **Northern spotted owl contiguous.** Contiguous means sharing a boundary with another adjacent forested stand when possible, or with gaps in stand boundaries smaller than 300 feet.

5.5.1.2 Marbled Murrelet Definitions

- **Designated occupied habitat.** Designated occupied habitat consists of areas mapped as occupied by marbled murrelets based on historical survey data. This includes areas formerly designated as marbled murrelet management areas by the Oregon Department of Forestry and those mapped as occupied by Oregon State University (OSU) researcher Kim Nelson, with refinements based on 2021 light detection and ranging (LiDAR) data. This is further explained in Chapter 2, Section 2.4.2.2, *Plan Area Status*, and shown on Figure 2-13.
- **Modeled potential habitat.** Modeled potential habitat is modeled as having potential to be occupied by marbled murrelets by OSU researchers. The modeled potential habitat layer originated from a 2020 model (Betts et al. 2020b) and has been subsequently updated using 2021 LiDAR data and an improved 2022 model (Betts and Yang 2023). Methods are described in Chapter 2, Section 2.4.2.2, *Plan Area Status*, and shown on Figure 2-13.
- **Nest site.** The nest site consists of the nest tree and other trees within 300 feet of the nest tree.
- **Marbled murrelet contiguous potential habitat.** Marbled murrelet contiguous potential habitat is marbled murrelet habitat that contains no gaps in suitable forest cover wider than 328 feet (Evans Mack et al. 2003).[12]
- **Survey area.** The survey area is the area determined by identifying the extent of habitat within 402 meters (0.25 mile) of the project footprint where covered activities are planned. Survey areas will typically consist of one or more forest stands and may be broken into two or three strata to distribute sampling effort (Pacific Seabird Group 2024a).

[12] Note that this HCP is currently using the 2003 protocol to define habitat contiguity. A larger 200-meter (656-foot) buffer is suggested to encompass more stands in a heavily fragmented landscape in the more recent protocol (Pacific Seabird Group 2024a). Habitat models may be updated as needed in coordination with the Services to reflect current science.

5.5.2 Condition 1: Seasonal Restrictions Around Northern Spotted Owl Nest Sites

To minimize adverse effects on nesting northern spotted owls, covered activities will follow USFWS-recommended seasonal disturbance distances (U.S. Fish and Wildlife Service 2020b; Table 5-5). This condition will apply to any active nest sites found in the permit area through monitoring or other means over the permit term. In addition, seasonal disturbance restrictions will also apply to the 22 historic northern spotted owl activity centers identified in Chapter 2, *Environmental Setting*, Table 2-5, unless a determination has been made that nesting is not occurring (per USFWS-accepted protocols).

Actively nesting northern spotted owls that may become established in the permit area would be detected as part of the species monitoring commitments described in Chapter 6, Section 6.4.2.1, *Northern Spotted Owl Surveys*. Activities for known or assumed active nest sites will be restricted during the critical nesting season for active single and pair sites, and within the distances given in Table 5-5, unless it is determined that no nesting is occurring, or has failed, or until July 7, whichever is sooner. Determination of probable absence of nesting will be made following USFWS-accepted survey protocols.

Exceptions to these restrictions will only occur in situations where either (1) applying these restrictions would compromise the safety of staff, contractors, or members of the public; or (2) applying a more limited restriction is clearly justified based on site conditions (e.g., topographic features on the landscape shield the nest site from the activities in question). Exceptions from these restrictions are expected to be rare and will be applied by the Permittee only after a site-specific review by a northern spotted owl expert and documentation of recommendations. Any exceptions will be summarized in the annual report.

Table 5-5. Seasonal Distance Restrictions for Active Northern Spotted Owl Nest Sites During the Nesting Season [a,b]

Covered Activity	Critical Breeding Season (March 1–July 7) [c]	Late Breeding Season (July 8–September 30)
Light maintenance of roads and facilities	No restrictions	No restrictions
Log hauling on open roads	No restrictions	No restrictions
Chainsaws (includes felling hazard/danger trees), drones	65 yards	No restrictions
Heavy equipment for road construction, road repairs, bridge construction, culvert replacements, etc.	65 yards	No restrictions
Pile-driving (steel H piles, pipe piles), rock crushing, and screening equipment	120 yards	No restrictions
Blasting [d]	0.25 mile	100 yards
Helicopter: Chinook 47 [d]	265 yards [e]	100 yards (hovering only)
Helicopter: Boeing Vertol 107, Sikorsky S-64 (SkyCrane)	150 yards [e]	50 yards (hovering only)
Helicopters: K-MAX, Bell 206 L4, Hughes 500	110 yards [e]	50 yards (hovering only)
Small fixed-wing aircraft (Cessna 185, etc.)	110 yards [e]	No restrictions

Covered Activity	Critical Breeding Season (March 1–July 7) [c]	Late Breeding Season (July 8–September 30)
Tree climbing	25 yards	No restrictions
Burning (prescribed fires, pile burning)	0.25 mile	No restrictions
Drone use	65 yards	N/A (as long as spotted owls are not pursued)
Other activities	35 yards	35 yards

Source: U.S. Fish and Wildlife Service 2020b.
[a] Applies to any active nest sites and the 22 historic activity centers. Suitable northern spotted owl nesting habitat is assumed to have a probability of containing active nests unless verified non-nesting through surveys conducted following USFWS-accepted protocols.
[b] These restrictions apply except for emergency situations, including fire, search and rescue, or other public emergency in the vicinity of the designated occupied habitat or likely nesting habitat. Distances are measured from the nest tree location if known or edge of nesting stand if exact location is not known.
[c] As measured from the edge of the active nest site to the limit of the activity performed, unless the Permittee determines that young are not present, based on USFWS-accepted survey methods, at which point distance restrictions may be lifted on a case-by-case basis.
[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.
[e] Distance should be measured from top of tallest tree. Rotor-wash from large helicopters is expected to be disruptive at any time during the nesting season due to the potential for flying debris and shaking of trees located directly under a hovering helicopter.
N/A = not applicable

5.5.3 Condition 2: Retention of Northern Spotted Owl Nesting Core Areas

To achieve the biological goals and objectives outlined in Section 5.2.1, *Norther Soitted Owl,* Conditions 2, 3, and 4 include habitat commitments around the 22 historic activity centers identified in Chapter 2, Table 2-5. While many of these areas may be unoccupied at the time of permit issuance, and actual nesting locations are likely to move over time, the conservation strategy is intended to provide habitat for northern spotted owls at the landscape level by retaining cores of habitat around the areas most recently occupied at the time of permit issuance.

Under Condition 2, a 100-acre nesting core area of the highest-quality contiguous habitat will be maintained around the nest sites (or designated activity center if nest site unknown). This standard will be applied to at least 22 northern spotted owl core use areas at any one time. There will be 100% retention of trees in the nesting core area (i.e., no modification or treatment will occur in the 100-acre nesting core area). This nesting core area does not have to be circular in shape, but habitat will be contiguous with the nest site. The location of the nest site will be as currently mapped (Chapter 2, Figure 2-9) unless adjusted based on actual occupancy field data.

The nesting core area will be designated prior to any harvest activities occurring in the surrounding approximately 502-acre core use area. If new owl nest locations are discovered in the future, outside of those shown in Chapter 2, Table 2-5, the Permittee will collaborate with USFWS, in accordance with the relevant provisions outlined in Chapter 7, Section 7.6, *Modifications to the Habitat Conservation Plan*, to determine whether to remove protections from another (inactive) nesting core area and apply protections to the nesting core area of the newly discovered (active) nest site. This "swapping" of nest sites would maintain protections on at least 22 nesting core areas and allow the Permittee to focus on the 22 nest sites with the highest-quality habitat and documentation of nesting activity at any one time.

5.5.4 Condition 3: Retention of Northern Spotted Owl Core Use Areas

Core use areas of at least 502 acres of the highest-quality contiguous habitat will be established around the historic northern spotted owl activity centers listed in Chapter 2, Table 2-5. The 502 acres do not need to be in a circle but will be contiguous, and the edge of the core use area will be no less than 300 feet from the nest location. Within the core use areas, at least 50% (more than 251 acres) of the highest-quality contiguous habitat will be retained at all times. For core use areas that extend beyond the permit area the Permittee will be responsible for retaining nesting, roosting, and foraging habitat on at least 50% of the total area inside the core use area (which is also inside the permit area).

The 50% amount is based on the *Revised Recovery Plan for Northern Spotted Owl*, which identifies sites currently with >50% nesting, roosting, and foraging habitat in the core use area (i.e., 0.5-mile radius) as a high priority for conservation because such sites are most likely to support nesting spotted owls (U.S. Fish and Wildlife Service 2011).

The definition of nesting, roosting, and foraging habitat will be based on the most up-to-date scientific information and regulatory standards. At present, the assumed definition is that described in Davis et al. (2016) and equates to how that publication defines highly suitable, suitable, and marginal nesting and roosting habitat (Chapter 2, Section 2.3.2, *Population and Habitat Status*).

Core use habitat will not need to be kept in the same location through time, as long as minimum quality and quantity are retained. The location of designated core use areas may be reallocated within each 502-acre core use area. Any core use areas that currently do not meet the minimum standard of at least 251 acres of nesting, roosting, and foraging habitat will not be thinned or harvested until that minimum is met. Once met, the percentage of nesting, roosting, and foraging habitat will not drop below the 50% threshold. Retention and long-term application of ecological forestry practices within extensive and thinning treatment areas may contribute to the maintenance and improvement of the highest-quality contiguous habitat selected to meet this 50% threshold.

This standard will be applied to at least 22 northern spotted owl core use areas at any one time. Initially, this condition will apply to northern spotted owl activity centers shown in Chapter 2, Figure 2-9. If new owl nest locations are discovered in the future, outside of those shown in Figure 2-9, the Permittee will collaborate with USFWS, in accordance with the relevant provisions outlined in Chapter 7, Section 7.6, *Modifications to the Habitat Conservation Plan*, to determine whether to remove protections from another (inactive) core use area and apply protections to the core use area of the newly discovered (active) nest site. This “swapping” of nest sites would maintain protections on at least 22 core use areas and allow the Permittee to focus on the 22 nest sites with the highest-quality habitat and documentation of nesting activity at any one time.

In addition, if a nesting area were to shift from the designated activity center, the Permittee would have the option to shift the protection areas within core use areas in collaboration with USFWS, in accordance with the relevant provisions outlined in Chapter 7, Section 7.6, *Modifications to the Habitat Conservation Plan*, but such shifts are not a condition or requirement of the HCP and may not be feasible, considering the importance of long-term predictability of management to retain the research framework.

5.5.5 Condition 4: Retention of Habitat in Northern Spotted Owl Home Ranges

The Permittee will retain at least 40% of the home range (a 1.5-mile-radius circle centered on the activity center) as the highest-quality nesting, roosting, and foraging habitat around the 22 historic activity centers also covered under Conditions 2 and 3. If new owl nest locations are discovered in the future, outside of those shown in Chapter 2, Figure 2-9, the Permittee will collaborate with USFWS, in accordance with the relevant provisions outlined in Chapter 7, Section 7.6, *Modifications to the Habitat Conservation Plan*, to determine whether to remove protections from another (inactive) home range and apply protections to the home range of the newly discovered (active) nest site. This "swapping" of home ranges would maintain protections on at least 22 home ranges and allow the Permittee to focus on the 22 nest sites with the highest-quality habitat and documentation of nesting activity at any one time. For a 1.5-mile-radius circle, 40% equates to 1,809 acres. For areas within the home range but outside of the core use area, the contiguous habitat requirement will not apply to the broader home range area, although any habitat grown and used as replacement habitat must meet the requirements of the highest-quality nesting, roosting, and foraging habitat. The definition of highest-quality nesting, roosting, and foraging habitat is the same as that described in Condition 3. Similar to the requirements in core use areas, activity centers for which the home range radius (1.5 miles) extends outside of the permit area, the Permittee is only responsible for retaining at least 40% of the total area that is inside the permit area and, therefore, in the Permittee's control.

The 40% amount is based on the *Revised Recovery Plan for Northern Spotted Owl*, which identifies sites currently with more than 40% nesting, roosting, and foraging habitat within the home range (i.e., 1.5-mile-radius circle from nest tree/activity center) as a high priority for conservation because such sites are most likely to support nesting spotted owls (U.S. Fish and Wildlife Service 2011).

5.5.6 Condition 5: Maintenance of Northern Spotted Owl Dispersal Landscape

This condition establishes the commitment to retain at least 40% of the MRW as dispersal habitat, which is habitat that both juvenile and adult northern spotted owls use to move across the landscape to establish a new territory (Lesmeister et al. 2018). Although suitable nesting, roosting, or foraging habitat is likely the best dispersal habitat, owls will use younger forest for dispersal. Dispersal habitat can occur between larger blocks of nesting, foraging, and roosting habitat or within blocks of nesting, roosting, and foraging habitat. Dispersal habitat is believed to be essential for the establishment of new territories in unoccupied habitat and to allow gene flow across the range of the species, and is considered essential to maintaining stable populations (USFWS 2011).

The Interagency Scientific Committee (Thomas et al. 1990) first suggested the 50–11–40 standard for maintaining dispersal habitat across landscapes, and this continues to be the standard used by USFWS (2011). The standard is met when forests—at a landscape level—are composed of at least 50% of trees with 11 inches diameter at breast height or greater, and with roughly a minimum 40% canopy cover. Setting the commitment in this condition at 40% dispersal habitat meets this standard.

The majority of the CRW and MRW Reserves are expected to continue to develop into nesting, roosting, and foraging habitat over the permit term. These areas will also continue to support dispersing northern spotted owls. The Permittee's commitment to retaining at least 40% of the MRW as dispersal habitat is an acknowledgment that habitat quality will be reduced in areas that are intensively harvested, and in some areas that are extensively harvested, if retention is low.

Suitable nesting, roosting, and foraging habitat is also dispersal habitat, so that the 40% minimum dispersal landscape will consist of a mixture of suitable and dispersal-only habitat, as needed to meet HCP's biological goals and objectives, including Objective 1.3 (dispersal habitat). It is anticipated that the dispersal habitat commitment will be achieved through the covered activities and conservation measures, and that this commitment is primarily to monitor and report that dispersal habitat in the MRW is being maintained at 40% or greater.

5.5.7 Condition 6: Seasonal Restrictions in Marbled Murrelet Occupied Habitat

To avoid disturbance to nesting marbled murrelet adults and chicks, the Permittee will apply seasonal restrictions for covered activities. Under Condition 6, seasonal restrictions will apply in designated occupied habitat, or other areas that have been determined to be occupied using surveys described in Condition 7, during the murrelet nesting season (April 1–September 15). Seasonal restrictions prohibit certain covered activities from occurring within a set distance of occupied habitat, using distances approved as adequate by USFWS. Recommended distances identified by USFWS (2020b) for marbled murrelet—as applied to covered activities—are listed in Table 5-6. Some activities can have daily restrictions as well, which avoid disturbance during certain times of day later in the nesting season.

Table 5-6. Seasonal Restriction Distances for Marbled Murrelet Occupied Habitat [a]

Covered Activity	Critical Breeding Season (April 1–August 5) [b]	Late Breeding Season (August 6–September 15)
Light maintenance of roads, campgrounds, and administrative facilities	No restrictions [c]	No restrictions
Log hauling on open roads	No restrictions	No restrictions
Chainsaws (includes felling hazard/danger trees), drones	110 yards	Time-of-day restrictions [d]
Heavy equipment for road construction, road repairs, bridge construction, culvert replacements, etc.	110 yards	Time-of-day restrictions
Pile-driving (steel H piles, pipe piles), rock crushing, and screening equipment	120 yards	Time-of-day restrictions
Blasting [b]	0.25 mile	0.25 mile
Helicopter: Chinook 47d (described as a large helicopter in the rest of this document)	265 yards [e]	100 yards (hovering only)
Helicopter: Boeing Vertol 107, Sikorsky S- 64 (SkyCrane)	150 yards [e]	50 yards (hovering only)
Helicopters: K-MAX, Bell 206 L4, Hughes 500	110 yards [e]	50 yards (hovering only)

Covered Activity	Critical Breeding Season (April 1–August 5) [b]	Late Breeding Season (August 6–September 15)
Small fixed-wing aircraft (Cessna 185, etc.)	110 yards [e]	Time-of-day restriction
Tree climbing	110 yards	Time-of-day restrictions
Burning (prescribed fires, pile burning)	0.25 mile	Time-of-day restrictions
Drone use	110 yards	110 yards
Other activities	100 yards	100 yards

[a] These restrictions apply unless DSL is under a fire, search and rescue, or other public emergency in the vicinity of the designated occupied habitat. Distances are measured from the nest tree location if known or edge of nesting stand if exact location is not known.
[b] 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.
[c] Disturbances with no likely adverse effects and associated no restrictions needed are based on conclusions presented in USFWS 2016.
[d] No disturbance from 2 hours before sunset until 2 hours after sunrise.
[e] Distance should measure from top of tallest tree. Rotor-wash from large helicopters is expected to be disruptive at any time during the nesting season due the potential for flying debris and shaking of trees located directly under a hovering helicopter. Because murrelet chicks are present at the nest until they fledge, they are vulnerable to direct injury or mortality from flying debris caused by intense rotor-wash directly under a hovering helicopter.

The Permittee may deviate from these restrictions only in situations where either (1) applying these restrictions would compromise the safety of ESRF staff, contractors, or members of the public; or (2) applying a more limited restriction is clearly justified based on site conditions (e.g., topographic features on the landscape shield the occupied site from the activities in question), and there would be little to no likelihood of incidental take. Deviations from these restrictions are expected to be rare and will be applied by the Permittee only after a site-specific review by the wildlife biologist, documentation of recommendations, and approval by the ESRF'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 annual reporting requirements, as described in Chapter 6, *Monitoring and Adaptive Management*.

5.5.8 Condition 7: Survey Requirements for Modeled Potential Marbled Murrelet Habitat

To minimize effects, and regardless of stand age, all modeled potential marbled murrelet stands, as defined in this HCP (Chapter 2, Figure 2-13), that are subject to proposed harvest treatments, will be examined for presence of marbled murrelet nest sites prior to treatments utilizing the following three-step process. Harvest treatments will not occur in habitat determined to be occupied through this process.

1. **Desktop review.** All harvest treatments in the modeled potential marbled murrelet habitat layer will be reviewed using the most current air photos and LiDAR imagery to determine which have contiguous patches of trees older than 80 years (estimated current age at time of review)

that are 5 acres[13] or larger. Contiguous potential habitat is that which contains no gaps in suitable forest cover wider than 328 feet. Stands that do not have contiguous patches of trees older than 80 years (estimated current age at time of review) can be managed as described in Chapter 3, *Covered Activities*. Those stands that do have contiguous patches of trees older than 80 years will undergo a field assessment.

2. **Field assessment.** Harvest treatments in modeled potential marbled murrelet habitat that have contiguous stands of residual trees 5 acres or larger that are likely older than 80 years will undergo a field assessment by a marbled murrelet biologist to determine the likelihood that those stands support nesting marbled murrelets. Aspects of stand size, stand age, and habitat structure will be considered in the field assessment. Those stands that are determined to have characteristics that could support nesting marbled murrelets will be included in a marbled murrelet survey effort (Step 3).

3. **Marbled murrelet nesting survey.** Those stands that are determined in the desktop review to have contiguous habitat and in the field assessment to have characteristics that could support nesting marbled murrelets will be surveyed for murrelets. Surveys will follow occupancy survey methods accepted by USFWS at that time to determine site occupancy status (currently Pacific Seabird Group 2024a, 2024b). Current protocols call for 2 consecutive years of intensive surveys to determine presence or probable absence. This may include acoustic detection at some point during the permit term, as defined by future protocols. Surveys may also be modified to meet the needs of ongoing marbled murrelet research projects, upon approval from USFWS. At a minimum, all survey protocols will include survey information sufficient to make occupancy determinations (i.e., presence or probable absence) and to make comparisons across the permit area and across survey years (e.g., surveying during “favorable” and “unfavorable” ocean condition years (Betts et al. 2020a).

4. **Modeled potential habitat redesignation.** Those stands surveyed using occupancy survey methods accepted by USFWS and found to be occupied will be designated as *occupied* and managed as an MRW Reserve, expanded RCA, or aggregate retention under extensive harvest treatments. For those stands found to not be occupied (i.e., probable absence) after completing the required number of surveys over each of 2 consecutive years, the survey area will be classified as *not occupied* for a period of 5 years (Pacific Seabird Group 2024a).

Ultimately, presence or probable absence is what will influence decisions around how a stand is managed. Surveyed stands planned for harvest treatments that are found to be occupied shall have the contiguous occupied habitat designated as occupied and managed in accordance with other marbled murrelet occupied habitat (Conservation Measure 5, Conditions 6 and 8). This could take the form of an aggregate retention area in portions of extensive treatment areas, but with no future thinning or harvest activities and subject to Conservation Measure 5’s buffering approach (if future harvest is proposed in adjacent modeled potential habitat). Areas of modeled potential habitat found to be occupied and, therefore, rendered ineligible for harvest, can be reallocated to another part of the subwatershed not occupied by marbled murrelets or, if relocation in that subwatershed is not possible, then as below.

[13] The 5-acre cutoff for modeled potential habitat was chosen in consultation with USFWS as a reasonable cutoff for mapping modeled potential habitats in the permit area. Small stands are not considered high-quality nesting habitat due to pervasive edge effects. A 100-meter radial edge effect buffer on a nest tree is equal to an area of 7.76 acres.

If modeled potential habitat in areas that became designated for extensive treatment are found to be occupied, an equivalent amount of timber volume as the treatment acreage found to be ineligible would become available for extensive harvest subject to availability in the Volume Replacement allocations (Chapter 3, Section 3.3.4, *Volume Replacement Allocations*) or other eligible allocations where the Services concur with a finding of probable absence. Harvest in Volume Replacement allocations or other eligible replacement allocations, should they be necessary, would be subject to other restrictions applicable to habitats in northern spotted owl activity centers (Section 5.5.4, *Condition 3: Retention of Northern Spotted Owl Core Use Areas*), marbled murrelet buffers within 164-foot of occupied habitat (Section 5.4.5, *Conservation Measure 5, Harvest and Thinning Adjacent to Occupied Marbled Murrelet Habitat*), RCAs (Section 5.4.2, *Conservation Measure 2, Expanded Riparian Conservation Areas on Select Management Research Wetland Streams*), and any remaining areas of old growth (pre-1868 trees and stands).

5.5.9 Condition 8: Limits on Harvest and Designation Changes in Occupied and Modeled Potential Marbled Murrelet Habitat

Intensive or extensive harvest treatments in modeled potential marbled murrelet habitat are prohibited unless they are in areas determined as not occupied (i.e., probable absence) through the process set forth in Condition 7.

Locations that were previously determined to be occupied will continue to be considered occupied if there have been no changes to habitat condition since the last marbled murrelet detections were made (e.g., pre-HCP harvest or other stand management activities, or substantial changes in habitat quality due to natural events such as storms, fire, or disease). Currently, there is no protocol for establishing when a site that was occupied is considered no longer occupied, apart from substantial changes to forest composition detailed in Chapter 7, Section 7.8, *Changed and Unforeseen Circumstances*. However, an acceptable method for designation changes of occupied marbled murrelet habitat has the potential to be accepted in the future if scientifically supported. Any changes to an occupied stand designation will be addressed in accordance with Chapter 7, Section 7.6*, Modifications to the Habitat Conservation Plan*.

This condition only applies to designated occupied and modeled potential habitat as defined in Chapter 2, Figure 2-13. Any areas outside of designated occupied or modeled potential habitat, as shown in Figure 2-13, can be managed as described in Chapter 3, *Covered Activities*.

The Permittee anticipates future research relevant to the impacts of forest management activity on marbled murrelet behavior, including edge or disturbance-related effects. Such research may focus on effects from extensive harvest or related management activity in modeled potential habitat immediately adjacent to occupied habitat, subject to Conservation Measure 5, the 3,200-acre cap on harvest in stands older than 65 years (as of 2020), and other relevant conditions in this HCP. While responses in occupied habitat may be the focus of the research, and while research, equipment, and data collection may occur within the occupied habitat, harvest activity will be located outside of it. Further, any known nest trees or trees within 300 feet of known nest trees will be included in retention areas for any allowable extensive treatment.

5.5.10 Condition 9: Maintaining Aggregate Amount of Marbled Murrelet Occupied Habitat Over Time

There will be no temporal loss of the aggregate number of acres of designated occupied habitat or HSI-weighted-acres (HSI-acres) as a result of harvest treatments in the permit area. This condition applies to designated occupied habitat as defined in this HCP (Chapter 2, Figure 2-13). Any areas of modeled potential habitat that are found to not be occupied and areas outside of modeled potential habitat, are not subject to this requirement and can be managed as described in Chapter 3, *Covered Activities*. This measure will support achieving Goal 2 and associated objectives, specifically Objectives 2.1 and 2.3.

Potential marbled murrelet habitat will be maintained across the permit area by maintaining an area-weighted mean marbled murrelet HSI value as described in Objective 2.3. Although the likely future scenario will involve increasing levels of both occupied and suitable marbled murrelet habitat over time, this condition will ensure, at a minimum, that acres of habitat suitable for marbled murrelet occupancy will not fall below 2022 forest conditions at any point during the permit term.

Additionally, buffering and protection of newly occupied habitat and nesting habitats managed as reserve could be used to offset temporary degradation of occupied habitats in areas adjacent to modeled potential habitat not yet surveyed for occupancy, or in areas where forest is too young or incontiguous to have been classified as modeled potential habitat as of 2020. If harvest activities indicate the HSI-weighted-acres will drop below committed retention levels, the Permittee can modify harvest activities to reduce impacts. Modifications could include additional buffering (beyond those described in Conservation Measure 5) and protection of nesting habitats to offset temporary degradation of nesting habitat.

Acres of occupied habitat and HSI-acres will be accounted for annually and summarized in annual reports along with 6-year Summary Reports and 12-year Comprehensive Reviews, including the newly discovered locations in the CRW or MRW Reserves, to demonstrate compliance with this condition.

5.5.11 Condition 10: Management on Steep Slopes

The forestry management activities covered in this HCP are designed to protect the ecological processes associated with landslides while minimizing detrimental impacts on the aquatic environment supporting Oregon Coast coho. These processes include but are not limited to delivery of sediment, nutrients, and large wood to streams supporting fish and amphibians. Landslides are also important processes to promote storing and processing of organic materials critical for invertebrate production in fish-bearing streams. The goal of steep-slope management is to provide protections to fish-bearing streams while preserving the ecological function of the landscape and providing opportunities to further understand the effect of forestry management on steep slopes. The permit area will be managed such that research into the effects of a suite of forestry management strategies on steep-slope stability can be evaluated along with the ecological consequences of any resulting slope failures. Research in the permit area will examine key processes leading to the production and delivery of large trees and sediment/nutrient pulses to aquatic systems and how specific forestry actions affect those processes.

Given the extent of steep topography in the permit area, a high proportion of treatments in the MRW may occur on slopes greater than 65% (Chapter 4, Table 4-10). During harvest planning and layouts, intensive harvests will avoid slopes identified to be unstable by the Slope Stability Analysis tool (TerrainWorks 2021) unless field surveys reveal that areas are suitable for harvest. Moreover, in the full subwatersheds associated with the Triad research design, each acre slated for intensive harvest will be matched with an equal amount of acreage placed in Reserves in the same subwatershed designation. This approach will ensure that at least 50% of any given intensively managed subwatershed will be placed in a Reserve, which provides further protections to the function of landslides. In extensive or restoration thinning treatments, field surveys and/or retention commitments can address concerns over areas identified as unstable by the Slope Stability Analysis tool. Also, across treatment types, cable or tethered logging systems will primarily be used on slopes >40%, new road construction (temporary and permanent) will be located in stable locations (ridgetops, stable benches, or flats). Additionally, treatments in stands <65 years (as of 2020) will be focused on previously logged stands where construction of new roads will be minimal.

5.5.12 Condition 11: Road Construction and Management

5.5.12.1 Construction

Construction of road networks can lead to accelerated erosion rates in a watershed (Furniss et al. 1991). 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 (Furniss et al. 1991). Many of these problems with forest road construction can be traced back to poor road design; however, in the permit area most roads are sited on upper slopes (58%), where they are hydrologically disconnected and unlikely to degrade the aquatic resource. With continued careful siting of roads and appropriate planning to minimize the length of roadbed needed to support timber management activities, fire protection, and recreational uses, the impacts of road construction and maintenance can be minimized.

Geotechnical specialists will be consulted, as needed, while designing roads. Their input, based on interpretive geology and the use of soil and rock mechanics in slope stability analysis, provides a rationale for risk assessment and mitigation in road construction decisions. The use of geotechnical analysis in road construction makes it possible to minimize the number or magnitude of road construction activity–induced soil movements and protect Oregon Coast coho.

The following road design measures will be implemented to minimize potential impacts on the covered aquatic species. The intent of these road design measures is to hydrologically disconnect the road system from streams and supplement the Oregon FPA restrictions included in Chapter 3, Section 3.6.1, *Road System Construction and Management*.

- Temporary and permanent roads and landings will be located on stable locations (e.g., upper slope, midslope, or flats) and gentle to moderate side slopes, and will be constructed at least 35 feet from the edge of the aquatic zone, whenever possible. Road development within the RCAs will only occur when other alternatives are not operationally feasible (Chapter 3, Section 3.6.1.1, *Road Construction*).
- All new roads will be located away from sensitive resource sites (including streams, wetlands, and unstable areas) and sensitive wildlife habitats (known northern spotted owl nesting core areas and marbled murrelet occupied habitat) to the maximum extent practicable.

- Removal of trees older than 150 years old (in 2020), or trees with structures known to be important to the covered species (e.g., potential murrelet nesting platforms, within retained northern spotted owl core areas) will be avoided.
- Where crossings of fish-bearing streams occur, bridges and culverts will be designed to meet current standards (National Marine Fisheries Service 2022b; ODFW fish-passage laws [Oregon Revised Statute 509.580 through 910 and OAR 635, Division 412]).
- New roads will use the minimum practical design standards with respect to road width, radius, and gradient. This will minimize road width and the resultant cut-and-fill slopes, minimizing effects on the covered aquatic species from new road construction.
- Road designs will provide for proper drainage of surface water and will not introduce runoff into streams. These measures could include the use of grade breaks, outsloping, insloping, ditching, road dips, water bars, and relief culverts.
- Cross drains will not discharge onto unstable slopes, and full-bench construction (no sidecast fill) will be used on steep slopes (>65%) to avoid sidecast failure.
- Rock fill will be installed over culverts to reduce the risk of erosion and failure, in case culverts become plugged or overtopped.
- The road runoff to the stream channel will be disconnected by outsloping the road 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 through cross-drain placement above the stream crossing (minimum of 200 feet from a stream).
- Underdrain structures will be installed when roads cross or expose springs, seeps, or wet areas rather than allowing intercepted water to flow downgradient in ditch lines.
- Surface drainage structures (e.g., broad based dips, leadoff ditches) will be armored to maintain functionality in areas of erosive and low-strength soils.
- To reduce surface erosion, vegetation removal, soil disturbance, and clearing and grubbing will be limited to the minimum needed to construct the road.
- Excess road excavation materials will be disposed of at a stable site outside the 100-year floodplain that will not contribute to sedimentation or otherwise degrade covered species habitat.
- Roads with high erosion potential will be rocked. The hardest crushed rock available will be used when rocking a road with the potential to deliver sediment to streams to reduce road surface erosion and generation of sediment into adjacent waterbodies. Increased thickness of surfacing material has been found to reduce surface erosion by approximately 80%.
- All road drainage structures (e.g., ditches, outsloping, culverts, water bars, dips) will be in place during construction of the road and before the rainy season.

5.5.12.2 Maintenance and Use

As described in Chapter 3, Section 3.6.1, *Road System Construction and Management*, forest roads will be designed, built, and maintained to minimize impacts on the covered species. Proper construction practices will reduce erosion and stream sedimentation impacts on the covered species. However, soil erosion and stream sedimentation may occur during and following road construction or maintenance. During the road assessment described in Conservation Measure 3, the Permittee will identify existing roads that pose a sediment delivery risk to streams in the permit area. Roads with the potential to deliver sediment to streams will be identified as part of the road assessment.

The following guidelines will be followed during road maintenance activities and use.

- Roads within or adjacent to RCAs that cannot be hydrologically disconnected (or connection cannot be mitigated), or are otherwise unsuitable for wintertime haul, will be closed to logging trucks during wintertime wet weather as specified by the Permittee. This includes all native surfaced roads (dirt).
- Commercial road use will be suspended where the road surface is deteriorating due to vehicular rutting, or where standing water and turbid runoff is likely to reach waters of the state.
- In-water construction (e.g., stream crossings) will follow the established *Oregon Guidelines for Timing of In-Water Work to Protect Fish and Wildlife* (Oregon Department of Fish and Wildlife 2023) to minimize impacts on the covered species and their habitat.
- Storage and staging areas for road construction, harvest activities, and HCP management and restoration projects will be sited at least 150 feet away from a waterbody or wetland to avoid erosion or contamination of waters of the United States. Staging areas may be closer than 150 feet if the area is outside the 100-year floodplain and spill prevention measures have been approved by the Permittee.
- Maintenance activities will be conducted outside of wintertime wet weather, as described in Chapter 3, Section 3.6.1, *Road System Construction and Management*, and specified by Permittee. If rainy weather occurs, erosion and sediment control measures will be implemented and reinforced to ensure no sediment has potential to reach streams. Soils that are saturated with water, that would become muddy when disturbed, will be allowed to drain before maintenance or construction resumes.
- Areas of bare soil that could deliver sediment to waters will have effective drainage established or will be mulched and 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.
- When a road construction or maintenance project is partially completed at the start of the rainy period (mid-October), the project will be left in a condition that minimizes erosion and the sedimentation of streams during the rainy period. Drainage measures will be performed on uncompleted subgrades, such as surface smoothing, outsloping, water-barring, and dip installation. Mulching and 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 or hay dams will be used near streams to prevent sedimentation. The road will be barricaded to prevent unauthorized use. Additional mitigation will be completed to address unanticipated impacts on covered species, if needed.

- The road surface will be drained effectively by using crowning, insloping or outsloping, grade reversals (rolling dips), and water bars 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, ditch lines, and waste-disposal sites with the potential for sediment delivery to wetlands, RCAs, 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 have soil-binding properties. Weed-free mulch will be applied at site-specific rates to prevent erosion.
- Prior to October 1, 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 gravel, 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. Crowning, outsloping, or insloping will be restored for the road type for effective runoff. Outlets will be removed or provided through berms on the road shoulder.
- Cleaned ditch lines and bare soils that drain directly to wetlands, floodplains, and waters will be seeded with native species and mulched with weed-free mulch.
- Undercutting of cut slopes will be avoided when cleaning ditch lines.

5.6 Beneficial and Net Effects

This section describes the positive impacts of HCP implementation that are expected to have a net beneficial effect for the covered species.

5.6.1 Northern Spotted Owl

While this HCP allows for take of northern spotted owl in the form of impacts including localized habitat loss and disturbance, the conservation strategy described in this chapter has been designed to result in long-term net benefits to northern spotted owls, as summarized below.

- **Net habitat gain.** The analysis indicates that covered activities will result in a net beneficial effect on northern spotted owl habitat. This effect includes long-term habitat gains that will enhance the permit area's capacity to support nesting pairs of northern spotted owls.
- **Habitat quality improvement.** Forest stands in the protected areas (including Reserves and RCAs) are expected to develop into higher-quality habitat over time, potentially increasing the capacity to support northern spotted owls. This includes improved stand structure, foraging habitat, and potential nesting and roosting habitat.
- **Large block of habitat.** The 33,571-acre CRW provides a significant block of habitat that will improve over time through natural growth and silvicultural treatments. This habitat block will be managed to support long-term ecological functions and cultural practices compatible with conservation efforts.

- **Restoration treatments.** Restoration treatments in former plantation stands in the reserves and RCAs will move these areas toward older forest conditions while minimizing harm to northern spotted owls.
- **Immediate suitable nesting habitat.** Approximately 53% (28,495 acres) of areas available for only restoration thinning or no treatments are currently modeled as highly suitable or suitable nesting/roosting habitat, providing an immediate stronghold for nesting habitat. An additional 443 acres of highly suitable or suitable habitat is further encumbered by the presence of marbled murrelet occupied habitats in the MRW owl circles and could not be harvested.
- **Potential expansion of suitable nesting habitat.** Stands in areas available for only restoration thinning or no treatments that do not currently provide suitable nesting/roosting habitat (approximately 25,500 acres) are expected to increase in their older forest characteristics, including stand structure, that will benefit northern spotted owls by providing more foraging habitat and potentially more nesting and roosting habitat.
- **Demographic support.** While habitat increases alone may not guarantee population growth due to factors like barred owl competition, the capacity of the permit areas to support northern spotted owl territories and provide important demographic support for the Coast Range population is projected to increase.
- **Research findings.** The ESRF design will provide scientific evidence relevant to management for northern spotted owl and its habitat in a commercial forestry context, including strategies involving partial retention forestry within extensive treatments, restoration treatments in reserves, and barred owl management in high-quality habitat (Appendix C, *Proposal: Elliott State Research Forest*).
- **Barred owl management.** Lethal removal of barred owl has been experimentally shown to be an effective management tool to mitigate negative impacts on northern spotted owls. Management will remove barred owls in amounts that facilitate sustained improved conditions for northern spotted owl persistence and recolonization in the ESRF (i.e., areas where barred owl and northern spotted owl competition is substantially reduced and sustained over time).

In summary, the avoidance, minimization, and mitigation provided by the covered activities and conservation strategy are expected to have a net beneficial effect on northern spotted owls, with a focus on habitat preservation, improvement, and potential expansion over time.

5.6.2 Marbled Murrelet

The conservation strategy outlined in this chapter would result in the following beneficial effects for marbled murrelets.

- **Net habitat gain.** The capacity for the permit area to support marbled murrelet nesting and reproduction is expected to increase over the permit term. Based on the HSI analysis conducted to evaluate edge effects over time, habitat value for marbled murrelets in the permit area is projected to increase more than 50% over the permit term (Chapter 4, Section 4.5.1.4, *Edge Effects*, and Appendix D, *Marbled Murrelet Habitat Suitability Index Approach*). This increase in habitat value over time will support the long-term conservation of the Oregon Coast Range population of marbled murrelets.
- **Habitat quality improvement.** While some short-term changes in habitat quality may result from treatments in the MRW (intensive or extensive), the extensive forestry objectives,

retention standards, MRW Reserve allocations, as well as combined conservation measures and conditions in the HCP are expected to lead to longer-term increases in habitat quality as near-term stand management activities result in larger-diameter trees over time.

- **Large block of habitat.** The CRW is expected to develop into a substantial block of habitat capable of supporting a high density of nesting pairs of marbled murrelets within the species' range, with a significant proportion of interior habitat and minimal habitat edge.
- **Habitat expansion.** The research design outlined in Chapter 3, *Covered Activities*, when implemented in accordance with the conservation strategy, is projected to expand habitat in the permit area over time. While not all stands that are currently nonhabitat and located in areas available for only restoration thinning or no treatments are expected to become occupied habitat during the permit term, the area suitable for supporting nesting marbled murrelets is anticipated to substantially increase (Section 5.3.3, *Forest Maturation Through the Permit Term*).
- **Immediate nesting habitat.** Currently, 69% (37,043 acres) of the total 54,062 acres in areas available for only restoration thinning or no treatments are designated as occupied or modeled potential marbled murrelet habitat, providing an immediate stronghold of potential nesting habitat.
- **Protected areas.** A significant portion of the permit area, approximately 65%, will be in conservation-dedicated areas safeguarding older trees and associated marbled murrelet habitat, including the 33,571 contiguous acres in the CRW and 20,491 acres in MRW allocations that are limited to restoration thinning, inoperable, or reserve status.
- **Demographic support.** The permit area is anticipated to offer demographic support to marbled murrelet populations along the Oregon Coast. The CRW's habitat will continue to improve over time, either through natural growth or restoration treatments aimed at accelerating late-successional stand development.
- **Research findings.** The ESRF design will test and provide evidence related to management for marbled murrelet and its habitat in a commercial forestry context, including habitat restoration and minimization of edge effects while allowing forest harvest operations (Appendix C, *Proposal: Elliott State Research Forest*). In summary, the avoidance, minimization, and mitigation provided by the covered activities and conservation strategy are expected to have a net beneficial effect on marbled murrelets by increasing their nesting and reproduction habitat capacity, safeguarding existing habitat, and offering demographic support to the species' populations along the Oregon Coast.

5.6.3 Oregon Coast Coho

The HCP covers three independent populations of the Oregon Coast coho ESU that occur in the permit area. While limiting factors vary across independent populations, the main factors limiting the Oregon Coast coho ESU in the permit area that could be affected by the covered activities are physical habitat quality and quantity and water quality associated with land management.

Full implementation of the HCP will result in a net increase in quality of available habitat for the Oregon Coast coho ESU populations in the permit area. With full implementation of the HCP, all fish-bearing streams, including all Oregon Coast coho streams in the permit area, will be managed and protected in the RCAs. Expected long-term benefits in and downstream of the permit area associated with the conservation actions include improved habitat, increased channel complexity, improved water quality conditions, increased habitat access, and improved functioning of riparian forest, which would address limiting factors for the Oregon Coast coho, and improved habitats over the course of the permit term.

Water temperatures within 31 miles of streams in the permit area are projected to reach between 18.1 to 23 degrees Celsius by 2080 (Chapter 4, Table 4-14). The proposed RCAs along fish-bearing streams are intended to ensure that riparian vegetation is functioning to provide stream shading and to mitigate climate change impacts on water temperatures. Riparian buffers of a size similar to that being proposed for the HCP can potentially offset temperature increases (Groom et al. 2011, 2018). In addition, the HCP's approach to landslide and wood delivery (HLDPs) and habitat restoration (instream and riparian) is anticipated to increase instream habitat complexity in ways that provide thermal refugia benefits to coho.

Reduction in summer flows (Figure 5-1) and increases in winter flows (Figure 5-2) are projected to be negligible in the permit area because intensive harvest will not exceed 50% in a given watershed, limiting the amount of clearcut areas and associated water quanity effects (Perry and Jones 2016). One potential consequence of increased winter flows is an increase in landslides. The establishment of RCAs along HLDP streams increases the likelihood that when landslides do occur wood will be delivered to fish-bearing streams. Large wood in debris flows and landslides influences the run-out length of these events (Lancaster et al. 2003). Debris flows without large wood move faster and farther than those with wood and are less likely to stop high in the stream network.

A debris flow without wood is likely to be a concentrated slurry of sediments of various sizes that can move at relatively high speeds over long distances, scouring substrate and wood from the affected channels. Both types of debris flows are more likely to negatively affect fish-bearing channels in the short term, as compared to the potentially favorable effects that result from the presence of wood. However, woodless debris flows can further delay or impede the development of favorable conditions for fish and other aquatic organisms. In contrast, those containing wood can help store sediments (Bunn and Montgomery 2004) and build terraces that can persist for extended periods (Lancaster and Casebeer 2007; May and Lee 2004), contributing to high-quality habitat for coho salmon.

Chapter 6
Monitoring and Adaptive Management

This chapter describes the monitoring and adaptive management framework for this habitat conservation plan (HCP), including guidelines, and specific recommendations that will help the Oregon Department of State Lands (DSL, the Permittee) 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, assess the status of covered species habitat, and evaluate the effects of management actions such that the conservation strategy described in Chapter 5, *Conservation Strategy*, including the biological goals and objectives, is achieved. Adaptive management and monitoring are integrated processes; monitoring will help inform potential changes to management actions, as appropriate and in coordination with the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) (together, the Services). This chapter provides an overview of the program, monitoring and management actions, and data and reporting requirements.

6.1 Regulatory Context

The *Habitat Conservation Planning and Incidental Take Permit Processing Handbook* (HCP Handbook) (U.S. Fish and Wildlife Service and National Marine Fisheries Service 2016) describes that an HCP must provide for the establishment of a monitoring program that (1) generates information necessary to assess compliance; (2) verifies progress toward achieving the biological goals and objectives of the HCP; (3) assesses the effectiveness of the conservation strategy to minimize and/or mitigate impacts; and, (4) to determine whether there is a need for adjusting measures to improve the conservation strategy. 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 HCP Handbook (U.S. Fish and Wildlife Service and National Marine Fisheries Service 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. Monitoring intentions will remain consistent throughout the permit term, aimed at tracking progress toward the biological objectives; however, the monitoring program and priorities may evolve to align with research projects and employ the latest accepted techniques and technologies. Any substantive changes will be reviewed and approved by the Services, in accordance with the relevant provisions of Chapter 7, Section 7.6, *Modifications to the Habitat Conservation Plan*. All data collected will be used to determine if the HCP effectively meets the biological goals and objectives. This information will be included in reporting, and any changes needed to continue to comply with the Stay-Ahead provisions will be completed. The reporting requirements and Stay-Ahead provision are described in Chapter 7, *Implementation and Assurances*.

6.2 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). The monitoring program will provide the information necessary to assess HCP compliance and project effects, verify progress toward achieving the biological goals and objectives, and provide the scientific data necessary to evaluate the success of the HCP's conservation program, using routine monitoring and modeling of ecosystem function that supports covered species. The Permittee will conduct compliance monitoring to ensure adherence to HCP implementation and management requirements, and effectiveness monitoring to determine if conservation measures are having the intended effect of improving conditions for covered species. Both compliance and effectiveness monitoring are discussed together in the monitoring sections that follow. Effectiveness monitoring will track long-term trends in ecosystem processes, covered species' responses to habitat management, and habitat quality over time. The following subsections describe these monitoring types.

6.2.1 Compliance Monitoring

Compliance monitoring (also known as implementation monitoring) tracks the status of HCP implementation and documents that the requirements of the HCP and permits are being met, including information on avoidance, minimization, and mitigation measures. The Permittee will track compliance monitoring internally to ensure the HCP is working as planned and will provide the monitoring results in the annual report to the Services, who will verify the Permittee remains in compliance with the HCP and incidental take permit requirements. As defined by the HCP, compliance monitoring will at a minimum track and report to the Services on the components listed below on an annual basis. Where applicable, these components will also be tracked by their occurrence in the conservation research watersheds (CRW) or management research watersheds (MRW), as well as by the allocations described in Chapter 3, *Covered Activities*.

- Location,[1] acres, and timing of loss of covered terrestrial species habitats. Geospatial data identifying the location of covered activities that were implemented during the year will be made available. For northern spotted owls, habitat losses and gains will also be tracked by habitat type (i.e., by nesting, roosting, and foraging habitat types as described in Chapter 5, Section 5.2.1, *Northern Spotted Owl,* and modeled potential habitat and habitat suitability index [HSI]) in Section 5.2.2, *Marbled Murrelet*).
- Types, acres, and location of silvicultural activities and supporting activities conducted in the permit area, including thinning, salvage harvest, prescribed fire or slash burning.
- Location of removal of cedar trees for Indigenous cultural use.
- Details regarding removal of any trees that predate the 1868 fire, including number, location, species, dimensions, age, forest stand conditions and context, and reason for removal.
- Miles and locations of all roads built and vacated, including those in reserves and riparian conservation areas (RCAs), and temporary and spur roads that have not been vacated after 5 years (Chapter 3, Section 3.6.1.5, *Road Vacating*).
- Monitoring and reporting of instances where roads are constructed within RCAs including the rationale for justification of the development within the RCA and why development outside of RCAs is not feasible.

[1] For coho, location identifies the independent population.

- Number and location of fish-passage barriers upgraded or removed and demonstrated consistency with NMFS' most recent fish-passage criteria when applicable.
- Emergency fish-passage work to include location, cause of issue, and if the fix is permanent or temporary.
- Acres of upland restoration activities completed by allocation type.
- Miles of stream and acres of riparian habitat thinned, percent retained, and resulting stand density in relation to the 40-square-foot/acre minimum.
- Location of harvest and width of RCAs implemented in harvest units by allocation type.
- Location and percentage of steep slopes purposely avoided pursuant to Condition 11 in all harvest treatment types.
- Type, number, and location and stream miles treated of aquatic restoration projects completed.
- Monitoring the number of coho salmon taken during fish salvage or fish surveys associated with the research plan.
- Any waivers to the proposed actions, conservation measures, and conditions, as well as documentation of any required pre-approvals by the Services.

6.2.2 Effectiveness Monitoring

Effectiveness monitoring assesses the biological success of the HCP. Effectiveness monitoring evaluates whether the effects of the conservation strategy are achieving the HCP's biological goals and objectives as described in Chapter 5, *Conservation Strategy* (U.S. Fish and Wildlife Service and National Marine Fisheries Service 2016). Effectiveness monitoring typically measures the effects of management actions on covered species, status and trends in resources, and status and trends of stressors to the covered species (Atkinson et al. 2004).

Understanding the effects of management actions is a critical component of the monitoring and adaptive management program. The purpose of this monitoring is to ascertain the success of management in achieving the biological goals and objectives, to provide information and mechanisms for altering management if necessary, and to evaluate whether the conservation strategy described in Chapter 5, *Conservation Strategy*, is successful.

The biological goals and objectives will inform success criteria so it is clear whether progress is being made toward biological goals and objectives during the permit term. The proposed approach for developing baseline conditions for aquatic and terrestrial monitoring is described in Section 6.3, *Aquatic and Riparian Monitoring*, and Section 6.4, *Terrestrial Monitoring*, respectively.

Completed monitoring activities will be reported in annual reports, while monitoring results will be summarized in the 6-year Summary Report and then analyzed in more depth in the 12-year Comprehensive Review, as described in Chapter 7, *Implementation and Assurances*.

6.3 Aquatic and Riparian Monitoring

In addition to the compliance monitoring commitments in Section 6.2.1, *Compliance Monitoring*, as the forests in the permit area age and research progresses, effectiveness monitoring will track long-term habitat trends and track the conservation strategy's effectiveness in achieving the biological goals and objectives. Additionally, data collected through the research program will be shared with NMFS. The treatments applied throughout the permit area and the data collected will be used to improve knowledge around forestry management and its effects on Oregon Coast coho (*Oncorhynchus kisutch*) habitat.

The aquatic monitoring program focuses on monitoring trends in aquatic habitat quality associated with reserve, extensive, and intensive treatments (including road development and other related covered activities) over the course of the permit term; it is not intended to be a measure of production (i.e., number of fish) of Oregon Coast coho in the permit area.

Instream habitat monitoring will occur as described Section 6.3.3, *Instream Habitat Monitoring*, on up to five, 200-meter reaches in each treatment type (reserve, extensive, intensive; up to 15 reaches total) based on where potential high-quality coho habitat has been mapped and where harvest treatments or other ground-disturbing actions are expected to occur within the first 5 years of HCP implementation. The 200-meter reach length is consistent with Oregon State University (OSU) research study designs and would facilitate coordination and comparisons across the HCP, associated Elliott State Research Forest (ESRF) research programs, and potentially with monitoring efforts advanced by other entities the area (e.g., the Oregon Department of Fish and Wildlife [ODFW], watershed associations). Each site will be established at least 1 year prior to harvest treatment or related activities and will be maintained for at least 9 years and includes monitoring pre- and post-harvest treatment and related covered activities (e.g., road maintenance or construction). Monitoring data collection for turbidity (Section 6.3.1, *Turbidity Monitoring*) and temperature (Section 6.3.2, *Water Temperature Monitoring*) will tier to these instream habitat monitoring sites as described below, whereas monitoring of RCA thinning (Section 6.3.4, *Riparian Restoration Monitoring*) will occur independently as described below.

Instream habitat monitoring sites may be moved after their 9-year cycle to capture additional treatment areas and effects elsewhere on the ESRF. Establishment of new sites will be coordinated with the implementation and adaptive management committee (Chapter 7, Section 7.2.5, *Implementation and Adaptive Management Committee*).

Research-related monitoring would occur in addition to the HCP monitoring program. A central component of the 2021 Research Proposal advanced for the ESRF is evaluating the effects of restoration thinning in previously managed RCAs on coho habitat and abundance. OSU is actively engaged in developing rigorous study plans to evaluate the effects of RCA thinning on coho habitat quality in the permit area. The data and findings from OSU research will be made fully available to the HCP team and will be incorporated into HCP monitoring reports submitted to the Services. RCA thinning prescriptions and monitoring plans will be shared with the Implementation and Adaptive Management committee for approval prior to implementation. As stated in Chapter 3, *Covered Activities*, RCA thinning would only occur as part of research, meaning that unless a specific research study with pre- and post-monitoring is being funded and advanced design, the RCA thinning would not occur. Thus, any associated evaluations of effects of RCA thinning would be conducted as part of the implemented research projects.

Habitat monitoring data will be collected at all instream habitat monitoring sites every third year. Data loggers collecting temperature and turbidity data will be download yearly. Completed monitoring activities will be reported in annual reports, while trends in habitat quality will be summarized in the 6-year Summary Report (Chapter 7, Section 7.3.2, *Six-Year Summary Report*) and a more comprehensive assessment will be completed during the 12-year Comprehensive Review (Chapter 7, Section 7.3.3, *Twelve-Year Comprehensive Review*). The intention is to track trends in coho salmon habitat quality over time and relate the trends back to the management activities and conservation measures in the permit area to determine if the conservation strategy is performing as anticipated.

6.3.1 Turbidity Monitoring

Paired turbidity monitors will be installed in the 15-instream habitat monitoring reaches described above in Section 6.3, *Aquatic and Riparian Monitoring*. The intent is to position loggers to capture changes in turbidity conditions caused by extensive, intensive, and reserve treatments. Placement of loggers will allow the Permittee to report on trends in turbidity at relevant reporting intervals.

Additional turbidity monitoring may occur in locations that are determined to be "problem" areas identified during the road analysis (Chapter 5, Section 5.4.3, *Conservation Measure 3, Reduce Density of the Forest Road Network in the Permit Area*), where the 15-instream monitoring reaches would not otherwise detect turbidity impacts. Additional monitoring will attempt to determine the degree to which those locations contribute sediment in order to prioritize when and how to address those road segments. Monitoring will occur both before (6–12 months prior to work occurring) and after those road segments are addressed to determine whether there is a measurable difference in sediment delivery to the stream. These data will inform how the Permittee addresses future road segments that can contribute sediment to the aquatic environments.

Reporting of turbidity data will be provided in the annual reports and summarized and reviewed during the 6-year Summary Report and 12-year Comprehensive Review. Road issues that are identified during monitoring activities will be added to the road inventory described in Chapter 5, Section 5.4.3, *Conservation Measure 3, Reduce Density of the Forest Road Network in the Permit Area*, and be prioritized for improvement or vacating.

6.3.2 Water Temperature Monitoring

The Permittee will implement a year-round monitoring program to track trends in water temperatures across the permit area for the duration of the permit term. The Permittee will place recording thermographs in the 15 instream habitat monitoring reaches (Section 6.3, *Aquatic and Riparian Monitoring*), which will be distributed between the treatment types to ensure adequate data is collected to evaluate effects of HCP implementation. Data collected will be provided to the Services in the annual reports, 6-year Summary Report, and 12-year Comprehensive Review to show trends in temperature change. If trends reported in the 6- and 12-year reports show management related temperature increases that result in watershed exceedances of greater than 0.3 degrees Celsius (°C) for more than 5 years post-harvest, adaptive management responses will occur as described in Section 6.5, *Adaptive Management*.

In addition to what is stated in Section 6.3.4, *Riparian Restoration Monitoring*, changes in water temperatures associated with RCA thinning will be quantified using a paired watershed approach to control for environmental variability, so that effects caused by restoration thinning within RCAs can be appropriately quantified. Control watersheds, where restoration thinning does not occur, are critical for the analytical design to control for confounding factors (e.g., climate) and ensure that estimates of temperature changes caused by the restoration thinning are accurate. Temperature trends will be evaluated in relation to the Biologically Based Numeric Criteria (BBNC) and the

Protecting Cold Water (PCW) criterion (Oregon Administrative Rule 340-041-0028(4) and 340-041-0028(11)), which, should temperatures rise above these criterion, presents a unique opportunity to determine the ecological impacts of exceeding the BBNC and the PCW. However, as stated in Chapter 3, Section 3.3.7.4, *Operational Standards for Restoration Thinning in Riparian Conservation Areas*, and in Chapter 5, Section 5.4.1, *Conservation Measure 1, Targeted Restoration and Stream Enhancement*, the goal would not be to cause temperatures to increase but rather to support and enhance the long-term ecological functions of the RCAs by minimizing the likelihood of adverse conditions developing.

The initial assessment of riparian restoration thinning inside ELZs on 160 acres of RCAs along fish and non-fish-bearing streams will provide the basis for subsequent thinning actions. For example, if after the initial assessment water temperatures are found to be trending higher due to the magnitude of thinning, all subsequent restoration thinning actions would be designed and implemented using the findings from the initial study to minimize the likelihood of reducing shade to the point that water temperatures increase. Temperature monitoring would continue following the initial assessment and restoration thinning actions would continue to be refined to ensure risk of increasing water temperatures are minimized.

6.3.3 Instream Habitat Monitoring

The Permittee will collect and monitor data on instream habitat variables annually consistent with the overarching approach to sites described in Section 6.3, *Aquatic and Riparian Monitoring*. The collection methods and sampling regime will generally be consistent with techniques set by ODFW Aquatic Inventories Project data, to monitor trends in physical habitat attributes in the permit area over the course of the permit term.

For the purposes of this HCP, the following variables will be tracked over time to represent the trends in habitat quality.

- Wood (size classes to be determined); total count.
- Pools; number, depth, and size.
- Fine sediments in riffles; at systematically determined intervals.
- Summer low flow; 30-day average water flow; length of dry channels and/or distance of dry channels between pools.
- The extent of multiple channels; number of channels and total length.
- Beaver activity; number of sites and estimated area affected.
- Vegetative conditions; metrics to be determined.
- Monitor amount of solar radiation reaching the channel.

Vegetation data may be gathered using remote-sensing technologies (e.g., light detection and ranging [LiDAR]) and other automated monitoring capabilities. Automation provides more consistent application of methodologies and therefore more repeatable sampling. The methods and technologies will evolve during the permit term as technological advances are made.

Habitat monitoring data will be collected at all sites every third year. The monitoring activities that are completed each year will be summarized in the annual report, and monitoring results will be summarized in the 6-year Summary Report and the 12-year Comprehensive Review. Monitoring changes in riparian and aquatic conditions will provide information for tracking status and trends based on the covered activities and natural disturbance. Any changes to monitoring or enhancement will be made in accordance with the relevant provisions outlined in Chapter 7, Section 7.6, *Modifications to the Habitat Conservation Plan*, and will be discussed with the implementation and adaptive management committee (Section 7.2.5, *Implementation and Adaptive Management Committee*).

6.3.4 Riparian Restoration Monitoring

Given the ESRF's novel approach of conducting restoration thinning and related research in RCAs (as described in Chapter 3, *Covered Activities*), the effectiveness and potential consequences of RCA treatments, including inside the equipment limitation zone (ELZ), will be assessed in a limited area before proceeding with a full-fledged RCA thinning restoration effort.[2] Assessment of the initial 160 acres of RCA thinning, and in particular thinning inside the ELZ, will occur over a 5-year period and include 2 years of pre-restoration assessment and 3 years of post-restoration assessment. Monitoring activities will focus on a range of variables such as bank instability, turbidity, temperature, and shading to measure the short-term response of aquatic habitat to RCA thinning, including activity inside the ELZ. Additional language relevant to RCA restoration monitoring is included in Section 6.3, *Aquatic and Riparian Monitoring,* and Section 6.3.2, *Water Temperature*.

Data collected each year will be summarized in the annual report, and monitoring results will be summarized in the 6-year Summary Report. Outcomes of the monitoring activities and any proposed changes to RCA thinning protocols based on this initial study will be documented and the rationale for the change will be provided in the 6-year Summary Reports or 12-year Comprehensive Review and discussed with the implementation and adaptive management committee (Chapter 7, Section 7.2.5, *Implementation and Adaptive Management Committee*); any changes will be made in accordance with the relevant provisions outlined in Section 7.6, *Modifications to the Habitat Conservation Plan*. Upon completion of the initial 5-year assessment of RCA thinning inside the ELZ, this monitoring will conclude; future habitat conditions will be captured as part of the instream habitat monitoring.

6.3.5 Landslide Monitoring

OSU has created a baseline landslide[3] inventory for the ESRF (Oregon State University 2022), which will be updated as landslides occur during the permit term. During HCP implementation, the Permittee will monitor and report any landslides at harvest sites and/or sites associated with road system work, for 5 years post-harvest. In addition, the Permittee will report any direct landslide observation from forest managers. All reported landslides will include location, site photos, and if the slide reached a fish-bearing stream.

In the event that the 15 designated habitat monitoring reaches (Section 6.3, *Aquatic and Riparian Monitoring*) are deemed insufficient for capturing the impact of landslides on habitat for the covered species, paired turbidity monitors will be installed at up to 10 additional sites within the permit area. The intent of this monitoring effort is to support the adaptive management program (Section

[2] Riparian restoration outside of the ELZ (>35 feet from the aquatic zone) is permitted to occur at any point; this monitoring effort does not need to be complete.

[3] The inventory primarily captures deep-seated landslides.

6.5, *Adaptive Management*) and evaluate the effectiveness of the conservation measures and conditions. Parameters that will be monitored include the ability to achieve wood and sediment delivery objectives; to evaluate the effectiveness of RCAs on high landslide delivery potential (HLDP) streams and other stream types to reduce debris-flow runout path length to limit adverse effects on fish-bearing streams; and the accurate designation of non-fish-bearing streams with the highest modeled potential to deliver wood to fish-bearing streams (HLDP streams) to improve complexity and physical structure through large wood recruitment.

The outcomes of landslide monitoring will allow the Permittee to track occurrence over time and review the results to determine if the management activities and conservation measures in the permit area are functioning as expected. This data will also inform management decisions moving forward. Additional landslide data may be collected as part the research platform and research efforts described in the forest management plan, as well as through Oregon Department of Geology and Mineral Industries (DOGAMI) LiDAR mapping pursuant to DOGAMI's commitment to this work on behalf of state agencies. While these data, where available, will be shared with the Services and may be used to supplement HCP-related landslide monitoring and inform management decisions, this research-related landslide work and data collected by other state agencies are distinct from the HCP and not required for HCP compliance.

The monitoring activities that are completed each year will be summarized in the annual report, and monitoring results will be summarized in the 6-year Summary Report and the 12-year Comprehensive Review.

6.4 Terrestrial Monitoring

The terrestrial monitoring program will consist of both habitat monitoring and species response monitoring. Habitat monitoring tracks progress toward the biological objectives for each terrestrial species. Species monitoring tracks the response of covered species to the conservation measures to improve those measures over time. In both cases, the intention is to provide data that allows long-term trend analysis and tracking of habitat conditions and species presence over time. The terrestrial monitoring methods will rely on current protocols based on the best available science, as accepted for use by USFWS. Over time, the intent is to pair those field-based protocols with passive acoustic monitoring. Once such automated monitoring becomes scientifically accepted as a way to monitor habitat condition, species presence, and species use, it will be the primary tool used for monitoring. Bio-acoustic monitoring will allow the Permittee to track presence of covered species across various allocations and habitat types. Use of remote-sensing tools (e.g., air photos, LiDAR imagery) will allow the Permittee to track changes in habitat quality for northern spotted owls (*Strix occidentalis*) and marbled murrelets (*Brachyramphus marmoratus*).

In line with the aquatic and riparian monitoring program, the northern spotted owl monitoring program will cover one-third of the permit area in any given year. One-third of northern spotted owl nesting territories (i.e., home range, which includes habitat within a 1.5-mile radius of a circle centered on the activity center) will be monitored, meaning that all sites will be visited at least once every 3 years and data collected. The distribution of survey effort across the landscape will be flexible due to the many considerations involved, including survey efficiency, access, and specific information needs for research or planning for covered activities. Bio-acoustic monitoring will allow the Permittee to track the presence of northern spotted owl, as well as the success of invasive barred owl (*Strix varia*) removal efforts, with greater frequency and with less intrusive methods.

Marbled murrelet occupied and potential habitat will generally be monitored following USFWS-accepted protocols. Surveys will follow occupancy survey methods accepted by USFWS at that time (Pacific Seabird Group 2024a) to determine presence or probable absence. Current protocols call for 2 consecutive years of intensive surveys to determine presence or probable absence. Presence surveys will occur in modeled potential habitat where timber management will occur. Conditions 7 and 8 in Chapter 5, *Conservation Strategy*, outline the marbled murrelet monitoring requirements in designated occupied and modeled potential marbled murrelet habitat. Conservation Measure 5 and Condition 9 in Chapter 5 describe the HSI metric that will be used to track the aggregate amount of marbled murrelet habitat using area-weighted acres (HSI-acres), net of edge effects, as a result of harvest treatments in the permit area. The method of tracking HSI is discussed in Section 6.4.1, *Habitat Monitoring*.

Long-term trends in the presence of northern spotted owls and marbled murrelets in the permit area will provide an extensive dataset upon which the pace, scale, and type of forest management activities can be related to each species' response.

6.4.1 Habitat Monitoring

Habitat monitoring will be conducted annually. Northern spotted owl and marbled murrelet habitat removed through harvest or other management activity will be reported annually and summarized in 6-year Summary Reports, and a more comprehensive assessment will be completed during the 12-year Comprehensive Review, as described in Chapter 7, Section 7.3, *Reporting*. Notable incidents of habitat loss or degradation due to other disturbances, such as fire, including any hazard tree removal or salvage harvest, will also be tracked and reported. The commitment to increase the quantity and quality of habitat over time will be monitored using the acreage or HSI-acre metrics, tracking habitat loss versus gain.

The primary way that habitat quality will improve over time is through forest growth. In that way, the stand age (from projections), tree height (LiDAR-dependent), and the HSI-acres (for marbled murrelets), are three metrics that will be used as surrogates to determine if a stand is generally improving in habitat quality or declining in habitat quality. As trees get older and bigger, they also develop structural features that northern spotted owls and marbled murrelets use for nesting. However, the simple metrics of stand age, average tree height, stand density, number of large trees (>30 inches diameter at breast height) per acre, and percent canopy closure will be used to determine whether a given stand is more suitable for the covered species than it was in previous years. This information will be gathered on an annual basis, primarily using stand-specific thinning and timber harvest records and secondarily with remote-sensing capabilities. Habitat quality of stands in reserve status, where no harvest or thinning treatments are proposed, will be projected based on age-based metrics and LiDAR or other remote sensing, when available.

Conversely, if a stand is harvested, those same metrics (stand age, stand density, canopy closure, and tree height) from pre- and post-harvest conditions will be used to determine that the habitat quality in that stand has been reduced due to a covered activity. Changes in habitat quality or acres of temporary disturbance that result from covered activities will be tracked as those activities are implemented (e.g., acres of habitat lost at the time of harvest, acres and intensity of thinning activities, acres of habitat temporarily disturbed by forestry operations during marbled murrelet and northern spotted owl nesting season). The baseline number of acres of species habitat is based on the published habitat models described in Chapter 2, *Environmental Setting*, and the acres of habitat loss or disturbance from covered activities, as estimated in Chapter 4, *Effects Analysis and*

Level of Take, based on those habitat models and the covered activities that are anticipated in those locations (i.e., whether intensive, extensive, or thinning activities will occur).

Those habitat models will continue to be important in tracking changes in habitat quality on a landscape scale during HCP implementation, but research on the forest is likely to reveal a new understanding of habitat when stand-level parameters are measured. New modeling may occur and changes in how habitat acres are tracked may follow. Regardless of changes in how habitat is modeled or mapped in the permit area, the permits will still authorize habitat loss based on the analysis in the HCP and its commitments to habitat retention and enhancement. In other words, while the methods used to identify and track habitat for covered species may change, the habitat commitments of acres to be retained or enhanced will remain fixed.

In accordance with Conservation Measure 5 and Condition 9 in Chapter 5, *Conservation Strategy*, HSI is a function of stand age. HSI-acres were constructed as a method to quantify the aggregate value of marbled murrelet habitat across the permit area and allow for an analysis of habitat quality net of edge effects (Appendix D, *Marbled Murrelet Habitat Suitability Index Approach*). HSI-acres are the product of the HSI value of a subject stand and the area, in acres, of the subject stand. The aggregate habitat value for an area of interest at a given point in time is the sum of HSI-acres, net of edge effects, of all stands in the area of interest. These calculations will be determined and reported annually and trends summarized at each 6-year and 12-year milepost throughout the permit term based on stand age and stand thinning or harvest details collected annually. The HSI-acres will be determined using the generalized methodology detailed in Appendix D; however, model parameters will be adjusted to reflect the location and amounts of actual harvest and thinning through the permit term for the purposes of assuring the effects are comparable to that originally considered.[4] The assumptions and inputs used to determine HSI-acres, net of edge effects, will be presented and discussed annually and during each 6-year and 12-year milepost.

If there are changes in the understanding of species habitat or habitat use that cause a significant change in how covered activities are affecting the species or in how species benefits need to be calculated, the Permittee will coordinate with USFWS to determine whether the HCP needs to be amended to reflect those changes in accordance with Section 7.6, *Modifications to the Habitat Conservation Plan*.

6.4.1.1 Monitoring Restoration Thinning Treatments

The Permittee will implement restoration thinning treatments, as described in Chapter 3, *Covered Activities*, to accelerate growth and improve the quality of habitat. Within the CRW and MRW Reserves and the RCAs, these activities will mostly occur during the first 20 to 30 years of HCP implementation.[5] Restoration thinning treatments in RCAs are limited to 1,200 acres and are to be completed as part of a research effort designed to support and enhance the long-term ecological functions of the RCAs. Restoration thinnings in CRW and MRW Reserves could be implemented by the Permittee in the absence of a research partner to meet habitat goals of this HCP.

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[4] This will be particularly important when calculating the edge effects associated with varying intensities of thinning that may leave lower densities or canopy closures than that modeled in Appendix D, Table 4. For example, the analysis in Appendix D assumes a canopy closure of 60% adjacent to modeled potential habitat, but the HCP allows lower stand densities.

[5] Thinning in the MRW Reserves and MRW RCAs may take longer, depending on how the stepwise implementation corresponds to the original OSU research design or some other design; therefore, it is not subject to the 30-year cap (Chapter 3, Section 3.3.7.4, *Operational Standards for Restoration Thinning in Riparian Conservation Areas*).

A key element of the research and the HCP monitoring program will be to track changes, after management has occurred, to determine if stand management activities had the desired effect. The same metrics (stand age, stand density, canopy closure, and tree height) recorded pre-thinning will be used to determine that the habitat quality in that stand has been reduced or enhanced by thinning treatments, through time. These stands will be monitored in conjunction with other habitat monitoring described above, on an annual basis and reported on at 6-year and 12-year mileposts, to determine whether and when these managed stands grow into habitat for northern spotted owl and marbled murrelet. While the habitat attributes collected may vary depending on the specific enhancement objective, annual tracking of where management occurred, the type of management that 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, the Permittee will use adaptive management to adjust management practices in other locations to minimize short-term habitat degradation and maximize long-term habitat improvement.

6.4.1.2 Monitoring Retention of Legacy Features

Chapter 5, *Conservation Strategy*, outlines standards for retention in stands that are harvested. The retention standards for extensive and intensive treatments are described in Chapter 3, *Covered Activities*. These standards vary depending on the type of harvest expected but are aimed at retaining features on the landscape that are important for covered species. Monitoring of compliance with retention standards will be completed during sale closeout or completion of the harvest activities and included in the annual report. Demonstration of compliance with these standards will be summarized in the 6-year and 12-year mileposts.

6.4.2 Species Monitoring

The aim of terrestrial species monitoring is to continue to track long-term trends in northern spotted owl and marbled murrelet nesting activities in the permit area, build upon 30 years of data collection at the Elliott State Forest, and better understand how these two species respond to the conservation measures described in the HCP. Though success of the HCP is not tied to species numbers or population sizes, it is helpful to know whether the conservation measures benefit the species and how populations respond. The monitoring described for each species below is designed for that purpose.

6.4.2.1 Northern Spotted Owl Surveys

The monitoring goal for northern spotted owl is to determine site status at the 22 historic sites described in Chapter 2, *Environmental Setting*, detect new nesting sites, and document presence and trends in nesting, roosting, and foraging habitat as well as dispersal habitat. One-third (7 to 8) of the 22 historic nest sites in the permit area will be surveyed each nesting season, meaning that all of the 22 historic sites will be monitored every 3 years. The purpose of surveying existing nest sites is to ascertain how northern spotted owls respond to covered activities and conservation measures. Because northern spotted owls do not nest every year, the 3-year monitoring cycle will likely miss some nesting attempts both within and outside of the 22 historic sites. Additional USFWS-accepted survey protocols may be used in attempts to confirm resident pair status even during non-nesting years. Until it can be established that bio-acoustic sampling accurately detects nesting activity, field survey protocols will be used. Passive acoustic monitoring uses acoustic recording devices that have been shown to be effective in detecting the presence of both northern spotted owls and barred owls

(Duchac et al. 2020), and use of such equipment may allow more efficient and thorough monitoring of spotted owl nesting activities. Passive acoustic monitoring will be implemented in coordination with regional efforts for passive monitoring, including monitoring as part of regional northern spotted owl demography studies.

All habitat in the permit area will be surveyed every 3 years. Searches for new northern spotted owl nest sites, whether systematic or in locations where habitat is improving as a result of any research design, will be completed at a minimum in the same one-third of the forest where surveys are being completed in a given year. Distribution of acoustic recording devices in additional locations beyond known activity centers will allow the Permittee to determine when northern spotted owls begin to use new locations and to generally track long-term trends in nesting activity in the permit area. The acoustic recording devices will detect both barred owls and northern spotted owls.

In general, the intent is to determine if conservation measures are resulting in broader use of the permit area than before and if northern spotted owl is reestablishing in locations that it historically used. It is also likely that the monitoring effort may be intensified to focus on specific areas within a research context where necessary to determine if treatments (e.g., harvests, thinning) or management activities (e.g., barred owl removal, ingrowth) are having an effect. Monitoring of northern spotted owl activity in the areas where active barred owl removal has occurred will be key to determining the effectiveness of this conservation measure. Survey results for both northern spotted owl and barred owl will be reported annually.

6.4.2.2 Marbled Murrelet Surveys

As with northern spotted owls, the purpose of monitoring marbled murrelet nesting behavior is to determine if use of the permit area changes in response to conservation measures. Monitoring will be conducted using passive acoustic sampling, as described by Borker et al. (2015). Until it can be established that continuous acoustic recording device or other passive sampling accurately detects occupied areas, and until such protocols for such passive surveys are accepted by USFWS, field surveys following standard USFWS-accepted survey protocols (Pacific Seabird Group 2024a) will be used to verify acoustical surveys or to calibrate automated systems. Current protocols call for 2 consecutive years of intensive surveys to determine presence or probable absence. Therefore, the location of marbled murrelet monitoring will also be tailored to those areas in modeled potential habitat where timber management is expected. Conditions 7 and 8 in Chapter 5, *Conservation Strategy*, outline the marbled murrelet monitoring requirements in designated occupied and modeled potential marbled murrelet habitat. Monitoring will include a sufficient number of sites and replication so the results will have enough statistical power to meaningfully inform future management decisions. Survey results for marbled murrelet will be reported annually.

6.5 Adaptive Management

This section describes how the Permittee will use adaptive management to respond to monitoring results and new information. Chapter 7, *Implementation and Assurances*, describes how the Permittee 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 ESRF programs that are related to or support the HCP. The Permittee strives for efficiency and effectiveness on all research forest fronts and all programs, including how HCP implementation will adhere to that objective in the context of efforts tied to outcomes for conservation, research, partnerships, and harvest or other active management activity.

For the purposes of this HCP, adaptive management is a decision-making process used to examine alternative strategies (e.g., conservation measures) 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 assumptions change. Monitoring and learning from the outcomes of past actions are the foundation of adaptive management (Williams et al. 2007). Adaptive management in the permit area will be informed by more information than is described in the HCP or permits. Conservation measures may also be modified in response to research findings, if doing so would improve implementation of or remain consistent with achieving the HCP conservation strategy. The Services will determine if any modification would require an amendment in accordance with Chapter 7, Section 7.6.4, *Process Determination.*

The covered activities and conservation strategy in this HCP are based on the best available scientific information. It is expected that the covered activities and conservation measures will effectively achieve the biological goals and objectives stated in Chapter 5, *Conservation Strategy*. That said, the context of a research forest allows future research-based information to support future achievement of the conservation strategy through adaptive management. Future improvements in forest inventory methods and increased accuracy or precision of important metrics, or improvements in species habitat models and species detections, may result in different estimations of current and projected habitat trends. Effectiveness monitoring and research may indicate that some management techniques are more or less effective than anticipated, resulting in an increase or decrease in their use, or modifications to how they are implemented. Evolving science on the habitat requirements, life histories, and distributions of covered species may inform changes to the pattern of strategies on the landscape. Monitoring strategies themselves may change as they are improved to better quantify or describe specific habitat metrics.

To address uncertainties or limitations of current knowledge, the monitoring and adaptive management program allows the Permittee to learn from experience, reevaluate and revise the approach (i.e., type, extent, and location) to advancing conservation measures, conditions, and covered activities under this HCP when necessary, in coordination with the Services and implementation and adaptive management committee, to meet the biological goals and objectives of the HCP. If covered activities need to change, or revisions are significant enough to change the expected outcomes assessed in this HCP or in the permits associated with it, a formal amendment may be needed. The Permittee will make that determination in coordination with and as approved by the Services, or the Services may indicate to the Permittee that an amendment is necessary before implementing any changes from the HCP.

6.5.1 Adaptive Management Process

The adaptive management process will follow the conceptual model provided in the HCP Handbook (U.S. Fish and Wildlife Service and National Marine Fisheries Service 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). As that information is gathered early in the permit term, adjustments will be made to the research design, including how treatments are deployed. This section describes how adaptive management will be used in the context of the HCP to refine implementation of the conservation strategy.

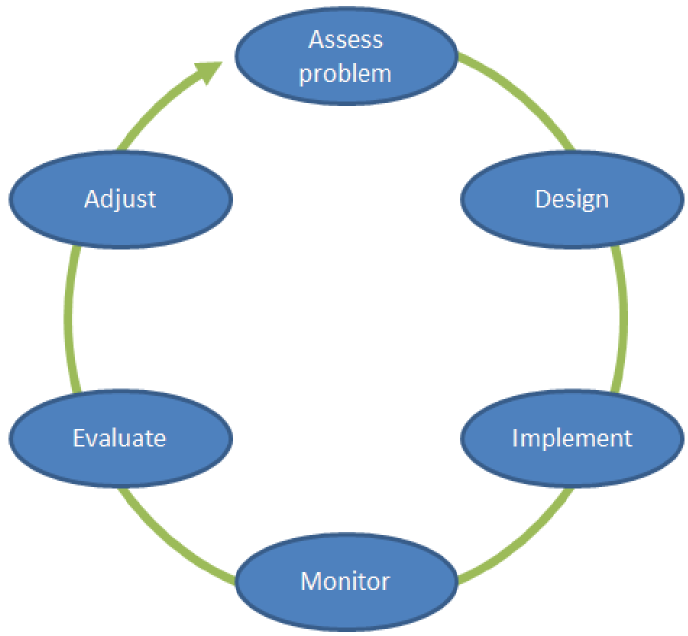

Figure 6-1. Adaptive Management Process

Based on this model, the general adaptive management process of the HCP will be as follows.

1. **Assess Problem**
   a. The HCP assumes that the habitat protections and conservation measures, as written in Chapter 3, *Covered Activities*, and Chapter 5, *Conservation Strategy*, will ultimately achieve the biological goals and objectives.
   b. Determine if habitat protections and conservation measures are not moving the HCP toward meeting the biological goals and objectives set in the HCP and preclude achievement of Stay-Ahead provisions.
2. **Design**
   a. To test new management actions or techniques, thoughtful consideration must be given to how changes in management are made, so it is evident what is working and what is not. Because the permit area will consist of many large experiments, designing adequate experiments or tests of new approaches will be inherent in many of the covered activities.
   b. Due to the resources under consideration in this HCP, timing will be an important part of design and implementation. In many cases it may be decades before it is apparent whether a new technique or method works as anticipated.
3. **Implement**
   a. Once it is determined what new activities or techniques need to be tested, those activities will be implemented on the ground, pending coordination with the Services in accordance with the relevant provisions of Chapter 7, Section 7.6, *Modifications to the Habitat Conservation Plan*. The new activities will be paired with monitoring, as described below.

4. **Monitor**
    a. The monitoring and reporting program will be implemented as described in this chapter and in Chapter 7, Section 7.3, *Reporting*.
    b. The Permittee 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.
    c. Monitoring results and associated lessons learned will be compiled and documented in annual reports to the Services, which are intended to evaluate compliance and effectiveness, and inform adjustments going forward.
5. **Evaluate**
    a. The ESRF Manager (Chapter 7, Section 7.2.2, *Elliott State Research Forest Manager*) 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 ESRF Manager will facilitate discussions with Permittee staff along with the Services to fully understand the trends identified, evaluate options for adjustments and corrective actions, and select an adaptive management response. If adjustments are needed, the Permittee will coordinate with federal agencies to confirm adjustments meet the standards of the HCP and permits, in accordance with the relevant provisions of Chapter 7, Section 7.6, *Modifications to the Habitat Conservation Plan*.
6. **Adjust**
    a. The corrective or adaptive management response will be defined, and adjustments made with the Services' approval (as necessary to comply with permit terms, and in accordance with relevant provisions of Chapter 7, Section 7.6, *Modifications to the Habitat Conservation Plan*) to correct the issue. Due to the experimental nature of the ESRF, this may include testing different options for correcting any issues before making any permanent adjustments.
    b. Monitoring results will be tracked, as will any modifications to management practices or alternative strategies selected in response to monitoring results.
    c. There will be continual learning about how resources are responding to management in the permit area, as that is a core principle behind the research forest. This information will be continually considered in the adaptive management process.

6.5.2 Adaptive Management Triggers

Adaptive management responses will be triggered when monitoring or other information indicates either of the following.

- Existing practices are not achieving the biological goals and objectives as illustrated in Table 6-1.
- 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 made at the forest management planning level and more minor adjustments made at the annual operating plan level. Triggers may also change based on the results of research or new survey or monitoring results. For instance, species responsiveness or detectability may vary considerably year to year, or habitat response to silvicultural activities and monitoring of that response may take many years.

The specific type of triggers and associated adaptive management responses will also vary on the specific monitoring metric indicating potential deficiencies. Table 6-1 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 that a trigger has been met. The next step will be to determine the underlying causes of the identified deficiencies and triggers. Depending on monitoring results, the Permittee will determine whether circumstances have changed such that conservation targets may not be met, and adaptive management is necessary. Adaptive management responses will be developed with review and input provided by the implementation and adaptive management committee described in Chapter 7, Section 7.2.5, *Implementation and Adaptive Management Committee*. Proposed adaptive management responses will be evaluated by the Permittee to ensure consistency with Stay-Ahead provisions identified in Chapter 7, Section 7.4, *Stay-Ahead Provisions*. Stay-Ahead provisions will be tracked by the Permittee on a continual basis and will be reported to the Services annually and during each 6-year Summary Report and 12-year Comprehensive Review. Proposed management adjustments will also be considered in accordance with the relevant provisions of Chapter 7, Section 7.6, *Modifications to the Habitat Conservation Plan*.

Additional triggers may be identified as part of routine annual reporting, 6-year Summary Reports, or 12-year Comprehensive Reviews, and Permittee may advance them as updates to the adaptive management process in this HCP. The Permittee may also add new triggers 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—as approved by the Services—and will be set to provide adequate notice to accommodate the decision-making process and make adjustments as needed. Prior trigger adjustments will be tracked in annual reporting.

Table 6-1. Triggers for Adaptive Management

Actions	Trigger	Adaptive Management Response Example
Aquatic Actions		
Wood recruitment in streams	Trend in large wood frequency/ volume in streams is not meeting the anticipated wood recruitment goals.	Alter riparian management in order to incorporate additional wood enhancement in deficient stream reaches (e.g., additional large wood placement, riparian thinning prescriptions).
Stream temperature	Harvest related temperature increases that result in watershed exceedances of greater than 0.3°C for more than 5 years post-harvest as measured by thermographs as described in Section 6.3.2, *Water Temperature Monitoring*.	Implement targeted riparian conservation strategy adjustments in locations where temperature increases are detected and there are similar stream segments in the permit area. Revise harvest plans or modify amount of riparian thinning in an affected watershed and minimize changes to water temperatures.

Actions	Trigger	Adaptive Management Response Example
Riparian enhancement	Riparian enhancement projects are not achieving expected results. RCA thinning activities are having unintended negative consequences to development of instream habitat.	Identify and capture additional opportunities to fund and implement riparian enhancement. Increase number of riparian enhancement projects identified in near-term harvest plans. Apply lessons learned to selection and design of riparian enhancement projects to improve efficiency and effectiveness. Modify riparian restoration thinning treatments to reduce or eliminate unintended negative consequences to instream habitats.
Debris-flow derived wood	Over time, debris-flow studies show that riparian buffers are insufficient at capturing debris that is detrimental to aquatic system health, when slides occur.	Reconsider buffering strategy on specific stream types or in specific locations, to address debris-flow issues based on best available scientific information.
Road improvement and vacating	Sediment and flow impacts from roads identified within a catchment.	Implement road improvement to treat problem areas through adjustments to budgets and operations. Continually prioritize road locations causing ecological damage to address the most impactful first.
Fish passage	Passage enhancement projects do not achieve intended results of effective fish passage.	Apply lessons learned to selection and design of where fish-passage upgrades should be applied to improve efficiency and effectiveness of fish-passage improvement projects.
Terrestrial Actions		
Habitat for covered species	Habitat levels fall below Stay-Ahead commitments specified in Chapter 7, *Implementation and Assurances*.	Increase number and extent of conservation treatments in near-term management planning. Reevaluate and revise management prescriptions used in Douglas-fir plantations as new information becomes available on the effectiveness of treatments on habitat development.
Edge effects	Edge effects, as calculated by HSI-acres, are in danger of exceeding commitments specified in Chapter 5, *Conservation Strategy*.	Adjust harvest schedule to reduce creation of edge adjacent to potential nesting habitat. Preferentially leave retention stands to act as edge buffers in extensive treatment areas.
Barred owl	Results of barred owl management are found to be ineffective at providing a positive benefit to northern spotted owl after 15 years of barred owl management in the permit area.	The Permittee will not be obligated to continue funding it.

Actions	Trigger	Adaptive Management Response Example
Douglas-fir (*Pseudotsuga menziesii*) plantation management	Results of habitat treatments (e.g., thinning) do not seem to be achieving intended trend in forest development and habitat improvement.	Adjust treatments through near-term harvest plans. Revise or adjust enhancement treatment prescriptions to improve efficiency and effectiveness.

HSI = habitat suitability index; °C = degrees Celsius

6.5.3 Adaptive Management and Climate Change

In terms of adaptive management, climate change effects may be detected through monitoring results that, in turn, trigger adaptive management responses. 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. Due to the broad scope and effects of climate change on covered species, the Permittee anticipates that adaptive management for climate change will be informed through ongoing discussions and coordination at the state and federal level with other major forest landowners in western Oregon, including private industrial forest landowners, federal land managers (the Bureau of Land Management and U.S. Forest Service), Tribal governments, the Services, and other natural resource agencies. Climate change research will be central to everything that occurs in the permit area; therefore, adapting to new information that emerges from that research is part of the fabric of the research forest itself.

Chapter 7
Implementation and Assurances

7.1 Implementation Overview

This chapter describes how the Elliott State Research Forest (ESRF) 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.

7.2 Implementation Roles and Responsibilities

7.2.1 Oregon Department of State Lands

The Oregon Department of State Lands (DSL) is the Permittee. The Permittee will oversee HCP implementation, including staffing internal positions, reporting, monitoring, and maintaining all program records. The Permittee will carry out planning, monitoring, adaptive management, and periodic coordination with and reporting to U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) (together, the Services). The Permittee will make all final decisions regarding the management and operations of the ESRF consistent with the HCP and incidental take permits (ITPs).

7.2.2 Elliott State Research Forest Manager

The ESRF Manager will serve as the point of contact for HCP-related issues between the Permittee, USFWS, and NMFS. The ESRF Manager is a full-time position based in the vicinity of the ESRF. This position will be hired by and work directly for DSL. The ESRF Manager sits at the head of DSL's staff management structure for the ESRF and will report to DSL's Director and, ultimately, the State Land Board. This position will oversee other key staff and contracts relevant to ensuring the ESRF's successful operation and management.

The ESRF Manager will oversee and provide support for the following tasks.

1. Develop and maintain annual budgets and work plans for HCP implementation.
2. Coordinate communication and decision-making on HCP implementation and between DSL, USFWS, and NMFS, as needed and as prescribed in the HCP (i.e., annually, and during 6- and 12-year reviews).
3. Prepare and submit annual reports to USFWS and NMFS, including 6-year Summary Reports and 12-year Comprehensive Reviews (Section 7.3, *Reporting*).
4. Coordinate compliance and effectiveness monitoring activities (Chapter 6, *Monitoring and Adaptive Management*).
5. Maintain effectiveness and compliance monitoring and survey data reports and archives, including monitoring results, and incorporate results into the annual report.

6. Coordinate the development of policies needed to communicate HCP expectations and requirements to staff.
7. Coordinate updates to existing policies, guidelines, and business practices to align with HCP requirements.
8. Ensure adequate training on HCP implementation, including all compliance requirements.

7.2.3 Staff and Other Specialists

The ESRF Manager will be supported by several ESRF staff during HCP implementation, as well as contracted professionals hired by DSL for roles or services important to ESRF operations. Other staff will include full-time permanent employees of DSL dedicated to the ESRF in positions that include an ESRF Lead Forester and ESRF Biologist. These two positions will have the primary duties of managing covered activities on the ESRF and ensuring conservation measures, conditions, monitoring activities, and other HCP commitments are met.

These positions will have distinct roles that, along with the ESRF Manager, collectively coordinate and track HCP-related activities on the forest and facilitate implementation to ensure the Permittee remains in compliance with the terms of the HCP and permits. This will include collecting information from other staff—researchers or contractors performing implementation work to complete the annual compliance report, 6-year Summary Reports on biological effectiveness, and 12-year Comprehensive Reviews on biological effectiveness. This work will be maintained and tracked in a database managed by a data analyst.

DSL also intends to hire a Research Coordinator. While not essential to implementation of this HCP, this position will ensure operational management on the ESRF is coordinated and integrated with research activity, and vice-versa. Further, DSL intends to employ other new agency positions and/or task existing DSL staff with duties relevant to successful ESRF implementation but perhaps less central to HCP compliance. Intended new positions include an Executive Assistant and a Policy and Partnership Engagement Coordinator. Areas where existing DSL staff capacity will be drawn upon include human resources, data and information technology, contracts and procurement, communications, policy, budget, and operations. DSL also intends to contract with professionals possessing expertise relevant to the ESRF geography, research forest design, resource management for advancement of covered activities, data gathering, resource protection, and informational management on the ESRF.

More specifics on the amount of time expected from each of these staff, and their role in HCP implementation, are provided in Chapter 8, *Cost and Funding*.

7.2.4 U.S. Fish and Wildlife Service and National Marine Fisheries Service

USFWS and NMFS monitor HCP implementation, including the following expected tasks.

1. Receive and review annual reports, 6-year Summary Reports, and 12-year Comprehensive Reviews submitted by the Permittee.
2. Attend annual meetings on HCP implementation.

3. Monitor the Permittee's compliance with the HCP and ITP, based on the annual and other reports, and other information provided by the Permittee, and site visits as necessary.
4. Participate as a member of the implementation and adaptive management committee.
5. Respond to requests by the Permittee for HCP modifications, amendments, or input on implementation including adaptive management responses (Section 7.6, *Modifications to the Habitat Conservation Plan*).
6. Notify the Permittee of the potential for unforeseen circumstances and possible voluntary remedial measures to address them, as described in Section 7.8, *Changed and Unforeseen Circumstances*.
7. Enforce the provisions of the ITPs, as needed.

7.2.5 Implementation and Adaptive Management Committee

The Permittee will develop and engage the implementation and adaptive management committee to participate in the planning and future potential revision of research, monitoring, implementation reviews, and adaptive management approaches as they pertain to the covered species and their habitat. This committee will be created and managed by the Permittee and will include, but will not be limited to, participants with natural resource management and/or science expertise from DSL, Oregon State University (or other lead research partner), USFWS, NMFS, Oregon Department of Fish and Wildlife (ODFW), Tribes connected to the ESRF geography, and members of the ESRF Board of Directors. Subject matter experts not affiliated with other entities represented on the committee would also be engaged in committee meetings and work (e.g., restoration practitioners, technical experts).

The implementation and adaptive management committee will receive annual reports, 6-year Summary Reports, 12-year Comprehensive Reviews, and any other HCP-related information that may influence or inform work of the committee. The implementation and adaptive management committee is integral to the sustainability and success of the ESRF. The committee will provide input and advice to the Permittee on areas including but not limited to ESRF planning, research, and management activity; effectiveness of past management and research; and adaptive management considerations and decisions related to future management in compliance with the HCP and foundational agreements and documents central to the ESRF's design.

7.2.6 Public Engagement

Public accountability and transparency in forest management decisions and operations has been a central and consistent principle supported by the State Land Board, Oregon State Legislature, and collaborative process underpinning the ESRF's creation. As a public agency subject to state public meeting and transparency laws, the Permittee will conduct ESRF management in a manner open to public review, engagement, oversight, and transparency. This includes in the creation and operations of the ESRF public board of directors, whose meetings and written documents will be open and available to the public. Prior to DSL making forest management decisions, documents and related information will be made available for public review, and there will be a process for public engagement. This will encompass disclosure of all materials related to the HCP monitoring and the reporting process, including ensuring that all annual reports, 6-year Summary Reports, 12-year Comprehensive Reviews, and other HCP-related information will be made available to the public.

Public engagement on any HCP amendments will also occur, including authorization by the State Land Board after consideration and action at a public meeting. These Permittee commitments will be in addition to the public processes undertaken by the Services.

The Permittee will disclose information related to HCP compliance and effectiveness to the public through the annual reporting process. Public engagement will include implementation and adaptive management committee reporting, as described in Section 7.2.5, *Implementation and Adaptive Management Committee*. Additional public engagement specifically for the HCP will occur as needed.

7.3 Reporting

7.3.1 Annual Reporting

The Permittee will prepare and submit an annual report to the Services for the duration of the permit term to document compliance. The annual reports will summarize the previous state fiscal year's implementation activities (July 1–June 30) and upcoming fiscal year's planned activities and expenditures on the ESRF. The report will be provided to the Services by November 15 of each year. Annual reports will require synthesis of data, analysis, and presentation in a clear format. If the Permittee requires more time to prepare and submit the annual report, the Permittee may request from the Services a 30-day extension of this deadline. In addition to submitting to the Services, annual reports will be made available to the public. An annual meeting with the Services will be held within 60 days of receipt of the annual report, potentially coordinated with the implementation and adaptive management committee (Section 7.2.5, *Implementation and Adaptive Management Committee*).

The goals of the annual reports demonstrate to USFWS, NMFS, and the public that the HCP is being implemented properly, and deliver information necessary to assess whether the level of take is within the respective agency's ITPs. 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. Such actions or changes will be processed and carried out in accordance with the provisions described in Section 7.6. *Modifications to the Habitat Conservation Plan*.

The annual reports will contain the following required content.

1. Description of covered activities implemented during the reporting year, as well as cumulative total (i.e., from the start of the permit term as it relates to the HCP commitment).
   a) Acres and location of timber harvested by harvest type.
   b) Treatments by allocation (Chapter 3, Section 3.3, *Stand-Level Treatments and Operations Standards, by Allocation*) within the conservation research watersheds (CRW) and management research watersheds (MRW).
   c) Details regarding removal of any trees that predate the 1868 fire, including number, location, species, dimensions, age, forest stand conditions and context, and reason for removal.

   d) Acres treated or harvested, including acres disrupted for supporting management activities (such as road maintenance or construction), and dates of operations in modeled terrestrial species habitat. Habitat data will include modeled quality ratings (e.g., highly suitable, suitable, marginal) (Chapter 2, Tables 2-6 and 2-7) for stand conditions prior to and after treatment. For extensive treatments, habitat data will also include pre- and post-treatment stand density conditions.
   e) Acres thinned in the CRW, MRW Reserves, as well as riparian conservation areas (RCAs), including location (by stream type and independent population), thinning regime, pre- and post-thinning stand conditions (e.g., density, species composition, age, stream shade, tree diameter).
   f) Acres of barred owl management type(s), specifically, the acres of northern spotted owl habitat treated, total barred owl removal results (i.e., total area, effort, and individuals removed), and the results of monitoring northern spotted owl activity in all the areas where active barred owl removal has occurred.
   g) Aquatic restoration projects (Chapter 5, Section 5.4.1, *Conservation Measure 1, Targeted Restoration and Stream Enhancement*) completed by Oregon Coast coho (*Oncorhynchus kisutch*) independent population.
   h) Road miles constructed or vacated and location (by treatment allocation and location with respect to stand age, modeled terrestrial species habitat, and independent coho population).
   i) Road management actions performed, including location and number of culverts upgraded or replaced.
   j) Supporting activities completed, including location and acres or other metrics describing the nature and extent of activity completed, as well as the primary activities or outcomes they supported.
   k) Details regarding removal of trees (or restoration actions) associated with the Indigenous Use of Cedar covered activity.
   l) Barriers to fish passage upgraded or removed, including location and length of newly accessible habitat.
2. Documentation of any known instances of direct mortality of covered species.
3. To the extent practicable, approximate acres and location of habitat for covered terrestrial species lost to disturbance events such as fire, wind, drought, insects, or disease, and any other documentation of unforeseen circumstances as described in Section 7.8.2, *Changed Circumstances Addressed by this Plan*.
4. Reporting of landslides and debris flows location, site photos, and if the slide reached a fish-bearing stream.
5. Summary of the implementation of conditions on covered activities.
6. Documentation and justification for deviations/exceptions (to conditions on covered activities) that fall outside pre-approval requirements, for those that may have occurred in the reporting

year as well as those that are proposed for the upcoming year[1] (Chapter 5, *Conservation Strategy*).

7. Summary of all conservation measures implemented.
8. Summary of acres of Reserves and Intensive allocations by subwatershed, including RCA widths applied by treatment type, stream type, and independent population.
9. Progress toward achieving the HCP biological goals and objectives by conservation actions (including avoidance, minimization, and mitigation).
10. Compliance with the Stay-Ahead provision, including an assessment of whether the loss of habitat and habitat quality from natural disturbance caused the Permittee to fall behind the Stay-Ahead provision, as described in Section 7.4, *Stay-Ahead Provisions*.
11. Monitoring actions conducted in the reporting year (monitoring results will be reported annually as well as summarized every 6 years as part of the 6-year Summary Report or 12-year Comprehensive Review).
12. Summary of surveys conducted through the monitoring program in the reporting year, including a description of surveys conducted, protocols used, and survey results (e.g., presence, breeding, occupancy, location, species response,).
13. Discussion of possible changes to the monitoring and research program based on interpretation of monitoring results and research findings, if applicable.
14. Documentation of any changed circumstances described in Section 7.8.1, *Changed Circumstances*, that were triggered during the reporting year, if applicable. If any such circumstances were triggered, also include any responses implemented (i.e., remedial measures) and resulting monitoring.
15. If changed circumstances were triggered in prior years, documentation of ongoing responses to those past changed circumstances in the current reporting year, and the ongoing results of remedial measures.
16. Discussion of any possible changes relevant to HCP implementation that are a result of the adaptive management decisions during the reporting year, as applicable (Section 7.6, *Modifications to the Habitat Conservation Plan*). This description will include the information that triggered the potential change consideration (whether met or unmet), the rationale for the planned responses, and the results of any applicable monitoring actions or changes to identified triggers for adaptive management.
17. A comprehensive list of adaptive management triggers and responses from previous annual reports.
18. Any administrative changes or amendments proposed or implemented during the reporting year (Section 7.6, *Modifications to the Habitat Conservation Plan*).
19. Summary of any substantive coordination between the Permittee and local, state, federal, and Tribal governments and other stakeholders regarding implementation of the HCP.

[1] Activities would not be permitted until concurrence from the Services is received in accordance with the provisions of Section 7.6.

20. Total costs associated with HCP implementation for the fiscal reporting year, as well as any budget projections for the next fiscal year.

7.3.2 Six-Year Summary Report

Every 6 years of HCP implementation, the following items will be summarized in the 6-year Summary Report from the previous 6 years of annual reports and monitoring results. In the final year of the 6-year Summary Report, it is anticipated that there will still be an ongoing accounting of activities needed for that individual year and an annual report will be prepared. Whether that report is provided as a separate document or under the same cover as the 6-year Summary Report is up to the preference of the Permittee, USFWS, and NMFS. This frequency of reporting allows the completion of two full 3-year cycles of monitoring, as described in Chapter 6, *Monitoring and Adaptive Management*. One goal of the 6-year Summary Report and 12-year Comprehensive Review is to present information on any detectable trends.

In addition to the summary of annual report components rolled up at this 6-year interval, the 6-year Summary Report will also address the following.

1. A summary of compliance and effectiveness monitoring efforts and activities, including trends in aquatic and riparian habitat and water quality/quantity parameters.
2. A summary of monitoring efforts and activities and relative trends in terrestrial habitat quality, species presence, breeding, and occupancy along with their locations, and species response data.
3. Amount and general location of habitat for covered terrestrial species lost to covered activities and, to the extent practical, due to other disturbances (e.g., fire, wind, insect, drought) and amount and general location of modeled and onsite evaluated terrestrial habitat gained through management actions and natural succession. This will include an updated evaluation of Habitat Suitability Index (HSI)-weighted acres from the preceding years.
4. Amount and general location (e.g., subwatershed) of CRW and MRW Reserve allocations that are treated with restoration thinning and a 6-year projection of additional thinning that will occur.
5. Amount and general location (e.g., subwatershed) by independent coho population of RCAs treated with restoration thinning and a 6-year projection of additional thinning that will occur.
6. Updated wood recruitment modeling with known buffer widths included to gauge progress toward biological objectives for each independent population of Oregon Coast coho.
7. Compliance with the Stay-Ahead provision as described in Section 7.4, *Stay-Ahead Provisions*.

7.3.3 Twelve-Year Comprehensive Review

Every 12 years of HCP implementation a comprehensive review of the monitoring program and monitoring results will be completed. This frequency of reporting allows for the completion of four full 3-year cycles of monitoring, as described in Chapter 6, *Monitoring and Adaptive Management*. Information gathered for the 12-year Comprehensive Review will largely be the same as described in Section 7.3.2, *Six-Year Summary Report*, except it will contain a more comprehensive analysis as described in Chapter 6, Sections 6.3, *Aquatic and Riparian Monitoring*, and 6.4, *Terrestrial Monitoring*. These reviews will include information from the annual reports in the intervening 12 years and the summary provided in the 6-year mid-point check-in. These reviews 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. Information generated during the 12-year comprehensive review process will be informed by Permittee staff along with USFWS, NMFS, and ODFW.

7.4 Stay-Ahead Provisions

The federal 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)). As described in the *Habitat Conservation Planning and Incidental Take Permit Processing Handbook* (HCP Handbook) (U.S. Fish and Wildlife Service and National Marine Fisheries Service 2016), Stay-Ahead provisions are often (but not always) included in HCPs to minimize the risk of impacts from covered activities occurring before the benefits of mitigation are realized. This HCP includes several Stay-Ahead provisions that will be applied in conjunction with monitoring, reporting, and adaptive management throughout the permit term.

Stay-Ahead provisions will be tracked by the Permittee on a continual basis and will be reported to the Services annually and during each 6-year Summary Report and 12-year Comprehensive Review. Stay-Ahead provisions will be documented primarily through the tracking of completed conservation commitments and the modeling and monitoring of terrestrial and aquatic habitat changes over the permit term.

The underlying assumption in the terrestrial and aquatic conservation strategy is that 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 the CRW and MRW Reserve allocations and RCAs as part of the ESRF design carried forward in the covered activities will provide conservation benefits to covered species. It marks an immediate change from harvest types and impacts that would otherwise be allowable in those areas by law, and the lack of regeneration harvest in those areas will allow habitat to develop gradually over time. By maintaining the boundaries of the allocations through the permit term, the Permittee provides certainty that the total acres of covered species habitat will not be reduced.

"Replacing" habitat for northern spotted owl (*Strix occidentalis*) and marbled murrelet (*Brachyramphus marmoratus*) by restoring non-habitat takes time, usually decades. Because of this, tracking of mitigation offsets to impacts as part of the Stay-Ahead provisions will include tracking of multiple metrics reflecting accomplishments toward meeting the biological goals and objectives, including the following.

1. Acres of existing habitat commitments established as part of the conservation strategy.
2. Acres of new ingrowth of habitat (using modeled suitability values).
3. Acres of restoration thinning treatments completed.
4. Acres of habitat retention in allocations subject to intensive treatments and habitat retention and restoration thinning in allocations subject to extensive treatments.

These metrics, in turn, will be compared against habitat impacts to establish if mitigation is fully offsetting impacts. This approach aligns with an example presented in Chapter 9 of the HCP Handbook, which describes a hypothetical "timber plan" HCP where "trees are harvested (causing impacts), but other trees are left standing to grow into habitat for wildlife (the trees are left as part of the mitigation). In this case, impacts and mitigation are happening simultaneously throughout the plan area."

Adjustments to how Stay-Ahead provisions are measured in response to landscape-scale events such as fire, storms, and pests are described in Section 7.5, *Adjustments to Stay-Ahead*. The following sections provide more specifics about how Stay-Ahead provisions will be tracked for covered species.

7.4.1 Northern Spotted Owl Stay-Ahead Provisions

7.4.1.1 Replacement Habitat

The Stay-Ahead provisions for the HCP require the Permittee to 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 or through field verification) grown over the permit term in the CRW and MRW Reserves.

As previously described, monitoring will track and report the development of northern spotted owl habitat over time. The confirmation that habitat conservation commitments fully offset impacts will be based on the cumulative biological value of habitat retained and "created" by the Permittee (through passive forest growth and active management) together with the amount of habitat retained that would not otherwise be conserved, including conservation of northern spotted owl habitat on lands currently not occupied by northern spotted owls.

The Stay-Ahead evaluation for northern spotted owl will include the following metrics.

1. Acres of existing habitat conserved as part of the conservation strategy, including occupied and unoccupied habitat (based on monitoring data).
2. Acres of restoration thinning treatments to improve habitat.
3. Acres of habitat retention in allocations subject to intensive treatments and habitat retention and restoration thinning in allocations subject to extensive treatments.
4. Acres of new habitat ingrowth in the CRW and MRW Reserves, RCAs, areas subject to extensive treatments, and home ranges of the 22 activity centers included in the conservation strategy, and across the permit area.

The Permittee will propose a draft determination of whether conservation actions and accomplishments are collectively on track to meet the biological goals and objectives and associated Stay-Ahead provisions as part of the 6- and 12-year HCP reporting cycle.

7.4.1.2 Habitat Retention Around Historic Activity Centers

Monitoring and reporting will be completed to ensure that nesting, roosting, and foraging habitat acreages are retained above the minimum thresholds established for each of the 22 historic sites identified for protection in this HCP, as specified in Chapter 5, *Conservation Strategy* (Conditions 2, 3, and 4).

7.4.1.3 Dispersal Landscape Retention

In addition, northern spotted owl dispersal habitat will be tracked and reported to document that dispersal habitat is retained at or above minimum levels, per Condition 5 (Chapter 5, *Conservation Strategy*).

7.4.2 Marbled Murrelet Stay-Ahead Provisions

For marbled murrelet, per Condition 9 in Chapter 5, *Conservation Strategy*, there will be no temporal loss of the aggregate number of acres of designated occupied and HSI-weighted habitat as a result of harvest treatments in the permit area. Therefore, the Stay-Ahead provision for marbled murrelet requires that adequate marbled murrelet replacement habitat has been identified to replace any habitat lost due to covered activities, following the substantive and procedural commitments of Condition 9. The adequacy of replacement habitat will be determined through the processes specified under Condition 8, which details that changes in determinations of occupancy in designated occupied or modeled potential habitat will be coordinated with USFWS. This Stay-Ahead provision will maintain habitat for marbled murrelet over the permit term, ensuring that habitat mitigation stays ahead of habitat impacts.

7.4.3 Oregon Coast Coho Stay-Ahead Provisions

Stay-Ahead provisions will ensure that riparian habitat ingrowth and enhancement projects in the RCAs stay ahead of habitat lost to covered activities (e.g., new roads through RCAs). Documenting Oregon Coast coho habitat quality improvement through the monitoring of habitat condition in RCAs and aquatic habitat trends (Chapter 6, Section 6.4.1, *Habitat Monitoring*) will ensure that there is no decrease in aquatic habitat quality due to covered activities.

RCAs themselves are a minimization measure, and the thinning that occurs within them, including wood added to streams, is part of the conservation strategy described in Chapter 5, *Conservation Strategy*. For coho, the underlying assumption in the aquatic conservation strategy is that there will be continual improvement in aquatic habitat quality, with some episodic events that also contribute to habitat quality (e.g., tree fall, landslides). The only harvest activities occurring in RCAs will be those aimed at transitioning Douglas-fir (*Pseudotsuga menziesii*) plantations to more dynamic ecosystems. The only streams without RCAs are seasonal, non-fish-bearing streams that do not have high potential to deliver wood to a fish-bearing stream (referred to as XNFBs). Temporal effects on the aquatic environment are expected to be minimal due to the implementation of the covered activities and conservation strategy, which limits activities in riparian forests and promotes ongoing improvement in aquatic habitat quality for coho.

Because harvest in RCAs is limited to no more than 1,200 acres of restoration thinning to promote increased ecological function occurs in RCAs, riparian habitats will continue to grow. If natural disturbances happen in RCAs, there cannot be an adjustment or reduction in harvest activities, since none occur there. The Stay-Ahead provisions for the aquatic strategy will be centered on the use of monitoring (Chapter 6, *Monitoring and Adaptive Management*) to ensure that riparian management activities inside the RCAs do not reduce habitat quality for Oregon Coast coho. This approach will ensure that conservation values in riparian areas do not regress at any point during the permit term.

7.5 Adjustments to Stay-Ahead

The permit area is a forested landscape subject to natural events, as described in Chapter 2, *Environmental Setting*, and Section 7.8.2, *Changed Circumstances Addressed by this Plan*. 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 possible that the CRW and MRW Reserves and 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 toward those commitments will be linear, due to these stochastic events. The potential for these events to occur in the future is described in Section 7.8.2.2*, Temporary Change in Species Habitat Quality from Natural Events,* in the context of historical examples of how natural events have already changed the permit area. Adjustments to the Stay-Ahead provisions—which would require approval from the Services—could allow for HCP changes associated with changed circumstances to be addressed administratively and avoid the need for an amendment; this will be evaluated consistent with the processes of Section 7.6, *Modifications to the Habitat Conservation Plan*.

When these natural events occur, the Permittee will respond as described in Section 7.8.2, *Changed Circumstances Addressed by this Plan*. 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 the Reserves, the Permittee will adjust (upon conference with and approval from the Services) how those acres are measured against the Stay-Ahead requirement because, depending on the type and severity of the natural event, habitat quality may or may not return to pre-disturbance quality by the end of the permit term.

Those acres affected by natural disturbance will continue to be reported in annual reports, 6-year Summary Reports, and 12-year Comprehensive Reviews, but they will be reported as disturbed acres or habitat rehabilitation areas in the CRW or MRW Reserves and RCAs. Data collected will include acres of terrestrial species habitat lost or Reserves lost to a particular disturbance. An assessment will be completed to determine whether the loss of habitat quality from disturbed acres caused the Permittee to drop below Stay-Ahead provisions for any of the covered species. Adjustments to the pace of management activities will be made following subsequent 6-year Summary Reports and 12-year Comprehensive Reviews to ensure that the Stay-Ahead requirement is met and ultimately that the biological objectives are met. For disturbances in RCAs, the episodic nature of events in the stream environment will be taken into consideration when determining whether the Stay-Ahead requirement is being met. Resetting events, like debris flows resulting from a 100-year storm event that affects much of the permit area, can change the habitat quality over many streams very quickly. From that point forward, those affected sections of stream would be monitored with the new condition in mind, and habitat quality would be tracked in those sections and downstream from that point forward, with the new stream condition, created by the episodic event, as the reference point.

7.6 Modifications to the Habitat Conservation Plan

The HCP and associated ITP may be modified or amended in accordance with the ESA, USFWS, and NMFS implementing regulations, and the provisions outlined in this section. HCP modifications or permit amendments are expected to be rare. Modifications or amendments may be requested by the Permittee, USFWS, or NMFS. USFWS or NMFS 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) 13.23(b) and the No Surprises assurances described in Section 7.7, *Federal No Surprises Assurances*. Changes to the HCP will fall into one of the two categories: HCP modifications or permit amendments, each of which is described in the following subsections.

7.6.1 Habitat Conservation Plan Modifications (Corrective Revisions and Plan Clarifications)

The Permittee will submit requested modifications to the Services after conferring with the implementation and adaptive management committee (Section 7.2.5, *Implementation and Adaptive Management Committee*). HCP modifications may be acknowledged by the Services through an exchange of formal correspondence with the Permittee, followed by an addendum or revision to the HCP. Any request to modify the HCP will include a statement of the reason for the proposed modification, an analysis of any environmental effects—including effects on operations under the HCP and on covered species, the conservation strategy, and the Permittee's ability to achieve the HCP's biological goals and objectives. Modifications are not anticipated to entail the level of time, process, and review that is involved in a permit amendment (e.g., NEPA, ESA, *Federal. Register* [FR], and related process and levels of review). Following acknowledgement by USFWS and/or NMFS, HCP modifications will be made publicly available through updates on a website maintained by the Permittee.

The following HCP modifications may generally be appropriate for minor changes.

1. Correction of typographical, grammatical, or similar editing errors.
2. Clarification of vague or undefined language or phrases.
3. Correction of errors in maps, exhibits, or factual depictions or statements.
4. Slight modifications to covered activity descriptions or avoidance, minimization, and mitigation measures.
5. Minor changes to survey, monitoring, or reporting protocols.
6. Changing funding sources, where no change to financial assurances would occur.
7. Changing the names or addresses of responsible officials.

HCP modifications may also be appropriate for other changes, including for certain land acquisitions or exchanges in the plan area, where the effects on covered species, the conservation strategy, and the Permittee's ability to achieve the HCP's biological goals and objectives are either beneficial or not significantly different than those analyzed for the initial permit issuance. In general, these modification types would include changes that will not increase or change impacts as analyzed in the HCP, environmental impact statement (EIS), Biological Opinions, and permit issuance documents, and changes that will not increase or change the impact of the taking as authorized by the permits.

7.6.2 Permit Amendments

Substantial changes beyond those described previously would likely require a permit amendment, which will require a review to ensure National Environmental Policy Act and ESA compliance for the amendment and which may include an FR notice. Any request to amend the permit will include a statement of the reason for the proposed amendment and an analysis of any environmental effects—including effects on operations under the HCP and on covered species, the conservation strategy, and the Permittee's ability to achieve the HCP's biological goals and objectives. The Permittee will confer with the implementation and adaptive management committee (Section 7.2.5, *Implementation and Adaptive Management Committee*) before requesting permit amendments. Notification of requested amendments will be made publicly available through updates on a website maintained by the Permittee. In addition, the public will be informed based on the nature of the federal permit amendment process.

Changes that would require a permit amendment include, but are not limited to, the following actions.

1. Changes in the extent of Permittee-managed lands that add any lands outside of the plan area.
2. Changes to or within the permit area that increase or change the level or type of impact on the covered species beyond that authorized.
3. Changes that may result in impacts not analyzed in the existing HCP, EIS, Biological Opinions, or permit issuance documents.
4. Changes that cause a significant reduction or delay in attainment of expected conservation outcomes.
5. Changes in the conservation strategy that that no longer offset the impacts of take on one or more covered species.

7.6.3 Agency Input on Habitat Conservation Plan Implementation

In those instances where a decision from the Services is necessary for HCP activities to move forward but the HCP is not being modified (e.g., the HCP identifies the need for the Services' approval, concurrence, or agreement, or other input or response) the Permittee will provide a description of the proposed action(s) in writing at least 60 days in advance to allow for the Services' consideration and written response.

7.6.4 Process Determination

In all cases, the Services will decide the level of review needed to satisfy statutory and regulatory requirements and will determine whether the proposed change may be processed as an HCP modification or if a permit amendment is required.

7.7 Federal No Surprises Assurances

This section discusses the rights and responsibilities of the Permittee and the Services regarding changed and unforeseen circumstances that may occur over the permit term. The No Surprises regulation limits the scope of the Permittee's responsibility to provide additional mitigation under the ESA.

The federal No Surprises regulation was established in 1998. It provides assurances to Section 10 permit holders that no additional money, commitments, water, or land, or restrictions on land or water will be required should unforeseen circumstances requiring additional mitigation arise once the ITP is in place. The No Surprises regulation states that if the Permittee is properly implementing an HCP, no additional commitment of resources, beyond that already specified in the Plan, will be required.

The Permittee understands that No Surprises assurances are contingent on proper implementation of the HCP. The Permittee also understands that USFWS or NMFS may suspend or revoke the ITP, in whole or in part, in accordance with federal regulations (50 CFR 13.27, 13.28, and 17.32 and other applicable laws and regulations) in force at the time of such suspension (Section 7.9, *Permit Suspension or Revocation*).

7.8 Changed and Unforeseen Circumstances

Changed circumstances are defined in the federal No Surprises regulation (63 FR 35 amending 50 CFR 17.22(b)(5) and 222.307(g)). With respect to HCPs, Congress recognizes that "circumstances and information may change over time and that the original plan might need to be revised" (H.R. Rep. No. 97-835, 97th Congress). Section 10 regulations (50 CFR 17.22(b)(2), 17.32(b)(2), and 222.307) describe changed and unforeseen circumstances and specify procedures for addressing changed circumstances that may arise during the permit term. Changed and unforeseen circumstances describe what changes can and cannot be anticipated over the permit term and, thus, be bound by the Permittee's commitment.

7.8.1 Changed Circumstances

Changed circumstances are defined by the HCP No Surprises rule as "changes in circumstances affecting a species or geographic area covered by a conservation plan that can be reasonably anticipated by the plan developers and USFWS and NMFS and that can be planned for (e.g., the listing of a new species, or a fire or other natural catastrophic event in areas prone to such events) (50 CFR 17.3)." This regulation requires that potential changed circumstances be identified in the HCP, along with responsive actions that would be taken to address these changes. The changed circumstances that could arise in the plan area have been identified and are described in the following subsections.

Subject to Section 7.7, *Federal No Surprises Assurances*, if a changed circumstance occurs in the permit area, the Permittee will implement the responsive actions prescribed in this section. The Permittee will engage the implementation and adaptive management committee (Section 7.2.5, *Implementation and Adaptive Management Committee*) in conversations related to changed circumstances and any effort to address them.

7.8.2 Changed Circumstances Addressed by this Plan

Changes in the environment are anticipated and will be addressed adaptively as part of the conservation strategy and its adaptive management program. Nonetheless, HCPs are required to identify specific changed circumstances that could arise during implementation affecting a species or geographic area covered by the HCP and describe responsive actions the Permittee will take to address changed circumstances. Changed circumstances recognized by this HCP are provided in the following subsections, along with responsive actions to address them. The Permittee has designated a portion of the HCP implementation budget for the responsive actions.

Climate change poses the most uncertainty and risk to the permit area. 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, 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 permit 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). Climate change is 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 northwestern United States 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 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). Warmwater predatory fish, such as bass, will likely affect the survival and recovery of salmonids.

Because of the variability of climate change and because it is so interconnected to fire, storm, and wind events, as well as invasive species, thresholds discussed below for setting changed circumstances take into account any potential implications of climate change.

Costs for responding to changed circumstances will be considered as adaptive management costs, which are funded as needed under the overall operations budget (Chapter 8, *Cost and Funding*).

7.8.2.1 New Species Listed or Designation/Revision of Critical Habitat

Over the course of the permit term (80 years), USFWS or NMFS could list species as threatened or endangered that occur in the permit area that are not covered under the HCP. The Permittee 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. In addition, the Services may designate or revise critical habitat for ESA-listed species over the course of the permit term.

Response

If a noncovered species is listed, the Permittee will take the following responsive actions.

1. **Determine the potential for covered activities to affect the species.** Once a species is listed, the Permittee will evaluate and determine the potential distribution of the species on Permittee-managed lands, how covered activities affect the species, and the necessary coordination with the Services.
2. **Coordinate with USFWS or NMFS and implement avoidance measures.** If the Permittee determines that the newly listed species may be present in the permit area and may be incidentally taken, they will initiate timely coordination. Through technical assistance with USFWS or NMFS, 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 the Permittee and USFWS or NMFS determine that the newly listed species occurs or could occur in the permit area, the Permittee will identify and implement any necessary measures to avoid take of the species. The Permittee will implement the interim take or adverse modification avoidance measures for the species until a permit amendment is finalized, or an alternate permit is issued to ensure compliance with the ESA.
3. **Apply for permit amendment or alternative take coverage**. If the Permittee wishes to proceed with activities that have the potential to cause take of the newly listed species, they can only begin those activities after the HCP and permit are amended or take authorization is granted through a separate permitting process.

If new critical habitat is designated or existing critical habitat is revised in the permit area, the Permittee and Services will review the new or revised designation(s) in light of the ongoing as well as permitted future research and management under the HCP obligations. The Permittee and the Services will first consider whether or the extent to which HCP covered activities or avoidance, minimization, or mitigation activities may, individually or cumulatively, adversely modify critical habitat. If implementation of the HCP will result in effects on newly designated or revised critical habitat not otherwise considered under ESA intra-Service Section 7 consultation, the Services may reinitiate consultation. If the Services determine adverse modification to be likely, then the Services and Permittee will discuss reasonable and prudent alternatives to address this outcome. As with other cases of changed circumstances, the Services will not require any conservation and mitigation measures in response (beyond the steps identified above) as long as the Permittee has been properly implementing the HCP.

7.8.2.2 Temporary Change in Species Habitat Quality from Natural Events

Some natural events can cause significant temporary changes in terrestrial and aquatic species habitat quality. The following natural events occur in a forested landscape in western Oregon, including the permit area.

- Fire
- Storms (e.g., rain, ice, wind, snow)
- Floods

- Drought
- Invasive species and diseases

The following sections summarize how these natural events and climate change have affected forests in the permit area historically. This information provides context for the thresholds defined for this HCP and is 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

Fire is the primary coarse-scale disturbance agent of forests in the western hemlock (*Tsuga heterophylla*) zone of the Oregon Coast. Wildfires can be natural or human-caused events. The effects on forested lands are the same, no matter the initiation cause. Catastrophic forest fires are defined as wildfires that cover more than 100,000 acres of contiguous forestland during the course of a single event (Zybach 2003). The Coos Bay Fire of 1868 and the Chetco Bar Fire of 2017 are the two largest known catastrophic fires in the region. The Coos Bay Fire burned approximately 90% of the area now known as the Elliott State Forest (Oregon Department of State Lands and Oregon Department of Forestry 2011). Such catastrophic disturbances affect both healthy and weakened trees, and usually result in significant or complete mortality over wide areas. Large-scale wildfires generally return a forest stand to an earlier developmental state by killing many plants, favoring the establishment of early-seral species. Since the 1868 fire, the Elliott State Forest has been spared any major catastrophic fire event (Chapter 2, Section 2.2.4.1, *Disturbance Agents: Fires*). Smaller-scale fires occur in the permit area and are moderated because of its proximity to the coast and generally wet condition (Chapter 2, Section 2.1.5, *Climate*), which greatly reduces fire risk except in extreme weather conditions (as occurred in 1868).

The permit area is in an infrequent high-intensity fire regime, meaning that fire is infrequent (in the range of 130 or more years between events), but that when it does occur, the severity is typically high, with extensive, stand-destroying crown fires such as characterized the 1868 fire (Agee 1993). That said, while evidence of this more infrequent return interval, high-severity fire pattern exists in the permit area, fire history data also indicate more frequent, smaller-scale or moderate intensity fire behavior in the permit area (whether part of aboriginal/Indigenous burning or natural fire starts is difficult to ascertain with certainty). Further, climate change may increase the frequency and severity of such fires in the permit area as late-season drought and incidents of drying east winds are expected to increase risks of stand-replacing fires (Hagmann et al. 2021; Hessburg et al. 2021).

Storms

Storm events (e.g., ice storms, severe wind, heavy snow) can lead to underproductive forest conditions and susceptibility to insects and disease. Affected stands often require immediate action to restore resilient and productive forest conditions.

The Oregon Coast 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 (*Dendroctonus pseudotsugae*) 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 (two events), and 2016.

The storms that occurred in February and November 1996 are more common examples of important storm events in the plan area (Robison et al. 1999). Both storms were "atmospheric river" events that produced very heavy precipitation over a multi-day period and were accompanied by shallow and rapid landsliding and debris flows. Landslides and debris flows from large rain events cause mass movement of soil material and increase sediment loads to waterways. Similar events have been recorded in many other areas of western Washington and Oregon. Such events may be expected to occur more frequently and with greater severity in the future due to climate change (Mahoney et al. 2018).

Floods

Natural disturbance regimes, including floods, debris flows, and beaver activity, historically determined the temporal and spatial distribution of the range of riparian characteristics (Pierson 1977; Swanson 1994). Floods are generally restricted to more predictable areas than fires or windstorms, and their magnitude and frequency of occurrence can be estimated for a given river (Oliver and Larson 1996). The effects of flooding are dependent on local weather and drainage basin conditions.

Drought

Contributors to drought are high air temperatures and low precipitation, such as rain or snowfall, which influence snowpack, soil moisture, and streamflows. Drought conditions can decrease streamflow, which may reduce the amount of aquatic habitat and contribute to the stream warming that is predicted with climate change (Isaak et al. 2012) and may be exacerbated by forest management (Groom et al. 2018). Such drought-associated changes in stream flow and temperature may negatively affect aquatic ecosystem health generally and more specifically the amount and accessibility of high-quality habitat for coho salmon in the permit area, particularly during late summer and early fall. Western Oregon is currently in a megadrought[2] and drought conditions have become more persistent and more intense in recent years. According to the U.S. Drought Monitor, over half of Oregon is in severe to exceptional drought (State of Oregon 2023). Severe drought occurrences are not intended to have trigger thresholds, themselves, but would rather be addressed when drought effects contribute to mortality events or increased fire sizes or intensities.

Invasive Species and Diseases

Invasive species and diseases currently occur in the permit area. Several diseases have reached noticeable levels of damage in the Elliott State Forest in recent decades (Chapter 2, Section 2.2.4.3, *Disturbance Agents: Insects and Disease*). For example, Swiss needle cast (*Phaeocryptopus gaeumannii*), the highly visible native foliage disease of Douglas-fir, is causing serious growth decline over a large area along the west slope of the Coast Range. The growth reduction is severe enough on some sites that the future of those stands is uncertain. Black stain root disease (*Leptographium wageneri*) has reached epidemic proportions in some locations in southwest

[2] A megadrought is a period of extreme dryness that lasts for decades.

Oregon but is found infrequently in Douglas-fir in the Elliott State Forest (Decker et al. 2011). In addition to disease, there are insect issues in the mid- to late-successional Douglas-fir stands. The most significant pest is the Douglas-fir bark beetle, whose outbreaks follow major wind events. The Sitka spruce weevil (*Pissodes strobi*) continues to limit Sitka spruce management (Decker et al. 2011).

There are nonnative species and diseases in areas outside the permit area that have the potential to spread into the permit area and adversely affect the covered species. Given the nature of invasive species and diseases, there is no unforeseen circumstance, only an upper limit to which changed circumstances will be funded. In other words, a new disease or invasive species that spreads throughout the permit area during the permit term is a foreseeable event. If a disease or nonnative species spreads beyond the thresholds identified in the *Changed Circumstance* subsection, it will be considered unforeseen, and the Services will not require the Permittee to fund remedial actions to address it.

Changed Circumstance

If more than 5,000 acres of suitable[3] habitat in conservation areas for terrestrial covered species are collectively affected by any combination of the events described here in 1 calendar year, that will be considered an unforeseen circumstance. The 5,000-acre threshold was developed in consultation with USFWS as a reasonable threshold to be considered a changed circumstance.

No changed circumstances are defined for RCAs. The Permittee will attempt to restore riparian areas regardless of acres affected by a single natural event within 1 calendar year. However, restoration will be designed with stream processes in mind and will not necessarily return the location to the pre-disturbance condition. For example, if there is a blowdown in a riparian area, the downed trees would likely be left in place, provided there was no safety risk, so that they could be naturally recruited into the stream system.

Response

The Permittee will implement remedial measures to address the temporary loss of suitable northern spotted owl and marbled murrelet 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 the Permittee's ability to successfully maintain conservation values from the research forest design, as described in Chapter 3, *Covered Activities*, and Chapter 5, *Conservation Strategy*.

- **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 the Permittee is still meeting the Stay-Ahead provision (as described in Section 7.4, *Stay-Ahead Provisions*) for each covered species despite the habitat loss incurred by the natural event, using modeled habitat or field verification. If the Stay-Ahead provision is still being met for a given covered species, then no further response is needed. If the Stay-Ahead provision is not being met for one or more species, an adjustment to the Stay-Ahead provision may be completed with the approval of USFWS, as described in Section 7.5, *Adjustments to Stay-*

[3] Suitable is defined here as northern spotted owl or marbled murrelet habitat within CRW or MRW Reserves, northern spotted owl habitat for the 22 historic nest sites, or occupied or modeled potential marbled murrelet habitat.

Ahead. Along with the potential adjustment to the Stay-Ahead provision the Permittee will also undertake actions described in Step 3.

- **Step 3.** Examine current and future harvest plans to assess potential harvest that may affect covered species habitat and seek opportunities to adjust harvest in proximity to the disturbance event, 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. If, despite deferments, the Stay-Ahead provision cannot be met by the end of the current harvest planning cycle, the Permittee will meet the Stay-Ahead provision during the next harvest planning cycle. Potential deferments will not result in reductions to planned harvest volume or acres in total. Deferments are 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 resumes.

Priorities for locations to temporarily defer harvest are the following, in order of priority and subject to change after consultation with ODFW and federal permitting agencies (as part of the implementation and adaptive management committee; Section 7.2.4, *Implementation and Adaptive Management Committee*) in order to maintain the integrity of ongoing research objectives.

1. Defer harvest in Reserves or RCAs in locations that are not part of an operation currently under contract.
2. Defer harvest in areas available for extensive or intensive treatments, but within the same watershed where the natural disturbance occurred, that is not part of an operation currently under contract.
3. Defer harvest in areas available for extensive or intensive treatments in different watersheds than where the natural disturbance occurred, but still within the permit area, that are not part of an operation currently under contract.

7.8.2.3 Aquatic Invasive Plants, Nonnative Fish, and Disease/Parasites

Nonnative aquatic plant species, disease, and warmwater predatory fishes may currently occur in portions of the permit area, as well as outside the permit 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 (Oregon State University 2014).

Nonnative mussels, nonnative fish such as the brook trout (*Salvelinus fontinalis*), and other nonnative aquatic organisms compete with the covered species for habitat uses including spawning, rearing, and foraging. As stream temperatures increase, the range of nonnative warmwater predators, such as smallmouth bass (*Micropterus dolomieu*), that prey upon juvenile salmon and steelhead, expands. Rising stream temperatures also increase the susceptibility of the covered fish 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, the Permittee will manage the permit area in accordance with the biological goals and objectives to ensure the riparian and aquatic habitat are maintained to benefit the covered species.

Changed Circumstance

Aquatic invasive plants, nonnative fish, and disease/parasites will be considered a changed circumstance under the following conditions. A changed circumstance will be considered if the spread of aquatic invasive plant species affects up to 25% of stream miles in any given subwatershed for an independent population of Oregon Coast coho in a 3-year time period. If this occurs, the Permittee will work with the Oregon Department of Agriculture and ODFW (as well as other entities in the implementation and adaptive management committee; Section 7.2.4, *Implementation and Adaptive Management Committee*) 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 Oregon Coast coho to a point where it becomes a limiting factor for covered species populations in the permit area, the Permittee will coordinate with ODFW on what measures, if any, should be taken to address the species expansion that would be consistent with the terms of the HCP and permits.

Any new invasion that expands beyond 25% of stream miles within any given hydrologic unit code–10 for an independent population of Oregon Coast coho within a 3-year time period will be considered an unforeseen circumstance.

Response

The Permittee will address changed circumstances using manual, mechanical, cultural, chemical, and biological treatments to manage new occurrences of aquatic invasive plant infestations in the permit area. For unforeseen circumstances, the Permittee will coordinate a response with ODFW and other state and federal agencies, but it would not be required to commit additional funding or resources beyond those already committed to in the HCP.

7.8.2.4 Stream Temperature Changes

Climate change is projected to raise temperatures and alter the flow regimes of streams and rivers in the permit 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 affect 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 runoff, and wildfires—also affect stream temperature and flow.

Changed Circumstance

While water temperature varies over time based on location, time of day, and season, the mean August water temperatures across the Pacific Northwest averaged 58 degrees Fahrenheit (°F) (14.2 degrees Celsius [°C]) from 1993 to 2011 (Isaak et al. 2017). 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) across the permit area during the permit term would be considered unforeseen.

Response

In response to potential changes in water temperature and flow from climate change, which will be identified during reporting (Section 7.3, *Reporting*), the Permittee will take preventive measures for streams and rivers in the permit area, as well as responsive measures if HCP-based monitoring of water temperature and flow trends, as described in Chapter 6, Section 6.3.2, *Water Temperature Monitoring*, and Table 6-2.

These measures may include, but are not limited to, the following.

- Expand stream buffers in key locations on fish-bearing streams or in perennial non-fish-bearing streams upstream of Oregon Coast coho presence to further minimize risk of temperature rise should the HCP monitoring program establish that stream temperatures are rising.
- Reconnect streams to floodplains and protect seeps, springs, and wetlands to facilitate flow (including hyporheic) and water-related temperature benefits.
- Increase the potential of large wood production to the streams through management of the buffers in the Reserves to promote shading and large wood. Increased bed load will lead to cooler groundwater temperature, reducing stream temperatures.
- Introduce large wood during restoration projects (e.g., riparian thinning) to provide habitat for Oregon Coast coho.
- Manage RCAs to increase beaver habitat and presence where possible to create improved habitat conditions for Oregon Coast coho. This may include translocation of beaver consistent with other state and federal regulations and policies.
- Consider adjustments in harvest management and retention of cover within subwatersheds to manage streamflow over the long term.

7.8.3 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 Service 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 circumstances not described in this HCP or as a changed circumstance in this chapter are considered unforeseen circumstances. The Permittee is not obligated to respond to an unforeseen circumstance but may do so voluntarily. This section describes the procedures to deal with unforeseen circumstances that may arise during implementation of the HCP.

The procedure for dealing with unforeseen circumstances will begin with the identification of any such circumstances or as part of ongoing compliance reporting and coordination with the Services. Either the Services or the Permittee may initiate the process for declaring and documenting unforeseen circumstances. Once initiated by either the Services or the Permittee, the Permittee will provide available information to the Services regarding the circumstances and associated adverse changes to covered species and their habitat in the plan area. If applicable, the Permittee will identify specific biological goals and objectives of the HCP that are or will be affected by the circumstances.

Pursuant to implementing regulations (e.g., 50 CFR 17.22(b)(5) and 50 CFR 222.307(g)(3)), upon determining that unforeseen circumstances exist, the Services will inform the Permittee of any additional avoidance, minimization, or mitigation measures that may be warranted and the Permittee will work with the Services to determine an appropriate response in accordance with Section 7.7, *Federal No Surprises Assurances*. Responses may include additional mitigation, which may be implemented at the option of the Permittee or by third-party stakeholders under the direction of the Permittee. The Permittee will document and track any unforeseen circumstances—and associated metrics and mitigation—as part of the HCP monitoring and reporting program. The Permittee will engage the implementation and adaptive management committee (Section 7.2.4, *Implementation and Adaptive Management Committee*) in conversations related to unforeseen circumstances and any effort to address them.

7.9 Permit Suspension or Revocation

USFWS and NMFS have the ability under federal law to suspend or revoke all or a portion of the permits if the Permittee is out of compliance with the HCP or ITPs. USFWS and NMFS 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), 222.307(a)(1)) or if the Permittee does not comply with the conditions of their permits (50 CFR 13.27, 13.28, 222.306(e)).

If the permit is revoked, the Permittee will have to fulfill any outstanding mitigation requirements for any impacts of take that occurred prior to the revocation, including land management actions and restoration/enhancement actions.

7.10 Permit Transfer

In the event of a sale or transfer of ownership of the ESRF during the permit term, the permittee and new owner(s) will submit to the Services written documentation providing assurances pursuant to 50 CFR 13.25 (b)(2) and 50 CFR 222.305(a)(3) that the new owner(s) will sufficiently fund 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 NMFS. Permit transfer will be carried out in accordance with relevant requirements in Section 7.6, *Modifications to the Habitat Conservation Plan*.

Chapter 8
Cost and Funding

8.1 Introduction

The federal Endangered Species Act (ESA) requires that habitat conservation plans (HCPs) specify "the funding that will be available to implement" conservation actions that minimize and mitigate impacts on covered species (16 United States Code 1539(a)(2)(A)(ii)). Consequently, the ESA requires the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS) (collectively, the Services) to find that the applicant will ensure that adequate funding is available to implement the Elliott State Research Forest (ESRF) HCP. This chapter outlines the estimated costs to implement the HCP over the proposed 80-year permit term (Section 8.2, *Implementation Cost*) and provides assurances that the Oregon Department of State Lands (DSL, the Permittee) will pay for those costs (Section 8.3, *Implementation Funding*).

8.2 Implementation Cost

As described in Chapter 7, *Implementation and Assurances*, the Permittee will oversee implementation of the HCP. This includes the ESRF managers, staff, and contractors who will carry out the research forest operations, HCP monitoring, adaptive management, and coordination with the Services. The cost estimate to implement the HCP is summarized in Section 8.2.1, *Habitat Conservation Plan Administration and Conservation Strategy*, Section 8.2.3, *Habitat Conservation Plan Monitoring and Reporting*, and Section 8.2.4, *Adaptive Management and Remedial Measures*.

All costs were estimated based on cost estimates for the same or similar actions conducted currently. In cases where actual Permittee cost data were 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.

These cost estimates are planning-level estimates only, whose purpose is demonstrating assured funding for the HCP. The Permittee will prepare a biennial budget to implement the HCP that may differ from these cost estimates (either more or less). The cost estimate in this chapter is not a requirement of funds the Permittee 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 2023 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 Permittee operations, including HCP implementation, are reevaluated each year and adjusted for inflation, as necessary. This is discussed further in Section 8.3, *Implementation Funding*.

As described in Chapter 3, *Covered Activities*, much of the day-to-day operation and management of the ESRF will occur as part of the research forest itself. Day-to-day operations and management will be paid for by the Permittee from revenues derived either from harvest operations consistent with the HCP or other nonharvest revenue sources. These typical and routine operations and management activities are not considered as HCP implementation costs because they are not required as part of the conservation strategy (Chapter 5, *Conservation Strategy*), or the HCP monitoring and adaptive management program (Chapter 6, *Monitoring and Adaptive Management*), or to support HCP implementation (Chapter 7, *Implementation and Assurances*). Therefore, only those costs directly related to the HCP are estimated in this section.

8.2.1 Habitat Conservation Plan Administration and Conservation Strategy

8.2.1.1 Habitat Conservation Plan Administration

Research forest operation includes the harvest and habitat management program, including road system management, and HCP implementation. The Permittee will oversee management in the permit area. The Permittee will be responsible for oversight of all administration including contract management, leading coordination efforts with the Services on HCP implementation, and facilitating the implementation and adaptive management committee. Table 8-1 summarizes ESRF annual operation costs associated with implementing the HCP, including personnel (technical and support staff), equipment and supplies, and maintenance and other related costs. One-time costs associated with other cost categories (e.g., conservation strategy, monitoring) are presented later in the chapter. The monitoring actions in Table 8-2 are also incorporated into Table 8-1.

Table 8-1. Elliott State Research Forest Annual Operation Costs Associated with the Habitat Conservation Plan

Cost Category	Total Annual Cost to ESRF	Share to HCP a	Annual Cost for HCP
Personnel (Salary + Benefits)			
Forest Manager	$170,000	0.10	$17,000
Forester (Lead/Manager)	$168,000	0.15	$25,200
Lead Biologist	$150,000	0.80	$120,000
Research Coordinator	$150,000	0.50	$75,000
Subtotal	$488,000	-	$162,200
Monitoring, Maintenance, and Other Expenses			
HCP Monitoring (Table 8-2)	$500,000	1.0	$500,000
Monitoring Equipment	$100,000	1.0	$100,000
Monitoring Equipment Maintenance	$10,000	1.0	$10,000
Vehicle Maintenance and Fuel	$40,000	0.10	$4,000
Road Operations and Maintenance	$400,000	0.10	$40,000
IT/Data Storage/Software/QA/QC	$60,000	1.0	$60,000
Subtotal	$1,110,000	-	$714,000
Total	$1,598,000	-	$876,200

[a] Estimated average annual proportion of a full-time equivalent staff person dedicated to the HCP. This proportion will vary over time, likely being a larger share early in the permit term.

ESRF = Elliott State Research Forest; HCP = habitat conservation plan; IT = information technology; QA/QC = quality assurance/quality control.

8.2.1.2 Conservation Strategy

As stated in Chapter 5, *Conservation Strategy*, the conservation strategy implements the approach to fulfilling the HCP requirement to avoid, minimize, and mitigate impacts of the taking of the covered species to the maximum extent practicable. Estimated costs associated with the conservation strategy include the following conservation measures. The staff expected to support the treatments, and, thus, the activities described in the conservation strategy, are listed in Table 8-1. Funding for research activities or projects that are not directly part of HCP conservation measures and HCP compliance is not included in this table because costs related to HCP implementation and compliance are distinct from broader management and research costs associated with the ESRF. Funding for research activities and projects will come, in part, from harvest or other revenue tied to the ESRF, as well as from other sources, such as grants, foundations, or other public or private funding sources. The Permittee will ensure revenue from timber harvest or other sources is budgeted and allocated to first cover annual HCP commitments and compliance costs, with revenue above and beyond that amount going to support broader operations and management, followed by then being made available for research.

Conservation Measure 1: Targeted Restoration and Stream Enhancement

This conservation measure involves the application of silvicultural tools and management techniques in riparian conservation areas (RCAs), using approaches that differ from traditional “no touch” aquatic and riparian management strategies, to change the vegetative community so that the HCP’s aquatic and riparian habitat objectives can be more effectively achieved. It is assumed that there will be HCP-related costs associated with applying alternative vegetation treatments. In the conservation research watersheds (CRW) and management research watersheds (MRW), timber that is felled will follow the approach described in Chapter 5, Section 5.4.1.2, *Riparian Vegetation Management in Riparian Conservation Areas*). These costs are captured in the timber harvest and financial modeling results in Table 8-4.

Conservation Measure 2: Expanded RCAs on Select MRW Streams

This conservation measure will establish and maintain expanded RCAs for Lower West Fork Millicoma River and its fish-bearing tributaries from its entry into the permit area in the southwest portion of the permit area through the confluence with Elk Creek. This addresses the lower amount of wood recruitment expected in the Coos independent population, as it is almost entirely in the MRW and will have variable RCA widths when compared to the Tenmile and Lower Umpqua independent populations. This conservation measure also designates expanded RCAs in Volume Replacement allocations and in the Flexible Extensive allocations in the Big Creek and Palouse watersheds. There is no direct cost for Conservation Measure 2, and the revenue foregone from the expanded RCAs is captured in the timber harvest and financial modeling results in Table 8-4.

Conservation Measure 3: Reduce Density of Forest Road Network in the Permit Area

The objectives for managing the forest road systems are to keep as much forestland in as natural productive condition as possible, prevent water quality problems and associated impacts on aquatic and riparian resources, minimize disruption of natural drainage patterns, and minimize exacerbation of natural mass-wasting processes. There will be a reduction in the density of the forest road network across the forest by the end of the permit term, with a focus on the CRW. To facilitate that, roads unnecessary to support future forest management actions or emergency management, or roads with a high relative likelihood of impairing resource conservation concerns compared to assisting forest or emergency management, will be vacated. Any new roads will be constructed in the best locations for minimizing impacts on aquatic and riparian systems. To inform this conservation measure, a one-time road assessment will be conducted with an estimated cost of $200,000. Capital costs to vacate roads identified by the road assessment will be funded by the Permittee as part of modeled revenue (Table 8-4). All other costs relevant to implementing this conservation measure are accounted for in the operations budget in Table 8-1.

Conservation Measure 4: Barred Owl Management and Research

This conservation measure includes the design and implementation of barred owl management on the ESRF in support of federal management strategies for northern spotted owl (*Strix occidentalis*) conservation. In addition, ESRF will provide research opportunities, such as the consequences of, and mechanisms behind, the invasion of northern spotted owl habitat by a highly successful generalist predator on other ecosystem processes. The management research initiative associated with this mitigation measure will be designed and budgeted within 16 months of incidental take permit issuance and begin no later than the field season the following year, assuming appropriate federal Migratory Bird Treaty Act take permit(s) are in place and other state and federal legal compliance has been addressed. Costs associated with barred owl management will be covered by revenue modeled for the forest.

Conservation Measure 5: Harvest and Thinning Adjacent to Occupied Marbled Murrelet Habitat

This conservation measure includes buffers around designated occupied marbled murrelet (*Brachyramphus marmoratus*) habitat in certain locations. In the CRW and MRW Reserves, this conservation measure requires buffers where restoration thinning is planned adjacent to designated occupied habitat, and in the MRW where modeled potential marbled murrelet habitat exists immediately adjacent to occupied marbled murrelet habitat and is outside of MRW Reserves. There is no direct cost for implementing Conservation Measure 5, other than timber revenue foregone in the areas protected by this measure.

8.2.2 Habitat Conservation Plan Monitoring and Reporting

The HCP monitoring program is described in Chapter 6, *Monitoring and Adaptive Management*. Reporting requirements are described in Chapter 7, *Implementation and Assurances*. Monitoring the outcomes of covered activities and conservation measures is central to the HCP's conservation strategy 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 estimated costs in Table 8-2, which are also incorporated into Table 8-1. Reporting is critical to demonstrating compliance with the HCP and permits and progress. Reporting costs are accounted for in the operations budget in Table 8-1.

Table 8-2. Estimated Costs for Monitoring Actions Annually

Cost Category	Estimated Annual Cost
Effectiveness Monitoring for Oregon Coast coho [a]	$150,000
Effectiveness Monitoring for Northern Spotted Owl	$85,000
Effectiveness Monitoring for Marbled Murrelet	$150,000
Compliance Monitoring (additional contracting services)	$115,000
Annual Reporting	Included in staff time in operational budget in Table 8-1
Total	$500,000

[a] Assumes an estimated 3-year cost of $450,000, with lower annual costs in nonhabitat surveys years and higher costs in habitat survey years.

8.2.3 Adaptive Management and Remedial Measures

Chapter 6, *Monitoring and Adaptive Management*, describes the processes for addressing the specific uncertainties associated with the covered activities and conservation strategy, and the adaptive management measures and potential responses associated with those measures. Proposed adaptive management triggers, and measures that are likely to be implemented to address necessary program changes, must be documented so the Permittee will know when and how to respond to monitoring results. Chapter 7, Section 7.8, *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.

The need for adaptive management (Chapter 6, Section 6.5, *Adaptive Management*) or remedial measures is not anticipated to result in additional costs to the Permittee or the need to hire additional staff. Instead, the costs of advancing adaptive management or remedial measures would be absorbed into the operational costs described in Table 8-1 and also met by shifting expenditures of revenue from the forest. For example, if harvest patterns or approaches need to be modified through adaptive management, that would be accommodated through the ongoing management planning (i.e., biennial operations plans) that is already funded. These adaptive management or remedial measures may temporarily affect revenue from forest operations. If so, the Permittee will revisit related funding commitments. In other instances, if, for example, the road system needs to be managed differently through adaptive management, the assumption is that it would not result in a cost increase, but rather that funding would be shifted from within the road maintenance budget to accommodate the change. In this way, funding for adaptive management and remedial measures is built into the existing operations costs and is not accounted for separately.

If the covered activities and conservation strategy do not result in achievement of biological goals and objectives, or a trajectory that makes achievement of them likely during the permit term, the Permittee will engage with the Services in changes to covered activities or conservation actions aimed at achieving biological goals and objectives, as described in Chapter 6, *Monitoring and Adaptive Management,* and Chapter 7, *Implementation and Assurances*. In this instance, the Permittee will revisit related funding commitments in accordance with the relevant provisions of Chapter 7, Section 7.6, *Modifications to the Habitat Conservation Plan*.

8.2.4 Total Habitat Conservation Plan Costs

Table 8-3 summarizes all costs for the HCP over the 80-year permit term. Details for each cost category are included in Tables 8-1 and 8-2.

Table 8-3. Total Estimated Costs for the Elliott State Research Forest Habitat Conservation Plan

Cost Category	Average Annual HCP Cost	HCP Cost Over 80-Year Permit Term [a]
HCP Administration and Conservation Strategy (Table 8-1)	$876,200	$70,096,000
Monitoring and Reporting (Table 8-2)	$500,000	$40,000,000
Road Assessment (one-time cost for CM3)	N/A	$200,000
Adaptive Management	Included in operations costs (Table 8-1)	-
Remedial Measures	Included in operations costs (Table 8-1)	-
Total	$1,376,200	$110,296,000

[a] Totals over the permit term are in 2023 dollars and do not include inflation.
CM = Conservation Measure; N/A = not applicable

8.3 Implementation Funding

To fund the costs to implement the HCP (i.e., costs summarized in Table 8-3) as well as covered activities, the Permittee will rely primarily on revenue from the sale of forest products (in particular, timber) in the permit area that is based on the research forest framework and conducted consistent with the HCP. DSL is also pursuing options for state and federal funds that could be used to supplement funding available for actions that are not tied to HCP mitigation activities, or to expand actions beyond mitigation. DSL has also secured funding to cover costs of forest management and HCP implementation during the time period prior to when timber or other revenue is received.

8.3.1 Timber Sale Revenue

Operations on the ESRF (including HCP implementation) will be financially self-sufficient based on revenue generated primarily but not exclusively through forest products, including but not limited to timber. Timber harvest will occur as part of implementing HCP covered activities in allowable harvest areas. The Permittee modeled anticipated timber harvesting and related revenue based on constraints and commitments contained in the original Oregon State University Proposal (Appendix C, *Proposal: Elliott State Research Forest*) for the research forest, as well as those associated with this HCP as of August 2023 (Table 8-4).

The harvesting model resulted in an average harvest of approximately 16.1 million board feet (MMBF) per year over the permit term. Under that most recent modeled scenario (August 2023), it was assumed that annual harvest per decade will range from 389 to 1,225 acres, with an average over the permit term of 634 acres annually (plus or minus 222 acres for the standard deviation). The harvesting model assumed an average log price of $775 per thousand board feet and a mean annual increment value for harvest of 583 board feet per acre per year. Acres of active management in the first 30 years are expected to be higher than the long-term average because of the age-class structure of the forest and because restoration harvests are conducted in the CRW and MRW Reserves to set them on their future trajectory as older forests with natural variations.[1] Harvest acres are expected to drop below the mean during the middle decades of the permit term and then increase again above the mean by the last decade of the permit term (Table 8-5). However, this is a modeled scenario in a financial feasibility analysis and, thus, may not reflect actual operations on the forest over time or actual forest or market conditions at a given point in time; it is an estimate that will differ during actual implementation. Average annual harvest acreages and volumes (as well as revenue) will be adjusted over time based on operational constraints and opportunities, natural disturbance, other unforeseen circumstances, as well as variables including actual tree volumes, which will become clear as part of project-level planning and implementation. Further, revisions reflected in the current final HCP related to covered activities and harvest flexibility may not have been fully incorporated into that modeled scenario and may result in timber volume levels above 16.1 MMBF.

Regardless, timber harvest will be managed within the acreage constraints described in Chapter 3, *Covered Activities,* and, as part agreements reached over the ESRF's design to achieve multiple forest values (e.g., biodiversity, carbon sequestration, recreation, forest products, research and others) and reflected in DSL's forest management plan direction for the ESRF (October 2024), timber harvest volume will be managed within the constraint of a 4-year rolling average of 17 MMBF per year, with annual deviation not to exceed 20 MMBF in a given year.

The ESRF timber harvest, as modeled by the August 2023 mid-point scenario, is estimated to generate approximately $5.1 million in revenue annually (Table 8-4). Estimated annual HCP costs (Table 8-3) represent 22.6% of this revenue. The HCP budget's proportion of net revenue varies over the permit terms based on variation in net revenue (Table 8-4), ranging from 17.0% in the first 10 years to 34.2% in Years 31 through 40. The net revenue estimated to be generated annually by the entire ESRF will be sufficient to cover the costs of HCP implementation summarized in Table 8-3 throughout the permit term.

Table 8-4. Estimated Average Annual Harvest Volumes, Acreage, and Net Revenue to the Elliott State Research Forest

Category	Harvests in Intensive Treatments	Harvests in Extensive Treatments	Harvests in Reserves [a]	Harvest Total
Estimated Average Annual Harvest (thousand board feet)	8,543	6,733	843	16,119
Estimated Average Annual Harvest (acres)	274	290	70	634
Estimated Average Annual Net Revenue [b]	-	-	-	$5.10 million

[a] Harvests in reserves are for restoration thinning and are scheduled to be completed within the first 30 years.

[b] Net revenue was estimated in 2023 based on a mid-point scenario in the 2023 financial analysis, which includes assumptions about average annual timber prices, the estimated volume generated from harvest activities using a mean annual increment of 583 board feet/acre/year, and the projected silviculture, harvest, and hauling costs incurred.

Table 8-5. Estimated Average Annual Harvest Volumes and Net Revenue to the Elliott State Research Forest, by Decade

Decade of the Permit Term	Estimated Total Average Annual Harvest [a]	Estimated Annual Average Net Revenue [b]	HCP Annual Budget as Percent of Total Net Revenue
Year 1–10 (Decade 1)	17,000	$6,778,459	17.0%
Year 11–20 (Decade 2)	17,000	$5,290,598	21.8%
Year 21–30 (Decade 3)	12,647	$4,013,063	28.8%
Year 31–40 (Decade 4)	10,564	$3,377,616	34.2%
Year 41–50 (Decade 5)	14,857	$4,834,993	23.9%
Year 51–60 (Decade 6)	15,745	$5,354,151	21.6%
Year 61–70 (Decade 7)	15,969	$5,275,482	21.9%
Year 71–80 (Decade 8)	17,000	$5,885,407	19.6%

[a] Despite modeled estimates that are higher in decades 1, 2, and 8 based on the age-class structure of the forest and average rotation/stand ages when timber-harvest covered activities would occur, the average annual harvest volume has been constrained in this table to the 4-year rolling average of 17 thousand board feet (MBF) commitment. As a result, some timber volume would be shifted into later decades, meaning that harvest volume in decades 3 through 7 will likely be higher than projected here (but still within the 4-year rolling average 17 MBF commitment). Also, this table estimates harvests in intensive treatments, extensive treatments, and in reserves in thousands of board feet per year.

[b] Net revenue was estimated in 2023 based on a mid-point scenario in the 2023 financial analysis, which includes assumptions about average annual timber prices, the estimated volume generated from harvest activities using a mean annual increment of 583 board feet/acre/year, and the projected silviculture, harvest, and hauling costs incurred.

Chapter 9
Alternatives to Take

9.1 Introduction

The federal Endangered Species Act (ESA) requires that applicants for an incidental take permit (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 habitat conservation plans (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 the U.S. Fish and Wildlife Service (USFWS) or National Marine Fisheries Service (NMFS).

The preferred and proposed approach is described in Chapters 1 through 8 of this HCP. This proposed approach represents the best attempt of the Oregon Department of State Lands (DSL or Permittee) to minimize take of the covered species while carrying out covered 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.

The alternatives described in this chapter are different from 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*.

9.2 Description of Alternatives to Take

Three alternatives to take were considered but not selected for analysis in the HCP: no take, reduced covered activities, and no forest management in covered species habitat. These alternatives to take and the rationale for their elimination are discussed in this chapter. In addition, the Permittee considered an increased timber harvest alternative, which would ultimately remove more habitat, 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 primarily 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.

[1] From Section 3(18) of the ESA: "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."

9.2.1 No Take Alternative

Under the no take alternative, the Permittee would not engage in forest management and research activities that result in the take of any of the covered species, removing the need for ITPs from USFWS or NMFS. This alternative was not selected because the Permittee intends to permit forest management activities and research that guides and informs sustainable forest management, yielding substantial benefits for Oregon's environment, economy, and communities. The Elliott State Research Forest (ESRF) provides Oregonians with access to forest education and recreation, as well as jobs in forest products, forestry, and forest research.

Timber harvest on the Elliott State Forest has been severely limited since 2013 due to the presence of ESA-listed species and their habitat and the need to comply with the ESA by avoiding adverse effects on the species in the absence of ITPs. This harvest limitation dramatically reduced timber revenue to the point where the cost of managing the Elliott State Forest in 2013 far exceeded its revenue. Forestry practices need to maintain the financial certainty to support management as well as the flexibility to sustain an evolving set of research priorities. The Permittee believes that this HCP and the anticipated ITP that provides take authorization are essential to ensure that the Permittee can successfully manage the forest and conduct research. Therefore, the no take alternative was rejected.

9.2.2 Reduced Covered Activities Alternative

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 system construction and maintenance. Use of roads in the ESRF supports forest management. Road construction and maintenance requires the removal or modification of habitat through tree removal and stream crossings. While the elimination of these select activities could reduce or delay implementation of some remaining covered activities under the HCP, the majority would continue to occur without significant limitations.

Road construction and maintenance have the potential to affect covered species habitat and individuals in a manner similar to timber harvest. While eliminating road construction and maintenance from the HCP would reduce take of covered species, this alternative was not selected because road construction and maintenance are necessary to the activities covered in the HCP. The Permittee does not expect that in the future it will be able to fully avoid take of the covered species from road construction/maintenance. Also, covering these activities will provide the Permittee with the necessary flexibility in its operations to optimize designs to minimize all a broad range 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, including improvements to existing roads that could be affecting covered species, that will provide greater conservation benefit to covered species. Therefore, the reduced covered activities alternative was rejected.

9.2.3 Limit Forest Management in Covered Species Habitat

This alternative would include a prohibition on forest management activities in locations designated as, or known to be, habitat for covered species. This would include no management in riparian conservation areas (RCAs), designated occupied or modeled potential marbled murrelet

(*Brachyramphus marmoratus*) habitat, or inside known northern spotted owl (*Strix occidentalis*) core use areas. A prohibition of forest management in these locations would reduce incidental take of covered species, at least in locations where the species have been documented in the past, or, in the case of RCAs, locations that have a direct link to instream habitat quality for covered fish species.

This alternative would limit the type of research that could be completed on the forest, including specifically any research on the response of covered species to forest management practices covered by the HCP. This would likely reduce the long-term habitat value provided under the HCP, because without management of some locations (i.e., young even-aged Douglas-fir [*Pseudotsuga menziesii*] plantations), habitat quality is expected to be lower, in the future, than it would be if management were to occur.

Further, one of the primary objectives of the ESRF is to conduct experiments in forest management to gain a better understanding of how marbled murrelets, northern spotted owls, and Oregon coast coho (*Oncorhynchus kisutch*) and their habitat respond to management actions over time. This alternative would prohibit conducting research on the landscape-level integration of multiple resource interests and the approaches for managing a forest to meet these multiple objectives. One research question of interest, that could not be examined under this alternative, is the long-term response of covered species to forest management practices covered by the HCP. Designing a landscape-level experiment that includes conducting limited forest management entries in areas of occupied or modeled occupied habitat, increases understanding of how marbled murrelets, northern spotted owls, and Oregon coast coho and their habitat respond to management activities over time and space.

The experimental design is important to the applicability of the results beyond the ESRF and the species studied. As described in Chapter 5, Section 5.5, *Conditions on Covered Activities*—for Conditions 2, 3, and 4 for northern spotted owl and Conditions 6 and 7 for marbled murrelet—the HCP has provided strict criteria for the acreage allowable for this facet of the research. In addition, the HCP includes detailed survey requirements for when forest management is practiced in designated marbled murrelet occupied or modeled potential occupied habitat, so that the actual impact on habitat is very small relative to the forest, while still allowing for enough acreage to provide strong statistical evidence for measuring and reporting results. Furthermore, forest management must be conducted in some locations (i.e., young even-aged Douglas-fir plantations) to improve the quality of habitat that may have been designated as occupied historically but is no longer suitable or ideal. Active management in these areas will allow them to grow into habitat of superior quality relative to dense Douglas-fir plantations.

Finally, this alternative would result in a net reduction of timber volume and resulting harvest revenue, jeopardizing the research forest's ability to be self-sustaining financially because the wood production is a derivative of the experimental design.

For the reasons described above, this alternative was rejected.

Chapter 10
References

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Appendix A

Active Management of Riparian Conservation Areas

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Active Management of Riparian Conservation Areas

Introduction

Riparian forests throughout western Oregon have been changed by the land use activities over the past century. They were harvested extensively, often to the edge of the stream, prior to the advent of current management policies (Everest and Reeves 2007). Subsequently, many were planted with commercially valuable conifers, primarily Douglas-fir (*Pseudotsuga menziesii*), resulting in the development of dense, relatively uniform conifer stands and a decrease in hardwoods. Where conifers were not successfully reestablished, riparian areas are now dominated by alder (*Alnus rubra*), often with a dense salmonberry (*Rubus spectabilis*) understory (e.g., Hibbs and Giordano 1996). In watershed-scale simulations, Wondzell et al. (2012) estimated that, under historical conditions, 28 percent of the stream network in the Oregon Coast Range was in alder-dominated riparian forests, and that presently it is more than 40 percent. Clearly, the direct effects of logging on the structure and composition of present-day riparian forest can be varied, but overall, the distribution of conditions has changed dramatically relative to those under natural disturbance regimes (McIntyre et al. 2015; Naiman et al. 2000; Swanson et al. 2011).

Indirect effects of logging have also modified riparian forests in the Oregon Coast Range. Rates of landslides and debris flows have increased in heavily roaded and logged watersheds (Goetz et al. 2015; Guthrie 2002; Jakob 2000), which has led to systematic changes in riparian vegetation. Debris-flow tracks are frequently scoured free of large wood and subsequently recolonized by red alder (Russell 2009; Villarin et al. 2009). Further, the frequency of debris flows and landslides has contributed additional sediment to stream channels, driving more severe floods, with the combined effect of increasing the width of stream channels (Lyons and Beschta 1983). Exposed gravel bars within these channels are most often colonized by hardwoods, leading to substantial changes along the stream corridor.

Changes to riparian forests described above create substantial challenges for restoration. For example, thinning of dense riparian Douglas-fir stands could open stands, allowing increased hardwood presence and, thereby, increasing the diversity of riparian vegetation, while also promoting growth of the remaining trees to decrease the time needed to grow trees large enough to act as key structural elements in the stream channel. However, although such restoration treatments may speed the restoration of some ecological functions, they also may reduce dead wood (see Spies et al. 2013 and review in Reeves et al. 2018), and may present risks, such as development of novel conditions and loss of a particular species or ecological condition.

Because the current distribution of conditions of riparian forests in many stream networks is far different from the historical distribution, there is substantial interest in active restoration treatments—especially thinning dense conifer plantations (Reeves et al. 2016) or logging hardwood-dominated stands and replanting to convert them to conifer dominance (Cristea and Janisch 2007). Active restorations of altered riparian conditions have been limited to the outer portions of the designated riparian area (Reeves et al. 2018). Primary reasons for this include (1) differing perspectives about the characterization of reference conditions, conservation, and management; (2) concerns about the potential effects of mechanical treatments on stream temperature and wood recruitment; (3) concerns about rare and little-known organisms that made managers reluctant to alter default prescriptions (Reeves 2006); and (4) lack of trust by the regulatory agencies in management agencies. On the proposed Elliott State Research Forest (ESRF), an estimated 35 percent of the riparian area has been harvested previously. The distribution of these areas is not uniform but varies widely between portions of the ESRF and by three independent populations of the Evolutionarily Significant Unit (ESU) of Coastal Oregon coho salmon (*Oncorhynchus kisutch*) found there. Also, the ESRF is portioned into areas with differing research emphasis from strict conservation to varying types and intensities of management. These present a unique opportunity to evaluate current approaches to riparian restoration as well as develop and access new approaches, including active management.

Restoration Challenges

Reference condition versus restoring ecological function. Restoration activities require a “target” condition or conditions toward which the activity is intended to move a system. Part of the debate about restoration needs for riparian areas may derive from differing views of riparian reference conditions (as a goal for restoration), and how they differ with scale and across watersheds. Although many studies (e.g., Acker et al. 2003; Pabst and Spies 1999) have found that riparian vegetation and upland vegetation frequently differ in structure, composition, and dynamics depending on stream size, some have noted that differences between riparian and upland vegetation may be small for some stand types, and that in some cases upland sites can supplement riparian sites to increase sample size for describing target conditions for riparian management. For example, Pollock and Beechie (2014) noted that, for Douglas-fir–dominated stands in western Washington, “both forest types [upslope and riparian] are generally similar, but riparian stands have more live tree wood volumes and basal areas, suggesting they may be growing on sites that are more productive.” Therefore, they concluded that riparian restoration in Douglas-fir–dominated riparian areas should aim to produce stand characteristics with densities and sizes of live and dead trees that are within the range of reference conditions (both upland and riparian). Others (Gregory 1997; Pabst and Spies 1999; Welty et al. 2002; Wimberly and Spies 2001) have found that the type and magnitude of differences in features between upslope and riparian forests can be large, suggesting that upslope vegetation should not be assumed to be a reference for designing and assessing managed strategies for riparian vegetation in other stand types, or where riparian stands differ significantly from upland stands (e.g., in floodplains). This variety of findings makes it difficult for managers and regulators to design and implement management actions in riparian reserves. On the ESRF, a variety of approaches will be considered and evaluated as part of the research program to help advance and develop options for restoring riparian ecosystems.

Water temperature. Active management in the riparian conservation areas could potentially lead to an exceedance of the 0.3 degree Celsius (°C) “non-degradation standard” for water quality. The 0.3°C standard is important from a regulatory perspective, limiting potential cumulative effects from multiple actions, none of which individually might be sufficient to impair water quality. Research discerning the effect of vegetation management other than clearcutting on water temperature has been limited. A few studies examined clearcut harvesting combined with partial harvest of riparian buffers (Kreutzweiser et al. 2009; Roon et al. 2021; Wilkerson et al. 2006) and suggest that the effect of riparian thinning on summer stream temperatures will be correlated positively with the amount of forest stream that the activity occurs, and thus the amount of shade lost (Leinenbach et al. 2013). However, the amount of shade lost from a given thinning treatment can be highly variable, and the small number of studies makes it difficult to draw strong generalities. The shade loss can be smaller than the amount of tree basal area removed, and, in one study, removal of 10 to 20 percent of the basal area had no measurable effect on angular canopy density (Kreutzweiser et al. 2009). Further, any shade loss and stream-temperature increase from riparian thinning are likely to be short lived because riparian forest canopies can close relatively quickly (within 3 years) after thinning (Chan et al. 2006; Yeung et al. 2017).

Reach-scale studies clearly demonstrate that solar radiation is the primary factor affecting stream-water temperatures during summer (Leinenbach et al. 2013). Thus, the likely effect of forest harvest on stream temperatures will be a function of the amount of shade lost. The largest effects are generally seen with clearcut logging right to the streambanks, whereas retention of forested buffers tends to reduce these effects (Roon et al. 2021), as does thinning rather than clearcutting outside the buffer. The actual magnitude of stream-temperature increases can vary greatly and is determined by factors such as discharge, water depth, width, flow velocity, hyporheic exchange, and groundwater inflows (Janisch et al. 2012; Johnson 2004; Moore et al. 2005). Topographic shading can also influence water temperatures, particularly in small streams flowing in narrow, steep-sided valleys, as much as or perhaps more than shade from streamside forests (Zhang et al. 2017). Canopy removal also results in nighttime long-wave radiation loss, leading to lower water temperatures that in turn contributes to increased thermal variability, whose biological consequences are poorly understood.

The potential magnitude of stream-temperature increases in response to riparian thinning will be highly dependent on forest attributes outside the riparian buffer, the buffer size, the pre-thinned riparian forest attributes (Leinenbach et al. 2013), the thinning prescription, and the thermal sensitivity of the stream (Janisch et al. 2012). Further research is needed to improve understanding of the impacts of thinning, but there is some evidence that light thinning may not substantially increase stream temperatures. The steep topography of the proposed ESRF provides the opportunity to examine this issue because topographic shading is the primary determinant of water temperatures in a large proportion of the stream network (Figure 1).

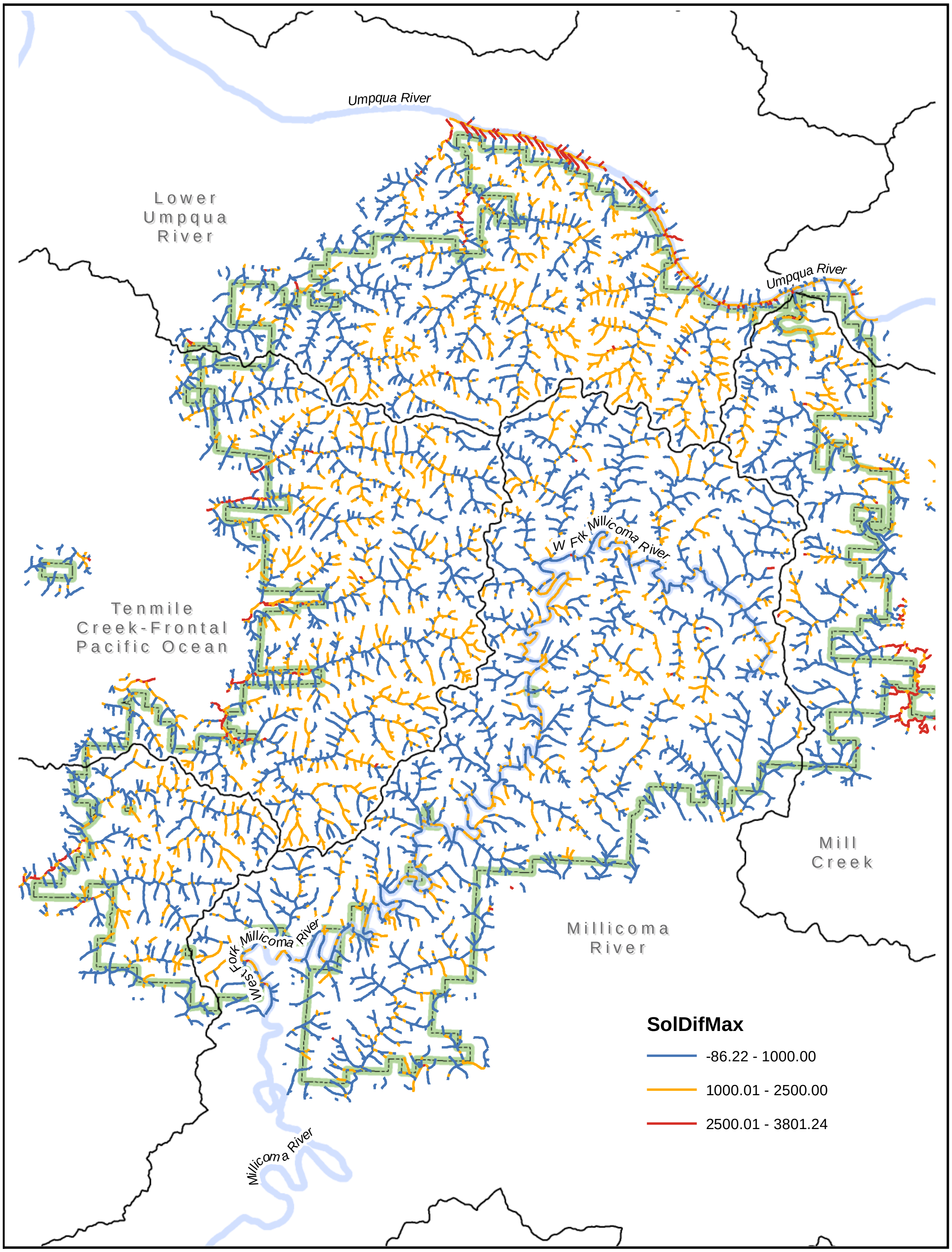

Figure 1. Influence of Solar Radiation on Water Temperature on Streams (SolDifMax) in the Elliott State Research Forest

Riparian thinning and large wood. The absence or reduced quantity of wood in streams throughout western Oregon, and elsewhere in the state and Pacific Northwest, is a primary concern for managers and regulators because of wood's importance for creating habitat and performing other ecological functions. Thinning and other active management in plantations in riparian areas can reduce the potential amount of wood that can be delivered to streams and the forest floor (Beechie et al. 2000; Pollock and Beechie 2014) if the trees are removed from the site. Additionally, thinning may negatively affect habitat, at least in the short run, for some species that are favored by dense conifer cover, potentially increase water temperature (Leinenbach et al. 2013), and reduce carbon storage (D'Amore et al. 2015).

However, there are also many potential benefits to thinning, including increasing structural diversity, species richness, and flowering and fruiting of understory shrubs and herbs (Burton et al. 2014; Carey 2003; Hagar et al. 1996; Muir et al. 2002), and faster development of mature-forest conditions, including very large trees with thick limbs that may be used for nesting by marbled murrelets (*Brachyramphus marmoratus*) (Carey and Curtis 1996; Franklin et al. 2002; Tappeiner et al. 1997).

Since Spies et al. (2013) summarized the state of the science, other studies have increased understanding of the effect of restoration thinning in riparian areas. Benda et al. (2015) simulated the idea of adding wood to channels during thinning by modeling the amount of instream wood that would result from thinning a 50- to 80-year-old Douglas-fir stand from below (i.e., removing the smallest trees to simulate suppression mortality) from 400 to 90 trees/acre, which is considered a moderate amount of thinning, then directionally falling or pulling over varying proportions of the harvested trees into the stream. This wood loading was compared to the amount that would be expected in the stream if the existing stand was not thinned. Not surprisingly, the amount of wood increased above the "no-thin" level immediately after the tipping simulation in all the wood-addition options. However, the cumulative total amount of wood expected in the stream over 100 years relative to the unthinned stand varied depending on the amount of wood delivered. Adding ≤10 percent of the wood that would be removed during thinning resulted in less wood in the channel over time than the unthinned option (i.e., if the stand were not actively managed). When 15 to 20 percent of the volume of thinned trees from one side of the stream was directed to the stream at each entry, the total amount of dead wood in the channel exceeded the unthinned scenario over time. Carah et al. (2014) found that adding unanchored wood into the stream was less costly than securing the wood, and improved habitat conditions for coho salmon.

Ecological tradeoffs. There are potential ecological consequences of limiting tree harvest (thinning) only to the outer portions of the riparian reserves. A myriad of ecological processes create and maintain the freshwater habitats of Pacific salmon (Bisson et al. 1997, 2009) and the ecological context in which they evolved (Frissell et al. 1997). This is especially relevant to the goals of the HCP, which are broad and include more than aquatic conditions. Holling and Meffe (1996) contended that uniform management prescriptions often fail when applied to situations in which processes are complex, nonlinear, and poorly understood, such as in aquatic ecosystems on the ESRF, and may lead to further degradation or compromising of the ecosystems and landscapes of interest (Dale et al. 2000; Hiers et al. 2016; Rieman et al. 2006). For example, managing for a single purpose (e.g., maximizing dead wood) may compromise or retard other ecological functions, such as development of hardwoods and shrubs or growing large trees, in areas near the stream and ultimately may alter the structure of the food web (Bellmore et al. 2013). Pollock and Beechie (2014) stated that "species that utilize large-diameter live trees will benefit most from heavy thinning, whereas species that utilize large-diameter deadwood will benefit most from light or no thinning. Because far more vertebrate species utilize large deadwood rather than large live trees, allowing rapid and sustained development of structural features." Clearly an assessment of tradeoffs and prioritization is needed.

There are risks from any active restoration treatment, but choosing not to act also poses risks, not only by increasing the time needed to attain a desired future condition, but also leaving the riparian zone at greater risk of uncharacteristic disturbance—for example, dense conifer stands in dry forest zones are more prone to high-severity wildfire. Also, there may be increases in primary production (Warren et al. 2016) and fish growth (Wilzbach et al. 2005) with the opening of the canopy along small and medium streams. The choice of priority conservation targets (e.g., dead wood, plant-community diversity, large live trees, geomorphic disturbances) for riparian management is a difficult one to make, involving scientific criteria, risk assessment, and social values. Pollock and Beechie (2014) stated that "management strategies that seek to create a range of large live and dead tree densities across the landscape will help to hedge against uncertain outcomes related to unanticipated disturbances, unexpected species needs, and unknown errors in model assumptions." It will be important to consider the full suite of ecological functions across a watershed; focusing only on one condition or metric may limit recovery of riparian ecosystems in ways that prevent full achievement of the broad objectives of the HCP. The diversity of conditions in riparian areas on the ESRF along with the large proportion of the forest that will receive minimal management provides a unique setting to test and evaluate a suite of approaches to riparian restoration.

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Appendix B
Species Considered for Coverage

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Species Considered for Coverage

Fish and Wildlife Species Considered for Permit Coverage

	Status [a]		Criteria [b]						
Species	**State**	**Federal**	**Range in Permit Area**	**Listed or Likely to be Listed**	**Likely to be Impacted by Covered Activities**	**Enough Data Available to Assess Impacts and Determine Conservation Needs**	**Proposed for Coverage in 2008 HCP**	**Recommended Covered Status[3]**	**Notes**
Fish									
Oregon Coast Chinook *Oncorhynchus tshawytscha*	--	--	Y	N	Y	Y	Y	N	
Oregon Coast steelhead *Oncorhynchus mykiss*	--	--	Y	N	Y	Y	Y	N	
Pacific coast chum *Oncorhynchus keta*	--	--	Y	N	Y	Y	Y	N	
Oregon Coast coho *Oncorhynchus kisutch*	--	T	Y	Y	Y	Y	Y	Y	
Coastal cutthroat trout *Oncorhynchus clarki clarki*	--	--	Y	N	Y	Y	Y	N	
Western River lamprey *Lampetra ayresi*	--	--	Y	N	Y	N	Y	N	
Pacific lamprey *Entosphenus tridentatus*	--	--	Y	N	Y	N	Y	N	
Western Brook lamprey *Lampetra richardsoni*	--	--	Y	N	Y	N	Y	N	
Eulachon *Thaleichthys pacificus*	--	T	N	Y	Y	N	N	N	Southern Distinct Population Segment listed as Threatened in 2010

	Status [a]		Criteria [b]						
Species	**State**	**Federal**	**Range in Permit Area**	**Listed or Likely to be Listed**	**Likely to be Impacted by Covered Activities**	**Enough Data Available to Assess Impacts and Determine Conservation Needs**	**Proposed for Coverage in 2008 HCP**	**Recommended Covered Status[3]**	**Notes**
Amphibians									
Southern torrent salamander *Rhyacotriton variegatus*	--	--	Y	N	Y	N	Y	N	FY23 Listing Decision
Red-legged frog *Rana aurora*	--	--	Y	N	Y	N	Y	N	
Coastal tailed frog *Ascaphus truei*	--	--	Y	N	Y	N	Y	N	
Birds									
Bald eagle *Haliaeetus leucocephalus*	T	D	Y	N	N	Y	Y	N	
Northern goshawk *Accipiter gentilis*	--	--	Y	N	Y	Y	Y	N	
Northern spotted owl *Strix occidentalis*	T	T	Y	Y	Y	Y	Y	Y	
Marbled murrelet *Brachyramphus marmoratus*	E	T	Y	Y	Y	Y	Y	Y	
Olive-sided flycatcher Contopus borealis	--	--	Y	N	Y	Y	Y	N	
Western bluebird *Sialia Mexicana*	--	--	N	N	Y	Y	Y	N	
Mammals									
Pacific fisher *Pekania pennant*	--	--	Y	N	?	N	Y	N	
Red tree vole *Arborimus longicaudus*	--	FC	Y	Y	Y	Y	Y	N	FY19 Listing Determination.

[a] **Status**

State Status

E	=	state-listed as endangered
T	=	state-listed as threatened
C	=	state candidate for listing

Federal Status

E	=	federally listed as endangered
T	=	federally listed as threatened
D	=	federally delisted

[b] **Criteria**

Range: The species is known to occur or is likely to occur within the HCP permit area, based on credible evidence, or the species is not currently known in the permit area but is expected in the permit area during the permit term (e.g., through range expansion or reintroduction to historic range).

Status: The species is either:

- Listed under the federal ESA as threatened or endangered, or proposed for listing;
- Listed by the State of Oregon as threatened or endangered or a candidate for such listing, or
- Expected to be listed under the ESA within the permit term. Potential for listing during the permit term is based on current listing status, agency listing priorities, consultation with experts and wildlife agency staff, 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 permit 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 HCP were limited to those species for which impacts from covered activities were likely, in order to provide take authorization for the highest priority species.

[3] **Recommended Covered Status**

Y	initially recommended as covered species in the HCP
N	not recommended for coverage in the HCP

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Appendix C

Proposal: Elliott State Research Forest

PROPOSAL

Elliott State Research Forest

Oregon State University

Table of Contents

SECTION 1

Executive Summary

In December 2018, the State Land Board requested that Oregon State University explore with the Oregon Department of State Lands the potential transformation of the Elliott State Forest into a state research forest managed by OSU and its College of Forestry. This exploratory work has been ongoing since early 2019 and has included the engagement of advisory committees at the state and college level and the solicitation of input from stakeholders. This document outlines OSU's initial proposal in response to the state's request.

THE OPPORTUNITY FOR OREGON

The world faces growing climate and sustainability crises. Forestry as a profession has a responsibility and the potential to contribute to a more sustainable future. Oregon State University believes forests should be managed to support human needs, foster economic opportunity, and not only sustain but advance the environment. In order to accomplish those objectives, it is imperative that sustainable forestry practices be developed through careful scientific inquiry. Of particular importance is research that will inform how forests can help achieve broad-scale conservation goals and alleviate climate change while producing traditional and alternative forest products for a growing global population.

It is possible to accelerate high impact research that meaningfully guides and informs sustainable forest management, yielding substantial benefits for Oregon's environment, economy and communities, if that work can be conducted on a landscape of sufficient scale and diversity. An Elliott State Research Forest (ESRF) could be that landscape and opportunity.

In addition to being a platform for this critical research, an ESRF would provide Oregonians with access to forest education and recreation, as well as jobs in forest products, forestry and forest research. Together, these elements would make the ESRF a global model for holistic management and best practice in environmental and natural resources policy.

OSU College of Forestry's proposal for an Elliott State Research Forest is a collaboratively developed research design, including a structure for governing the forest, and a financial framework. These components are designed to enable an ESRF not only to meet the State Land Board's vision of providing a forest that shares Oregonians' values, but also provide world-class scientific research aimed at addressing policy and information needs of crucial importance to Oregonians and the world.

MANAGEMENT PLATFORM TO SUPPORT PUBLIC VALUES

The State Land Board and Oregonians have been clear that the ESRF must always be a public forest. Accordingly, this enclosed proposal includes specific commitments to ensure that key public values always are honored. These include commitments to recreation and public access, partnerships to promote education programs, a transparent governance structure, adherence to strong and enduring conservation ethics, and plans for a working research forest infrastructure that will support local rural and Tribal communities.

RESEARCH TO INFORM FUTURE DECISIONS

Practical, relevant and collaborative scientific research conducted at the Elliott State Research Forest will yield critical insights into sustainable forest management. We aim to tackle the fundamental question: What is the best landscape-scale approach to providing society with sustainable wood resources without compromising biodiversity, ecosystem function, climate resilience, and social benefits? For decades, a wide range of approaches have been proposed but to our knowledge, a quantitative comparison of these potential practices has not yet been conducted anywhere in the world. We therefore plan to employ the first replicated landscape-scale experimental assessment of the best way to manage forests to integrate the needs of humans and nature. Is it best to conserve nature in reserves, and intensify production in tree plantations? Or is a better strategy to reduce harvest impacts using extensive (e.g., ecological forestry), but spread out harvests across the landscape? We will test a range of intermediate strategies too, that include differing proportions reserve, plantations and extensive forestry. In these experiments, scientists at OSU and other universities will measure water quality (and flow), carbon storage, endangered species (e.g., murrelets, owls, and salmon) and a host of other plants and animals, landslides, fire risk, climate resilience, as well as social values such as employment, recreation and education. Importantly, this approach will also allow us to test the most effective ways to conduct a range of climate adaptive silvicultural practices. For instance, we know little about how to conduct ecological forestry in this region, because the focus on most landownerships to date has been on intensive production. This framework will also afford the implementation of a range of nested experiments within the larger platform allowing researchers to conduct a host of short-term and site specific experiments.

The research platform outlined in this proposal provides a landscape-scale approach to projecting how long-term sustainable forestry research could be conducted at this scale in a manner that is adaptive, dynamic and flexible. Results gleaned from this research platform will inform future policy and decision making in state, federal, indigenous and private forest landscapes throughout the Pacific Northwest, the Nation, and globally.

In this research plan, over 65% of the forest will be in reserve with approximately 34,000 contiguous acres in the Northwest portion of the forest set aside, creating one of the largest forests in reserve in the Oregon Coast range. The remaining 15,000 acres of reserve are smaller units protecting older trees and critical species habitat and distributed throughout subwatersheds that also receive smaller units of intensive forest management. In 50 years, about 73% of the forest will be 100 years old or older – nearly a 50% increase from today. See 'Summary of the Research Platform' and 'Appendix 4' for details.

With 17% of the forest assigned intensive treatments and 16% assigned extensive treatments, harvests conducted within the Elliott as a part of the research design will be relatively small. The proposal includes a harvest of approximately 1% (about 735 acres) of the forest per year. The harvest acres are higher initially given they include time-sensitive restoration-oriented thinning treatments conducted in former plantations of trees in the first 20 years. After thinning treatments are complete, less than 1% of the forest will be harvested annually as a part of the research design. See 'Financing Management, Operations and Research' section for details.

The research design allows for transformative landscape scale research on a variety of forest management issues that will no doubt evolve with time. Holding operational management constant over time creates certainty for researchers and the public and allows for long-term studies essential for long-lived forests, something impossible to accomplish using private or other public lands that are not designated as research forests. A few key issues include:

- climate adaptation of forests and carbon sequestration
- conservation of biodiversity and at-risk species dependent upon forested landscapes
- economics and technology of sustainable timber production
- recreation and public education opportunities in relation to forest management activities
- implications of fire and other forest disturbances on long-term health of forested landscapes

TRANSPARENCY AND ACCOUNTABILITY TO THE PUBLIC INTEREST

An OSU-managed ESRF will be open and accessible to Oregonians. As proposed by the OSU College of Forestry—and subject to approval by the OSU President and the OSU Board of Trustees—OSU will make decisions regarding the management and operations of the Elliott according to an adaptive forest research plan and with the advice of a stakeholder advisory committee that will provide input on planning and management decisions, and the assessment of the effectiveness of the management plan that flows from the research activities. This approach will enable OSU to exercise appropriate forest ownership while holding the property in the name of the State of Oregon and with continued public access, engagement, and accountability. OSU will operate with transparency, legislative oversight and accountability through an administrative review process currently under development. See 'Governance Structure' for details.

FINANCIAL OVERVIEW

Total net annual revenue for a 50-year forecast of timber harvests that are aligned with the research and conservation goals of the proposal is estimated at $5.7 million, which is insufficient to support projected core annual forest management and operations expenses (including personnel, equipment, fire management and recreation management) and core annual research management and operations expenses (including personnel, monitoring, maintenance, and administrative overhead) of approximately $7.8 million. See 'Financing Management, Operations, and Research on the ESRF' for details. OSU requires an additional $2.1 million annually from the state to operate the forest under the current proposed plan.

There is potential that an ESRF would create opportunity to enter into a carbon credit market to yield revenues that could help the state offset some of its costs of achieving one or more of the following: decoupling from the Common School Fund; funding OSU's working capital and start-up costs (estimated at $35 million); funding OSU's annual operating costs in excess of net harvest revenues (estimated $2.1 million annually). The research design does not preclude the potential sale of carbon to help the state's expenses. However, meeting OSU's costs cannot be directly contingent upon carbon credit offset revenues, given the high level of uncertainty in the carbon credit market and the potential risk it would place on the university's mission and increasing dependence on tuition and fees.

While sophisticated in its design, this financial modeling analysis will need to be refined as on-the-ground surveys of tree stands are conducted, additional OSU review of operational and start-up costs is completed, and a forest management plan is developed.

KEY ISSUES REQUIRING ADDITIONAL WORK

While the research proposal submitted here is comprehensive in scope and detail, additional work remains to be completed before a final decision can be reached on the vision developed by the College of Forestry, including:

- Approval by the OSU President and the OSU Board of Trustees;
- Decoupling of the Elliott State Forest from the Common School Fund prior to transfer to OSU as the Elliott State Research Forest, with recognition that OSU cannot financially assume compensatory obligations to the State or the Common School Fund;
- Development and adoption by OSU, with transparency and input from an ESRF Advisory Committee, of a forest management plan; OSU would subsequently implement and revise that plan, as appropriate, with advice of the Advisory Committee;
- Assurance provided to OSU that adequate resources will be available to the university to cover working capital, research start-up costs, and annual operating costs, including the costs to complete a forest inventory and

draft and adopt a research-based forest management plan prior to transfer of the forest to OSU;
- Arrival by the State Land Board, OSU and other engaged parties to terms that, prior to the transfer, will protect and promote the financial viability of the research forest without creating reliance or liability, or unreasonable risk of same, on other OSU resources;
- An investigation by OSU and DSL of the opportunity of entering the carbon credit market as a means of offsetting costs of decoupling the forest from the Common School Fund and/or recovering start-up, operating and research costs;
- Agreement reached on an administrative review hearing process that is structured to be similar to that used by Oregon state agencies to resolve disputes related to the management and operations of the research forest. Consistent with the principle of financial viability above, OSU's strong preference is that the university will continue to be exempt from existing APA statutes regarding attorney fees stemming from disputes over the research forest.
- Collaboration by OSU and the Department of State Lands on the finalization of the Habitat Conservation Plan to protect endangered species.

In this next phase of planning, should the State Land Board advance OSU's proposal for the Elliott State Research Forest, OSU remains committed to full transparency and to seeking—via the advisory committee and public engagement—continuing guidance from research scientists, interested members of the public, and stakeholders.

SECTION 2

Introduction to an Elliott State Research Forest

A MESSAGE FROM T. H. DeLUCA

Dean of the Oregon State University College of Forestry

Oregon forests have sustained life for millennia. By merely closing our eyes, we can imagine rolling hills and rising mountains, deep green forests and pastel meadows; salmon runs churning rivers and birds making the most extraordinary sounds. With some careful effort, we can find a patchwork of spaces that provide this experience in the first person. As European presence occurred across the western United States, and the expansion of populations and cities, the ability to grow trees for timber became a critical component of Oregon's rural communities and of expanding economies across the region.

In seeking to create an Elliott State Research Forest, we are reflecting on the immense capacity that exists for forests of Oregon, and beyond, to provide the values we need to sustain ecosystems and economies. We believe that carefully crafted research and scientific inquiry in a dedicated area can inform the conservation and management decisions required to protect endangered species that ultimately lead to their delisting; to sequester carbon in above-ground and below-ground systems for mitigating climate change; and to engage the public in science, recreation, and education that supports an informed democracy. With broad engagement in designing such a process, economic growth in a genuinely sustainable manner could stabilize and revitalize communities that have been flailing for decades and are always at risk to the boom and bust of policy changes.

We cannot do this with our eyes closed or an unwillingness to dialogue and listen to the voices, calls, and sounds of nature. We must all recognize that this is a unique time for Oregon, the Pacific Northwest (PNW) and the world. We are experiencing the fruits of our unbridled consumption of fossil fuels in the form of human-induced climatic change. The impacts of these changes are evident in the increasing occurrence of extreme weather events, increased scale and effects of wildfire, and an accelerated loss of species. During the 'Anthropocene' we have witnessed a startling decline in species diversity at the hands of large scale land management and development. Thoughtful forest management has a significant role in helping to bring back balance to the PNW and once again take a front seat in the environmental movement, but this remains to be seen. Science and discovery must lead in informing forestry's future.

Forestry must accept its role and responsibility in managing forests for the good of people and the environments upon which they depend. The responsibility is not a small task; people demand many values of their forests, including clean water and air, habitat for species to thrive and survive, climate regulation, places to recreate and gain the benefits of time in nature, and yes, fiber production. The Elliott State Research Forest represents an enormous and unique opportunity to apply science to sustainably provide its myriad values and guide and inform forest management everywhere in an ethical, and life-sustaining manner. The opportunity includes the study of innovative practices, investigating climate resilience of these practices, demonstrating the forest is far more than timber to be logged, and maximize the value and sustainability of ecosystem goods and services provided by the coastal slopes of western Oregon. The efforts will be for the betterment of people and society, whether they are aware of them or not.

Over a century ago, the discipline of forestry was introduced to the western US as a response to the cut-out-get-out logging of the 1800s that only viewed forests as stumpage value. Forestry as a discipline was radical, and it was the first environmental science put into practice on the landscapes of the western United States. The framing of American forestry through millennia of indigenous management that led to the development of the dramatic and beautiful forests. The condition that we often hold up as 'natural,' was actually a construct of indigenous human design, expert use of fire and conservative, yet broad scope utilization of forest resources. Importantly, it was managed for sustainability and as a part of their community identity. The establishment of American forestry was to address the scars left by wasteful, hasty logging practices and to ensure forests for future generations – to protect ourselves from ourselves.

A century later, economic demands shifted the focus of forestry from conservation and correcting past inadequacies to centering on net present value and financial returns. Environmental values often associated with sustainable forest management were frequently cast in a subordinate role to efficient fiber production and addressed within that context—not quite as bad as the cut-out-get-out principles of the 1800s. The listing of at-risk species sharpened this contrast and led to increasingly polarized views of appropriate goals for active forest management and healthy working landscapes. Fast forward to today, and this history defines the forestry profession. More recently, areas of active management on federal lands greatly diminished without consideration of the impacts of a rapid shift from managed to unmanaged. Today, forestry is often categorized and perceived as one of several extractive industries that are struggling (and failing) to adapt to a changing world. This characterization must change, but at the same time, forestry must change.

In the future, forestry must conserve biological diversity, minimize fragmentation and enhance habitat for species of concern, optimize carbon storage, and provide for recreation activities while still meeting fiber demands of a growing population. Forestry and its science should draw upon the wisdom, knowledge and history of indigenous partners to learn how to ethically approach and apply management so that nature and people may thrive. Forestry needs to support and sustain rural economies with skilled jobs that support families and livelihoods. Forestry needs to protect and promote the health and well-being of rural communities through ecosystem services and places to recreate. The practice of forestry must maximize its contributions to societies to offset global warming. Forestry can accomplish this by yielding sustainable, renewable and value-added timber for homes and cost-effective mass timber products for commercial wood buildings that displace carbon-emitting steel and concrete construction with carbon-sequestering wood products. To ensure we practice forestry in a manner that provides these multiple values on a sustainable basis will require operational scale research in representative settings that can seed enhanced methods and practices that can be implemented on forest lands across the Pacific Northwest and beyond.

Can we create such a path forward for a forestry's future? Yes, absolutely, and the size, location, and multiple values that define the Elliott State Forest present a singular opportunity to study, develop science, and demonstrate how to attain this future.

To transform the Elliott State Forest into the "Elliott State Research Forest" will require forethought and adherence to a platform that will support research initiatives today and into the future with the controls and replication that define the rigorous expectations for thoughtful science. As others in this process suggest, we must be capable of undertaking science that helps address how we can achieve broad-scale conservation goals and ameliorate climate change on forest landscapes while also producing fiber for a growing world population and public access for recreation and education. Undertaking science of this scale is the central challenge that the Elliott State Research Forest must meet to fulfill its potential. While there are many issues to address before the ongoing conversations narrow to a recommendation to the Land Board, I believe there are five pillars essential to accomplishing the vision for the OSU College of Forestry to oversee an Elliott State Research Forest:

1. The primary purpose of an Elliott State Research Forest is research; however, the values people hold for it and forests everywhere drive its management. The prime motivation is the sustainable and ethical provision of all of the values. We base decisions on the principles of diversity, equity, and inclusion of all values and the people that hold them.

2. A cross-section of management strategies that represent a spectrum of operational settings from reserves and conservation-oriented thinning to more intensive management must support the research design. The Triad research design currently being considered has excellent potential for creating a platform capable of supporting a variety of research over an extended time. The challenge is to align these different strategies with stand attributes and species concerns without introducing bias that will compromise that research.

3. While the forest must be financially self-supporting, harvests will not take place for the sole purpose of generating revenue. Only when there is certainty and transparency that revenue from harvests is a derivative of maintaining and implementing the research design platform can stakeholders and the public be assured that OSU management reflects public expectations for what the research forest is supposed to represent.

4. Triad treatments need to maximize the values of older forests by minimizing impacts to the structure, composition (including species of concern) and function of older forest stands. The research design should generally protect past unmanaged, naturally regenerated stands. However, this has to be accomplished without limiting the scope of future research to test the relationship of management actions in different age classes to a variety of response variables.

5. The structure and values associated with how we make decisions relating to the management of the Elliott into the future are as important as the research design we agree to implement. We aim to achieve a transparent structure, collaborate with a cross section of stakeholders, and create clear lines of decision-making authority and accountability to ensure the development and execution of a forest management plan is always supportive of the research goals for the forest.

We stand at the edge of a new frontier with a choice to make. We can move forward into as-yet uncharted territory and work together to place forestry at the forefront of a sustainable future, or accept the status quo. As we know, forestry as a practice is far more than just a means of acquiring timber. Forestry, in its essence, is a conservation science and an adaptive practice that considers ecosystems holistically and seeks to meet multiple objectives and provide for future generations. Being adaptive means being able to evolve to meet challenges and opportunities. The evolution of the forestry profession requires thorough scientific inquiry, application and evaluation. The Elliott State Research Forest represents our path into this new frontier. It will require that those who care deeply for this forest, forested landscapes across the Pacific Northwest, and for the practice of forestry, remain committed partners to our College well into the future.

Thomas H. DeLuca
Cheryl Ramberg-Ford and Allyn C. Ford Dean of the Oregon State University College of Forestry

ACKNOWLEDGEMENTS

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First and foremost we would like to acknowledge and thank the many members of the community who directly reached out to us to provide their thoughts, opinions, and reactions to the proposal.

We also thank the University leadership and the Board of Trustees for their support of the College during the exploratory process.

PROJECT TEAMS

We thank the following project teams and their members for the countless contributions to this process:

Oregon Consensus

Peter Harkema	Director
Brett Brownscombe	Senior Project Manager
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Jennah Stillman	Project Associate

Oregon Department of State Lands

Vicki Walker	Director
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Caitlyn Reilley	Project Coordinator
Anthony Davis	Former Interim Dean of the College of Forestry

COMMITTEES

This process and the enclosed proposal benefited greatly from the expertise and guidance provided by members of the following committees:

OSU Exploratory Committee

Meg Krawchuk	Landscape Ecologist
Ben Leschinsky	Geotechnical Engineer
John Sessions	Forest Engineer
Ashley D'Antonio	Recreation Ecologist
Klaus Puettmann	Silviculturist
Matt Betts	Landscape Ecologist
Clark Binkley	Managing Director Institute for Working Forest Landscapes
Shannon Murray	Continuing Education Program Coordinator
Jenniffer Bakke	Wildlife Biologist
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Department of State Lands Advisory Committee

Asha Aiello	Oregon Outdoor Council
Steve Andringa	Confederated Tribes of the Coos, Lower Umpqua and Siuslaw Indians
Paul Beck	Douglas Timber Operators
Jen Clark	Reedsport School District
Melissa Cribbins	Coos County
Eric Farm	Barnes & Associates
Geoff Huntington	Oregon Department of State Lands
Michael Kennedy	Confederated Tribes of Siletz Indians
Michael Langley	Confederated Tribes of Grand Ronde
Ken McCall	Oregon Hunters Association
Mary Paulson	Oregon School Boards Association
Bob Sallinger	The Audubon Society of Portland
Mark Stern	The Nature Conservancy (retired)
Keith Tymchuk	Other
Bob Van Dyk	Wild Salmon Center

External Science Advisory Panel

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Eric White	Forest recreation and economic development, USDA Forest Service
Gwen Busby	Natural resource economics, GreenWood Resources Inc.
Linda Nagel	Silviculture, climate change, Colorado State University
Mark Swanson	Landscape ecology, early seral forest development, Washington State University
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Ryan Haugo	Conservation science, The Nature Conservancy
Serra Hoagland	Tribal relations, biologists, USDA Forest Service, Salish Kootenai College

ADDITIONAL CONTRIBUTERS

University Faculty, Staff, and Students

We thank the numerous University faculty, staff, and students who contributed to the development of this proposal:

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Scientists

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Christian Messier	Center of Forest Research, University of Quebec in Montreal and in Outaouais
Andrew Balmford	Department of Zoology, University of Cambridge
Jerry Franklin	Emeritus Professor of Forest Ecology, University of Washington
Sue Baker	School of Natural Sciences, University of Tasmania, Australia

Experts

Lastly, we thank the experts from Mason, Bruce & Girard Inc and US Forest Capital LLC for their consultation.

SECTION 3

Guiding Principles and College of Forestry Commitments

GUIDING PRINCIPLES

Recognizing that the Elliott State Forest (ESF) is incredibly important to the people of Oregon, the state Land Board voted to keep the forest in public ownership in 2017. The Land Board's collective vision, as articulated at the May 2017 Land Board meeting, was a future forest that *"maintains public ownership and access, is decoupled from the Common School Fund, and has a habitat conservation plan."*

This collective vision initiated an assessment by Oregon Consensus (OC) in 2018 for the purpose of gathering perspectives and informing a process for finding a path forward for the Elliott State Forest. Following this assessment, at the December 2018 Land Board meeting, the Land Board directed the Department of State Lands (DSL) to work with Oregon State University (OSU) to explore the feasibility of OSU's management of the Elliott State Forest as a research forest.

In early 2019, OSU agreed to develop a plan in collaboration with DSL that engaged local tribal nations, local governments, and other stakeholders and is consistent with the Land Board's vision.

- Keeping the forest publicly owned with public access
- Decoupling the forest from the Common School Fund, compensating the school fund for the forest and releasing the forest from its obligation to generate revenue for schools
- Continuing habitat conservation planning to protect species and allow for harvest
- Providing for multiple forest benefits, including recreation, education, and working forest research

OSU began an exploratory process in early 2019 that included public listening sessions, outreach to stakeholders, and engagement with local tribes around a potential research forest concept. During public listening sessions, attendees were divided into discussion groups that roughly aligned with public values the Land Board had articulated as important to consider in the design and management of a research forest. Listening session discussion groups included: Recreation and Public Access; Research and Education; Timber, Economy and Forest Management; and Conservation.

As OSU was conducting its exploratory work, holding public listening sessions, and investigating aspects of transforming the Elliott State Forest for research, DSL formed an Advisory Committee composed of community leaders and stakeholders to provide insight and input on key elements of an Elliott State Research Forest (ESRF) proposal.

With the initial Land Board vision and data from the Oregon Consensus assessment report as the foundation, the DSL Advisory Committee and OSU Elliott project team collaboratively reviewed the input from the OSU led outreach to develop guiding principles also known as public values.

Throughout 2019, guiding principles were developed for the following areas:

- Forest Governance
- Recreation
- Educational Partnerships
- Local and Regional Economies
- Conservation

Each set of principles is a reflection of stakeholder input synthesized and reconciled to provide overarching statements of suggested direction for management of the Elliott State Research Forest in the context of the primary research mission.

COLLEGE OF FORESTRY COMMITMENTS

The public, including all of the people it represents, hold multiple values and perspectives for the Elliott State Forest (ESF) and genuinely care about its future. Currently, the ESF provides various types of ecosystem goods and services, such as wood production, species habitat, and recreational opportunities to varying degrees. As one might expect, members of the public carry a variety of expectations regarding how to manage the ESF and which of the ecosystem goods and services of the ESF are most important to them.

The proposed research framework for an Elliott State Research Forest (ESRF) is multifaceted, and is designed to provide opportunities for the provision and expression of many of the public's interests. The research theme, discussed more fully in the research section of this proposal, is a systems-level understanding of synergies and trade-offs for conservation, production, and the livelihood objectives on a forested landscape within a changing world. The goal of the ESRF is to conduct research that provides a science-based understanding of how to sustainably deliver ecosystem goods and services, delivering on multiple values important to the public, while maintaining the Land Boards vision of a publicly owned and accessible working forest. However, first and foremost, the ESRF needs to be a viable research forest. In this context it is not a preserve or park (although it supports the same or similar ecological, social, and economic values), but rather it is a working forest—working to achieve multiple values through a combination of active and passive research-based management approaches.

Recognizing that the success of such a research forest will require broad public support, the College of Forestry has articulated a set of commitments to the diverse public values expressed in each of the five sets of guiding principles developed by OSU and the DSL Advisory Committee in the process outlined above. These guiding principles align with the Land Board's vision and will aid decision-making as the research design is implemented and management actions are undertaken on the forest. These commitments will shape future ESRF planning and management, but they cannot be carried out by the College or Oregon State University alone. The College will rely upon an external ESRF Advisory Committee to remain in alignment with its primary goals, objectives, and commitments, upon public and private partnerships and collaborations to secure adequate resources and funding, as well as assistance in meeting many of these commitments.

The following subsections list the DSL Advisory Committee's guiding principles followed by the College of Forestry's commitments to the public and the forest based on, and in response to these guiding principles.

FOREST GOVERNANCE

DSL Advisory Committee's Guiding Principles

1. **Accountability.** The history and unique public nature of the Elliott Forest requires placing a premium on establishing a governance structure that will provide clear lines of accountability for forest management decisions that support research programs and articulated public values into the future. This structure should include formal and informal mechanisms that ensure commitments and principles are honored in the context of fiscal and operational management of the forest over time.

2. **Transparency.** Management of the Elliott Forest requires a commitment to transparent operations and decision making that will maintain and enhance public support for the research forest over time. This includes clear and defined processes for governance and oversight, clearly defined pathways for public inquiry and input, and accessible information related to forest operations.

3. **Representation.** An Elliott State Research Forest governance structure should engage and incorporate multiple interests and partnerships that reflect key public values the forest will represent over time. Representation of these values in governance of the forest should be balanced, accountable, and transparent with regard to fiscal and operational management of the forest to support research programs over time.

4. **Decision Making.** Regardless of governance structure, decision-making processes directing the fiscal and operational management of the Elliott State Research Forest must be accountable, transparent, and open to input while also empowered to operate the forest efficiently and effectively to meet identified objectives.

College of Forestry Commitments

OSU's proposed governance structure for the ESRF is described in detail in the governance section of this proposal. It clearly articulates ownership rights, responsibilities, and accountability, as well as a role for representatives of public interests in the decision-making process.

The College of Forestry is committed to:

1. **Transparency and accountability** in the management and use of the ESRF through a governance structure that includes meaningful engagement with public interest groups, local communities, the private sector, Tribes, and others, primarily through a stakeholder committee that advises on ESRF management. The **publicly-represented committee** will address issues such as revenue generation and economic outcomes, conservation, Tribal interests and traditional cultural uses, research and monitoring, recreation and education, and the other myriad ecosystem services benefits provided by the ESRF.

2. Owning and managing the ESRF **as a public forest and guarantee public access** for recreation, education, and foraging in ways consistent with research objectives and activities.

3. **Engaging, coordinating, and promoting research and management partnerships** with local watershed councils and associations, Tribes, conservation NGO's and other public and private entities.

4. **Collaborating with scientists and researchers** from other institutions in Oregon, the USA and globally.

RECREATION

DSL Advisory Committee's Guiding Principles

1. **Ensure Public Access Into the Future.** The Elliott State Research Forest ("forest") will remain accessible to the public for a variety of uses from multiple established entry points, by both motorized and non-motorized transportation, but not all places at all times.

2. **Promote Recreational Access and Use that is Compatible with Research and Ecological Integrity.** Public use of the forest will be supported and managed for different recreational opportunities consistent with a management plan reflecting stakeholder interests and historical activities in concert with public safety, ongoing research, harvest, and conservation of at-risk and historically present species.

3. **Support and Promote Diverse Recreational Experiences.** The Elliott State Research Forest recreational program will leverage partnerships within the local community and others to accommodate multiple and diverse recreational

uses to provide a range of user experiences within the context of a working forest landscape. Recreational planning will not favor one recreational type over another, but will seek to ensure high-quality experiences on the forest by managing to minimize the potential for conflict between users while safeguarding research and management objectives, and conservation values.

4 **Partner with Stakeholders and Manage Locally.** Elliott State Research Forest recreation programs will be managed by local staff who live in the community and work with stakeholders to enhance and protect the identified values of Elliott recreationists.

5 **Conduct Research on Sustainable Recreation Practices.** An Elliott State Research Forest recreation program will support relevant research on recreation and eco-based tourism, with the goal to advance scientific knowledge and inform the general public on the opportunities and impacts of balancing multiple interests within forested landscapes.

6 **Cultivate Multi-Generational Respect for the Forest.** Utilizing a collaborative approach to partner with schools, organizations, and volunteer groups recreation planning and management will seek to create more opportunities for engagement and a more widely informed forest-user community that is vested in the future of the Elliott State Research Forest.

College of Forestry Commitments

The ESRF will remain a publicly owned forest and will continue to be accessible for recreational uses. Through a direct, transparent and engaging governance structure, we will be held accountable to the public for their access and use that is consistent and does not conflict with research activities and outcomes.

The College of Forestry is committed to:

1 Providing and enhancing **public recreation access and use** of the Elliott, including **building upon existing partnerships and developing new ones**.

2 **Collaborating with local stakeholders** in developing and implementing a **recreation management plan** for the ESRF. The work may build on or integrate with existing efforts, such as Oregon's Websites and Watersheds, Southwest Oregon Community College (SWOCC), hunting organizations, motorized and non-motorized interests, trail groups, and the amenity sector.

3 **Conducting research on sustainable recreation management practices** that **advance knowledge and inform the general public** about forested landscapes represented by the ESRF and as used by locals and visitors.

4 **Principles of diversity, equity, and inclusion** associated with recreational access and use of the ESRF.

EDUCATIONAL PARTNERSHIP

DSL Advisory Committee's Guiding Principles

1 **Seek and Incorporate New Educational Partnerships.** An Elliott State Research Forest will offer opportunities to leverage and integrate existing local and state educational programs and institutions that support and generate forest-based research and knowledge.

2 **Expand Accessibility to Forestry Education.** An Elliott State Research Forest will provide and promote a diversity of values, and in doing so will leverage efforts by OSU's College of Forestry to engage students with diverse social, economic, ethnic, and cultural backgrounds in forestry education programs.

3 **Serve Students at All Levels of Education Through Programs on the Forest.** OSU will seek to foster and establish a programmatic link with K-12, community colleges, informal collaborative educational initiatives, and educational programs at other universities so that the forest becomes a resource for students at all educational levels.

4 **Integrate and Demonstrate Elements of Traditional Knowledge in Educational Programs on the Forest.** Through active partnerships with local Tribal Governments, the Elliott State Research Forest will seek to provide demonstration areas that use traditional forest management practices and focus on Traditional Ecological Knowledge outcomes for use in educational programs.

5 **Foster Public Awareness and Understanding of Sustainable Forest Management.** Management and research actions on the Elliott State Research Forest will seek to promote broader understanding and awareness of the role of healthy working forest landscapes to local economies, resilient ecosystems, innovative competitive products, and healthy communities.

6 **Develop an Educational Partnerships Plan.** The Elliott State Research Forest will work with stakeholders to develop a plan to foster and implement educational partnerships consistent with the foregoing principles and will implement it pending available resources.

College of Forestry Commitments

The ESRF will remain a publicly owned forest and will continue to be accessible for educational uses. Through a direct, transparent and engaging governance structure, we will be held accountable to the public for their access and use that is consistent and does not conflict with research activities and outcomes.

The College of Forestry is committed to:

1 Providing and enhancing **educational access and use** of the ESRF, including building upon existing partnerships and developing new ones. For example, we will work to integrate

and build on existing efforts and partnerships, such as historical research and data from Oregon's Websites and Watersheds, and partnerships with SWOCC, local school districts, Tribes, and OSU's Outreach and Extension.

2 **Collaborating with stakeholders** in developing and implementing an education/outreach plan for the ESRF, including its human and natural history as well as social and economic research opportunities (in addition to other research relevant to ecological and management issues). Collaborations will ensure the forest provides professional and educational benefits to Oregonians, in particular, and to the broader public and scientific communities in general.

3 The ESRF being a showcase and place of **learning about the role of healthy working forest landscapes** to local economies, resilient ecosystems, innovative competitive products, and healthy communities.

4 **Principles of diversity, equity, and inclusion** associated with educational access and use of the ESRF for students of all backgrounds, ages, and levels.

LOCAL AND REGIONAL ECONOMIES

DSL Advisory Committee's Guiding Principles

1 **Operate as a Working Forest While Managing for Research.** The Elliott State Research Forest will be owned and managed as a working forest that produces wood supply as a by-product of research, consistent with the mission of the Institute for Working Forests Landscapes at Oregon State University College of Forestry.

2 **Be Financially Self-Sustaining.** The financial model of the forest should incorporate traditional and innovative options for generating revenue to support forest management, and research programs without requiring continued funding support from outside sources.

3 **Generate Consistent and High-Quality Timber Harvest.** A sustainable supply of wood volume will be produced over time as a by-product of the research program on the Elliott State Research Forest. Quality should be prioritized over the quantity of harvest.

4 **Support Employment Opportunities for Local Communities.** The Elliott State Research Forest should not be managed from a remote location. Management and operation of the forest should be located in proximity to the forest and promote local partnerships that provide opportunities to local businesses and residents of Coos and Douglas counties.

5 **Study and report on the Relationship between the Research Forest and Local Economies.** The connections between OSU, the Elliott State Research Forest, and local economies should be documented and reported with transparency over time.

College of Forestry Commitments

The ESRF, as a working forest, will provide benefits to the economies and communities surrounding it. There is great potential for positive impacts on local economic sectors as we grow capacities associated with timber and other forest products, research, forest management, infrastructure building, maintenance, restoration, education, and recreation activities on or related to the ESRF. We also anticipate that the ESRF will generate spillover workforce and economic benefits to the broader region, state, and elsewhere.

The College of Forestry is committed to:

1 Operating the ESRF as a research forest that is financially **self-sustaining** based on revenue generated directly and indirectly from the forest through timber harvesting and other revenue-generating activities, gifts, grants, and contracts.

2 **Providing local jobs and other economic values** associated with activities on the ESRF. These include jobs in support of timber production, supplying timber to local mills, managing and monitoring the forest, recreation, education, and other activities on the ESRF whenever possible. In addition, recreation and education opportunities may draw people from outside the local economy who spend money as they recreate and learn.

3 **Sustainable production of timber products and growing high-quality trees** by maintaining approximately 33% of the forest in some level of timber harvesting. Harvesting provides wood products and research opportunities relevant to advancing market opportunities tied to high-quality wood products. Harvesting supports traditional and new wood products pertinent to the health of Oregon's forest products sector in the future.

4 **Managing the ESRF locally**, including key personnel living in the surrounding communities as well as building the infrastructure necessary to house researchers, students, and other stakeholders. Over time, OSU envisions the forest will attract researchers from around the region, the nation, and the world to conduct research that brings significant investments in housing, food, and research infrastructure to Coos and Douglas counties.

5 **Advancing financial partnerships** tied to recreation, education, research, forest management, and habitat restoration that individually and collectively improve local economic and workforce benefits both on and off the forest. While timber harvest revenue will directly support forest research and management, it will be insufficient to fund all opportunities or needs on the forest, thus making partnerships and related external funding critical to achievement of broad public values on an ESRF (e.g., Cougar

Pass fire tower restoration, habitat restoration, road removal, recreation infrastructure development and maintenance, and educational programming).

CONSERVATION

DSL Advisory Committee's Guiding Principles

1. **Improve Conservation Status of At-Risk Species.** The Elliott State Research Forest will undertake studies, research, and associated forest management activities that seek to change the way forests are managed throughout the region and beyond to ultimately promote the recovery of at-risk species and the ecosystems upon which they depend.

2. **Implement Science-Based Conservation Efforts to Enhance the Productivity and Conservation Values of the Research Forest.** In adhering to the academic mission of Oregon State University, and to ensure the sustainability of any management or activity that occurs on the landscape, all conservation decisions or proposed projects on the Elliott State Research Forest will be rooted in the best available science.

3. **Manage for Multiple Conservation Values to Maintain and Enhance Essential Elements of a Forest Ecosystem.** With a holistic, ecological approach, management of the Elliott State Research Forest will support the protection and enhancement of at-risk species and preservation of biodiversity, along with promoting improved natural hydrologic function and opportunities of carbon sequestration.

4. **Preserve and Proactively Steward a Diversity of Forest Structures.** Management of the Elliott State Research Forest will emphasize key ecological areas ranging from early seral to late-successional forest structure in the context of the greater landscape. The future growth of the forest should encompass diverse objectives of biological quality and resilience for future adaptability.

5. **Collaborate with Local Partners for Monitoring and Restoration of Habitat.** Management planning for the Elliott State Research Forest will partner with local conservation stakeholders to maintain transparency and mutual trust that protection of sensitive natural values will be prioritized.

6. **Management Decisions Will Not Be Driven by Potential Financial Returns.** The integrity of the research objectives and conservation values on the Elliott State Research Forest will not be compromised by the presence of active management and economic influences on the forest.

7. **Conduct Innovative Research on the Intersection of Forest Ecosystems Functions and Climate Change.** The Elliott State Research Forest will provide a unique opportunity to conduct innovative research on the role that native, mature, and managed forests can play in ameliorating the impacts of climate change for sensitive species, water quality/retention, and carbon sequestration.

College of Forestry Commitments

The ESRF will make meaningful contributions to species persistence and recovery through its research platform, specific research programs on habitat restoration and enhancement, and broader commitments below. As a result of a research design that promotes older forests, complex early seral, and other valuable habitats, and the functions of resilience and resistance in riparian, aquatic, and terrestrial systems, conservation and biodiversity outcomes and values will be enhanced. The ESRF research design and commitments outlined below support a goal of conserving and recovering species including coastal coho salmon, marbled murrelet, the northern spotted owl, and other species of concern; while species recovery is dependent upon actions and actors across a broader landscape, the ESRF can positively contribute to the achievement of this aspirational goal.

The College of Forestry is committed to:

1. **Conserving, enhancing, and sustaining high-quality habitats for endangered species and other wildlife** through actions such as placing approximately 66% of the ESRF into reserves where recurring timber harvests will cease and habitat restoration and protection would be their primary focus. Doing so creates the largest contiguous reserve networks in the Oregon Coast Range (detail in Appendix 5). We also will foster the growth of older forest stands in the ESRF well beyond current levels, which will be a significant gain of older complex forests relative to today.

2. **Providing and enhancing other habitats**, in particular for complex early seral forests diminished through plantation practices and the focus on late seral conservation.

3. **Conserving, enhancing, and sustaining native riparian conditions and vital ecological processes** that influence the aquatic system of the ESRF and connected aquatic networks. This commitment includes recruitment of instream wood, shading for water quality and thermal refugia, and active restoration projects related to these and other aquatic system attributes.

4. **Conserving, enhancing, and sustaining ecosystem processes including carbon storage and soil productivity** on the forest by increasing rotation ages in intensively managed stands, retaining older trees in extensively managed stands, and designating reserves.

5. **Reducing the current road network density** and known related adverse impacts on the ESRF (in particular in the Conservation Research Watersheds), while maintaining and balancing for necessary access for research, harvesting, management, education, fire protection, and recreation.

6 **No salvage harvests in reserves** (CRW and other reserve watersheds) when tree mortality is due to natural disturbances (drought, disease, wind, insects, and fire).

7 Helping advance a **Habitat Conservation Plan** that improves the certainty around OSU's ability to advance research, while conserving endangered species over an extended timeframe.

8 **Working forest approach** that, through research and applied project work, is intentional about better understanding and highlighting the role of coastal pacific forests in carbon sequestration and climate adaptation, and the impacts of climate change on the diverse public interests associated with forests.

TRIBAL ENGAGEMENT

Oregon currently has nine federally-recognized Indian Tribes. These Tribes are sovereign nations and Oregon has recognized this relationship through various statutes, Executive Orders and policy statements. Thus, this unique status will require the establishment of formal Government-to-Government agreements that guide future partnerships and collaboration. Sustained involvement of Tribes is essential to the future management and potential of a public forest. Therefore, the guiding principles for Tribal engagement will revolve around:

- Respect for Tribal sovereignty and Government-to-Government relationships.
- Develop sustainable partnerships with Tribes.
- Promote shared generation of knowledge from activities on and related to the ESRF.
- Understand and appreciate the unique values of individual Tribes and their respective connections to the ESRF.
- Honor Tribal Ecological Knowledge (TEK).
- Ensure accessibility by Tribes to OSU's educational programs, research, and information resources.

A necessary first-step in expressing our commitments to Tribes, we intend to establish government-to-government MOUs between College of Forestry / Oregon State University and local Tribal governments that set standards and expectations for sustaining meaningful and productive partnerships in research, education, and outreach that directly co-benefit Tribal communities, individuals, and businesses, and OSU.

The DSL Advisory Committee and sub-committees, including Research Platform and Governance, have included representatives from various Tribes. As the new governance structure of the ESRF evolves, we anticipate continued involvement from Tribal representatives on committees in an advisory capacity.

The College of Forestry's commitments express our desire to own and manage the ESRF for the good of science, the land, and the people it sustains. Our commitments to the public values are enduring in that they are long-term, enabling research to be conducted over large spatial and temporal scales addressing ecological, social, and economic questions in the context of sustainable forest management, including natural disturbances, changing climates, and social pressures on these forested systems. We also acknowledge that not all commitments can be honored simultaneously in the same spaces, which will require a balanced and sustainable approach to forest research and management. The following section provides information on the research objectives for an ESRF.

SECTION 4

Summary of the Research Platform

Forests are integral for the health and wellbeing of humanity and the conservation of biodiversity and ecosystem functions and services. With increasing global demand for forest products and influences from a changing climate, it will be critical to find ways to provide these essential resources without compromising global forest biodiversity, carbon sequestration, and ecosystem health. We propose the Elliott State Research Forest (ESRF) be a center – both in Oregon and worldwide – for sustainable forestry using the scientific method.

The research platform consists of a series of documents drafted collaboratively over the past two years that establish the experimental design, goals, and outcomes for an ESRF. The primary research platform documents are the Research Charter (Appendix 1), presented to the Land Board in 2019, and a set of appendices describing elements of the research design and implementation (Appendices 2-11), developed primarily by members of the OSU Exploratory Committee and College of Forestry faculty.

The research platform incorporates input from local citizens and a diverse group of stakeholders through public listening sessions, focus groups, the Department of State Lands Advisory Committee (DSL AC), and local tribes. The research platform documents went under review by the DSL Research Platform subcommittee, members of the OSU College of Forestry, and an external Science Advisory Panel (SAP). Additionally, research concepts in the platform were reviewed by several scientists external to OSU from the Pacific Northwest and beyond (a summary of these reviews are in Appendix 13). Together, the research platform, DSL AC guiding principles, and governance structure outlined in this proposal will guide decision-making and research well into the future.

The following guiding principles serve as the foundation for establishing a long-term research program that remains focused and relevant to the overarching vision set forth by the Oregon State Land Board for a publicly owned and accessible forest. Research initiatives executed on the forest must collectively support a unifying question. The collective work of different research program initiatives will contribute to a greater body of work over time. As such, the following guiding principles are established and detailed more fully in the Research Charter in Appendix 1.

1 **Principle 1: Research:** The ESRF will advance and sustain science-based research. We will accomplish all management objectives related to fulfilling other public values and revenue generation within a 'research first' context.

Figure 1. Conceptualizing the Elliott State Research Forest as a social-ecological system

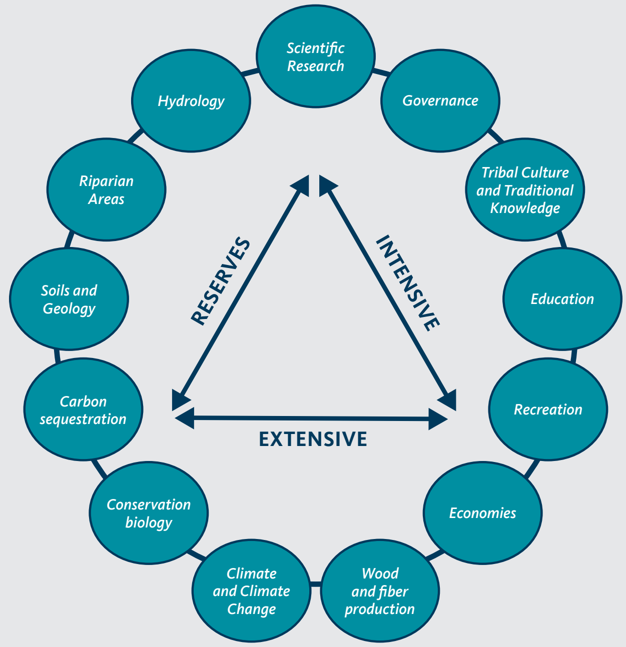


Figure 1. *Conceptualizing the Elliott State Research Forest as a dynamic system with an array of interconnected elements. Note that our research is embedded within the ecological and social systems.*

2 **Principle 2: Enduring:** Research on the ESRF should aim to remain relevant across many years, generations, and social, economic, and environmental contexts.

3 **Principle 3: At Scale:** An overarching research question, research design, and long-term monitoring on the ESRF should leverage the unique opportunity to quantify the synergies and tradeoffs associated with different amounts and arrangements of treatments at a landscape scale through time.

4 **Principle 4: Tailored to the Landscape:** The overarching research question will guide a research design that is tailored to existing and potential future biological, physical, social, and economic conditions on the ESRF.

5 **Principle 5: Practical, Relevant, and Collaborative:** The Land Grant mission of Oregon State University and the history of the ESRF as a public forest require that research on the forest be relevant to forest management issues and challenges facing Oregonians.

The goal of research on the Elliott State Research Forest (ESRF) is to advance more sustainable forest management practices through the application of a systems-based approach to investigating the integration of intensively managed forests, forest reserves, dynamically managed complex forests, and the aquatic and riparian ecosystems that flow within them (Figure 1). Notably, the ESRF's size will enable us to explore and quantify the synergies and tradeoffs associated with these land management practices at a landscape scale through time. We will be able to quantify the complex relationships among the multiple ecological, economic, and social values in response to landscape-scale research treatments (intensively managed forests, forest reserves, dynamically managed complex forests). To honor the rich legacy of this land, an ESRF should do nothing less than attempt to reimagine the future of forestry. We have chosen to use a Triad theme as a framework for the research to be conducted on the Elliott. This framework facilitates our ability to broadly ask fundamental questions about tradeoffs in conservation and provide a general layout of treatment applications, but in no way does this limit us to one set of questions. Rather, we envision conducting a variety of parallel and nested experiments that push the limits of knowledge and practice in forestry and a sense of the range of those questions can be found below and in Appendix 3.

CONTEXT TO THE TRIAD FRAMEWORK

The United Nations has reported our planet is facing unprecedented threats to biodiversity and ecosystem services (e.g., clean water, wood, food). Meanwhile, livelihoods in resource-dependent communities have been declining for some time – particularly in Oregon. Indeed, according to the Food and Agriculture Organization, over 1.6 billion people globally depend on the forest for their livelihoods. The number is much larger than that if you include how many of us rely on wood products in our daily lives. **Therefore, a fundamental question for humanity is whether it is possible to support the forest product needs of 8 billion people without further eroding nature's life support system.**

Four approaches have been suggested to achieve this balance. First, society could reduce its dependency on wood. Although this is the most palatable strategy for many, our consumption habits indicate little progress. Wood consumption is up – in lock-step with population growth. Second, a regional option is to import wood, or wood alternatives, from elsewhere. This option exports environmental consequences of our behavior, and is unappealing to many because it harms developing, highly biodiverse regions that cannot afford strong environmental laws.

Third, we could manage landscapes using ecological approaches to forestry. This strategy reduces per acre wood production, so more of our planet would need to be logged to meet demands. Already, more than 2/3 of the Earth's productive surface is used for agriculture or timber.

Fourth, we could intensify production – via technology – to generate higher wood yields. With concentrated production, it becomes possible to set aside more wildlands for nature. The downside is that this intensification often uses fertilizers and pesticides may have unforeseen consequences to human and ecosystem health.

Unfortunately, to our knowledge, there are no experimental landscape-scale tests of which of these strategies would be best for the conservation of forest biodiversity along with a suite of forest products, services and other values. This leaves the unanswered question: "how can we best manage our forests to meet biodiversity, timber, and economic needs in the face of global change?"

Figure 2

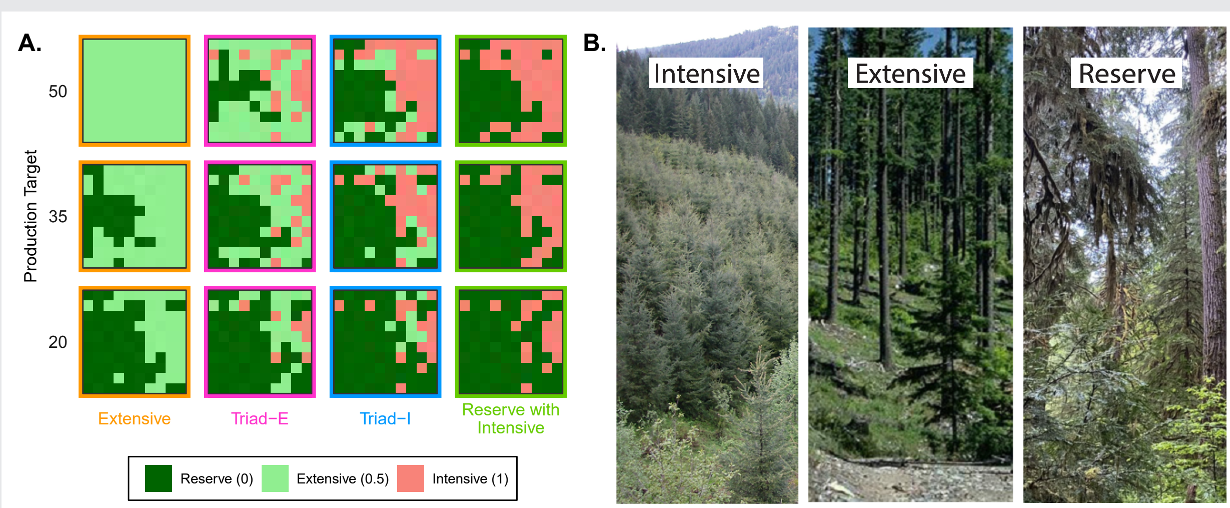


Figure 2. *Conceptual illustration of contrasting approaches to managing landscapes for timber production and biodiversity conservation in mixed-wood yield landscapes along a continuum from where extensive (ecological) forestry dominates to landscapes comprised of reserves and intensive management. In (A), each of the nine panels is a schematic map of a region with unmanaged habitat (also termed 'reserve', dark green; 0 units of production per pixel), ecological forestry (also termed 'extensive management', light green; 0.5 units/pixel), and high-yield forestry (also termed 'intensive management', coral; 1 unit/pixel). Region maps in the same row all produce the same quantity of wood, but use different proportions of forest management approaches to provide the production target. The three rows show results from low (20) to higher production targets (50). Note that even the highest production target depicted here is still only ½ of the total production possible. Due to the reduced per acre production afforded by extensive forestry, 'Extensive' landscapes (left column) necessarily have reduced reserve compared to the 'Reserve with Intensive' landscapes. Intermediate options (Triad-E and Triad-I) will also be examined and represent balanced options where reserves, extensive and intensive management occur in the same landscapes. At the ESRF, we will test the 50% production target (top row). In (B), examples of each type of management are shown: intensive management (Douglas-fir plantation), ecological forestry (variable retention harvesting in native forest), and unmanaged, protected old growth.*

Oregon State University's College of Forestry aims to answer this question by applying the first experimental test of the "Triad" approach. The plan – the first of its kind globally – would employ a large-scale long-term experiment to determine how to manage forests to balance human's and nature's needs. Is the best strategy to conserve nature in reserves and supply wood by intensifying production in tree plantations? Is it better to reduce harvest impacts using ecological forestry but expand harvests across the landscape to meet wood demand? Or are intermediate strategies that utilize reserves, intensive management and ecological forestry – called the "Triad" approach – best? In these experiments, scientists will measure water quality, carbon storage, endangered species, biodiversity, landslides, fire risk, and socioeconomic values like timber production, recreation and hunting. This framework allows for a great deal of flexibility in terms of where and to what scale different treatments are placed on the landscape. And the design affords flexibility in terms of nesting a range of experiments within the larger platform allowing researchers to test a range of hypotheses from climate resilience to issues surrounding social acceptance of forest practices to facilitation of recreational opportunities.

Figure 3. Percentage of reserve, intensive and extensive treatments in the TRIAD framework

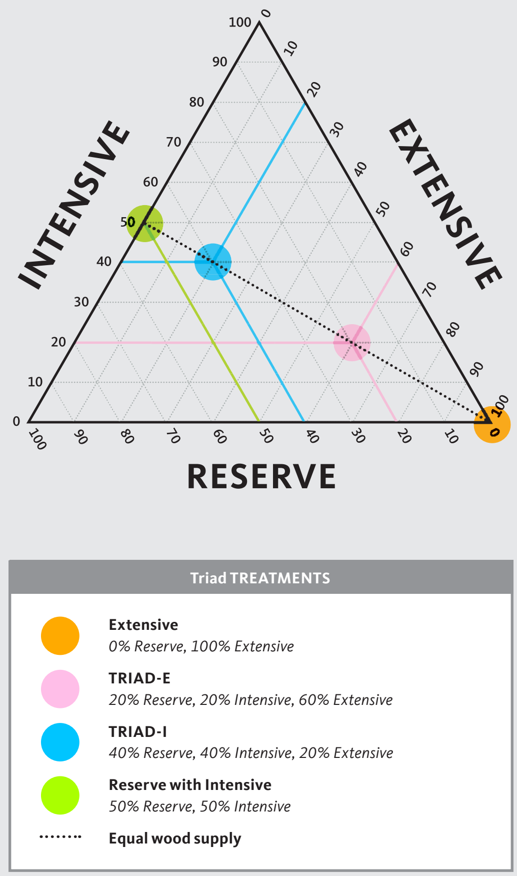


Figure 3. *Conceptualizing the four different Triad Treatments. Each colored dot represents a subwatershed level Triad treatment. The text below specifies the proportions of stand level research treatments (intensive, extensive, reserve).*

TRIAD RESEARCH FRAMEWORK

Our goal is to investigate promoting biodiversity, ecosystem processes, and ecosystem services while achieving a given wood supply using existing and novel land management strategies. Expansion of high-yielding tree plantations could free up forest land for conservation provided the implementation is in tandem with more robust policies for conserving native forests. However, because plantations and other intensively managed forests often support less biodiversity than native forests, a second approach argues for widespread adoption of extensive management, or 'ecological forestry', which better conserves key forest structural elements and emulates a broad range of disturbance regimes. Extensive management often reduces wood yields, and hence there is a need to harvest over a larger area to maintain an equivalent supply of wood. A third, hybrid suggestion involves 'Triad' zoning where we divide the landscape among reserves, extensive management, and intensive management in varying proportions.

We will utilize a "Triad" design, which will experimentally vary these three general land management approaches at the scale of whole landscapes:

1. Reserves with Intensive (hereafter "Intensive") forestry,
2. Extensive ("ecological") forestry (hereafter "Extensive"), and
3. the combination of reserves, ecological forestry, and intensive forestry (hereafter "Triad").

We will test two Triad options that vary in the proportions of each forestry type (intensive, extensive, and reserve - see Figures 2 and 4). We can visualize this approach as a triangle with its endpoints being reserve, intensive, and extensive stand management practices applied in varying proportions (Figure 3). To reflect society's demand for wood products, each Triad treatment will produce the same wood supply (illustrated by the dashed line in Figure 3), but using very different approaches. We structure the endpoints for the Triad design ('Reserve with Intensive' and 'Extensive,' green and orange circles respectively in Figure 3) under the premise that you can increase the amount of land in reserve as you intensify management while maintaining a stable output of wood products. On one end of the spectrum, the larger amount of intensively managed land would result in a greater amount of land in reserves (due to the high production in plantations, less land areas needs to be under management). On the other, Extensive (ecological) management, where multiple ecosystem service objectives are likely to be provided simultaneously, is only likely to provide a fraction of the timber per acre, and thus less area can be set aside in reserves. Within the Triad design, we will also explore riparian strategies (e.g., Riparian Conservation Areas, wood delivery potential, and restoration thinning) with terrestrial ecosystem management strategies to ensure the conservation of aquatic and terrestrial ecosystems as an integrated system. The four treatments that we will allocate across the landscape are depicted in Figures 3 and 4 and described below.

The experimental unit for the research design are subwatersheds 400 to 2,000 acres in size. The 66 subwatersheds are designated to be in either the Conservation Research Watersheds (CRW) shown in green or Management Research Watersheds (MRW) shown as a mosaic of orange, pink, light blue, and lime green in Figure 5.

Over 9,000 acres of the forest are in partial watersheds (MRW Partial) that are either less than 400 acres or not fully contained within the ESRF's boundaries, resulting in multiple ownership. The forty watersheds that are wholly contained within the MRW will receive the varying Triad treatments (Extensive, Triad-E, Triad-I, Reserves + Intensive) outlined below and illustrated in Figures 2 and 4. We chose subwatersheds to define boundaries (ridges) to give us the ability to use water as an integrator of the effects of the different Triad Treatments. We have approximately 10 replicates per subwatershed Triad treatment, which gives us sufficient statistical power to detect treatment differences for several variables, as is more fully described in Appendix 10. The initial subwatershed and stand level treatment allocation processes are more fully described in Appendix 4.

TREATMENTS

1. Extensive Treatments would be 100% extensive stand management across the entire subwatershed, outside of the RCA.
2. Triad-E Treatments would have 60% of the subwatershed acreage, outside of the RCA, in extensive, 20% intensive, and 20% reserve stand management.
3. Triad-I Treatments would have 20% of the subwatershed acreage, outside of the RCA, in extensive, 40% intensive, and 40% reserve stand management.
4. Reserves with Intensive Treatments would have 50% of the subwatershed acreage, outside of the RCA, in intensive and 50% reserve stand management.

We assessed the level of prior forest management in each subwatershed by evaluating stand age (Figure 6). Given that logging commenced in earnest (approximately) in 1955, we concluded that any stand that originated after this date (based on revised inventory data) resulted from harvest, including disturbance and salvage. Stands older than this are assumed to have originated from stand-replacing wildfires. Overall, about 50% of the Elliott State Forest has been clearcut in the past 65 years. The percentage of area within the individual subwatersheds in the MRW that are younger than 65 years of age ranges from 19% to 98%. Details about assigning the initial draft allocation of subwatersheds to Triad treatments are in Appendix 4.

STAND-LEVEL RESEARCH TREATMENTS

The ESRF is well-positioned to support the proposed integrated Triad research design. Currently, 42,000 acres of the forest are Douglas-fir plantations, established primarily between 1955 and 2015. These stands reflect conventional even-aged forestry practices over the past six decades. Intensive (production-oriented) stand-level research treatments in these forests will allow us to investigate management options that primarily emphasize wood fiber production at rotations of 60 years or longer. We aim to examine various intensive management treatment options, including those that do not utilize herbicides. Simultaneously, we can assess methods to reduce this harvest regime's impact on other attributes such as biodiversity, habitat, carbon cycling, recreation, and rural well-being.

Reserve stand-level research treatments primarily from unlogged, naturally regenerated stands that comprise 35-40,000 acres (or up to 49%) of the landscape. The reserve treatments include former plantations, recognizing the need for a focused effort to recruit future old stands. Such treatments will have two starting points: a) Exploring treatments to restore and enhance conservation value in established plantations that will transition to reserves; and b) Conserving unmanaged mature forests as they move through natural successional processes. These unlogged forests are ideal for monitoring ecosystem attributes such as biodiversity, recreation, carbon cycling, and water in the absence of any timber harvest. Thus, they serve as benchmarks for research treatments and managed habitat.

While intensive and reserve treatments provide opportunities to study management extremes, a third research treatment, extensive research treatments, will strive to increase forest complexity to help achieve multiple values across the landscape. The purpose of these widespread dynamically managed forests will be to explore the implementation of a new set of alternatives in a continuum between intensive plantation management and unlogged reserves. The research design on this continuum of extensive options will enhance diverse forest characteristics and better integrate them with riparian areas to meet a broad set of objectives and values in any stand. We can accomplish this goal by retaining (or creating) structural complexity while ensuring conditions exist to obtain regeneration and sustain the complex forest structure through time. Extensive alternatives represent the most significant opportunity for learning and expanding timber management's frontiers by aiming to simultaneously achieve biodiversity objectives and timber demand at the stand scale. The extensive treatments are where we will test a vision for a genuinely sustainable approach to land management - reflecting social values, needs, and ecosystem function. The Oregon Department of Forestry and Bureau of Land Management are implementing similar alternative approaches making the scientific findings from the ESRF on how species and ecological processes, such as carbon sequestration, respond to extensive treatments especially relevant. Detailed descriptions of intensive, extensive, and reserve stand level research treatments are available in Appendix 5.

We envision a robust experimental design consisting of integrated plantations, unlogged reserves, streams, riparian forests, and dynamically managed forests for the complexity of species and canopy layers (Figure 7 and Figure 8). As the ESRF ages and research progresses, we will see at-scale results that quantify combined effects and tradeoffs among ecological, economic, and social values. The research treatments applied to the CRW and MRW will deliver the knowledge needed to support forestry's next evolution.

'NESTED' (STAND-SCALE) RESEARCH AT THE ELLIOTT STATE RESEARCH FOREST

Although the unifying 'grand vision' for the ESRF is how to meet society's wood demands while maintaining biodiversity, carbon

Figure 4. Triad Landscape-level (Subwatershed) Treatments

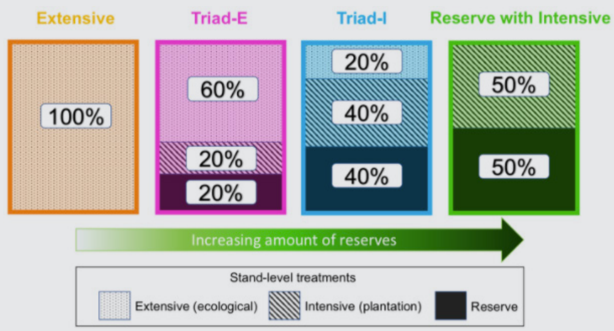


Figure 4. *The four Triad treatments that we will apply at the subwatershed scale at the ESRF. All of the subwatersheds (400-2000 ac) in the Management Research Watersheds will receive one of these four treatments. Treatments are designed to produce approximately equivalent wood yields using different combinations of stand-level treatments: reserves, extensive (ecological forestry) and intensive management (plantations). The 'Extensive' Triad treatment (orange) will be 100% ecological forestry, the 'Reserve with Intensive' Triad treatment (light green) will comprise 50% intensive forestry and 50% reserve. 'Triad-E' and 'Triad-I' contain differing proportions of reserve, ecological and intensive forestry.*

Figure 5. Potential Subwatershed Triad Treatment Assignments

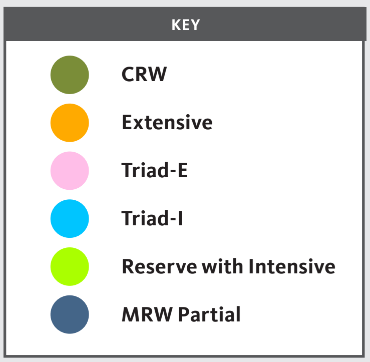


Figure 5. *Map illustrating the proposed western reserve area (Conservation Research Watershed; CRW, in dark green) and the potential allocation of subwatershed-scale Triad treatments in the ESRF's eastern part. Partial watersheds (dark blue) are only partly contained in the ESRF, so they will not have a formal subwatershed Triad treatment assigned. Map is based on August 2020 allocation.*

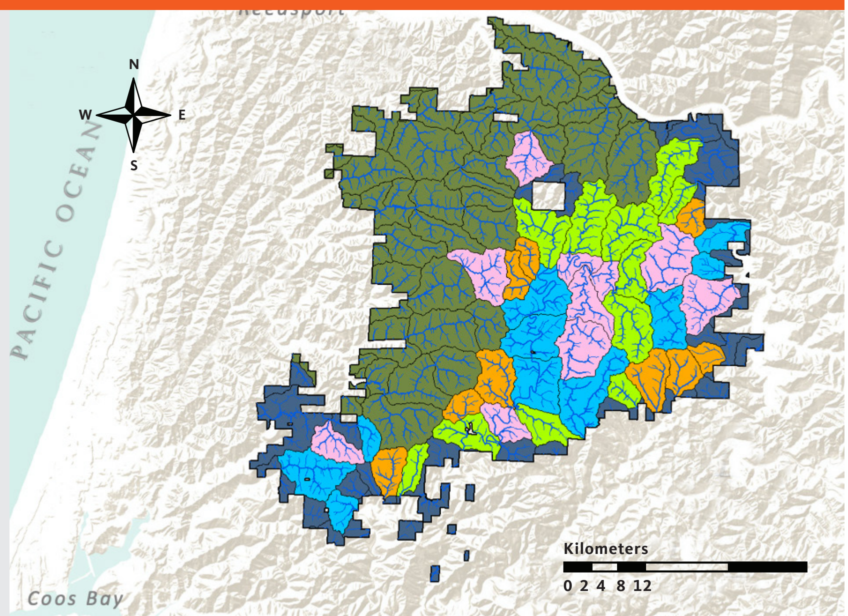


Figure 6. Age class distribution in the Conservation Research Watershed and the Management Research Watershed

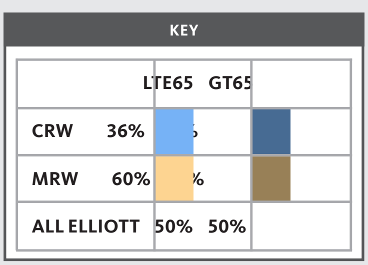
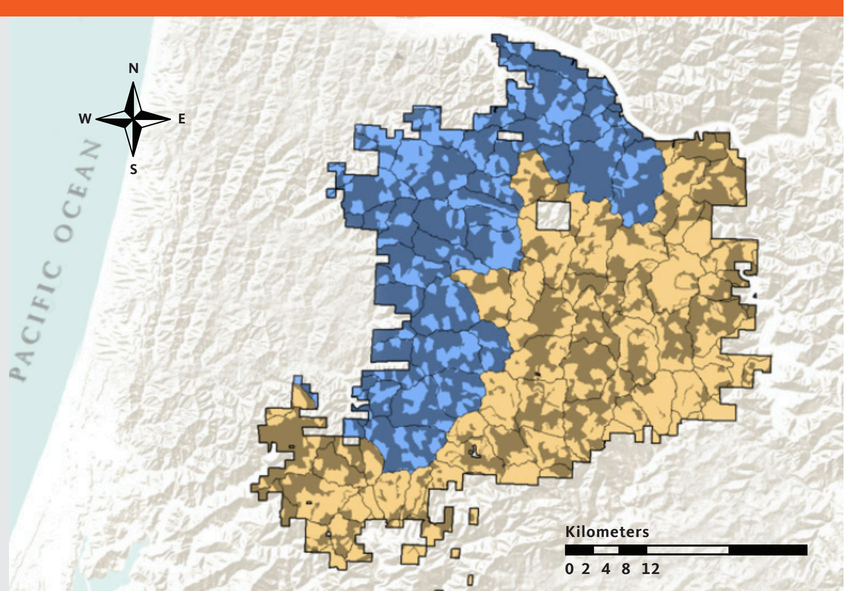


Figure 6. *Subwatersheds of the Elliott State Research Forest color coded by classification into the Conservation Research Watersheds (CRW) and Management Research Watersheds (MRW) and color coded by stand age greater than 65 years (GT65) and less than 65 years (LTE65). Uncolored regions indicate this portion of watershed is not part of the proposed Elliott State Research Forest.*



sequestration, and other social and ecological objectives, there are numerous opportunities for research and collaborations to nest within the Triad framework. Potential vital areas of research include biodiversity and conservation (Marbled Murrelet, Spotted Owl, Coho salmon), climate change adaptation, disturbances such as landslides and fires, water quality, fragmentation and connectivity issues, and socio-economic and cultural impacts. A list of potential research projects and collaborations is available in Appendices 2 and 3. These projects can be 'nested' within the landscape-level Triad framework. The idea is to conduct rigorously designed stand-scale studies on, for example, (1) different approaches to conducting ecological forestry, (2) how to do intensive forest management with minimal use of herbicides, and (3) whether mixed-species plantations can increase yields and show greater resilience in the face of changing environmental conditions (see Appendix 13, Figures 13a & 13b). Studies at these finer spatial scales will have a full random allocation of treatments across a gradient of conditions, which will enable inference to forests beyond the Elliott.

The research performed on the ESRF will achieve several outcomes (listed more fully in the Research Charter in Appendix 1); and, hopefully, increase public trust in active management on public and private forest lands. Using a landscape approach to research, the proposed work will improve the health of rural economies, communities, and citizens; increase the competitiveness of Oregon's private landowners and businesses, and enhance ecosystem health while leading to long-term improvements in the sustainability of forest management throughout the region. The research conducted on the ESRF will provide long-standing and emerging solutions to forest management issues and allow us to pursue future research questions we can't even imagine today.

With novel and increasingly uncertain future environmental and social conditions, landscape-level research provides a chance to test alternative forestry practices. We must research alternatives to specified rotation lengths, stem density, species diversity, age diversity, configurations of riparian buffers, and assess how these choices the systems within and outside of the forest through time. We need to explore all options and tradeoffs – not just those with which we are most familiar. Exploration is the essence and function of a research forest and will not happen through

Figure 7. Percentage of ESRF allocated to stand level research treatments as of August 2020 draft allocation*

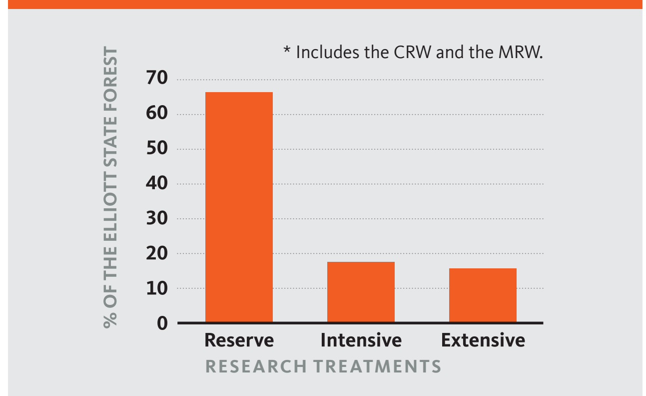


Figure 8. Proposed stand level allocation of extensive, instensive and reserve treatments

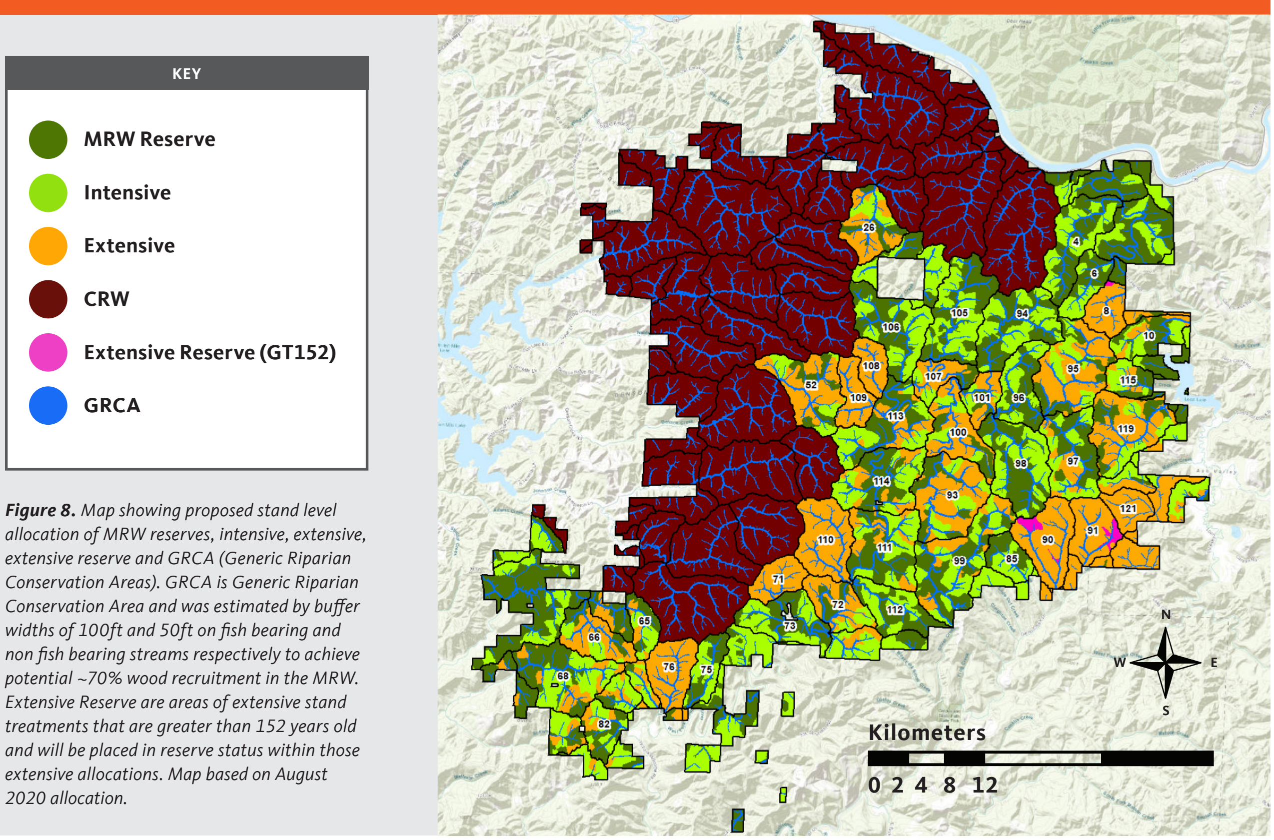


Figure 8. *Map showing proposed stand level allocation of MRW reserves, intensive, extensive, extensive reserve and GRCA (Generic Riparian Conservation Areas). GRCA is Generic Riparian Conservation Area and was estimated by buffer widths of 100ft and 50ft on fish bearing and non fish bearing streams respectively to achieve potential ~70% wood recruitment in the MRW. Extensive Reserve are areas of extensive stand treatments that are greater than 152 years old and will be placed in reserve status within those extensive allocations. Map based on August 2020 allocation.*

merely establishing isolated reserves in a landscape of traditionally managed forests.

ADAPTIVE SILVICULTURE FOR CLIMATE CHANGE

Projected increases in temperatures and summer moisture deficits in Pacific Northwest forests are expected to promote increased drought stress, more frequent insect outbreaks, increased risk of large wildfires, increased frequencies of severe winter storm events, reduced summer streamflows, and increased water temperatures (Dalton et al. 2013, May et al. 2018). These changes pose significant risk to the region's timber economy, outdoor recreation economy, indigenous livelihoods, and habitat quality for threatened and endangered populations of salmon, northern spotted owls, and marbled murrelets. The proposed treatment design framework for the Elliott State Research Forest (ESRF) offers a unique opportunity to evaluate the effectiveness of a range of climate change adaptation strategies within a landscape where all of these resource concerns overlap.

The flexibility of the proposed ESRF treatment themes, and the interspersion of intensive management, extensive management, and reserve areas within the triad treatment subwatersheds provides an exceptional foundation to develop and test climate change adaptation treatments within the framework of an existing, multi-region climate change adaptation experiment known as the Adaptive Silviculture for Climate Change project (ASCC, Nagel et al. 2017). For instance, climate change adaptation strategies designed to increase ecosystem resilience to wildfire, insect outbreaks, and drought by increasing forest compositional diversity, structural heterogeneity, and age-class diversity at stand to landscape scales fit naturally within the goals of the extensive treatment theme. Alternatively, adaptation strategies such as reforesting with climate-adapted genotypes, managing on shorter rotations to provide more frequent opportunities to adjust to changing conditions, installing fuel reduction treatments and/or fuelbreaks to facilitate fire suppression efforts, and controlling competing vegetation or managing stand densities to reduce drought stress and associated synergies with some insect pests all fit under the umbrella of the intensive management approach. Leveraging the existing resources and treatment design processes of the ASCC project will facilitate the development of an array of site-specific climate change adaptation treatments on the ESRF within the context of regional climate change vulnerabilities and resource concerns. Unlike existing sites in the ASCC network and other manipulative climate change adaptation experiments, however, the ESRF offers an opportunity to compare the effectiveness of different climate change adaptation strategies at management-relevant spatial and temporal scales due to the size of the ESRF, the proposed funding mechanisms to support multi-decadal research initiatives, and the flexibility of the existing extensive and intensive treatment themes to accommodate several common climate change adaptation strategies. Ultimately, the ESRF would offer a globally-unique opportunity to address climate change adaptation questions at management-relevant scales, within the context several regionally-specific natural resource management concerns.

The ESRF represents an enormous and unique opportunity to study novel practices and the climate resilience and resistance of ecosystems managed under these practices. The ESRF will also attempt to honor the millennia of stewardship these forests experienced from generations of Indigenous peoples by demonstrating the forest is far more than timber to be logged and maximizing the value and sustainability of wood products.

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SECTION 5

Adaptive Management and Phased Research Implementation

Undertaking the design and implementation of a research program of this magnitude and complexity is daunting. Accordingly, we have explicitly chosen to use a combination of a phased research implementation plan coupled with adaptive management protocols, modeling, ecosystem assessment and monitoring, and stakeholder input to reduce uncertainty and ensure the viability of the research through time. The phased approach (progressive increase in research activity across the ESRF over time) will include selecting a suite of watersheds from the Management Research Watersheds (MRWs) to conduct trial treatments and then utilize data analysis, modeling, and stakeholder input to adapt and refine the research plan. The length of time that this adaptive process will take is difficult to predict at this time. At first glance, it makes sense to estimate somewhere between 10-20 years, given the slow rate that trees grow. However, we intend to be highly responsive in the early years (1 - 5) when treatments are initially put on the ground. If concerns or problems arise during this stage, we will adjust accordingly. The adaptive approach (increasing depth of activity within the first phase of the ESRF over time) is briefly envisioned as follows (Figure 9):

A Conduct an in-depth landscape analysis of the ESRF.

B Identify and test the criteria for selection of 16 subwatersheds (4 replicates of the 4 treatment categories) plus up to 4 watersheds to serve as no-harvest controls.

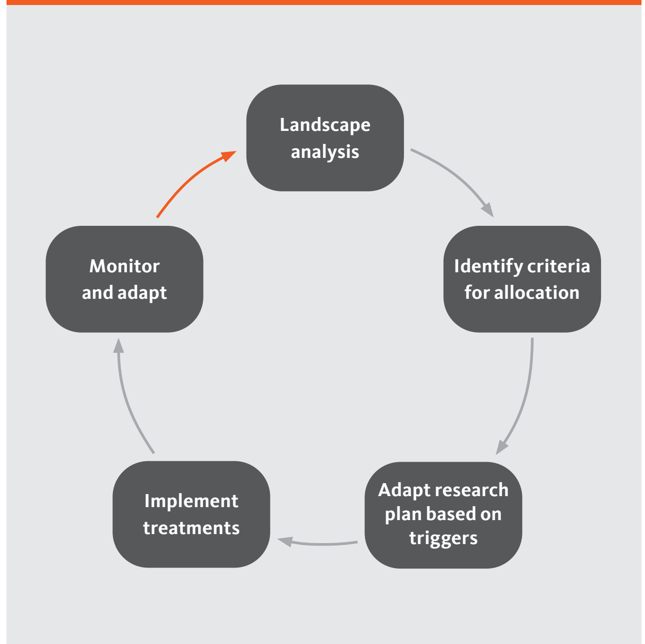
C Based on these data, allocate treatments to each stand within the subwatershed in proportion to the initial experimental design.

D Develop a list of criteria or outcomes that would trigger changes in experimental protocols.

E Explore what changes are experimentally and socially acceptable if triggers are met. (Both D and E should be an open and transparent discussion, i.e., with external peer and public input).

F Design and implement monitoring protocols that include previously established triggers in initial subwatersheds and several untreated watersheds.

Figure 9. Illustrating the iterative process of adaptive management



G Initiate treatments and monitoring within the first 16 subwatersheds and monitoring in controls.

H Monitor criteria that trigger changes in experimental protocols; revisit E.

I Adapt treatments for remaining watersheds as needed based on monitoring results, analysis, and stakeholder input.

There are numerous benefits to a stepwise implementation plan. These include:

- Increase in input from the broader research community and local and regional public entities with each progressive step.
- Collection of multiple years of pre-treatment monitoring data on up to 4 control subwatershed replicates to inform future applications of treatments.
- Development of a better understanding of the system we are experimenting within and the ability to design a study that is adaptive and flexible enough to withstand changes in social, economic, and ecological conditions over the very long life of a forest.

Over time, as we add more watersheds to the matrix of experiments, the phasing will continue. We anticipate a similar process and outcome for the former plantations in the Conservation Research Watershed experimental treatments. Since there is only one phase of active management planned (thinning plantations), the timeline may not be as long. We will describe other attributes of timing and implementation of activities on the ESRF in governance documents.

SECTION 6

Governance Structure

Note: Details of the governance structure are still under consideration. The content included in this section is unchanged from the December 2020 proposal. An updated proposed governance structure will be available soon.

~~Governance of the Elliott State Research Forest (ESRF) is important for the effective management of the forest by OSU, for ensuring State Land Board expectations for the forest, and for accountability to the public, stakeholder groups, and other interested parties. OSU anticipates that more work will be conducted after, and conditional on, the December 8, 2020, State Land Board meeting and decision regarding OSU's proposal for an ESRF. The following is offered as a potential governance framework; the final governance structure, including the terms of authority and accountability within Oregon State University, are subject to the approval of the OSU Board of Trustees. This governance structure enables OSU to exercise all of the attributes of forest ownership while holding the property in the name of the State of Oregon and with continued public access, engagement, and accountability. OSU supports the establishment of an ESRF Advisory Committee whose purpose is to provide advice and recommendations to OSU on ESRF planning/management decisions and public dispute resolution, and to provide input on assessments of the effectiveness of OSU's implementation of its public commitments and forest management planning.~~

~~OREGON STATE UNIVERSITY~~

~~Oregon State University, through a successful transfer and subject to approval by OSU's Board of Trustees, President, and Provost and the State Land Board, will accept ownership of the Elliott State Forest. The Elliott State Forest must be decoupled from the Common School Fund (CSF) and with no debt obligation to the CSF by OSU. As the effective owner of the ESRF, OSU will make all final decisions regarding the management and operations of the ESRF with the primary purpose of maintaining the integrity of all research and management activities on or associated with the forest in a manner that is generally consistent with the conceptual framework proposed to and accepted by the State Land Board on December 8, 2020 (Figure 10). This will include any refinements through management plans, and with respect to relevant state and federal laws (e.g., the Endangered Species Act through a Habitat Conservation Plan approved by federal listing agencies) prior to transfer from the CSF.~~

~~COLLEGE OF FORESTRY DEAN~~

~~The COF Dean will seek authority from the OSU President, OSU Provost, and OSU Board of Trustees to make all ESRF management and operations decisions, subject to compliance with the research design, commitments to the public, management plans, and with relevant and applicable state and federal laws, including the federal Endangered Species Act through a Habitat Conservation Plan approved by federal listing agencies. Accountability to these plans and commitments are as described below in the Accountability and Restrictions section. The Dean's additional authority and responsibilities are for oversight of forest management, research, and HR and budgets. The Dean may delegate these functions and responsibilities but maintains accountability for the outcomes.~~

1. ~~The COF Dean appoints and oversees an Executive Director for the ESRF.~~

2. ~~The COF Dean, on behalf of OSU, will decide what scientific research projects are conducted on the ESRF and nested within the research design. As such, the COF Dean appoints a Science Advisory Committee (ala the Science Advisory Panel; terms and membership yet to be determined) that is composed of scientific experts representing a variety of disciplines internal and external to OSU. An internal to OSU Research Advisory Committee (terms and membership yet to be determined) may also be established by the COF Dean to provide guidance and advice on research projects to be undertaken on the ESRF, and to support research autonomy and academic freedom for scientific investigations on the ESRF. The external and internal science/research advisory committees will review all proposed research on the ESRF and provide feedback to the COF Dean, including their integration with other research projects or landscape treatments, feasibility, and propensity to generate new knowledge.~~

3. ~~The COF Dean charges each advisory committee (including the ESRF Advisory Committee detailed below) to interact with each other in order to ensure the integration of science, economics, and social issues and to effectively communicate across disciplines and stakeholders.~~

~~ESRF EXECUTIVE DIRECTOR~~

~~The ESRF Executive Director reports to and is overseen by the COF Dean, and is responsible for delegated duties including long-term planning, implementing research, maintaining and restoring the ecological health of the forest, harvesting, and access for recreation and education, overseeing forest management and operations (including facilities, staff, and contractor management), performing fiscal accountability duties (budget development and fundraising), assisting ESRF associated advisory committees, advancing partnership opportunities, and engaging the public.~~

1. ~~The Executive Director is an OSU employee who is hired/appointed by and reports directly to the Dean of the College of Forestry.~~

2. ~~The Executive Director is stationed at the ESRF (i.e., lives in the surrounding community).~~

3 The Executive Director directly supervises management/operations staff (Figure 11) who are also stationed at the ESRF (number and type yet to be determined; does not include research scientists, FRAs, and Graduate Assistants or others engaged in active research and teaching).

4 The Executive Director submits and posts on the ESRF website an Annual Forest Management Report (AFMR). This annual report will address activities associated with restoration, harvest and forest operations, finances, research initiatives conducted on the forest, recreation and public access, and community outreach and education (examples are included below in Public Input and Dispute Review section, 1.B.).

5 The Executive Director seeks input from the ESRF Advisory Committee, OSU staff, and relevant parties and publics in developing management plans, including forest management, restoration, wildlife management and protection, recreation, education and outreach (process yet to be determined).

6 The Executive Director regularly engages the public and communicates about proposed actions and intended outcomes on the ESRF. While the process is yet to be defined, it will include notice of public meetings, posting of materials and minutes, and public comment (oral and written) that will be considered in substantial management actions undertaken on the forest.

ESRF ADVISORY COMMITTEE

The ESRF Advisory Committee is established as part of OSU's proposed governance structure and is appointed by the Director of the Department of State Lands in consultation with OSU and the Governor's Office to ensure a level of independence in its representation and function. The ESRF Advisory Committee is integral to the sustainability and success of an ESRF. The ESRF Advisory Committee provides an active, diverse forum for input and advice on ESRF planning and management, on effectiveness of past implementation of the forest management plan, and on compliance with foundational documents and codified allowable activities and public dispute resolution. As such, reasonable staffing and administrative support for the ESRF Advisory Committee is part of the core ESRF expenditures (Figure 11). The ESRF Advisory Committee is not responsible for day to day or project specific management or operations of the forest and serves OSU in an advisory capacity.

Given the ESRF Advisory Committee fosters public dialogue, accountability, and communication on matters relating to the management of the forest, and to surface issues for constructive discussion with OSU concerning management of operations in the forest, the Committee members must broadly represent the various interests concerned with the ESRF, including local governments, recreation groups, environmental/conservation groups, underrepresented local community members, educational interests, timber/forest product sector interests, Tribal governments, and a state agency representative with expertise relevant to management considerations.

Figure 10. Governance structure for the Elliott State Research Forest

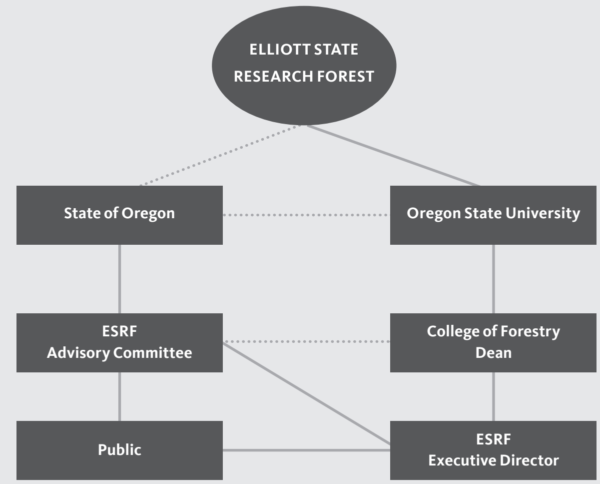


Figure 10. *Governance structure for the ESRF. Solid lines show direct relationships and the dashed lines show indirect relationships.*

ESRF ADVISORY COMMITTEE'S RESPONSIBILITIES:

1 Provide timely and constructive input and advice on decisions impacting the long-term management trajectory of the forest and operations consistent with forest management, restoration and conservation, recreation, and education/outreach plans adopted by OSU.

2 As a condition of appointment, each member will work to support the ESRF vision and foundational documents, including its research design, public commitments, and related foundational elements captured in the State Land Board decision or statutory framework establishing the ESRF.

3 Receive public input and, if called upon by the COF Dean, assist as an initial layer of review and feedback on resolving formal disputes in accordance with the administrative review process detailed below.

4 The ESRF Advisory Committee is charged with substantively participating in the following activities associated with the ESRF in an advisory capacity to the COF Dean and Executive Director:
- Participate in development, review, and comment on forest management, recreation, and education planning activities conducted by the College before those plans are adopted and implemented, including participation in any revision process (yet to be determined).
- Review and comment on biennial plans stating activities to be conducted by the College pursuant to the adopted Forest Management Plan. The biennial plan will address activities associated with harvest and forest operations, restoration, wildlife management,

recreation, public access, and community outreach.

- Review biennial budget planning documents prior to the start of the relevant fiscal year.
- Review and provide comments on reports to federal and/or state agencies associated with implementation of HCP terms and conditions.
- Receive annual updates on financial matters associated with forest operations.
- Review and provide comments on the AFMR.
- Take comments from the public at meetings.

ESRF ADVISORY COMMITTEE APPOINTMENTS AND MEMBERSHIP CRITERIA INCLUDE:

1 Composition - the size and composition of this committee will be a continuation of or patterned after the DSL Advisory Committee that is in place to guide the creation of an ESRF (up to 20 members).
   - The committee will consider expanding its current membership to include one additional recreation representative, and one youth natural resource/environmental education representative.

2 Bylaws are yet to be developed and adopted by OSU, and will include a specific charge to the committee and include the following items:
   - Terms and conditions; e.g., four-year staggered terms with option for renewal.
   - Nomination, including self-nominations, and vetting (e.g., attributes such as solutions-oriented, collegial, service-oriented) processes for open positions on the committee.
   - Selection process for filling open positions on the committee.
   - Removal for cause procedures.

PUBLIC

The ESRF remains in public ownership. Therefore, the public must be empowered to provide input and influence on the ESRF's overall operations in a transparent and meaningful way. Transparency provides an effective strategy to proactively avoid or resolve potential conflicts with stakeholders or other public parties, including the provision of adequate information and the opportunity to comment in order to effectively identify where conflicts may be anticipated to occur. The following are part of OSU's approach to meeting its commitment to transparency:

1 The public is represented through membership on the ESRF Advisory Committee, its ability to have notice and comment on decisions related to the ESRF, its ability to access ESRF public records and to attend meetings convened by OSU, and its elected representatives.

2 The Executive Director regularly engages and informs the public about decisions related to the ESRF.

3 OSU communications regarding the ESRF are subject to the Oregon Public Records Act unless otherwise subject to non-disclosure under State law.

4 ESRF Advisory Committee and any subcommittee meetings will honor the spirit of Oregon statutes relating to meetings laws, regardless of whether they are deemed to be applicable to OSU.

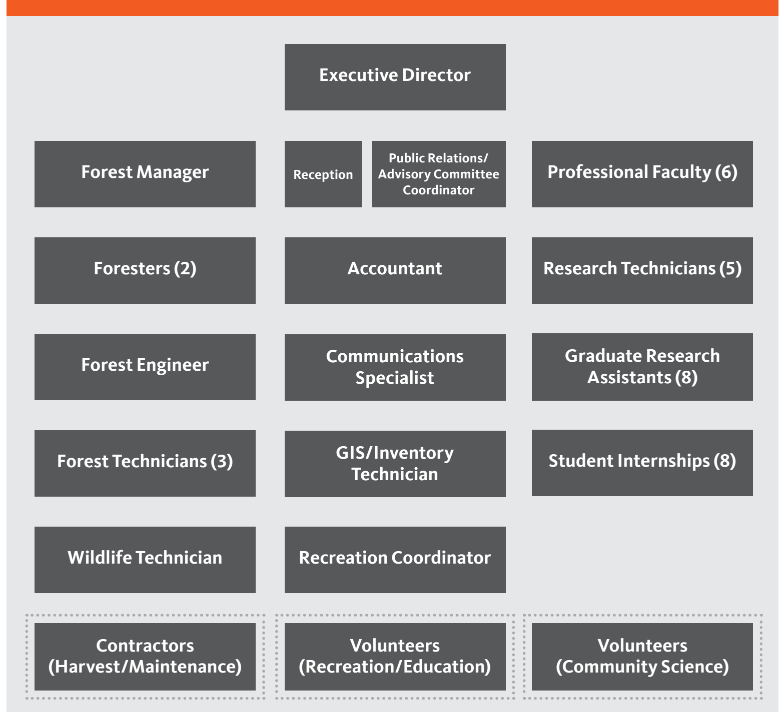
5 Formal processes and structures for advance public review and comment are to be developed, including public notices, comment periods, a website that provides the management plans and updates, and annual local open public meetings.

6 Individuals may also engage in forest activities that contribute to its overall goals and objectives, including volunteering in research (community science), recreation, education, and contractors in harvesting activities and vehicle/facilities maintenance (Figure 11).

ACCOUNTABILITY AND RESTRICTIONS

OSU commits to ensuring accountability to the integrity and transparency of the ESRF's management and operations. A set of ESRF foundational documents will be completed and ratified by OSU and DSL that will be used as the framework for OSU's implementation of the ESRF research design and management activities after the transfer from the CSF[1]. These foundational documents include:

Figure 11. Organization Chart for the ESRF



1 The ESRF Proposal advanced by OSU that contains specific, citable content including:
   A The ESRF Research Design, containing related maps and description of research and management treatment approaches.
   B OSU's Commitments to the Public, describing OSU's commitments to actions, approaches and outcomes relevant to conservation, local community and economic development, recreation, education, and tribal engagement.
   C OSU's commitments to the framework for providing transparent and accountable forest management decisions after transfer from the CSF.
   D OSU's commitment to managing a financially self-supporting research forest upon transfer from the CSF and contingent upon the provision of working capital and startup costs that is based on sources of revenue associated with the operation and management of the ESRF.

2 Habitat Conservation Plan and related Incidental Take Permit covering federal Endangered Species Act compliance approved by relevant federal regulatory agencies and included in the transfer of the forest from DSL to OSU.

3 A Forest Management Plan (FMP) with terms and provisions consistent with the other documents in this section and that binds and guides annual ESRF operations planning.

4 A forest conservation easement, deed restriction or other protective covenant that attaches to the ESRF when transferred from the CSF, and reflects key attributes of the ESRF Proposal, including but not limited to the following (subject to approval by the OSU Board of Trustees and DSL):
   A OSU cannot sell, partition, trade or otherwise transfer any portion of the Elliott State Forest/ESRF real property to a third party other than the State of Oregon as part of exercising terms of a reversion right (terms yet to be determined and agreed upon by OSU and DSL). While this document would not prohibit additional acreage from being added to the ESRF over time, it would ensure the ESRF is not reduced from its status subsequent to CSF transfer of the forest to OSU.
   B The ESRF cannot be used as direct collateral for a loan (although the ESRF would be part of OSU's asset base and available for purposes of supporting bond capacity).
   C Prohibition of lease or sale of any mineral resources (including hardrock minerals such as gold or fluid minerals such as oil, gas, geothermal resources), except for rock quarry activity to support the road system or for direct use in the operations of the forest.
   D Prohibition of commercial-scale energy development, including, but not limited to, wind, solar, or hydro, with potential exception for on-site use (including sale of energy to the grid) or for approved research purposes.

PUBLIC INPUT AND DISPUTE REVIEW

If members of the public allege that the ESRF is not being managed in compliance with its goals, commitments, terms of transfer, management plans, or applicable laws – and substantiate such allegation in writing in a manner that (1) specifies the connection between asserted facts and the goals, commitments, transfer terms, plans or laws being violated, (2) demonstrates that the alleged non-compliance is substantial and consequential, and (3) establishes that the alleged non-compliance actually harms the person's use and enjoyment of the ESRF – then OSU will provide an administrative review hearing process. Should OSU not respond to a complaint, not recognize the complaint as valid, or rules against the complaint in the hearing, then the complainant will have a pathway to appeal before the Oregon Court of Appeals to address those allegations.

OSU management activities that are consistent with the foundational documents and/or any revised forest management plan cannot be the subject of an administrative mechanism complaint (examples include but are not limited to intensive management practices in pre-approved locations, harvest of large trees or trees that were eligible for harvest in 2020 but have since aged to be over 65 years, choice of logging systems, or miscellaneous matters related to forest health, timber volume, or employment related issues attached to the ESRF). Should OSU receive a notice showing irreparable harm, and the complainant is likely to prevail, OSU shall provide an expedited hearing (as discussed below). While the specific details governing public input and review/hearing procedures/restrictions are to be developed, the following are examples of potential documentation of and limitations to such actions:

1 As part of its accountability and transparency, OSU produces and makes publicly available on the ESRF website:
   A A biennial Forest Operations Plan (FOP) that delineates active forest management actions to be conducted on the ESRF in the 2-year period following the FOP's finalization. FOP development includes public review

[1] The intent of OSU, DSL, and the ESRF Advisory Committee is that a Forest Management Plan will be collaboratively crafted and adopted by OSU prior to the transfer of the ESRF to OSU unless DSL and OSU agree otherwise after consultation with the ESRF Advisory Committee. Pending transfer to OSU the following limitations on forest management activities will apply:

- Management activities undertaken prior to final transfer of the Elliott Forest from the Common School Fund will be the responsibility of DSL and will be undertaken in collaboration with the ESRF Advisory Committee and OSU consistent with preserving the integrity of the research design, terms outlined above, and the financial integrity of the CSF
- Forest management activities would be subject to review and comment by the ESRF Advisory Committee
- Management activities involving harvests would be limited to partial watersheds identified in the ESRF Proposal outside of the ESRF research watershed replicates, unless otherwise agreed to by OSU and DSL after consultation with the ESRF Advisory Committee

~~and comment, as well as input and advice from the ESRF Advisory Committee. Once a FOP is finalized, it will be made public for a period of time (yet to be determined) prior to the first FOP-scheduled activity in order to allow adequate opportunity for comment and response by OSU. The FOP includes:~~

- ~~Description of overall management activities planned to be undertaken during the period of the FOP.~~
- ~~Nature and purpose of on-the-ground activity (harvest, road/trail work, herbicide use, mountain beaver, etc.), including the type of silvicultural prescription to be implemented, if any .~~
- ~~Size and location of individual project areas–reference ESRF Research Design/map.~~
- ~~Description of any significant construction-related activities, including road or trail building/removal or additions/subtractions from existing infrastructure.~~
- ~~Anticipated restrictions (type and duration), if any, to public access from any activity.~~
- ~~Current condition of area to be impacted (including forest age) as well as expected condition and outcomes of implementation (not just research or ecological objectives but anticipated jobs, harvest volume, etc.).~~
- ~~Whether the activity is likely to impact (positively or negatively) threatened or endangered species, water sources, steep or landslide-prone slopes, recreational or educational opportunities, public access (e.g., restrictions during the project or after), tribal partnerships, local community partnerships, workforce and jobs.~~
- ~~A budget reflecting projected revenue and expenses associated with operations, administration, and research treatments and related projects on the ESRF over the relevant FOP period.~~
- ~~Any other information reasonably necessary that demonstrates whether proposed forest management activities are consistent with the FMP and HCP.~~

B ~~An Annual Forest Management Report (AFMR) that documents FOP implementation over its covered period of time, including the following:~~

- ~~Location and particulars of forest management undertaken.~~
- ~~Description of any activity undertaken that was not covered in the FOP and reasons for deviations, if any.~~
- ~~Restrictions on public access, and whether those restrictions were observed.~~
- ~~Primary outcomes from the annual work, including conservation, jobs/economy, recreation, education, partnership objectives.~~
- ~~Financial components related to costs, expenses, revenue generated (from harvest or otherwise) related to ESRF operational viability.~~
- ~~Any other activities associated with advancing public accountability, engagement, and transparency objectives.~~

2 ~~The subject matter for a hearing conducted or authorized by OSU is available in the following limited circumstances:~~

A ~~Alteration of or changes to the foundational documents without prior public engagement and review, ESRF Advisory Committee input and recommendations that the changes are consistent with the intent of the ESRF Research Proposal approved by the State Land Board (a process for revising foundational documents is yet to be determined).~~

B ~~Adoption of an FMP or amendments thereto with provisions contrary to the foundational documents.~~

C ~~Planned (e.g., as set forth in the FOP) or actual (e.g., revealed in the AFMR or otherwise discovered) implementation of actions that are, by clear and convincing evidence, in substantial non-compliance with the FMP and/or foundational documents. The administrative review hearing process would attach only to non-compliance resulting from matters within OSU's knowledge and responsibility (i.e., not force majeure), as opposed to disagreements over the degree or manner in which an otherwise allowable activity is conducted. The following situations are examples of some, but not all, actions that can trigger the hearing:~~

- ~~Harvest treatments or other activities (e.g., road work, herbicide use, etc.) of a nature and type inconsistent with the designation of the watershed within which the treatments occur, or that are contrary to the treatment descriptions contained for that designation in the Research Design or FOP/FMP.~~
- ~~Violation of provisions of the HCP, recorded forest conservation easement, deed restrictions, or other protective covenants.~~
- ~~Harvest in full watershed replicates identified in foundational documents as "Managed Research Watersheds" that is unrelated to a) research, b) maintaining forest conditions in support of future research activities, or c) the funding of research and monitoring-related operational efforts on the ESRF.~~
- ~~Creation of additional reserve acreage (designation or de-facto) beyond what is in the Research Design without the ESRF Advisory Committee's engagement and recommendation.~~
- ~~Creation of harvest volume or financial targets or requirements.~~
- ~~Abandonment of the HCP during its term for reasons other than force majeure.~~
- ~~Failure to implement or adopt elements of the foundational documents, including adoption of recreation and educational plans.~~

SECTION 7

Financing Management, Operations, and Research

FINANCIAL OVERVIEW

A key foundation for an ESRF is that it will be financially self-sufficient as a research forest based on revenue generated through harvesting operations and other alternative sources of revenue to fund and advance the mission and vision of the ESRF as a research forest Other sources of funding are possible to complement operations revenue sources, such as grants, contracts, gifts, and in-kind contributions from agencies, partners, and collaborators; however, the following financial analysis is based only on harvest revenue, management and operations costs, and research costs.

Financial modeling outputs (i.e., annualized estimated revenue) are averaged to an annualized basis for comparison with annualized estimated costs. Management and operations revenue and costs estimates are based on historic trends–actual revenues and costs will fluctuate both in modeling assumptions and aligning with a forest management plan (yet to be developed). Estimates for research management and operations expenses are included as a direct cost of a research forest.

Based on the current research platform design and allocation of watersheds across the different treatments, preliminary financial analysis demonstrates that the ESRF is not self-sustaining from a financial perspective without an alternative source of revenue to cover the annual deficit, and up front sources of funds to cover contingencies and establishing the ESRF. Currently there is a $2.1 million deficit on an average annual basis for the first 50-years. Given these are estimates and assumptions are conservative, there is flexibility in these estimates if they are close to what is realized over time. Total revenue needed for financial self-support is estimated to be $7.8 million (annualized harvest and alternative sources of revenue, potentially including carbon offsets). This annualized revenue stream would support core annual forest management and operations expenses (including personnel, equipment, fire, and recreation) and core annual research management and operations expenses (including personnel, monitoring (carbon, water, wildlife, and recreation), maintenance, and overhead).

Table 1. ESRF Financial Analysis - Annual	
Category	**Estimate**
Total Harvest Revenue (MMBF Harvested)	$5.7M (16.6 MMBF)
Forest Management and Operations Costs	-$2.3M
Net Harvest Revenue	$3.4M
Research Management and Operations Costs	-$5.5M
Subtotal	-$2.1M
Alternative Revenue Needed	$2.1M
Balance	**$0M**

This analysis assumes an even flow of revenue and costs, and does not consider cash flow necessary to implement the research design on the forest, nor does it include an ability to build a financial reserve or endowment to ensure against natural disturbance, market fluctuations, or other factors that could affect revenue generation from the forest. It also is unknown at this time if there will be annual insurance costs beyond OSU's self-insurance policy. Startup investment needs are also identified. These startup costs are associated with purchasing and installing research equipment necessary to measure initial conditions and long-term monitoring for carbon, water, wildlife, and recreation research, as well as other monitoring costs. In addition, investments in building the infrastructure and facilities necessary for a world-class research center are included as startup costs. Startup costs are estimated to be $24.8 million. In addition, OSU will need working capital during the transfer and initial implementation phases before a steady revenue stream is realized from the forest, estimated at $3.3 million per year for three years, or $10 million. Therefore, total startup and working capital costs are equal to $34.8 million.

HARVEST MODELING ASSUMPTIONS

Timber harvests occur on the ESRF to implement the research platform design in allowable harvest areas. One of six treatments were applied to each of the 119 sub-basins. This results in the following acreage allocations:

1. 51,560 acres are in reserve or no harvest classifications (does not include thinning).
2. 30,981 acres are in harvest classifications
   - 15,335 acres in extensive
   - 15,646 acres in intensive

Table 2. Average Annual Harvest Volumes and Acreage				
Category	**Harvests in Intensive**	**Harvests in Extensive**	**Harvests in Reserve***	**Total**
Average Annual Harvest (MMBF)	10.6	3.9	2.1	**16.6**
Range Over First 50-years (Annual MMBF)	1.4-17.2	0-10.7	0-6.6	**N/A**
Average Annual Harvest (Acres)	349	216	171	**736**
Range Over First 50-years (Annual Acres)	64-489	0-747	0-548	**N/A**

**Harvests in Reserves are for restoration thinning and are scheduled to be completed within the first 20-years.*

Harvest revenue is maximized subject to the constraints of standards and guidelines, including Habitat Conservation Plan expectations, riparian prescriptions, reserves, and stand harvest prescriptions. Additional assumptions in the model include:

1. Non-declining, sustained yield flow.
2. OSU Experimental Design treatments were tailored to fit with the existing landscape. Therefore, Intensive management was assigned to young stands, extensive to intermediate and older stands, and Reserves to older stands.
3. Once established, average rotation ages are 60-years for intensive (non-reserve status) and 100-years for extensive
4. Assumed no log exports.
5. Log prices based on current market prices – similar to long term average.
6. No harvest in existing stands >160 years old.
7. Habitat restoration thinning harvests in the reserve areas of the Conservation Research Watershed and the Managed Research Watersheds would occur within 20 years of initial management.

The harvesting model results in approximately 17 MMBF per year while maintaining a consistent revenue stream over time. The average number of acres per year in active harvests (regeneration and thinning) are 736. The initial periods will be higher than this as restoration harvests are conducted in the reserves to set them on their future trajectory as older forests with natural variations, and the latter periods will likely drop to below 600 acres per year in active harvests. These average annual harvest acreages and volumes may change given they are based on even flow assumptions in a financial feasibility analysis, and may not reflect actual operations on the forest over time.

ALTERNATIVE REVENUE

Financial analysis shows a $2.1 million annual revenue deficit for which alternative revenue sources would need to be secured external to OSU. A significant potential source of revenue from the ESRF is through the sale of carbon offset credits certified by the California Air Resource Board (CARB) program based on the current stock and future flow (i.e., tree growth) of sequestered carbon in the forest. A forest carbon offset credit is one metric ton of carbon dioxide equivalent (CO_2e) sequestered through management actions and externally validated and registered by CARB. These credits can then be sold on the open market to organizations either required by law to compensate for their own carbon emissions, or that seek to voluntarily offset their emissions.

A detailed analysis was conducted by an independent contractor for OSU and DSL based upon baseline carbon accounting estimates from the forest modeling conducted in 2019, and a draft governance structure. While acreage allocations on the ESRF and California compliance market prices have changed since the modeling work was completed in 2019, values reported here are based on the low range of past and current carbon prices, and do not account for a general increase in sequestered carbon potential that the newer research design is anticipated to provide based on an increase number of acres held in reserve status. It is anticipated that DSL would access the carbon sequestered on the forest (initial period value) for the purpose of paying toward the State's compensatory obligation to the Common School Fund, while the annual payments (yearly vintage value) could be used to recover some of the upfront and alternative revenue needed to ensure the forest is financially viable and sustainable. The yearly vintage value would nearly close the $2.1 million financial gap between annual timber revenue and annual research forest costs. And the initial period value would cover upfront costs needed, but only under a private protocol market.

FOREST MANAGEMENT AND OPERATION EXPENSES

Forest management and operations costs vary based on the number of acres managed/harvest volume. These costs include personnel such as forest manager, foresters, forest engineer, forest technicians, GIS/Inventory technician, wildlife technician, business/log accountant, and recreation coordinator (Figure 11) are estimated to be $1 million. Annual

Table 3. Estimated Carbon Credit Value

Program Type	Initial Credit Period (tonnes)[a]	Initial Period Value	Average Annual Metric Tons of Credit per Year[b]	Yearly Vintage Value
Private Protocol, Compliance Market	4.9M	$49M	105,000	$1.7M
Public Protocol, Compliance Market	0.9M	$9.5M	145,000	$1.7M

[a]*Establishes % of gross credits to be contributed to buffer pool* [b]*Estimated for years 2-10, but will continue for the length of the contract period*

Table 4. Annual Forest Management and Operations Costs

Category	Cost	Notes
Personnel - annual and ongoing	$1.0M	Includes forest manager, foresters, forest engineer, forest technicians, recreation coordinator, GIS/inventory technician, accountant, wildlife technician
Annual maintenance and expenses	$1.3M	Includes fire management, HCP monitoring, business/legal support, vehicle replacement/maintenance, computer/software support, road maintenance, recreation program expenses, rent/supplies
Total Annual Costs	**$2.3M**	

Table 5. Annual Research Management and Operation Costs		
Category	**Cost**	**Notes**
Research Personnel	$2.3M	Includes executive director, communication specialist, public relations/advisory committee coordinator, secretary/receptionist, professorial faculty, technicians, graduate students, student interns
Variable Research Backbone Monitoring Cost	$0.9M	$300K (10%) for inventory, re-measurement, equipment updates $146K (10%) for C, $129K (10%) for aquatic, 200K (20%) for wildlife. Social Science ($100K) or 20%. Misc $25K
Vehicle and Facility Maintenance	$0.1M	Estimated $9 per sq/ft for a 5,000 sq/ft building on an ESRF, maintenance of vehicles $5k per year
IT/Data Storage/Software/QA/QC includes personnel to manage data analysis	$1.0M	Patterned after HJ Andrews annual IT/data costs
Research Equipment Maintenance	$0.2M	Estimate by Katy Kavanagh
OSU Overhead for administrative services (payroll, accounting, etc)	$1.0M	13% of total forest revenue (carbon and harvest) this assumes $7.6 million in revenue per year at 10%
Total Annual Research Expenses	**$5.5M**	

maintenance and expenses associated with forest operations, including HCP monitoring, IT/legal support, vehicle/road maintenance, recreation program, fire management, and miscellaneous rent/supplies are estimated to be $1.3 million. Total annual forest management and operations costs, as detailed below, are estimated to be $2.3 million.

RESEARCH MANAGEMENT AND OPERATION EXPENSES

Research management and operations costs are also estimated and included here as fixed annual costs to oversee and manage research activities in the forest. Annual research personnel costs include an executive director, communication specialist, public relations/advisory committee coordinator, secretary/receptionist, professorial faculty, research technicians, graduate students, and student interns (Figure 11) are estimated at $2.3 million. Annual variable research monitoring and equipment upagerades are estimated at $0.9 million. Annual maintenance of vehicles and facilities are important, and are estimated at $0.1 million. Active large-scale research such as that proposed for the ESRF, as well as inventory and monitoring data, requires significant annual investments in IT, software, and data storage, and are estimated at $1 million. Research equipment is anticipated to be placed throughout the forest to collect carbon, wildlife, water, and recreation data; annual maintenance costs of this research equipment is estimated at $0.2 million. Some support services will be accessed through OSU, and compensation of these resources is anticipated to be approximately 13% of total annual revenue, or $1 million. Total annual research management and operations costs are estimated to be $5.5 million.

WORKING CAPITAL AND BUILDING RESEARCH CAPACITY AND INSTRUMENTATION EXPENSES

It is anticipated that it will take approximately three years for transfer of the property to OSU and before a revenue stream is generated from the forest. However, inventory, monitoring, and wildlife surveying must be conducted in a timely manner to expedite transfer and begin revenue generation. It is estimated that $3.3 million per year for three years is needed in working capital, or $10 million.

Implementing the research design and meeting the goals and objectives of the ESRF will require major investments in facilities and infrastructure, and instrumentation for research and monitoring. While these startup investments are not part of the financial analysis, they are related. If debt is incurred by the ESRF in order to cover these expenses, then annual debt payments will be assessed against the annualized net revenue generated from the forest. Many of these foundational expenses would accrue at the beginning of the enterprise, e.g., capital construction of the ESRF Research Station or installing research instruments to capture baseline data prior to any landscape or resource changes.

Four primary categories of startup costs are identified, including:

1. **Infrastructure / Research Station -** this includes facilities that would house research labs; bunkhouses for scientists, students and others actively engaged in research and educational activities where onsite lodging is needed; workshop; climate-controlled storage; classrooms; and an event/visitor center. Comparable research stations cost $17 million to construct.

2. **Vehicles / Accessories -** an estimated 15 vehicles dedicated to research activities would be needed to ensure access to research sites and are estimated to cost $0.5 million. These vehicles would be in addition to those needed for the operations side of the forest, although some dual purpose of them could occur.

3. **Research Plots and Inventory -** an integral part of a research project is the development of permanent and temporary research plots. Inventory would be a combination of lidar and aerial photography. The development of a forest management plan is prefaced on having good inventory data. While it is not possible to conduct an inventory on all acres simultaneously, the staged implementation of the research design enables this work to be done over time. However, ensuring that funds are available to complete this work in an ongoing manner is critical to the success of an ESRF. Research plot and inventory costs are estimated to be $3 million.

4 **Priority Research Areas -** four research areas were identified as being high priority and that require baseline data collection and long-term monitoring. These four areas align with public values for the forest, and will help to assess the College's success at meeting its commitments as well as sustaining them over time.

A **Carbon / Climate Monitoring -** carbon measurement and monitoring meets several objectives of the forest, including aligning with carbon offset credit tracking. Needed equipment includes carbon soil pits, C/N analyzers, drying ovens, etc., to measure carbon concentration and decomposition rates in live and dead wood, forest floor, and soil. Climate measurement and monitoring equipment and labor includes climate and soil stations for measuring temperature, precipitation, relative humidity, soil moisture, and radiation. Equipment and labor costs are estimated to be $1.5 million.

B **Aquatic / Riparian Monitoring -** measurement and monitoring includes conducting fish surveys and assessing and tracking stream morphology. Equipment and labor would be needed for weir construction; sensors for water temperature monitoring (longitudinal stream and air), flow, and turbidity; autosamplers for measuring suspended sediment/solutes/dissolved oxygen; and data loggers for automated data collection. Equipment and labor costs are estimated to be $1.3 million.

C **Wildlife Monitoring -**various equipment and labor is needed to measure and monitor a variety of wildlife that are important indicators of ecological quality and resilience. These include the establishment of vegetation plots, wildlife cameras (primarily for mammals), and arthropod/bee/salamander monitoring. Also important is instrumentation of the forest for measuring and monitoring marbled murrelet and spotted owl (as well as songbirds) through wildlife surveys (complements community science efforts) and bioacoustic technology. In addition, some eDNA sampling and analysis may be conducted. Equipment and labor costs are estimated to be $1 million.

D **Social Science / Recreation Monitoring -** measuring and monitoring how people, both on and off the forest, are affected by landscape changes and recreation infrastructure development is an important aspect of learning from the forest. Equipment and labor needs include infrared trail counters, recreation cameras, permanent and portable roadway traffic counters, and surveys of recreation users and surrounding communities (or regional/statewide). An assessment of biophysical locations for the development of trail systems/networks would be important to developing a recreation management plan. In addition, the establishment of permanent photo plots for illustrating and tracking landscape changes for use in evaluating public perceptions and values of these changes. Equipment and labor costs are estimated to be $0.5 million.

Table 6. Estimated Working Capital and Startup Research Costs

Category	ESRF	Notes
Working capital	$10M	Working capital for three years during transfer phase
Infrastructure/Research Station	$17.0M	Research facility that includes labs, bunkhouses, classrooms, shop, climate-controlled storage, event center
Vehicles & Accessories	$0.5M	Estimated 15 vehicles at $34,000 ea. for vehicle and accessories
Research Plots & Inventory	$3.0M	Aerial and ground based LiDAR, aerial photography and permanent or temporary plot installation
Carbon/Climate Monitoring Equipment	$1.5M	Carbon soil pits, lab equipment for analysis, climate/weather stations
Aquatic/Riparian Monitoring Equipment	$1.3M	Fish surveys, stream morphology, sensors for temperature, discharge, suspended sediment, stream and air temperature
Wildlife Monitoring Equipment	$1.0M	Vegetation plots, bioacoustics, wildlife surveys, cameras, eDNA sampling and analysis
Social Science / Recreation Monitoring Equipment	$0.5M	Infrared trail counters, recreation cameras, traffic counters, community surveys and assessments, photo plots
Total Start Up Expenses	**$34.8M**	

SECTION 8

Appendices

The following appendices are included to provide additional context and detail on the research platform.

APPENDIX 1

Research Charter

NOTE: This document was originally delivered to DSL director Vicki Walker in Dec. 2019. Minor updates have been made to ensure this document is consistent and integrated with the full ESRF proposal. The revised version is included below.

Prepared by the Exploratory Committee for the Elliott State Research Forest. The committee consists of ten members from College faculty, staff, and outside the University representing a variety of scientific fields including forest biological, physical, and social sciences. By bracketing perspectives on the committee such as; thought leaders and appliers, those with global and local experiences, focused researchers and educators we are maximizing participation and broadening the dialogue in the College and beyond.

FOREWORD

Forests are integral for the health and wellbeing of humanity, as well as to the conservation of biodiversity and ecosystem functions and services. With increasing global demand for forest products and with influences from a changing climate, it will be critical to find constructive ways to provide these essential resources without compromising global forest biodiversity, carbon sequestration, and ecosystem health. We propose that the Elliott State Research Forest (ESRF) be a center – both in Oregon and worldwide – for sustainable forestry using the scientific method.

Two major alternatives have been put forth to minimize tradeoffs between timber production and ecosystem health. First, extensive management attempts to mimic natural disturbances using adaptive silviculture regeneration techniques such as retention harvests. However, such ecological approaches tend to have less timber production per unit area, and thus require a higher proportion of the landscape to meet fiber demand.

Alternatively, others suggest conserving portions of the forest in strict reserves, while using intensive forest management, such as even-age regeneration harvests and plantations, to generate the necessary wood supply on a smaller area in comparison to extensive management. There are a variety of intermediate options that vary the proportions of reserve, intensive management and extensive management in the landscape and can be encompassed into a Triad design. The overarching objective of the ESRF will be to provide the first landscape-scale experimental tests of such strategies for producing timber products while minimizing risk to forest ecosystem services.

ESRF Exploratory Committee Members		
Member	**Expertise**	**Affiliation**
Katy Kavanagh (Chair)	Associate Dean of Research	College of Forestry
Matt Betts	Landscape Ecologist; emphasis on biodiversity	College of Forestry
Ashley D'Antonio	Recreation Ecologist	College of Forestry
Shannon Murray	Continuing Education Program Coordinator	College of Forestry
Klaus Puettmann	Silviculture, Forest ecology	College of Forestry
Meg Krawchuk	Landscape Ecologist, fire & conservation science	College of Forestry
John Sessions	Forest Engineer, Forest Operations Planning & Management	College of Forestry
Ben Leshchinsky	Geotechnical Engineer; focus on forest road design, hydrologic process, landslides, and slope stability	College of Forestry
Jenniffer Bakke	Wildlife Biologist, Environmental Services Manager	Hancock Natural Resource Group
Clark Binkley	Managing Director	Institute for Working Forest Landscapes
Gordon Reeves	Aquatic Ecologist	USFS, College of Forestry

RESEARCH CHARTER INTRODUCTION

"The ultimate goal of the research programs at the OSU College of Forestry is to provide innovative approaches to enhancing people's lives while also improving the health of our lands, businesses, and vital ecosystems, and to do so collaboratively with active involvement of multiple partners with different perspectives."
- OSU Institute for Working Forest Landscapes, 2013, page. 1.

The ESRF would become an integral part of realizing this vision. This Research Charter is intended to guide the design and implementation of research on the Elliott forest over time, and in doing so ensures that these important tenets of the Institute are honored. Work on the Charter will progress until all of the components are fully described so that it will guide governance and remain fundamental to management of the forest into the future.

COLLABORATIVE APPROACH

The collaborative component of this research plan to date has incorporated input from local citizens and other stakeholders from public listening sessions, focus groups, the Department of State Lands Advisory Committee, and information received in discussions with the local tribes. We incorporated this information into our overarching research theme, desired outcomes, the selection of a diverse set of treatments and need to have specific research questions that could be tested under these sets of treatments. We are continuing to receive input and as this research plan is still a draft document, we fully expect to incorporate additional input by engaging constituencies in discussions with the Exploratory Committee about key areas for research inquiry into the future. We will have continued collaboration on subsequent drafts of the experimental design, implementation and monitoring.

1 GUIDING PRINCIPLES FOR RESEARCH

Guiding principles are the foundation for establishing a long-term research program that remains focused and relevant to the overarching vision set forth by the Oregon State Land Board. In December 2018, the Oregon State Land Board directed the Oregon Department of State Lands (DSL) to work collaboratively with Oregon State University (OSU) to develop a plan for transforming the Elliott State Forest into a research forest. A successful plan will be consistent with the Land Board vision for the forest, which includes:

- Keeping the forest publicly owned with public access
- Decoupling the forest from the Common School Fund, compensating the school fund for the forest and releasing the forest from its obligation to generate revenue for schools
- Continuing habitat conservation planning to protect species and allow for harvest
- Providing for multiple forest benefits, including recreation, education, and working forest research

An ESRF program must rise to the true potential associated with the size and complexity of the Elliott by ensuring that it fosters research that is enduring across generations, takes advantage of the forest's size, landscape, and habitat characteristics, and is highly relevant to Oregon and beyond. Research initiatives executed on the forest must collectively support a unifying question so that the collective work of different research program initiatives will collectively contribute to a greater body of work over time.

Principle 1: Research

The ESRF will be managed to advance and sustain science-based research that does not introduce statistical bias. All management objectives related to fulfilling other public values as well as revenue generation on the forest will be accomplished within a

Figure 1a. Research Charter Diagram

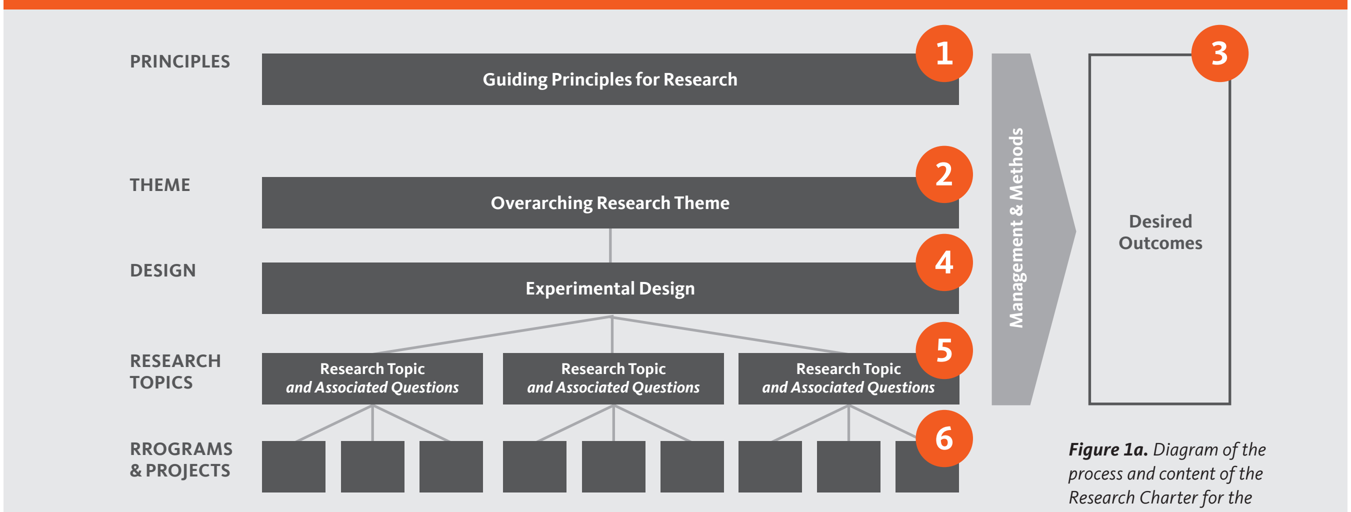


Figure 1a. *Diagram of the process and content of the Research Charter for the Elliott State Research Forest.*

research first context. Fundamental to this vision for a research forest is the use of unbiased locations of treatments and controls, adequate unit size to avoid edge-related influences, manipulative experimentation to understand the processes controlling the response, and sufficient longitudinal observations to assess both short- and long-term response. The statistical analysis will attempt to further improve the comparability of treatments, e.g., through analysis of covariance.

Principle 2: Enduring

The overarching research question for the ESRF should aim to remain relevant across many years, generations, and social, economic and environmental contexts. Though research programs and projects on the forest may address more immediate challenges and current needs, the greater arc of the research will take advantage of the University's tenure and consequent stability and mission-based research focus as a Land Grant Institution. Long-term monitoring and adaptation will be incorporated to determine if it is possible to sustain a system-based approach to exploring the integration of plantations, forest reserves, aquatic and riparian ecosystems, and actively managed multiple-strata forests through time. Designed treatment protocols will sustain ecological function and biota by retaining valuable biological legacies that represent complex early successional through late-successional attributes.

Principle 3: At Scale

An overarching research question, research design, and long-term monitoring on the ESRF should leverage the unique opportunity the forest offers for experiments at large spatial and long temporal scales. While different research may be conducted on different areas within the forest, the entirety of the forest should advance knowledge under an overarching research question. **Most importantly, the size of the ESRF will enable us to explore and quantify the synergies and tradeoffs associated with different amounts and arrangements of treatments at a landscape scale through time.** We can experimentally test the ability to emulate the natural range of natural disturbances that were historically typical of the Oregon Coast Range (and natural disturbances that may not have analogs in the past). By maintaining these experimental treatments through time we will observe the full suite of outcomes, including impacts on nutrients, wildlife, fish, aesthetics, and cultural values.

Principle 4: Tailored to the Landscape

The overarching research question will guide the research design and will be tailored to the ESRF based on existing biological, physical, social, and economic conditions. Research treatments will represent and reflect the diverse age class and disturbance history of the forest, and to the maximum extent possible, utilize previously managed stands. The experimental design needs to be tailored to ensure that research on the forest takes full advantage of the forest's capacity to provide knowledge while addressing research themes that are highly relevant beyond the borders of the ESRF, the State of Oregon, or even North America.

Principle 5: Practical, Relevant, and Collaborative

The Land Grant mission of Oregon State University and the history of the Elliott State Forest as a public forest require that research conducted on the forest be relevant to forest management issues and challenges facing Oregonians. Setting the objectives of a research program as it grows over time will require active engagement of a cross-section of stakeholders who work closely with the University to ensure that this publicly owned research forest continues to serve the public with credible, relevant and timely science. We will actively engage and collaborate with the greater research community and a cross-section of stakeholders to ensure the research treatments achieve desired goals of the ESRF and are based on sufficient data to design appropriate experimental protocols.

2 OVERARCHING RESEARCH THEME

Research synergies and tradeoffs for conservation, production, and livelihood objectives on a forested landscape within a changing world.

The overarching research theme is the umbrella under which different research areas and program initiatives reside. Research conducted under this broader inquiry should meet the guiding research principles while addressing the desired outcomes.

3 DESIRED OUTCOMES

These are the outcomes that an ESRF will support and achieve over time as part of the Institute for Working Forest Landscapes. In doing so, these outcomes will set the context for linking together a diverse research program framed around the overarching research question to yield prominent, relevant and rigorous science.

Specific to the Overarching Research Question:

- Successfully install a landscape level research platform on the ESRF that uses a systems-based approach (Figure 1) to investigate the integration of intensively managed forests, forest reserves, dynamically managed complex forests and the aquatic and riparian ecosystems that flow within them.
- Being able to answer a long-standing question; given the societal need for a determined volume of wood supply, what is the best combination, in amount and spatial arrangement, of reserves, intensive and extensive (complex) forestry (at the landscape-level) to supply wood while maintaining water quality, biodiversity, human needs and other forest ecosystem services.
- An experimental design that is robust enough that natural disturbances will not disrupt the long-term goals. We fully expect disturbance to be an integral part of the design.
- A research platform that is capable of incorporating a wide variety of research that varies in spatial and temporal scales.
- A nested set of experiments capable of producing data sufficient in time and space to prove or disprove hypotheses arising from our research question.

Overall

- **Increase Public Trust in Active Management of Public and Private Forest Lands.** Restoring broad scale public understanding and trust entails more than compliance with existing laws. It requires proactive, transparent, and collaborative land management so that multiple interests are vested in the outcomes sought.
- **Improve the Health of Rural Economies, Communities, and People.** The economic base and future opportunities of rural communities can be strengthened by a more diverse economy that is interwoven with a fully functioning working landscape – one that integrates production of merchantable timber with restoration activities, ecosystem services, conservation and recreation/tourism-based markets.
- **Increase the Competitiveness of Oregon's Private Landowners and Businesses.** Capitalizing on the true potential for our westside private forests to compete in expanding world markets for value-added products will require driving innovation at all stages of forest land management from seed stock to harvest methods.
- **Enhance Ecosystem Resiliency.** Implementing and studying a landscape scale approach to forestland management to further forest resilience through changing global environmental and social conditions.

4 EXPERIMENTAL DESIGN INTRODUCTION

Research conducted under this broader inquiry should meet the guiding research principles; science-based, enduring, at scale, tailored, and relevant while addressing the desired outcome of understanding **synergies and tradeoffs of conservation, production and livelihood objectives on a forested landscape within a changing world.**

Approach

Our goal is to investigate promoting biodiversity, ecosystem processes, and ecosystem services while achieving a given fiber supply using existing and novel land management strategies. As our research framework for this investigation, we will use a Triad design. The Triad design is a triangle with its endpoints being reserve, intensive and extensive stand management practices applied in varying proportions. The endpoints are structured under the premise that as you intensify management, you are able to increase the amount of land in reserve, while maintaining a stable output of products or values. Extensive stand management, where multiple ecosystem service objectives are met, with no separate lands set aside as reserves. As contrasted by a dichotomy of intensively managed lands for wood production coupled one to one with reserves. The larger amount of intensively managed land would equate to a larger amount of reserves. Within the Triad design we will integrate a set of riparian conservation areas (RCA) that play a key role in integrating the aquatic and terrestrial ecosystem management.

A **The goal of 'Reserve' research treatments** being very limited intervention and management with initial treatments focused on restoration and enhancing conservation values in the prior plantation areas then transitioning towards no further harvests. In cultivating natural forest successional processes, one-time thinning would be done for ecological purposes in stands that regenerated following clearcut logging. Natural processes would be unmanaged and allowed to create disturbances and seral stages (with the exception of fire). The forests receiving this treatment are located in the western and northern watersheds and the older forests in the remainder of the Elliott.

B **The goal of intensive research treatments** being to maximize wood productivity per acre. Research treatments in these forests will allow us to investigate management options that primarily emphasize the production of wood fiber at rotations of 60 years or longer. At the same time, we can assess methods to reduce the impact of this harvest regime on other attributes such as biodiversity, habitat, carbon cycling, recreation, and rural well-being. These treatments are explicitly applied in areas with younger, previously managed forest stands. The production of wood is an important contribution to society. Intensive treatments will serve as a benchmark for wood production potential and trade offs associated with wood production relative to extensive and reserves.

C **The goal of the 'extensive' research treatments** will be to explore the implementation of a new set of alternatives to intensive plantation management and unmanaged reserves thereby expanding the frontiers of forest management. Research on "extensive" alternatives will aim to accomplish diverse forest characteristics to meet a broad set of objectives and ecosystem services while simultaneously achieving wood production. This will be done by retaining structural complexity while ensuring conditions exist to obtain regeneration and sustain the complex forest structure through time. These treatments are applied across watersheds within stands representing most age classes.

D **The goal of the riparian conservation areas (RCAs)** will be to maintain and restore vital ecological processes that influence the aquatic ecosystem in the intensively managed and extensively managed treatments. The aquatic and riparian conservation component of the system-based research strategy will rely on a set of designated RCAs.

Subwatershed Catchments

The experimental unit of measure will be subwatersheds 400 to 2000 acres in size. The 66 subwatersheds in the ESRF are designated to be in either the Conservation Research Watersheds (CRW) or Management Research Watersheds (MRW), (Figure 5) with over 9,000 acres in partial watersheds that were either less than 400 acres or not fully contained within the ESRF. Subwatersheds were chosen to give us defined boundaries (ridges) and the ability to use water as an integrator of treatment effects. With 40 subwatersheds, we could have approximately 10 replicates per treatment level.

Forty watersheds that are wholly contained within the MRW will receive the varying treatments outlined in Figure 4. The sizes of the individual reserves will range from 80-1000 acres, depending on the percentage of the subwatershed in reserve, the spatial arrangements of the reserves and size of subwatershed. We assessed the level of prior forest management in each subwatershed by looking at stand age. Since the first logging started circa 1955, we concluded any stand younger (based on the 2020 inventory) than this was a result of harvest including disturbance and salvage. Stands older than this are primarily a product of stand replacing fires. Overall, about 50% of the Elliott State Forest has had a regeneration harvest in the 65 years preceding the 2014 inventory. The percentages of the individual subwatersheds in the MRW that are less than 65 years old range from 19% to 98%.

- Extensive or treatment 1 would be 100% extensive stand management across the entire subwatershed.
- Triad-E or treatment 2 would have 60% of the sub basin acreage in extensive, 20% intensive and 20% reserve stand management.
- Triad-I or treatment 3 would have 20% of the sub basin acreage in extensive 40% intensive and 40% reserve stand management.
- Reserves with Intensive or treatment 4 would have 50% of the sub basin acreage in intensive and 50% reserve stand management.

SCOPE OF INFERENCE

In the strictest sense, the scope of inference for any statistical results based on the proposed design will encompass only these particular subwatersheds in the ESRF. However, by using manipulative experiments and conducting scientific research to understand mechanisms controlling responses – the work will be generalizable beyond the scope of the Elliott especially if they are contributing to a process model or other modeling framework. In addition, there is no reason to believe that observed relationships between different forest management approaches and ecosystem processes and services will be relevant only to the conditions that exist in the ESRF. Given this, inference of many results can be extended at least to

Figure 4. Triad Landscape-level (Subwatershed) Treatments

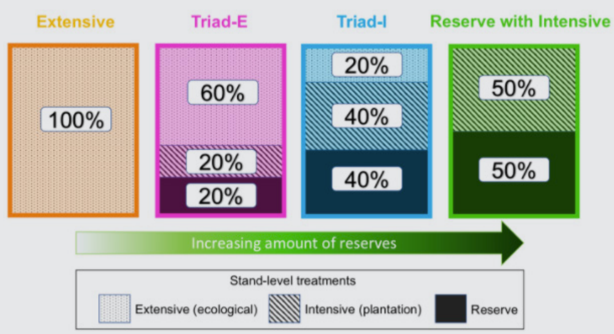
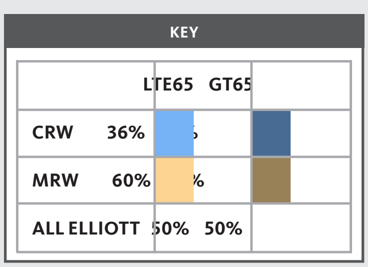


Figure 4. *The four Triad treatments that we will apply at the subwatershed scale at the ESRF. All of the subwatersheds (400-2000 ac) in the Management Research Watersheds will receive one of these four treatments. Treatments are designed to produce approximately equivalent wood yields using different combinations of stand-level treatments: reserves, extensive (ecological forestry) and intensive management (plantations). The 'Extensive' Triad treatment (orange) will be 100% ecological forestry, the 'Reserve with Intensive' Triad treatment (light green) will comprise 50% intensive forestry and 50% reserve. 'Triad-E' and 'Triad-I' contain differing proportions of reserve, ecological and intensive forestry.*

Figure 6. Age class distribution in the Conservation Research Watershed and the Management Research Watershed



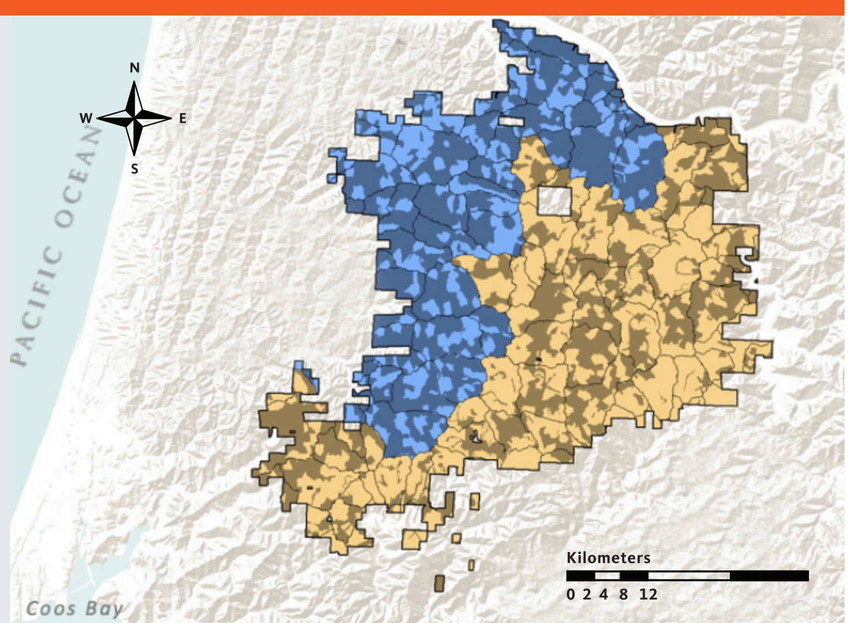


Figure 6. *Subwatersheds of the Elliott State Research Forest color coded by classification into the Conservation Research Watersheds (CRW) and Management Research Watersheds (MRW) and color coded by stand age greater than 65 years (GT65) and less than 65 years (LTE65). Uncolored regions indicate this portion of watershed is not part of the proposed Elliott State Research Forest.*

places with similar forest structure in the same region. Other jurisdictions in tropical and temperate zones have already expressed an interest in mirroring this research design. With this commitment and potential for replicates beyond the Elliott, the scope of inference will broaden significantly.

SUMMARY

Using this approach, future generations can ask and answer what, in times of rapid change, are the most effective means of ensuring biodiversity, ecosystem processes, and ecosystem services are sustained while achieving a sustainable wood supply? The fundamental aspiration for an ESFR is to have an experimental design that is broadly applicable, capable of testing basic knowledge, answering why and how, be based on experimentation, and developing and deploying solutions all while maintaining the capability of addressing the current and next generation of forest-related research and policy questions. We believe we are well positioned to achieve these ideals.

5 THEMATIC RESEARCH AREAS

Thematic areas define the boundaries for which individual research program initiatives can nest within the overall research theme. These areas describe the "playing field" that collectively defines how research on the forest will support the big, overarching research question. While the thematic areas may evolve and change over time, in respects to the context of adaptive capacity and governance, they are intended to function as guideposts to ensure focus and continuity of research programs in service of the long-term goals of the forest. The thematic areas are intended to provide opportunities for nested sets of research activities, including short-term studies of specific research questions that are compatible with the research design.

An initial set of thematic research areas are being identified and developed as the Research Charter is discussed and finalized with input from stakeholders both internal and external to the College of Forestry. The following areas have already been highlighted in initial conversations:

- **Biodiversity and At-Risk Species:** As the Elliott contains a number of potentially at-risk and sensitive species, research needs to address the most pressing of issues associated with sustaining and enhancing terrestrial and aquatic species in the context of managed forested landscapes.
- **Climate Change Adaptation:** Forest and ecosystem health related to climate change impacts; research to identify potential suite of management approaches to help mitigate impacts with a goal of forest resiliency and reduced vulnerability.
- **Natural and Human-Caused Disturbance:** Disturbances such as landslides, debris flows, fires, different types of harvest regimes and recreation all play a crucial role in forested landscapes. The Elliott has and will continue to be the site of significant disturbances – whether natural or human-caused. Research conducted on the forest will be tailored to account for this important opportunity.
- **Structure:** The Elliott has demonstrated inherent potential for older, larger trees to dominate as well as complex early seral that can potentially dominate the northwest forests associated with our region. Research will explore management options that provide for a variety of stand structures, including late-successional conditions, and associated range of biodiversity, wood products and ecosystem services.
- **Socio-economic and cultural impacts.** Opportunities to investigate the human dimensions of a Triad dichotomy. A massive opportunity given to study community engagement and collaborative governance.
- **Water Quantity and Quality in Relation to Forest Management:** The Elliott provides excellent opportunities to develop better scientific understanding of the effects and biological responses of natural and human-caused disturbances in forest landscapes on water quality and quantity.
- **Landscape and Scale Issues.** Opportunities to investigate the role of adjacency, fragmentation (amount and shapes), and connectivity on e.g., source-sink relationships, migration potential (rates and barriers) for plants and animals, habitat area-population size relationships, edge effects.

6 PROJECTS AND PROGRAMS

See Appendices 2 and 3 for lists of nested research opportunities, potential collaborations, and examples of research programs in key areas.

APPENDIX 2

Research Opportunities Within the Triad Research Design

Our vision is to conduct research on a large landscape that leads to science that addresses how forests can help achieve broad-scale conservation goals and alleviate climate change, all while producing fiber for a growing population and meeting various social and economic needs.

The goal of research on the ESRF is to advance more sustainable forest management practices through the application of a systems-based approach to investigating the integration of intensively managed forests, forest reserves, dynamically managed complex forests, and the aquatic and riparian ecosystems that flow within them.

Notably, the ESRF's size will enable us to explore and quantify the synergies and tradeoffs of these land management practices at a landscape scale through time. We will quantify the complex relationships among the multiple ecological, economic and social values in response to experimental landscape-scale treatments. To honor the rich legacy of this land, the ESRF should do nothing less than attempt to reimagine the future of forestry.

The below list are the types of potential short- and long-term research projects, questions, and collaborations that can occur on the ESRF.

The list is a result of conversations with the ESRF Exploratory Committee, researchers and collaborators participating in the college's Fish and Wildlife Habitat in Managed Forests Research Program, and external reviews from research faculty at the University of Oregon, Swedish University of Agricultural Sciences, University of Sheffield (UK), The National Center for Air and Stream Improvement, Colorado State University, and OSU.

Research at the ESRF should extend well beyond OSU. As we have for many of our programs, OSU will continue to look for partnerships and collaborations with local, state, regional, national, and international colleagues.

CLIMATE CHANGE & CARBON

- Microclimate instrumentation and modeling such as forest canopy wetness, temperature dynamics and accompanying physiological research.
- Interdependence of carbon sequestration and biodiversity across regions.
- Modeling of forest carbon, water stocks and fluxes to examine questions like the impacts of harvesting on carbon stocks, fluxes, and surface energy balance.
- Does terrain and fog in this rugged ecosystem provide hydroclimatological heterogeneity that contributes important biophysical refugia and environmental buffering to this system?
- Can we use forest management and conservation approaches to support ecosystem resiliency in a changing climate?
- What is the relationship between forest management practices and carbon cycling in temperate, conifer forests? The question can include an assessment of above and below ground (soil and root) carbon stocks.
- What are the impacts of climate change on soils, soil resources and soil processes? Contemporary harvesting practices have potentially brought down sedimentation levels back to normal levels, but rare events could negatively impact this outcome.

SOCIAL ECONOMIC & RECREATION

- How do we monitor and manage human access to forested landscapes across large spatial and temporal scales?
- How do we efficiently and effectively monitor the levels and patterns of recreation when it is low and highly dispersed/diffused across a large area?
- How do different management practices influence the social capital of stakeholder groups?
- How do we incorporate traditional ecological knowledge into the research, education, and outreach objectives for the ESRF?
- How do recreationists' perceptions of management practices change in relation to management treatments, and over time as landscapes change?
- How are experiences and values influenced by tree density and age, slope, viewshed, trail complexity and difficulty?
- What are the types, levels, and extent of recreation-related impacts across the ESRF?
- What are the socio-economic and cultural impacts of the management treatments?
- How do we provide a sustainable supply of forest products without compromising cultural ecosystem services?

AQUATIC

- Developing an intrinsic potential model from LIDAR to evaluate habitat conditions for Coho Salmon under different scenarios of forest management.
- Implementing stream temperature network instrumentation to evaluate downstream effects of forest management.
- Utilizing environmental DNA to assess aquatic biodiversity across working forests.
- How does the forest structure created by regeneration management and natural disturbances affect streams?
- How does timber harvests or fire influence how water storage and transit times change within a catchment? Is there a gradient considering a range of management activities?

- How does the gradient of potential management activities affect hydrologic and geomorphic processes (flow of groundwater, water T, landslides, debris flows, wind throw)? Is there a threshold where management levels produce a significant change?

FOREST PRACTICES & MANAGEMENT

- How do alternate road surfacing systems perform (operational performance, environmental impact, cost, sensitivity to fire, etc.)?
- Measure forest worker hazards recognition and risk assessment in complex silviculture systems.
- How can forest operations minimize energy consumption by comparing new ground-based steep slope harvesting systems and traditional cable systems?
- Partner with research forests throughout the globe to create a mirrored experimental project in a tropical forest.
- How does the gradient of potential management activities affect hydrologic and geomorphic processes (flow of groundwater, water temperature, landslides, debris flows, windthrow)?
- How does the frequency and magnitude of landslides change in managed and unmanaged terrain? How does this compare under baseline conditions or extreme events?
- What are organismal responses to harvest? How do harvests impact the dispersal of organisms that have sub-stand home range?
- What is the best way to meet the increasing wood demand while minimizing costs to other ecosystem processes/services (including biodiversity)?
- Are there ways to conduct harvest system planning that lessens impacts on soil and water?
- Can we achieve a combination of biodiversity conservation and timber production goals under various climate change projections?

FIRE/DISTURBANCE

- Measure large-scale, prescribed fire impacts on terrestrial and aquatic ecosystems.
- Do natural influences (extreme events, geology, climate) outweigh management activities in the long-term?
- How do disturbances (fire, wind, invasive species) move across the landscape with different levels of management?
- Does a combination of management and prescribed fire improve ecosystem resilience to wildfire?
- How did historical indigenous burning practices influence the current ecosystem structure and function? What can we learn from these past practices that improve modern system function?

SOIL

- How will climate change impact soil productivity?
- How do intensive and extensive forest management practices influence soil productivity, nutrient stocks, and soil carbon?
- How does the inclusion of fire in management systems influence soil biodiversity and function?
- How do various management treatments influence soil biodiversity, composition and function? How does this change over time?

TERRESTRIAL

- How does edge density/ distance to edge influence marbled murrelet occupancy rates and nest success?
- Does mature fragment size influence occupancy and nest success?
- What management strategies best conserves Marbled Murrelet populations?
- How can we utilize audio data to monitor for species in diverse and expansive terrains?
- How do thinning activities impact nest success?
- Does edge contrast matter (mature forest to intensive management versus mature forest to 'ecological forestry')?
- Do conclusions about land management strategies from tropical agricultural landscapes hold, or are an entirely different set of hypotheses supported?

FISH AND WILDLIFE HABITAT IN MANAGED FORESTS (FWHMF) CONCEPT SUBMISSIONS

The FWHMF program's mission is to provide new information about fish and wildlife habitat within Oregon's actively managed forests through research, technology transfer, and service activities. The goals are to provide the information needed by forest managers to guide responsible stewardship of fish and wildlife habitat resources consistent with land management objectives, and by policy makers to establish and evaluate informed forest policy and regulations. Below is a list of concept research project submissions by OSU researchers and collaborators that could occur on the ESRF.

- How do riparian forest gaps affect macroinvertebrates and fish diet in headwater streams? –Dana Warren
- Development of a UAV based method of assessing the effectiveness of riparian areas in regulating stream temperature- Bogdan Strimbu, Kevin Bladon
- Balancing values in forested landscapes: Prioritizing distributions of beaver dams in riparian systems- Jimmy Taylor, Jason Dunham, Brenda McComb, Vanessa Petro, John Stevenson
- Choosing retention trees for cavity nesting wildlife- David Shaw, Jared LeBoldus, Joan Hagar, Francisca Belart
- The impact of fire and management actions on demographic rates of a forest health indicator group- James W. Rivers, Jake Verschuyl
- Aggregated early seral habitat in intensively managed plantations – do songbirds notice? - Klaus J. Puettmann, Matthew Betts
- Development of molecular monitoring tools for enhanced management of high priority species- Taal Levi, Brian Sidlauskas, Jim Rivers, Rich Cronn, Brooke Penaluna

- Biodiversity in natural and managed early seral forests of Southern Oregon - Meg Krawchuk, Matthew Betts, James Rivers, A.J. Kroll, Jake Verschuyl
- Assessing pollinator response to forest management: Method development that will determine the soil and ecological factors controlling the distribution of ground-nesting bee nests- Jeff Hatten, Jim Rivers, Ben Leshchinsky, John Bailey, Rebecca Lybrand, Chris Dunn
- Purple martins as indicators of high quality early seral forest habitat - Joan Hagar, Taal Levi
- Impacts of cable-assisted steep slope harvesting on soil and water resources- Woodam Chung, Kevin Bladon, Jeff Hatten, Ben Leshchinsky, and John Sessions
- Early seral habitat longevity in production forests in the Oregon Coast Range - Matt Betts, AJ Kroll
- Effect of tethered assist harvesters on water quality- Francisca Belart
- How does contemporary forestry influence aquatic food webs in headwater streams? – Ivan Arismendi, Dana Warren
- Development of molecular monitoring tools for enhanced management of high priority species – Taal Levi, Jim Rivers
- Reducing sediment discharge from forest roads using alternate surfacing materials – Kevin Lyons
- Assessing stump use by small mammals and pollinators in young and mature Douglas-fir stands – Matthew Powers, Joan Hagar
- Assessing the response of aquatic biota to alternative riparian management practices – Dana Warren, Ashley Coble
- Quantifying postfire salvage woodpecker habitat with 3D remote sensing – Michael Wing
- Black-Backed Woodpecker vital rates in unburned and burned forest within a fire-prone landscape – Jim Rivers, Jake Verschuyl
- Assessing pollinator response to natural and anthropogenic disturbances in mixed-conifer forests – Jim Rivers, Jim Cane
- Revisiting the CFIRP: Assessing long-term ecological value and characteristics of snags created for wildlife – Jim Rivers, Joan Hagar
- Assessing early seral songbird species' demographic response to intensive forest management – Matt Betts, Jim Rivers.

EXAMPLES OF NEAR-, MID-, AND LONG-TERM STUDIES

The list below represents a broad and in-depth look at the potential for research using our proposed research design. The time dimension of these projects spans one season to centuries with projects that could be classified as near-term (0-10 years), mid-term (20-60 years) and long-term (70+ years). This list demonstrates that the ESRF can provide a base for essential forest research.

Near-term

- Structured tests for tethered harvesting and grapple yarding on steep slopes (no one on the ground).
- Structured tests comparing short and longwood harvesting systems (stump to mill).
- Testing rock replacement strategies for forest roads.
- Testing rock substitutes for forest roads.
- Improving logistics for tree planting on steep ground.
- Improving pole recovery from forest stands.
- Testing non-mechanical methods of PCT.
- Optimizing thinning decisions in real-time.
- Monitoring 2nd generation genetically improved stock.
- Testing all electric trucks on steep forest roads.
- Monitoring regeneration under alternative leave tree configuration for extensive.
- Monitoring growth under extensive and intensive systems.
- Monitoring biodiversity and individual species under extensive, intensive and reserve systems.
- Monitoring soil productivity and function under extensive, intensive and reserve systems.

Mid-term

- Monitoring regeneration under alternative leave tree configuration for extensive.
- Monitoring growth under extensive and intensive systems.
- Monitoring biodiversity under extensive, intensive and reserve systems.
- Monitoring ecosystem carbon under extensive, intensive and reserve systems.
- Monitoring micronutrient needs for forest stands and micronutrient stocks in soils.
- Structured fertilization trials to accelerate growth in intensive and extensive systems.
- Testing 3rd/4th/5th generation genetically improved stock.
- Testing remote-controlled harvesting and transport equipment.
- Testing alternative harvesting systems that minimize soil disturbance.
- Monitoring human use of recreational trails and public perceptions.
- Assessment of integration of forest research and management activities with public use and perceptions.

Long-term

- Monitoring regeneration under alternative leave tree configuration for extensive.
- Monitoring growth under extensive, intensive and reserve systems.
- Monitoring biodiversity under extensive, intensive and reserve systems.
- Monitoring soil productivity under extensive, intensive and reserve systems
- Monitoring ecosystem carbon under extensive, intensive and reserve systems.
- Monitoring human well-being as influenced by recreational opportunities.

APPENDIX 3

Example Research Projects

Below are a few example research programs that could exist within the Triad research design. Descriptions of projects were drafted by members of the OSU Exploratory Committee and OSU College of Forestry faculty.

1. **Outdoor Recreation Research at the Elliott State Research Forest**
   Ashley D'Antonio, Oregon State University, College of Forestry, Dept. of Forest Ecosystems and Society

2. **Aquatic and Riparian Forest Research at the Elliott State Research Forest**
   Dana Warren, Oregon State University, College of Forestry, Dept. of Forest Ecosystems and Society
   Gordon Reeves, US Forest Service, Pacific Northwest Research Station

3. **Research on Hydrology, Geomorphology and Geologic Hazards at the Elliott State Research Forest**
   Ben Leshchinsky, Oregon State University, College of Forestry, Dept. of Forest Engineering, Resources and Management

4. **Marbled Murrelet Research at the Elliott State Research Forest**
   Matt Betts, Oregon State University, College of Forestry, Dept. of Forest Ecosystems and Society
   Jim Rivers, Oregon State University, College of Forestry, Dept. of Forest Engineering, Resources and Management

OUTDOOR RECREATION RESEARCH AT THE ELLIOTT STATE RESEARCH FOREST

Ashley D'Antonio
Oregon State University, College of Forestry, Dept. of Forest Ecosystems & Society

NOTE: The specifics of these questions and methodologies will depend on: 1) how outdoor recreation is ultimately managed on the ESRF, and 2) whether additional recreation-related facilities are provided beyond what currently exists.

Despite this, there are few recreation ecology or recreation social science studies that occur at large spatial scales, across long temporal scales, and at low use levels. The ESRF, regardless of how recreation will be managed, provides the perfect setting to examine these recreation-related research gaps in spatial and temporal scales.

RESEARCH OBJECTIVE

Develop monitoring approaches for measuring low density recreation use across large landscapes at longer temporal scales.

Relevancy

Outdoor recreation researchers have well-established approaches for monitoring the levels and extent of recreation use in heavily used areas at relatively small spatial scales. However, it is challenging to efficiently, both in terms of cost and labor, and effectively monitor low levels of recreation use. It can also be incredibly challenging to measure specifics of behavior, such as density and patterns of recreation use, when use is not only low but highly dispersed/diffuse across a large area. Methodological developments related to how to measure and monitor recreation use at large landscapes and across longer temporal scales will provide the baseline data needed for future outdoor recreation-related studies on the ESRF. Additionally, creative solutions to detailed, long-term recreation monitoring across large spatial scales are relevant to protected areas in both the U.S. and internationally.

RESEARCH QUESTION

How are the experiences, values, and perceptions of outdoor recreationists influenced by landscape attributes (including tree density, viewshed, Triad design treatments, etc.)?

Relevancy

Many protected areas provide outdoor recreation opportunities while also managing for multiple values (ex: U.S. Forest Service lands), yet few studies have explored how silviculture treatments impact the experience of outdoor recreationists. The Triad design provides a mosaic of landscape features that outdoor recreationists can experience within a single managed landscape. Thus, the ESRF provides the ideal setting to understand how recreational visitors' experiences and perceptions vary, if at all, with different treatments. Additionally, many recreation-related studies are short term. The long-term nature of research at the ESRF provides the opportunity to explore how outdoor recreationists' perceptions of treatments may change over time. Such studies could inform how to better manage landscapes to provide quality outdoor recreation experiences while also managing for other values and ecosystem services.

RESEARCH QUESTION

How do low levels of recreation use impact various components (vegetation, water quality, wildlife, etc.) of the ESRF ecosystem?

NOTE: The specifics of this question can be refined once a recreation management plan is in place, and we have a better understanding of what types of ecosystem components recreationists will experience and interact with and where this will occur in space and time. The above question could also explore the impacts of specific activity types such as motorized vs. non-motorized recreation and mechanized vs. non-mechanized recreation.

Relevancy

In the recreation ecology literature, we assume that initial use into an area and lower visitor use levels cause proportionally more resource impact compared to higher use levels at the same site/on the same resource. But this relationship has only been thoroughly empirically tested in vegetation. All this work has been done at small spatial scales using plot-style experimental designs borrowed from agriculture. Despite these obvious limitations, managers and some recreation researchers apply this generalized relationship between use and impact to many other ecological components of systems (wildlife, water, etc.). This relationship drives many outdoor recreation-related management decisions. Part of the lack of empirical studies around the impacts of low levels of recreation use on ecological systems is because most recreation-related research (in recent years especially) has focused on heavily used sites. The ESRF provides an excellent opportunity to better understand the impacts of low use levels on ecosystems and to do this in a long-term capacity. Such studies would go a long way in contributing to the basic research and understanding of the impacts of outdoor recreation on ecosystems.

METHODOLOGIES

Outdoor recreation-related studies are often inherently interdisciplinary– therefore, a variety of methods will be employed to understand and study outdoor recreation on the ESRF. These methodological approaches could include, but are not limited to: visitor use estimation techniques such as trail counters and vehicle counters, qualitative interviews, qualitative surveys/questionnaires, observational studies of visitor behavior, recreation ecology studies focused on mapping and quantifying the level and extent of any recreation-related ecological impacts to vegetation and/or wildlife.

AQUATIC AND RIPARIAN FOREST RESEARCH AT THE ELLIOTT STATE RESEARCH FOREST

Dana Warren, Oregon State University, College of Forestry, Dept. of Forest Ecosystems & Society

Gordon Reeves, US Forest Service, Pacific Northwest Research Station, Corvallis, OR

Forests and fish are ecologically, economically and culturally important resources in Oregon. Unfortunately, these two iconic natural resources for our state are often placed at odds with each other. The extraction of forest resources has been tied to negative impacts on stream fish and the regulations applied to forest management designed to protect fish impacts the capacity of landowners to utilize all of their forest resources. The most obvious place where this conflict between forestry and fisheries arises is in the designation of streamside (riparian) buffers. All parties agree that buffers are necessary, however, there is a great deal of debate around what those buffers should look like, and how much flexibility there should be in laying out or managing in a riparian buffer area. Further, recognizing that historic forest management actions (e.g cutting to the stream edge, wood removal and splash-damming) did negatively impact streams, there is also currently considerable effort and interest in stream restoration. However, there is debate in this field about where restorations should be focused and how extensively restoration actions need to be applied. Below, we outline three focal policy-relevant research questions about stream/riparian management and restoration that we would address working at the Elliot.

RESEARCH QUESTION

How does the size & vegetative composition of a Riparian Management Area (RMA) interact with stream size to affect key aquatic characteristics and processes such as water temperature & aquatic productivity (invertebrates & fish)?

Establishing and evaluating alternative RMA configurations would allow us to test the assumption that setting the size of the RMAs based on wood recruitment potential creates buffer areas that provide other ecological functions of riparian ecosystems such as, litter input, controls on temperature, and channel stability.

Relevancy

We will test how different process change with different buffer widths across 3 streams sizes. This will allow us to test a key conceptual framework around buffers as illustrated in the "FEMAT Curves".

RESEARCH QUESTION

How do effects of resource patches created by canopy gaps and/or wood addition "scale-up" along a stream network?

While we generally see localized increases in biota and nutrient cycling in the areas immediately around wood or immediately beneath gaps, few studies have addressed the spatial extent of these effects. Therefore, we do not know how many gaps or how much wood might be needed generate a response at the whole stream scale. We propose an experimental gap and wood addition to evaluate a series of alternative hypotheses about how the system will respond to increases in gaps and/or wood (Figure 3a).

Relevancy

Understanding how the larger system responds to increases in the density of these resource patches will provide information about how extensive our restoration efforts could or should be. And, in implementing these efforts, we will explicitly test the effect of alternative restoration actions.

RESEARCH QUESTION

Are stream networks in managed landscapes "better-off" (i.e. maintain or increase biota production or ecosystem processes) if we put more buffer protections in the headwaters or if we focus protections along mainstem streams?

Streams are connected networks. The contributions from fishless headwaters can be critical in the mainstem systems, but currently they receive much less protection. If we consider a larger network system with approximately the same amount of Riparian Conservation Area (RCA), what would be the impact of allowing smaller buffers on larger streams while increasing buffers in fishless headwaters? The Elliott State Forest has over 2000 miles of stream (including both fish-bearing and fishless streams). The size and extent of the Elliot will allow us to test alternative buffer configurations and their influence on aquatic ecosystems and aquatic biota, not only at the scale of a single reach or individual stream, but across different sub-catchments, allowing us to explore processes at the stream network scale (Figure 3b).

Figure 3a.

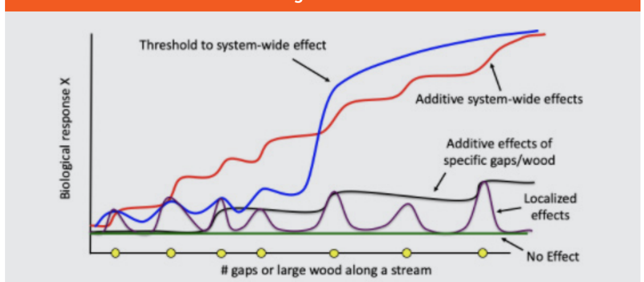
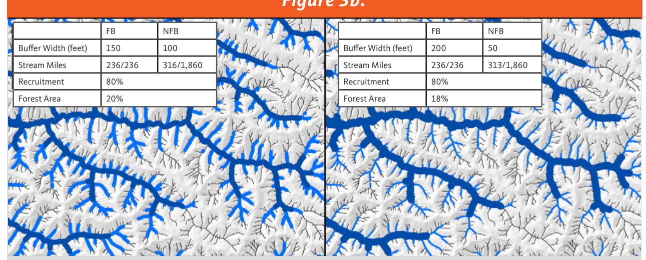


Figure 3a. *Alternative hypothesis for how biological processes or biota in streams will respond to increasing frequency of large wood or canopy gaps along a stream. Each dot on the x-axis represents a hypothetical gap or piece of large wood (or both since they often occur together).*

Figure 3b.



	FB	NFB
Buffer Width (feet)	150	100
Stream Miles	236/236	316/1,860
Recruitment	80%	
Forest Area	20%	

	FB	NFB
Buffer Width (feet)	200	50
Stream Miles	236/236	313/1,860
Recruitment	80%	
Forest Area	18%	

Figure 3b. *Alternative Riparian Management Area (RMA) configurations at the network scale for a sub-section of the Elliott Research Forest. FB refers to fish-bearing streams and NFB refers to non-fish-bearing streams).*

RESEARCH ON HYDROLOGY, GEOMORPHOLOGY AND GEOLOGIC HAZARDS AT THE ELLIOTT STATE RESEARCH FOREST

Ben Leshchinsky
Oregon State University, College of Forestry, Dept. of Forest Engineering, Resources and Management

Some very brief potential research questions relating to water and landslide hazards that would be served well through a Triad research design in the Elliott State Forest are briefly described below.

RESEARCH QUESTION

In context of landslide magnitudes and frequencies, what are the landsliding rates associated with current practices (conservation or harvest)? Where do these conditions fit in context of the equilibrium of ecosystems (terrestrial or aquatic) during typical conditions versus extreme events?

Hypothesis

Conventional forest management practices will result in more frequent shallow landslides during typical conditions, but less so during extreme events. The magnitude of shallow landslides/debris flows will not be sensitive to treatment, but will be sensitive to the extreme event. Extreme events will account for a majority of mass wasting observed in both treatments.

The size and geologic consistency of the ESRF size presents a unique opportunity to understand how forested terrain affects the equilibrium of a landscape, particularly in terms of how soil moves downslope in both short- and long-terms. There is significant uncertainty regarding the window in which timber harvest makes slopes susceptible to failure. This is a function of climate, vegetation, lithology, topography, and most importantly, time. Landslides are often driven by extreme events – heavy rains, earthquakes, wildfires – which often limit our true understanding of "baseline" conditions (i.e. rates of landsliding normalized to disturbance). A previous lack of infrastructure dedicated towards long-term monitoring of landslide activity at timescales of relevance have precluded our understanding of the relative impact of current practices from a perspective of typical winter conditions or that of extreme events. This part of the Coast Range has been subject to significant disturbances before (earthquakes, wildfires, intense storms) and still maintained an equilibrium in terms of landscape and ecology – what role do we play in the short- and long-term and can we (or are we already) managing this role? What about in the future or after a great change?

Relevancy

By establishing the infrastructure for long-term monitoring of unstable hillslopes in the Elliott, we would be better-suited to characterize baseline conditions in terms of sediment, mass wasting, etc., and likewise assess the relevance of frequent, smaller changes (e.g. management activities) with context of baseline conditions.

RESEARCH QUESTION

What is the best landscape-level design (Extensive, Reserves with Intensive, Triad-I, Triad-E) that minimizes deleterious landslide/debris flow occurrence? Activation or reactivation of deep-seated failures?

Hypothesis

The gradient of treatments will demonstrate that intensive treatments will increase the frequency of small landslides, but will have a more muted effect on larger landslides (e.g. earthflows, landslide complexes). The treatment threshold and timing at which management results in altered, weakened conditions for slope failures will vary with landslide size. That is, larger failures will be less sensitive to treatment, but may see a changed response over a longer period than shallow failures. Shallow failures will be more sensitive to treatment (e.g. threshold at extensive), but will see a short window in which weakened conditions exist.

Not all landslides are created equal. Deep-seated failures are dictated by major hydrologic disturbances and are of a magnitude where the reinforcing role of root systems in the soil mantle is questionable. However, the impact of lost evapotranspiration, reduced canopy cover, and amplified infiltration and snowmelt that stems from management practices may be critical to the activity of these large slope failures. If the influence of infiltration is key to the behavior of these slow-moving failures, then at what gradient off treatments can canopy interception and evapotranspiration be preserved to prevent slope movements? Do treatments matter for the activity of these types of failures? Shallow-seated failures that are typically associated with debris flows are largely governed by rapid changes in superficial hydrologic conditions and the loss of stabilizing root systems. Can we perform rapid replanting after intensive treatments or use prolonged extensive treatments to attenuate heightened landsliding rates?

Relevancy

The aforementioned changes have rarely been observed beyond a single hillslope or catchment scale. For example, how will earthflows/ landslide complexes (of which there are several in the Elliott) or shallow failures respond to a gradient of changes in land use or will they largely behave as they always have regardless of management activities? The only way to determine this is through monitoring and understanding the hydrological and geological changes that the suite of treatments is associated with (from conservation to intensive), both during typical winters and significant storm events.

RESEARCH QUESTION

How will the gradient of treatments influence the timing and transport of water, both through runoff and subsurface flow? How will these conditions evolve with climate change?

Hypothesis

The hydrologic, topographic and climatic conditions will strongly affect the magnitude and seasonality of stream flows, but treatments within catchments will be a second-order control on water movement.

The movement of water is a phenomenon that becomes increasingly complex as the scale of observation increases. At the scale of the ESRF, hydrologic conditions are already complicated despite the relatively uniform geology and topography. Current management practices may result in increased surface runoff, reduced water storage, and potentially altered summer flows. These conditions are subject to climatic variability, and highlight the importance of enabling forest management to evolve with a warming climate. The gradient of treatments and long-term monitoring of groundwater and stream flows will enable an understanding of whether a threshold exists between conservation and intensive management in context of water storage, flows and stream temperatures.

Relevancy

Determining such a threshold enables better forest management by (1) better planning forest management to meet a variety of ecosystem services that are dependent on cool, clean water, (2) highlighting the short- and long-term importance of a variety of treatments (how long and by how much is water storage affected?), and (3) providing a quantitative basis for future forest management for potentially hotter, drier summers and variably wet winters (i.e. how can we adapt?).

METHODS

Answering these questions will require extensive monitoring, both remotely and in-situ. Landslide activity will be monitored remotely through (1) repeat collection of aerial lidar, (2) high-resolution satellite imagery, and (3) InSAR change analyses. Soil moisture will be monitored remotely through (1) SMAP time-series and (2) NDVI. Landslide activity (i.e. movements) will be monitored in-situ through an extensive series of (1) extensometers, (2) in-place GNSS units, (3) inclinometers, and (4) time-lapse stereo cameras. Water will be monitored using an extensive series of (1) tensiometers, (2) piezometers, and (3) stream gauges. This only presents a small subset of potential tried-and-true techniques for monitoring that will certainly be enhanced with new remote and in-situ technologies being developed.

MARBLED MURRELET RESEARCH AT THE ELLIOTT STATE RESEARCH FOREST

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Below is a very short summary of potential research projects that could occur at the Elliott State Forest in the context of the Triad platform.

RESEARCH QUESTION

What is the best landscape-level design (Reserve with Intensive, Triad-I, Triad-E, Extensive) to maximize murrelet density and reproductive output?

Hypotheses

If marbled murrelet density and reproductive success respond poorly to thinning and other silviculture that disturbs mature forest canopy, the intensive/reserve treatment should be best. This is because timber production is concentrated in non-murrelet habitat (stands <50) and reserves will retain undisturbed habitat. Alternatively, if marbled murrelets are resilient to thinning effects over time, the extensive treatment should maximize murrelet densities because a greater proportion of the landscape will be covered in mature forest than in the Intensive treatment.

Relevancy

Addresses question of whether it is better to concentrate harvesting effects in a small area, or spread out harvesting effects using an ecological silviculture approach.

RESEARCH QUESTION

To what extent do ocean conditions drive marbled murrelet occupancy and reproductive success?

Hypothesis

Marbled murrelet occupancy will be strongly driven by ocean conditions, with warm ocean conditions that reduce food availability resulting in low breeding prevalence (see Betts et al. in press, Conservation Letters). Although we see this signal in the existing long-term timber harvest occupancy data for Oregon, it will be important to replicate this result using long-term data that establishes 'true' occupancy, and is a continuous, site-scale dataset (rather than cessation of monitoring once occupancy is established as in the current effort).

Relevancy

Will inform how often occupancy surveys should be conducted to determine proposed timber harvests, and will help parameterize murrelet population models under differing climate regimes.

RESEARCH QUESTION

Can marbled murrelet habitat be restored through silviculture, artificial platforms, and conspecific attraction playback?

We have already succeeded at attracting marbled murrelets to existing, previously unoccupied habitat using conspecific attraction playback (Valente et al. in review, Auk). We predict that if nesting platforms can either be created via silviculture (e.g., epicormic branching) or artificial means (installment of constructed platforms), we will be able to attract new breeders to these stands. This will potentially increase the effective population size (breeding population) of murrelets, thereby enhancing population viability.

Relevancy

Will inform potential murrelet restoration efforts for land-bases that have objectives less focused on timber harvest and may speed development of suitable murrelet habitat relative to traditional methods.

RESEARCH QUESTION

Is murrelet nesting success and density influenced by edge (due to clearcutting and/or thinning) and, if so, at what scales?

Previous work indicates that predation risk might increase near 'hard' edges, however little is known about whether other forest management treatments (e.g., thinning, variable retention harvesting) influence murrelet density and reproduction. Although the methods implemented to address Question 1 will likely address this question as well, it would be ideal to establish an experimental study that collects pre-treatment data on murrelet abundance and reproduction, and then implements various silvicultural methods and examines the 'scale of effect' (distances over which edge exerts an influence on these response variables).

Relevancy

The USFS and BLM frequently implement thinning treatments near murrelet habitat, so this research will inform the minimum size of no-harvest buffers in occupied areas.

RESEARCH QUESTION

Can deep learning methods be used to monitor murrelets from sound recordings, and to what extent can audio information be used to infer nest success?

Ultimately, our objective is to implement a long-term population monitoring program for marbled murrelets. To date, population monitoring (that informs ESA listing) is based on every other year at- sea surveys, that have been criticized on the grounds that they do not provide accurate information on population abundance. We expect that information from audio-recordings (e.g., number of calls, timing of calls over the day and season) may provide information not only on occupancy, but potentially on breeding success

Relevancy

If successful, such methods could lead to a long-term auto-ID monitoring system across the PNW (similar to the one implemented by USFS- PNW for spotted owls) and would help inform listing decisions.

BRIEF METHODS

We will collect murrelet data using multiple methods: (1) Nests will be found via ground- based surveys, then monitored using remote video cameras to determine nest success and causes of nest failure, (2) Audio monitoring sites will be established in a systematic design across all potential habitat at the Elliott, (3) Ground-based murrelet surveys will occur in a subset of these same habitats to enable us to relate (a) nesting and occupancy, (b) nesting and audio-recordings, (c) occupancy and audio-recordings.

APPENDIX 4

Draft Research Treatment Allocation Process

Outlines the processes used to determine the initial spatial extent and location of treatments in the proposed Triad research design.

ELLIOTT STATE FOREST AGE PATTERN

The Elliott State Forest has a bi-modal age class distribution (Figure 4a.) that can be explained by three general scenarios. Note these may not represent the stand history of every single stand, but the primary activities in the recent past.

1 Forests that regenerated naturally following fire, wind events, or landslides that were regenerated following clearcut harvests starting in 1955 (aside from one early harvest in 1945) to generate revenue for the Common School Fund. Some of them may have had a pre-commercial or commercial thinning. Regeneration methods varied over this period, starting with a reliance on natural regeneration, followed by aerial seeding, and hand planting starting around 1970. These practices resulted in approximately 41,000 acres of forest, consisting primarily of Douglas-fir with some alder, western hemlock, and western redcedar. Understory diversity is limited. These stands are 65 years or younger as of 2020.

2 Forests that regenerated naturally following fire, wind events, or landslides and had about 30% of the tree volume removed when the forests were approximately 75 to 125 years to improve the growth of remaining trees and generate revenue. These harvests occurred primarily between 1957 and 1977. Several of these forest stands have subsequently been clearcut and converted to Douglas-fir plantations, but we suspect, based on some old records, that somewhere between 5,000 to 10,000 acres may still exist. These stands are primarily 100 to 160 years in 2020.

3 Forests that regenerated naturally following fire, wind events, or landslides. The primary stand-replacing fire occurred in 1868, but other more localized fires and other disturbances may have happened. There are a little over 40,000 acres of naturally regenerated forests, but it is uncertain how many acres were partially logged (treatment outlined in scenario 2) due to spotty historical records. However, if one assumes that approximately 5-10,000 acres of these older forests were partially harvested, then that leaves 30,000-35,000 acres of unmanaged forests. The age range of these forests is from 80 to 230 years, with 71% of this forest type between 130 to 160 years.

Figure 4a. Elliott Forest Age Pattern

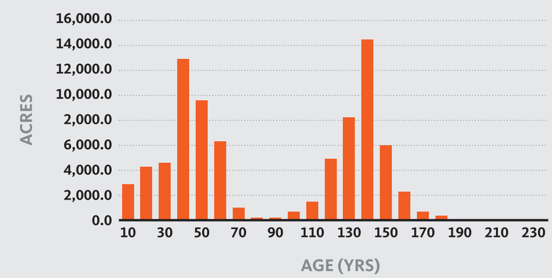

Figure 4a. *Age distribution on the Elliott State Forest by age class as of 2020. Under 65 years of age are forests that regenerated following a clearcut. Stands over 65 years of age regenerated naturally primarily from wildfire.*

4 Snags from the 1868 fire and other disturbances were systematically felled and sometimes removed from the Elliott State Forest to reduce fire danger. The activities occurred in areas that may not have been logged otherwise. Therefore, even the unlogged forests may not be an accurate baseline for the level of standing and down deadwood. We do not have records of the extent of this practice, but it warrants consideration.

INITIAL METHODS FOR ASSIGNING SUBWATERSHEDS AND THEN STANDS TO RESEARCH TREATMENTS

Obtain the most recent set of information with accurate stand locations and ages. This includes working with indigenous communities to ensure appropriate care is taken to avoid culturally significant areas and spiritual places. Identify recent management practices such as locating the approximately 10,000 acres of the 1868 burned areas that were partially harvested between 1957 to 1977.

1 **Look for bias in the placement of historic management units on the forest, based on elevation, aspect, and slope percentage.** There are several well-known scientific reasons for random allocation of treatments. Randomization aims to avoid true bias caused by confounding factors. For instance, it might not be by chance that old forest remains where it does (e.g., steep slopes, low productivity forest); harvests may have occurred in the most productive and easily accessible stands. Ignoring such factors may lead to misinterpretation by erroneously associating results with the Triad treatments. However, we did not find evidence that stand-scale treatments were biased as a function of such biophysical factors (see Figure 9a in Appendix 9). The results of our analysis are available upon request.

2 Forest regeneration harvesting began in 1955 about 65 years before the 2020 adjusted ages, so we consider anything below 65 years as managed for this analysis. We assigned treatments non-randomly using the following criteria: (1) ensure that there is no detectable bias among treatments in biophysical factors (i.e., elevation, aspect, site productivity, slope and aspect).

3 **Assign subwatersheds and stands within watersheds to the treatments by optimizing the following:**

A Prohibit any harvesting in stands that predate the 1868 fire. There are approximately 400 acres or 0.5% that remain from the nearly 5,000 acres of forests that predated the 1868 fire, when the Elliott State Forest was established. They are the remaining link to the past, are culturally and socially significant, and serve as an essential control to scientific study.

B Focus harvests in stands that have had prior clear-cut harvests and regenerated with a focus on wood production (primarily less than 65 years old in 2020 since harvests started in approx. 1955).

C Limit harvesting of stands greater than 65 years in 2020 to extensive treatments. No forests older than 65 years in 2020 will be assigned to the intensive treatment. We will include only forests that were clear-cut, starting in approximately 1955, in the intensive treatments going forward.

D Extensive harvests that are in stands greater than 65 years will be preferentially done in stands closest to 65 years in 2020, and the older stands (90-152 years), once identified, that have had a prior thinning. Thereby preserving the oldest unlogged forests in reserves to the greatest extent possible.

E Any stand that we determine predates the 1868 fire will be placed in reserve. In the case of Extensive subwatersheds (where there are no reserves) we will place in a special category called Extensive Reserve. Based on our current inventory, we have identified 164 acres in this category.

3 **Review and adjust assignments and this initial set of criteria based on:**

A continuing to work with indigenous communities to ensure that appropriate care is taken to avoid culturally significant areas and spiritual places;

B updated inventory, landscape analysis including the aquatic component and the ecological importance of headwater (non-fish bearing streams); and,

C other relevant information that is unavailable today.

4 The process is intended to be iterative and adaptive and will take place in the context of the decision-making structure and protocols established for managing the forest over time.

Following these criteria, the below figures and tables illustrate the age distribution across treatment types in the August 2020 iteration of the stand level research treatment allocations (Figure 4b-d, Table 4a and 4b).

Table 4a. Stand-level Allocations by Age

Stand Age	STAND LEVEL ALLOCATIONS (ACRES)					ESRF Total
	MRW Intensive	MRW Extensive	MRW Reserve	MRW RCA	CRW (incl RCA)	
<= 65 yrs	14,334	10,047	1,905	2,852	12,528	41,666
> 65	0	3,366	12,190	3,686	21,612	40,854
Total	**14,334**	**13,413**	**14,096**	**6,538**	**34,140**	**82,520**

Table 4a. *Number of acres per treatment by age class on the proposed ESRF based on the August 2020 draft allocation and November 2020 Riparian Conservation Area (RCA) designations. We assume that forests 65 or younger are forests that regenerated following clearcuts and those over 65 years regenerated from natural disturbance, primarily wildfire.*

Table 4b. Stand-level Allocations by Age

Stand Age	STAND LEVEL ALLOCATIONS (PERCENT OF TOTAL FOREST AREA)					ESRF Total
	MRW Intensive	MRW Extensive	MRW Reserve	MRW RCA	CRW (inclu RCA)	
<= 65 yrs	17.4%	12.2%	2.3%	3.5%	15.2%	50.5%
> 65	0.0%	4.1%	14.8%	4.5%	26.2%	49.5%
Total	**17.4%**	**16.3%**	**17.1%**	**7.9%**	**41.4%**	**100.0%**

Table 4b. *Percent of acres per treatment by age class on the proposed ESRF based on the August 2020 draft allocation and November 2020 Riparian Conservation Area (RCA) designations.*

Figure 4b. Stand-level Intensive

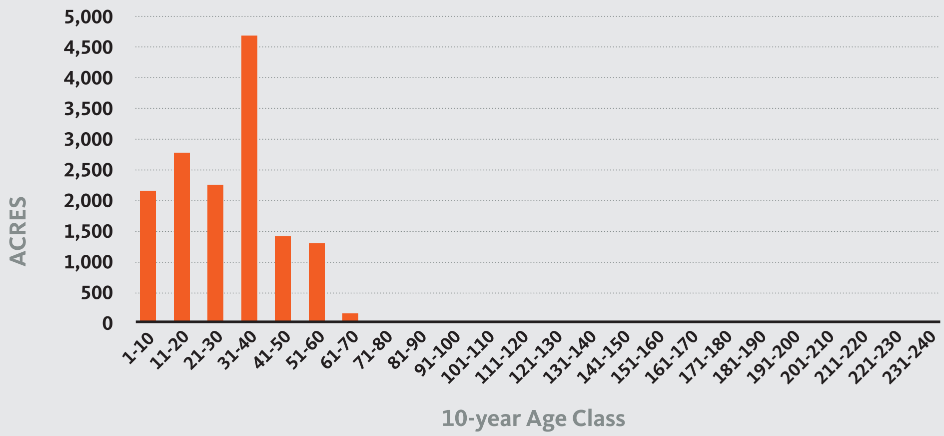

Figure 4b. *Proposed acres of forest in intensive treatment in the MRW by age class as of 2020. Allocation based on August 2020 draft allocation. We assume that stands under 65 years are forests that regenerated after clearcuts and those over 65 years regenerated from natural disturbance, primarily from wildfire.*

Figure 4c. Stand-level Triad Reserve

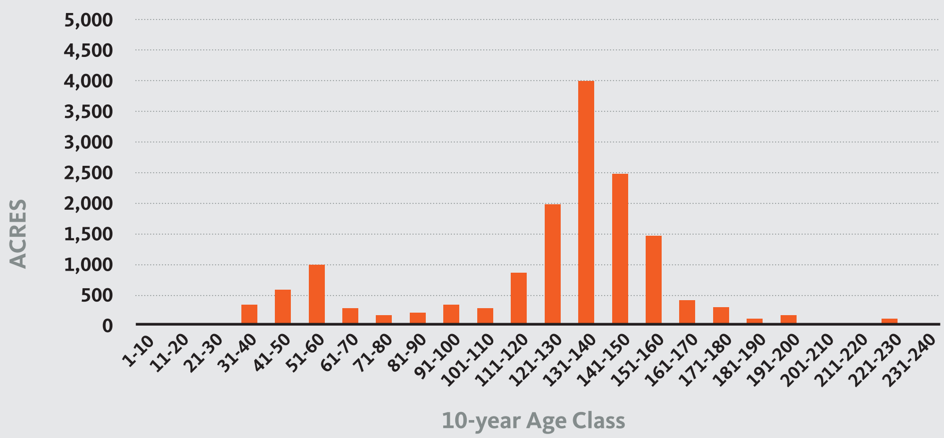

Figure 4c. *Proposed acres of forest in reserve treatment in the MRW by age class as of 2020. Allocation based on August 2020 draft allocation. We assume that stands under 65 years are forests that regenerated after clearcuts and those over 65 years regenerated from natural disturbance, primarily from wildfire.*

Figure 4d. Stand-level Extensive

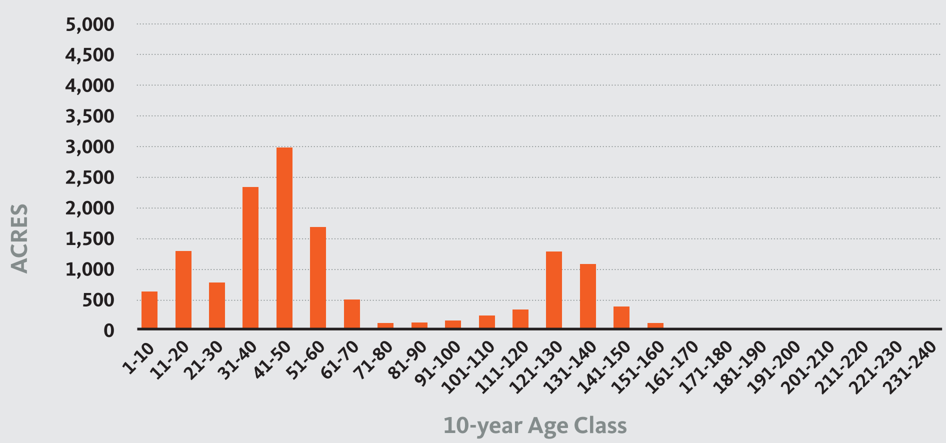

Figure 4d. *Proposed acres of forest in extensive treatment in the MRW by age class as of 2020. Allocation based on August 2020 draft allocation. We assume that stands under 65 years are forests that regenerated after clearcuts and those over 65 years regenerated from natural disturbance, primarily from wildfire.*

APPENDIX 5

Descriptions of Research Treatments (intensive, extensive, and reserve)

This appendix contains proposed descriptions of the scope and attributes of what is intended to constitute intensive, extensive, and reserve research treatments in stands on an ESRF within the context of the research principles, design, and attributes described above. We intend to use it as the starting point for designing the implementation of research treatments and experimentation that will occur within the context of the forest's future decision-making structure in support of research. There will be monitoring protocols established in all cases, including remote sensing, emerging instrumentation and technology, and historical records to determine if we are meeting key benchmarks before moving forward.

Figure 5a. Four largest wilderness areas in the Oregon Coast as compared to the Conservation Research Watershed

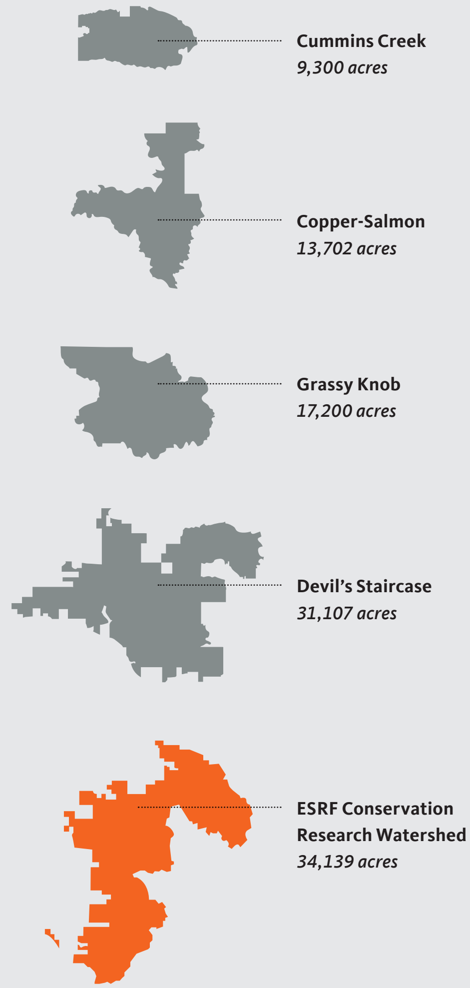

Figure 5a. *Size of the four largest wilderness areas in the Oregon Coast as compared to the Conservation Research Watershed. The CRW and Devil's Staircase Wilderness Area are adjacent and represent a 65,246 acre reserve, the largest in the Oregon Coast Range.*

RESEARCH TREATMENTS

RESERVES IN THE MANAGEMENT RESEARCH WATERSHEDS (MRW) AND CONSERVATION RESEARCH WATERSHEDS (CRW):

1 Committed to maintaining the current proposed CRW as one of the largest contiguous reserves in the southern Coast Range (See Figures 5a and 5b).

2 No logging in forests greater than 65 years as of 2020.

3 Assess plantations (forests 65 years and younger) in the CRW and MRW for conservation and restoration within the context of the surrounding landscape.

4 Design and implement an experiment to explore methods for increasing the likelihood of achieving old forest structure, increasing species diversity and creating complex early seral forests from dense single-species plantations. This experimenta will take advantage of recent findings from various studies that investigated the possibility of accelerating development of late-successional stand structures and compositions(Bauhus et al. 2009), including DEMO, DMS, YSTD, others (for a summary of studies, see (Monserud 2002; Poage and Anderson 2007). For examples of findings, e.g., (Puettmann et al. 2016). Depending on conditions, thinnings treatments could be composed of one or several of following treatments: variable density thinnings, including skips and gaps, creation of snags and downed wood, retain unique tree forms and structures, retain and/or encourage the variety of tree sizes and species, protecting desirable understory vegetation, planting in gaps or in the understory to encourage species diversity, or removal of invasive species.

5 Design and implement an experiment to explore methods for increasing the likelihood of achieving old forest structure, increasing species diversity and creating complex early seral forests from dense single-species plantations.

6 The research protocols will include treatments and controls and will be implemented over a range of forest ages up to 65 years as of 2020.

7 The timing of the treatments will depend upon the experimental design and stand age; however, anticipate

Figure 5b. Forest Reserves in the Oregon Coast Range

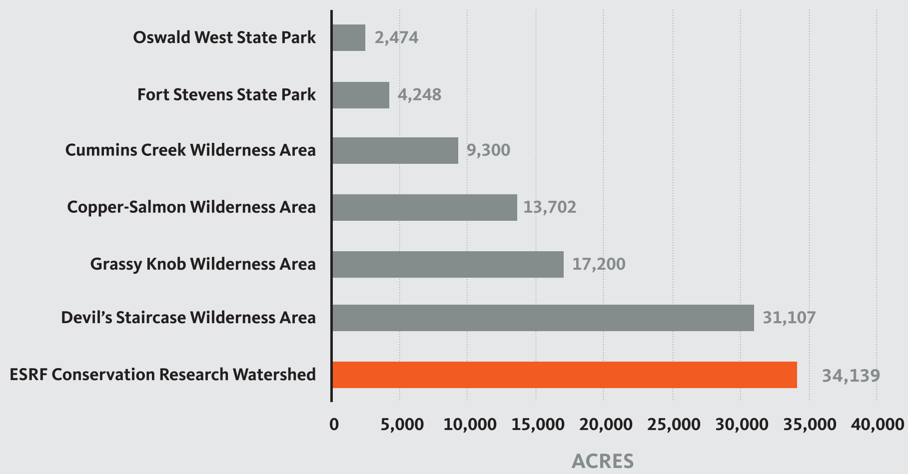

Figure 5b. *Number of acres of the largest state parks and wilderness areas in the Oregon Coast Range as compared to the proposed Conservation Research Watershed in an Elliott State Research Forest.*

the experimental treatments will complete in the CRW in approximately two decades. The MRW may take longer, given the stepwise implementation.

8 Following initial treatments, the only disturbances going forward will be natural and will not include logging.

9 Natural disturbances such as drought, disease, wind, and insects will occur without salvage.

10 Suppress fire, but will not salvage if mortality does occur.

11 Potentially treat riparian areas on a limited basis during thinning to reduce density and promote the development of older forest structure. No individual trees older than 65 years in 2020 will be harvested or felled.

Examples of research concepts and outcomes associated with reserve treatments:

- Emulate natural disturbances
- Incorporate tribal perspectives and traditions
- Vary the level of retention of the existing forest canopy in the plantations and riparian forests
- Vary distribution of retained trees in a dispersed or aggregated fashion in the plantations and riparian forests
- Apply treatments across the spectrum of forest ages up to age 65
- Natural thresholds of the size and quantity of standing dead and downed wood
- Carbon uptake and release with natural disturbance
- Climate impacts in unmanaged forests relative to actively managed forests
- Active management as compared and contrasted with natural disturbance processes

A more comprehensive list of potential research questions and opportunities that are compatible with our experimental approach on the ESRF can be found in Appendix 2.

INTENSIVE TREATMENTS IN THE MANAGEMENT RESEARCH WATERSHEDS

1 Even age management using clearcut harvesting techniques suitable for the terrain.

2 Follow all Oregon Forestry Protection Act rules except for self-selected, more stringent requirements in the ESRF riparian areas in headwalls and all streams.

3 Post-harvest application of site preparation and vegetation control practices to ensure seedling establishment and initial growth. This can include a variety of experimental methods to increase our knowledge about the role of vegetation control on seedling establishment and growth. This may consist of the aerial application of herbicides if in compliance with OFPA. Aerial spraying will be used only when necessary and other types of herbicide application are operationally impractical. Over a 60 year period, an intensively treated stand could potentially receive 1-2 applications of herbicide. We need to conduct research using broadly applicable practices so our work can extend beyond the borders of the ESRF. In addition, we are committed to transparency in our herbicide applications and monitoring of them. OSU will engage in monitoring water quality in areas where aerial spraying takes place. Should any evidence be found that herbicide applications in specific target areas are adversely affecting nearby aquatic areas, the practice will be changed in that area.

4 Animal control techniques will not involve the use of rodenticides.

5 Establish plantations at densities that ensure relatively quick canopy closure using species and seed sources best suited for future predicted climate conditions.

6 Maintain stand densities at levels that provide vigorous trees and maintain high wood production through thinning

operations. With commercial thinning typically occurring between 35-50 years.

7 Determine regeneration harvest and commercial thinning by growth patterns (mean annual increment), vulnerability to disturbances, and markets. With a minimum rotation age of approximately 60 years.

8 Based on context, treatments may vary in rotation length, type of site preparation, species planted, and other processes. Riparian buffers will be a minimum of 120 feet on fish bearing streams and 50ft on non-fish bearing streams. The specific size and configuration of the different RCA components will depend on the level of desired wood delivery potential.

9 As a baseline, all activities will comply with the Oregon Forest Practices Act, the federal Clean Water and Endangered Species Acts.

Examples of research concepts and outcomes that may be associated with intensive treatments:

- Resilience and resistance to minimizing tree loss to drought and diseases over decades
- Social values as represented by differences in perceptions and behaviors
- Economic and carbon analysis of increasing rotation length
- Market analysis and impacts of tree size
- Carbon fluxes and pools through time
- Logging technology and forest engineering
- Site preparation and seed sources
- Species and genotypes for climate resilience and resistance
- Clear-cut harvest impacts hydrological changes, erosion and mass wasting events
- Recreation use levels/patterns and perceptions over time
- Density management and wood yield over time
- Response of aquatic ecosystems
- Non-lethal strategies for animal control

A more comprehensive list of potential research questions and opportunities that are compatible with our experimental approach on the ESRF can be found in Appendix 2.

EXTENSIVE TREATMENTS IN THE MANAGEMENT RESEARCH WATERSHEDS

1 On average, extensive treatments will seek to produce harvest volumes that are approximately 50% of the fiber production of stands managed according to intensive experimental treatments. This means that some treatments with lower retention (20%) will have more than 50% relative yield, and those with high retention (80%) will have a less than 50% relative yield. The goal is to have the yield average 50% at the subwatershed level.

2 Extensive stand treatments are limited to stands that were established following the 1868 fire or regeneration harvests that have occurred primarily since the 1950's. If there are obvious discrete stands and individuals within younger stands that predate the 1868 fire, we make a commitment to not harvest these. However, aging large trees is not precise enough to specify an age to the year. Even with increment cores, determining tree age is not an exact science, especially when some of the oldest trees do not always "look" their age. We also recognize that due to safety issues in camp sites and logging operations and other unforeseen circumstances trees that predate the 1868 fire may need to be removed on rare occasions. However, we are committed to working with the stakeholders to achieve our commitment to the oldest forests and individual trees as part of further planning and project-level implementation of the research platform. The adaptive management approach calls for the development of a list of criteria or "trigger points" that would trigger changes in experimental protocols. Our intention is that members of the advisory board will be a part of developing these criteria or trigger points.

3 Retain the number of live trees needed to meet various experimental goals. The percent retained will range from 20-80% of pre-harvest density and should occur in a variety of spatial and age class patterns (including aggregated and dispersed) to encourage a wide range of conditions that align with the integration of objectives.

4 Size of the experimental units will represent the ecosystem's natural disturbance patterns, including the appropriate mix of clumps and open patches, snags, and down wood while recognizing operational constraints. This design will function as a test of pressing questions such as reduced fragmentation on biodiversity and other attributes such as harvest efficacy and safety.

5 Tree age will vary within a stand, with most having a minimum of two age or canopy position age classes. Return intervals for harvest will depend on monitoring growth and meeting the objectives for a range of conditions, including complex early seral to old growth forests.

6 Focus retention areas and prioritize retention preference based on the following:
   - A A landscape analysis that identifies what is limiting biodiversity today and into the future using a variety of metrics, including species richness, species at risk, genetic diversity, and landscape diversity).
   - B Prioritize retention of large, mature (complex canopy structures) trees (based on a combination of factors, including DBH, bole and bark characteristics, tree height, and crown and branching characteristics that are underrepresented.
   - C If the number of large standing dead and down trees are low relative to controls, experimentally test ways to increase their abundance.
   - D Incorporate designated marbled murrelet management areas and northern spotted owl habitat (not already

located in designated reserves) into the highest (80%) retention category to explicitly incorporate into an experimental protocol designed to quantify the impact of extensive treatments on species abundance. Selective tree harvests in murrelet occupied stands will be done for research purposes and will not reduce current tree relative density by more than 20%. We will survey for the presence of murrelets in all potential occupied habitat. See Appendix 11 for more detailed recommendations and analysis of occupied murrelet habitat.

6 Experimentally test if aggregating retention on unstable slopes is critical to providing attributes including mitigation of landslides, delivery of large wood to streams, habitat for owls, murrelets, and other terrestrial species, and corridors for movement within and among watersheds.

7 Limit and selectively use herbicides only where necessary to manage invasive species or as a last resort to promote tree regeneration.Targeted application of herbicides will be used in extensive treatments if regeneration is not successful. Use of fixed wing planes or helicopters will not be practiced due to the large number of retained trees.

8 Plant only where regeneration goals cannot be met otherwise.

9 In the landscape analysis, assess and monitor the spatial pattern of retention areas using a combination of factors; including, but not limited to: population dynamics of at-risk species, maximizing opportunity for biodiversity, aesthetics, promoting wildlife habitat favoring early seral conditions, retention of hardwood trees, wood production, harvest methods, and harvest unit size.

10 Riparian forests that emulate their critical roles in natural disturbance and are fully integrated with upland management, thereby meeting the goals outlined in the riparian management plan. These extensive forests will have different configurations of the riparian ecosystem that maintain critical ecological processes.

11 While the goal to enhance biodiversity may be the same in all cases, the extensive treatments will be adjusted because the initial conditions are highly variable. For example, the initial conditions as represented by age on the ESRF are highly variable; therefore, the experimental treatments will require flexibility to maintain relevance.

12 Considering these treatments at a landscape level will allow us to incorporate varied seral-stages into our research design thereby allowing us to fully attain biodiversity, habitat, and recreation objectives.

Examples of research concepts that may be associated with extensive treatments:

- Emulate and measure response of natural disturbance including reintroduction of complex early seral ecosystems that are being replaced by rapidly growing plantations.
- Tribal perspectives and traditions
- Level of retention of the existing forest canopy
- Distribution of retained trees in a dispersed or aggregated fashion
- Treatments across the spectrum of forest ages
- Thresholds of size and quantity of standing dead and downed wood
- Selective and no use of herbicides
- Tree and shrub regeneration
- Prescribed fire to generate pyro-diversity
- Riparian integration with upslope conditions
- Logging systems under varying levels of retention
- Economic thresholds and markets
- Monitoring objectives and protocols

A more comprehensive list of potential research questions and opportunities that are compatible with our experimental approach on the ESRF can be found in Appendix 2.

Examples of attributes that would not characterize an extensive treatment:

- Conversion of a forest from a diverse to a less-diverse condition by not retaining key existing legacies
- A selective harvest without accounting for whether the objective of regeneration has been accomplished so that the long-term desired characteristics of the stand are not sustained
- Establishing merchantable volume as the primary or dominant management objective
- Routine or pervasive use of herbicide
- No plan for or monitoring of desired forest, riparian or wildlife attributes
- No landscape level plan

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APPENDIX 6

Aquatic and Riparian Area Research Strategy

KEY ATTRIBUTES OF A RIPARIAN CONSERVATION STRATEGY

A Land Use Allocation and Arrangement

Land use allocation is a primary means by which aquatic and riparian values are protected within the proposed Elliott State Research Forest. The two broad land-use classes referred to throughout the proposal – the CRW and MRW – provide the foundation of the riparian and aquatic conservation strategy.

At 34,140 acres the CRW anchors the conservation strategy by establishing a contiguous reserve area managed for long term ecological functions supported by restored and undisturbed terrestrial, riparian, and aquatic ecosystems. Within the CRW site-disturbing research and management activity will be limited to projects that are likely to benefit the long-term conservation of native biota (e.g., restoration thinning to enhance forest complexity, stream restoration projects, road decommissioning). The MRW comprises four primary land treatments totaling 48,380 acres: intensive (14,334 acres), extensive (13,413 acres), reserve (14,096 acres), and RCA (6,538 acres). Research and management in the MRW will include the implementation of forest management strategies that apply different spatial arrangements and practices to these treatments in support of timber harvest, and the evaluation of corresponding ecological and economic outcomes.

The Triad research design allows for flexibility in how each sub-watershed in the MRW can best be arranged to optimize desired outcomes for a given set of management objectives and constraints. The relative proportions of each Triad treatment type in the MRW (reserve, extensive, intensive) are fixed and correspond to sub-watershed designations (Figure 4); however, the spatial arrangements of these treatments within the designated sub-watersheds are flexible within other constrains such as age. Flexibility in the spatial arrangement of retention areas in extensive, intensive, reserve treatments facilitate the accommodation of non-timber values, such as habitat for old-growth dependent species, protections for areas prone to landslide and debris torrent not otherwise protected in RCAs, and refugia and migration corridors for amphibians. In extensive treatments, for example, steep headwall areas could preferentially be afforded additional tree retention to support root-zone integrity and soil stability, and to provide a source of large wood should the slope fail.

Although less flexible than the spatial arrangement of tree retention in extensive treatments, in some areas we expect that boundaries between intensive and reserve stand-level treatments will be adjusted to afford such protections. This spatial arrangement of the treatments will be refined further using a landscape analysis as part of the Elliott State Research Forest Management Plan.

Inclusive of MRW reserves, MRW RCAs, and the CRW, a total of 54,774 acres of the 82,520-acre ESRF (66% of total ESRF acres) will be in reserve status. Aside from single-entry restoration treatments in existing plantations expected to take place over the next 10 to 20 years (see discussion on thinning below) OSU is proposing no timber harvest in these reserve areas. Though subject to natural disturbance processes such as wildfire and extreme weather events, we intend these areas to follow successional pathways largely unaffected by human intervention.

B Conservation and Modeling of the Wood Recruitment Process

Throughout the Pacific Northwest, including the Oregon Coast Range (OCR) and the ESRF, past and current land management practices have led to a reduction in both the quantity of large wood in streams and rivers and potential sources of large wood on the terrestrial landscape. Reestablishing natural wood recruitment processes is a key component of OSUs riparian and aquatic conservation strategy; a means of evaluating wood recruitment is therefore necessary for planning, research, and adaptive management purposes.

Stream-adjacent sources of large wood recruitment, such as bank erosion, mortality, and windthrow, are assumed to be protected to a greater or lesser degree according to the width of a stream buffer, are the customary focus of wood recruitment evaluation (see, for example, Murphy 1995). Recruitment models that evaluate only stream-adjacent large wood sources may overlook other important sources of large wood, however. Specifically, large wood delivered by landslide and debris torrent from small headwater streams potentially comprise a sizeable fraction of the total large wood budget of fish-bearing streams in the OCR. For example, May and Gresswell (2003) found that 33% of large wood pieces in a third-order alluvial mainstem stream had been transported to the stream by debris torrent through second-order tributaries, Bigelow et al. (2007) reported that between 31% and 85% of large wood pieces identified in fish-bearing streams came from debris torrent deposits associated with first- or second-order tributaries, and Reeves et al. (2003) reported that 65% of large wood pieces surveyed in a fourth-order stream were delivered by landslides or debris flows from distances greater than 90 meters. Given these findings we expect large wood recruitment by debris torrent to be a significant component of the large wood budget of fish-bearing streams on the ESRF.

For the evaluation of wood recruitment protected under prospective management strategies we use a wood recruitment model, *ElliottSFWood,* developed by Dr. **Dan Miller** of Earth Systems Institute that estimates the relative proportions of total wood recruitment attributable to streamadjacent, landslide, and debris torrent processes (Miller and Carlson, in prep). Output of ElliottSFWood is integrated with large wood source-distance relationships described by McDade et al. (1990) within a GIS environment to estimate protected wood recruitment (Carlson et al. in prep).

We employ the concept of *potential wood recruitment* to facilitate evaluation of the degree to which a prospective riparian conservation strategy protects sources of large wood. As the name suggests, potential wood recruitment is the quantity of large wood that could be recruited to a specified aquatic ecosystem, given the existence of certain conditions. A more complete exposition of this concept is being prepared by OSU doctoral candidate **Deanne Carlson**. In summary, *full potential wood recruitment* (FPWR) is an estimate of the potential total annual large wood quantity expected to be delivered to a wood recruitment target, given reference forest stand conditions. *Protected potential wood recruitment* (PPWR) is an estimate of the quantity of potential annual wood recruitment protected by specified conservation strategies, such as recruitment protected within RCAs, the CRW, and MRW reserve allocations. PPWR is expressed as a percentage of FPWR.

C Riparian Conservation Areas

The management of riparian ecosystems is a challenge for managers and policy makers. Policies and practices often include protective buffers, within which activity, such as vegetation management, is restricted (Richardson et al. 2012; Boisjolie et al. 2017). Management has almost exclusively used fixed-width buffers, with the prescribed width determined by the stream size (average flow) or type (presence or absence of fish) (Richardson et al. 2012). This approach is easy to administer and apply, and is less costly than developing site-specific recommendations, in part because of the analysis required for the latter approach. The combination of these factors and uncertainty about results has limited the development and application of a context-dependent approach to riparian management.

Delineation of the stream network

The delineated stream network used for OSU's ESRF planning process is based on LiDAR-derived digital elevation models (DOGAMI 2009). LiDAR-derived topographic data provides greater stream mapping accuracy and finer resolution than do older stream delineation methods based on, for example, 40-foot contour interval topographic maps. The delineated stream network used by OSU is intended to facilitate the identification of areas of convergent topography susceptible to landslide initiation and debris torrent, including features such as zero-order basins and bedrock hollows with no defined stream channel or surface water flow. In nearly all cases the OSU-delineated stream network extends further into headwall areas than do the Oregon Department of Forestry (ODF) and National Hydrography Dataset (NHD) stream delineations (see Figure 6a). Total delineated stream miles differ by data source: there are 2,087 miles of stream in the OSU layer, 702 miles of stream in the ODF layer, and 747 miles of stream in the NHD stream layer. The greater number of stream miles in the OSU stream layer should not be interpreted to mean that all of these stream miles will be protected within an

Figure 6a. CRW Example Area Full Stream Network

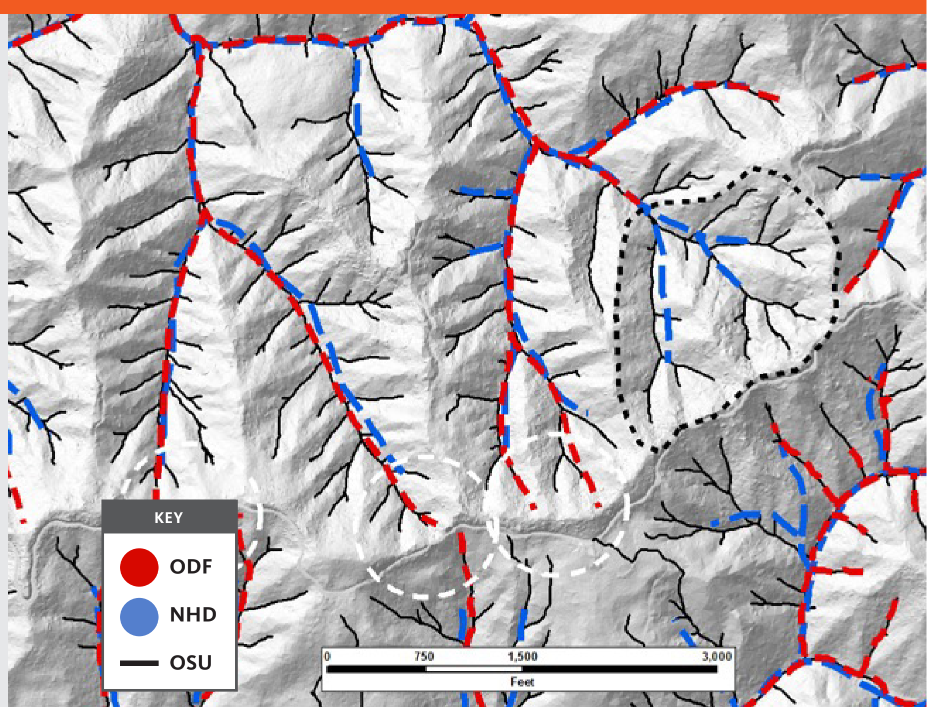


Figure 6a. *Example comparison of stream delineations for the ESRF. The OSU stream layer is based on a LiDAR-derived DEM, and in nearly all cases extends further into headwall areas than do ODF and NHD stream layers. The ODF layer is less consistent than either the OSU layer or the NHD layer. For example, no streams within a 65-acre catchment (center-right, encircled by black dashed lines) are delineated in the ODF layer, yet that layer delineates some streams initiating near the ridgetop with very little hydrologic contributing area (white-dash circles).*

RCA; however, we believe the LiDAR-derived stream layer provides a more suitable basis upon which to evaluate stream protections. A stream protection strategy based on the ODF stream layer that affords some degree of protection for all delineated streams, for example, would include only those streams that were part of the delineated stream network; such a strategy would not protect potentially important streams that were not part of the delineated network (Figure 6a). Our stream delineations make express the potential importance of all headwater streams. By fully delineating the stream network to a fine scale of resolution we are better able to evaluate what is protected within the boundaries of reserve allocations and riparian conservation areas, and what is not protected outside of these areas.

Fish-bearing and non-fish-bearing stream classifications

We used the regulatory definition of fish-bearing streams, which encompasses the upper limit of coastal cutthroat trout in stream networks. Cutthroat trout presence generally extends further into the headwaters of stream networks than any other fish species, even higher than non-game fish such as sculpin. We have defined fish bearing streams as those with a gradient of 20% or less, which is based on eDNA (Penaluna et al. 2021) and electofishing (Latteral et al. 2003) for resident cutthroat trout and provides a fish-bearing stream network approximately 70 miles longer than that identified by OFPA on the Elliott State Forest.

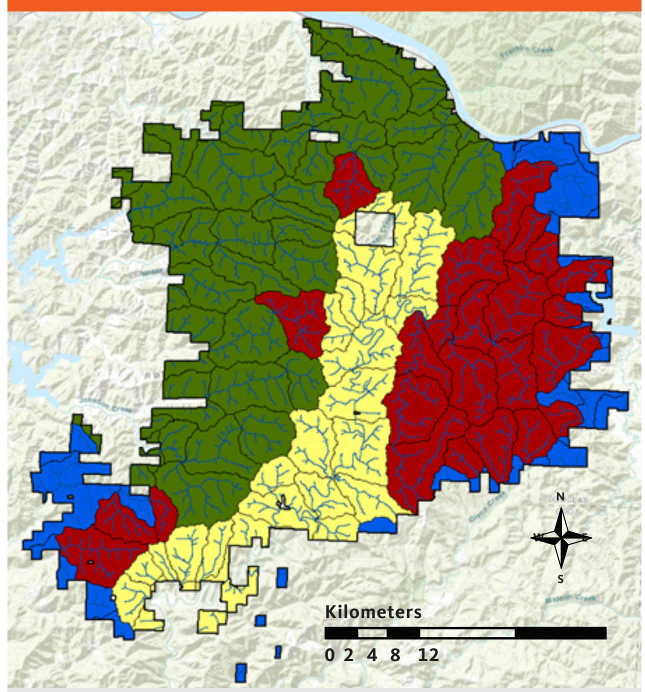
The scientifically recognized extent of the riparian ecosystem has expanded beyond fish-bearing streams as result of the flurry of research conducted after the implementation of the Northwest Forest Plan in 1993. Of particular significance is the recognition of the ecological importance of non-fish bearing streams, which generally make up 70 percent or more of the stream network (Downing et al. 2012, Gomi et al. 2002). Headwaters are sources of sediment (Benda and Dunne 1997a, 1997b; May and Lee 2004; Zimmerman and Church 2001) and wood (Bigelow et al. 2007; May and Gresswell 2003, 2004; Reeves et al. 2003) for fish-bearing streams; provide habitat (Kelsey and West 1998, Olson et al. 2007) and movement corridors (Olson and Burnett 2009, Olson and Kluber 2014) for several species of native amphibians and macroinvertebrates (Alexander et al. 2011, Meyer et al. 2007); and may be important sources of food for fish (Wipfli and Baxter 2010, Wipfli and Gregovich 2002, Wipfli et al. 2007). Wood jams in small streams are important sites of carbon storage (Beckman and Wohl 2014), and these streams export large amounts of carbon; one-third is emitted to the atmosphere and the remainder transported downstream (Argerich et al. 2016).

Non-fish bearing streams are the most abundant portion of the riverine network of the ERSF, comprising approximately 89% of delineated stream miles. ESRF-based research on these streams will focus on: (1) Their ecological role and influence on fish-bearing streams; (2) How they may serve as movement corridors within and among watersheds for terrestrial organisms and riparian organisms, energy and carbon; (3) How to treat previously managed forest areas adjacent to these streams to change the vegetative composition and structure. Doing so will create opportunities to study the influences on riparian soils and use by terrestrial and riparian organisms, the behavior of landslides and the effects on fish-bearing streams, and the production of invertebrates and nutrients that transport to fish-bearing streams.

The following stream classifications have been applied across the ESRF according to the following definitions:

- Fish-bearing (FB) streams are defined as streams with a maximum downstream channel gradient[1] of 20% and a

Figure 6b. ESRF Stream Protection Zones



KEY

- **CRW**
- **Lower Milicoma**
- **Other MRW (full watersheds)**
- **Other MRW (partial watersheds)**

Figure 6b. *Four stream protection zones proposed for the Elliott State Research Forest.*

[1] Maximum downstream gradient is the maximum channel gradient downstream of the subject reach, as calculated over a reach length equivalent to 20 channel widths. It is the steepest channel gradient game fish would be expected to pass; channel gradients greater that 20% are assumed to be complete fish-passage barriers.

minimum average annual streamflow of approximately 0.2 CFS.

- Perennial non-fish-bearing (PNFB) streams are non-fish-bearing streams that have flowing water throughout the year, with no minimum streamflow requirement. Flow duration can vary from year-to-year and may also vary depending on the vegetative condition of the contributing watershed. We assume that streams with a contributing watershed area greater than 6.2 hectares (approximately 15 acres) are perennial streams.
- Wood-delivery non-fish-bearing (WNFB) streams are non-fish-bearing streams that are estimated to deliver greater than a threshold quantity of large wood to fish-bearing streams by debris torrent; they may be either perennial or non-perennial. To determine WNFB status, all non-fish-bearing stream reaches were ranked according to estimated annual wood recruitment contributions to fish-bearing streams, and the top-ranked of these streams were classified as WNFB.
- Other non-fish-bearing (XNFB) streams are streams that are not classified as FB, PNFB, or WNFB. XNFB streams are seasonal or intermittent streams, usually located in the headwalls of stream networks. In many instances delineated XNFB streams may not have a defined stream channel, and thus do not meet the regulatory definition of a stream (e.g., OAR 629-600-0100[76]).

The above stream classifications are applied across the entire ESRF; however, RCA widths associated with these classifications vary according to the protection zone in which streams are situated. For purposes of RCA implementation, there are four stream protection zones: the CRW, Lower Millicoma watersheds (includes all full and partial watersheds tributary to the Millicoma River downstream of Elk Creek), other MRW full watersheds, and other MRW partial watersheds (Figure 6b).

Stream buffer widths and stream miles within each of the four stream protection zones are summarized in Table 7c in Appendix 7.

D Steep Slopes and Headwater Streams

Steep slopes are a distinguishing feature of the ESRF. The topography of the ESRF is variable, as reflected in the difference in distribution of classified slope gradients between the CRW and the MRW (Figure 6c). For example, slopes with gradients greater than 65% comprise 73% of the area of the CRW, whereas such slopes comprise just 54% of the area of the MRW. Similarly, slopes less than 50% gradient comprise 30% of the MRW, compared to 13% of the CRW.

As with most of the Oregon Coast Range, the ESRF is characterized by high stream channel densities and, by extension, high headwater stream channel densities. Perennial stream density of the ESRF is 2.3km•km^{-2}, and stream density of all first order and larger stream channels is 4.8km•km^{-2}. Stream channel density based on all delineated streams, including zero-order channels, is 10.1km•km^{-2}. In more conventional terms, zero-order channels have an average of (approximately) 2 acres of contributing area and first-order channels have an average of (approximately) 8 acres of contributing area. Based on an analysis of flow duration of streams on the Siuslaw National Forest (Clarke et al. 2008), streams with a contributing area greater than (approximately) 15 acres are classified as perennial streams.

The delineation of stream channels facilitates our understanding and analysis of hydrologic and erosional processes as they apply separately to streams and their adjacent topography; however, on steep hillslopes and headwall areas of the Oregon Coast Range these processes are intertwined, and clear distinctions between stream and hillslope processes are seldom possible. Our delineation of the ESRF stream network is intended to facilitate the identification of areas of convergent topography susceptible to landslide and debris torrent processes. These processes occur at the transition between hillslopes and stream channels, forming a crucial link between hillslope, headwall, and stream channel processes, and between terrestrial and aquatic ecosystems

Figure 6c. Distribution of classified hillslope gradient across the MRW and the CRW

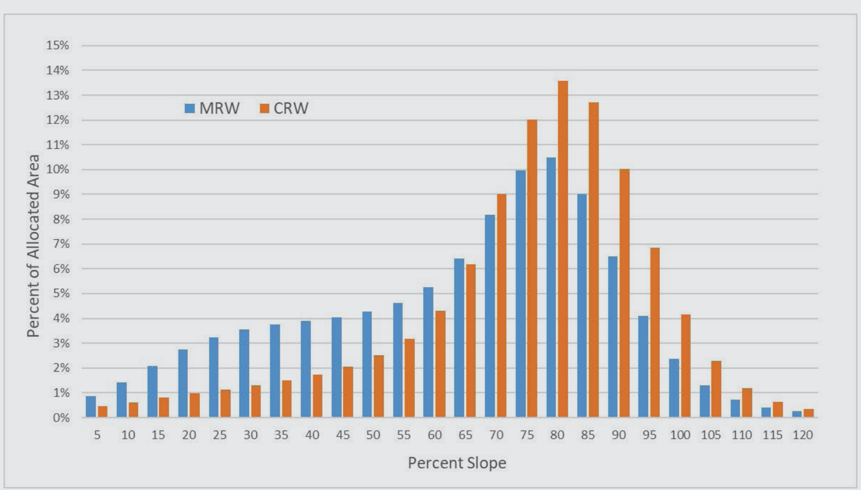


Figure 6c. *Distribution of classified hillslope gradient across the MRW and the CRW. Both the CRW and MRW have areas of very steep slopes, but the MRW and CRW exhibit some generalized topographic differences. Vertical axis values refer to the percent of MRW area and percent of CRW area, not percent of total ESRF area.*

(Benda et al. 2005, Gomi et al 2002). As described above in subsection (c) *(Delineation of the stream network)*, for planning and analytical purposes we have extended the stream network into headwall areas to better recognize the integral nature of streams and their associated terrestrial counterparts, and the effects that these transitional processes have on downstream aquatic ecosystems.

As integrators of local and watershed-scale processes, streams are ideal locations to research how steep slopes and headwater channels, directly and indirectly, affect ecological processes in downstream aquatic ecosystems. There are opportunities to better understand the integration of steep slopes and the streams confined by them and how this relationship changes with time and space. Do key processes leading to the production and delivery of large wood and sediment/nutrient pulses to the aquatic systems occur at different rates in steep landscapes? And if so, what implications does this have for the retention of carbon, nutrients, and biota in headwater ecosystems? We are particularly interested in quantifying the role of large wood in sorting sediments and creating functional habitat in steep landscapes. This process is generally understood but lacks long-term empirical data. Studies on the ESRF will seek to provide knowledge of short and long-term impacts of headwater stream tree retention (such as will occur in extensive harvests and reserves) and headwater stream tree removal in intensive harvests following current Forest Practices Rules.

Protection Strategies for Steep Slopes (65%) and Headwater Streams

OSU's conservation strategy is placed within the context of an over-arching research forest strategy of integrating multiple objectives, including the conservation of listed species (e.g., coho salmon) and research that is relevant to the management of lands beyond the borders of the ESRF (e.g., federal, state, and private forestlands). The conservation strategy is organized around different layers of protection that together provide significant protection and conservation benefits to riparian, aquatic, and terrestrial ecosystems while allowing research that is relevant across multiple land ownership classes, including intensively managed forests. These layers of protection are:

- CRW (approx. 34,000 acres of reserves in one block)
- Reserve treatments within the MRW (approx. 14,000 acres of reserve distributed throughout the MRW with each subwatershed having equal amounts of reserve and intensive treatments see Figure 4 in Appendix 1)
- RCAs within the MRW (approx. 6,500 acres in the MRW See Table 7e for widths and Figures 7a, b and c)
- Extensive treatments with 20-80% retention and longer rotations (see Appendix 5 for more details on practices, approx. 13,000 acres in the MRW)
- Intensive treatments with riparian RCA widths meeting or exceeding the Oregon Forest Practices Rules (every acre of intensive is matched with an acre of reserves in all subwatersheds with intensive treatments in them, a 60yr min rotation age see Appendix 5 for more details on proposed practices and Table 7e for RCA widths, approx.14,000 acres of intensive treatment areas in the MRW.)
- Steep slopes are slightly over-represented in reserve areas. Combined, the CRW, MRW reserves, and RCAs comprise 67% of the total area of the ESRF and 72% of the area of the ESRF with hillslope gradients greater than 65%. The balance of these steep slopes is in the extensive allocation (13%) and in the intensive allocation (16%) (Figure 6d). The prevalence of headwater streams with gradients greater than 50% shows a similar distribution pattern to steep slopes relative to reserve, extensive, and intensive treatments. Thus, at the scale of the entire ESRF, reserve treatments (CRW, MRW

Figure 6d. Distribution of classified hillslope gradient by allocation

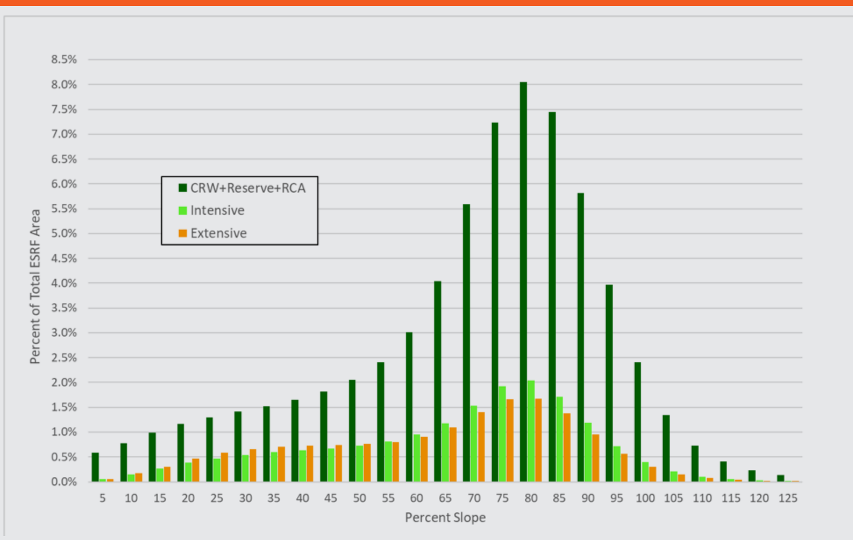


Figure 6d. *Distribution of classified hillslope gradient by allocation. Reserve treatments (red) are non-harvest areas that are protected* from the effects of forest harvest. Intensive treatments (green) are intended to be representative of lands managed primarily under an industrial timber production approach within Oregon Forest Practices Rule requirements and the additional ESRF intensive approach overlays. Extensive treatments (orange) represent alternative forest management strategies, including high retention and extended rotation lengths and retention of an average of 50% of pre-harvest forest density providing increased conservation.*

**once restoration thinning of Douglas-fir plantations is complete.*

reserve, and RCAs) provide an appreciable level of protection to steep slopes and headwater streams.

By design extensive treatments are intended to explore forestry practices that result in enhanced conservation practices compared to intensive forestry practices by using extended rotation lengths and by retaining 20-80% of the pre-harvest forest density during harvest cycles. Consideration of and protections for steep slope and headwall areas at risk to landslides from management activity can be part of this retention allocation, integrated into other considerations (e.g., terrestrial habitat / MaMu) during the FMP landscape assessment and project-level process.

The intent of intensive treatments is to explore management practices relevant to industrial forestland management. Protective mechanisms that apply to industrial forestland in Oregon are the Oregon Forest Practices Rules (OFPR); therefore, OFPR will provide the minimum regulatory standards for practices within intensive treatments. As proposed, RCAs are allocated on all FB, NFB perennial and HLDP streams adjacent to intensive (and extensive) treatments and provide a greater level of protection (e.g., wider) than OFPR. Therefore, in practice OFPR will apply only to the terrestrial landscape (i.e., steep slopes) and to XNFB streams. OFPR provides the minimum standards in these areas; we expect to use a range of protective measures in intensive stand treatments, depending on research designs and objectives. Intensive treatments will always be coupled with an equivalent area of reserve within each sub-watershed (see, for example, figure 4 in Appendix 1); thus, exclusive of RCAs, no more than 50 percent of any sub-watershed will be in the intensive treatment.

Figure 6e. Lidar-based stream network for the ESRF

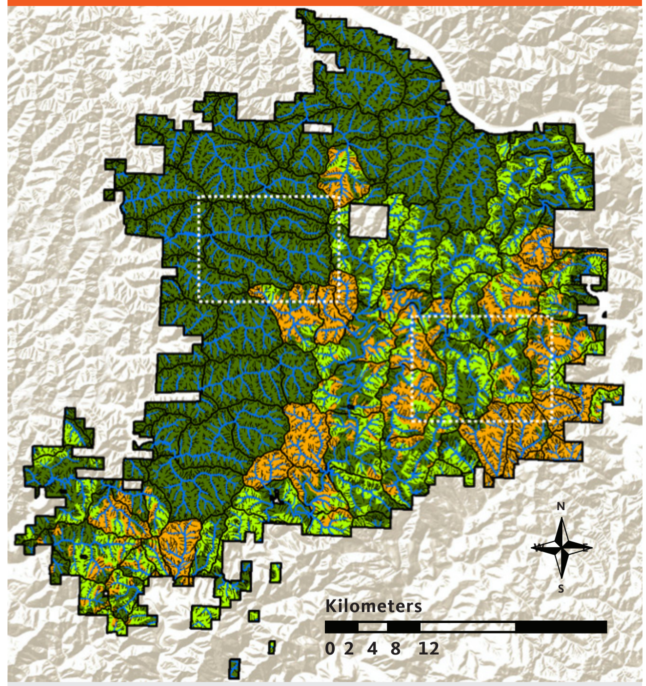


***Figure 6b**. The Lidar-based stream network layer for the ESRF overlaid upon the subwatershed land allocation assignments and other OSU protective designations (e.g., RCA buffers, 50% of intensive subwatersheds assigned to reserves, etc.). The figure depicts higher gradient steep slope XNFB streams and the extent to which they exist within the various treatment areas (bright green and orange colors) versus protected areas (green). As explained in Appendix 6 & 7, further refinement of XNFB protections in extensive and intensive treatment areas will occur as part of the FMP process and project level based on the flexibility retained to do such protections. Boxes outlined are shown in more detail in Figures 6f and 6g. Note due to scale not all XNFB streams could be represented in this map. If we did map them all, the entire subwatershed would be obscured.*

KEY

- **CRW, MRW Reserve, RCA**
- **Extensive treatment**
- **Intensive treatment**
- **RCA-protected stream network**
- **XNFB streams**
- **Sub-watershed boundary**

E Restoration Thinning in Riparian Conservation Areas

Some proportion of riparian areas on the proposed ESRF will require restoration efforts because they have been altered by past management. The exact extent of this is currently unknown but is likely to be at least moderately extensive given past activities and policies that allowed for timber extraction in riparian areas. Affected areas likely have dense overstocked stands of conifers and/or an absence of hardwoods. In any case, prudent management may be needed to set these stands onto a different and more ecologically appropriate trajectory focused on aquatic health, and OSU intends flexibility (within sideboards articulated further below) to pursue this restoration approach.

Active management-based restoration activities in riparian reserves have been limited regionally because of concerns about potential negative effects, particularly increased water temperatures and decreased wood-delivery potential, but also due to lack of funding and lack of trust of land managers. The lack of active riparian restoration activities has resulted in a lack of data on the effect of management activities that may have net benefits to aquatic and riparian ecosystems and their associated biota. Given the limited extent of riparian alteration that has occurred in western Oregon and elsewhere, developing and evaluating methods to manage riparian areas to restore their ecological capacity will be a component of the ESRF research program. The intent of active management is that that the activities will promote key ecological processes such as development of the largest trees (Reeves et al. 2018).

Thinning is a potential technique for increasing tree growth (Dodson et al. 2012), and the purposeful placement of some

Figure 6f. Portion of the MRW on the ESRF Illustrating level of riparian conservation relevant to all streams

Figure 6f. *A portion of the MRW on the Elliott State Forest illustrating the level of riparian conservation relevant to all streams especially the abundant higher gradient / steep slope XNFB streams. The extent of protections and increased conservation for a given XNFB will vary depending on research treatment designation and may differ on each side of the stream where there is a reserve on one side and intensive or extensive treatment area on the other. Extensive treatments offer the ability to offer increased conservation for XNFBs as part of the longer rotation and 20-80% retention strategy. And in intensive treatment areas, opportunities for additional XNFB protection exist at the FMP and research planning scale.*

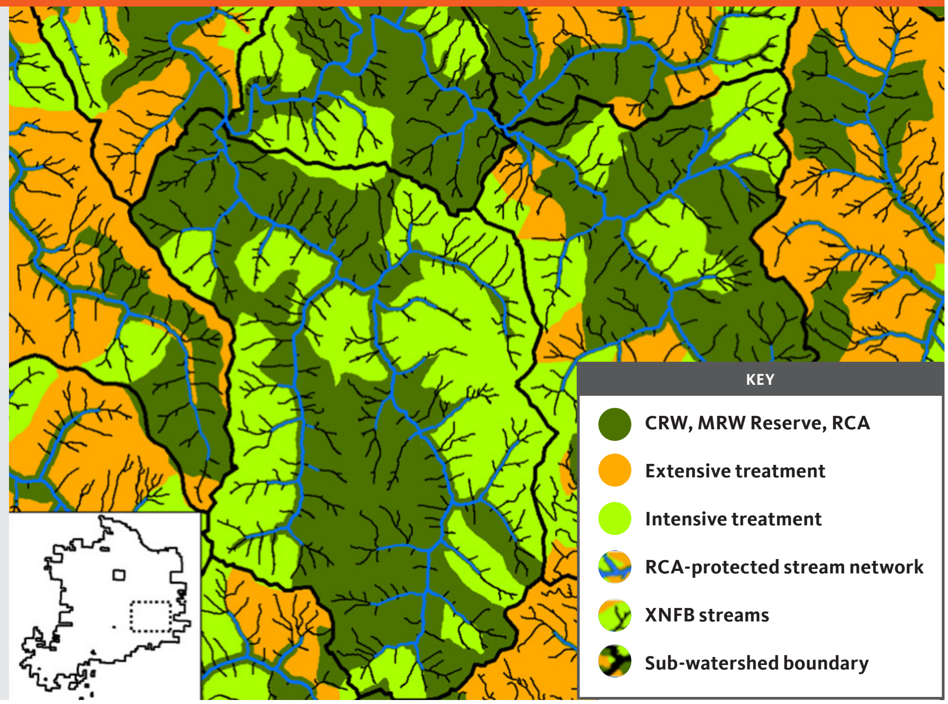
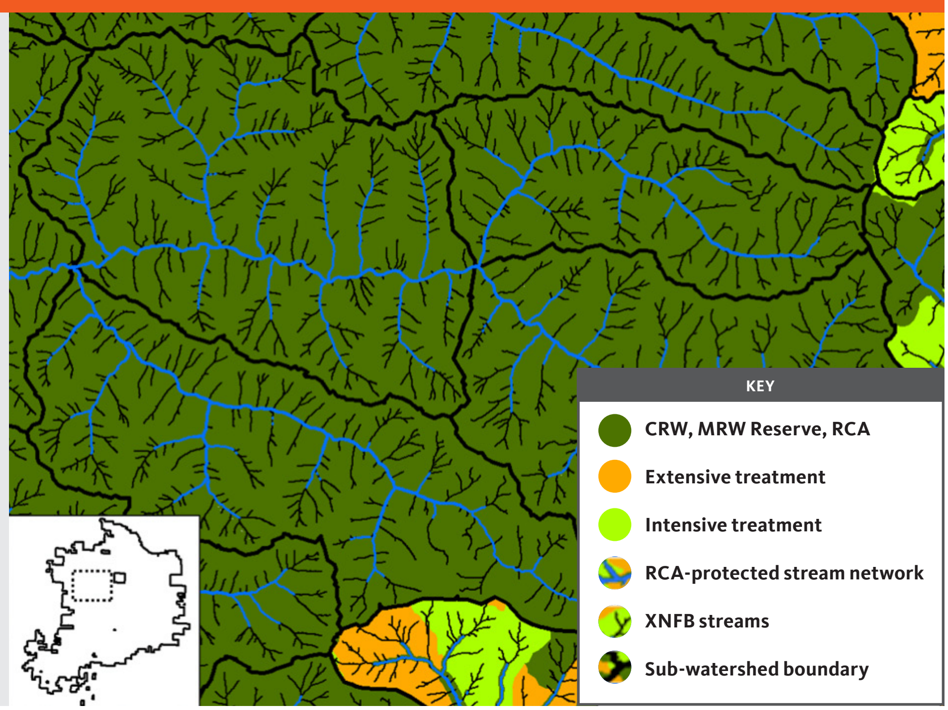


Figure 6g. Portion of the CRW primarily in the CRW reserve on the ESRF illustrating density of/the level of riparian conservation relevant

Figure 6g. *A portion of the CRW primarily in the CRW reserve on the Elliott State Forest illustrating density of the and level of riparian conservation relevant to higher gradient / steep slope XNFB protections. As depicted in Figure 6(d) and Table 7(a), the majority of steep slopes on the ESRF exist within protective reserve designations (CRW, MRW reserves, or RCAs).*

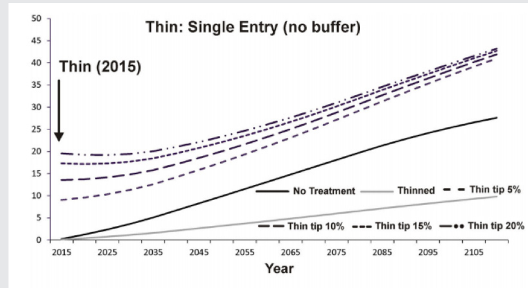


proportion of the harvested wood in the channel or on the forest floor could immediately reduce deficiencies in dead wood that exist in many streams and riparian areas (Benda et al. 2015; see also Olson and Burnett 2009 and Olson and Kluber 2014). Thinning would produce larger dead wood in riparian areas and streams, following placement, in the short term than a stand that is left unthinned, where dead trees accumulate slowly from the smallest size classes as a result of competition, disease, disturbance, and other factors. In some stand conditions, such actions could have the added benefit of accelerating future development of very large-diameter (>40 inches) trees (Spies et al. 2013). However, any thinning activity to increase wood recruitment in the near and long terms will also have to consider potential impacts on water temperature and water quality.

Benda et al. (2015) explore potential effect of introducing portions of the wood thinned to the wood loading in a stream by modeling the amount of instream wood that would result from thinning a stand from 400 trees per acre to 90 trees per acre, then directionally falling or pulling over varying proportions of the trees scheduled for harvest (Figure 7). This was compared to the amount of wood that would be expected to be found in the stream without thinning the stand. The amount of wood increased above the "no thin" level immediately after the entry in all of the options of wood additions. However, the cumulative total amount of wood expected in the stream over 100 years relative to the unthinned stand varied depending on the amount of wood delivered. Adding less than 10 percent of the wood that would be removed during thinning produced less wood in the channel over time than the unthinned option. However, when 15-20% of the volume of thinned trees was tipped from one side of the stream at each entry, the total amount of dead wood in the channel over time exceeded the unthinned scenario (Figure 7a). Management of riparian areas on the ESRF will include devoting 15-20% of the thinned total volume to the stream channel.

The challenge is to be able to pay for restoration efforts. Writing the cost of doing thinning into timber sale contracts without being able to harvest any of the thinned trees is likely to severely restrict restoration efforts and opportunities to conduct research on approaches to riparian restoration. Therefore, the removal of some proportion of the thinned trees beyond 120' will be allowed in the entire Riparian Conservation Area (RCA) where appropriate within the CRW and MRW reserve designations. The RCA in these reserves is 200', which is the distance equal to the height of one site potential tree. It is unlikely that trees in the area between 120' and 200' will be tall enough at the time of thinning to reach the channel. Attempting to place such pieces in the stream would incur additional costs to the operation and potentially result in additional undesirable disturbance to the RCA. Therefore, the 15-20% of the total volume thinned that is devoted to the channel placement will come from the first 120', provided there is sufficient volume in this area to do so.

Figure 6a. Prediction from reach scale wood model of Benda et al. (2015).



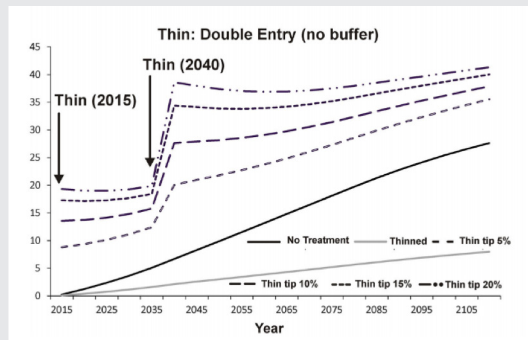


Figure 6h. *Predictions from the reach scale wood model showing cumulative wood volume over time (included decay) for a single and double entry thinning, without a 10 m buffer, simultaneously on both sides of the channel. Also shown are results from tree tipping from 5 to 20% of the thinned trees into the stream.*

The predicted increases in the volume of in-stream wood due to tipping could offset concerns about reductions of instream wood and loss of fish habitat during a thinning operation (Beechie et al. 2000). Additionally, in tipping, the amount of wood increases immediately rather than being delayed for 25–50 years in the no treatment, unmanaged stand. This could be particularly important for improving habitat conditions for U.S. Endangered Species Act-listed species such as the Coho salmon in the near term, rather than waiting an additional half century or more for higher levels of wood recruitment and storage. The increase in the size of the trees in the riparian zone over time that results from thinning is also important ecologically because they will be more effective in forming pools than smaller sized pieces, although the instream piece size effect might not occur until after the first century.

Trees sold from RCA thinning will be a biproduct of the restoration thinning research design. In keeping with the ESRF's "research-first" mission, OSU will not conduct RCA thinning for the purpose of generating profit. The sole purpose of this activity is to restore riparian stands that have been affected by previous management. No conifers >65 years old (in 2020) will be harvested. Of the conifers harvested, 15-20% of the total volume thinned will be devoted to the channel placement and will come from the first 120 feet adjacent to subject streams, provided there is sufficient volume in this area to do so. Log volume in the zone from 120' to 200' will be removed and revenue from this work will remain part of the overall ESRF operations and accounting. Net revenue from all timber sale operations, including restoration thinning, will be used to fund and advance the mission of the ERSF as a research forest.

F Roads

We commit to reducing the current road network density and their related adverse impacts on the ESRF, particularly in the Conservation Research Watersheds, while maintaining and balancing for necessary access for research, harvesting, management, education, fire protection, and recreation. Roads are imposed on the landscape to maintain access to remote sites for several uses, including recreation, firefighting, and removing wood products. Roads also represent a significant human impact on the larger forest system in terms of chronic long-term disturbance, fragmentation, sediment yield, and access for invasive species. Regardless of the use, gaining access via roads often disrupts ecosystem processes essential for the proper functioning of aquatic and riparian ecosystems. This disruption is especially evident where there are hydrologic connections between the road and aquatic networks such as sediment-laden runoff and rapid peak flows. Given the density of roads and streams on the ESRF and the presence of listed species, ways to mitigate impacts of strong hydrologic connections are areas of potential significance and wide application in the Northwest.

While still early in development, the OSU proposal for an ESRF envisions studies on the degree of hydrologic connections of current and legacy roads and their primary locations on the ESRF. Monitoring will identify candidate roads for modification to test methods for reducing hydrologic connections through road restoration and long-term monitoring of subsequent habitat impacts. In support of this, the ESRF will maintain an inventory of the road network to identify current and legacy roads that present a risk to the aquatic and riparian system and seek to implement modifications to the road system prioritizing segments that pose the highest risk to aquatic resources.

We will decommission some roads to reduce ecological risks but will also be mindful of providing access for firefighting and recreation consistent with reserve goals and State Land Board guidance. The road network in the CRW and MRW reserve watersheds will decline over time, and new, permanent roads may be constructed as part of a strategy to decommission road segments that are a problem. Still, we must implement such a strategy in the context of the forest research plan.

In addition to the aforementioned attributes of the riparian strategy, OSU commits to working with the local watershed councils and other organizations to restore and improve the ecological condition of streams on the ESRF. OSU will ensure that the work of these groups continues by:

- Supporting their efforts to secure funds from OWEB and other sources.
- Attempting to integrate restoration efforts into the research design.
- Providing data for and input into the restoration work of the various watershed groups.

The councils should be able to use the establishment of the ESRF as the foundation for developing a comprehensive watershed recovery program for each of the independent populations that occur on the ESRF. The councils will be briefed on research activities and findings regularly once the ESRF is established.

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APPENDIX 7

Riparian Area Research and Conservation Tactics

Intended to provide initial riparian area treatments and details on stream buffers in the CRW, MRW, and the West Fork of the Millicoma River.

A SUITE OF RIPARIAN AREA RESEARCH TREATMENTS

Aquatic and riparian treatments are structured to test the effectiveness and tradeoffs of providing critical ecological processes, such as wood recruitment, cold water, litter fall, and sediment, all of which are important to Coho salmon.

The focus of OSU's riparian approach is on maintaining key ecological processes that influence the productivity of aquatic ecosystems and associated resources. Rather than relying on a single mechanism, such as RCAs, land use allocation, and outcome-based wood delivery potential, or a single stream type such as fish-bearing or non-fish perennial or non-perennial, steep headwall vs defined stream channel, it is the combination of these attributes that provides protection and conservation of many of the key ecological processes essential for aquatic ecosystems. Protection (e.g., reserves) and increased conservation (e.g., extensive) will include fish bearing streams and non-fish bearing streams. Under the ESRF proposal:

- approximately 1,595 miles (or 86%) of non-fish bearing streams on the ESRF--from headwalls down to fish bearing streams--are in a protected (CRW, MRW reserve, and RCA) or increased conservation (extensive allocation) status.
- the remaining 14% of the ESRF's non-fish bearing streams are in an intensive or less protected status, with 29 miles having 50-120-foot RCA protection and 252 miles having no RCA.

This overall riparian approach is in alignment with the research platform on the ESRF using a systems-based approach to investigate the integration of intensively managed forests, forest reserves, dynamically managed complex forests and the aquatic and riparian ecosystems that flow within them.

STREAM TYPES

1. **Fish-bearing (FB):** Streams with a maximum downstream gradient of less than 20% and a minimum average annual streamflow of approximately 0.2 CFS.

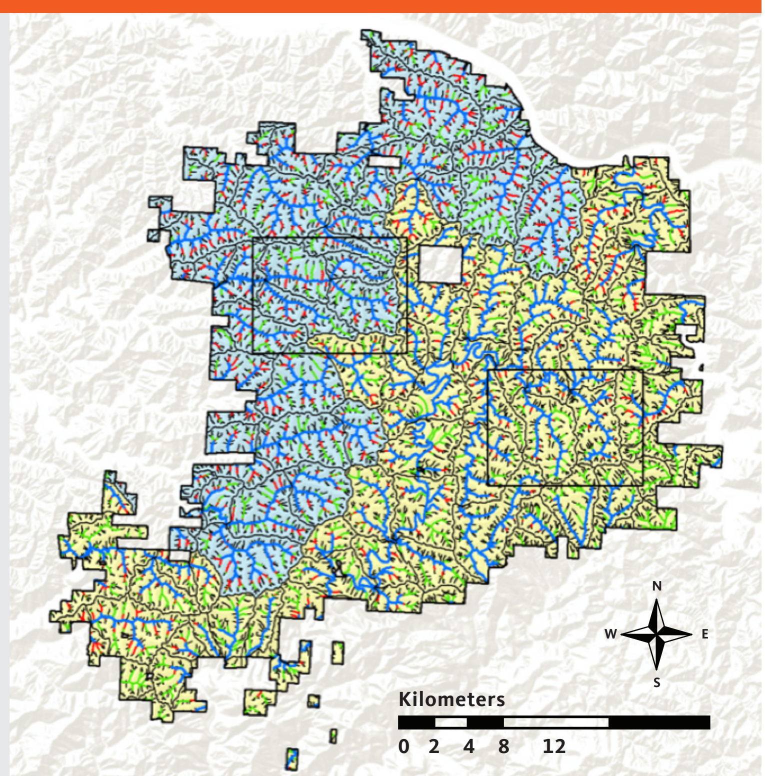
2. **Perennial non-fish-bearing (PNFB):** Streams modeled as providing year-round flow but not having game fish.

Figure 7a. Elliott Research Forest Stream Protection Classes

KEY

- Fish-bearing stream
- HLDP non-fish stream (perennial and non-perennial)
- Perennial non-fish stream
- Other non-perennial, non-fish stream

__Figure 7a.__ The Lidar-based 2087-mile stream network on the Elliott State Research Forest (for visual purposes not all non-fish streams are shown). There are approximately 235 miles of fish bearing and 1852 miles of non-fish perennial streams and non-fish non-perennial streams identified. The high landslide delivery potential (HLDP) non fish streams are highlighted in red, note their abundance in many of the reserved areas. Boxes outlined are shown in more detail in Figures 7b and 7c.



3 **Priority wood delivery non-fish-bearing (WNFB) debris torrent streams:** Non-fish-bearing streams (perennial, seasonal, or intermittent) with a high relative potential to deliver large wood to fish-bearing streams.

4 **Other (XNFB):** Streams primarily intermittent streams with low potential for wood delivery to fish-bearing streams.

Our analysis begins with many more miles of stream than typically assessed. This increase is a function of using a stream layer based on Lidar that identifies 2087 miles of streams on the Elliott (Figure 7a). In contrast, the ODF layer, identifies about 702 miles of stream. Fish-bearing streams are those with a gradient of less than 20% gradient. This results in 42% more miles (235 ESRF vs. 165 ODF) of fishbearing streams being identified on the ESRF. Thus, in comparison to the ODF stream layer, seventy miles of stream previously classified as perennial non-fish bearing are now classified as fish-bearing on the ESRF as a result of using the 20% gradient.

Research protocols call for RCAs to vary in size and configuration according to stream type and upslope research treatment (Table 8b). Stream types reflect the presence of fish, timing of flow (perennial versus seasonal), and susceptibility to landslide-associated debris flows that deliver wood to fish-bearing streams. Measure RCAs as the horizontal distance from the outer edge of the channel migration zone and reference to a site potential tree height of 200 feet, per local BLM data. The ESRF research design, in which the RCAs play a critical role, allows for varying, site-specific implementation, with a minimum set of standard prescriptions applied as set forth below.

RCA BUFFERS IN THE CRW AREA AND AREAS DESIGNATED AS RESERVES IN THE MRW

The treatments in the CRW and MRW reserves include restoration-based thinning in Douglas-fir plantations, recognizing that past management the CRW area and MRW reserves has created dense plantation stands in areas including riparian zones and that the need exists for a focused effort to recruit future old stands and unlogged naturally regenerated older forests. Therefore, reserves will have two starting points: a) Exploring treatments to restore and enhance conservation value in established plantations by transitioning to older, more complex forests including in RCAs; b) Conserving unmanaged mature forests as they move through natural successional processes. Since there is no harvesting in "b", there is no need for designated RCAs. Designated RCAs are only applicable when thinning adjacent to reserve stands to restore dense Douglas-fir plantations and/or increase the presence of desired hardwoods. Once these thinning treatments are complete, there will be no more harvesting in the reserve treatments, thus the designated RCA will integrate with the surrounding forest over time. However, during thinning, RCAs at these locations will be 200 feet slope distance on fish-bearing and non-fish-bearing perennial streams, and key debris flow torrents that deliver wood to the fish-bearing streams (see Table 7a).

Thinning to reduce the density of existing plantation stands within RCAs buffers will be undertaken only in plantation stands less than 65 years of age as of 2020 and only if determined necessary to support and enhance long-term ecological functions of the RCAs. Thinning would occur as part of the one-time entry into these plantations and for conservation purposes primarily focused in promoting the more rapid development of large trees that can potentially be recruited to the stream or the establishment of hardwoods to provide higher quality litter resources to the stream, increase habitat diversity and stream productivity. No harvest of trees will occur from the RCA if they are determined to be older than 65-year-old as of 2020, situated on landslide-prone steep or unstable conditions, or if there is overlap with designated wildlife habitat (e.g., Mamu).

RCA BUFFERS IN THE MRW

Initially, specific size and configuration of the different RCA components in the respective stream types will depend on the level of desired wood delivery potential needed to attain the MRW outcomes-based wood recruitment objective of a minimum of 70% outside the MRW reserves. Table 7c and 7d describes the minimum buffer widths and approach for the various stream types and stream protection zones. Within the MRW, the flexibility to reallocate buffer protections from fish bearing streams to HLDP upper reaches, especially those within intensive stand treatments, is important to our research-based desire to develop and test different configurations of riparian conservation on fish-bearing and non-fish bearing streams to achieve the target level of wood delivery (min. of 70%). This is the reason for a range of 100'-120' for the fish bearing portion of streams outside the lower Millicoma (i.e., where 100' is applied, increased buffering would be allocated to the HLDP portions of the stream network in order to attain the target level of wood delivery and associated resources) and to ensure areas with a high potential for failure will have trees in place for soil stability and root

Table 7a. Proposed level of protection of riparian and aquatic systems in all non-fish bearing streams on the ESRF

Land-use category adjacent to NFB streams	PNFB (miles)	WNFB (miles)	XNFB (miles)	Total (miles)
Reserves >65 years (CRW and MRW)	77.5	43.1	737.4	858.0[1]
Restoration Thin in Reserves <65 years	29.0	21.0	275.0	325.0
Extensive (20-80% retention harvest outside of RCA)	31.9	6.8	264.4	303.1
Subtotal of Conservation and Restoration miles	138.4	70.9	1276.8	1486.1
Intensive Treatment (clear-cut 60yr rotation)	22.5	7	252.1	281.6
Total	**160.9**	**77.9**	**1528.9**	**1767.7**

Table 7a. *Quantifying the proposed level of protection of riparian and aquatic systems in all non-fish bearing streams on the Elliott State Research Forest by calculating the number of stream miles adjacent to each land management strategy. In addition, all non-fish perennial streams (PNFB) and the high landslide delivery potential (HLDP) streams have a minimum 50'buffer where wood harvest may occur adjacent to the buffer. Remaining non-fish bearing non-perennial streams (XNFB) have a minimum buffer width of 0. (For additional details on fish-bearing and non-fish bearing streams see Table 8b).*

[1] *All streams have a 200' Riparian Conservation Area buffer*

Figure 7b. CRW Example Area Full Stream Network

KEY

CRW/Reserve	Fish-bearing stream
Intensive	HLDP non-fish stream (perennial and non-perennial)
Extensive	Perennial non-fish stream
RCA	Other non-perennial, non-fish stream

Figure 7b. *A portion of the CRW on the Elliott State Forest illustrating the level of riparian conservation in the CRW. See Table 8b for details of RCA widths. Given that CRW thinning will be limited to existing dense Douglas fir plantations < 65 years old (as of 2020), the research design will result in nearly 100% of the potential wood recruitment within the CRW.*

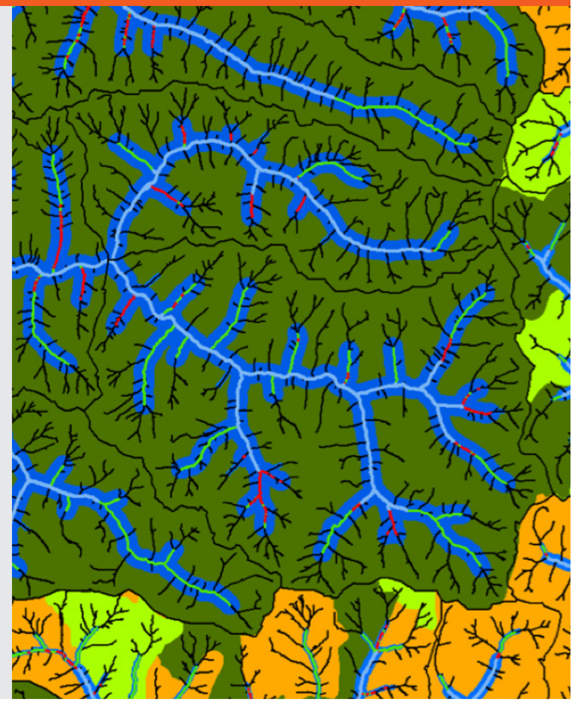
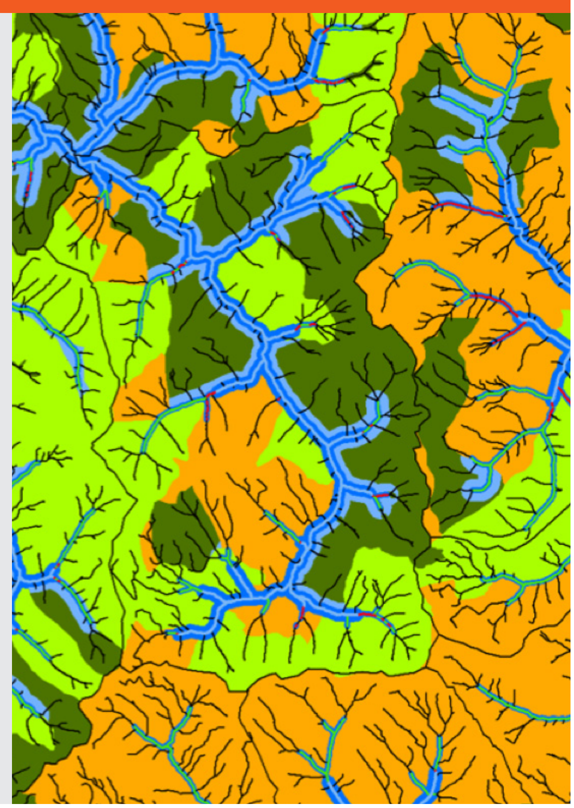


Figure 7c. MRW Example Area Full Stream Network

KEY

CRW/Reserve	Fish-bearing stream
Intensive	HLDP non-fish stream (perennial and non-perennial)
Extensive	Perennial non-fish stream
RCA	Other non-perennial, non-fish stream
Reserve Recruitment	

Figure 7c. *A portion of the MRW on the Elliott State Forest illustrating the range of riparian conservation strategies. See Table 8b for details of RCA widths. Note that the size of the RCA will vary depending on research designation and may differ on each side of the stream where there is a reserve on one side and intensive harvest on the other. Note the number of other non-perennial non-fish streams located in treatments that will maintain tree cover in the reserve and extensive stand-level treatments. Regardless of the RCA widths in other portions of the landscape, all streams flowing through reserves will have much larger riparian buffers since harvest activities will not take place (except for limited one-time restoration thinning in Douglas-fir plantations if needed).*



strength. This also provides researchers a means to consider other factors (wildlife, operational efficiency, etc.) in designing an efficient and effective riparian protection network.

WEST FORK MILLICOMA RIVER PROPOSED RCAS

In recognition of the distinct relative values the Millicoma system provides to Coho salmon and other ecological values, the designated RCAs for the West Fork Millicoma River from its entry into the ESRF in the southwest portion of the forest through the confluence with Elk Creek will be established and maintained as follows (see also Table 7b below):

- The RCA will be a distance equal to the site potential tree height, (200 feet measured as the horizontal distance from each side of the channel migration zone) on either side of the river mainstem and 120 feet measured as horizontal distance along any non-fish bearing stream that has a high potential to deliver wood to the adjacent fish-bearing stream and fish-bearing tributaries to the mainstem.
- Note that under the current research plan, the river's main channel will be bordered by 68% reserves, 26% extensive and 6% intensive treatments. Since 68% of the river will be bordered by reserves that will not experience timber harvests, the actual area protected within the Millicoma system greatly exceeds the 200' designated RA (Table 7b.).
- To further minimize the potential for adverse impacts to this ecologically and recreationally valuable region, the approximately 30% of the West Fork Millicoma watershed in reserves and 30% of the area in extensive can be integrated with the non-fish bearing streams identified as high potential for debris flow torrents that deliver wood to fish-bearing streams. Doing so would ensure the wood delivered during a debris flow will be large diameter.

SUMMARY

A primary purpose of the Elliott State Research Forest is to explore a range of options for managing forested landscapes and their associated aquatic and riparian ecosystems to achieve a suite of legal, social, economic, and ecological objectives. We will test the hypothesis that an approach relying on land use, wood delivery potential, restoration thinning, and RCAs will result in a high level of protection for Coho and other riparian and aquatic species while maintaining flexibility to conduct research that will inform future policy.

Table 7b. Percent of river miles along the West Fork of the Millicoma River

Treatment	Percent bordering river	Proposed riparian conservation area width (ft)
Extensive	26%	200
Intensive	6%	200
Reserve	68%	NA

Table 7b. *Percent of river miles along the West Fork of the Millicoma River that are bordered by the proposed experimental treatments in Figure 7c.*

Figure 7d. Example of the first step in integrating treatments along the West Fork of the Millicoma River

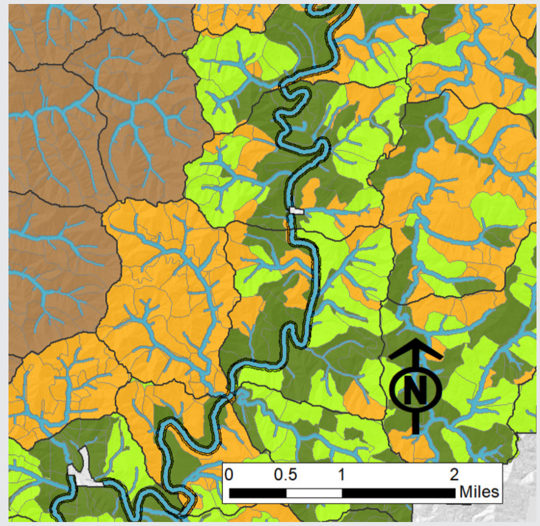
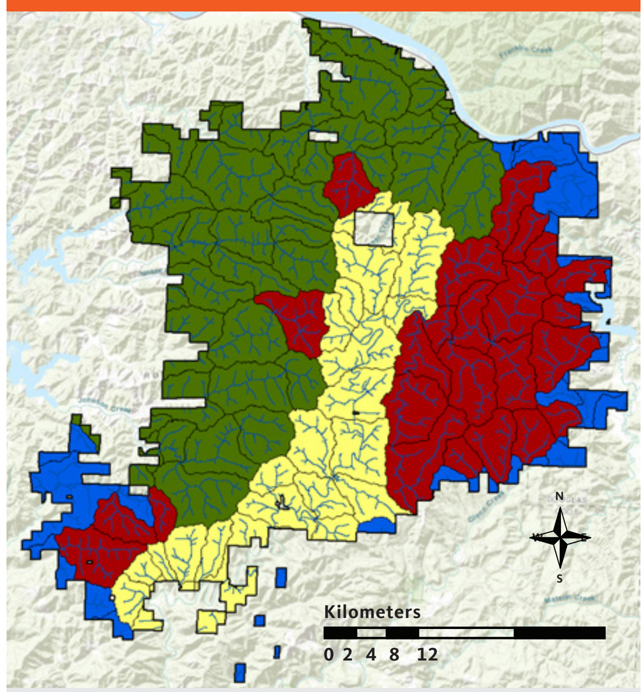


Figure 7d. *Example of the first step in integrating riparian and upslope treatments along the West Fork of the Millicoma River on the ESRF. The goal is to ensure the presence of large trees where wood recruitment is most likely to occur from riverside to headwall. The current percentage of each riverside riparian treatment is listed in Table 7b.*

Figure 7e. ESRF Stream Protection Zones



KEY

- **CRW**
- **Lower Milicoma**
- **Other MRW (full watersheds)**
- **Other MRW (partial watersheds)**

Figure 7e*.* *Proposed stream protection zones on the Elliott State Research Forest.*

Table 7c. Stream buffer widths and approximate number of stream miles by stream protection zone

Stream Protection Class	Buffer Width	CRW	MRW Lower Millicoma Watersheds	MRW Other (full watersheds)	MRW Other (partial watersheds)	Total
		MILES OF STREAM				
FB	100	0	0	74	0	74
FB	120	0	43	0	15	145
FB	200	87	16	0	0	16
PNFB	50	0	38	49	24	111
PNFB	120	67	0	0	0	67
HLDP	50	0	0	15	5	20
HLDP	120	48	9	0	0	57
Total RCA miles		202	106	138	44	490
XNFB	0	680	308	434	174	1,596
Grand Total		882	415	572	218	2,087

Table 7d. Proposed minimum buffer widths and the number of stream miles in each category on the ESRF

Stream Class	Minimum Buffer Width (feet)	STREAM ADJACENCY: MILES OF STREAM WITHIN 100 FEET OF ALLOCATED STAND**										
		MRW Lower WF Millicoma Full & Partial Watersheds			Other MRW Full Watersheds			Other MRW Partial Watersheds			CRW	
		Reserve	Intensive	Extensive	Reserve	Intensive	Extensive	Reserve	Intensive	Extensive	Native Forest (GT65)	Restore Thin (LTE65)
FB	100	0.0	0.0	0.0	39.0*	23.2	34.6	0.0	0.0	0.0	-	-
FB	120	19.8*	16.4	15.7	0.8*	0.5	0.5	12.9*	2.8	1.3	-	-
FB	200	13.2*	1.3	4.7	0.0	0.0	0.0	0.0	0.0	0.0	69.0	37.0
HLDP	50	0.0	0.0	0.0	6.9*	6.1	6.6	1.1*	4.1	0.6	-	-
HLDP	120	2.7*	5.1	3.7	0.0	0.0	0.0	0.0	0.0	0.0	-	-
HLDP	200	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.0	21.0
PNFB	50	16.2*	19.0	14.5	21.3*	18.9	25.1	13.0*	8.1	8.4	-	-
PNFB	200	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	51.0	29.0
XNFB	0	112.4*	133.6	102.7	165.1*	147.7	187.1	97.9*	58.6	32.3	458.0	275.0

Table 7d. *Proposed minimum buffer widths and the number of stream adjacency miles in each category on the Elliott State Research Forest. We have broken the forest into four areas for this calculation: 1)The MRW Lower Millicoma (includes partial watersheds that are not directly part of the research but do flow in the WF Millicoma below Elk Creek), 2) the other full watersheds that are part of the MRW study area, 3) the remaining partial watersheds in the MRW, 4) the Conservation Research Watersheds (CRW) as seen in Figures 7a, b and c.*

FB = Fish-bearing stream (235miles total ESRF)
HLDP = High landslide delivery potential non-fish bearing stream. May be either perennial or non-perennial (77 miles total ESRF)
PNFB = Perennial non-fish bearing stream not otherwise protected as WNFB (244miles total ESRF)
XNFB = NFB streams that are neither WNFB nor PNFB (1596 miles total ESRF)

**The width will be 200ft within allocated reserves with a few exceptions for longitudinal reserves along the streams that are narrower than 200' or if the reserve (LT65) is going to have a restoration thinning.*
***Note, could be reserve allocation on one bank of the stream and intensive or extensive on the other so these may exceed the lengths measured on GIS since we counted them in both categories.*

APPENDIX 8

Integrating Riparian Areas with Adjacent Research Treatments

Describes the steps we are taking to conduct a landscape analysis to allocate and integrate the riparian areas with adjacent research treatments and for determining RCA width requirements in intensive and extensive research treatments.

The process for determining where wood delivery will occur and prioritization for RCA width requirements in extensive and intensive stand level research treatments.

We propose to use modeled potential large wood recruitment to fish-bearing streams as a criterion for the development and evaluation of stream buffer strategies incorporated into the research designs of MRWs. The aquatic and riparian research strategy envisioned for the ESRF relies on wood recruitment for its specific value as habitat for imperiled species and as a proxy for the attainment of other ecological functions. Typically, most large wood recruited to fish-bearing streams comes from channel-adjacent sources through processes such as chronic and episodic tree mortality, bank erosion, and landslides. These same processes recruit large wood to non-fish-bearing channels. In steep and constrained non-fish-bearing (NFB) channels, episodic debris flows can deliver substantial quantities of accumulated large wood to fish-bearing streams. However, not every NFB tributary has the same potential to deliver wood. Therefore, we want to integrate our treatment of the riparian system with the upslope forests' treatments to ensure water quality and fish habitat as follows.

1. Establish the wood recruitment goal for the MRWs in the ESRF. The CRWs will have a goal of 100% of potential wood recruitment to fish bearing streams since the system is being managed as a reserve.
2. Delineate and classify NFB streams on the ESRF as to their potential for wood recruitment to fish bearing streams. Identify tributaries and headwalls with high potential for wood recruitment and other conservation components.
3. Calculate site potential tree height and riparian buffer needed to ensure wood delivery to the stream.

Figure 8. Proposed stand level allocation of extensive, instensive and reserve treatments

KEY

- MRW Reserve
- Intensive
- Extensive
- CRW
- Extensive Reserve (GT152)
- GRCA

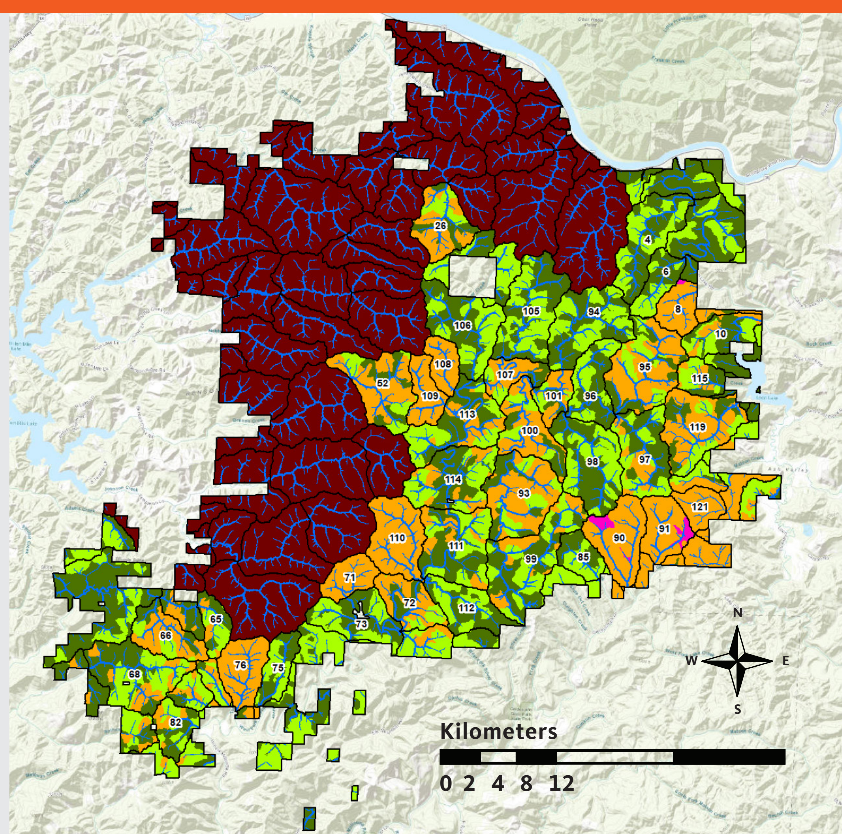


Figure 8. *Map showing proposed stand level allocation of MRW reserves, intensive, extensive, extensive reserve and GRCA (Generic Riparian Conservation Areas). GRCA is Generic Riparian Conservation Area and was estimated by buffer widths of 100ft and 50ft on fish bearing and non fish bearing streams respectively to achieve potential ~70% wood recruitment in the MRW. Extensive Reserve are areas of extensive stand treatments that are greater than 152 years old and will be placed in reserve status within those extensive allocations.*

4 Overlay potential reserves, intensive and extensive treatments, and adjust to better integrate reserves and extensive with NFB streams with high potential for wood recruitment. Forest reserves, extensive treatments, and RCA's will have the largest trees on the landscape, so they will best emulate historical conditions.

5 Calculate wood recruitment potential and compare against goal. Repeat as needed.

6 Create riparian systems in which different combinations of stream buffers on fish-bearing and non-fish-bearing systems achieve a stated goal for wood recruitment into FB streams.

7 Use riparian systems to test the effectiveness of buffer combinations relative to tradeoffs with other social and ecological attributes, such as habitat, accessibility, and fiber yield. Design several different wood recruitment strategies that meet the goal and develop an experiment to test effectiveness and tradeoffs with other values (see example Figure 8a and Table 8a).

Figure 8a. Two example buffer configurations with ~70% wood yield on the Elliott State Forest

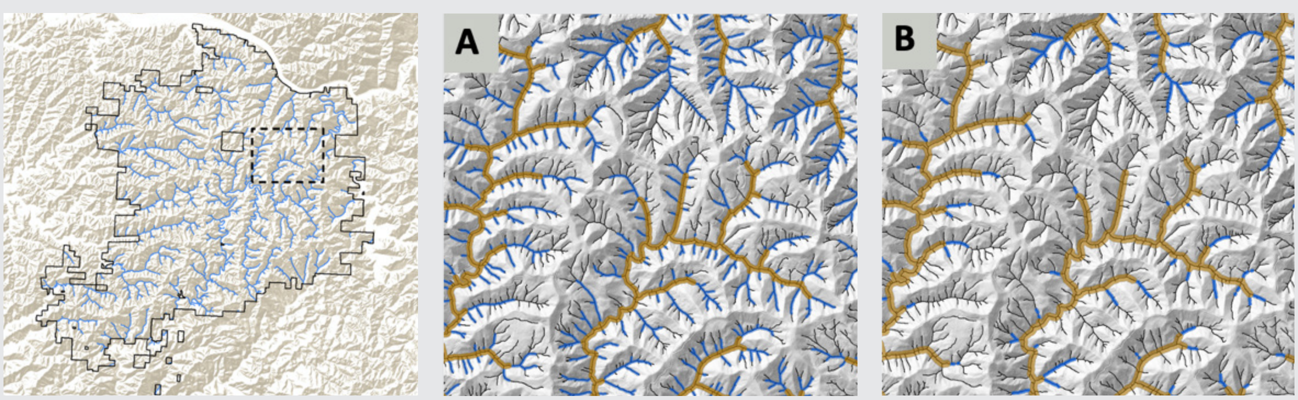


Table 8a. Two example riparian buffer width scenarios attaining ~70% wood recruitment

Alternative	FISH-BEARING			NON-FISH-BEARING			Total Modeled Stream Miles	Total ODF Stream Miles	Total NHD Stream Miles	Protected Potential Recruitment	Total NHD Stream Miles
	Buffer Width (ft)	Buffered Miles	Total FB Stream Miles	Buffer Width (ft)	Buffered Miles	Total NFB Stream Miles					
A	100	237	237	50	721	1,862	2,099	702	747	70%	16.5%
B	120	237	237	60	151	1,862	2,099	702	747	70%	10.8%

APPENDIX 9

Figures, Tables, and Photos

Provides figures, tables and photos illustrating the elements of the proposed research design for an Elliott State Research Forest.

Figure 5. Potential Subwatershed Triad Treatment Assignments

KEY

- CRW
- Extensive
- Triad-E
- Triad-I
- Reserve with Intensive
- MRW Partial

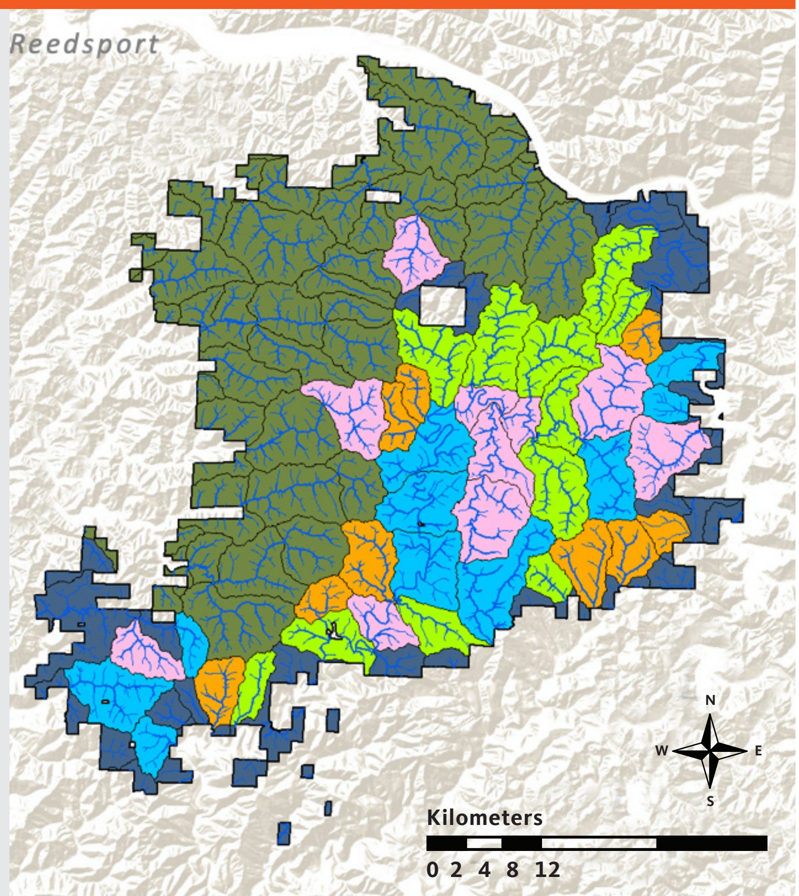


Figure 5. *Map illustrating the proposed western reserve area (Conservation Research Watershed; CRW, in dark green) and the potential allocation of subwatershed-scale Triad treatments in the ESRF's eastern part. Partial watersheds (dark blue) are only partly contained in the ESRF, so they will not have a formal subwatershed Triad treatment assigned. Map is based on August 2020 allocation.*

Figure 8. Proposed stand level allocation of extensive, instensive and reserve treatments

KEY

- MRW Reserve
- Intensive
- Extensive
- CRW
- Extensive Reserve (GT152)
- GRCA

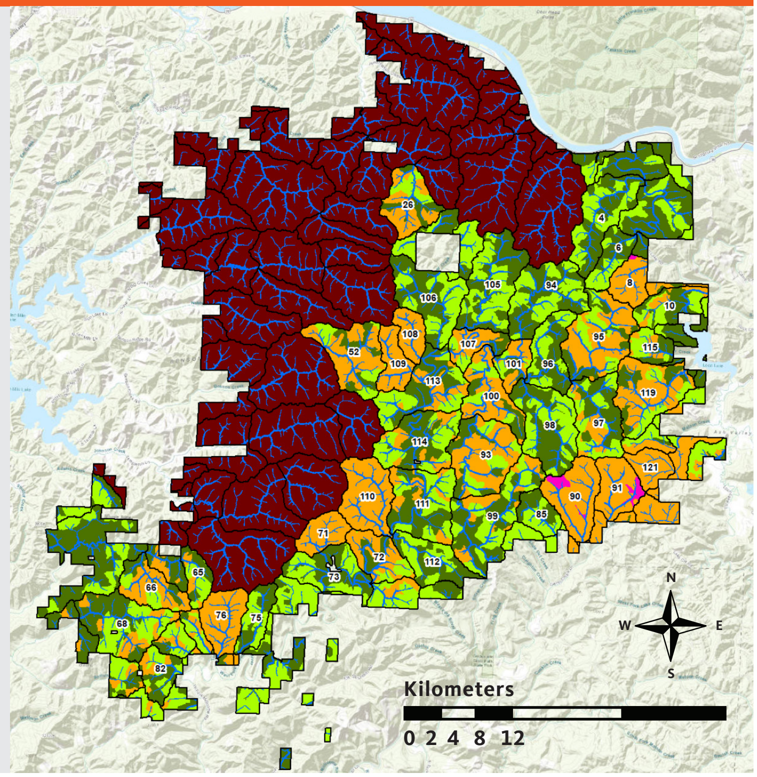


Figure 8. *Map showing proposed stand level allocation of MRW reserves, intensive, extensive, extensive reserve and GRCA (Generic Riparian Conservation Areas). GRCA is Generic Riparian Conservation Area and was estimated by buffer widths of 100ft and 50ft on fish bearing and non fish bearing streams respectively to achieve potential ~70% wood recruitment in the MRW. Extensive Reserve are areas of extensive stand treatments that are greater than 152 years old and will be placed in reserve status within those extensive allocations. Map based on August 2020 allocation.*

Table 4a. Stand-level Allocations by Age

Stand Age	STAND LEVEL ALLOCATIONS (ACRES)					ESRF Total
	MRW Intensive	MRW Extensive	MRW Reserve	MRW RCA	CRW (incl RCA)	
<= 65 yrs	14,334	10,047	1,905	2,852	12,528	41,666
> 65	0	3,366	12,190	3,686	21,612	40,854
Total	**14,334**	**13,413**	**14,096**	**6,538**	**34,140**	**82,520**

Table 4a. *Number of acres per treatment by age class on the proposed Elliott State Research Forest based on the August 2020 draft allocation and November 2020 Riparian Conservation Area (RCA) designations. We assume that forests 65 or younger are forests that regenerated following clearcuts and those over 65 years regenerated from natural disturbance, primarily wildfire.*

Table 4b. Stand-level Allocations by Age

Stand Age	STAND LEVEL ALLOCATIONS (PERCENT OF TOTAL FOREST AREA)					ESRF Total
	MRW Intensive	MRW Extensive	MRW Reserve	MRW RCA	CRW (inclu RCA)	
<= 65 yrs	17.4%	12.2%	2.3%	3.5%	15.2%	50.5%
> 65	0.0%	4.1%	14.8%	4.5%	26.2%	49.5%
Total	**17.4%**	**16.3%**	**17.1%**	**7.9%**	**41.4%**	**100.0%**

Table 4b. *Percent of acres per treatment by age class on the proposed Elliott State Research Forest based on the August 2020 draft allocation and November 2020 Riparian Conservation Area (RCA) designations.*

Table 9a. Acres per stand level treatment in each Triad subwatershed allocation based on August 2020 draft allocation

Subwatershed Level Triad Treatment	STAND-LEVEL ALLOCATION (ACRES)					ESRF Total
	MRW Intensive	MRW Extensive	MRW Reserve	CRW Reserve	RCA	
Extensive	0	5,028	146	0	756	5,930
Triad-E	1,691	4,985	1,650	0	1,452	9,778
Triad-I	3,550	1,759	3,422	0	1,591	10,322
Reserve with Intensive	4,715	0	4,638	0	1,508	10,861
MRW Partial	4,378	1,641	4,242	0	1,229	11,490
CRW	0	0	0	34,139	Included in CRW acres	34,139
Total Acres	**14,334**	**13,413**	**14,098**	**34,139**	**6,536**	**82,520**

Table 9a. *Estimated acres per stand level treatment in each Triad subwatershed allocation based on the August 2020 draft allocation. The Riparian Conservation Area (RCA) was allocated as proposed in November 2020 and described in Appendix 6.*

For political, ethical, and logistical reasons we deliberately chose not to implement a fully randomized design to test the Triad at the Elliott. There are several important scientific reasons for random allocation of treatments. Most importantly, randomization avoids true bias. For instance, it might not be by chance that old forest remains where it does (e.g., steep slopes, low productivity forest). To explore this possibility, we tested whether the particular watershed-scale treatments tended to fall on steeper slopes than others, or were characterized by higher site-quality ground. We found no evidence for such biases, except that our "extensive" treatment watersheds tend to be smaller, on average.

Figure 9a. tests for whether lack of fully random subwatershed-scale treatments at the Elliott resulted in any substantial confounding between treatments and other underlying features at the Elliott State Forest. If this were the case, it would be possible to mis-attribute treatment effects when in fact other features were the cause. Neither elevation, site index, precipitation showed substantial differences among treatments. Only watershed areas in the Extensive treatment tended to be smaller than the other treatments. Not that the CRW (Conservation Research Watershed) is not a formal treatment, so the differences above are not detrimental to the overall Triad design.

Figure 9a.

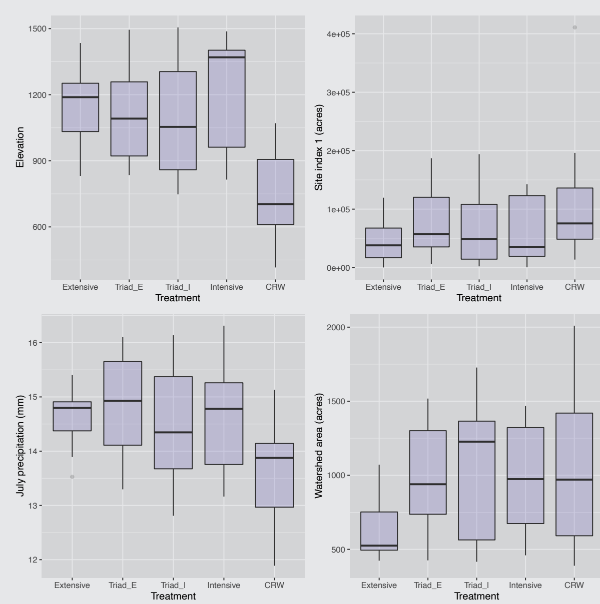


Figure 9a. *Analysis of subwatershed treatments for bias in elevation, July precipitation, site index and watershed area on the Elliott State Forest.*

Photo 1. Range of age classes in the Upper end of Big Creek Management Basin

Photo 1. *Photo illustrating the range of age classes in the ESF as shown in the Upper end of Big Creek Management Basin. All stand ages were based on information provided by DSL GIS data. Photo from Scott Harris.*

Photo 2. ESF looking NW from the top of Dean Mountain

Photo 2. *Photo of the Elliott State Forest (ESF) looking NW from the top of Dean Mountain. Photo illustrates the road network, mosaic of clear-cuts, young plantations, and older stands current in the Elliott State Forest. Photo from Scott Harris.*

Photo 3. Diversity of age classes

Photo 3. *Photo of a stand in the Elliott State Forest that includes a diversity of age classes. This photo is illustrative of the types of complex forest that would be generated through extensive harvest treatments in an Elliott State Research Photo.*

Photo 4. Dean Mountain

Photo 4. *Photo taken from the top of Dean Mountain in the ESF. The clear-cut on the right side of the photo is illustrative of intensive, production oriented, harvest treatments that would be conducted under the current research design in parts of the ESRF. Photo by Katy Kavanagh.*

Photo 5. Jerry Phillips Reserve

Photo 5. *Old growth forest in Jerry Phillips Reserve. The DSL GIS information ages these stands at 172 years, signs in the grove state 250 years (photo from Scott Harris). This photo is illustrative of the potential for the upwards of 65% of the proposed ESRF that will be in reserve treatment. These forests will be managed for conservation, over time adding to the amount of older forest in the Oregon Coast Range.*

APPENDIX 10

Power Analysis of the Elliott State Forest Research Design

Report prepared by:
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College of Forestry, Oregon State University

SUMMARY

One component of the Elliott State Forest Research Design is to examine how a Triad-based forest management plan can integrate timber output and biodiversity conservation, over broad spatial and long temporal scales. To support this experimental design, we conducted a power analysis that examined the effect of altering the number of replicates of subwatershed scale treatments on the probability of detecting differences in important response variables. Our analysis helps to answer the question: does the experimental design with 9 to 11 replicates have the statistical power to detect differences in important responses over the course of a 100-year experiment? Our nine response variables were carbon stored in live and dead trees, the densities of seven early seral songbird species, and potential nesting platforms for marbled murrelets. We developed a forest planning model with the Woodstock software package that optimized the timing of harvests for even timber flow and calculated our estimated responses over a 100-year planning horizon. Our power analysis using these estimated responses showed high power at 100 years (all responses) and 50 years (8 out of 9 responses). Estimated power at 20 years was affected by the number of treatment replicates. These results suggest that the current experimental design has sufficient sample size to detect differences by at least 50 years. However, this conclusion should not be extrapolated for other responses we did not examine. Furthermore, our model does not account for important effects such as natural disturbance, climate change, and the surrounding landscape – factors that can potentially increase error and therefore lower statistical power. We discuss limitations in detail at the end of this report.

WOODSTOCK

We developed our forest planning model with the Woodstock forest planning software (Remsoft Corporation, Fredericton, New Brunswick, Canada) to parameterize response variables and run a 100-year Triad-based forest management plan based on the Elliott State Forest Research Design. Woodstock uses linear programming to optimize the timing of specified forest management activities. Woodstock is widely used by the global forest industry and has been used to model Triad forest management approaches in Canada (MacLean et al. 1999, Ward and Erdle 2015).

Figure 3. Percentage of reserve, intensive and extensive treatments in the TRIAD framework

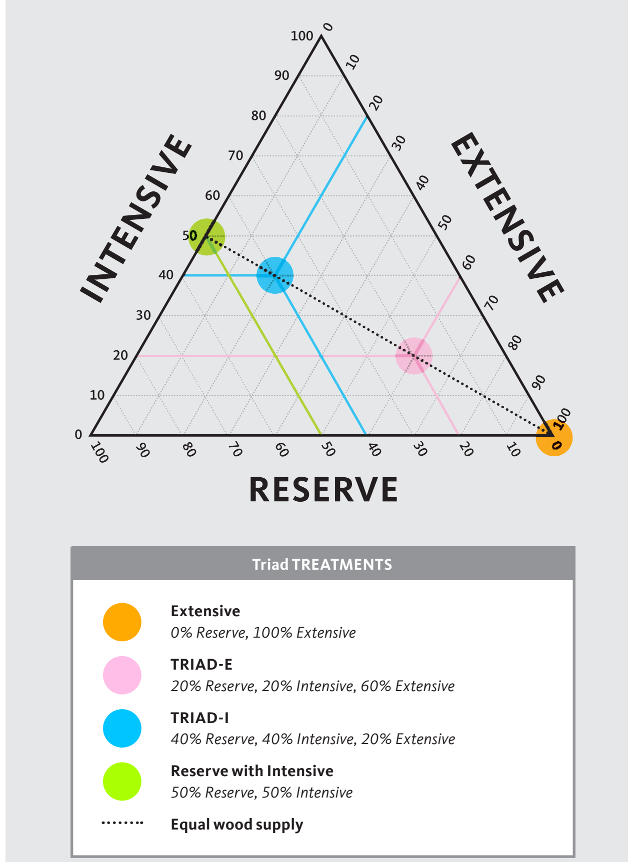

***Figure 3.** Conceptualizing the four different Triad Treatments. Each colored dot represents a subwatershed level Triad treatment. The text below specifies the proportions of stand level research treatments (intensive, extensive, reserve).*

We used Woodstock to optimize the timing of harvests in the intensive and extensive stand-level treatments to meet our goal and constraints, and then calculate responses at each 5-year planning period. Our goal (objective function) was to maximize the combined timber harvest (but constrain harvest in each subwatershed, see below), at each planning period, for the 32,573 acres that comprise the Managed Research Watersheds (Figure 10a). Our constraints were based on the Elliott State Forest Research Design as follows:

1. **Upper limit of timber output for each subwatershed.**
   The research design specifies that the four watershed-level treatments in the Managed Research Watersheds (MRW) produce equal wood supply (Figure 3). We calculated that quantity to be 3.01 mbf/ac per 5-year planning period. This calculation was based on the average yield from the 11 intensive subwatersheds (where approximately 50% of the acres are intensive and 50% are reserve), assuming a clearcut harvest at 60 years, and using the regenerated intensive

Figure 10a.

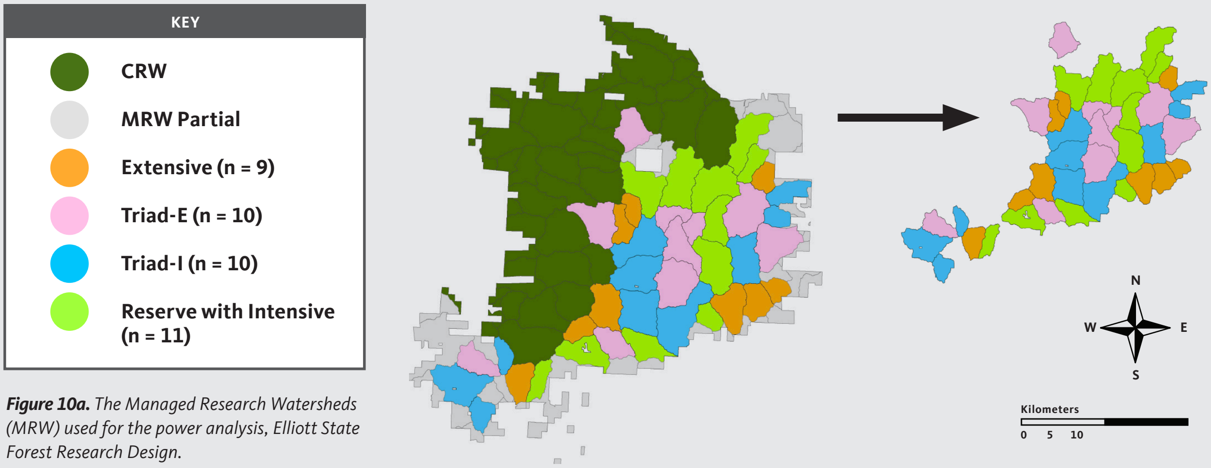

Figure 10a. *The Managed Research Watersheds (MRW) used for the power analysis, Elliott State Forest Research Design.*

stand yield tables provided by Mason, Bruce, and Girard (see description below). In Woodstock, we specified that the timber output for each subwatershed (harvests plus any commercial thinnings) cannot exceed 3.10 mbf/ac/period. This subwatershed timber yield constraint is equivalent to a timber yield of 19.6 MMBF/yr for the Elliott State Forest. Historically, the Elliott State Forest produced an average of 51.5 MMBF (1972-01968), 17.74 MMBF (1991-1996), and 25 MMBF (1995-2010) of timber per year across an approximately 90,000 acre forest (Phillips 1996, ODSL-ODF 2011).

2 **Sustainability.** To ensure that Woodstock did not "overharvest" and that the research design would be sustainable indefinitely, we specified that the inventory of merchantable volume at the end of our planning horizon (100 years) in each subwatershed meet or exceed the starting inventory. This quantity was calculated for each subwatershed.

3 **Even harvest flow.** To ensure that timber supply from the whole forest was relatively constant, we specified that the combined yield from harvests and commercial thinnings never varied by more than 10% over subsequent 5-year periods for the 100-year planning horizon.

TREATMENTS

SUBWATERSHED LEVEL TREATMENTS

We used the Managed Research Watershed (MRW) allocations according to the September 2020 version of the Elliott State Forest Research Design. Conservation Research Watersheds were not included in this analysis (Figure 10a). We removed the 9,061 acres assigned to riparian management zones and the "MRW partial" treatment – resulting in 32,574 acres for our analysis. Subwatershed treatments and number of replicates in the MRW consisted of: Extensive (n=9), Triad-E (n=10), Triad-I (n=10), and Reserves with Intensive(n=11). Henceforth, we refer to this set of replicates as the "complete sample".

STAND-LEVEL TREATMENTS

We also assigned stand level treatments according to the September 2020 allocations. Specific stand-level treatments (e.g. the timing and type of thinning and harvest) are dictated by Woodstock model limitations and the growth and yield estimates provided by Mason, Bruce, and Girard (MBG). Allowing for multiple timing options for commercial thinning greatly increases the complexity of Woodstock models, so we specified the timing of commercial thinning, but allowed the timing of harvest to be optimized based on our model goal and constraints. The MBG growth and yield estimates are based on the 2014 inventory of the Elliott State Forest. The MBG growth and yield estimates and the stand-level treatment simulations were done during a 2019 financial analysis. The week prior to this report, MBG provided another set of estimated yields that modeled different treatments than we describe here. There was insufficient time for us to develop a new Woodstock model based on these new yield projections. Details of stand-level treatments from 2019 we used for our analysis are:

1 **Reserve stands.** Grow only. No management actions (Figure 10b - A).

2 **Intensive stands.**

A **Existing stands.** For stands younger than 40 years, a commercial thin occurs when those stands reach 40 years of age and if relative density meets a commercial thin threshold. Clearcut harvest can occur anytime at 45 years or later (Figures 10b - B and 10b - C).

B **Future stands.** Following clearcut harvest, MBG modeled future stand development using a forest inventory from an intensive management regime (site preparation and broadleaf release control with herbicides, pest control (beaver), and dense planting of Douglas fir). Future stands are commercially thinned at 40 and 60 years of age and are eligible for clearcut harvest starting at 65 years.

3 **Extensive stands.**

A **Existing stands.** For stands younger than 60 years, a commercial thin occurs when those stands reach 60 years of age and if relative density meets a commercial thin threshold. An RD20 harvest can occur anytime at 90 years or later. The RD20 harvest is intended to represent an extensive, or ecological forestry, type of treatment where the harvest reduces Curtis' Relative Density to 20. For a 100 year-old stand, the RD20 harvest is roughly equivalent to a 30% dispersed retention harvest (Figure 10b - D).

B **Future stands.** Following harvest, MBG modeled future stand development starting with the trees retained from the RD20 harvest. These retained trees were evenly distributed across diameter classes. To account for expected delays in regeneration and slower growth due to the presence of an overstory, regeneration establishment was delayed by 20 years. Future stands are commercially thinned at 60 years of age and are eligible for RD20 harvest starting at 90 years.

4 **Commercial thinning.** Commercial thinning is the same prescription in intensive and extensive stands. Stands are thinned to 40% maxSDI, evenly distributed across all diameter classes.

ESTIMATING YIELDS AND RESPONSES

TIMBER

We used the yield tables provided by MBG to calculate timber yields from harvest and thinning activities, as previously described.

CARBON

We used published forest volume-to-biomass models to estimate stored carbon in live and dead standing trees (Jenkins 2003, Smith et al. 2003). Jenkins (2003) conducted a meta-analysis to develop individual-tree diameter-based regression equations for estimating biomass for multiple tree species in the United States. This approach is widely used to estimate national-scale forest carbon stocks when detailed inventory data are available. To forecast carbon stocks based on growth and yield models at stand scales, Smith et al (2003) expanded the scope of this work by developing stand volume-to-biomass regressions. The Smith regressions estimate the biomass of standing live and dead trees, including coarse roots. For our analysis, we use the volume provided by the MBG yield tables and the Smith regressions for Douglas-fir forests on the west-side of the Cascade Mountains. Carbon was then estimated to be 50% of our calculated biomass (Schlesinger 1991).

SONGBIRDS

We chose seven species of songbirds that utilize early seral forests, represent a wide range of habitat preferences, for which we have sufficient data, and met at least one of the following additional criteria:

Figure 10b.

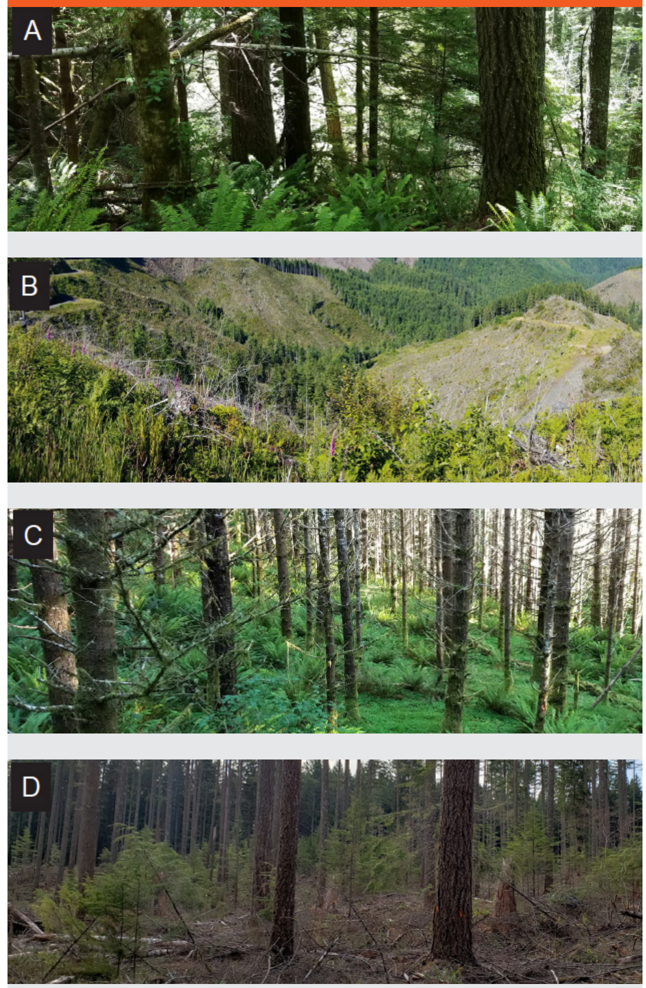

Figure 10b. *Representative examples of stand-level treatments. A) Reserve, 169 years. B) Intensive, 3 years. C) Intensive, 47 years. D) Extensive, 1 year. A, B, and C are stands in the Elliott State Research Forest. D is a BLM stand in the west Oregon Cascades (BLM photo).*

1 Are a species of regional concern according to the Partners in Flight Database (PIF 2020a, PIF 2020b): rufous hummingbird, willow flycatcher, black-throated gray warbler, golden-crowned kinglet,

2 The Pacific Northwest region contains at least 60% of their breeding population: rufous hummingbird, hermit warbler,

3 Are uniquely representative of early seral forest habitat: willow flycatcher, orange-crowned warbler, Wilson's warbler.

We collated estimates of songbird densities from published studies conducted in forests of the Oregon Coast Range and the west side of the Oregon Cascades, as well as data from unpublished sources (Table 10a).

Figure 10c.

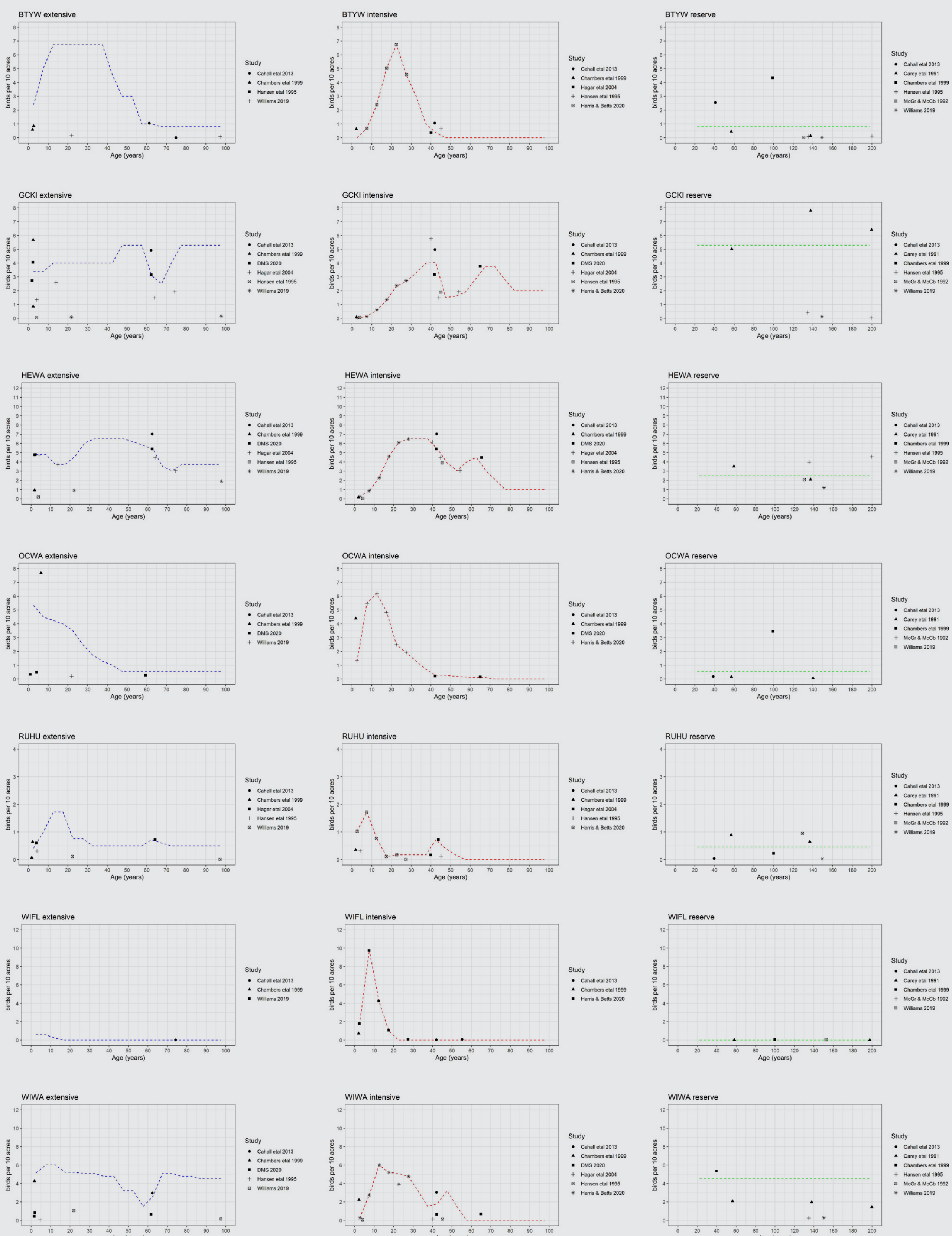

__Figure 10c.__ Estimated responses of the density of 7 early-seral songbird species as a function of stand age, for the three stand-level treatments of the Elliott State Forest Research Design. Estimated responses are indicated by the dashed lines. Empirical data and sources are indicated by the symbols.

Table 10a.

Study	STAND LEVEL RESEARCH TREATMENTS: Intensive	Extensive	Reserve	Study Area
Harris and Betts. In prep	X			Central Oregon Coast Range
Williams 2019		X	X	Oregon Coast Range, W. Oregon Cascades
Density Mgmt Study, unpub.	X	X		Western Oregon
Cahall et al. 2013	X	X	X	Tillamook State Forest
Hagar et al. 2004	X	X		Willamette National Forest
Chambers et al. 1999	X	X	X	McDonald-Dunn Forest (OSU)
Hansen et al. 1995	X	X	X	W. Oregon Cascades
McGarigal & McComb 1992			X	Central Oregon Coast Range
Carey et al. 1991			X	Central Oregon Coast Range

Table 10a. *Sources of empirical data used for deriving estimated response curves of 7 songbird species to management treatments. The extensive treatments described in each of these studies only approximated the extensive treatment defined in the Elliott State Forest Research Design. We assigned the treatments described in each study to one of our Triad stand-level treatments (reserve, intensive, extensive). We plotted these estimates as a function of stand age and treatment, then relied on expert opinion to fill in gaps in the empirical data. We made every effort to consistently convert the raw abundance numbers reported in these studies to a density estimate (birds per 10 acres). The available data for treatments that approximated our intensive stand treatment were robust and at relatively fine temporal scale. The data for the reserve treatment was sparse, but we assumed songbird densities in reserve stands to be relatively constant because of the advanced age of the stands and the lack of treatments. For the extensive treatment, we relied heavily on expert opinion due to the paucity of data for extensive forest management. Figure 10c shows our estimated response curves.*

NESTING PLATFORMS FOR MARBLED MURRELET

We used empirically-based estimates of potential tree-branch nest platforms for murrelets. Platforms are good predictors of nesting habitat for murrelets (Burger et al. 2010) and platforms have been shown to be the best-performing covariate when comparing model predictions to known nesting sites (Raphael et al. 2011). Potential nesting platforms are defined as horizontal tree limbs with a diameter of at least 6 inches. Using a large sample of trees, Raphael et al. (2011) developed estimates of the number of platforms by tree diameter class for multiple conifer species. We combined this data with the MBG growth models to estimate the number of potential platforms as a function of age in each stand. Figure 10d shows the estimated change in density of potential murrelet nesting platforms for each subwatershed level treatment over the 100-year planning horizon.

Figure 10d. Estimates of Potential nesting platforms for Marbled Murrelets

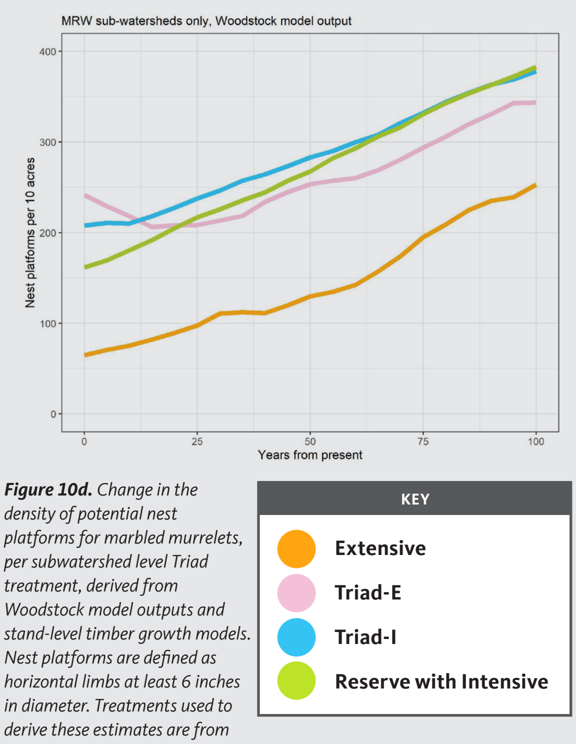

Figure 10d. *Change in the density of potential nest platforms for marbled murrelets, per subwatershed level Triad treatment, derived from Woodstock model outputs and stand-level timber growth models. Nest platforms are defined as horizontal limbs at least 6 inches in diameter. Treatments used to derive these estimates are from the previous 2019 treatment descriptions and differ from the current ESRF treatments. For example, the extensive harvest treatment used for this model removed a greater density of large trees than in the current proposal for the ESRF, and therefore this model likely represents a conservative estimate of platform density. We used nest platforms primarily as a variable to determine the power to detect a difference among treatments, and not to estimate the amount of habitat suitability for murrelets."*

THE POWER ANALYSIS

Power is the long-run probability of detecting a specific effect given that the effect exists. A power analysis can be used to estimate power for a given alpha level (here we use 0.05), sample size per group, and defined effect sizes and variances. In our power analysis, groups are the subwatershed treatments and effect sizes and variances are defined as the Woodstock Model outputs for the complete sample of Managed Research Watersheds (11 Reserves with Intensive, 10 Triad-I, 10 Triad-E, and 9 Extensive subwatersheds). In a simulation-based power analysis, true effects are defined and then assumptions from the model used for analysis are assumed to be true.

Our analysis is based on a Welch's ANOVA, which assumes normality of errors but variances can differ among treatments (Welch 1951). Therefore, we assume that the observed values in a sample taken will follow a normal distribution that is defined by the Woodstock Model outputs for each treatment. Since there is variability around our defined true mean, any observed sample will contain different values; how different each sample is depends on the variability around the effects. To estimate power we draw some number of samples (1000 draws, or simulations, in our analysis) per treatment from our defined distribution, fit the model we expect to use, and record the p-value from the overall F test that tests against the null hypothesis that the means for all treatments are the same. We then estimate power as the proportion of times we reject the null hypothesis based on our defined alpha across all simulations. To estimate power at different sample sizes, we vary the number of samples per treatment.

Note that for any given field experiment we will only take a single sample. Power is a theoretical construct about long-run behavior to help with study planning as long as 1) our estimates of effects and variances are reasonably what we expect and 2) model assumptions are met and so the distribution we draw samples from mirrors what can truly happen in the landscape.

In our power analysis, the Woodstock model run gives us estimates of values for every subwatershed. There are no other subwatersheds to select. What does the power analysis do for us in this case? We still assume that if we actually take a sample on the group there will be variability in the outcome, based on the variability around the Woodstock-based estimates. Power analysis allows us to understand if we are likely to reject the overall null hypothesis for different sample sizes based on the modeled effect sizes and variances.

Code for power analysis is available on GitHub at https://github.com/aosmith16/elliott-power

RESULTS

TIMBER

Our Woodstock model run over a 100-year planning horizon resulted in an annual timber yield of 16.8 MMbf. This annual yield was lower than our upper limit of 19.6 MMbf likely due to the timing limits imposed by our additional model constraints. All existing intensive stands were harvested by year 60 and 99% of existing extensive stands were harvested by year 100. The average stand age at harvest for the existing intensive and existing extensive stands was 55 and 105 years, respectively.

ESTIMATED POWER FOR THE 9 RESPONSE VARIABLES

At the end of the 100 year planning horizon, the estimated power for all 9 responses was greater than 0.8, for sample sizes of 6 and greater. After 50 years, the estimated power for all responses except orange-crowned warblers was greater than 0.8, for sample

Figure Set 1. Stored Carbon

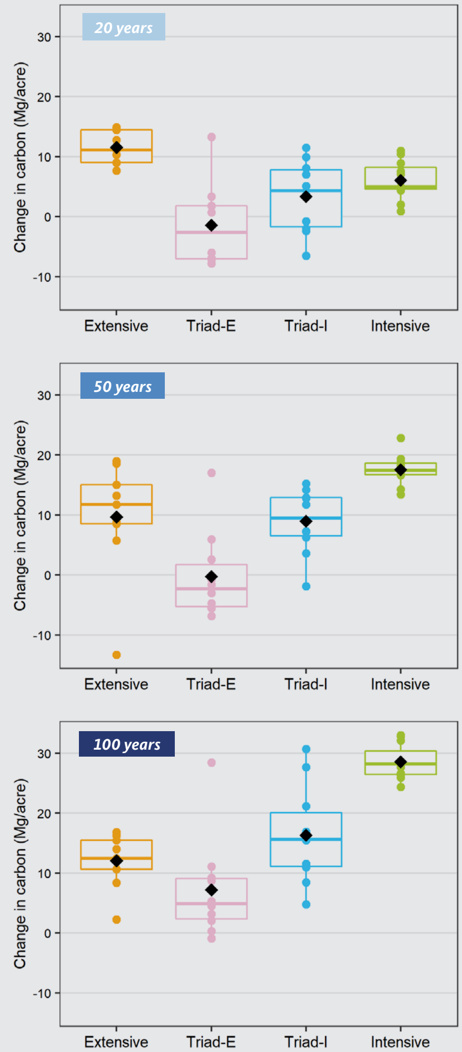

Figure Set 1. Boxplots (above). *Estimates of the change in stored carbon (standing live and dead trees including coarse roots) between the specified time and initial carbon stores at the beginning of the forest planning model (year 2020), for the complete sample of the four subwatershed treatments, Elliott State Forest Research Design. Mean responses are indicated by the black diamonds. The complete sample is Extensive (n=9), Triad-E (n=10), Triad-I (n=10), and Intensive (n=11).*

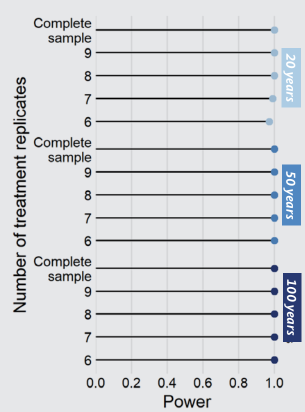

Figure Set 1. Power plot (left). *The estimated power to detect a difference among the treatment means, for different sample sizes (number of subwatershed treatment replicates) at 20, 50, and 100 years.*

Figure Set 2. Orange-crowned warbler

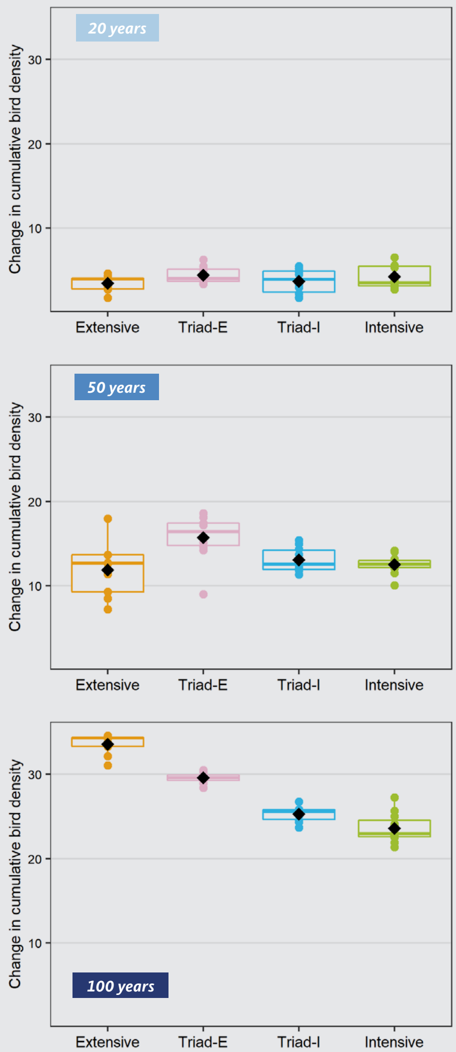

Figure Set 2. Boxplots (above). *Estimates of the change in cumulative density (birds per 10 acres) of orange-crowned warblers between the specified time and initial density at the beginning of the forest planning model (year 2020), for the complete sample of the four subwatershed treatments, Elliott State Forest Research Design. For example, the "20 years" boxplot is the cumulative density over the first 4 5-year periods minus the initial density. Estimates derived from the Woodstock forest planning model. Mean responses are indicated by the black diamonds. The complete sample is Extensive (n=9), Triad-E (n=10), Triad-I (n=10), and Intensive (n=11).*

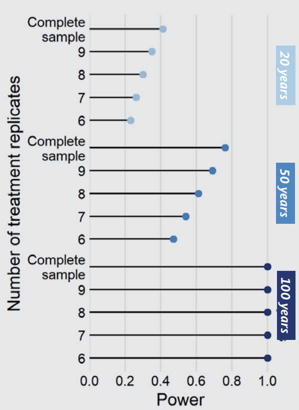

Figure Set 2. Power plot (left). *The estimated power to detect a difference among the treatment means, for different sample sizes (number of subwatershed treatment replicates) at 20, 50, and 100 years.*

Figure Set 3. Marbled murrelet

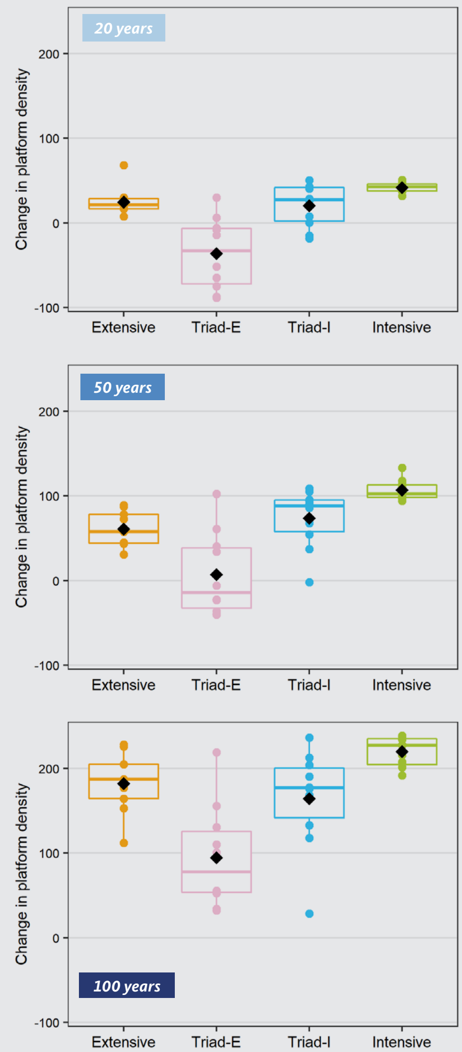

Figure Set 3. Boxplots (above). *Estimates of the change in density (platforms per 10 acres) of potential nesting platforms for marbled murrelets between the specified time and the initial density at the beginning of the forest planning model (year 2020), for the complete sample of the four subwatershed treatments, Elliott State Forest Research Design. Estimates derived from the Woodstock forest planning model. Mean responses are indicated by the black diamonds. The complete sample is Extensive (n=9), Triad-E (n=10), Triad-I (n=10), and Intensive (n=11).*

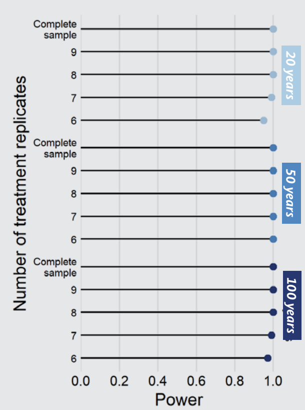

Figure Set 3. Power plot (left). *The estimated power to detect a difference among the treatment means, for different sample sizes (number of subwatershed treatment replicates) at 20, 50, and 100 years.*

sizes of 6 and greater. After 20 years, the estimated power was affected by sample size for all responses except carbon, golden-crowned kinglets, and hermit warblers. For example, we estimated a minimum sample size of 6 in order for power to be at least 0.8 for marbled murrelet nest platforms. Figure sets 1-3 (for carbon, orange-crowned warblers, and murrelet platforms, respectively) are good examples of the range of the influence of sample size and time on power. For carbon, we estimated high power for all sample sizes and times. For orange-crowned warblers, we estimated low power for all sample sizes until year 100. And the estimated power for marbled murrelet falls between these two extremes. We show results for the other 6 response variables in Figure sets 4-9.

LIMITATIONS

Several limitations and caveats are important to consider when making inference about the results of this power analysis. Any of the following limitations could increase uncertainty around our estimated responses. Therefore, our estimates of the minimum number of replicates to achieve satisfactory power should be considered conservative.

Modeling processes

1. Woodstock does not easily allow for the modeling of variability around timber yield estimates and the responses. The implication is that, for example, the error around the point estimate for the density of a songbird at 10 years in one of the treatments is not propagated to the watershed-level estimates, nor to the treatment-level estimates.

2. There will be many other response variables measured in the actual experiment. Our power analysis may not apply for these additional variables. Also, the effect sizes of importance for these additional variables may differ from our estimates, again affecting power to detect differences.

3. We had insufficient empirical data to validate our estimated response curves for the 7 songbird species and the habitat score for marbled murrelet.

4. There is a paucity of empirical and observational data for the extensive treatment – one good reason for this experiment! We relied more on expert opinion for estimating responses to the extensive treatment than for the intensive and reserve treatments.

5. Assumptions inherent to power analyses are described above.

Ecological processes

1. Our models do not account for natural disturbances or changing environmental conditions, such as those induced by climate change. In our analysis, we assume that environmental conditions are constant throughout the 100-year planning horizon.

2. We estimated our responses for songbirds and marbled murrelet based on stand age. In this way, we assume that stand age is a surrogate for the full suite of changing habitat conditions in the forest.

Figure Set 4. Black-throated gray warbler

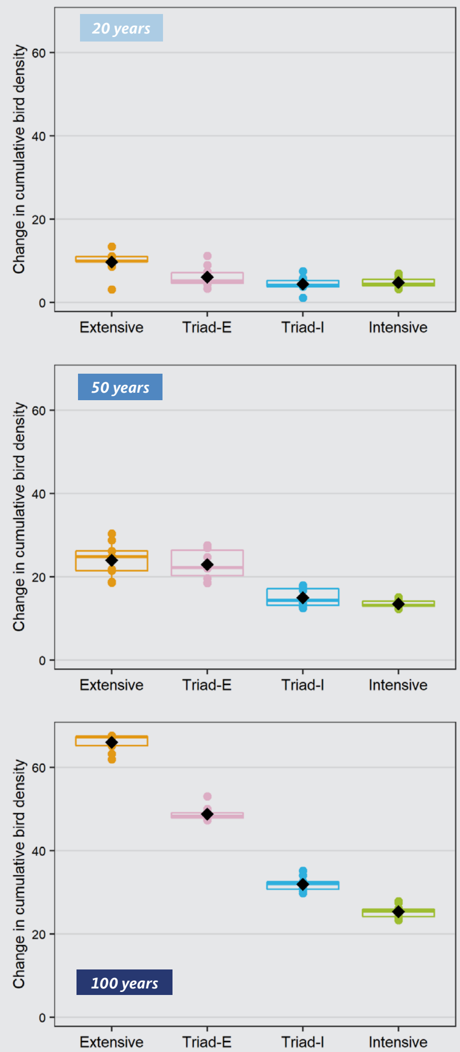

Figure Set 4. Boxplots (above). *Estimates of the change in cumulative density (birds per 10 acres) of black-throated gray warblers between the specified time and initial density at the beginning of the forest planning model (year 2020), for the complete sample of the four subwatershed treatments, Elliott State Forest Research Design. For example, the "20 years" boxplot is the cumulative density over the first 4 5-year periods minus the initial density. Estimates derived from the Woodstock forest planning model. Mean responses are indicated by the black diamonds. The complete sample is Extensive (n=9), Triad-E (n=10), Triad-I (n=10), and Intensive (n=11).*

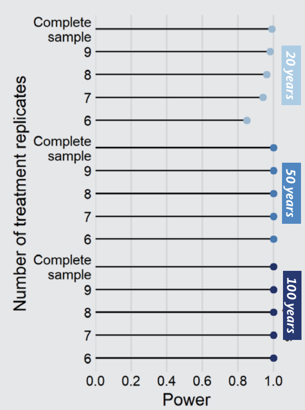

Figure Set 4. Power plot (left). *The estimated power to detect a difference among the treatment means, for different sample sizes (number of subwatershed treatment replicates) at 20, 50, and 100 years.*

Figure Set 5. Golden-crowned kinglet

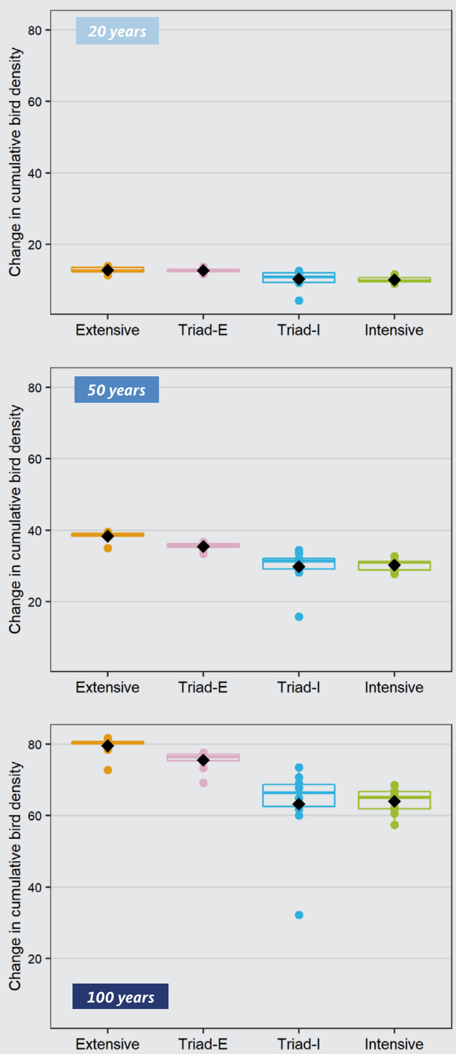

__Figure Set 5. Boxplots (above).__ Estimates of the change in cumulative density (birds per 10 acres) of golden-crowned kinglets between the specified time and initial density at the beginning of the forest planning model (year 2020), for the complete sample of the four subwatershed treatments, Elliott State Forest Research Design. For example, the "20 years" boxplot is the cumulative density over the first 4 5-year periods minus the initial density. Estimates derived from the Woodstock forest planning model. Mean responses are indicated by the black diamonds. The complete sample is Extensive (n=9), Triad-E (n=10), Triad-I (n=10), and Intensive (n=11).

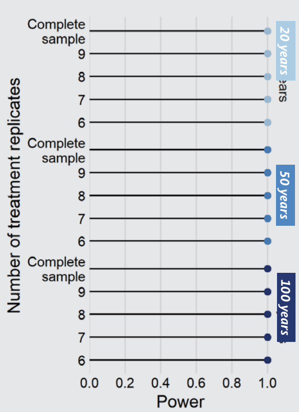

__Figure Set 5. Power plot (left).__ The estimated power to detect a difference among the treatment means, for different sample sizes (number of subwatershed treatment replicates) at 20, 50, and 100 years.

Figure Set 6. Hermit warbler

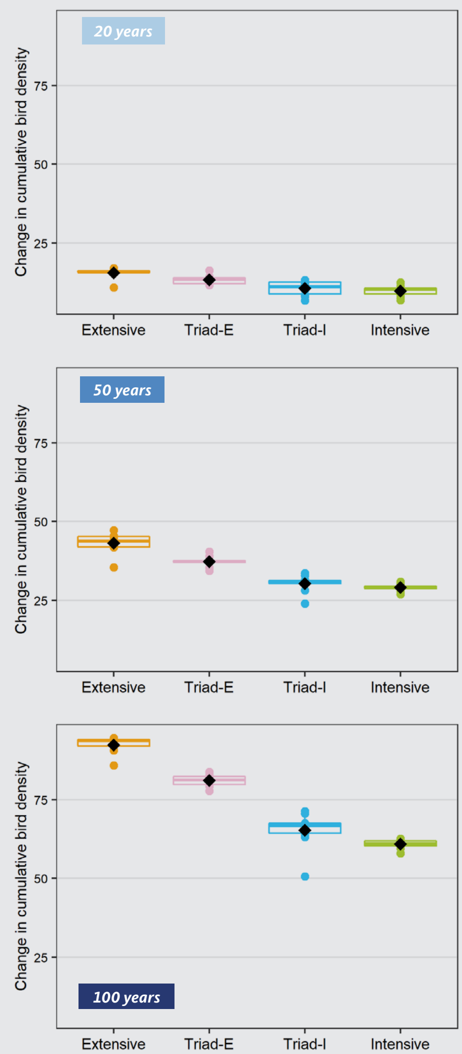

__Figure Set 6. Boxplots (above).__ Estimates of the change in cumulative density (birds per 10 acres) of hermit warblers between the specified time and initial density at the beginning of the forest planning model (year 2020), for the complete sample of the four subwatershed treatments, Elliott State Forest Research Design. For example, the "20 years" boxplot is the cumulative density over the first 4 5-year periods minus the initial density. Estimates derived from the Woodstock forest planning model. Mean responses are indicated by the black diamonds. The complete sample is Extensive (n=9), Triad-E (n=10), Triad-I (n=10), and Intensive (n=11).

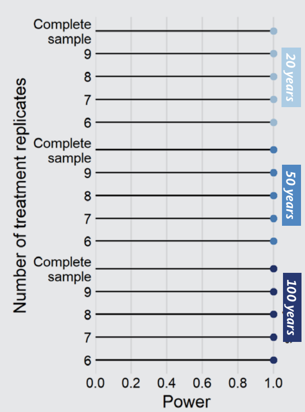

__Figure Set 6. Power plot (left).__ The estimated power to detect a difference among the treatment means, for different sample sizes (number of subwatershed treatment replicates) at 20, 50, and 100 years.

3 Our estimates do not account for landscape and riparian effects. This is particularly important for marbled murrelets as they are known to be negatively influenced by forest edges (van Rooyen et al. 2011), and the prevalence of nest predators in the surrounding landscape (Malt and Lank 2009).

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Figure Set 7. Rufous hummingbird

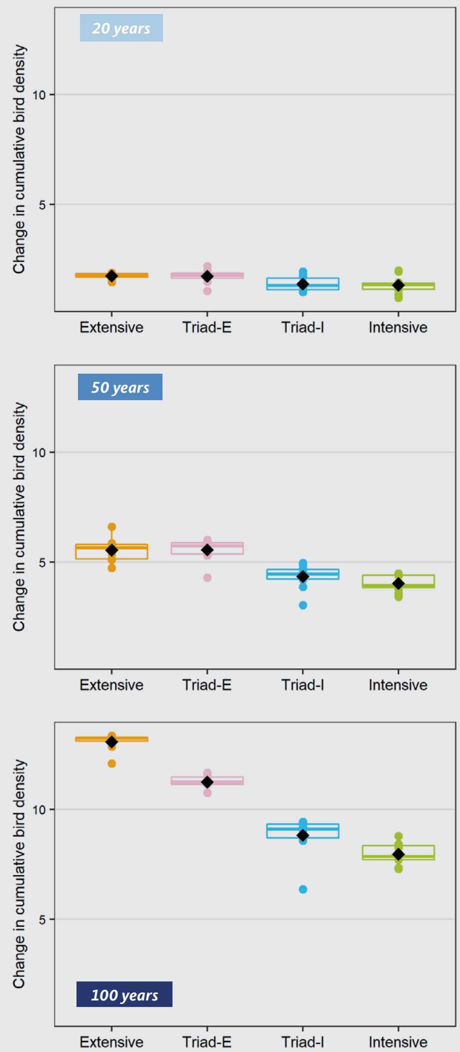

Figure Set 7. Boxplots (above). *Estimates of the change in cumulative density (birds per 10 acres) of rufous hummingbirds between the specified time and initial density at the beginning of the forest planning model (year 2020), for the complete sample of the four subwatershed treatments, Elliott State Forest Research Design. For example, the “20 years” boxplot is the cumulative density over the first 4 5-year periods minus the initial density. Estimates derived from the Woodstock forest planning model. Mean responses are indicated by the black diamonds. The complete sample is Extensive (n=9), Triad-E (n=10), Triad-I (n=10), and Intensive (n=11).*

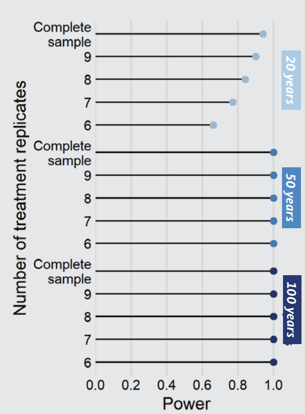

Figure Set 7. Power plot (left). *The estimated power to detect a difference among the treatment means, for different sample sizes (number of subwatershed treatment replicates) at 20, 50, and 100 years.*

Figure Set 8. Willow flycatcher

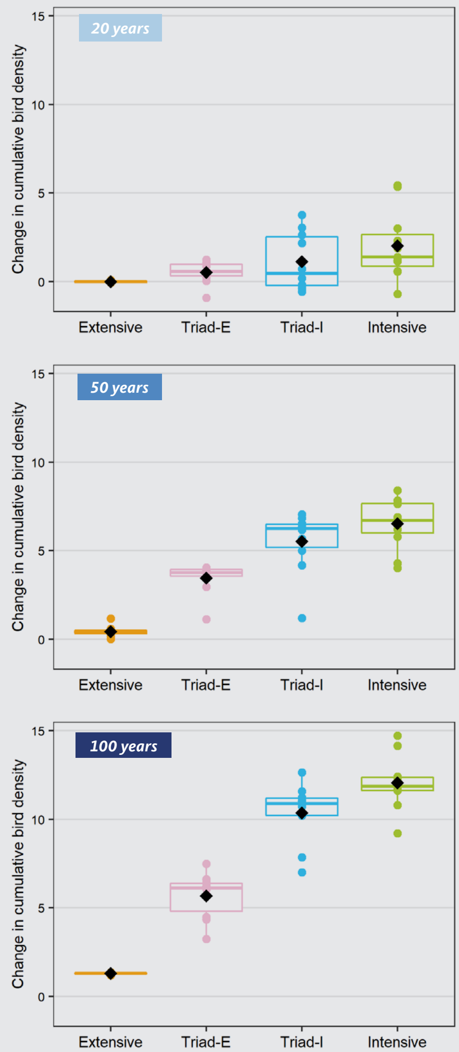

Figure Set 8. Boxplots (above). *Estimates of the change in cumulative density (birds per 10 acres) of willow flycatchers between the specified time and initial density at the beginning of the forest planning model (year 2020), for the complete sample of the four subwatershed treatments, Elliott State Forest Research Design. For example, the "20 years" boxplot is the cumulative density over the first 4 5-year periods minus the initial density. Estimates derived from the Woodstock forest planning model. Mean responses are indicated by the black diamonds. The complete sample is Extensive (n=9), Triad-E (n=10), Triad-I (n=10), and Intensive (n=11).*

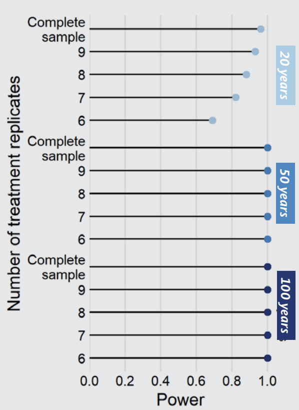

Figure Set 8. Power plot (left). *The estimated power to detect a difference among the treatment means, for different sample sizes (number of subwatershed treatment replicates) at 20, 50, and 100 years.*

Figure Set 9. Wilson's warbler

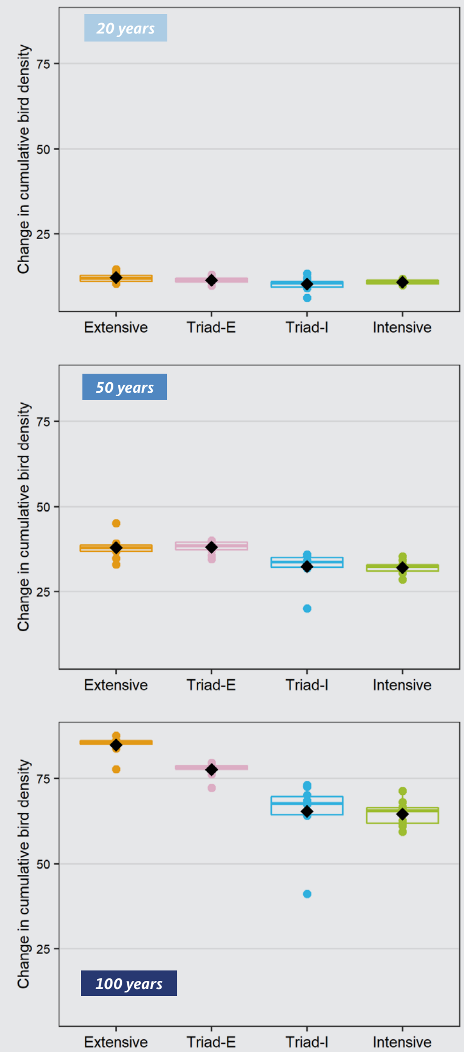

Figure Set 9. Boxplots (above). *Estimates of the change in cumulative density (birds per 10 acres) of Wilson's warblers between the specified time and initial density at the beginning of the forest planning model (year 2020), for the complete sample of the four subwatershed treatments, Elliott State Forest Research Design. For example, the "20 years" boxplot is the cumulative density over the first 4 5-year periods minus the initial density. Estimates derived from the Woodstock forest planning model. Mean responses are indicated by the black diamonds. The complete sample is Extensive (n=9), Triad-E (n=10), Triad-I (n=10), and Intensive (n=11).*

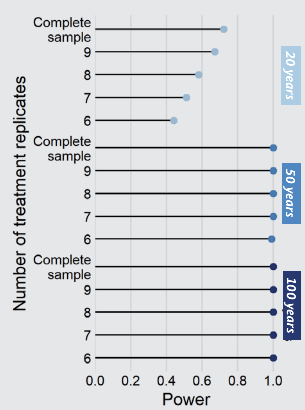

Figure Set 9. Power plot (left). *The estimated power to detect a difference among the treatment means, for different sample sizes (number of subwatershed treatment replicates) at 20, 50, and 100 years.*

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APPENDIX 11

Potential Marbled Murrelet Habitat Distribution and Research Strategy at the Elliott State Forest

Report prepared by:
Matt Betts, Kim Nelson, Jim Rivers, Dan Roby, Zhiqiang Yang

The purpose of this document is to (1) provide preliminary data and results on Marbled Murrelet occupancy at the Elliott State Research Forest, and (2) provide an outline and suggestions for research on harvest impacts on murrelets.

Our analysis indicates that ~7.8% of 'occupied' Marbled Murrelet habitat at the Elliott State Forest is >65 years old and overlaps with planned extensive ('ecological') forestry (based on murrelet occupancy data provided by Kim Nelson and ODF; Figure 11a, Table 11a). Thus, ~92.2% of identified occupied murrelet habitat will fall into some sort of reserve (either the large Conservation Research Watershed to the west, or the fine-scale reserves (200-800 acres) that form a basis for the proposed Triad design). This estimate assumes that: (1) all 40 Triad replicates will eventually be implemented, (2) historical Marbled Murrelet occupancy data accurately reflect current-day occupancy (i.e., there is strong temporal consistency in nesting habitat and low turnover), and (3) murrelet probability of detection approaches 1 (high detection probability).

It is important to note that these three assumptions are unlikely to hold, hence we should not rely entirely on these historical occupancy data to develop our strategic research plan for the Elliott. First, we are conducting a power analysis to determine the appropriate number of replicates and the timing of implementation of each replicate. It is not logistically possible for all 40 replicates to be implemented simultaneously. Second, murrelets are strongly expected to be site faithful; therefore, changes in occupancy will occur only with disturbance but some sites (currently not known to be occupied) could be colonized (likely by young prospecting birds) over time (Betts et al. 2020). Therefore, results should only be used as an initial proxy for the total area of mature stands that are likely to be occupied. Finally, we know that murrelets are often missed in surveys (there is imperfect detection). Thus, the estimates provided in Table 11a are likely to be an underestimate of the total area of murrelet habitat at the Elliott. To provide a better estimate of the total area of occupied habitat Yang and Betts (unpublished) developed a species distribution model (SDM) using Landsat and LiDAR data

Figure 11a.

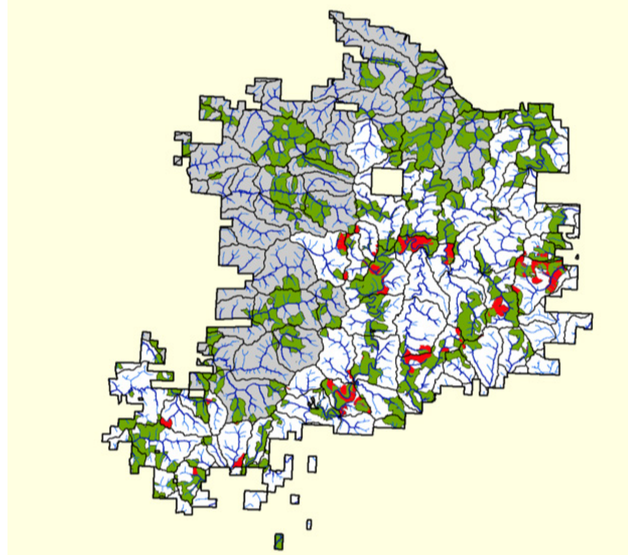

Figure 11a. *Extent of historically occupied stands according to S.K. Nelson and ODF data (green). Occupied stands currently designated as the 'extensive' treatment are highlighted in red. This area totals 1457 acres (7.8% of the historically occupied stands across the entire Elliott State Forest; Table 1). The remaining 92.3% or 17,137 acres >65 years old are in reserves where timber harvesting is prohibited. Total area of occupied habitat = 21,475 (18,594 acres is >65 year-old stands). An additional 2881 acres of murrelet habitat could potentially occur in younger stands (<65 years). Of this 1,444 acres is in the 'intensive management' category (See Table 11b). However, 65% (939 acres) of this shows no initial evidence of residual trees (likely because it has been cut since it was initially surveyed; Table 1). All of the remainder will be surveyed prior to harvest to determine occupancy. If occupied, it will be retained as habitat, at least until the results of the study on murrelet responses to selection cutting are complete and we can quantify potential negative impacts.*

Figure 11b.

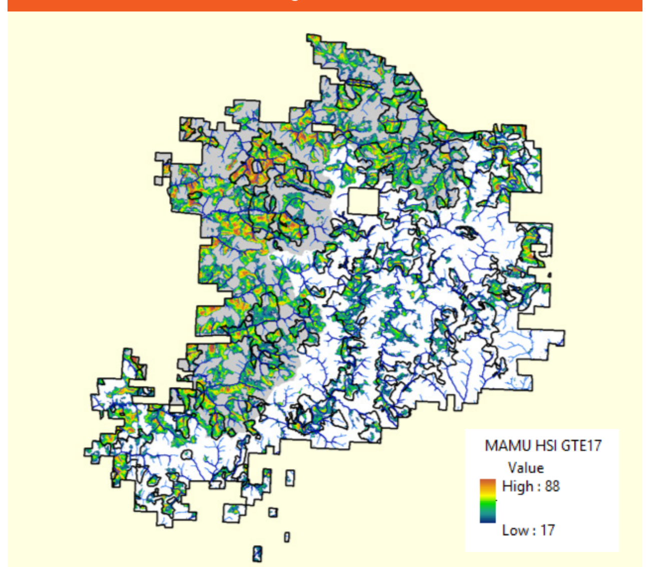

Figure 11b. *Extent of modeled Marbled Murrelet habitat across the Elliott. Occupancy data from Betts et al (2020) [117 points from Nelson and ODF data with known survey dates] were modeled with time-matched 6 visible Landsat TM bands along with 2014 Lidar data. Areas with canopy disturbance were removed. Prediction success on independently held out data was high (AUC=0.89 [out of 1]). The color ramp reflects occupancy likelihood on a scale from 0 to 100. The gray shaded area is in the Conservation Research Watershed (where no harvesting in mature stands would occur).*

that has good prediction success (when tested on independent data; Area Under the Curve = 0.89; Figure 11b, Figure 11c, Appendix 11A).

Conducting some degree of silviculture in >65 year-old murrelet occupied stands is important for two management, conservation, and science-based reasons (1) it upholds the Triad design, which is intended to directly address these hard tradeoffs between the extent and intensity of timber harvest (note that no >65 year-old stands occupied by murrelets would be harvested in the 'intensive treatment' because sufficient timber would be supplied by plantation forestry). (2) Cutting continues to occur on Federal and State lands in young forest (unsuitable murrelet habitat) adjacent to occupied stands, but not currently within known occupied murrelet habitat. It will be critical to understand how murrelets respond to selection cutting over the short and long terms because it is possible that policies protecting murrelet habitat could change, for example in the context of HCPs on State, BLM and private lands. Science should inform such management decisions. We hypothesize that the short-term effects on murrelets of even light harvesting will be negative; nest predation rates are likely to increase due to a higher prevalence of corvids (Marzluff et al. 2004, Cahall et al. 2013) and epiphytes needed for murrelet nesting are likely to decline due to reduced moisture (e.g., van Rooyen et al. 2011). We predict that these potential effects of 'extensive' harvest on murrelets will be compounded by canopy removal in adjacent unoccupied stands, which creates hard habitat edges. To our knowledge, no long-term data exist on the extent of these effects over time. We hypothesize that over the longer term, habitat may recover in light selection harvesting treatments **(i.e., <20% relative density removal; approximately 20% volume harvested)** versus if we were using a clearcut harvest regime.

RECOMMENDATIONS

1. Given the uncertainty involved in identifying the precise locations of future, additional occupied stands (see assumptions #2 and 3 above), and the formal objective of learning about murrelet responses to harvest, OSU would conduct formal murrelet surveys in all potentially occupied habitat stands that are intended for harvest. The exception to this is stands that were identified as being occupied, but have been clearcut harvested since, or had all residual trees removed (according to on-the-ground surveys).

2. As a first approximation from a science perspective, we suggest 10 'treatment' sites (where extensive harvest occurs) and 10 'control' sites (stands with no harvest) be established in stands deemed to be occupied by marbled murrelets. Each pair of treatment and control sites should be 'blocked' (i.e., within ~2 km of each other) and blocks should be spaced sufficiently far apart to ensure statistical independence. A 'site' would likely need to be >50 acres. Therefore, in the first 5 years of implementation, we expect that a total of ~500 acres should be sufficient to detect harvest effects on occupancy (with a paired ~500 acres to serve as controls). Timber harvests in occupied

Figure 11c.

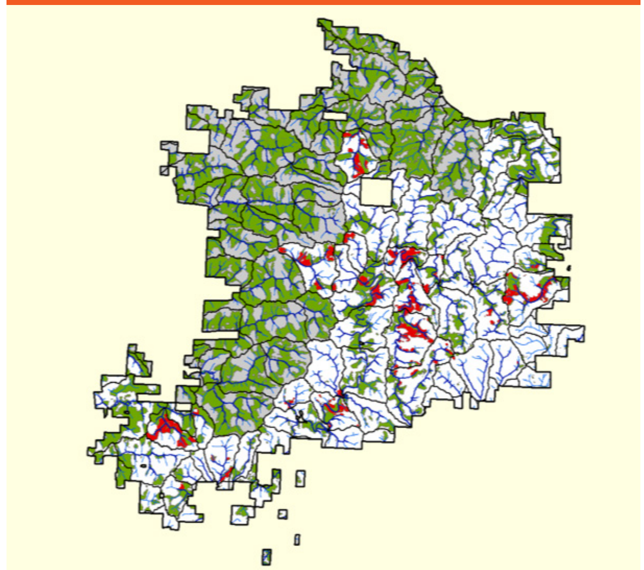

Figure 11c. *Extent of model predicted murrelet occupied stands (green) according to the Yang and Betts (unpublished) species distribution model. Predicted occupied stands currently designated as in the 'extensive' treatment are highlighted in red. This area totals 1676 acres (9% of the historically occupied stands across the entire Elliott State Forest). Note the substantial proportion of predicted occupied stands in the Conservation Research Watershed (CRW).*

Table 11a. Stand Level Research Treatment

Treatment	KN Occupied	ODF Occupied	KN + ODF
CRW	4,355	5,157	7,006
Extensive	1,083	1,220	1,452
Reserve	5,683	6,314	7,593
Reserve 2	121	121	125
GRMA	1,703	1,912	2,410
Total	**12,944**	**14,725**	**18,586**

Table 11a. *Area (in acres) of historically occupied murrelet habitat in proposed different management types at the Elliott State Research Forest. Calculations above are only for stands >65 years old, which are of the greatest conservation significance, and are most likely to be occupied habitat. CRW = Conservation Research Watershed; GRMA = Generic Riparian Management Area; "KN Occupied" indicates murrelet-occupied stands based on survey data supplied by Kim Nelson; "ODF Occupied" indicates murrelet-occupied stands based on survey data supplied by Oregon Department of Forestry. The final column is the union of the two. Note that there is substantial overlap in the two datasets. In total, 1,452 acres of habitat is identified as historically occupied by murrelets, falls into a mature forest category, and would also be available for 'extensive' harvest (low density removal, see above). Note that occupied stands <65 are not included in this table.*

Proportion of total habitat historically occupied by murrelets that would potentially be subject to extensive timber harvest = 7.81%

stands should not reduce tree relative density more than 20%, and retain the overstory as much as possible. Best management practices (BMP) will be developed as part of the sale planning process and will involve provisions to limit predation by corvids and other impacts on murrelets.

3 Surveys will occur each year in both harvest treatment sites and randomly assigned control sites. Surveys should occur only in 'good' ocean years (based on Betts et al. 2020) for a minimum of two years prior to harvest. In addition, we propose that nest searching be conducted in a subset of stands. This will be a non-trivial cost, but will likely be essential to determine harvest effects on murrelet demography. Additional monitoring of Corvids and microclimate will be needed to help determine impacts to harvesting.

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Marzluff, J.M., J.J. Millspaugh, P. Hurvitz, and M.S. Handcock. 2004. Relating resources to a probabilistic measure of space use: Forest fragments and Steller's Jays. Ecology 85:1411-1427.

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: 549–561

Table 11b.

Category	Acres
< 65 yr old stand with no residual trees outside of the riparian area	939
< 65 yr old stand with residual older trees present and should be surveyed before harvest	442
< 65 stand that serves as buffer around an older stand and needs to be reallocated to reserve	63
Balance	**1,444**

Table 11b. *Analysis of stand structure within each of the stands that are a combination of occupied murrelet habitat, <65 year old, and overlap with the intensive harvest allocation. Each of these stands was confirmed to be a former clearcut, and using the 2008 LiDAR imagery examined for the presence of older residual trees. If the harvest was after 2008, the stand was examined in Google Earth to confirm harvest and to determine if residual older trees are present. We propose to use on-the-ground surveys to (a) check for residual trees in the stands identified to have been occupied (by ODF and KN surveys). If residual trees exist, these stands will be surveyed.*

APPENDIX 11A

Potential Marbled Murrelet Habitat Distribution and Research Strategy at the Elliott State Forest

BRIEF METHODS FOR OUR MARBLED MURRELET SPECIES DISTRIBUTION MODELING

We used Maxent (https://www.rdocumentation.org/packages/dismo/versions/1.1-4/topics/maxent) to model Marbled Murrelet occupancy data for the Elliott State Forest. Maxent is a machine-learning based presence-only model that is extensively used for modeling species distributions. Our predictor variables included 6 visible Landsat TM bands (Shirley et al. 2013 – Diversity and Distributions), elevation, slope, and tree height (hmean) and tree height stand deviation (hstd) (the latter two were derived from LiDAR).

To process Landsat data, we used harmonic fitting to the spectral data from 1985-2020. Based on MCD12Q2.006 Land Cover Dynamics Yearly Global 500m, the average day of year for greenup and peak greenness were identified for the ESF as 64 and 182, which corresponds to March 4th and Jun 30. All variables summarized at 100, 500, 1000, 2000, 5000 m radii surrounding Marbled Murrelet occupied sites. Results presented here are only for 100 m spatial extent (which produced the best model performance).

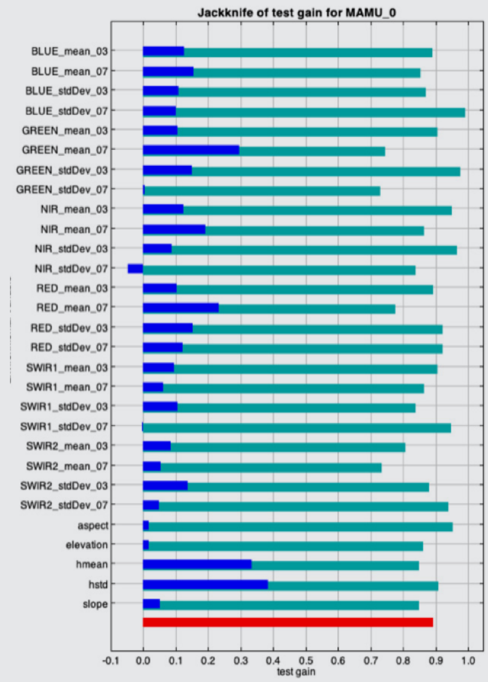
We used murrelet occupancy data 2008-2018 (N=117). Data are available at https://figshare.com/articles/dataset/Squeezed_by_a_habitat_split_warm_ocean_conditions_and_old-forest_loss_interact_to_reduce_long-term_occupancy_of_a_threatened_seabird_data_and_code_/12743762. Occupied areas disturbed by harvesting during this period were excluded from analysis.

We modeled murrelet presence as a function of the variables above, the interactions among them, and allowed linear and quadratic features. We randomly assigned 50% of the data for model training and 50% for testing. Note that these test data were therefore independent of those used for model building.

Results

Overall, the model performed well (AUC [independent data] = 0.89; Figure 11d, 11f). This is comparable to previous murrelet models (Hagar et al. 2014, Falxa and Raphael 2016) but

Figure 11d.



KEY

- Without variable
- With only variable
- With all variables

__Figure 11d.__ Relative performance of predictor variables in Marbled Murrelet Maxent model. Note that the overall model (red) performed well (AUC=0.89). Both Lidar (hmean, hstd) and Landsat data contributed to model performance.

Figure 11e.

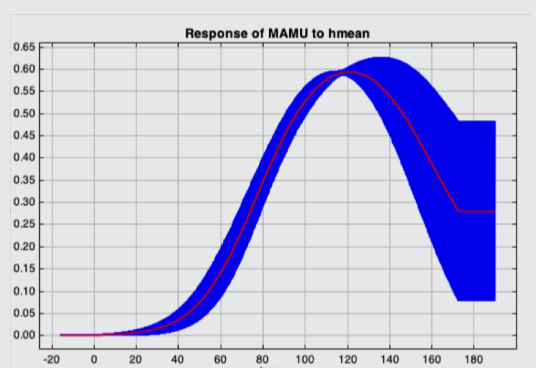


__Figure 11e.__ Fitted relationship between canopy height (hmean; derived from Lidar) at a 100 m scale and probability of murrelet occupancy. Note high confidence bands at tall tree heights reflect model uncertainty.

enables fine-scale prediction of murrelets at the Elliott State Forest. Landsat spectral bands were surprisingly effective at predicting distributions, but LiDAR data also contributed. As expected, we found a strong positive effect of canopy height on murrelet occupancy (Figure 11e). Fitted relationships (partial dependence plots), relative influence metrics, and model diagnostics are available on request.

Literature cited

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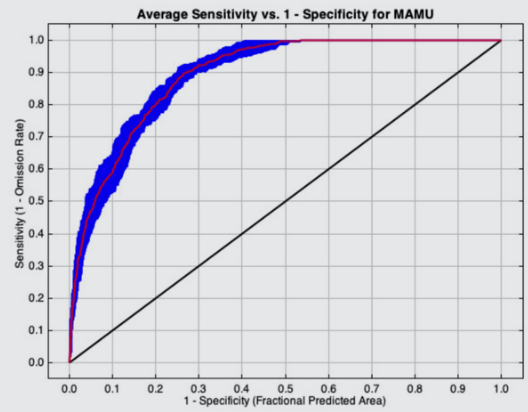
Hagar, J.C., B.N.I. Eskelson, P.K. Haggerty, S.K. Nelson, and D.G. Vesley. 2014 Modeling Marbled Murrelet (Brachyramphus marmoratus) habitat using LiDAR-derived canopy data. Wildlife Society Bulletin 38(2):237–249

Shirley, S.M., A. Yang, R.A. Hutchinson, J.D. Alexander, K. McGarigal and M.G. Betts, 2013. Species distribution modelling for the people: unclassified landsat TM imagery predicts bird occurrence at fine resolutions. Diversity and Distributions 19: 651-872.

Figure 11f.



KEY

- **Mean (AUC = 0.894)**
- **Mean +/1 one stddev**
- **Random prediction**

Figure 11f. *Receiver Operating Characteristics Curve for Marbled Murrelet Model*

APPENDIX 11B

Potential Marbled Murrelet Habitat Distribution and Research Strategy at the Elliott State Forest

SUPPLEMENTARY INFORMATION FOR POTENTIAL MARBLED MURRELET HABITAT DISTRIBUTION AND RESEARCH STRATEGY AT THE ELLIOTT STATE FOREST

Table 11c.

Stand Level Allocation	KN Occupied + ODF MMMA	ODF MMMA	KN Occupied MAMU	MAMU Habitat Suitability Index GTE 17
CRW	7,410	5,358	4,598	15,306
Intensive	1,444	354	1,196	646
Extensive	2,022	1,392	1,562	1,934
Reserve	7,893	6,575	5,881	6,814
GRMA	2,706	2,076	1,914	4,464
Total	**21,475**	**15,756**	**15,151**	**29,164**

Table 11c. *Summary of stand allocations in all analyses of marbled murrelet habitat. This includes stands that are less than and greater than age 65.*

APPENDIX 12

Summary of the Research Design for Peer Review

Summary prepared by:
Matt Betts, Klaus Puettmann, and Katy Kavanagh

RECONCILING MULTIPLE ECOSYSTEM SERVICES AND TIMBER PRODUCTION: AN EXPERIMENTAL TEST OF THE TRIAD APPROACH AT THE ELLIOTT STATE RESEARCH FOREST, OREGON

ABSTRACT

Background: Forests are integral for the health and wellbeing of humanity, as well as to the conservation of biodiversity and ecosystem functions and services. With increasing global demand for forest products and influences from a changing climate, it will be critical to find ways to provide these essential resources without compromising global forest biodiversity, carbon sequestration, and ecosystem services. Along with conservation of aquatic and terrestrial biodiversity, the Elliott state forest has a high potential for carbon sequestration and productivity of wood products making it the ideal place for research on these individual components and for studying the potential for integrating these often competing land uses. We propose that the Elliott State Research Forest (ESRF) be a center – both in Oregon and worldwide – for scientific exploration of sustainable forest management, with the aim of informing future policy and bridging political divides via the application of the scientific method and participatory governance.

The Triad framework: Expansion of high-yielding tree plantations could free up forest land for conservation provided this is implemented in tandem with stronger policies for conserving native forests. Because plantations and other intensively managed forests often support less biodiversity than native forests, a second approach argues for widespread adoption of extensive management, or 'ecological' forestry, which better preserves key forest structural elements and emulates a broad range of disturbance regimes. Extensive management often reduces wood yields and hence there is a need to harvest over a larger area to maintain an equivalent supply of wood. A third, hybrid suggestion involves 'Triad' zoning where the landscape is divided among reserves, extensive management, and intensive management in varying proportions. The overarching objective of the ESRF will be to provide the first landscape-scale experimental test of the Triad as a means to integrate multiple values. Most importantly, the size of the ESRF will enable us to explore and quantify the synergies and tradeoffs associated with different arrangements of these treatments at a landscape scale through time.

Methods: We will experimentally establish four Triad treatments that differ in the proportions of reserves, extensive and intensive forestry, but produce a comparable amount of wood products. The four Triad treatments are: 'intensive-reserve' (50% reserve, 50% intensive), 'Triad-I' (40% reserve, 20% intensive, 40% extensive),'TriadE', (20% reserve, 20% intensive, 60% extensive), and 'extensive' (100% extensive). All treatments will be implemented at the scale of whole subwatershed (which range from 2 ~400-2000 acres) and will be replicated 10 times (N=40 subwatersheds totaling ~52,000 acres). The entire western portion of the Elliott (~30,000 acres) will, following a 15-year period of restoration treatments in established plantations, be designated as a permanent reserve and will serve as a broad-scale control to determine the effect of reserve size and fragmentation on biodiversity, carbon sequestration and socio-ecological processes. In all treatment subwatersheds and the reserve, Elliott principal investigators will collect long-term data on a range of values that are of critical importance to socio-ecological systems. These include (in no order of importance and not an exclusive list): abundances of threatened and endangered (T&E) species (e.g., northern spotted owl, marbled murrelet, Coho salmon), above and belowground carbon pools and fluxes, water flow and quality, timber production, employment, hunting opportunities, total economic production, recreational benefits, biodiversity (e.g., plant, bird, arthropod, mammal abundances and diversity). Because forest management treatments will take decades to fully implement, the landscape-scale aspect of this research will necessarily be long term.

Nested within this broader landscape-scale study, a substantial suite of stand and tree neighborhood-level research will occur. Precise topics will depend on policy needs as well as researcher interest and capacity. These include questions relating to (for example): (1) the most environmentally benign ways to implement intensive forestry, (2) methods to increase fire resistance, (3) quantifying timber production and biodiversity associated with various ecological forestry methods, (4) appropriate buffer sizes to minimize impacts to stream ecosystems, (5) silvicultural methods for restoration of oldgrowth characteristics, and (6) management approaches to maximize carbon sequestration, (7) the long-term effect of selection cutting on the development of marbled murrelet habitat. Given that conclusions from short-term studies often change substantially when examined over the longer term (Cahall et al. 2014, Pabst and Harmon 2018) our aim is for each of these finer-scale studies to be conducted over the long-term.

Outcomes: In addition to delivering rigorous, policy relevant science the Elliott State Research Forest will be designed to provide a number of local and regional societal benefits. These include collaboration with local indigenous tribes in the planning and management process, local economic multipliers from timber harvested and research efforts, recreational opportunities, and the

largest formal forest reserve in the Oregon Coast Range – a region that is under represented in the existing protected areas network.

INTRODUCTION

Forests support the majority (about 70%) of terrestrial biodiversity (International Union for Conservation of Nature 2017), and forest loss and degradation are primary global drivers of biodiversity decline (Betts et al. 2017). The United Nations Convention on Biological Diversity and subsequent Strategic Plan for Biodiversity ("Aichi biodiversity targets", CBD 2011) were significant attempts to address biodiversity loss, but consensus is emerging that the overall objective – halting biodiversity loss by 2020 – has failed (Mehrabi, Ellis, & Ramankutty 2018, Díaz et al. 2019). Given that biodiversity is strongly associated with ecosystem processes (Brokeroff et al. 2017) and services (Nelson et al. 2014, Ricketts et al. 2016), it will be essential to develop management practices that ameliorate biodiversity loss.

Central to the challenge of conserving global biodiversity is an increasingly demanding human population with escalating rates of consumption (Tilman & Clark 2014) and CO2 emissions. The provision and use of forest products is no exception, with current roundwood production equal to 3.7 billion m^3/year and projected growth in wood demand of 30% by 2050 (Kok et al. 2018, FAO 2019). Forests remain of high economic value to humanity, worth over $US 600 billion annually (Duraiappah et al. 2005, Rametsteiner & Whiteman 2014), but wood production potentially threatens other critical values including forest biodiversity and carbon stocks, which are both in rapid decline (Butchart et al. 2010, Saatchi et al. 2011).

To meet the world's wood demand, foresters have often adapted the agricultural model of increasing production through intensive, high-input management practices aimed at increased tree growth and management efficiency by simplifying and homogenizing stand structure (Puettmann, Coates, & Messier 2008). This has been successful at boosting yields – in some cases as much as 40-fold [25-40 m^3/ha/year vs. 1-2 m^3/ha/year in unmanaged natural forests (Sedjo 1999, Wagner et al. 2005)]. Indeed, plantation forest area has increased by over 105 million ha since 1990, with an average annual increase of 3.6 million ha, and planted forests now account for 7% of the world's forests and 33% of roundwood production (Food and Agriculture Organization of the United Nations 2015). If current trends continue, tree plantations – of either native or non-native species – could provide most of global wood by 2050 (Jürgensen, Kollert, & Lebedys 2014).

Closing the wood production 'yield gap' through plantations has two important implications for biodiversity and carbon conservation. First, high-yielding plantations create the potential to reduce harvesting pressure on natural, unmanaged forests (Edwards et al. 2014,Pirard, Dal Secco, & Warman 2016, Runting et al. 2019) and to free up forest land for conservation, provided that appropriate conservation policies are implemented for native forests. Second, however, plantations themselves may have relatively low conservation value (Barlow et al. 2007, Brockerhoff et al. 2008, Swanson et al. 2011, Betts et al. 2013, but see Yamaura et al. 2019). For this and other reasons, researchers and land managers have proposed and developed various local versions of 'ecological forestry' or extensive management techniques (Pommerening & Murphy 2004, Franklin & Johnson 2012, Puettmann et al. 2015, Franklin, Johnson, & Johnson 2018). These techniques typically aim to emulate natural disturbance regimes and vegetation structure, often relying on retention of trees and downed wood and longer harvest rotations (MacLean et al. 2009, Lindenmayer et al. 2012, Root & Betts 2016). However, compared to management of homogeneous plantations, profits and yields of extensive forestry approaches are often substantially lower, in part because of the added complexity of management operations (Newton & Cole 2015, Kormann et al. In review).

THE TRIAD APPROACH

Attempts to reconcile conservation, production, and other objectives have prompted a proposed compromise approach involving forest management in three distinct zones. This 'Triad' zoning divides landscapes into discrete units that emphasize reserves, extensive management, or intensive management (Seymour & Hunter 1992). Reserve areas are managed for biodiversity conservation, which often means little or no intervention. Extensive forestry operations are typically characterized by partial retention, minimal use of external inputs, more time between harvests, and reliance on natural tree regeneration (Franklin & Donato 2020). Practices in the intensive zone can include planting of native or exotic tree species, use of herbicide to control competing vegetation, thinning, and fertilization (Paquette & Messier 2010). Triad provides a framework for assessing the implications for biodiversity and ecosystem services of these approaches. The Triad approach is grounded in the idea that producing wood from intensively managed forests can permit more land to be freed up for conservation (Côté et al. 2010, Tittler, Messier, & Goodman 2016) (Figure 2).

However, the few theoretical (Seymour & Hunter 1992) and modeling (Tittler, Messier, & Fall 2012, Tittler et al. 2015) studies aimed at determining optimal proportions of different management regimes in the Triad approach (Ward & Erdle 2015, Tittler, Messier, & Goodman 2016) are limited in scope due to the absence of sufficient empirical data to formally identify how best to minimize impacts to biodiversity while meeting any given level of demand for wood and providing ecosystem services (Messier et al. 2009, Yoshii et al. 2015, Yamaura et al. 2016). To our knowledge, there are still no empirical tests of how differing proportions of land under the three Triad compartments alter species' populations, wood yield and other ecosystem services across entire landscapes. Instead, the balance of reserves, extensive, and intensive forestry operations at landscape scales is typically determined in an ad hoc manner. This limitation is particularly concerning given that the Triad approach is now being implemented in several jurisdictions in North America and elsewhere (MacLean et al. 2009, Messier et al. 2009, Paquette & Messier 2010, Lahey 2018). This scarcity of scientific information is in stark contrast to the explosion of research on "land sharing" (reflecting a focus on softer, ecological farming) versus "land sparing" (reflecting a focus on strict reserves and intensive farming) in agricultural landscapes (Phalan et al. 2011) which has strong parallels to Triad. At a time when biodiversity continues to decline and the demands of a resource-hungry human population increase, it is critical that wood production strategies are based on science-based evaluations of alternatives (Tallis et al. 2018, Runting et al. 2019).

RATIONALE AND SIGNIFICANCE:

CONTEXT IN THE PACIFIC NORTHWEST AND RELEVANCE TO STAKEHOLDERS

Timber production in the Pacific Northwest has historically been highly controversial, with a range of interests vying for influence over the way forests are managed (Spies et al. 2019, Phalan et al. 2019). Current debates over the most appropriate ways to manage the forest are particularly heated, and focus on three major issues below.

1. **Biodiversity Conservation:** Although the Northwest Forest Plan resulted in the broad-scale conservation of late-successional old-growth forest across Washington, Oregon and California, this forest type and its associated species continue to decline (due to both harvesting and fire; Phalan et al. 2019). This has resulted in repeated legal action by environmental groups to halt logging on state lands (Hall 2019). On the other hand, species associated with complex early seral forest also appear to be declining (Betts et al. 2010, 2013). To address these issues, federal forest managers (particularly the Bureau of Land Management and the Forest Service) have recently experimented with and conducted regeneration harvests following various types of 'ecological' forestry practices.

2. **The role of intensive forest management.** In the Pacific Northwest, herbicides are commonly used in plantations to control competing vegetation and therefore substantially accelerate tree growth (Kroll et al. 2017). The degree to which plantations can support biodiversity and ecosystem services had been poorly understood prior to our AFRI-funded research (e.g., Betts et al. 2013, Stokely et al. 2019). At the stand (local) level, there are strong tradeoffs between timber production, biodiversity (Figure 12a, Kormann et al. In Press) and carbon sequestration (Boutte et al. 2020 Law et al. 2019). However, it remains unclear whether such tradeoffs can be ameliorated at the landscape level via a land-use zoning approach; in other words, certain areas are focused on timber production, while others sustain biodiversity and carbon sequestration with consequently reduced timber yields. Further, it is unknown whether there are landscape-scale thresholds in the amount of plantations before biodiversity in remaining natural forest begins to decline (Betts and Villard 2009) and the entry

Figure 2

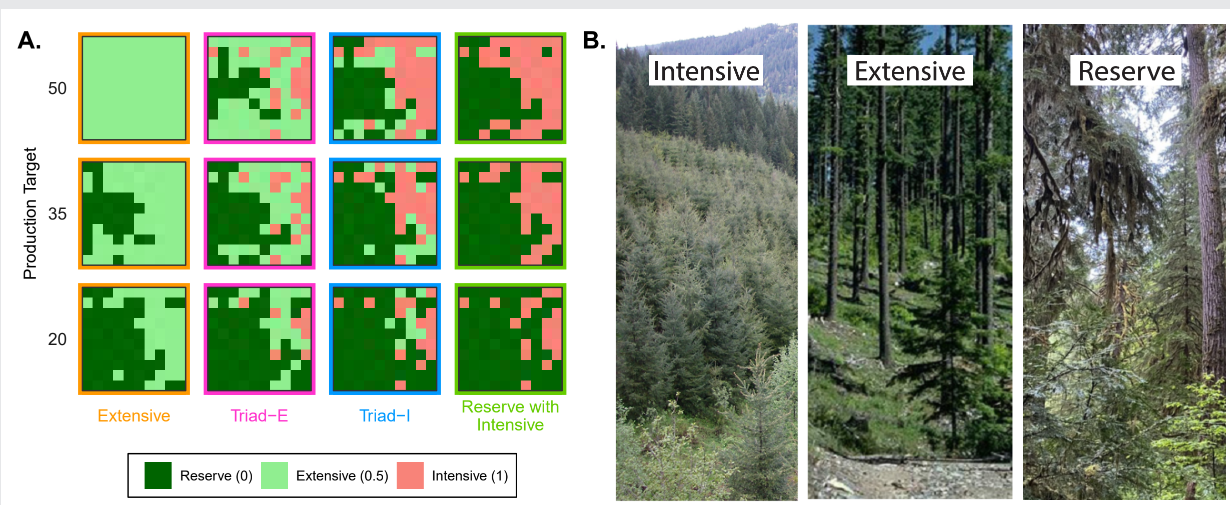


Figure 2. *Conceptual illustration of contrasting approaches to managing landscapes for timber production and biodiversity conservation in mixed-wood yield landscapes along a continuum from where extensive (ecological) forestry dominates to landscapes comprised of reserves and intensive management. In (A), each of the nine panels is a schematic map of a region with unmanaged habitat (also termed 'reserve', dark green; 0 units of production per pixel), ecological forestry (also termed 'extensive management', light green; 0.5 units/pixel), and high-yield forestry (also termed 'intensive management', coral; 1 unit/pixel). Region maps in the same row all produce the same quantity of wood, but use different proportions of forest management approaches to provide the production target. The three rows show results from low (20) to higher production targets (50). Note that even the highest production target depicted here is still only ½ of the total production possible. Due to the reduced per acre production afforded by extensive forestry, 'Extensive' landscapes (left column) necessarily have reduced reserve compared to the 'Reserve with Intensive' landscapes. Intermediate options (Triad-E and Triad-I) will also be examined and represent balanced options where reserves, extensive and intensive management occur in the same landscapes. At the Elliott State Research Forest, we will test the 50% production target (top row). In (B), examples of each type of management are shown: intensive management (Douglas-fir plantation), ecological forestry (variable retention harvesting in native forest), and unmanaged, protected old growth.*

of wood products into the built environment, offsetting fossil fuels, leads to an overall increase or decline of sequestered carbon.

3 Declines in timber production and tax revenue. There have been substantial declines in local timber and tax revenue to rural communities in the wake of substantial declines in timber harvest over the three decades since the Northwest Forest Plan (Spies et al. 2019) and due to other environmental regulations. In response, rural timber-producing counties in Oregon recently sued the state of Oregon and were awarded $1.1 Billion USD in lost revenue (Sickinger 2019).

The Elliott State Research Forest seeks to address these controversial issues by testing the hypothesis that multiple objectives can be better integrated via the Triad zoning approach at the landscape scale. We seek to test a range of scenarios with differing proportions of (1) extensive (ecological) forestry, (2) intensive forestry and (3) reserves to determine a suite of policy options to produce timber, sequester carbon (both ecosystem services) and maintain native biodiversity. Most 6 importantly, the size of the ESRF will enable us to

Figure 12a.

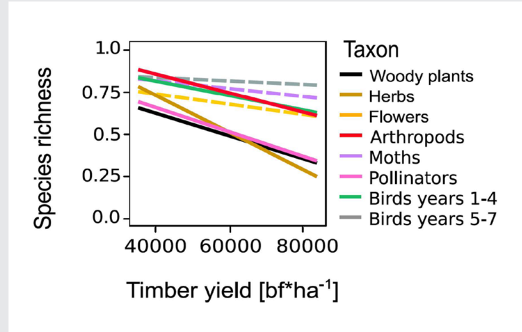


Figure 12a. *Results of a recent study (Kormann et al. In Press) demonstrating tradeoffs between species richness of biodiversity taxa (normalized to 1) and timber production. Statistically significant tradeoffs (solid lines) occur for arthropods, pollinators, woody & herbaceous plants, and birds in the first years of stand development. Our current proposal is to test whether such tradeoffs can be minimized at the landscape scale by implementing 'optimal' amounts of different forest management regimes using the 'Triad' approach.*

Figure 4. Triad Landscape-level (Subwatershed) Treatments

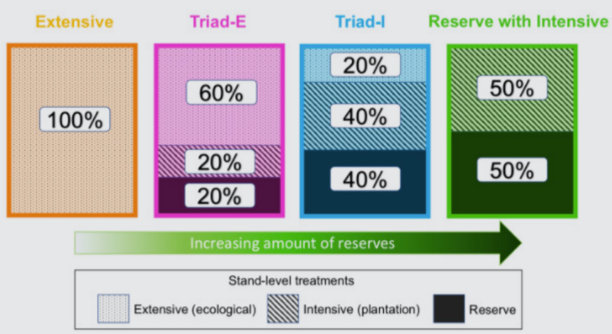


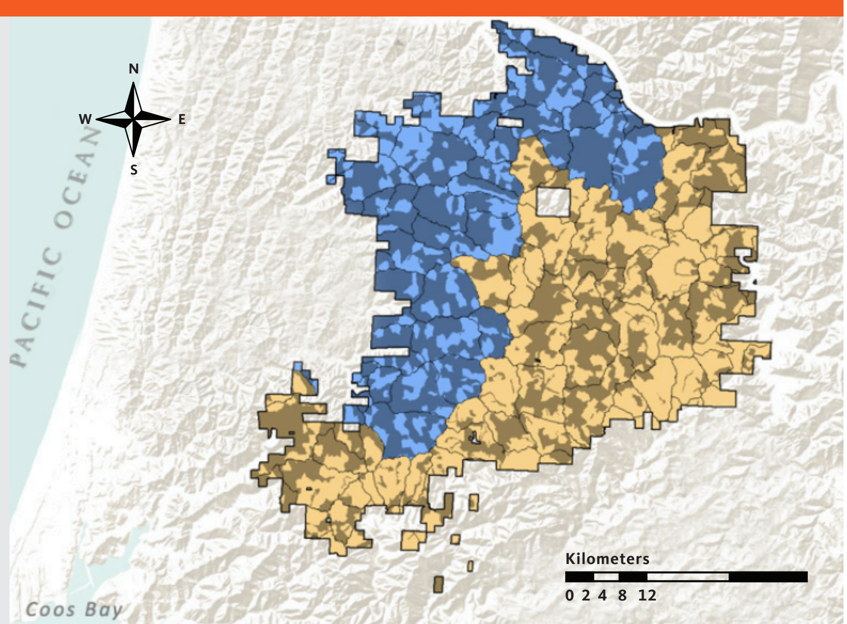
Figure 4. *The four Triad treatments that we will apply at the subwatershed scale at the ESRF. All of the subwatersheds (400-2000 ac) in the Management Research Watersheds will receive one of these four treatments. Treatments are designed to produce approximately equivalent wood yields using different combinations of stand-level treatments: reserves, extensive (ecological forestry) and intensive management (plantations). The 'Extensive' Triad treatment (orange) will be 100% ecological forestry, the 'Reserve with Intensive' Triad treatment (light green) will comprise 50% intensive forestry and 50% reserve. 'Triad-E' and 'Triad-I' contain differing proportions of reserve, ecological and intensive forestry.*

Figure 6. Age class distribution in the Conservation Research Watershed and the Management Research Watershed

KEY

	LTE65	GT65	
CRW	36%	%	
MRW	60%	%	
ALL ELLIOTT	50%	50%	

Figure 6. *Subwatersheds of the Elliott State Research Forest color coded by classification into the Conservation Research Watersheds (CRW) and Management Research Watersheds (MRW) and color coded by stand age greater than 65 years (GT65) and less than 65 years (LTE65). Uncolored regions indicate this portion of watershed is not part of the proposed Elliott State Research Forest.*



explore and quantify the synergies and tradeoffs associated with different arrangements of these treatments at a landscape scale through time.

METHODS SUMMARY

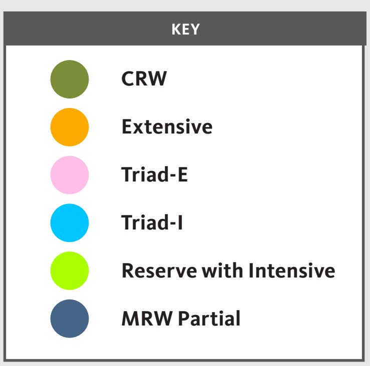
Study Area. The Elliott State Research Forest is located in the southern Oregon Coast Range, and lies within 10 km of the Pacific Ocean. The area is 98% forested, and dominated by Douglas-fir, with some western hemlock, western red cedar,and red alder. As a result of timber harvest, ~50% of these forests are Douglas-fir plantations <65 years old. The majority of the remaining forest is <152 years old, originating from a stand-replacing fire in 1868. Approximately 5000 acres escaped this fire and were subsequently harvested so there are a few hundred acres greater than >153 years.

Experimental Units and Sample Size. The experimental unit for implementation of our research design will be at the subwatershed scale. These subwatersheds range from 400 to 2000 acres in size, thereby reflecting a spatial scale relevant to most of the taxa and processes likely to be included in our study. The 66 subwatersheds in the Elliott State Research Forest are designated to be in either the Conservation Research Watersheds (CRW) or Management Research Watersheds (MRW), (Figure 5) with over 9,000 acres in partial watersheds that were either less than 400 acres or not fully contained within the ESRF. Subwatersheds were chosen to provide defined boundaries (ridges) and the ability to use water attributes (e.g., temperature, quality, quantity as an integrator of treatment effects. With 41 subwatersheds, we plan to have at least10 replicates per treatment level. Under this scenario, forty-one watersheds that are wholly contained within the MRW will receive the treatments outlined in Figure 4. Although the exact number of replicates will depend on the results of an ongoing power analysis that is based on simulation models for biodiversity responses to treatments across subwatersheds.

Treatment Assignment. The ESRF has experienced substantial anthropogenic and natural disturbance over the past 150 years. Approximately half of the area has been clearcut – mostly during the 1960-2016 period. As a result of this previous management history, fully random assignment of subwatershed-scale treatments is not socially or logistically feasible. For instance, initial tests of fully random assignment resulted in some subwatersheds with high-quality old forest being assigned substantial intensive forestry (which would result in these stands being clearcut). Similarly, existing young plantations were randomly assigned to 'reserve', which is suboptimal from a conservation perspective – in the short term at least. We therefore assigned treatments non-randomly using the following criteria: (1) ensure that there is no detectable bias among treatments in biophysical factors (i.e., elevation, aspect, site productivity, slope and aspect). (2) prohibit intensive harvest of old forest. Ultimately, no old forest will be clearcut in the current research design, (3) minimize the amount of silviculture conducted in T&E species habitat (i.e., marbled murrelet, spotted owl). The current design results in ~1400 acres of potential murrelet habitat attributed to 'extensive' forest management. Where this occurs, silviculture will be 'light touch' (low proportions of basal area will be removed). Long-term data will be collected on murrelet responses to these treatments (in relation to paired controls).

Non-random treatment allocation. There are several well-known scientific reasons for random allocation of treatments. First, randomization aims to avoid true bias caused by confounding factors. For instance, it might not be by chance that old forest remains where it does (e.g., steep slopes, low productivity forest; Lindenmayer and Laurance 2012); harvests are likely to have occurred in the most productive

Figure 5. Potential Subwatershed Triad Treatment Assignments



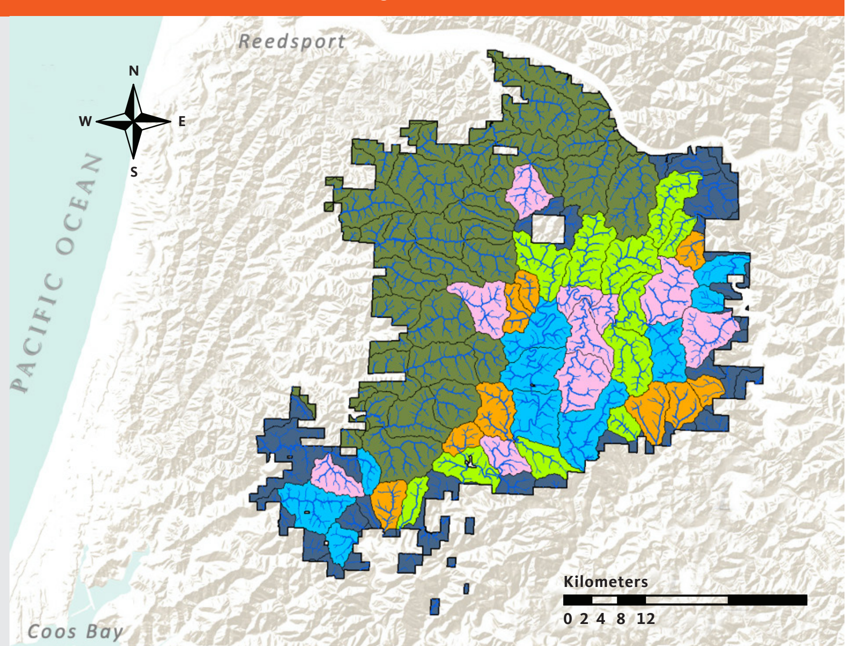


***Figure 5.** Map illustrating the proposed western reserve area (Conservation Research Watershed; CRW, in dark green) and the potential allocation of subwatershed-scale Triad treatments in the ESRF's eastern part . Partial watersheds (dark blue) are only partly contained in the ESRF, so they will not have a formal subwatershed Triad treatment assigned. Map is based on August 2020 allocation.*

and easily accessible stands. Ignoring such factors may lead to misinterpretation by erroneously associating results with the Triad treatments. However, we did not find evidence that standscale treatments were biased as a function of such biophysical factors. As noted above, we are conducting a simulation model to serve as the basis for power analysis to determine the appropriate subwatershed-scale replication. We will also use this process to compare modelled scenarios that use a fully random design to the current design. This will provide a quantitative estimate of whether sampling allocations are biased.

Second, randomization is more likely to result in spatial interspersion of treatments. It was of initial concern to us that our treatments seemed quite clumped as initially implemented (Figure 5; e.g., more 'extensive' watersheds occurred adjacent to each other than you would hope). However, when we tried a fully randomized design, spatial clumping occurred frequently by chance alone. Given the size of the Elliott, and the large scale of the experimental units, full interspersion of treatments is unattainable – even with a randomized design. We will address spatial autocorrelation by taking proximity of treatments into account during statistical analysis (via including spatial terms in the error structure).

Treatment Scheduling. Due to the large spatial extent of experimental treatments, it will not be logistically possible, or economically beneficial to local communities to implement all silvicultural activities simultaneously. We therefore propose to concentrate initial treatments on a subset of 16 subwatersheds (4 replicates). These watersheds will enable us to apply an adaptive management approach, wherein we will be able to test (a) the feasibility of current proposed treatments, and (b) the degree to which our initial estimates of necessary replication (from power analysis) were correct. This 'phased' implementation of the design also subverts the concern that our results are dependent on the climatic conditions of the treatment years (the range of inference will be expanded). We plan to account for temporal autocorrelation and yearly weather patterns in the statistical analysis. This treatment schedule will also give us the opportunity to collect long-term pretreatment data on the untreated subwatersheds.

Fragmentation and Spatial Effects: The sizes of the individual treatment areas, including reserves, will range from 80-1000 acres, depending on the percentage of the subwatershed in reserve and the size of the subwatershed. We acknowledge that this may be too small to serve as effective patch sizes for some of the species and processes in our study – however, such fragmentation effects have not been extensively studied in the Pacific Northwest (McGarigal and McComb 1995). We will therefore maintain one large reserve (35,000 acres) to serve as a 'benchmark' to which smaller reserves can be compared. Ultimately, the current design with a gradient in reserve size will enable us to test the effect of reserve size on biodiversity and ecological processes. Similar information could be gained by comparing how species and processes develop on neighboring land where larger areas received intensive management or extensive treatments.

Stand-level silvicultural treatments. One of our research goals is to explore the most effective ways to implement 'extensive' and 'intensive' forestry. Thus, we expect the exact specifications of 'intensive' and 'extensive' silvicultural approaches to vary within subwatersheds, and ultimately follow principles of adaptive management (see Appendix 2; see 'Nested Design' below).

A **Reserves:** This treatment will have very, very limited intervention and management. Natural processes including disturbance would be unmanaged and allowed to create disturbances and seral stages (with the exception of fire).

B **Intensive treatments** will maximize wood productivity per acre. Research treatments in these forests will allow us to investigate management options that primarily emphasize the production of wood fiber at rotations of 60 years or longer. At the same time, we can assess methods to reduce the impact of this harvest regime on other attributes such as biodiversity, habitat, carbon cycling, recreation, and rural well-being.

C **Extensive treatments** will be to explore the implementation of a new set of alternatives to intensive plantation management and unmanaged reserves. Research on "extensive" alternatives will aim to accomplish diverse forest characteristics to meet a broad set of objectives and ecosystem services. This will be done by retaining structural complexity while ensuring conditions exist to obtain regeneration and sustain the complex forest structure through time.

D **Riparian conservation areas:** The aquatic and riparian conservation component of the system-based research strategy will rely on a set of designated RCAs. These RCAs design will maintain and restore vital ecological processes that influence the aquatic ecosystem in the intensively managed and extensively managed treatments.

Biodiversity, Timber, and Ecosystem Monitoring Data. In each subwatershed, Elliott principal investigators will collect long-term data on a range of values that are of critical importance to socioecological systems. An initial set of thematic research areas have been identified by stakeholders and included in the ESRF Research Charter. These include:

- **Biodiversity and At-Risk Species:** As the Elliott contains a number of potentially at-risk and sensitive species (e.g., northern spotted owl, marbled murrelet, Coho salmon) research needs to address the most pressing of issues associated with sustaining and enhancing terrestrial and aquatic species in the context of managed forested landscapes.
- **Timber production:** The Triad design will enable us to track the quality and quantity of timber removed across treatments and the fate of the carbon in this timber as it moves into the manufacturing and built environments.
- **Carbon sequestration in reserves and managed forests:** We will monitor below and above ground carbon through

space and time under a variety of management scenarios. We will develop a database on carbon concentrations, mortality, and decay rates. We will use the results of these observational and manipulative studies to parameterize and test biogeochemical process models that will serve the Elliott and other forests.

- **Local and Regional Economic Benefits:** We will track not only direct employment in silvicultural and recreational activities, but also the 'multiplier effects' resulting from timber and non-timber benefits.
- **Climate Change Adaptation:** Forest and ecosystem health related to climate change impacts; research to identify potential suite of management approaches to help mitigate impacts with a goal of forest resiliency and reduced vulnerability.
- **Natural and Human-Caused Disturbance:** Disturbances such as landslides, debris flows, fires, different types of harvest regimes and recreation all play a crucial role in forested landscapes. The Elliott has and will continue to be the site of significant disturbances – whether natural or human-caused. Research conducted on the forest will be tailored to account for this important opportunity.
- **Stand Structure and Composition:** The Elliott has demonstrated inherent potential for older, larger trees to dominate as well as complex early seral that can potentially dominate the northwest forests associated with our region. Research will explore management options that provide for a variety of stand structures and composition, including late-successional conditions, and associated range of biodiversity, wood products and ecosystem services
- **Water Quantity and Quality in Relation to Forest Management:** The Elliott provides excellent opportunities to develop better scientific understanding of the effects and biological responses of natural and human-caused disturbances in forest landscapes on water quality and quantity.
- **Landscape and Scale Issues:** Opportunities to investigate the role of adjacency (source-sink relationship), fragmentation, and connectivity.
- **Socio-economic and cultural impacts:** Opportunities to investigate the human dimensions of a Triad design.

Additional response variables include, but are not limited to: above and belowground carbon, mortality rates, decay rates, water flow and quality, timber production, employment, hunting opportunities, total economic production, recreational benefits, biodiversity (e.g., plant, bird, arthropod, mammal abundances and diversity). Because forest management treatments will take decades to fully implement, the landscape-scale aspect of this research will necessarily be long term.

A NESTED DESIGN:

OPPORTUNITIES FOR STAND-LEVEL EXPERIMENTS WITHIN THE TRIAD FRAMEWORK

It is important to realize that although the unifying 'grand vision' for the Elliott is the question of how to meet society's wood demands while maintaining biodiversity, carbon sequestration and other socioecosystem processes, this in no way precludes many stand-level studies that only tangentially fit within this vision. For instance, it is certainly of policy relevance to find out how biodiversity responds to different approaches of "ecological forestry" (very little work has been done on this, despite the fact that it is being applied to 1000s of acres of Bureau of Land Management holdings). Nested within this broader landscape-scale study, a substantial suite of stand-or tree neighborhood level research will occur. Precise topics will depend on policy need and researcher interest and capacity. These include questions relating to, for example: (1) the most environmentally benign ways to implement intensive forestry, (2) methods to increase fire resistance or resilience, (3) quantifying timber and biodiversity yields from various ecological forestry methods, (4) appropriate riparian configuration to minimize impacts of harvesting to stream ecosystems, (5) silvicultural methods for restoration of old-growth characteristics, and (6) management approaches to maximize carbon sequestration. We provide a list of additional research opportunities that could nest within the broader Triad design in Appendix 2.

AN ADAPTIVE MANAGEMENT APPROACH:

Our goal is to implement Triad treatments in the context of adaptive management. Our intention is not to be held to a single "silviculture du jour" for the next 50-100 years, but we will learn by doing – both with extensive and intensive silviculture. For example, we will examine whether it is possible to conduct highly productive intensive management while minimizing herbicides, and in ways that conserve early seral biodiversity? We will also test whether there are innovative approaches to ecological forestry that will not reduce wood supply substantially.

Appendices 3, 5, and 7 were included along with this summary of the research design for reviewers.

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APPENDIX 13

Summary of Peer Reviews

A summary of the proposed Triad research design for the ESRF (Appendix 12) and an invitation to review the research forest proposal was distributed to select regional and international research scientists. Included below is a list of reviewers and an overview of the feedback received. It should be noted that this was not a 'blind review' meaning that these individuals were selected for review as a result of their relevant expertise in related fields and in research design. The purpose of seeking this external peer review was as a check on the quality of science being proposed, to determine if there were fundamental flaws in our logic, and to solicit additional ideas for research at the Elliott. Therefore, some of the recommendations were incorporated as changes in our current proposal, and some of the more operational attributes will be considered in more detail, if the Land Board approves moving forward with the Elliott State Forest being conveyed to Oregon State University College of Forestry as the Elliott State Research Forest.

REVIEWERS

- **David Lindenmayer**
  Professor, Australian Laureate Fellow, Fenner School of Environment and Society, Australian National University
- **John M. Marzluff**
  Professor of Wildlife Science, School of Environmental and Forest Sciences, University of Washington
- **Bernard T. Bormann**
  Professor of Forest Ecosystems and Director, Olympic Natural Resources Center, School of Environmental and Forest Sciences, College of the Environment, University of Washington
- **Christian Messier**
  Professor and Scientific Director, Center of Forest Research, University of Quebec in Montreal and in Outaouais
- **Andrew Balmford**
  Professor, Department of Zoology, University of Cambridge, Fellow of the Royal Society of London
- **Jerry Franklin**
  Emeritus Professor of Forest Ecology, University of Washington
- **Sue Baker**
  Professor, School of Natural Sciences, University of Tasmania, Australia

STATEMENTS OF SUPPORT

The following represents a few statements of support provided in review documents and letters of support from Dr. John Marzluff, Dr. Chrstian Messier, Dr. David Lindemeyer, and Dr. Andrew Balmford.

"I think the Elliott State Research Forest Plan represents an extraordinary opportunity for globally significant research across meaningful spatial and temporal scales. ...The Elliott Plan promises to address that critical data shortfall for the first time, with state-of-the-art measurement of all core outcomes, sensible time horizons, and sufficient replication of a broad swathe of real-world management practices. As such it is very likely to inform forest management across the Pacific Northwest for much of this century, as well as to serve as a paradigm for research into sustainable forest management worldwide." ***– Balmford***

"The Elliot Experimental Forest will enable managers and policy makers to research the critical tradeoffs between the services forests provide to nature and people; crucial information for Oregonians and all Northwesterners that wrestle with how to sustain our wonderful natural resources in a rapidly changing world." ***– Marzluff***

"Ideas of trade-offs has been well conceptualized in initiatives like the Triad program and land sharing-land sparing in agriculture, they have never been formally tested with empirical data in long-term experiments. This is a critical knowledge gap in ecologically sustainable forest management – and a gap that urgently needs to be closed because of the immense challenges facing the forest estate globally." ***– Lindenmayer***

"As you know, I have been very active in researching and implementing the Triad approach in Canada, but this research plan constitutes a major step toward testing the Triad approach in an innovative way. I particularly appreciate the fact that this approach will be tested in a large area over the long-term with true replicates for each of the four treatments being compared." ***– Messier***

Letters of support from Drs. Christian Messier, David Lindenmayer, and Andrew Balmford available upon request.

FEEDBACK FROM REVIEWERS AND OSU RESPONSES TO COMMENTS FROM REVIEWERS

Review by Dr. Sue Baker

- Main criticism is the language having such a strong focus on Triad rather than framing it as a Triad trial, it might be better to frame it as a sparing/Triad/sharing trial.
- Suggested Triad-I treatments have 30% reserve, 30% intensive and 40 % extensive.
- Suggested incorporating frequently neglected considerations for ecologically sustainable forestry, habitat for saproxylic species and ecological advantages of regeneration burning over mechanical/herbicide site preparation.

RESPONSES TO PROF. BAKER'S COMMENTS

Yes, we agree that it might be better to frame the proposed Elliott research as something other than 'Triad' – especially given that two of the four subwatershed treatments have one or two stand-level treatments (i.e., 'Extensive' = only extensive, ecological forestry, *'Intensive with Reserve' = only intensive management and reserve). We avoided 'Sharing/Sparing' due to the baggage this general concept has in the conservation biology literature.*

Yes, it would be excellent to have an additional treatment with 30/30/40 in addition to 20/20/60. Our concern was that the former would not enable an equal wood supply across subwatershed treatments. However, we will examine forest productivity carefully to determine if the 30/30/40 mix could be attainable.

It is a good point that we consider beetles as a biodiversity component. We have budgeted for DNA barcoding, and this should enable the deployment of pitfall traps for this taxon, and subsequent identification. Also, we do intend to test a variety of alternatives to herbicides as a means to intensify management. Post-harvest burning is one example of such an option.

Review by Prof. David Lindenmayer

- Impressed with the depth of thinking and planning that has been injected into the development of the research program for the forest.
- Supportive of long-term ecological experiments - relevant to forest management and are extremely rare worldwide.
- Ideas of trade-offs has been well conceptualized in initiatives like the Triad program and land sharing-land sparing in agriculture, they have never been formally tested with empirical data in long-term experiments. This is a critical knowledge gap in ecologically sustainable forest management – and a gap that urgently needs to be closed because of the immense challenges facing the forest estate globally.

RESPONSE TO PROF. LINDENMAYER'S COMMENTS

Thank you for these positive reviews.

Review by Prof. Christian Messier

- Nothing mentioned that the Triad will consider adaptation strategy to make the landscape more resilient to global changes and climate uncertainty.
  - Another question beside only biodiversity would be what of the 4 experimental treatments more appropriate to make the landscape more resilient to global change, of which biodiversity is an important aspect.
- Is intensive here is ONLY Douglas fir plantation or it includes other tree species depending on the site and if mixed tree species plantation could even be considered?
- Could OSU divide the 10 replicates into 5 where the treatments will tend to be homogenous and 5 where they will be more heterogenous to see how homogenous vs heterogenous landscape within each subwatershed treatment would work. This idea come from a recent study from agricultural landscape (e.g. Hass et al. 2018) that suggests that landscape diversity is as important as crop diversity at the farm scale in maintaining key ecosystem services. So could this be also tested with this site?

RESPONSE TO PROFESSOR MESSIER'S COMMENTS

The letter of support and thoughtful recommendations from Dr. Messier are greatly appreciated. We have tried to better highlight the adaptive management underpinning of the proposal recognizing that we are applying treatments in a highly variable and changing environment. We agree that this will make the proposal and the landscape to which the treatments are applied that much more resilient. We believe that the Extensive treatments which accommodate the greatest degree of structural complexity and species diversity is where we will see the greatest resilience to the impacts of climate change (whether that is manifest as insect, disease, or fire). At this point, the vast majority if not all of the plantations on the Elliott are Douglas-fir plantations. We envision broadening the species diversity as a nested study within the intensive treatments and assessing the influence of that diversity on productivity, disease occurrence, carbon and species diversity. With regard to the dividing replicates into homogeneous and heterogeneous, the answer is yes, that is a possibility. At this point we can only infer what conditions will be like for laying out experimental units, but once we have conducted a full forest inventory we will be in a position to assess whether such a split watershed approach might be appropriate.

Review by Dr. Bernard Bormann

- Need a clear definition of extensive, as it is referred to in different places in different ways. I suggest it should be defined as the space between max. NPV plantations and no-touch reserves. A number of places suggests at least some authors are thinking it's Jerry and Norm's ecological forestry, which needs to be broadened to include, at a minimum the following:
  - Engagement with rural communities and tribes to identify elements important to them, designed in from the beginning, not as a socio-economic analysis after the fact. This has been the single largest error in PNW forest policy in my view. If you do this, you will hear about fear of fire, road and other access, hunting and recreation, and culturally important plants diminished by past management (one in your case will be huckleberries on ridges managed by fire). These concerns can be designed into extensive approaches. Keeping extensive open to this is vital.
  - Early-seral biodiversity and ecological process (as well as structure) are not adequately handled in the current draft. The "complex early seral" story is not the whole story. The long-term ecosystem productivity program has been studying this since 1990, and recognizes the need to extend the time/space of pioneering species, nitrogen fixers, browse, mineral soil organic matter effects of shrubs, insect, pollinator, and fish food chains—all of which could be included in slightly longer rotations with conifers establish and well maintained at wide (near final-harvest) spacings. This is an active, managed early seral approach—quite different from the natural regen model. This could be an extensive model with few (or

really any) live-conifer residuals. Also consider crop rotations as another example. Mound-and-pit topography is another. The narrow complex-early-seral model also suffers from a key largely incorrect assumption, that whatever comes back is natural. When we looked at the 1880s GLO records from just south of the Elliott, the most common condition was "brush with a scattering of fir;" well-stocked fir stands were a small percent of the landscape. The demise of tribal people, fire exclusion, and site prep and planting are largely responsible for the huge expansion of conifer seed stores that alter natural succession. This requires active management to restore any similarity to past patterns. The active early seral model is also a great way to bring in needs of rural communities and tribes. Please refer to Bormann et al. 2015 (which I attach).

- Need a very precise definition of old forest. The WA DNR uses structure alone, not age. This allows them to consider (at least in theory) managing in mature stands with large but not that old trees.
- Make fire a much stronger element to the study (or at least allow this as it unfolds). The patterns driven by the current design might actually be a good fire strategy, but you will need to think about underburning and managing along ridge roads (or ridge burning [maybe for huckleberries] as prep for fire attack response.
- Depending on how constraining MM/NSO regulations are it might be worth a try to get a research HCP (like OESF).
- Emphasize more active management of the previously unmanaged 100-150 yr old stands. They are at a height now where major wind events will soon affect them as well as subject to possible total or partial loss from fire. I think of added questions such as:
    - How do you protect MM and NSOs from massive fire and wind?
    - How do you extract some timber and other human benefits from these as they fall apart in an accelerated fashion given climate and other changes?
- I'd make revenue a key focus. Efficiency of harvest/roads dictates the majority of remaining net revenue that can go to "restoration", research, or beneficiaries if there are any. You've got a great group (Woodam etc.. to do this).
- There are a few areas that could be strengthened:
    - Needs more on other ecological goals beyond ESA;
    - Should use ecosystem services correctly (includes timber production);
    - Aquatic goals should focus on biotic responses, not indicator thereof at this scale;
    - The 60 yr minimum rotation seems wrong—you might even think about adding an industry control treatment (if the questions is whether these ideas are better).

RESPONSE TO COMMENTS FROM PROF. BERNARD BORMANN

We as authors appreciate the detailed comments and recommendations provided by Professor Bormann. We have directly incorporated a number of these comments with edits to the text in an attempt to improve clarity. We completely agree that the definition of Extensive has been a source of confusion for some readers. We have taken your advice and tried to expand that definition to include some of the suggestions that you make above. While not explicitly presented in the section where we define "Extensive" we emphasize our commitment to working with our various partners and stakeholders and specifically tribal representatives to ensure that "Extensive" meets a broad set of interests. We specifically chose to not use the term "ecological forestry" to avoid defining the approach too narrowly or to a specific school of thought. It is not that we disagree with the tenets of ecological forestry, it is just that we wish to retain as much flexibility to accommodate the largest number of values/ecosystem services in this set of treatments.

The actively managed early seral approach described in your comments is highly appealing and is definitely something that we can incorporate into this study design. Currently, we do not provide much detail on how early seral habitat will be managed, but we have added some text to reflect some of the thinking that you provide here.

We appreciate the recommendation regarding needing a precise definition of "old forest." We do not actually use the term "old forest" in the proposal, but do refer to mature forests and naturally regenerated forests. We have attempted to emphasize stand complexity rather than age of trees as tree age is not as simple to estimate in the field as one might imagine and because beyond a certain point structure of the stand is far more ecologically meaningful than age. In working with different stakeholders we were asked to manage by age, but I think we have come to a general agreement on linking natural regeneration, habitat and structural complexity into a single package that is described as naturally regenerated mature stands.

We have added some acknowledgement of the importance of fire and fire as a management tool in the research opportunities section. We appreciate the suggestion that we should emphasize more active management of the previously unmanaged 100-150 yr old stands and specifically the questions around how we will protect murrelets from large crown fires or wind storms. However, this has been an area of particular concern raised by numerous stakeholders as well as in other research comments that push back against any active management in olders tands. The extensive treatments do include management strategies that include timber harvest with high rates of retention in mature stands, but we have also committed to avoiding the oldest, naturally regenerated, most structurally complex stands as a result of deliberations with stakeholders. Shortening rotation lengths on intensive harvest units goes against our intent to maximize wood production rather than revenue.

Review by Dr. John M. Marzluff

- The Elliot Experimental Forest will enable managers and policy makers to research the critical tradeoffs between the services forests provide to nature and people; crucial information for Oregonians and all Northwesterners that wrestle with how to sustain our wonderful natural resources in a rapidly changing world.

- You say the 4 main treatments will yield approximately equal amounts of wood, but I see no way that the 100% intensive and the 50:50 treatments can do that. Won't all treatments with some reservation or ecological forestry produce less wood than the 100% intensive?
- A critical feature of sparing vs. sharing debates is the extent to which sparing actually leads to land put into conservation. In the Midwest, for example, this does not happen because as the value of the crop (corn there) increases so to does the plowing of marginal lands that were initially spared. Can you build in a way to work on policies that would go with your treatments to assure conservationists that if land is intensively worked, then an equal amount will be reserved? This in specific, but in general involving social scientists looking at policy and governance necessary to implement your strategies on a wider PNW landscape would be a good addition.
- Can you measure how many jobs are created or maintained in each treatment as well?
- You mention owls and murrelets, but you aren't going to be able to study these well at the scale of your treatments. I suggest you focus on nest predator changes for mamu and barred owl changes for now. Those are the drivers of forest value for the species, so measure them directly rather than trying to say something about a rare species (though you might at least survey every 5-10 years for owls and murrelets).
- You should make an argument as to why this is needed given the HJ Andrews experimental forest nearby. What do we gain over the Andrews effort with the Elliot?
- You mention the ability to study landscape effects beyond the plots. You might add to that the aspect of recreation in the landscape and proxy to development. Both are frequent in the Elliot and spatially variable, so they might affect your replicates.

RESPONSE TO PROFESSOR MARZLUFF'S COMMENTS

We greatly appreciate the positive support and critical input from Professor Marzluff. We have attempted to integrate his comments into the text or we provide a brief response below. Within the Triad design, the intensive treatments are applied to 50% of the land area of extensive with the remaining 50% going into reserve. On the extensive treatments, a fraction of the timber is harvested in a given unit, but there are no reserves within these watersheds, it always totals to 50% of the maximum volume taken on the intensive harvest units. In the case of the Elliott, we are proposing to place 65% of the forest into reserve with only 17% going into Intensive and 16% in extensive treatments. We also commit to all intensive harvest units being matched in acreage by reserve units. It is also important to note that even under intensive, the forest conditions achieved from years 30 - 60 are not equivalent to intensive agricultural production, but accommodating a diversity of species, soil organic matter accumulation, and a diversity of recreational values.

Job creation as a result of stand management, harvest and milling will be assessed as part of the rural economy values that are described as one of the values influenced and studied in this set of experiments. We appreciate the suggestion with regard to murrelets and owls, we will certainly study predators and we intend to have regularly scheduled monitoring of endangered species throughout the study area.

The HJ Andrews is an ideal location to study the ecology and hydrology of natural forest systems. There are no longer any intensive or really any large scale extensive forest management experimentation on the Andrews. The Elliott allows us to study and demonstrate alternative forest management approaches and how they influence forest ecosystem processes, productivity, biodiversity, habitat, and recreational opportunities to name a frew. This is not and cannot be studied at the HJ Andrews. We intend to study recreational opportunities, impacts and potential throughout the forest. These possible studies are addressed in the research opportunities in Appendices 3 and 6.

Review by Dr. Jerry Franklin

Full text of emails from Jerry Franklin to members of the Elliott project team are included at the end of this section with his permission for reference. Because of the extensive nature of Dr. Franklin's comments, responses to key comments are provided by members of the OSU Exploratory Committee: Matt Betts, Klaus Puettmann, Ashley D'Antonio, Meg Krawchuk, Shannon Murray, John Session, and Ben Leshchinsky.

COMMENTS FROM JERRY FRANKLIN

"First, I find the concept of conducting an experiment that essentially involves the entire property at the outset of OSU's stewardship to be inappropriate. There is no way that any of us can possibly anticipate the critical forest conservation issues that we are going to be needing to address one, two or three decades from now. I don't believe that the most important challenge is going to be how to divide up amongst the different management philosophies though I may be wrong. Our track record at figuring out the most important issue(s) has been very poor in academia. We are going to be surprised. That being the case, taking what will be your major research property and committing it all to an experiment of any kind along with committing all of the financial resources necessary to sustain it is not – to use a kind word – prudent. All of the verbiage in the proposal about being able to superimpose many research projects on the current design may be true – but almost certainly there will be important research that needs to be done that will have been locked out or grossly compromised by the treatments imposed on the entire property. Thank God we in FS research did not do to the H. J. Andrews what many of us thought we should do – i.e., make it (the entire Andrews) a model of modern forest practices circa the 1960s and 1970s. I will make only one more comment about this – forest academics have an abominable record of identifying and conducting fundamentally important forest science projects."

COMMITTEE MEMBER RESPONSE

When the Dean formed the Elliott State Research Forest Exploratory Committee in 2019 he charged the group with developing a 'grand *vision' that warranted OSU taking on the massive responsibility of an 85,000 ac research forest. In our view, implementing a test of a single silvicultural approach (e.g., "ecological forestry") was insufficient to warrant such a step. Rather, we chose to address the most pressing problem facing humanity: how to provide for the carbon, timber, ecosystem services needs of a global population of nearly 8 billion people without compromising the conservation of biological diversity and ecosystem health.*

Although this is the 'grand vision' for the Elliott, this in no way precludes many stand-level studies that only tangentially fit within this vision. Here are some examples of the "nested" research projects:

1. *It is certainly of policy relevance to find out how biodiversity responds to different sorts of "ecological forestry" (very little work has been done on this in the PNW, despite BLM's intent to implement it widely).*
2. *How do Coho salmon respond to differing degrees of canopy removal adjacent to streams? This question could still be very effectively addressed within the rubric of Triad.*
3. *Can we generate high timber yields in plantations with reduced or no herbicides?*
4. *Over the long term, do mixed species plantations result in higher yield than single species plantations?*

Figures 13a and 13b show how such studies could be implemented within Triad using randomized block, replicated designs. All of these questions are central forest management questions that are of great interest to the people of Oregon, and can be implemented within the Triad design as "nested studies".earch program on the Elliott that will push us to bridge disciplines and develop a more systemic, integrative view of forestry. We'll be tracking numerous response variables including: timber yield, revenue, employment, data on a myriad of biodiversity and ecosystem processes, carbon storage, recreational benefits and use, among many other response variables. We agree that a major challenge will be to ensure that we not only analyze these variables separately and need to ensure that logistical and funding support plans specifically emphasizes integrative work.

Further, we plan to implement Triad silviculture in the context of adaptive management. So, we will not be married to a single "silviculture du jour" for the next 50-100 years, but we will learn by doing – for both extensive and intensive management. We will ask questions such as: Are there ways to do highly productive intensive management without herbicides, and in ways that conserve early seral biodiversity? Are there are ways to do ecological forestry without reducing wood supply substantially? Our descendants will likely look back at our current practices and be in awe of how simplistic and misplaced they are.

The adaptive management approach also allows us to cut an important balance between flexibility and the sort of "ongoing inspiration" questions/program that you describe, and a very important other element to the ESRF: trust-building and the development of the HCP supporting this work. In order to develop the Elliott's potential as a research forest, OSU recognizes the importance of collaboration, community building, and input that signals a desire to share governance and respect community perspectives. This trust-building requires some basic architecture that helps the broader community understand what is, and what is not, going to happen on the Elliott. The Triad approach provides that architecture. The Triad approach also provides the architecture to support a HCP that is critical to the Elliott. These two important elements are critical to the Elliott's success.

COMMENT FROM JERRY FRANKLIN

"Second, despite your efforts to find a way around it, I do not find that the design meets the high standards that are required for a statistically valid and, perhaps more important, a socially convincing outcome at some future date. The treatments are not randomly assigned and all of the manipulations and rationalizations that are created will not produce a definitive outcome on the questions posed. You don't like the aggregation that takes place with a random assignment? Then do a stratified random assignment where environmentally comparable watersheds are clustered in groups of four and randomly assign within those clusters. What you have done requires far too much explanation, manipulation, and rationalization to be a clean experiment. And if that isn't enough, you don't have any true controls! You need to have untreated controls right along with the treatments. Considering the big reserve to be a control is not credible. You need control "treatments" if you are going to be able to assess changes in biota, for example."

COMMITTEE MEMBER RESPONSE

First, given the natural disturbance and forest management history at the Elliott, it would not be politically feasible, ethical, nor strategic from a conservation standpoint to implement a fully random design at the Elliott. A fully random design would result in many old stands being clearcut and turned into intensive management. Similarly, it would result in large areas of plantations being set aside as reserves. These scenarios were completely unpalatable to the Exploratory, Advisory and Stakeholder Committees.

How to ameliorate this lack of randomization problem? There are several important scientific reasons for random allocation of treatments. First, randomization avoids true bias. For instance, it might not be by chance that old forest remains where it does (e.g., steep slopes, low productivity forest; Lindenmayer and Laurance 2012 – Biol. Cons.). To explore this possibility, we tested whether the particular watershed-scale treatments tended to fall on steeper slopes than others, or were characterized by higher site-quality ground. We found no evidence for such biases, except that our "extensive" treatment watersheds tend to be smaller, on average (Figure 9a).

A second reason for randomization is that it is more likely to result in spatial interspersion of treatments. Indeed, it was of concern to our group that our treatments seemed quite clumped as initially implemented (e.g., more 'extensive' watersheds occurred adjacent to each other than you would hope). However, when we tried a fully randomized design, it turns out that by chance alone substantial

Figure 13a. ***Nested study question: Does wildlife respond differently to ecological forestry conducted in young versus older stands?***

Question: Does wildlife respond differently to ecological forestry conducted in young versus older stands? In other words, does variable retention cutting in 40-year plantations provide the same quality of habitat as , the same treatment in older stands, that have large legacy elements (large residual green trees, large snags, downed wood)?

Relevance: BLM is in the process of implementing 1000s of acres of 'ecological forestry' treatments, and USFS may follow. Small private owners are also interested in implementing ecological forestry techniques. One might hypothesize that a number of taxa are dependent on large wood elements (e.g., beetles, lichens, fungi) in early seral systems and will be less prevalent in early seral forests that originated from 40-50 year old plantations.

Example nested design: Within subwatersheds (green) where any form of ecological forestry is permissible.

Ecological forestry (e.g., high retention with no herbicides) is implemented in either plantations (red) or natural (<150 year) stands. In this case, it would be impossible to attribute stand age randomly, but one could compare both treatments to untreated forest.

Species abundances are quantified (beetles, lichens, fungi, birds, small mammals)
NOTE: Again, this requires no deviation from the overall Triad framework because Extensive forestry would be implemented across age classes.

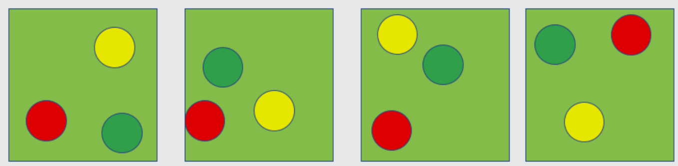


Figure 13a. *Nested study design for the question of whether ecological forestry techniques result in similar habitat quality in old versus young stands, both in relation to unharvested controls. This research is relevant because ecological forestry is being implemented on BLM land in stands up to 150 years old with an upper diameter limit of 40 inches. To our knowledge, little or no formal research has been done on these treatments.*

Figure 13b. ***Nested study question: What is the effect of planting species mixtures on "ecosystem stability"? (sensu Tilman 2006 – Nature)***

Relevance: It has been hypothesized that species mixtures might reduce disease vulnerability, result in "over-yielding", be more resilient in the face of climate change. Below and above-ground interactions could be examined at finer scales (among tree). Another hypothesis is that the effect of species mixtures could be contingent on stand and landscape context. For instance, monocultures embedded within a landscape of intensive management might be particularly vulnerable to disease-induced mortality. Multiple land-owners would benefit from knowing the answers to these questions. Also, such an experiment could be nested within broader, global-scale experiments asking similar questions: https://treedivnet.ugent.be

Example nested design: Within subwatersheds where Triad is implemented, randomly allocated experimental stands are attributed to a range of species mixtures (red=1, orange=2, yellow=3, pink=4). This is a randomized block design. In total, we could have up to 10 blocks in each Triad treatment (so total blocks = 40, or within a single Triad treatment N=10).

At the landscape (subwatershed scale) these four treatments are nested in a landscape of reserve/intensive (blue) or ecological forestry ("extensive"; green). This enables testing the question of whether the context of planting in mixtures matters.

NOTE: Such a design would not compromise the overall Triad question because the same stand-level treatments would be applied across watersheds.

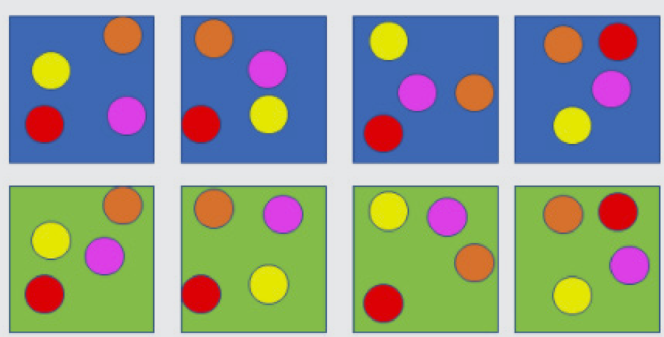


Figure 13b. *Nested study design for the examination of how plantations of different tree species diversity effects yield. These sorts of experiments are of particular importance over the long term to determine whether the current prevalent approach of Douglas-fir monocultures is a risky strategy in the face of climate change and potential disease outbreaks.*

clumping occurs. Given the size of the Elliott, and the large scale of the experimental units, full interspersion of treatments is unattainable – even with a randomized design. So, the best way to handle this issue is post-hoc, by taking spatial autocorrelation into account during statistical analysis, and by examining/integrating a wide suite of covariates that could contribute to variability.

All of this said, it is a fundamental principle of inferential statistics that to make inference to a broader population, treatments be randomized (this is primarily for the reasons above). One promising way forward is to model different research design scenarios using a landscape-scale harvest/ biodiversity simulation model (e.g., Woodstock). We will run different design scenarios for 50, 100 years etc. to test whether the outcomes of random allocation versus our current allocation differ. If changes need to be made, this can occur within the adaptive management process and supported using the full input and governance structure we establish for the Elliott. For example, if the finding is "extensive/ecological forestry results in a greater density of early seral associated birds for a given harvest level over the duration of the study", does this conclusion differ if we implement a fully random design versus the one currently proposed? Although a number of assumptions about yields, wildlife responses etc. are required for such modeling, this will be one effective way to ameliorate reviewer concerns about the effects of randomization.

Finally, randomization is essential for statistical inference but it could be argued that the Elliott experiments will be valuable even in the absence of statistical inference. For example, Hubbard Brook – one of the best-known forest management experiments in the world – was not randomly assigned as a watershed. Nor was there any replication at all. This has not precluded its value to the forest ecology and policy community. It is worth noting that highly cited empirical papers from the PNW (van Mantgem et al. 2009, Chen et al. 1995, Spies et al. 1990) all do not have randomized design. A random design would have been either inappropriate or impossible in any of these studies. For instance, Chen et al. examined the influence of forest edge in (a) old-growth and (b) plantations on microclimate. It would not have been possible to randomly attribute "old growth" as a treatment. One of the highest profile studies in forests in the PNW in recent decades has been the Donato et al. (2005) Science paper on post-fire salvage logging. Of course, in this study, fire was not randomly attributed, but neither was the salvage logging treatment. Finally, the experimental watershed treatments at the HJ Andrews were not randomly assigned. This is not to argue that random designs aren't critical, or ideal. The only point is that sometimes in ecology random designs are simply not feasible. This is particularly the case for landscape-scale studies. In these cases, ethical researchers will at least formally test, and report on, potential confounding factors (as we have at the Elliott).

Figure 9a.

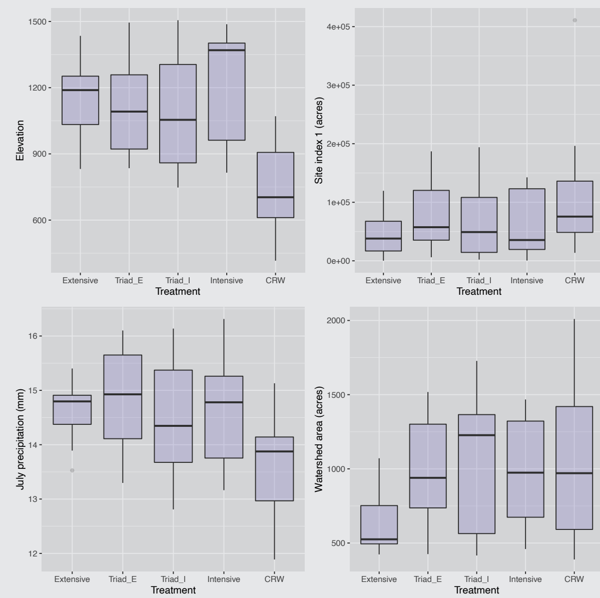


***Figure 9a.** Tests for whether lack of fully random subwatershed-scale treatments at the Elliott resulted in any substantial confounding between treatments and other underlying features at the Elliott State Forest. If this were the case, it would be possible to misattribute treatment effects when in fact other features were the cause. Neither elevation, site index, precipitation showed substantial differences among treatments. Only watershed areas in the Extensive treatment tended to be smaller than the other treatments. Note that the CRW (Conservation Research Watershed) is not a formal treatment, so the differences above are not detrimental to the overall Triad design.*

COMMENT FROM JERRY FRANKLIN

"Third, I see a lot about impacts of management on water yields, quality, biota but I see nothing in the plan about how you are going to assess those impacts. Watershed level studies require extended calibration periods (including on control watersheds) so that you can statistically assess changes following treatments. That kind of work requires incredible investments in time and money (and controls). We can see from the Andrews the incredible value of such calibrated watershed experiments but I don't see where that is built into this research plan – which could make inferences about aquatic systems should we say – difficult?! Unless you are really prepared to do watershed level assessments of impacts there really is no reason for you to be doing treatments at the levels of watersheds – is there?"

COMMITTEE MEMBER RESPONSE

Our plan is to implement such calibration, and funding has been budgeted to do so. The treatments roll out over multiple decades (both a pro and a con of the design), which provides opportunity for long-term pre-treatment monitoring for many sites.

COMMENT FROM JERRY FRANKLIN

"Fourth, the whole notion that you are doing a meaningful test of the

TRIAD concept is nonsense. You are trying to test it at the wrong scale. TRIAD in the PNW forests is occurring at the level of large landscapes, not small watersheds. The production emphasis element of TRIAD are the fiber farms of the REITs and TIMOs and are being done on a very short rotation. The integrated element of TRIAD are represented by the federal forests (BLManyway), trust forests managed by WA DNR, and many private forest lands, where ecological and economic goals are being integrated through ecologically-based management that includes recognition of special management areas (e.g., riparian habitats) and various forms and intensities of retention. The hard-core conservation element of TRIAD are the large reserved forest areas like the Late Successional Reserves on federal lands, national parks, wilderness areas, private reserves and trusts, etc. I do not find this experiment to be a credible test of what I understood as the Maine folks' version of TRIAD."

And, as I noted initially, I don't consider an experiment about how to divide forest landscapes at any scale among production and conservation goals to be a high priority in our current world; that probably has a much higher social than technical element to it anyway. There are so many important things to be done and this is not one of them. A comprehensive test of alternative approaches to preparing our managed forest landscapes to meet the challenges of climate change is one of them – great that you are aware of the continental-wide collaboration that is going on in this regard, but your current experiment does not fit the design. Some credible silvicultural experimentation to begin better quantifying the tradeoffs between ecological and economic goals in ecological forestry treatments would be another one."

COMMITTEE MEMBER RESPONSE

Differences in opinion are valuable, and your comments will help to refine elements of the proposal. This diversity of perspectives is the core of the critical review process. We now have external comments and reviews from a number of leading conservation biologists and forest ecologists worldwide, and they disagree with you that the research design is inappropriate. These scientists include: Prof. Andrew Balmford (University of Cambridge, UK), Prof. Sue Baker (U. Tasmania, Aus), Prof. Christian Messier (Université du Montreal, Canada), Prof. David Lindenmayer (Australian National University), Prof. John Marzluff (University of Washington). All reviewers had some important and valuable comments that we will incorporate into the proposal, but overall, the reception was highly enthusiastic.

Your point above about the spatial scale is important. Of course, it would be ideal to have an experiment that covered the entire western part of Oregon, but such region-wide experiments are clearly logistically and politically impossible. Although our experiment will not be useful for some wide-ranging species (e.g., mountain lion), it will be relevant to species and processes operating at finer spatial scales (e.g., songbirds, pollinators, murrelets, water quality, landslides, recreation opportunities, fine-scale deer and elk habitat selection).

We do wish that monitoring of multiple facets of social and ecological systems were being systematically carried out on the portfolio of management strategies that exist across the region, in a way that would help build our understanding of trade-offs in forest management. But they aren't. Accordingly, the ESRF provides a unique function, and an opportunity to test ideas of sustainability relevant (and necessary) to the region as a whole. This is somewhat of a mesocosm experiment, but a very large one.

COMMENT FROM JERRY FRANKLIN

"...I think that the quality of SOF's proposal for the Elliott – in terms of vision, creativity, relevance, practicality, among other things – is critical. And at the level of the School itself, it needs to be able to engage and excite a majority of the faculty, staff, and student body. The current proposal, in my view, falls far short."

COMMITTEE MEMBER RESPONSE

We have pushed for a high degree of faculty involvement in this process. Many might be under the impression that this has been a top-down process, but this is far from the case. The interim Dean asked for faculty volunteers and nominations to help come up with a "bold" vision for research at the Elliott. This formed the Exploratory Committee – which is made up of social scientists (Ashley D'Antonio), ecologists (Meg Krawchuk, Matt Betts, Klaus Puttemann), a geotechnical engineer (Ben Leshchinsky), a forest operations modeler (John Sessions), forest stream ecologists (Dana Warren and Gordie Reeves). The Exploratory Committee also organized a suite of meetings in 2019 to solicit ideas from other faculty in CoF and these formed the basis for a long list of interesting research questions. We also have an external science advisory panel composed of social and natural scientists outside of OSU. In short, despite the relatively short time line in putting the proposal together this has been a participatory, largely bottom-up process driven by researchers. There will be many further opportunities for other members of CoF, other faculty from OSU, UO, PSU and hopefully from other universities as well to be involved and develop their own nested experiments within the Triad design (see below). Also, we should note that the hope is that the research design is sufficiently interesting that we will attract researchers from far beyond OSU. Indeed, we've had enthusiastic responses from professors at the University of Washington, University of Cambridge, Australian National University, University of Tasmania, and University of Montreal.

COMMENT FROM JERRY FRANKLIN

"...A second tendency on the part of foresters (especially silviculturists) is to develop confounded designs. What I mean by that is that they simultaneously vary several variables with the result that you never get a clean test of any of the variables. They are all confounded together."

"...Credible large, long-term research projects are very costly in terms of both time and money. These are major investments that have very long-term consequences for the organizations that undertake them, in terms of administrative time, funds, and personnel. They have a tendency to take on a life of their own. The most successful of these kinds of efforts (as illustrated by Hubbard Brook, Coweeta, and Andrews) involve collaborations between institutions, particularly academic institutions and federal agencies."

"The first thing I would do is to develop a more meaningful vision for SOF's program on the Elliott. For example, as a starting point: To develop, quantify, and demonstrate approaches to forest management that integrate ecological, economic, and cultural objectives and that reduce risks to disturbances and climate change. Whether something like this works or not – some kind of over-riding guiding vision is needed. What is the general purpose/ goal of SOF in undertaking research at Elliott?"

COMMITTEE MEMBER RESPONSE

Our group agrees that we should avoid confounds, study ecological responses over the long term, and that such experiments will be expensive.

COMMENT FROM JERRY FRANKLIN

"I believe some significant changes in what is proposed is imperative but that this could be done in a relatively short time, if you chose to do it. The current proposal would not get a pass on peer review at NSF and probably not in the court of public opinion, either.

COMMITTEE MEMBER RESPONSE

It is fairly well known that it is difficult at best to get forestry studies funded by NSF and it is generally accepted that it is highly unlikely that any applied management research would be funded. For the Elliott project to be NSF funded, we would need to have a clear basic research angle that tests exciting ecological theory. Our faculty have served on many NSF panels and have led a number of funded NSF grants and can attest to this notion. It is more likely that the Elliott might attract funding from large foundations or applied funders such as USDA-AFRI. For these, a substantial, bold vision is necessary (not fine-scale stand-level studies examining micro changes to silvicultural practices). As for public opinion, time will tell, but the CoF Elliott group has been in extensive conversations with an integrated group of environmentalists (Audubon, Wild Salmon Center, Nature Conservancy), members of the forest products sector (Douglas Timber Operators, Barnes & Associates, and others) Confederated Tribes of Grand Ronde, Confederated Tribes of the Coos, Lower Umpqua and Siuslaw Indians, Confederated Tribes of Siletz Indians, members of the recreation community and others. Although things can be rocky, the group has moved to a surprising degree of consensus on the current ideas and design. The Elliott process seems to be a rare example of environmentalists and loggers working closely together to advocate for important research and conservation measures. There is a real opportunity here for a substantial research, conservation and social win.

COMMENT FROM JERRY FRANKLIN

"One real issue that needs to be addressed relates to integration of ecological, economic, and cultural goals in managed forests. Most forest owners/managers in the PNW are seeking that balance in their management and we have little information on how to do it. The second real issue is climate change and how to manage forests to increase resistance and resilience; the issue of wildfire I see as a part of this."

COMMITTEE MEMBER RESPONSE

The discussions among the various members in the Exploratory Committee have strongly emphasized developing a research program on the Elliott that will push us to bridge disciplines and develop a more systemic, integrative view of forestry. We'll be tracking numerous response variables including: timber yield, revenue, employment, data on a myriad of biodiversity and ecosystem processes, carbon storage, recreational benefits and use, among many other response variables. We will be tracking: timber yield, revenue, employment, data on a myriad of biodiversity and ecosystem processes, carbon storage, recreational benefits and use, among many other response variables. In our view, such an approach is highly "integrated". We agree that a major challenge will be to ensure that we not only analyze these variables separately and need to ensure that logistical and funding support plans specifically emphasize integrative work.

NOTE: The full text of emails from Dr. Jerry Franklin are provided in sequence below for reference.

"I have (admittedly quickly) gone through the document that you provided as an attachment. I tried to be as objective as I could in looking at it. I very much want OSU and the College of Forestry and all of you to be as successful as you can possibly be in taking responsibility for the management of this controversial property and I want the science to be highly credible and relevant given the investment that is going to be made.

That said, the changes that have been made in the research proposal I find to be minor in terms of what I view as basic major flaws in the concepts underlying the proposal and in its proposed implementation. I scarcely know where to start but let me give it a try – once again.

First, I find the concept of conducting an experiment that essentially involves the entire property at the outset of OSU's stewardship to be inappropriate. There is no way that any of us can possibly anticipate the critical forest conservation issues that we are going to be needing to address one, two or three decades from now. I don't believe that the most important challenge is going to be how to divide up the amongst different management philosophies though I may be wrong. Our track record at figuring out the most important issue(s) has been very poor in academia. We are going to be surprised. That being the case, taking what will be your major research property and committing it all to an experiment of any kind along with committing all of the financial resources necessary to sustain it is not – to use a kind word – prudent. All of the verbiage in the proposal about being able to superimpose many research projects on the current design may be true – but almost certainly there will be important research that needs to be done that will have been locked out or grossly compromised by the treatments imposed on the entire property. Thank God we in FS research did not do to the H. J. Andrews what many of us thought we should do – i.e., make it (the entire Andrews) a model of modern forest practices circa the 1960s and 1970s. I will make only one more comment about this – forest academics have an abominable record of identifying and conducting fundamentally important forest science projects.

Second, despite your efforts to find a way around it, I do not find that the design meets the high standards that are required for a statistically valid and, perhaps more important, a socially convincing outcome at some future date. The treatments are not randomly assigned and all of the manipulations and rationalizations that are created will not produce a definitive outcome on the questions posed. You don't like the aggregation that takes place with a random assignment? Then do a stratified random assignment where environmentally comparable watersheds are clustered in groups of four and randomly assign within those clusters. What you have done requires far too much explanation, manipulation, and rationalization to be a clean experiment. And if that isn't enough, you don't have any true controls! You need to have untreated controls right along with the treatments. Considering the big reserve to be a control is not credible. You need control "treatments" if you are going to be able to assess changes in biota, for example.

Third, I see a lot about impacts of management on water yields, quality, biota but I see nothing in the plan about how you are going to assess those impacts. Watershed level studies require extended calibration periods (including on control watersheds) so that you can statistically assess changes following treatments. That kind of work requires incredible investments in time and money (and controls). We can see from the Andrews the incredible value of such calibrated watershed experiments but I don't see where that is built into this research plan – which could make inferences about aquatic systems should we say – difficult?! Unless you are really prepared to do watershed level assessments of impacts there really is no reason for you to be doing treatments at the levels of watersheds – is there?

Fourth, the whole notion that you are doing a meaningful test of the Triad concept is nonsense. You are trying to test it at the wrong scale. Triad in the PNW forests is occurring at the level of large landscapes, not small watersheds. The production emphasis element of Triad are the fiber farms of the REITs and TIMOs and are being done on a very short rotation. The integrated element of Triad are represented by the federal forests (BLM anyway), trust forests managed by WA DNR, and many private forest lands, where ecological and economic goals are being integrated through ecologically-based management that includes recognition of special management areas (e.g., riparian habitats) and various forms and intensities of retention. The hard-core conservation element of Triad are the large reserved forest areas like the Late Successional Reserves on federal lands, national parks, wilderness areas, private reserves and trusts, etc. I do not find this experiment to be a credible test of what I understood as the Maine folks' version of Triad.

And, as I noted initially, I don't consider an experiment about how to divide forest landscapes at any scale among production and conservation goals to be a high priority in our current world; that probably has a much high social then technical element to it anyway. There are so many important things to be done and this is not one of them. A comprehensive test of alternative approaches to preparing our managed forest landscapes to meet the challenges of climate change is one of them – great that you are aware of the continental-wide collaboration that is going on in this regard, but your current experiment does not fit the design. Some credible silvicultural experimentation to begin better quantifying the tradeoffs between ecological and economic goals in ecological forestry treatments would be another one.

I have probably said more than I needed to at this point. It is your proposal. I do not think that it does credit to the institution or yourselves; you can do much better than this. Personally, I think you need to start all over beginning with a truly long-term perspective on the potential of the property and an examination of what research will benefit the people (and forests) of the PNW both in the short and long term."

–Full text from follow up email–

"After my initial response to your early email (attached below) I had an exchange with Brett (also attached below). After a long phone conversation further discussing these points with Brett and Norm, we concluded that the exchange should be shared with you folks, as well. It reflected my continued thinking about the current proposal and what some of the alternatives might be. Since then, I have continued to think broadly (often in the middle of the night) about what the Elliott Forest connection could mean to the OSU SOF as well as in more detail about alternatives to the current research proposal and deficiencies in the same. This is a truly profound opportunity for SOF that could have either an enormously important positive outcome or could be disastrous for SOF. I don't believe that in my lifetime SOF has had such an opportunity to be significantly engaged with such a broad array of stakeholders, including the state's social leaders. The SOF's previous involvements have all been with much smaller groups of folks that were more immediately impacted by program's that it proposed and carried out. At Elliott, SOF and its vision of itself and its future are on stage. This may be one of those rare and often unrecognized turning points that occasionally happen. I have an uncomfortable feeling that the previous Dean did not fully recognize its importance and ensure that it got the attention that it deserved. But, in any case, this may be where SOF defines for the citizens of Oregon its vision of its future role in management of natural resources in the region.

Which is to say I think that the quality of SOF's proposal for the Elliott – in terms of vision, creativity, relevance, practicality, among other things – is critical. And at the level of the School itself, it needs to be able to engage and excite a majority of the faculty, staff, and student body. The current proposal, in my view, falls far short.

Initially, I had not intended to get involved in the Elliott in any way, other than with Norm to try to warn SOF away from developing a proposal that would involve significant programmed harvest of older, naturally regenerated forest. We believed and still believe that, based on our experience, this would ultimately doom the proposal and have bad long-term consequences for SOF's reputation. But I have obviously gotten a lot more deeply engaged as I have learned more about the planned research, found it to be deficient in so many regards, and continue to imagine what the consequences might be for the school.

With this background as preface, read the exchange between Brett and I and then the following comments and suggestions.

Some key things I have learned about large long-term research projects

I have a lot of experience in planning and implementing long-term research projects. One principle that I learned very early on is the KISS principle – Keep It Simple Stupid. There is an incredible tendency on the part of foresters (and I am sure many others) to develop complex experiments with many variables. The successful long-term experiments that I know about have been simple designs with one or two very clear questions/variables that are addressed in a very robust fashion. Foresters tend to develop designs that are like Christmas trees, perhaps starting with a simple concept but then adding on more and more variables, diluting the clarity of original design. The large, longer, and more important the experiment the more important it is to keep it simple and to select treatments that truly offer a contrast – not small increments of variation in the key variables but significant contrasts. I will illustrate them in a minute with what was done with the DEMO experiment.

A second tendency on the part of foresters (especially silviculturists) is to develop confounded designs. What I mean by that is that they simultaneous vary several variables with the result that you never get a clean test of any of the variables. They are all confounded together. Let me illustrate with what happened with DEMO, which was a congressionally mandated experiment on alternatives to clearcut harvesting Douglas-fir. Logan Norris and I were the ones that talked the congressional committee into mandating this so we had a major interest in how the FS responded to it. PNW was given the responsibility to design the experiment and they had two silvicultural researchers put together the initial design (which did include random assignment of treatments and controls!). Their design was a nice series of treatments that involved increasing numbers of retained trees; however, each increment of tree retention involved a different spatial arrangement – i.e., of how the retention was distributed. So retention levels and spatial pattern of retention were confounded and no conclusion could be reached about either retention level or spatial arrangement. When the plan underwent review, I challenged it, as logical as it all seemed to the silviculturalists who had developed it. We ended up with a big meeting of researchers and management folks in Portland, to which I brought David Ford, an outstanding quantitative forester. The group concluded that they wanted DEMO to produce a credible statistical test of both retention level (15 and 40%) and pattern of retention (dispersed or aggregated). The confounded design was thrown out and replaced with what was basically a 2 X 2 factorial design.

Credible large, long-term research projects are very costly in terms of both time and money. These are major investments that have very long-term consequences for the organizations that undertake them, in terms of administrative time, funds, and personnel. They have a tendency to take on a life of their own. The most successful of these kinds of efforts (as illustrated by Hubbard Brook, Coweeta, and Andrews) involve collaborations between institutions, particularly academic institutions and federal agencies.

Strong, inspired leadership is critical to conceive and establish successful long-term research projects and, once established, successful transitions in leaderships are critical to their continuation. I have seen both successes and failures in this regard.

How would I approach the Elliott?

The first thing I would do is to develop a more meaningful vision for SOF's program on the Elliott. For example, as a starting point: To develop, quantify, and demonstrate approaches to forest management that integrate ecological, economic, and cultural objectives and that reduce risks to disturbances and climate change. Whether something like this works or not – some kind of over-riding guiding vision is needed. What is the general purpose/goal of SOF in undertaking research at Elliott?

I would engage more of the faculty and student body in planning the actual experiments.

I would not propose to use all of the Elliott in a single experiment but, rather, do a series of experiments on various topics (climate change adaptation, ecological-economic tradeoffs, etc.) in the younger forests, where the areas for replication were selected on comparability in terms of site and stand conditions. I imagine these experiments having treatment areas of 40-50 acres so that small mammal, songbird and other small vertebrate populations could be studied. Of course, with control areas as part of the treatments. I would do some smaller scale exploratory work before actually undertaking the longer-term experiments. I would select and begin calibrating a series of selected watersheds for future experiments.

I would do at least a back of the envelope calculation of the cost of whatever it is that is proposed in the final research proposal.

Closing Comments

I am momentarily running out of ideas and energy but want to get this off to you rather than just sit on it.

I believe some significant changes in what is proposed is imperative but that this could be done in a relatively short time, if you chose to do it. The current proposal would not get a pass on peer review at NSF and probably not in the court of public opinion, either.

I believe that the Triad theme is indefensible as a basis for the research program. One real issue that needs to be addressed relates to integration of ecological, economic, and cultural goals in managed forests. Most forest owners/managers in the PNW are seeking that balance in their management and we have little information on how to do it. The second real issue is climate change and how to manage forests to increase resistance and resilience; the issue of wildfire I see as a part of this.

I would be willing to talk with you further about revising the proposal, if it would be helpful to you and I suspect Norm would be willing, as well.

- Jerry F. Franklin"

APPENDIX 14

Summary of Science Advisory Panel Engagement and Feedback

Starting in May 2020, OSU College of Forestry convened an external Science Advisory Panel (SAP) to support the College in developing an inclusive vision for the Elliott State Research Forest that emphasizes long-term discovery and transformation of research capacity in forest ecosystems. The Panel members were explicitly selected for their expertise across a range of topical areas (forestry, forest ecology, wildlife biology, social science, policy) and work in various settings, including university, agency, industry and NGOs. Panel members served by advising the Dean of the College of Forestry on the scientific and operational opportunities and challenges associated with developing a comprehensive proposal.

SCIENCE ADVISORY PANEL MEMBERS

- **Jennifer Allen**
  Portland State University (Chair)
- **Gwen Busby**
  GreenWood Resources, Inc.
- **Ryan Haugo**
  The Nature Conservancy
- **Serra Hoagland**
  USDA Forest Service, Salish Kootenai College
- **Cass Moseley**
  University of Oregon
- **Linda Nagle**
  Colorado State University
- **Matt Sloat**
  Wild Salmon Center
- **Mark Swanson**
  Washington State University
- **Eric White**
  USDA Forest Service

The following is a summary of points of discussion at SAP meetings during 2020. OSU addresses the topics of discussion in the draft proposal as edits or modifications of existing text or additions to the document. We provide some detail below about how the comments were addressed for each section. SAP meeting materials are available online.

JULY 2020 - REVIEW OF THE DRAFT VISION STATEMENT AND RESEARCH PLATFORM DOCUMENTS

The SAP reviewed the draft vision statement from OSU College of Forestry Dean Tom DeLuca, the 2019 research charter (Appendix 1), the overview of the research design, and descriptions of intensive, extensive, and reserve research treatments (Appendix 5).

The SAP members present provided their reflections during the discussion, some of which include, but are not limited to:

- Provide consensus and positive feedback on the scale of research design at the watershed/landscape level.
- OSU could better communicate the larger and longer-term research objectives to a broader set of stakeholders and could do a better job explaining the project's temporal nature and adaptive approach.
- OSU could incorporate more details on reserve management objectives.
- Members were interested in seeing more information on governance and collaboration with stakeholders. Current documents lack information on what mechanisms will create feedback in the adaptive management approach and a decision-making framework about what research happens on the ESRF.
- OSU should bolster social science research considerations.
- SAP recommended broadening the discussions to include more scientists from U of O, PSU, OSU in other disciplines.
- SAP noted OSU should integrate resilience and resistance across treatments.
- There was broad agreement this exploratory time is the time to think big. These plans will require a lot of operational support, research infrastructure and funding to execute.
- SAP noted the integrity of the research is paramount (comes through in documents in areas that mentioned unbiased treatment selection). OSU should make this statement more boldly and earlier in the document.
- SAP suggested the design needs to speak more clearly to road and trail management as an essential part of ecological and social research.
- SAP members expressed concerns regarding older cohorts in extensive treatment. Is that learning worth the pressure and costs from a social perspective?
- SAP noted it would be beneficial to have a group that does iterative brainstorming of ideas for high impact questions and should be balanced and composed of multiple stakeholders.
- There was general feedback around the terminology used to describe the research design elements, including input the platform is jargon heavy. It could benefit from communications staff translating ideas for public consumption. There was a discussion of the confusion caused by Triad treatments and research treatments using the same names.

OSU incorporated this feedback into the proposal sections on adaptive management, governance, and OSU commitments to public values that were not developed when the SAP provided their thoughts on the initial research treatment documents. Additional text describing potential research projects, programs, and collaborations has also been generated and included in the proposal, in part, to respond to SAP suggestions to improve communication regarding potential research opportunities within the Triad design (Appendix 2 and 3). We address concerns about limited social science by including social science research in the lists of nested research and example research programs (Appendix 2 and 3) and social science research costs in the ESRF budget. OSU conducted a power analysis (Appendix 10) for inclusion in the final proposal to address comments about the importance of research integrity and unbiased treatment selection. We did not immediately address a few of the comments in the draft proposal. We did not address requests for more information on the HCP and decoupling and more details on monitoring mechanisms that create the feedback in the adaptive management approach in the proposal. They will be a part of future planning and development of research monitoring protocols and a forest management plan.

SEPTEMBER 2020 - GOVERNANCE STRUCTURE AND OSU COMMITMENTS TO PUBLIC VALUES

SAP members discussed the proposed Governance Structure (Section 6) of the Elliott State Research Forest, the draft proposal section on Guiding Principles and OSU's Commitments to Public Values (Section 3).

The SAP members present provided their reflections during the discussion, some of which include, but are not limited to:

- A recommendation that OSU develops a process map to show how decisions occur within the governance structure.
- There was an emphasis placed on developing metrics for tracking and transparency of the OSU Commitments to public values. As currently stated in the proposal, there is no concise way to measure them.
- Refinement is needed to the current values appendix, with further definition to some values and overall adjustment to make the language more accessible and less academic. Also noted, it was not enough to address social science through the values domains appendix.
- Regarding the governance structure, some wondered whether there might be opportunities to utilize existing governance structures within the university system and cautioned against creating overly complicated designs.

We address feedback on governance and OSU Commitments to public values where possible. The development of a governance structure for the ESRF was directly influenced by existing and similar governance structures from within OSU and other university forests, stakeholder input, and university legal counsel input. OSU has strived to keep the structure as straightforward as possible while affording necessary decision-making authority to implement research and operational activities and provide adequate accountability of the College and University to the commitments, proposed activities, and values in the ESRF proposal. We have only made commitments that we can meet and are necessary to meet our diverse set of stakeholders' needs. OSU agrees that we should develop metrics for tracking commitments in the next phases of planning.

OCTOBER 2020 - FINANCIALS AND RIPARIAN RESEARCH STRATEGY

The SAP members reviewed a preliminary report on projected research program expenses developed to better understand some of the associated costs of transforming the Elliott into a research forest. SAP members also reviewed the draft riparian research strategy (Appendices 8, 9, 10).

The SAP members present provided their reflections during the discussion, some of which include, but are not limited to:

- SAP suggested it could help to lay out costs in a progression of years and by category to provide a better expense profile over time.
- SAP noted the current document mainly reflects biophysical research costs. Costs are often composed of expensive physical equipment, and there was a lack of social science costs (i.e., permanent traffic counters, surveys, interviews, and analysis).
- SAP noted the personnel section did not indicate positions outside of academic/research positions. SAP inquired about how this budget reflects OSU's interests in supporting the local community with job opportunities. This could be an opportunity to add trainee positions, under technicians, or somewhere for an entry-level position.
- There was broad support amongst SAP members for an outcomes-based riparian research framework and the ability to study riparian buffer design, especially given recent conversations and policy focus around stream buffer widths in Oregon and opportunities to measure ecosystem services with flexible treatments.
- SAP suggested more explicitly incorporating climate risk/hazard management acknowledgment, which relates to disturbances.

As a result of SAP input, we added social science costs and additional personnel costs to the preliminary budget for research program costs. SAP members also vetted the numbers estimated for research/monitoring equipment in key areas (carbon, aquatic, and wildlife/biodiversity), leading to some initial research and start-up budget changes. Support for the outcomes-based riparian research strategy helped solidify the direction for riparian research on the ESRF.

NOVEMBER 2020 - FINAL PROPOSAL REVIEW

SAP members reviewed the final draft iteration of the proposal posted to the DSL website for public review. The discussion focused on updated sections of the proposal, including Financing Research and Management of the ESRF, Governance Structure, Appendix 10 Power Analysis of the Elliott State Forest Research Design, and Appendix 11 Potential Marbled Murrelet Habitat Distribution and Research Strategy at the Elliott State Forest.

The SAP members present provided their reflections during the discussion, some of which include, but are not limited to:

- There is an excellent reason to have the Governor appoint the Advisory Committee membership, but rather than the committee creating their by-laws, they should receive a charge from the Dean.
- Rather than having mediation and decisions flow through the Board of Trustees, that role should be at an appropriately high level.
- There was a suggestion to reserve that academic judgment not be subject to the public appeals process. A risk to academic freedom and integrity would be the reality of different stakeholders wanting different outcomes. To that end, OSU should list the topics or situations that would not be subject to appeal and what would be, rather than leaving that determination so broad.
- Recognizing that the proposal's 'commitments' are what OSU would be held accountable to, there could be a secondary annual report (from the ESRF Executive Director to the public) that reports on OSU's performance of accountability of those commitments.
- There was a lack of clarity around the scientific advisory body and who decides what research is conducted.
- SAP recommended making a cash flow profile with capital revenues mapped out (like timber, carbon, etc.) over time and investments clearly outlined. If so, we could conduct a more comprehensive sensitivity analysis to account for vulnerability and variability factors, like mill closures, timber prices, carbon prices, etc.
- There was conversation around engagement in the carbon market and generating revenue overtime. One SAP member noted that voluntary carbon markets have been performing well this past year and are expected to continue to perform well. Part of the long-term ESRF research goal is to understand soil-carbon dynamics better, and research could play a role in developing new components for carbon market credits.
- There was a discussion of the effort involved in ascertaining Murrelet occupancy, and SAP members expressed interest in research that would inform marbled murrelet response to varying levels of management.

The thoughtful input provided at the final SAP meeting allowed OSU to refine and finalize the proposal submitted to the State Land Board.

Appendix D

Marbled Murrelet Habitat Suitability Index Approach

Modeling timber harvest induced edge effects on marbled murrelet (*Brachyramphus marmoratus*) habitat under a prospective timber harvest scenario on the Elliott State Research Forest

Deanne Carlson, Dept. of Forest Ecosystems and Society, Oregon State University, Corvallis, OR.

Jennifer Bailey Guerrero, Dept. of Forest Ecosystems and Society, Oregon State University, Corvallis, OR.

Introduction

The marbled murrelet (*Brachyramphus marmoratus;* hereafter murrelet or MAMU) is a small diving seabird that lives and breeds along the North American Pacific coast from the Aleutian Islands south to central California. The species is listed as threatened under the federal Endangered Species Act from the Canadian border south along the Washington, Oregon, and California coasts, and is listed as endangered under the Oregon Endangered Species Act.

Throughout its range the murrelet forages for small fish and invertebrates in shallow, near-shore waters. In Alaska murrelet may breed on coastal cliffs or talus slopes, but south of Alaska murrelet nest almost exclusively in mature and late-successional coniferous coastal forests up to 80 kilometers inland from their marine foraging habitat (Hamer and Nelson, 1995). During the breeding season murrelet molt into a mottled-brown plumage for camouflage in their forest nesting grounds. The female lays a single egg in a depression formed in moss, lichens, or litter that accumulate on large or deformed (mistletoe) platforms within the tree canopy (Hamer, 1995; Burger, 2002; McShane et al., 2004; Nelson et al., 2006). Murrelet do not build nests, and instead select a stable, flat nesting platform of sufficient width to support the egg and developing chick, generally ≥ 10 cm in diameter (Evans Mack et al., 2003). Thus, murrelet nest locations are physically limited to forests old enough to develop such features, typically at least 100 years of age with large, well-developed canopy structures (Hamer et al., 2021). Murrelet breeding pairs share and alternate incubation and foraging activities over 24-hour cycles. Once the egg hatches both parents make multiple trips each day between their marine foraging grounds and the nest site, bringing food for the growing nestling. At the end of the breeding cycle the young bird fledges and finds its way to marine foraging areas alone. Although adults are well camouflaged and are fast flyers, eggs and young are susceptible to predation at the nest location by both avian and mammalian predators.

Commercial harvest of late-successional forests over the past century has directly removed and fragmented large areas of murrelet breeding habitat throughout the coastal region of the Pacific Northwest (Valente et al., 2023; Betts et al., 2020; Nelson, 2020; Raphael et al., 2018). Moreover, contemporary forestry practices on commercial forests throughout the region maintain non-habitat conditions by harvesting forests at rotation cycles that preclude the development of older forests and canopy structures required by marbled murrelet as breeding habitat. Where older forest does occur or is allowed to develop, timber harvest adjacent to such forest may degrade existing murrelet nesting habitat and reduce nesting success (Malt and Lank, 2007). Habitat degradation may be directly attributable to habitat loss caused by windthrow along forest edges, or by microclimate effects that, for example, may create unfavorable conditions at existing nest sites or diminish the growth of mosses and lichens necessary for the development of suitable nest sites. Harvested forest edges may also be a proximal cause of increased nest predation by making nest locations and adult flights to and from the nest site more visible to predators; moreover, the early seral habitat that develops in recently harvested areas may be attractive to predators by increasing the availability of forage and prey.

Objective

Management plans for the Elliott State Research Forest (ESRF) require both the protection of MAMU habitat and the harvest of timber in fulfillment of research and financial objectives. Measures for the protection of MAMU are embodied in ESRF planning documents, including the ESRF Research Proposal (OSU, 2021), the ESRF Forest Management Plan (FMP), and the ESRF Habitat Conservation Plan (HCP), while the ability to harvest timber on the ESRF without potentially violating "take" provisions of the federal Endangered Species Act requires issuance of an Incidental Take Permit by federal regulators. The goal of the modeling methodology described here is to provide a quantitative means of evaluating changes in the quantity and quality of MAMU habitat available over the duration of the Permit term such that terms of an Incidental Take Permit can be monitored and enforced. We intend that this methodology provide relevant information to decision-makers and regulators during planning and implementation of ESRF forest operations, including:

- The quantification of the effects of timber harvest, including edge effects, on MAMU habitat as measured against baseline conditions
- The quantitative comparison of the effects of alternative management scenarios on MAMU habitat through time
- Provide a quantifiable, spatially-aware, and scalable means of predicting the effects of prospective management operations on MAMU habitat during biennial planning, with the expectation that unacceptable adverse effects will be avoided, moderated, or mitigated during the planning process
- Provide a quantifiable, spatially-aware, and scalable means of monitoring the effects of management operations to MAMU habitat over the duration of the HCP for purposes of compliance with terms of the HCP and Incidental Take Permit

Analytical Framework

Edge Effects

Empirical evidence suggests that timber harvest is associated with decreased MAMU nesting success, primarily as a result of increased predation in nesting habitat adjacent to recently harvested areas (Nelson and Hamer, 1995; Raphael et.al. 2002; Malt and Lank, 2007). Edge effects attributable to timber harvest may also be a function of time since harvest and the seral state of the disturbed forest creating an edge (Malt and Lank 2009). In this analysis we assume that the diminution of MAMU habitat value associated with harvested forest edge is a function of both distance from a disturbed forest edge and time since disturbance. Following the analysis of WDNR (2019c), we employ "inner" and "outer" Edge Effect Evaluation Zones (EEEZs) and classify the severity of edge effect with respect to time since harvest as hard edge (zero to 20 years post harvest), soft edge (21 to 40 years post harvest), and no edge (more than 40 years post harvest). The outer EEEZ is defined as the outer 50-meter strip immediately interior to the exterior boundary of affected habitat, and the inner EEEZ is a 50-meter strip immediately interior to the outer EEEZ (Figure 1). For purposes of spatial analysis in a GIS, the outer EEEZ of any potentially affected habitat may be represented as a 50-meter buffer around a harvest area (or forest age class), and the inner EEEZ as a 50-meter buffer around the outer EEEZ (Figure 2).

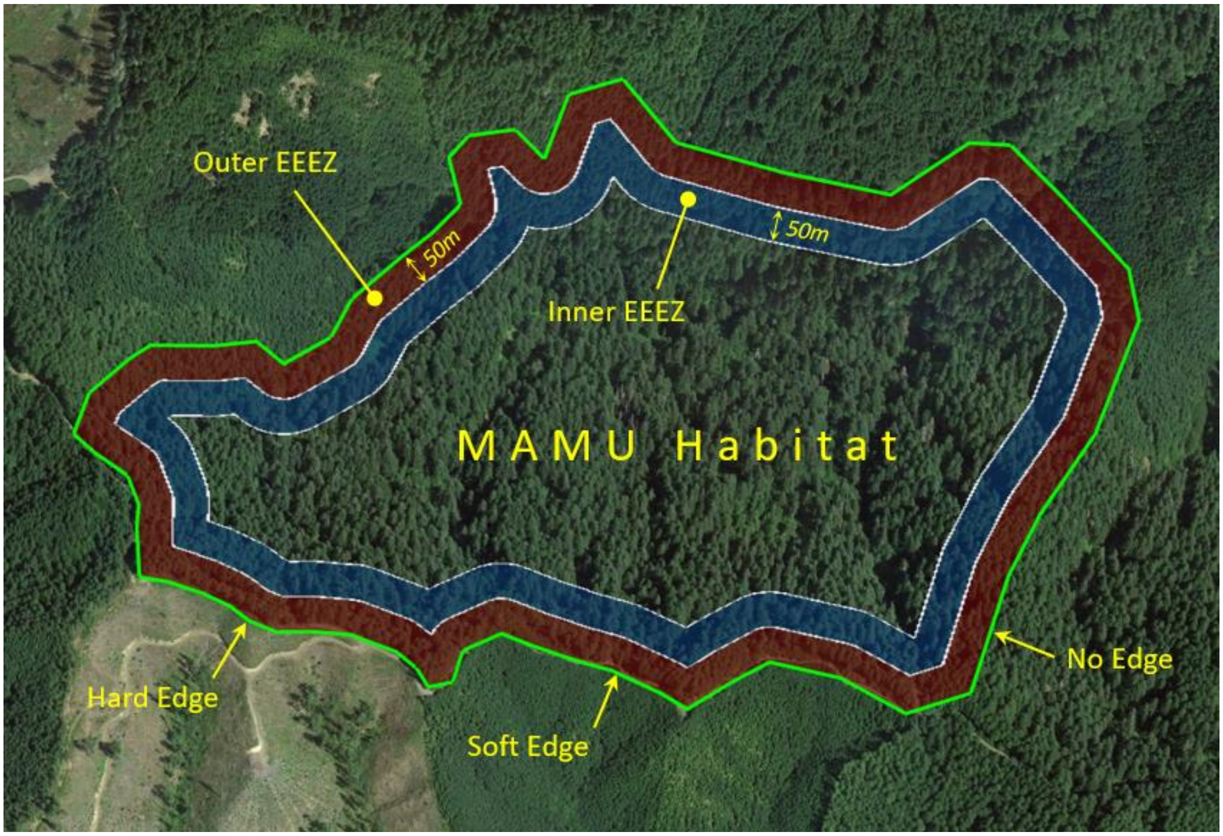


Figure 1. Edge effects (i.e. diminution of habitat) to an area of MAMU habitat (bounded by green) caused by disturbance in adjacent stands. Effects evaluated with respect to the diminution of MAMU habitat within the outer 50m EEEZ, and the diminution of habitat within the inner 50m EEEZ. Edges are classified as hard edge (0 to 20 years post disturbance), soft edge (21 to 40 years post disturbance, and no edge (more than 40 years post disturbance). *Image: Google Earth*

Unit of Analysis

We use a generalized habitat suitability index (HSI) to quantify the relative quality of MAMU breeding habitat on a scale of zero to 1, with zero being non-habitat and 1 being the best possible habitat. Stand age is the primary stand attribute used for harvest scheduling and for tracking forest status throughout the permit term; hence, we employ a quantitative model of HSI as a function of stand age for estimating the HSI values of delineated stands at decadal mileposts through the duration of the term of the HCP. As we employ it here, HSI is conceptually similar to the P-stage model used by the Washington State Department of Natural Resources (WDNR) in their 2019 amendment to the 1997 State Trust Lands HCP (WDNR 2019),

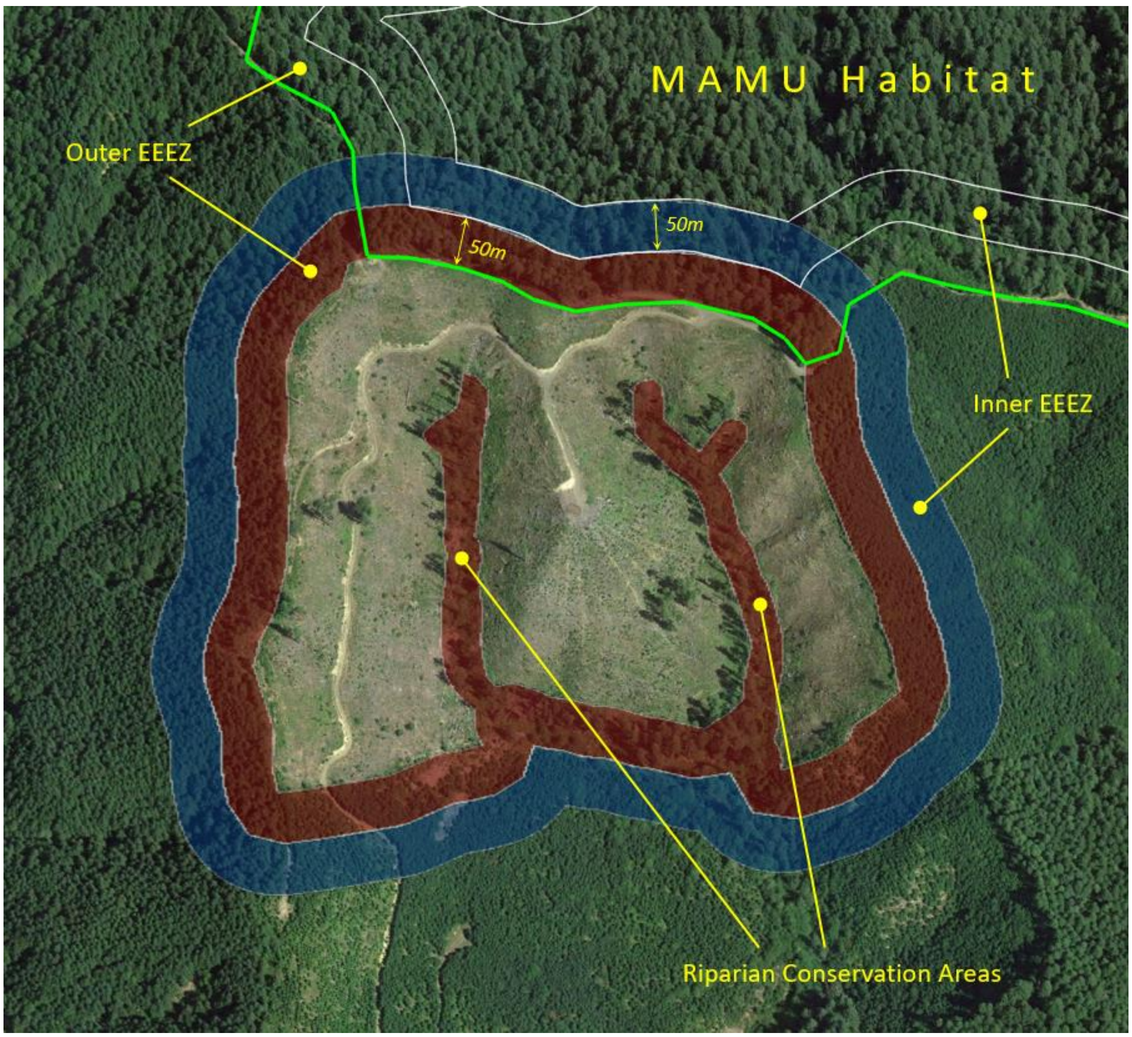


Figure 2. The EEEZs *within* the perimeter of MAMU habitat are coincident with concentric 50-meter "buffers" *around* a timber harvest area, and for purposes of analysis we specify EEEZs as buffers around the harvest area rather than as EEEZs within MAMU habitat. Inner and outer EEEZs are nevertheless identified with respect to interior MAMU habitat, not the harvest area; thus, the outer EEEZ is adjacent to the harvest area boundary. Within ArcMap the outer EEEZ is created as a 50-meter buffer around the harvest area, and the inner EEEZ is created as a 50-meter buffer around the outer EEEZ. Riparian Conservation Areas (RCAs) that project into the interior of the harvest unit are included in the geometry of the outer EEEZ, and are subject to the same Habitat Diminution Factor as the outer EEEZ. *Image: Google Earth*

but is modeled here as a single continuous exponential function with respect to stand age, rather than as separate step functions for Douglas-fir forests and for western hemlock forests (Figure 3).

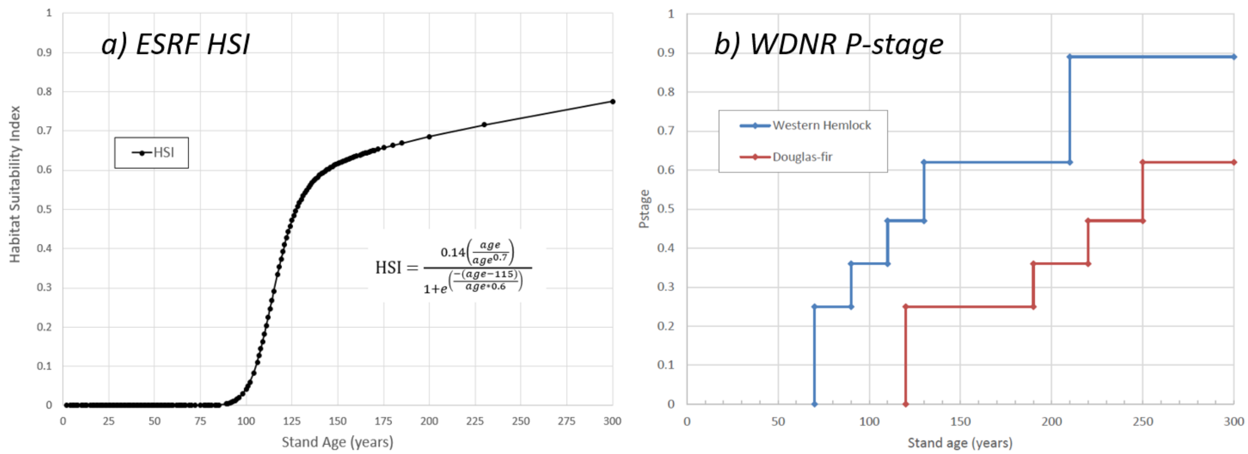


Figure 3. HSI-age function as employed on the ESRF for all forest types (a) and P-stage step functions for Douglas-fir and for western hemlock forests as employed by WDNR (b). The HSI-age function is a generalized habitat model based on a conservative assessment of empirical and observational data by OSU and USFWS scientists. (*P-stage graphics source: Figure E-1, WDNR 2019b*)

The ESRF HSI-age function is a generalization developed by OSU and USFWS scientists during consultation on the ESRF HCP, and is based on a conservative assessment of empirical and observational data. Stand age is strongly associated with the presence of habitat attributes necessary for MAMU occupancy (e.g. large, moss-covered limbs used by MAMU as nesting platforms; Hamer et al., 2021). We thus assume that even-age stands too young to produce these attributes have negligible value as MAMU breeding habitat, notwithstanding older residual trees that may be present. As stands age they are subject to localized mortality and/or damage caused by suppression, mistletoe, insects, disease, ice, snow, and wind, creating gaps in the forest canopy and features in the remaining live trees such as large or swollen branches, multiple tops, and mistletoe brooms that, over time, can develop into suitable MAMU nesting platforms. Observational data from the ESRF provide evidence that some stands become suitable for MAMU occupancy at around 100 years of age. Using MAMU survey data from the ESRF, Betts and Yang (2023, unpublished data) found a strong association between probability of MAMU occupancy and stand age. Based on the Betts and Yang data we assume that HSI values increase sharply at stand ages greater than 100 years, but that the rate of increase in HSI decreases at approximately 150 years of age (Figure 3a). Although the HSI-age function is a simplified, deterministic construct, it nevertheless provides a consistent, conservative theoretical model through which changes in habitat quantity and quality attributable to changes in forest condition, such as stand age and spatial patterns of timber harvest, may be assessed.

As discussed above, HSI is a function of stand age. The stand age of each stand on the ESRF can be determined at each decadal milepost throughout the permit term given an initial stand age (i.e. stand age in year 2024), harvest schedule, and the arithmetic progression of stand age through time. Given stand age, corresponding HSI values can be calculated according to the HSI-age function (Figure 3a); however, this does not take into account the size of a stand or total amount of habitat available. In order to quantify the *aggregate* value of MAMU habitat across a geographic area of interest at a given point in time we employ the construct of *HSI-weighted acres* (HSI-acres). HSI-acres is the product of the HSI value of a subject stand and the area, in acres, of the subject stand. The aggregate habitat value for an area of interest at a given point in time is the sum of HSI-acres of all stands within the area of interest. Our primary area of interest for this analysis is the entire ESRF, but any subset of stands within the ESRF could be specified as the area of interest and evaluated accordingly.

A fundamental assumption of this analysis is that the aggregate habitat value of a subject stand can be expressed as the product of stand area and HSI value. Thus, for any given stand of a given area there is a simple, linear relationship between HSI value and aggregate habitat value expressed in terms of HSI-acres. For example, the aggregate habitat value of a 100-acre stand with an HSI value 0.6 is twice the aggregate habitat value of a 100-acre stand with an HSI value of 0.3; alternatively, a 100-acre stand with an HSI value of 0.3 has the same aggregate habitat value as a 50-acre stand with an HSI value of 0.6. Another fundamental assumption of this analysis is that – with the exception of edge effects, which are calculated separately – the HSI value of individual stands are independent of one another. Thus, the aggregate habitat value of a set of stands can be expressed as the simple arithmetic sum of the HSI-acre values of member stands.

Methodology

This analysis has two specific modeling objectives:

- Create base rasters of HSI values at decadal mileposts (e.g. year 2034, 2044, 2054, etc.) throughout the permit term under an assumed harvest scenario, including initial forest condition (year 2024)
- Adjust the HSI base rasters for harvest-induced edge effects, including continuing edge effects from harvest that occurred prior to year 2024.

By comparing differences between base rasters and edge-effect-adjusted rasters (hence: *net HSI rasters*), harvest-induced edge effects can be quantified and evaluated spatially and temporally.

We used a combination of GIS software (ArcGIS Desktop) and Excel spreadsheets to model the spatial distribution, quality, and quantity of MAMU breeding habitat on the ESRF at decadal milepost for the expected 80-year duration of the ESRF HCP. “Decadal milepost” (hence, DM) refers to modeled habitat conditions at the end each decade of the Permit term, not the flux in habitat condition that occurs during the decade. The analysis begins with initial condition at the beginning of year 2024, and evaluates conditions at the end of each decade in years 2034, 2044, and so-on, to the anticipated end of the permit term in year 2104.

Primary model output is in the form of 3-foot resolution HSI rasters covering the area of the ESRF. There are two key rasters produced for each DM: 1) a base raster comprising HSI values for all stands and, 2) a net HSI raster derived from the base raster that is adjusted to account for habitat diminution attributable to harvest-induced edge effects. Data contained within the rasters may be further processed to show spatial and temporal differences in modeled MAMU habitat, and to show projected habitat diminution attributable to edge effects. A workflow diagram shows the relationships between inputs, parameters, and processes used to create these rasters (Figure 4).

Primary model inputs and parameters are:

- Spatial data
    - Spatially explicit stand definitions

- Stand ages
- Stand allocations
- Spatially and temporally explicit harvest scenario
  - Harvest parameters and assumptions for each harvest category
- Direct-effect and edge-effect parameters for each harvest category
  - Habitat Diminution Factors

These inputs and parameters are described in turn below, followed by a description of the processes used to create the output rasters.

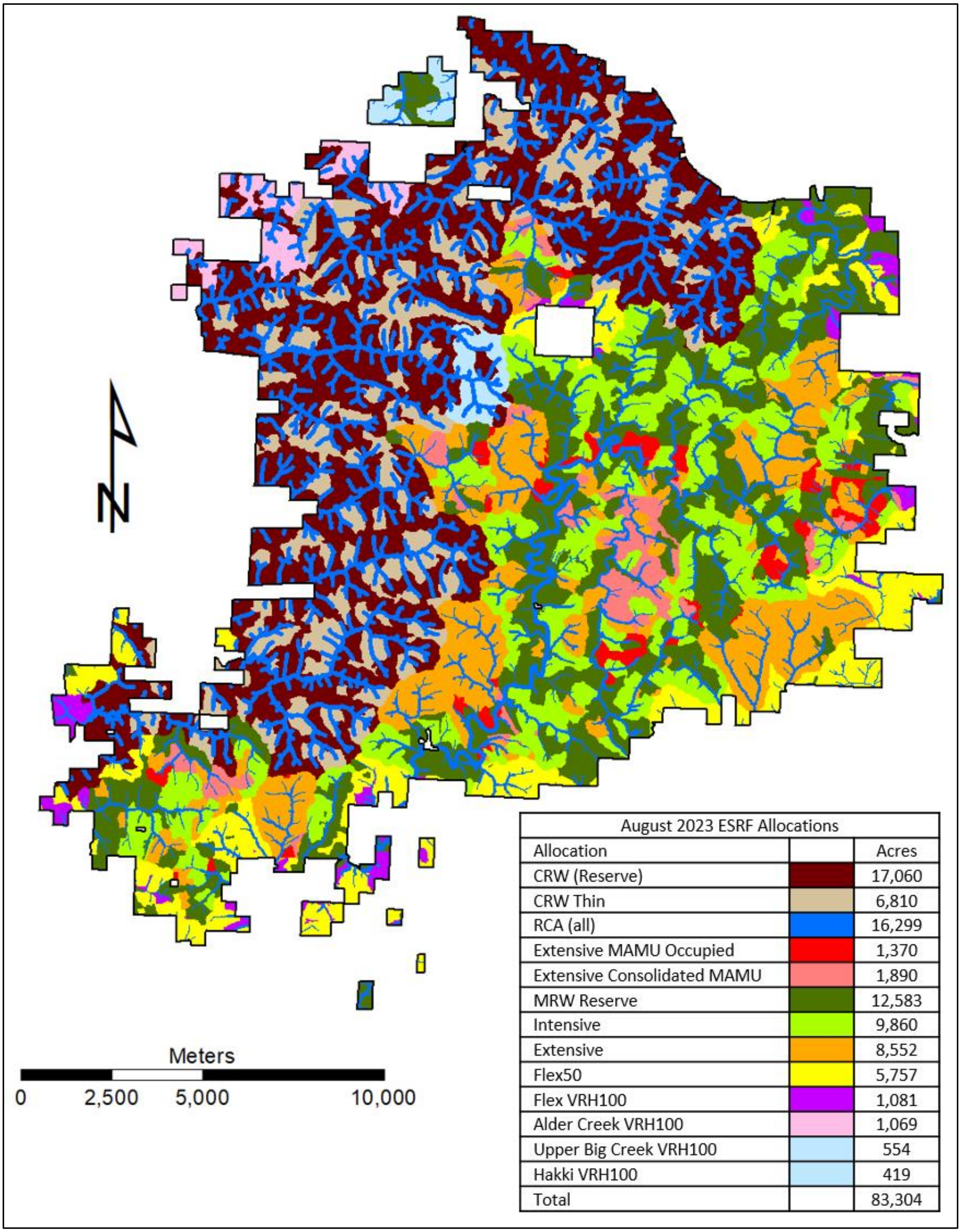
Spatial data: Stand Allocations and Attributes

The primary inputs to the model are spatial data containing ESRF stand definitions, allocations, and attributes in the form of a GIS shapefile. The GIS shapefile is used to integrate many other stand attributes that are necessary for this analysis, including stand allocations (Figure 5), stand age, stand area, and unique stand identification numbers to facilitate transfer of data between the GIS shapefile and an Excel spreadsheet, where most calculations and logical functions are performed.

The ESRF GIS shapefile[1] used in this analysis comprises 5,735 individual polygons. The original stand definitions used in this file come from Oregon Department of Forestry (ODF) 2016 GIS inventory data for the Elliott State Forest, and comprises 1,968 polygons over the same geographic area as the ESRF GIS shapefile. Many of the original 2016 ODF stands have been split or modified during the ESRF planning process as a result of the imposition of Riparian Conservation Area (RCA) boundaries, watershed boundaries, and other allocation requirements. Additionally, many stand boundaries and stand ages have been revised based on newly acquired lidar vegetation height data and satellite imagery.

The harvest classes and stand allocations used for this analysis are based on a June 2023 revision of land allocations by the Oregon Department of State Lands (Figure 5 & Table 1). Apart from the Triad research watersheds, which are unchanged, these allocations and harvest classes differ from those described in the ESRF research proposal (OSU 2021) in many locations. In addition, the 787-acre Hakki Ridge parcel is included in this analysis, whereas it was not included in original ESRF research proposal.

[1] Filename: *DSL_Allocations_August_2023_Take6_rev1*, available from OSU upon request.



August 2023 ESRF Allocations		
Allocation		Acres
CRW (Reserve)		17,060
CRW Thin		6,810
RCA (all)		16,299
Extensive MAMU Occupied		1,370
Extensive Consolidated MAMU		1,890
MRW Reserve		12,583
Intensive		9,860
Extensive		8,552
Flex50		5,757
Flex VRH100		1,081
Alder Creek VRH100		1,069
Upper Big Creek VRH100		554
Hakki VRH100		419
Total		83,304

Figure 5. ESRF Allocations, as revised June, 2023.

Table 1. Summary of Land Allocations on the ESRF, September 2023

Allocation	**Total Allocated Acres**	**HCP Silviculture Category**	**Allocation Notes**
CRW Reserve	17,060	Reserve	Does not include CRW RCA or CRW Thin
CRW Thin	6,810	Restoration Thin	Candidate stands for restoration thinning
CRW RCA	9,568	Limited Thin in stands <=65	Riparian Conservation Areas within the CRW
Triad Extensive MAMU Occupied	1,370	MAMU Experiment	"MAMU Experiment" Extensive allocations considered to be MAMU occupied as defined by the HCP
Triad Extensive Consolidated MAMU	1,890	Extensive	Triad research watershed stands allocated to extensive within the MAMU Consolidated habitat layer but that are not considered occupied as defined by the HCP
Triad Intensive	9,860	Even-age Intensive	Intensive even-age management within Triad research watersheds
Triad Extensive not Consolidated MAMU	8,552	Extensive	Triad research watershed stands allocated to extensive that are not within the MAMU Consolidated habitat layer
Triad Reserve	10,058	Reserve	Reserve stands within Triad watersheds
MRW Reserve (non-Triad, includes Hakki)	2,525	Reserve	Reserve stands outside of Triad watersheds, excluding CRW reserve
MRW RCA (Triad Watersheds)	5,141	Limited Thin in stands <=65	Riparian Conservation Areas within Triad watersheds
MRW RCA (Non-Triad)	1,590	Limited Thin in stands <=65	Riparian Conservation Areas outside of Triad watersheds, excluding CRW RCAs
Flex 50	5,757	Flexible	Stands <= 65 years as-of year 2020 located in MRW non-Triad watersheds. Generally open silvicultural options, with minimum rotation age of 50 years
Flex VRH100	1,081	Flexible Variable Retention	Stands > 65 years as-of year 2020 located in MRW non-Triad watersheds. Generally open silvicultural options, with average rotation age of 100 years and minimum retention of 20%
Alder Creek VRH100	1,069	"Replacement" Extensive	Stands <= 65 years as-of year 2020 located in the Alder Creek area. Intended to replace Extensive Consolidated MAMU acres in Triad watersheds that are removed from harvest base due MAMU presence.
Upper Big Creek VRH100	554	Flexible Variable Retention	Stands <= 65 years as-of year 2020 located in the Upper Big Creek area.
Hakki Ridge VRH100	419	Flexible Variable Retention	Stands <= 65 years as-of year 2020 located in the Hakki Ridge parcel.
Total	83,304		

Harvest Scenario – August 2023

The harvest base used for this analysis includes all harvest base acres less than or equal to 65 years of age as-of year 2020 (LTE65), and the greatest number of harvest base acres greater than 65 years of age as-of year 2020 (GT65) that could be harvested given a 3,400-acre cap on the total number of GT65 acres that may be harvested during the permit term. The harvest schedule imposed upon the harvest base is primarily determined by the year that each stand achieves a target age (e.g. rotation age) rather than, for example, a schedule based on the optimization of an objective function, such as the maximization of volume production or revenue. For both existing and future stands on the ESRF, the year that a subject stand achieves a target age is determined by its 2020 inventory age; thus, the existing age class distribution of the forest, in combination with the harvest base land allocations, largely determines the harvest schedule. The existing age-class structure of the ESRF is the primary reason harvest acres vary between decades under the harvest scenario employed here (Table 3c).

By design some allocation classes specified in the HCP have a large amount of flexibility in how they may be implemented. For example, the Flex 50 class was intended to make possible a wide variety of potential silvicultural prescriptions under terms of the HCP; however, it would not be possible to model all potential instances of how this class might be implemented. Because there was no average retention or average rotation length specified in the HCP for the Flex 50 class, it was modeled here at the lowest possible retention (0%) and rotation age (50 years) as a way to capture the assumed "worst case" effects to MAMU habitat under terms of the HCP. As with the Flex 50 class there are a wide range of silvicultural options under the variable retention harvest classes, which includes the extensive allocations in the Triad watersheds. However, based on language in the HCP and in the Research Proposal we infer a commitment to an average retention of 50% and rotation length of 100 years for all variable retention harvest classes other than the Extensive MAMU Occupied class, which is 80% retention, and model them accordingly.

<u>Conditional Harvest Acres</u>

Survey and manage requirements for Triad Extensive allocations that are within the Consolidated MAMU habitat layer (ConMAMU) complicate harvest scheduling because harvest in these allocations is conditional based on the results of MAMU occupancy surveys, which have yet to be performed. The Alder Creek variable retention harvest allocation was created by the Department of State Lands (DSL) as a way to mitigate potential reductions in Triad harvest base acres in the event that Triad Extensive harvest base stands are found to be occupied by MAMU. Because the Alder Creek allocation is restricted to LTE65 forests, and has relatively low volume per acre compared to the GT65 Triad Extensive allocations, DSL applied a factor of 1.5 in calculating "replacement" volume from the Alder Creek allocation. Thus, according to the DSL formula, the 1,069 acres of the Alder Creek allocation are the equivalent to 712 acres of Triad Extensive. For purposes of analysis we assume that 712 acres of Triad Extensive will be found to be MAMU occupied, and that the entirety of the Alder Creek allocation will be placed in the harvest base as volume replacement acres.

With 712 acres of GT65 forest removed from the harvest base in the Triad watersheds this creates space under the 3,400-acre GT65 harvest cap for the harvest of GT65 forest from the Flex VRH100 allocation. Thus, 712 acres of GT65 forest were scheduled for harvest in the Flex VRH100 allocation under the harvest scenario described here.

Harvest Scheduling Parameters

Primary harvest scheduling parameters, including harvest base acres, rotation age, and retention, are displayed in Table 2, and an outline of harvest scheduling specifications for each allocation follows the table.

Table 2. Harvest Schedule Parameters

Allocation	Total Allocated Acres	HCP Silviculture	Modeled Silviculture	Modeled Harvest Base Acres	Modeled Rotation Age	Modeled Average Retention	Thin?
CRW Reserve	17,060	Reserve	Reserve	0	NA	100%	No
CRW Thin	6,810	Restoration Thin	Restoration Thin	5,621	NA	100%	Yes
CRW RCA	9,568	Limited thin in stands <=65	Reserve	0	NA	100%	No
Extensive MAMU Occupied	1,370	MAMU Experiment	MAMU Experiment	1,370	NA	80%	No
Extensive Consolidated MAMU	1,890	Extensive	Variable Retention	1,178	100 years	50%	Yes
Intensive	9,860	Even-age Intensive	Even-Age Intensive	9,860	60 years	0%	No
Extensive not Con. MAMU	8,552	Extensive	Variable Retention	8,550	100 years	50%	Yes
MRW Reserve (Triad Watersheds)	10,058	Reserve	Reserve	0	NA	100%	No
MRW Reserve (non-Triad)	2,525	Reserve	Reserve	0	NA	100%	No
MRW RCA (Triad Watersheds)	5,141	Limited Thin in stands <=65	Reserve	0	NA	100%	No
MRW RCA (Non-Triad)	1,590	Limited Thin in stands <=65	Reserve	0	NA	100%	No
Flex 50	5,757	Flexible	Even-Age Intensive	5,757	50 years	0%	No
Flex VRH100	1,081	Flexible Variable Retention	Variable Retention	962	100 years	50%	Yes
Alder Creek VRH100	1,069	"Replacement" Extensive	Variable Retention	1,069	100 years	50%	Yes
Upper Big Creek VRH100	554	Flexible Variable Retention	Variable Retention	554	100 years	50%	Yes
Hakki Ridge VRH100	419	Flexible Variable Retention	Variable Retention	419	100 years	50%	Yes
Total	83,304			35,340			

1) CRW Reserve
    a. No scheduled harvest
2) CRW Thin
    a. There are a total of 7,614 acres of stands <=65 years of age in the (revised) CRW. Of these, 804 acres were identified as being either too young to commercially thin or already meeting CRW objectives (e.g. heterogeneous stand structure). The balance of 6,810 acres were assumed to be candidate stands for restoration thinning. 1,189 acres were set aside as restoration experiment controls, leaving 5,621 acres in the CRW thin category.
    b. The 5,621 acres of prospective restoration thinning in the CRW was scheduled to occur over the first two decades of implementation (approximately 280 acres per year)
3) CRW RCA
    a. No scheduled harvest
4) Extensive MAMU Occupied ("MAMU experiment")
    a. All Extensive MAMU Occupied stands are located in Triad (Full) Research Watersheds
    b. Harvest 500 acres of surveyed MAMU-occupied habitat in the first decade. Subsequent acres harvested are contingent on results of harvest in the first 500 acres, but this harvest scenario assumes the "worst case" that all available acres will be harvested. Subsequent harvests are scheduled for third and fifth decade, which allows time for interpretation of the results from previous harvests
    c. Retention = 80%
    d. No commercial thinning scheduled
5) Extensive Consolidated MAMU
    a. These are GT65 "survey and manage" stands currently classified as unoccupied
    b. All Extensive Consolidated MAMU stands are located in Triad (Full) Research Watersheds
    c. These stands may only be harvested if they are determined to be unoccupied. For purposes of analysis 712 acres in this class are assumed to be occupied, resulting in 1,069 acres of "replacement volume" being added to the harvest base from the AC_VRH100 (Alder Creek) allocation. We assume that the remaining 1,178 acres in this class will be found unoccupied and will be available for harvest.
    d. The 712 acres presumed occupied within Extensive Consolidated MAMU frees up GT65 harvest cap acres for harvest in the Flex VRH100 category
    e. Regen harvest age = 100 years.
    f. Retention = 50% (assumed average retention over permit term)
    g. Nearly all of the 1,178 acres in this class are >100 years, and thus are "backlog" harvest acres
        i. Backlog harvest was partitioned across the first four decades
        ii. Decadal harvest areas were spatially clustered to avoid creating small, isolated harvest areas.
    h. No commercial thin in existing stands
    i. Silvicultural thin stands that were regeneration-harvested after year 2023 at 40 years of age

6) Intensive (Triad Research Watersheds)
    a. All Intensive stands are located in Triad (Full) Research Watersheds
    b. Even-age, intensive management
    c. No retention
    d. Regen harvest age = 60 years
    e. Schedule harvest for the year a subject stand reaches 60 years of age
    f. Schedule backlog stands for harvest in first year of implementation (2024)
    g. Commercial thinning is not currently programmed under the FMP, and was not scheduled for this analysis
7) Extensive not Consolidated MAMU
    a. All Extensive not Consolidated MAMU stands are located in Triad (Full) Research Watersheds
    b. Regen harvest age = 100 years
    c. Retention = 50% (assumed average retention over permit term)
    d. Schedule for regen harvest for the year a subject stand reaches 100 years of age
    e. Schedule backlog stands for harvest in first year of implementation (2024)
    f. Commercial thin existing stands at 50 years of age ("maintenance thin")
        i. Existing stands >60 years of age as-of 2024 are not thinned
        ii. Existing stands >50 years and <=60 years thinned in first decade
    g. Commercial thin stands regen harvested after year 2023 at 40 years of age ("silvicultural thin")
8) MRW Reserve (Triad and non-Triad watersheds)
    a. No scheduled harvest
9) MRW RCA (Triad and non-Triad watersheds)
    a. No scheduled harvest
10) Flex 50
    a. Located in "Partial" MRW Watersheds
    b. Even-age, intensive management
    c. No retention
    d. Regen harvest age = 50 years
    e. Schedule harvest for the year a given stand reaches 50 years of age
    f. Schedule backlog stands for harvest in first year of implementation (2024)
    g. Commercial thinning is not currently programmed under the FMP, and was not scheduled for this analysis

11) Flex VRH100
    a. Located outside of MRW Triad Research Watersheds
    b. 692 acres of this allocation are within the Consolidated MAMU layer, and would be subject to MAMU survey prior to harvest.
    c. Most stands in this allocation are >65 years of age as-of year 2020 and would be constrained by the forest-wide 3,400-acre cap on the harvest of GT65 stands.
    d. 711 acres of GT65 stands in this allocation were scheduled for harvest; this assumes constraints elsewhere in the forest (e.g.; MAMU detections) will allow harvest of these acres without exceeding the forest-wide harvest cap, and that scheduled acres are not found to be MAMU-occupied.
    e. Regen harvest age = 100 years
    f. Retention = 50% (assumed average retention over permit term)
    g. Commercial thin stands regen harvested after year 2023 at 40 years of age ("silvicultural thin")
12) Alder Creek VRH100
    a. This allocation is intended to provide "volume replacement" for Extensive allocations within MRW Full Research Watersheds found to be MAMU occupied. Replacement acres were calculated at a ratio of 1.5:1
        i. Assume 712 acres of Extensive Consolidated MAMU allocation are found to be MAMU occupied, and that 1,069 acres of this allocation are shifted to harvest base
    b. All stands in this allocation are <=65 years of age as-of year 2020
    c. Regen harvest age = 100 years.
    d. Retention = 50% (assumed average retention over permit term)
    e. Commercial thin existing stands at 50 years of age ("maintenance thin")
    f. Commercial thin stands regen harvested after year 2023 at 40 years of age ("silvicultural thin")
13) Upper Big Creek VRH100
    a. All stands in this allocation are <=65 years of age as-of year 2020
    b. Regen harvest age = 100 years
    c. Retention = 50% (assumed average retention over permit term)
    d. Commercial thin existing stands at 50 years of age ("maintenance thin")
14) Hakki Ridge VRH 100
    a. All stands in this allocation are <=65 years of age as-of year 2020
    b. Regen harvest age = 100 years
    c. Retention = 50% (assumed average retention over permit term)
    d. Commercial thin existing stands at 50 years of age ("maintenance thin")

Table 3. MAMU HSI analysis harvest scenario: Decadal harvest in acres.

(a) Regeneration Harvest								
	2024-2033	**2034-2043**	**2044-2053**	**2054-2063**	**2064-2073**	**2074-2083**	**2084-2093**	**2094-2103**
Intensive	1,314.0	2,492.3	2,177.3	1,961.5	1,708.9	206.5	1,314.0	2,492.3
Flex50	3,249.1	861.3	390.7	877.8	377.9	3,249.1	861.3	390.7
Extensive	146.1	0.0	59.7	385.2	1,334.1	2,634.4	1,427.8	1,477.5
Extensive ConMAMU	286.3	312.6	268.9	310.0	0.0	0.0	0.0	0.0
Extensive MAMU experiment	518.8	0.0	431.7	0.0	419.0	0.0	0.0	0.0
UBC_VRH100	0.0	0.0	0.0	0.0	164.5	293.6	69.9	8.9
AC_VRH100	0.0	0.0	0.0	44.0	24.9	871.9	106.1	0.0
Flex_VRH100	1.7	323.0	570.7	4.5	0.0	52.5	9.0	0.0
Hakki_VRH100	0.0	0.0	0.0	0.0	101.0	179.4	138.3	0.0
All CRW	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
All RCA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
All Reserve	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
(b) Thinning								
	2024-2033	**2034-2043**	**2044-2053**	**2054-2063**	**2064-2073**	**2074-2083**	**2084-2093**	**2094-2103**
Intensive	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Flex50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Extensive	3,968.4	1,427.8	1,388.1	1,014.9	306.3	0.0	59.7	385.2
Extensive ConMAMU	0.0	0.0	0.0	0.0	286.3	312.6	268.9	310.0
Extensive MAMU experiment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UBC_VRH100	458.1	69.9	8.9	17.6	0.0	0.0	0.0	0.0
AC_VRH100	896.8	106.1	0.0	0.0	21.8	0.0	0.0	44.0
Flex_VRH100	52.5	9.0	0.0	25.1	0.0	266.8	414.4	4.5
Hakki_VRH100	280.4	138.3	0.0	0.0	0.0	0.0	0.0	0.0
CRW Thin	2,771.7	2,849.8	0.0	0.0	0.0	0.0	0.0	0.0
All RCA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
All Reserve	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
(c) Summary: Harvest by Silvicultural Class								
	2024-2033	**2034-2043**	**2044-2053**	**2054-2063**	**2064-2073**	**2074-2083**	**2084-2093**	**2094-2103**
Total Intensive Regen	4,563.1	3,353.6	2,568.0	2,839.3	2,086.7	3,455.6	2,175.4	2,883.0
Total Extensive/VRH Regen	952.9	635.6	1,331.1	743.7	2,043.5	4,031.8	1,751.1	1,486.5
Subtotal Regen Harvest	***5,516.0***	***3,989.2***	***3,899.1***	***3,583.0***	***4,130.2***	***7,487.4***	***3,926.4***	***4,369.5***
Total Thinning	8,427.9	4,600.9	1,397.1	1,057.6	614.4	579.5	743.0	743.7
Total Decadal Harvest	**13,943.9**[2]	**8,590.2**	**5,296.2**	**4,640.6**	**4,744.5**	**8,066.9**	**4,669.5**	**5,113.1**

Direct effects and edge effects: Habitat Diminution Factors

Habitat Diminution Factor (HDF) is a coefficient we employ to quantify the degree to which harvest reduces the value of MAMU nesting habitat, either directly to the area being harvested, or to habitat in the inner and outer EEEZs adjacent to the harvest area. HDF is conceptually the same as the "discount multiplier" described by WDNR (2019c); however, we employ HDFs at temporally discrete stand scales rather than temporally averaged landscape scales. HDF values were specified in cooperation with USFWS biologists during consultation on the ESRF HCP.

Edge Effects

We specified HDF values for five primary silvicultural classes proposed for the ESRF (Table 4). We defined hard edge, soft edge, no edge, and inner and outer EEEZs as had been defined by WDNR (WDNR 2019c). For Intensive and Flex 50 allocations (intensive, even-age management) we employed the same edge-effect discount multiplier values used by WDNR for managed forests (WDNR 2019c, Table 2 and Table 3). HDFs for extensive management and for thinning on the ESRF were determined based on the specified values for intensive management, descriptions of extensive silvicultural prescriptions proposed by OSU for the ESRF, and synthesis of available scientific information. Because retention could vary between 20% and 80% in extensive allocations during implementation we assumed an average retention of 50% for all extensive allocations over the permit term, with the exception of the Extensive MAMU Occupied experiment allocation, which specifies 80% retention. We assumed that retention in variable retention harvest units would not be preferentially distributed to provide buffers adjacent to occupied habitat. In determining HDFs for CRW restoration thinning and for extensive thinning we assumed that during implementation an average of at least 60% canopy closure[3] would be maintained within 50 meters of any occupied or potentially occupied MAMU habitat.

Table 4. Edge-effect Habitat Diminution Factors (HDF)

Allocation	Edge Effect HDF	
	Inner EEEZ	Outer EEEZ
Intensive (hard)	0.42	0.83
Intensive (soft)	0.2	0.4
Extensive MAMU experiment (hard)	0.1	0.17
Extensive MAMU experiment (soft)	0.0	0.1
Extensive Medium Retention (hard)	0.37	0.73
Extensive Medium Retention (soft)	0.18	0.35
Extensive Maintenance Thin (hard)	0.0	0.2
Extensive Maintenance Thin (soft)	0.0	0.0
CRW Thin (hard)	0.0	0.2
CRW Thin (soft)	0.0	0.0

[2] This would exceed the annual harvest cap. To stay within the annual harvest cap some of these acres could be re-scheduled for later decades.

[3] We distinguish between canopy closure, which measures the proportion of the total sky hemisphere visible from a point 1.5m above the forest floor, and canopy cover, which is the vertical projection of forest canopy across a specified area of forest floor (Jennings, Brown, and Sheil. 1999).

Direct Effects

Because some stands with non-zero HSI values are allocated for harvest we estimated HDF values that would be associated with the direct effects of harvest, independent of edge effects (Table 5). We assume that there is no habitat value following intensive harvest, and we assume that thinning will have no effect on habitat value because thinning is not expected to occur in stands with non-zero HSI values. Of relevance are HDF values for extensive allocations. As modeled here, when harvest to a stand with a non-zero HSI value occurs habitat value is reduced according to the appropriate HDF value (Table 5). As modeled, this diminution of habitat does not recover with age, as is the case with modeled edge effects; this was a "worst-case" assumption that we may be able to relax when more information becomes available on the effects of partial harvest in occupied stands. Although the direct effects of harvest on habitat are not modeled to recover with time since harvest, the diminished HSI value of affected habitat does increase according to the HSI-age function (Figure 3a).

Table 5. Direct-effect Habitat Diminution Factors (HDF)

Allocation	Direct HDF
Intensive	1.0
Extensive MAMUx (80% retention)	0.2
Extensive Medium Retention	0.88
Thin, all classes	0.0

June 2023 Allocation Revisions

Consultations between OSU and USFWS biologists to determine the HDFs specified in Table 4 and Table 5 occurred prior to the June 2023 allocation revisions. These revisions resulted in specification of the Flex 50 allocation, and in the specification of variable retention harvest allocations outside of the Triad research watersheds (Figure 5) that may be conceptually different from Triad Extensive allocations described in the Research Proposal (OSU 2021). We assume that all variable retention harvest systems outside of the Triad research watersheds (Alder Creek VRH100, Big Creek VRH100, Flex VRH100, and Hakki VRH100) fit the parameters for Extensive medium retention harvest and thinning (Table 4, Table 5) and, as noted above, we assume that Flex 50 allocations will be intensively managed as even-age forests on 50-year harvest rotation cycles.

Creation of Base Rasters and Net Rasters

The sequential process we used for the creation of base rasters and net HSI rasters is represented in a workflow diagram (Figure 4); the numbered procedural outline below corresponds to numbers in the workflow diagram.

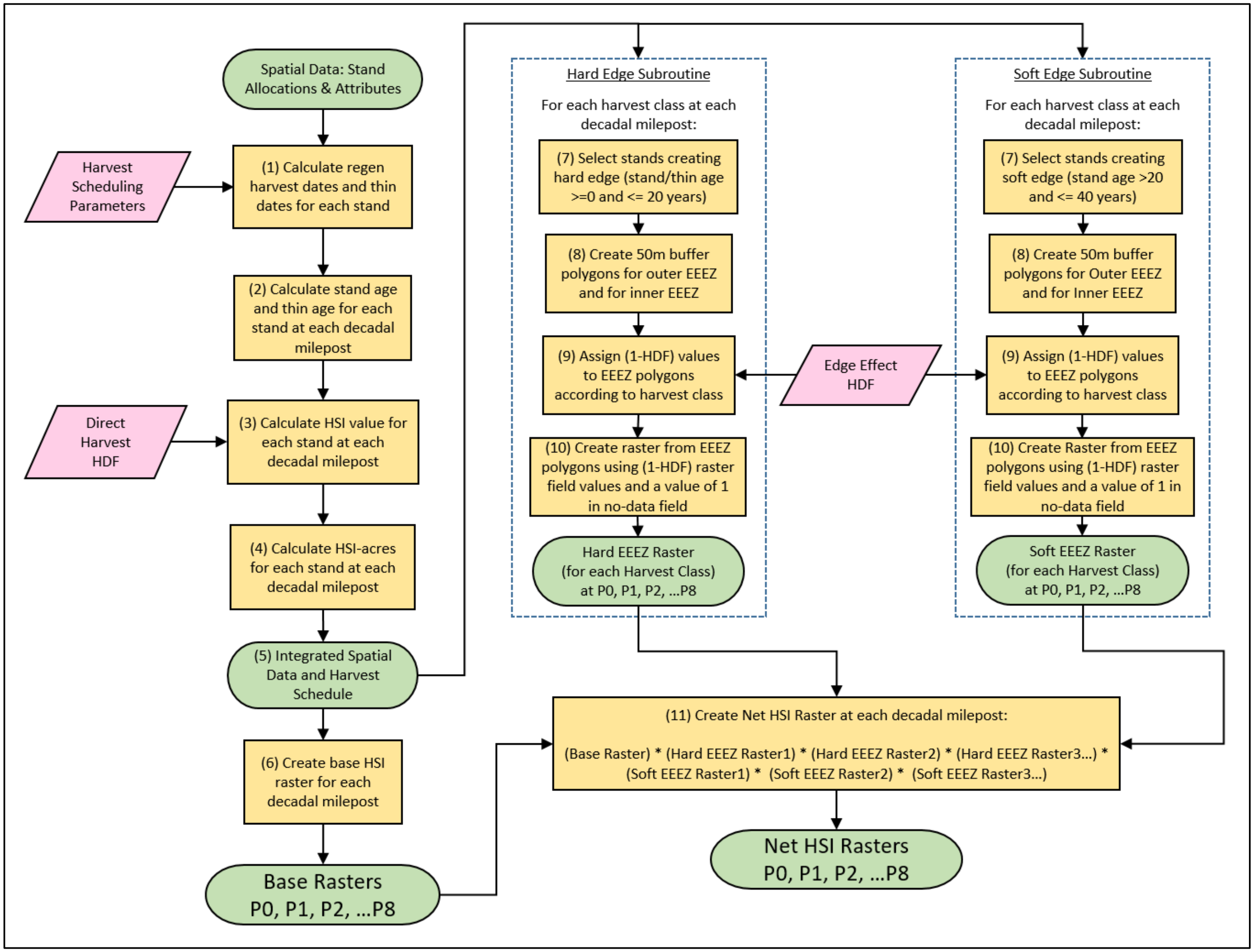


Figure 4. Workflow diagram for creating base rasters and net HSI rasters. Base rasters are 3-foot resolution rasters containing unadjusted HSI values for the ESRF at each decadal milepost. Net HSI rasters are derived from the base rasters, and represent HSI values net of edge effects at each decadal milepost.

Base Rasters

1) Specify harvest dates for each stand polygon:
    a. Add attribute fields to the spatial stand file (i.e. allocation file) to facilitate integration of harvest schedule with spatial stand data. These fields are: *Regeneration year 1, Regeneration year 2, Maintenance Thin year, Silvicultural Thin year,* and *CRW Thin year.* Attribute fields for *Stand Age, Thin Age, HSI Value, and HSI-acres* for each DM are also added
    b. Export spatial stand file, including all attributes, to an Excel spreadsheet.
        i. Note that each stand must have a unique identification number to facilitate transfer of data back to ArcMap at a later stage of this process
    c. Based on the harvest schedule parameters, for each allocation/harvest class and initial stand age calculate regeneration harvest dates and thin dates for each stand
        i. Assign value of 9999 where no harvest is scheduled
2) Calculate stand age and thin age at each DM based on regeneration/thin year(s) for each stand
    a. Extensive and VRH harvest classes use the age of the retained stand for stand age
3) Calculate the HSI value for each stand at each DM based on stand age
    a. Adjust stand HSI for direct-effects according to Table 5
        i. HDF values represent the fraction by which habitat is reduced. The fraction of habitat that remains is: (1 – HDF)
        ii. For all variable retention harvest allocations, including Triad extensive, post-harvest HSI is based on retained stand age, and the HDF applies to all decades post-harvest
4) Calculate HSI-acres for each stand at each DM
    a. HSI-acres = stand area (acres) * stand HSI
    b. HSI-acres may be summed across any area of interest
        i. This step should produce the same HSI-acres calculated from base rasters, and serves as a check for error.
        ii. HSI-acres values do not include edge effects
5) Transfer attribute values calculated in the Excel worksheet back to the respective spatial/GIS stand file attributes
    a. Create a "Join" in ArcMap between spatial stand file and Excel file using the unique stand identifier (i.e. "SID_011)
    b. Write Excel values to the spatial stand file
6) Create base HSI raster for each DM
    a. 3-foot raster resolution
    b. Validate this process by comparing the sum of HSI-acres for an area of interest (AOI) from the stand file with the value of [*mean base raster pixel value for AOI * AOI acres*]

Net HSI Rasters

A set of EEEZ rasters containing [1 – HDF] values for each harvest class (Table 4) at each DM is created. Each set of rasters will include a subset of rasters derived from stands creating hard edge, and a subset of rasters derived from stands creating soft edge. The following description applies to creating hard edge rasters; the procedure for soft edge rasters is identical, with the exception that the age parameters for soft edge are for stands >20 years and <=40 years.

For <u>each harvest class</u> at <u>each DM</u>, including initial condition:

7) Select stands with stand age of <=20 years of age at the subject DM. For thin harvest classes (e.g. CRW thin, extensive thin) select stands based on thin age
8) Create buffer polygons representing outer and inner EEEZs:
    a. Create a 50-meter buffer around the selected polygons. This defines the outer EEEZ (See Figures 1 and 2)
    b. Create a 50-meter buffer around the 50-meter buffer polygon. This defines the inner EEEZ (See Figures 1 and 2))
9) Assign [1-HDF] values to EEEZ polygons
    a. Create a blank rectangular polygon "mask" that covers the entire ESRF
    b. For each harvest class create a spatial union of the mask polygon, inner EEEZ polygons, and outer EEEZ polygons
    c. Assign [1-HDF] values to the inner and outer EEEZ features according to Table 4
    d. Assign a value of 1 to areas not within the EEEZ polygons
        i. In the step 11 (below) this allows areas not within EEEZs of a subject harvest class to pass through the edge raster calculation at full HSI value
10) Using the parameterized EEEZ union polygons created in step 9, create a 3-foot resolution raster for each harvest class at each DM
    a. For each DM there will be a separate hard edge raster for each harvest class.

---Repeat Steps 7 through 10 for stands creating soft edge---

11) Create the Net HSI Raster at each DM
    a. The Net HSI Raster is the Base Raster net of edge effects, and is the product of the base raster and all soft and hard EEEZ rasters for a subject DM (Figure 6)

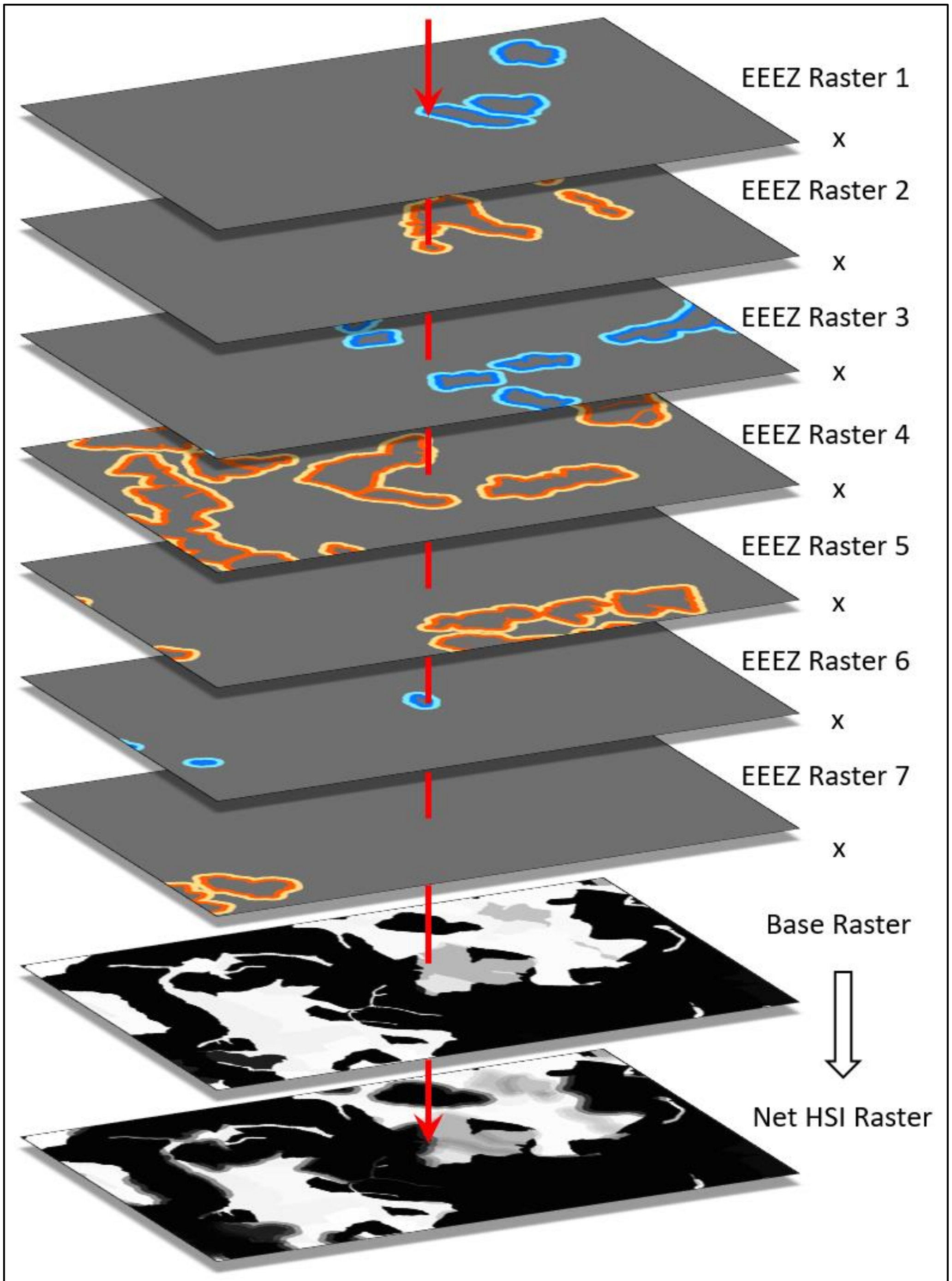


Figure 6. Calculation of the Net HSI raster was performed using the ArcMap Raster Calculator tool, which performs logical and mathematical functions on spatially coincident pixels of multiple rasters. The EEEZ rasters contain inner and outer EEEZ habitat diminution data for each harvest class; the pixels in the grey area of the EEEZ rasters have a value of 1, and the EEEZ pixels (colored bands in grey field) have values that represent HDF values from Table 4 (pixel values = (1-HDF). When all EEEZ rasters are multiplied together with the base raster, a new raster with pixel values net of edge effects is created – the Net HSI raster.

Results and Discussion

Compilation of Edge Effects and Direct Effects

Edge Effects

Base HSI-acres and HSI-acres net of edge effects for the entire ESRF are summarized for each DM (Table 6, Figure 7). Percent edge diminution is calculated as the difference between *Net HSI-acres* and *Base HSI-acres*, expressed as a percent of *Base HSI-acres*.

Table 6. ESRF forest-wide MAMU habitat: mean raster values and HSI-acres at DMs from beginning (2024) to end (2104) of HCP term. Base values are net of direct harvest effects (Table 5), but do not include edge effects. Net HSI raster values are net of both direct harvest effects *and* edge effects, as are net HSI-acres (Table 4). Percent edge diminution is the difference between *Net HSI-acres* and *Base HSI-acres*, expressed as a percent of *Base HSI-acres*

Year	Base Raster Mean HSI	Base HSI-Acres	Net HSI Raster Mean HSI	Net HSI-acres	Edge Diminution (%)
2024	0.26206	21,831	0.24314	20,255	7.2%
2034	0.28369	23,633	0.26452	22,035	6.8%
2044	0.29190	24,316	0.26919	22,424	7.8%
2054	0.30040	25,024	0.27899	23,241	7.1%
2064	0.30873	25,718	0.28738	23,940	6.9%
2074	0.32235	26,853	0.29985	24,978	7.0%
2084	0.34555	28,785	0.31479	26,223	8.9%
2094	0.37991	31,648	0.34445	28,694	9.3%
2104	0.41529	34,596	0.37885	31,560	8.8%

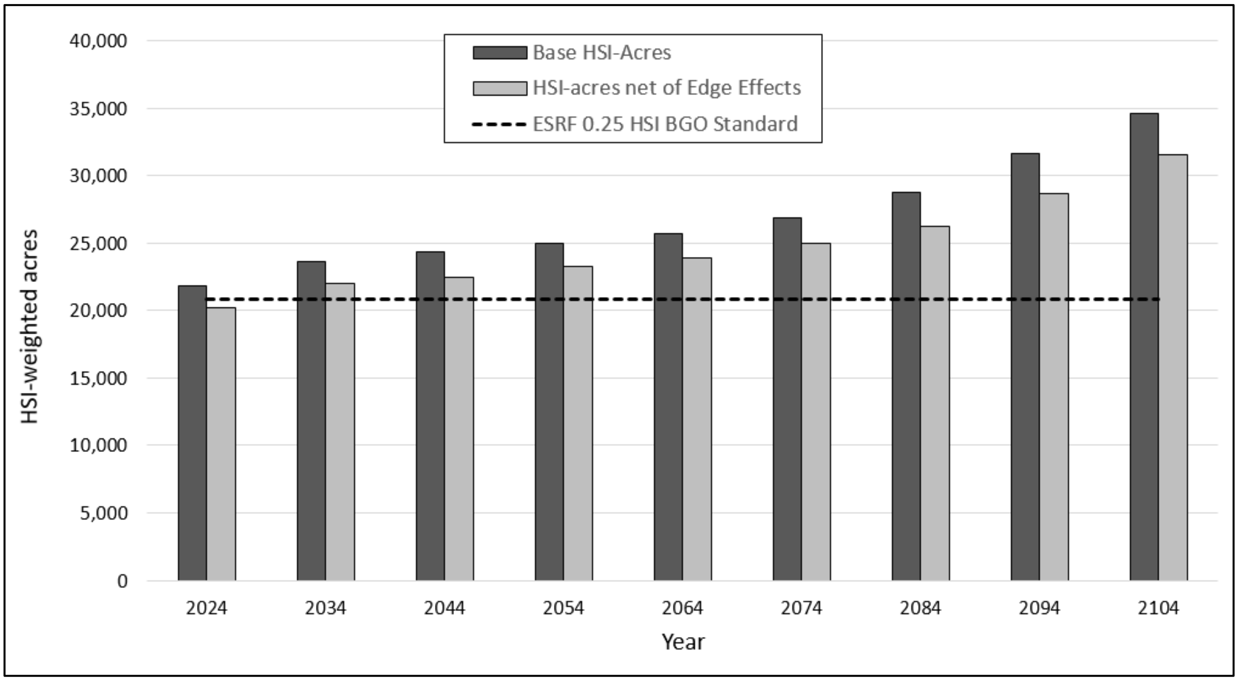


Figure 7. MAMU HSI-acres for the ESRF at DMs from beginning (DM 2024) to end (DM 2104) of the HCP term. *Base HSI-acres* values are net of direct harvest effects (Table 5), but do not include edge effects. *HSI-acres net of edge effects* are net of both direct harvest effects and edge effects (Table 4). At the scale of the ESRF as a whole and for all DMs, neither base HSI-acres nor HSI-acres net of edge effects decreased in value with respect to earlier DMs. The HCP Biological Goals and Objectives (BGO) standard requiring a mean net HSI value of 0.25 for the ESRF is the equivalent of 20,816 HSI-acres, shown here as a dashed horizontal line.

Direct Effects

Base raster values are net of the diminution of habitat directly attributable to the harvest or partial harvest of habitat with non-zero HSI values; thus, HSI values net of edge effects and percent edge diminution are also net of direct effects. To calculate what direct effects would be over the permit term we summed all scheduled harvest acres by allocation over the permit term. We then summed the *initial* state (year 2024) HSI-acres for each allocation and multiplied this value times the appropriate HDF value for each harvest class (Table 7). The baseline for estimating direct effects is thus the HSI value of harvested stands at the beginning of the HCP permit term, not the HSI value of stands at the time of harvest.

Table 7. Direct Harvest Effects. Direct harvest effects represent the direct reduction in habitat value of a harvested area, and do not include offsite effects, such as edge effects. The baseline for estimating direct effects is the HSI value of harvested stands at the beginning of the HCP permit term (year 2024).						
	Total Acres	Acres Scheduled for Harvest	Total HSI-Acres (year 2024)	HSI-Acres Scheduled for Harvest	Direct Effect HDF	Direct Effect (HSI-Acres)
Intensive	9,860.8	9,860.8	0.0	0.0	1	0.0
Flex50	5,757.0	5,757.0	0.0	0.0	1	0.0
Extensive (Not ConMAMU)	8,551.6	8,551.6	77.9	77.9	0.88	68.6
Upper Big Creek VRH100	554.5	554.5	0.0	0.0	0.88	0.0
Alder Creek VRH100	1,068.8	1,068.8	0.0	0.0	0.88	0.0
Hakki Ridge VRH100	418.7	418.7	0.0	0.0	0.88	0.0
Flex VRH100	1,081.2	986.6	452.0	402.0	0.88	353.8
Extensive ConMAMU	1,889.6	1,177.8	998.9	629.4	0.88	553.9
Extensive MAMU experiment	1,370.0	1,370.0	688.5	688.5	0.2	137.7
CRW Thin	6,810.0	5,621.5	0.0	0.0	0	0.0
CRW No Thin	17,059.8	0.0	8,553.5	0.0	0	0.0
CRW RCA	9,568.6	0.0	3,484.8	0.0	0	0.0
MRW Reserve	12,304.6	0.0	5,569.5	0.0	0	0.0
MRW RCA	6,640.2	0.0	1,842.1	0.0	0	0.0
Hakki Reserve	278.3	0.0	145.8	0.0	0	0.0
Hakki RCA	90.4	0.0	20.7	0.0	0	0.0
ESRF Total	83,304.1	35,367.3	21,833.6	1,797.8		1,113.9

<u>ESRF Subunits</u>

Edge effects for subunits of the ESRF can be derived by evaluating raster statistics within zones of interest. Such zones could be the Triad research watersheds, the conservation research watersheds (CRW), individual watersheds or sets of watersheds, or any other spatial delineation. We evaluated edge effects separately for the Triad research watersheds (Triad), the CRW, and the Multiple Objectives Zone (MOZ); together these three zones comprise the entire ESRF (Figure 8). We also evaluated as a single zone the combined Triad and MOZ, which together comprise the primary harvest base lands of the ESRF.

<u>Habitat Trends</u>

As might be expected, the relative fraction of net HSI-acres attributable to the CRW increases through the permit term while the relative fraction of net HSI-acres attributable to the Triad and to the MOZ declines (Figure 9; Table 8). This is in alignment with OSU's planning strategy of creating a large contiguous area with a conservation research emphasis – the Conservation Research Watersheds – where new fragmentation is avoided and existing fragmentation attributable to pre-existing plantation forestry is remediated, and an area with a research emphasis on active forest management – the Management Research Watersheds (OSU, 2021).

Considering the ESRF as a whole, habitat value net of edge effects increases from 20,255 HSI-acres in year 2024 to 31,560 HSI-acres in year 2104, with no DM showing a decrease in HSI-acres from prior years (Figure

7; Table 6). This overall increase in net HSI value across the forest, as well as the disproportionate increase in the HSI value of the CRW, is apparent in Figure 11.

When considering HSI trends for the three subunits of the ESRF, all showed an increase in both base and edge-adjusted HSI values between the beginning of the permit term and the end of term, with the CRW and Triad zones showing no periodic declines in HSI values throughout the permit term (Figure 10a and 10b). When evaluating the combined Triad and MOZ subunits there is no decline in base HSI value through the permit term; however, net HSI value declines slightly in years 2044 and 2054 (Figure 10d, Table 9).

Evaluated by itself, the MOZ showed periodic declines in both base HSI values and net HSI values (Figure 10c; Table 9) and a general suppression of net HSI values compared to the Triad watersheds. This suppression in net HSI values in the MOZ is at least in part attributable to the short-rotation Flex 50 allocation. The MOZ includes all 5,757 acres of the Flex 50 allocation, which was modeled assuming the "worst case" of 50-year rotation even-age intensive management. At a 50-year rotation, harvest units in this allocation would be in an edge state for 40 years out of the 50-year harvest cycle, with 20 years in hard edge and 20 years in soft edge. If actual management instead employed longer harvest cycles – for example, 100 years instead of 50 years – habitat diminution attributable to edge effects from this harvest class would be reduced by approximately 50%.

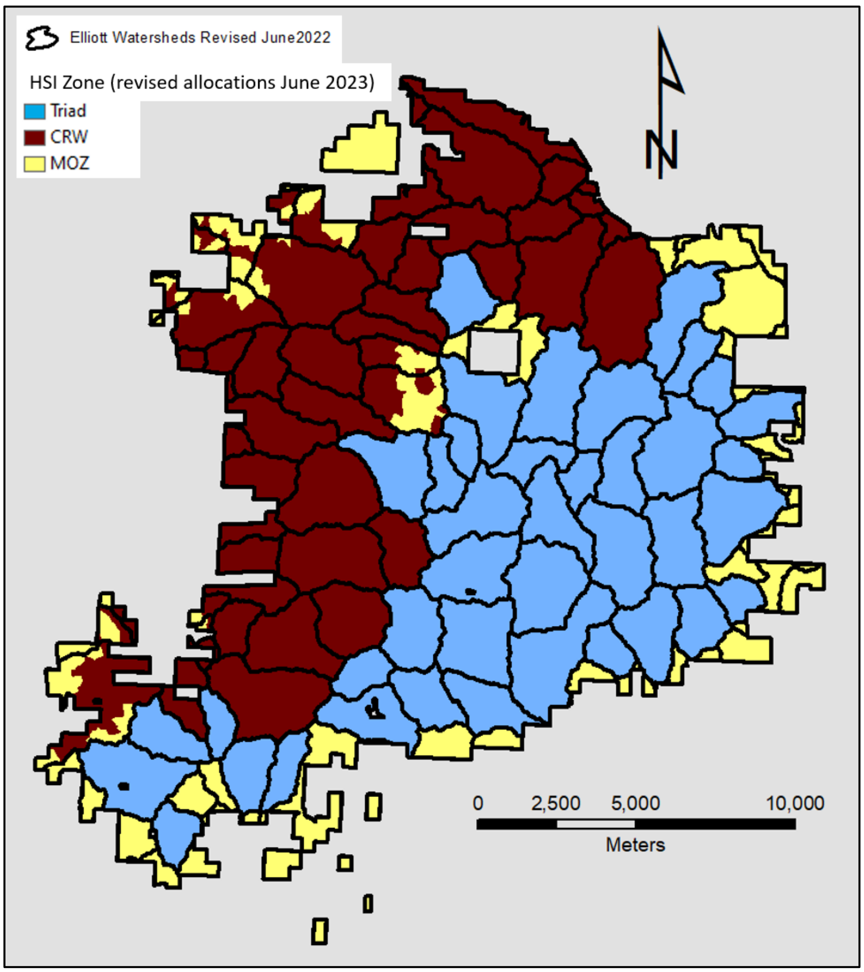


Figure 8. Edge effects for subunits of the ESRF can be derived by evaluating raster statistics within zones of interest which could, for example, be defined by administrative, ecological, or geophysical boundaries. Here we evaluated edge effects within three subunits of the ESRF: the Triad research watersheds, the CRW, Multiple Objectives Zone (MOZ).

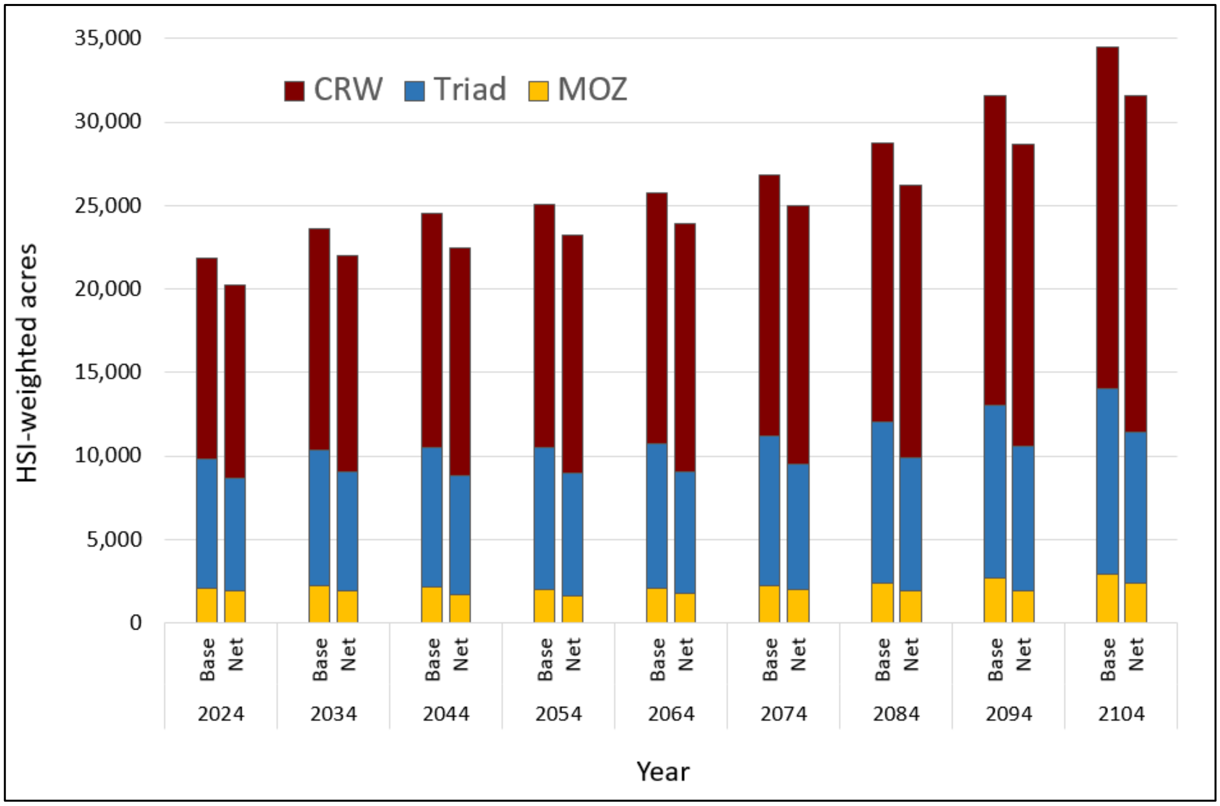


Figure 9. Base and edge-adjusted HSI-acres for the ESRF, partitioned by Triad research watersheds, the CRW, and the MOZ. The Triad and MOZ categories together comprise the primary harvest-base allocations on the ESRF and are evaluated together (Table 9 and Figure 10d).

Table 8. Percent of total net HSI-acres by DM. The relative proportion of net HSI-acres in the CRW increases through the permit term, whereas it declines in the two active forest management zones (Triad and MOZ).

DM (Year)	Triad	CRW	MOZ	Total
2024	33%	57%	9%	100%
2034	32%	59%	9%	100%
2044	32%	61%	8%	100%
2054	31%	61%	7%	100%
2064	31%	62%	7%	100%
2074	30%	62%	8%	100%
2084	30%	62%	7%	100%
2094	30%	63%	7%	100%
2104	29%	64%	7%	100%

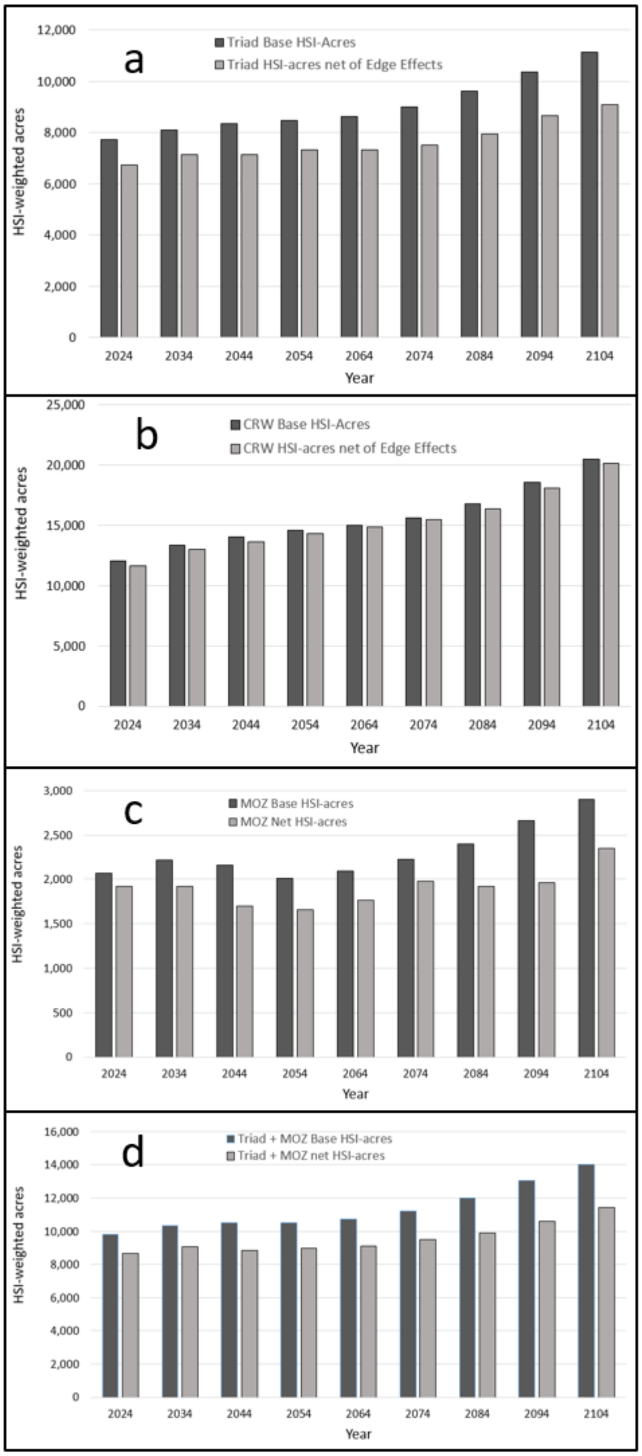


Table 9. Tabular data that accompanies Figure 10.

Decadal Milepost (year)	Base HSI-Acres	HSI-acres net of Edge Effects	Edge Diminution (%)
Triad Research Watersheds (36,871 acres)			
2024	7,726	6,750	13%
2034	8,102	7,134	12%
2044	8,363	7,140	15%
2054	8,484	7,314	14%
2064	8,622	7,324	15%
2074	8,988	7,520	16%
2084	9,607	7,960	17%
2094	10,380	8,649	17%
2104	11,141	9,082	18%
CRW (33,438 acres)			
2024	12,038	11,587	4%
2034	13,311	12,981	2%
2044	14,046	13,582	3%
2054	14,551	14,269	2%
2064	15,004	14,855	1%
2074	15,616	15,480	1%
2084	16,738	16,339	2%
2094	18,555	18,080	3%
2104	20,491	20,125	2%
MOZ (12,995 acres)			
2024	2,066	1,918	7%
2034	2,219	1,920	13%
2044	2,160	1,702	21%
2054	2,013	1,658	18%
2064	2,094	1,761	16%
2074	2,223	1,978	11%
2084	2,397	1,924	20%
2094	2,657	1,964	26%
2104	2,897	2,353	19%
Triad + MOZ (49,866 acres)			
2024	9,793	8,668	11%
2034	10,322	9,054	12%
2044	10,523	8,843	16%
2054	10,497	8,972	15%
2064	10,716	9,085	15%
2074	11,211	9,499	15%
2084	12,004	9,884	18%
2094	13,037	10,614	19%
2104	14,038	11,435	19%

Figure 10. Base HSI-acres and HSI-acres net of edge effects for the Triad Research Watersheds (a), the CRW (b), and the MOZ (c); these three zones comprise the entire ESRF. Combined, the Triad Research Watersheds and the MOZ (d) comprise the primary harvest-base allocations for the ESRF.

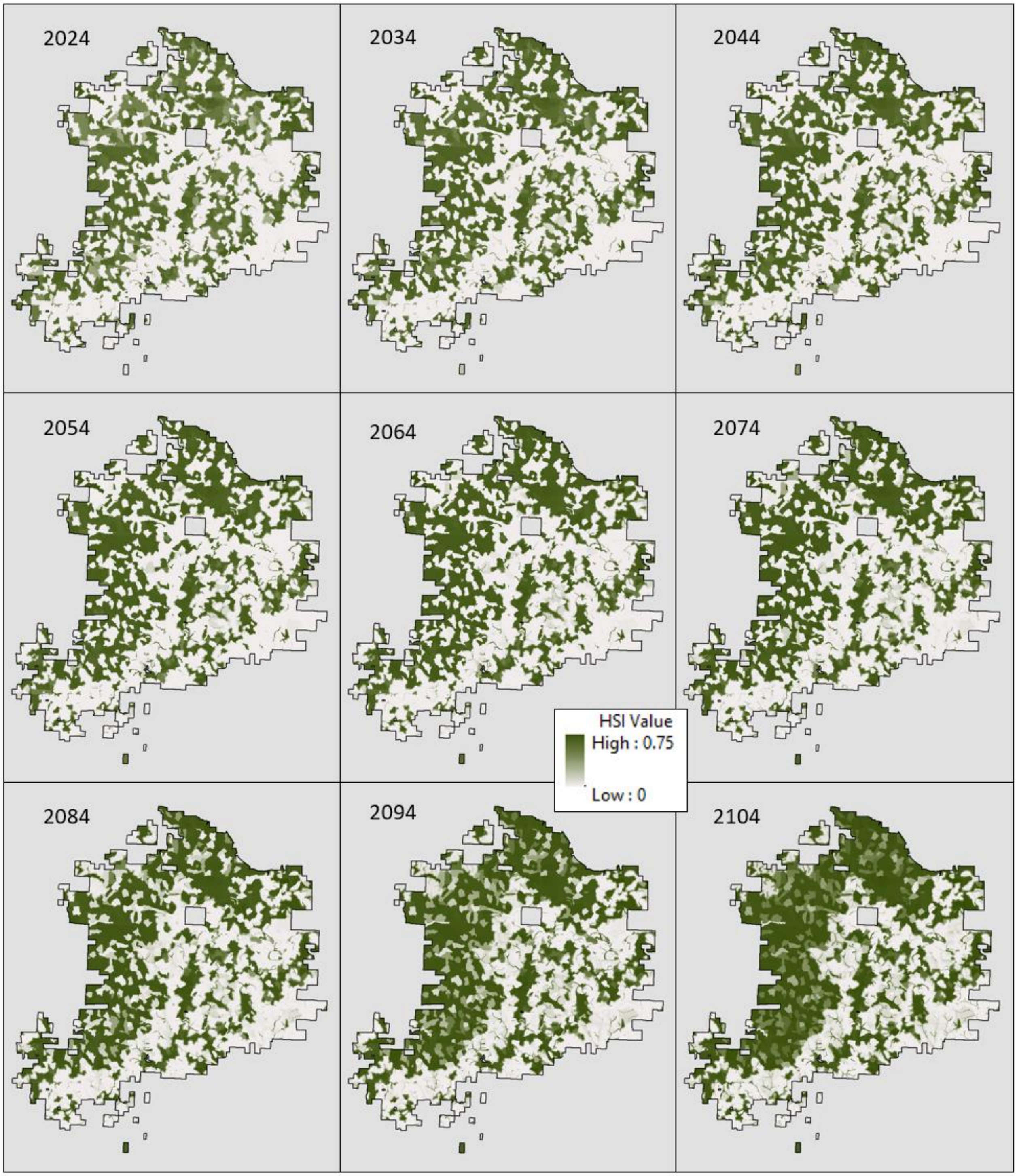


Figure 11. Map of Net HSI values across the across the ESRF at DMs throughout the permit term, including initial condition (year 2024). Net HSI values symbolized in the decadal maps shown here correspond to the decadal HSI values displayed in Table 6.

Monitoring and Adaptive Management

Objective 2.3 of the HCP specifies two quantifiable objectives related to HSI: 1) Maintain an area-weighted mean marbled murrelet Habitat Suitability Index (HSI) value of 0.25 across the permit area (net of all edge effects) and, 2) limit reduction of marbled murrelet habitat attributable to harvest-related edge effects to 7.2 percent of total permit area HSI-weighted acres throughout the permit term. Attaining these objectives while also achieving other goals and objectives for the ESRF will require ongoing monitoring of forest condition in terms of HSI, and will require the evaluation of prospective harvesting scenarios as part of the biennial planning process to ensure that planned harvests achieve HCP objectives.

Current forest condition is very close to the quantitative objectives described above, both in terms of mean net HSI and in terms of legacy edge effects from previous harvests (Figure 7 and Figure 12). The intent of Objective 2.3 is to ensure that forest condition, as quantified by HSI, does not drop below conditions that existed at the beginning of the permit term. As modeled, forest-wide mean net HSI is 0.243 at the beginning of the permit term, rises to a value of 0.265 by the end of the first decade of implementation (year 2034), and is projected to increase every decade thereafter (Table 6). HSI projections are based on worst-case assumptions, so it seems likely that with appropriate monitoring and adaptive measures during biennial planning and implementation the mean net HSI standard for the forest can be achieved. This does not preclude applying different standards at smaller scales of analysis however, such as maintaining a minimum standard for areas of concern outside of the CRW.

The 7.2% maximum diminution of MAMU habitat attributable to harvest-related edge effects may be a more difficult standard to achieve than the mean net HSI standard. As modeled, edge diminution is projected to be very close to the 7.2% standard during the first 5 decades of the permit term, but exceeds the standard in the final three decades (Figure 12). This increase is attributable to a convergence of scheduled regeneration harvests beginning in the fifth decade (Table 3), and is exacerbated by the modeled 50-year rotation in the Flex 50 allocation, which contributes to peaks in harvest-related edge diminution in the MOZ (Figure 12).

There are several adaptive measures available to planners that would allow the forest to remain within the edge diminution standard. Such adaptive measures could include: strategically removing lands from the harvest base that produce the most edge effects; strategically reallocating lands to reduce fragmentation; strategically employ variable retention silviculture (rather than even-age silviculture); where variable retention silviculture is employed spatially configure retention so as to reduce edge effects; increase the length of harvest rotation cycles; place no-harvest buffers adjacent to affected habitat. All of these measures require a means to identify areas where harvest-related edge effects can be expected to occur.

Given prospective harvest schedules developed during the planning process, an edge raster can be created of potential future HSI values given implementation of the prospective harvest schedule. When this raster is subtracted from another raster of existing or baseline conditions, a new raster showing changes in HSI values is produced (Figure 13). This raster map can be used to inform decisions about applying adaptive measures that moderate harvest-related edge effects.

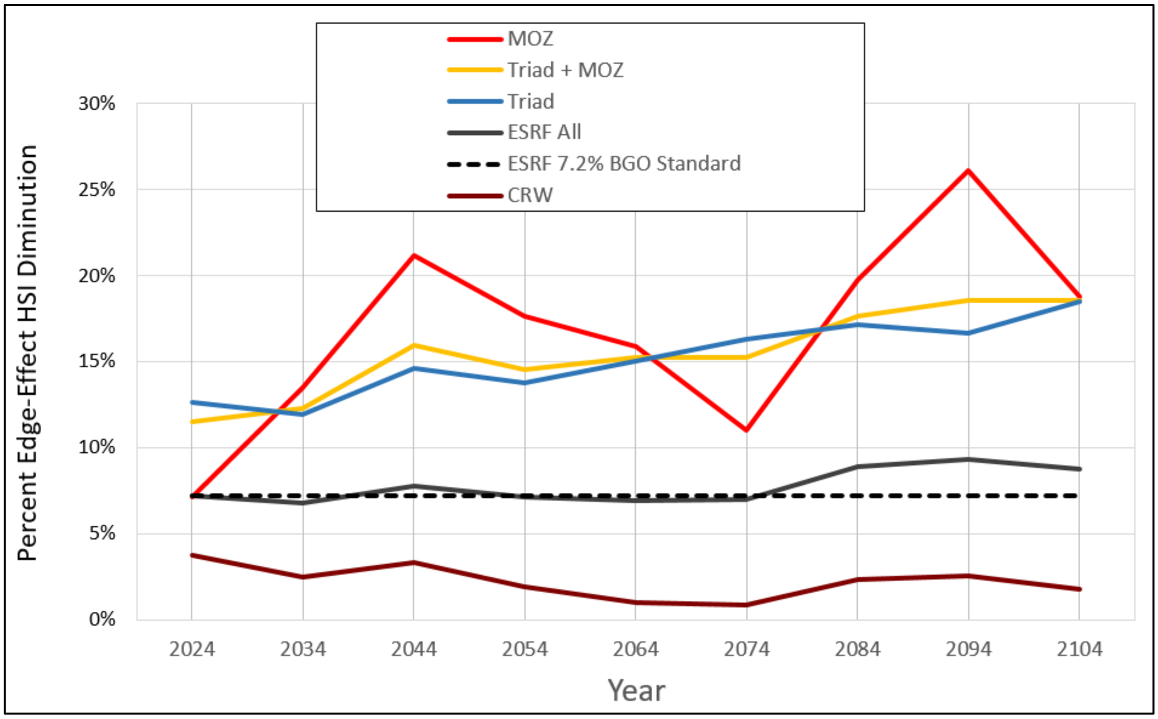
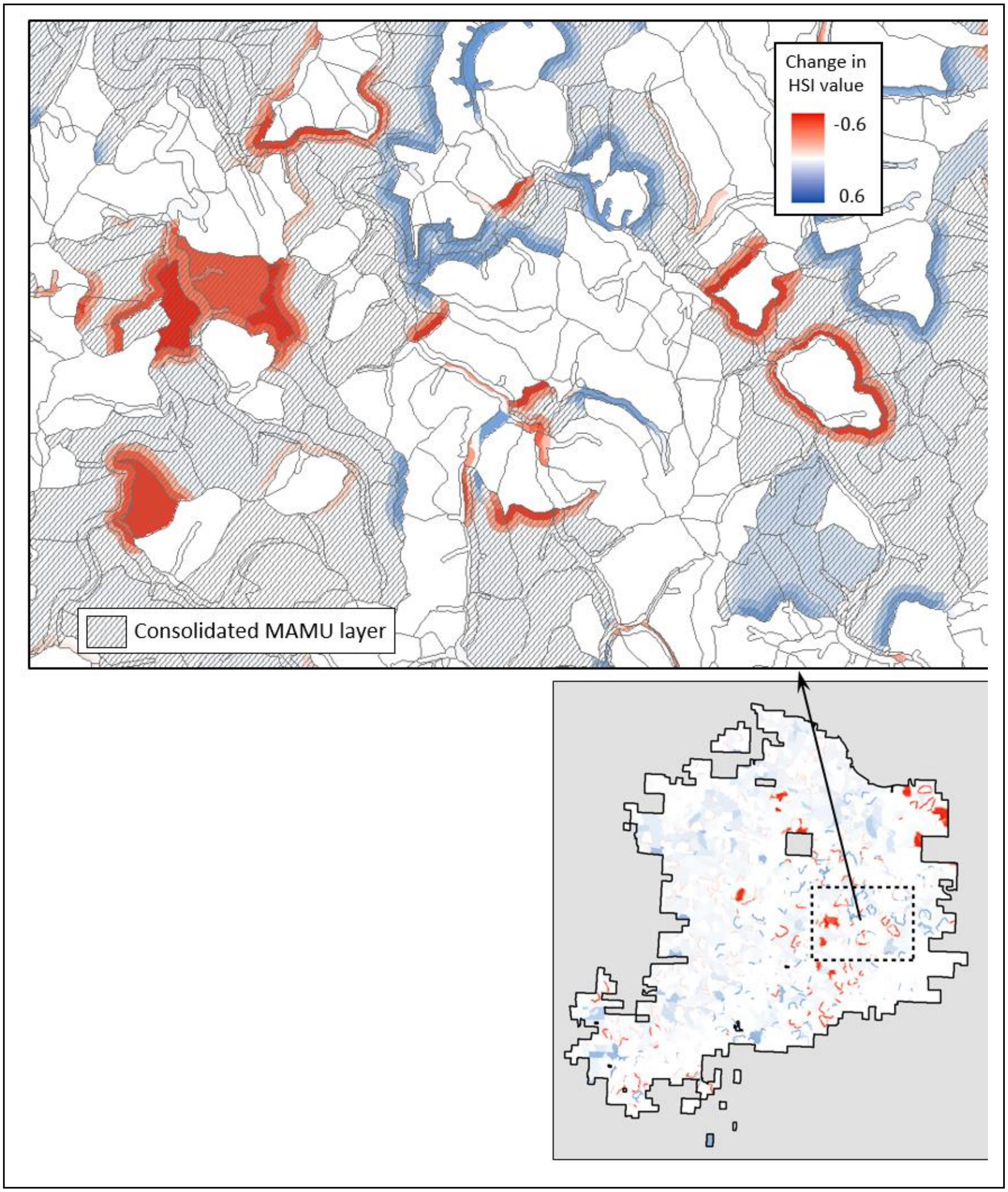


Figure 12. Percent of habitat diminution attributable to harvest-related edge effects, by management zone. Harvest-related edge effects are relatively low in the CRW, where the only programmed harvest activity is restoration thinning. In contrast, harvest-related edge effects are higher in areas with more scheduled harvest, such as the MOZ and Triad watersheds. As modeled, the ESRF as a whole remains very close to the 7.2% standard through the first 5 decades of the permit term, but is projected to exceed the standard in the final 3 decades.


Change in HSI value
-0.6
0.6
Consolidated MAMU layer

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Appendix E
Wood Modeling

Modeling the sources of large wood recruited to fish-bearing streams by debris flow processes in the Oregon Coast Range

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February 23, 2024

1. Introduction

Large wood is broadly recognized by researchers and by policymakers as a key component of riparian and aquatic ecosystems throughout the temperate forests of western North America. Large wood necessarily originates on the terrestrial landscape as trees, where management activities such as timber harvest take place that potentially remove trees that might otherwise be a source of large wood for riparian and aquatic ecosystems. Scientific research has sought to identify the sources of large wood to streams of interest so that on managed landscapes these sources might be protected through the application of science-informed policy.

A common means of describing sources of large wood to streams of interest is to specify the cumulative distribution of large wood observed within a stream as a function of the perpendicular distance from the stream bank to the wood's point of origin on the terrestrial landscape (Figure 1). These cumulative distribution functions, also referred to as a source-distance functions, have been estimated using both empirical findings and theoretical models. In a study of 39 first- through third-order streams in western Oregon and Washington, McDade et al. (1990) specified empirical source-distance functions for streams in mature conifer, mature hardwood, and old-growth forests, and compared these to geometric treefall models based on tree height and distance to stream. Van Sickle and Gregory (1990) developed a more detailed geometric recruitment model for stream-adjacent large wood sources and compared these to observations from an old-growth forest in the western Cascade Mountains of Oregon.

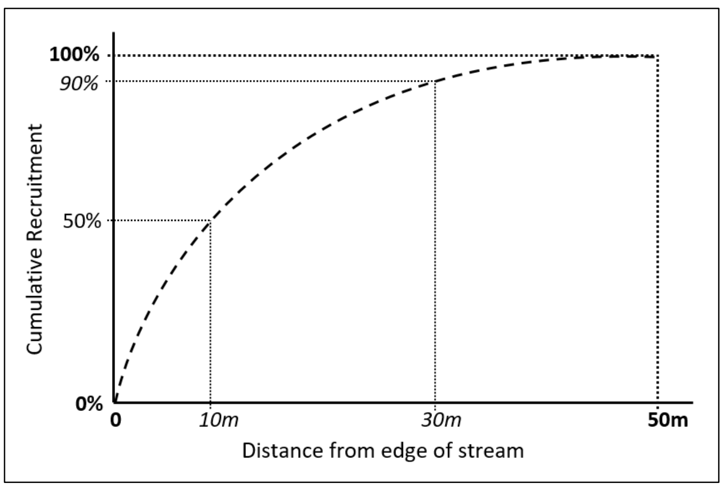

Figure 1. Generalized example of a source distance function for large wood. Source distance functions describe the cumulative distribution of an assumed total quantity of large wood recruited to a stream as a function of the perpendicular distance from the stream bank to the wood's point of origin on the terrestrial landscape. In this example, 100% of large wood originates from within 50 meters of the edge of the stream, with 50% and 90% originating within 10 meters and 30 meters, respectively.

McDade et al. (1990) and Van Sickle and Gregory (1990) evaluated only stream-adjacent large wood sources, such as bank erosion, tree mortality, and localized wind damage. Van Sickle and Gregory (1990) specifically excluded large wood recruitment attributable to debris flow from their analysis, and McDade et al. (1990) avoided study reaches that had been affected by landslides (Reeves et al. 2003). More recent studies of sources of large wood to streams in the Oregon Coast Range (OCR) suggest that large wood delivered by debris flow through colluvial tributaries may comprise a sizable fraction of the total wood budget to low-order alluvial streams. In a study of wood recruitment sources in a 3.9 km^2 catchment in the southern OCR, May and Gresswell (2003) reported that 33% of large wood pieces in a third-order alluvial mainstem stream had been transported to the stream by debris flow through second-order tributaries, and in a study of four small catchments in the central OCR Bigelow et al. (2007) reported that between 31% and 85% of large wood pieces identified in fish-bearing streams were found in debris flow deposits associated with first- or second-order tributaries. Also in the central OCR, Reeves et al. (2003) reported that 65% of large wood pieces surveyed in a fourth-order stream were delivered by landslide or debris flow from distances greater than 90 meters, and May (2002) reported that between 11% and 59% of large wood (by volume) in eleven third- through fifth-order streams had originated from debris flows that occurred during an intense rainstorm in February of 1996. In interpreting these findings we assume that streams identified by the respective authors as third-order and greater are alluvial and fish-bearing (FB) streams, and that streams identified as second-order and smaller are colluvial and non-fish-bearing (NF) streams.

The source-distance studies by McDade et al. (1990) and by Van Sickle and Gregory (1990) helped form the scientific underpinnings for riparian protections under the Northwest Forest Plan (FEMAT, 1993; USFS and BLM, 1994) and under the Oregon Forest Practices Act (Lorensen et al., 1994). Notably, source-distance functions lend themselves to implementation through the application of protective buffers adjacent to streams with recognized resource values, such as fish-bearing streams (USFS and BLM, 1994; Lorensen et al., 1994). Although the more recent findings of May and Gresswell (2003), Bigelow et al. (2007), Reeves et al. (2003), and May (2002) suggest that large wood recruitment attributable to debris flow through NF tributaries may be an important policy consideration, these studies do not provide a generalizable means of identifying potential debris flow recruitment sources.

Our research objective has been to develop a generalizable model capable of identifying potential source areas of debris flow wood recruitment to fish-bearing streams of the OCR. To this end our research is organized around a construct we refer to as *percent non-fish recruitment* (%NFR), which we define as the percent of the total large wood budget of an area of interest that is delivered to FB streams within that area of interest by debris flow through NF tributaries. Here we describe *ElliotSFWood*, a spatially explicit wood recruitment model that distinguishes between large wood recruited directly to FB streams by stream-adjacent sources and wood recruited to FB streams by debris flow through NF tributaries.

2. Study Area

The study area is the Elliott State Research Forest (ESRF), located in the southern OCR. The ESRF was chartered by the Oregon State Legislature in 2022 (Oregon Senate Bill 1546, 2022) and comprises approximately 33,400 hectares of forestland situated approximately between 10 and 30 kilometers of the Pacific Ocean (Figure 2). The ESRF is situated within the western hemlock (*Tsuga heterophylla*) zone described by Franklin and Dyrness (1973). Dominant overstory vegetation is Douglas-fir (*Pseudotsuga menziesii*), with a secondary component of western hemlock and western redcedar (*Thuja plicata*). Bigleaf maple (*Acer macrophyllum*) is present throughout the forest in areas with low to moderate conifer density. Red alder (*Alnus rubra*) is often the dominant tree species in riparian areas.

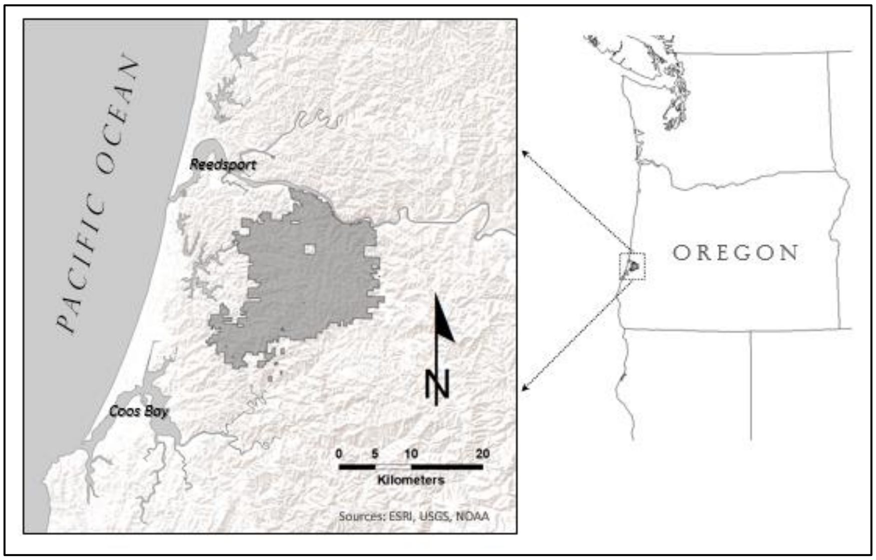

Figure 2. Location of the Elliott State Research Forest (ESRF).

The underlying geology of the ESRF is almost entirely the Eocene Tyee formation, which is characterized by rhythmic-bedded deposits of marine sandstones and siltstones, each approximately 1 – 2 meters thick, with a total formation depth of 1,800 to 3,000 meters (Snavely, Wagner, and MacLeod, 1964). The topography of the ESRF is characterized by steep ravines, constrained stream channels, and prominent ridges (Figure 3). The average slope of delineated watersheds (Figure 4) ranges between 40% and 80%, though locally slopes may be nearly zero on alluvial floodplains and exceed 100% in headwall areas. Elevation on the ESRF ranges from near sea-level to approximately 640 meters.

The climate of the ESRF is influenced by proximity to the Pacific Ocean, and is characterized by mild, wet winters, and warm, dry summers. Annual precipitation (30-year normal) ranges between 1,875mm and 2,785mm across the extent of the ESRF (PRISM, 2022), with most precipitation occurring during the winter months as rain. Prolonged dry periods during the summer months, combined with late-season continental winds from the east and low humidity, contribute to episodic stand-replacing wildfires.

A stand-replacing wildfire burned most of the area within the boundaries of the ESRF in 1868, though some drainages survived the fire (BioSystems, 2003). Following the 1868 wildfire Douglas-fir regenerated quickly over most of the burned area. Large-scale commercial timber harvest began on the ESRF in 1955, and since that time approximately 50% of the area of the ESRF has been harvested and converted to high-density Douglas-fir plantations. (OSU, 2021).

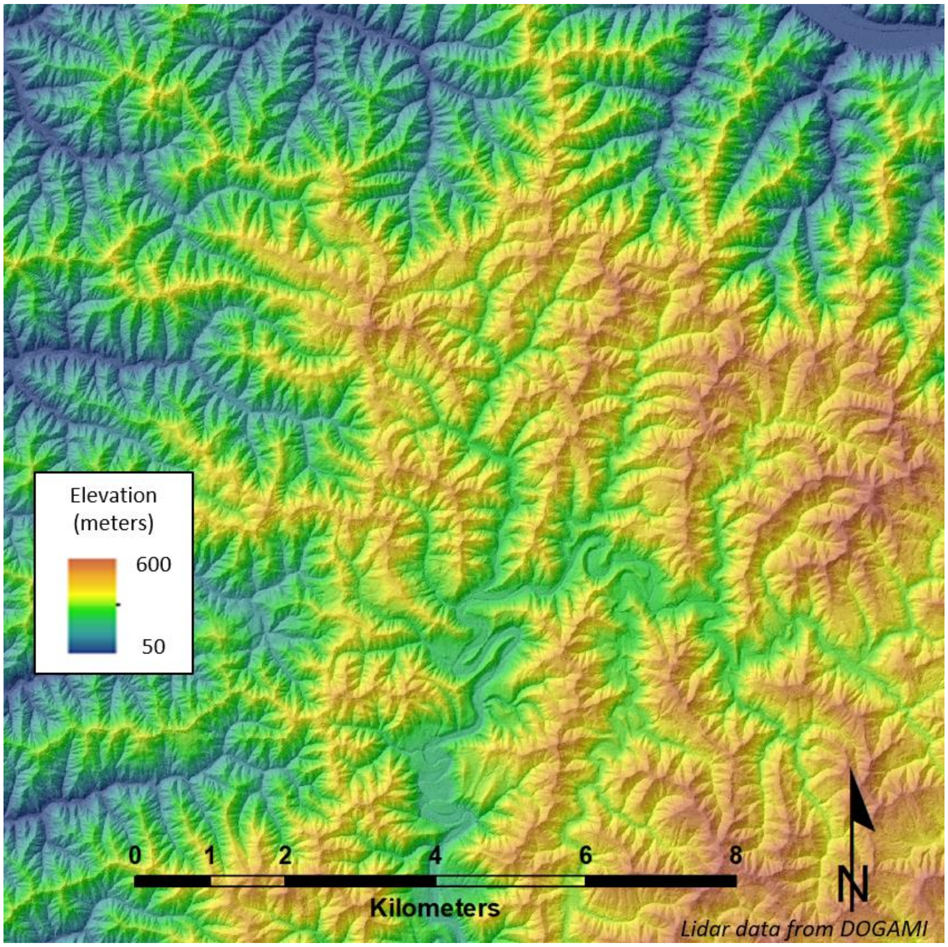

Figure 3. Shaded relief with elevation overlay showing the northerly half of ESRF. The ESRF is characterized by steep ravines, constrained stream channels, and prominent ridges. Hillslope gradients are steep, typically between 40% and 80%, and exceed 100% in many locations. The tidal Umpqua River (just north of the ESRF) is in the extreme top right of image. The West Fork Millicoma River (lower center) has headwaters almost entirely within the ESRF, and is a major tributary to the Coos Bay estuary.

During development of OSU's research proposal for the ESRF the forest was delineated into separate watersheds that are intended to provide a spatial template for anticipated future research (Figure 4). Delineated watersheds that are greater than 160 hectares and substantially complete (i.e. nearly all watershed area is within the boundary of the ESRF) are designated full research watersheds; watersheds less than 160 hectares, or with fragmented ESRF ownership, are designated partial watersheds (OSU, 2021). The contiguous area of the ESRF, including full and partial watersheds (33,200ha, excluding approximately 200ha of isolated parcels) was used for model calibration and sensitivity analysis.

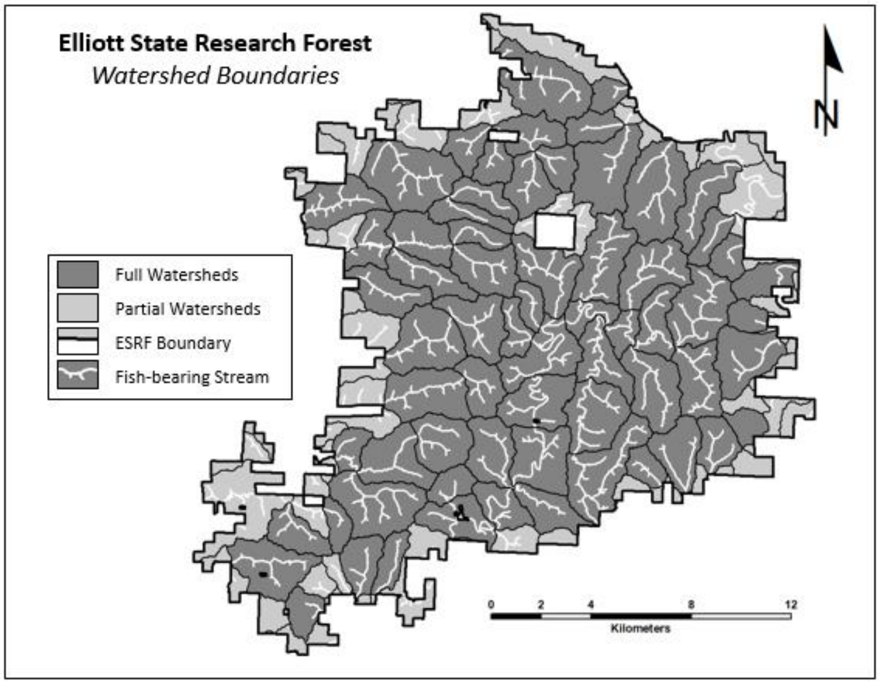

Figure 4. The contiguous area of the ESRF includes full and partial watersheds totaling 33,200ha; approximately 200ha in isolated parcels are excluded from analysis. Full watersheds are between 160ha and 800ha in size and are substantially complete, with no appreciable part of the watershed that is not within the boundaries of the ESRF. There are a total of 66 full watersheds, totaling approximately 26,000ha. Partial watersheds are smaller or incomplete watersheds that are within the boundary of the ESRF.

3. Conceptual Framework

3.1 Potential Wood Recruitment

We formalize the concept of *potential wood recruitment* (PWR) as a means of evaluating the recruitment of large wood to streams of interest. Embedded within the concept of potential wood recruitment are (1) a ***wood recruitment target,*** (2) a ***source of large wood*** on the terrestrial landscape from which wood originates, and (3) ***wood delivery processes***, which transfer large wood from its point of origin on the terrestrial landscape to the wood recruitment target.

The ***wood recruitment target*** refers to the streams of interest to which wood from the terrestrial landscape is recruited. The wood recruitment target could be, for example, some portion of the stream network, such as perennial streams, streams occupied by a taxa of interest, such as salmonids, or streams occupied by a species of interest, such as coho salmon. For this analysis we define the wood recruitment target to be streams capable of supporting salmonids during all or part of the year, henceforth referred to as fish-bearing (FB) streams.

The ***source of large wood*** is a hypothetical reference forest from which large wood is produced over time. The reference forest is intended to provide a plausible, spatially uniform condition for evaluating immutable topographic and geomorphic controls on the spatial distribution of large wood recruited to FB streams by shallow translational landslide (STL) and debris flow processes. We define the reference forest as a uniform, well-stocked native forest with dominant and co-dominant trees that have attained their maximum biological height given local site conditions. We conceptualize the height of the reference forest to be equivalent to *site potential tree height* (*sensu* FEMAT 1993). Native forests of the OCR are typically dominated by Douglas-fir (*Pseudotsuga menziesii*), which do not achieve site potential height until they are over 200 years of age (FEMAT, 1993); Douglas-fir forests that exceed this age may be characterized as old-growth forests (Franklin et al., 2002). Prior to Euro-American settlement during the mid-nineteenth century, the OCR forest landscape was a shifting mosaic of young, mature, and old-growth Douglas-fir forests (Wimberly et al., 2000). The reference forest is not intended to replicate this mosaic; rather, the reference forest condition represents the old-growth forest component of the mosaic, thus representing *potential* old-growth large wood recruitment conditions *throughout* the area of analysis.

Wood delivery processes include chronic and episodic disturbance processes. These processes include localized tree mortality (e.g. wind, disease, insects), bank erosion, STL, and debris flow that, in the aggregate, can be expected to occur somewhere within a subject watershed (160 to 800 hectares) at recurrence intervals of less than 100 years, although they may typically occur locally at recurrence intervals of much greater than 100 years (e.g. debris flow in a first-order channel).

3.2 Conceptual model of wood delivery processes in the OCR

All wood found in aquatic ecosystems originates on the terrestrial landscape as live, standing trees. For both FB and NF streams we evaluate two primary wood recruitment processes that transfer live trees from the terrestrial landscape into the stream network as large wood: ***treefall recruitment*** and ***STL recruitment***.

Debris flow is a secondary recruitment process whereby wood recruited to NF streams by treefall or by STL is transported to FB streams by debris flow through NF tributaries. Empirical estimates from the OCR of the fraction of large wood present in low-order FB streams that is attributable to debris flow from NF tributaries range between 33% and 65% (Table 3). Thus, unless the sources of large wood transported to FB streams from and through NF tributaries by debris flow processes is accounted for, an analysis of wood recruitment to FB streams would be incomplete.

3.2.1 Debris Flow Transport

Wood recruitment throughout most of the OCR occurs in the context of a steep forested landscape underlain by mechanically weak sedimentary lithology heavily dissected by high-density stream networks, high annual precipitation amounts, dense forest and riparian vegetation, and episodic disturbance regimes, such as wildfire and extreme precipitation events.

Through a combination of biophysical processes, erosion, and gravity, colluvium that is formed in upslope areas accumulates in areas of convergent topography, also known as bedrock hollows or zero-order basins (Benda and Dunne, 1997). These topographic depressions comprise a transition zone between the most distal extent of commonly recognized administrative stream networks where, by definition, streamflow is seasonal or intermittent and fluvial sediment transport is evident, though weak (e.g. NHD flowline data), and upland areas that are the primary source of colluvial materials.

Colluvium accumulates in colluvial hollows for centuries to millennia (Benda and Dunne, 1997). Stability of the accumulated colluvial wedge is influenced by topographic characteristics, depth of the colluvial deposit, physical soil properties, including the internal angle of friction of the soil and soil cohesiveness (Iverson et al., 1997), and by the presence of roots within the soil matrix (Iverson et al., 1997; Schmidt et al., 2001). Upslope convergent topography concentrates saturated subsurface water flow though the colluvial wedge, increasing soil pore pressure and decreasing the stability of the colluvial wedge as a function of the saturated soil depth. During periods of prolonged or intense precipitation, saturated soil depth and corresponding soil pore pressures increase, decreasing the shear resistance of the colluvial wedge (Benda and Dunne, 1997). If the gravitational stress acting on the colluvial wedge exceeds total shear resistance, the colluvial wedge is evacuated from the colluvial hollow as an STL. High pore pressures present within the STL mass, combined with conversion of the translational energy of the STL into internal vibrational energy of the evacuated colluvium, result in liquefaction of all or part of the STL mass and mobilization of a debris flow (Iverson et al., 1997).

Debris flows, once mobilized, exhibit fluid-like properties, and may entrain additional downslope sediments and organic material, including large wood, from their path. When a mobilized debris flow enters a downslope channel it may stop, depositing most or all of its material into the receiving channel, or, depending on channel geometry, it may continue down the channel network (Benda and Cundy, 1990). As modeled, all debris flows are initiated by STL, but not all debris flows terminate in FB streams. Large wood and sediments deposited by debris flows that terminate in NF streams may be re-mobilized by subsequent debris flows and deposited in FB streams.

3.2.2 Treefall recruitment

Treefall is the in-situ fall or toppling of a tree, usually without appreciable horizontal displacement of the tree's root structure from its point of origin in the forest floor. Treefall may be the result of insect, disease, or fire mortality, windthrow or wind damage, and bank erosion. As modeled, we assume equal probability for all fall directions, and that trees located at distance D greater than tree height H from the stream bank have zero probability of intercepting the stream channel. The probability p that a falling tree will intercept a stream channel can be expressed as a function of tree height H and distance D to stream bank, and ranges from $p = 0.5$ at $D = 0$ to $p = 0$ at $D > H$ (Figure 5).
Treefall recruitment occurs adjacent to both FB streams and NF streams. Because we specify the wood recruitment target to be FB streams, all treefall recruitment into FB streams is considered wood recruitment to the wood recruitment target (i.e. FB streams). Treefall recruitment into NF streams is not accounted for as wood recruitment to the wood recruitment target unless it is subsequently transported to an FB stream by debris flow processes.

3.2.3 STL recruitment

Shallow translational landslides (STL) and consequent debris flows are an integral component of the geomorphic processes that couple upslope and headwater terrain with downslope colluvial and alluvial channels of mountain stream networks, such as are present in the Oregon Coast Range (Benda and Dunne, 1997; Benda et al., 2005). STLs are characterized by the translational downslope movement of a discrete mass of accumulated colluvium and underlying regolith due to increased soil pore pressures, often in combination with diminished soil/root strength, during periods of intense or prolonged precipitation. For convenience we include other forms of shallow mass wasting, such as shallow rotational failures, under the term STL. We distinguish STL from deep-seated landslides, which involve deep structural failure of underlying lithology; deep-seated landslides are not evaluated here.

We define STL recruitment as live trees physically displaced and transported downslope by STL or consequent debris flow. The probability of STL recruitment is a function of the probability that a given tree location will be traversed by an STL or consequent debris flow. As modeled, STL initiation and debris flow traversal probabilities are based on empirical data collected in the OCR following intense winter storms with high precipitation amounts in 1996.

3.3 Mass balance of in-stream large wood

The mass-balance of in-stream large wood (Benda and Sias, 2003) provides a framework for making express our assumptions about the sources of large wood and delivery processes used in this analysis. Benda and Sias (2003) define the volumetric mass balance of large wood per unit length of stream channel as a function of input, output, and decay:

$$\Delta S = [I\ \Delta x - L\ \Delta x + (Q_i - Q_o) - D]\ \Delta t$$

where ΔS is the change in large wood storage within a stream reach of length Δx over a time interval Δt. The change in large wood storage is a function of large wood input (I), loss of large wood due to overbank deposition and jam abandonment resulting from floods or channel migration (L), fluvial transport of wood into (Q_i) and out of (Q_o) the stream reach, and decay (D).

This analysis is concerned only with large wood inputs to FB streams (the wood recruitment target). Wood recruited to NF streams that is not subsequently delivered to FB streams by debris flow processes is not included in this analysis. The fate of large wood after it has been recruited to FB streams is also not an element of this analysis; thus we do not consider wood losses (L), fluvial transport out of the stream network (Q_o), or decay (D) as it applies to wood once it has entered an FB stream. Decay is, however, a factor in determining the quantity of accumulated wood in NF stream channels available for transport to FB streams by debris flow processes, as discussed below in the model description.

Following Benda and Sias (2003), wood inputs (I) may come from multiple sources, and are defined here as any natural source of large wood that enters a subject stream other than by fluvial transport, for example:

$$\Sigma I = I_m + I_{be} + I_l + I_{df} + I_f + I_w + I_e + I_c$$

Large wood input sources used for this analysis are limited to tree mortality (I_m), bank erosion (I_{be}), landslide (I_l), and debris flow (I_{df}). Tree mortality (I_m) includes mortality caused by suppression, disease, insects, and localized wind damage (stem break and windthrow). Bank erosion (I_{be}) includes the toppling of trees attributable to streambank avulsion and to soil creep, the erosion of landslide and debris flow deposits along channel margins and at tributary junctions, and minor channel re-alignment. Due to the constrained topography of the ESRF we do not expect bank erosion input attributable to channel migration to be significant, and exclude it from analysis as a specific recruitment source. For modeling purposes we refer to the combined recruitment from mortality (I_m) and bank erosion (I_{be}) as treefall recruitment; these are stream-adjacent sources that can be defined by a source-distance recruitment function (McDade et al., 1990; Van Sickle and Gregory, 1990).

Landslide sources (I_l) include inputs from STL that initiate in areas not delineated as a stream by the recruitment model; these include both upslope and inner gorge areas. Inputs attributable to deep-seated landslide are excluded from analysis. Large wood inputs attributable to debris flow (I_{df}) are a specific component of the recruitment model. As modeled, debris flow occurs at predicted return intervals and carries material accumulated in NF stream channels (treefall and STL sources) to FB streams. Inputs from large-scale stochastic disturbance events such as wildfire (I_f) and windstorm (I_w) have occurred historically and can be expected to recur and produce large pulses of wood to streams (Benda and Sias, 2003). We do not include wildfire and windstorm as specific recruitment agents in the model, but account for them within the category of tree mortality (I_m); we assume that recruitment from these sources affects the timing of wood recruitment, but does not affect the time-averaged spatial distribution of wood recruitment. Sources of input from the fluvial exhumation of large wood (I_e) from streambank deposits are excluded from analysis, except as considered by the debris flow component of the recruitment model. Large wood inputs attributable to catastrophic events (I_c), such as subduction zone earthquake, are excluded from analysis. Finally, we exclude fluvial transport as a source of large wood to FB streams. Such input would necessarily come from NF tributary streams; because these streams have limited transport capacity (except as debris flow corridors) we assume the fluvial transport of large wood from NF tributaries to FB streams to be negligible.

4. Methods

4.1 Recruitment model overview

Large wood recruitment analysis is performed using the computer model *ElliotSFWood*. The program incorporates models for predicting STL initiation and debris flow runout described by Miller and Burnett (2007, 2008), and a geometric treefall model described by McDade et al. (1990). *ElliotSFWood* was developed by one of the co-authors of this paper (DM), and is available for download at [contact author]

ElliotSFWood calculates large wood recruitment to FB streams attributable to four primary recruitment sources:

a) Treefall recruitment (i.e. stream-adjacent mortality) directly into FB streams
b) STL recruitment directly to FB streams. This includes STL recruitment into NF channels that is concurrent with debris flow transport to FB streams
c) Treefall recruitment that accumulates in NF channels, and that is subsequently transported by periodic debris flow to FB streams
d) STL recruitment that is deposited in NF channels, and that is subsequently transported by periodic debris flow to FB streams

ElliotSFWood functions within a “virtual watershed” model environment of DEM-derived features (Barquín et al., 2015), which include topographic characteristics, stream nodes and their associated attributes, and shallow landslide initiation and debris flow traversal probability rasters. The DEM used for modeling the ESRF and surrounding vicinity is a mosaic of LiDAR-derived bare-earth DEMs obtained from Oregon Department of Geology and Mineral Industries (DOGAMI). LiDAR data were collected in 2008 as part of the DOGAMI South Coast LiDAR acquisition (DOGAMI, 2009).

Modeled stream features for which recruitment values are calculated are stream nodes that comprise the delineated stream network. Model output for each of the four recruitment sources for each stream node of the stream network within the area of analysis is returned as the number of tree stems recruited annually to the wood recruitment target (i.e. FB streams). Although empirically derived probabilities are used as model variables, model output itself is deterministic and represents spatially and temporally averaged values.

4.2 Stream Delineation

The DEM was conditioned to eliminate spurious water flow barriers (e.g. roads at stream crossings), and the stream network delineated following the methodology described by Miller et al. (2015). In nearly all cases the delineated stream network extends further into headwall areas than do other administrative delineations, such as the Oregon Department of Forestry (ODF) and National Hydrography Dataset (NHD) stream delineations. The delineated stream network employed here is intended to identify colluvial stream channels susceptible to debris flow, including streams that may show little or no evidence of fluvial erosion and that are not delineated in ODF and NHD datasets. As modeled, these upper reaches of the delineated stream network represent potential debris flow corridors from which treefall recruitment may be entrained by a debris flow, whereas adjacent un-delineated upslope topography, including bedrock hollows and zero-order basins, represent potential STL source areas (Benda et al. 2005).

The modeled stream network is comprised of doubly linked nodes to which stream characteristics such as channel gradient, wood recruitment values, and debris flow recurrence interval are assigned. Because we define the wood recruitment target to be FB streams, the classification of streams as either fish-bearing or non-fish-bearing defines a key modeling parameter. Fish-presence is assumed to occur within all stream reaches with a maximum downstream channel gradient of 20% and a minimum average annual streamflow of 0.005 CMS. *ElliotSFWood* classifies all delineated streams meeting these criteria as FB streams, and all other delineated streams as NF streams. Wood recruited to NF streams that is not subsequently delivered to FB streams by debris flow is not counted as a source of wood recruitment.

4.3 STL and Debris Flow Probability Rasters

Modeled rates of wood recruitment to FB streams from upslope sources depend explicitly on:

1. the initiation locations of STLs that deposit in NF channels with a non-zero probability of debris flow delivery to FB channels,
2. the initiation locations of STLs that trigger debris flows that travel directly (forthwith) to FB channels,
3. the paths traversed by those debris flows, and
4. the frequency at which those debris flows occur.

Items 1, 2, and 3 are determined using methods developed by Miller and Burnett (2007, 2008); item 4 requires an extension of those methods to estimate annual debris flow recurrence intervals for delineated stream channels and STL traversal areas, as described in section 4.3.3.

4.3.1 Shallow Translational Landslide Initiation

Miller and Burnett (2007) described an association between a field-based landslide inventory collected by the Oregon Department of Forestry (ODF) following two major storms in 1996 (Robison et al., 1999) and a DEM-derived topographic index. The topographic index is an adaptation of the shallow landslide initiation model described by Montgomery and Dietrich (1994), and is based on contributing area (i.e. flow accumulation) and slope gradient for each mapped pixel of an area of interest (Miller and Burnett, 2007). The relationship between topographic index and observed landslide density described by Miller and Burnett (2007) was used to model STL density on the ESRF. In doing so we assume that the relationship between topographic index and landslide density is the same on the ESRF as it is within the area surveyed by ODF following the 1996 storms, and that this relationship does not change through time. We do not include deep-seated landslides in our analysis. Modeled STL density for each mapped pixel of the ESRF is interpreted to represent the relative probability of landslide initiation as instantiated by the 1996 storm events.

4.3.2 Debris Flow Runout Path

Again using the 1996 ODF survey data (Robison et al., 1999), Miller and Burnett (2008) showed that the runout paths of debris flows triggered by the ODF-surveyed landslides can be characterized in terms of distance from the initiation point, channel gradient, topographic confinement, and changes in channel direction along a debris flow runout path. These attributes are measured from potential debris flow paths traced on the DEM and are used to estimate the probability that a debris flow starting at any potential landslide initiation site could travel to an FB channel. This delivery probability, multiplied by the landslide initiation probability described in 4.3.1, gives the probability that a debris flow that traveled to an FB stream was observed on any specific runout path in the survey data. This probability is then assigned to each cell along the potential debris flow track traced between the initiating cell and the FB channel.

This procedure is repeated for every raster cell in the area of analysis, so that every possible path for debris flows that travel to FB channels from every potential initiation site is examined. A single NF channel pixel may be subject to debris flow traversal from multiple upslope landslide sources, each with its own probability of delivery. The probability that any point along an NF channel is traversed by a debris flow that travels to a FB channel is estimated as $P_T = 1 - \Pi(1-P_{Di})$, where P_{Di} is the probability that a debris flow from the i^{th} upslope initiation site traverses the point, $1-P_{Di}$ is the probability that a debris flow from that initiation site did not traverse that point, $\Pi(1-P_{Di})$ is the probability that no debris flow from any of the upslope initiation points traversed the point (Π indicates the product of all terms), and $1-\Pi(1-P_{Di})$ is therefore the probability that a debris flow from any of the initiation sites did traverse that point, defined as the traversal probability P_T. (Miller and Burnett, 2008).

We create traversal probability rasters for two cases:

(1) Traversal by STL and debris flow that transports wood directly to FB streams. This includes STL recruitment into NF channels that is transported forthwith by associated debris flow through NF channels to FB streams, as-well-as STL recruitment directly into FB streams. The model variable representing these raster values is P_{Tf}.
(2) Traversal by STL and debris flow that deposits wood into NF channels with a non-zero probability of debris flow delivery to an FB stream. Traversal probability values for this raster exclude probabilities associated with traversal directly to FB streams (i.e., case 1, above). The model variable representing these raster values is P_{Tnf}.

These traversal probability rasters are in terms of relative probabilities as instantiated by the 1996 storms and documented in the ODF survey data (Robison et al. 1999). Translation of relative traversal probabilities P_{Tf} and P_{Tnf} to annual traversal probability, and hence debris flow traversal recurrence interval R (in years), is necessary to estimate annual wood recruitment rates attributable to debris flow.

4.3.3 Annual Debris Flow Recurrence Interval and Scaling Factor

We assume that STLs and debris flows instantiated during the 1996 storms represent a probability template constrained by immutable topographic characteristics such that the relative STL and debris flow traversal probabilities associated with the 1996 storms (P_{Tf} and P_{Tnf}) are proportional to their respective annual probabilities. We express this proportionality with a scaling factor s:

$$P_A = P_T/s$$

We assume that the average recurrence interval of an event R expressed in years is the inverse of the annual probability P_A of that event, such that $R = 1/P_A$; we thus define debris flow traversal recurrence interval (in years) to be:

$$R = s/P_T$$

We use the scaling factor to calibrate the recruitment model estimate of %NFR for the ESRF to empirical estimates of the proportion of wood recruited to FB streams from NF debris flow sources in the OCR, as described is Section 4.7.

4.4 Modeled Recruitment Processes

The four modeled recruitment processes outlined in Section 4.1 are described below:

4.4.1 Treefall Directly into FB Streams

Treefall recruitment to both FB and NF streams is based on a geometric treefall recruitment model described by McDade et al. (1990), and assumes that a tree of height H and distance from stream D will fall with equal probability in any direction (Figure 5). As used in the model description below H is synonymous with site potential tree height (*sensu* FEMAT 1993), and represents the height of the reference forest.

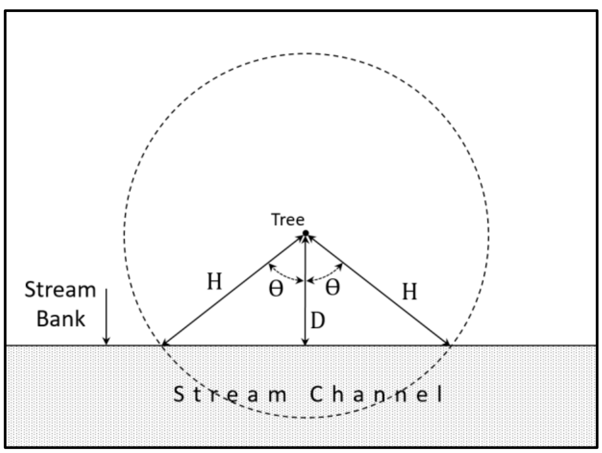

Figure 5. Treefall probability model. The probability of fall is assumed to be equal for all possible fall directions (dashed line = 360-degree circle = 2π radians). The probability that a falling tree will intercept an adjacent stream channel is a function of tree height (H) and perpendicular distance to the stream bank (D). The probability that a given tree will fall through any angle Θ is equal to Θ/2π and the angle subtended by fall directions that intercept the stream channel is 2Θ; therefore, the probability that a falling tree will intercept the stream channel is equal to $2\Theta/2\pi = \Theta/\pi$*. The angle Θ is equal to the arc-cosine of (D/H); therefore, the probability that a falling tree will intercept a stream channel, expressed as a function of tree height (H) and distance to stream bank (D) is equal to* $\cos^{-1}(D/H)/\pi$*. The probability that a falling tree will intercept a stream varies from 0.5 at D = 0 to zero at D = H. We assume that at D > H the probability that a falling tree will intercept a stream is zero.*

The probability that a falling tree will intercept a stream channel, expressed as a function of tree height H and distance to stream bank D is equal to $\cos^{-1}(D/H)/\pi$ (Figure 3). Expressing stem density as

$trees/area = \rho$ and expressing the annual treefall probability as M, the number of falling trees that intercept the channel over channel length L annually for a given H and D can be expressed as:

$$Annual\ treefall\ recruitment\ (stems) = \frac{LMH\rho\left(cos^{-1}\left(\frac{D}{H}\right)\right)}{\pi} = \frac{LMH\rho}{\pi}\left(cos^{-1}\left(\frac{D}{H}\right)\right)$$

We assume that no falling trees will intercept the channel at distances of $D > H$, that trees do not occur at distances of $D < 0$, and that the value of D/H varies continuously between 0 and 1. The integral of $cos^{-1}(D/H)$ with respect to D/H for values of D/H between 0 and 1 is equal to 1, hence:

$$Annual\ treefall\ recruitment\ (stems)\ = \left(\frac{LMH\rho}{\pi}\right)\int_0^1 \cos^{-1}\left(\frac{D}{H}\right)d\left(\frac{D}{H}\right) = \frac{LMH\rho}{\pi}$$

This is annual treefall recruitment for one side of the stream channel; for both sides of a channel this would be:

$$Annual\ treefall\ recruitment\ (stems) = \frac{2LMH\rho}{\pi}$$

ElliotSFWood calculates recruitment from all sources with respect to a stream network defined by doubly linked nodes. These nodes represent points where a subject stream channel intersects the cells of the traversal probability rasters, with each stream node linked to its upstream and downstream neighbors. The length associated with each node is equal to the sum of one-half the distance to the upstream node plus one-half the distance to the downstream node. Thus, for each FB channel node with node length L_n annual treefall recruitment is:

$$Annual\ treefall\ recruitment\ to\ FB\ channel\ node\ (stems) = \frac{2L_nMH\rho}{\pi}$$

4.4.2 Direct STL recruitment to FB streams

As modeled all standing stems within non-channel areas traversed by STL are entrained and transported downslope to an FB stream as a consequence of the triggering STL. Such transport may occur directly to an FB stream node, or as a result of associated debris flow forthwith through NF channels to an FB stream node; in the first case direct STL recruitment is reported to the first encountered FB channel node and in the second case STL recruitment is reported to the first encountered NF channel node. The number of stems available for recruitment in each cell of the traversal probability raster is ρA_C, where ρ is stem density and A_C is the area of a raster cell. Raster cell value P_{Tf} is the relative probability that the cell was traversed by an STL or debris flow that initiated upslope (or at the subject cell) and continued downslope to an FB stream as a consequence of the triggering STL. The annual recurrence interval Rf for such events is defined as $Rf = s/P_{Tf}$ where s is the scaling factor described in section 4.2.3. Landslide inputs from each raster cell are accumulated downslope at the first encountered channel node in the delineated stream network. Rf_i is the recurrence interval for landslide traversal of the i^{th} raster cell for all cells tributary to a receiving channel node, thus:

$$Annual\ STL\ recruitment\ to\ stream\ channel\ node\ (stems) = \sum_{i=1}^{n} \frac{\rho A_C}{Rf_i}$$

We assume that some fraction of STL and debris flow transported wood is deposited in fans and along terraces, where it eventually decays away without entering the FB channel. Studies in the Oregon Coast Range estimate that about 60% of debris flow sediment is deposited on fans and terraces (Benda and Dunne, 1997; May and Gresswell, 2003); we assume that this same proportion of wood carried by STL and debris flow is deposited outside of the stream channel, and so employ a "delivery efficiency" factor E, which we assume to be 40%. The net annual direct landslide recruitment to receiving stream channel nodes is thus:

$$Net\ annual\ STL\ recruitment\ to\ stream\ channel\ node\ (stems) = \sum_{i=1}^{n} \frac{\rho E A_C}{Rf_i}$$

4.4.3 Treefall to NF streams and subsequent debris flow transport to FB streams

Treefall recruitment to NF streams accumulates over time until it is transported downstream to target (FB) streams by debris flow at recurrence interval Rf. The annualized quantity of treefall recruitment attributable to each NF channel node is a function of (1) annual treefall recruitment to the NF channel node, (2) annual decay rate of accumulated large wood and, (3) the recurrence interval (in years) at the subject NF channel node for debris flows that terminate in FB streams.

The annual treefall recruitment rate to NF stream nodes is the same as the annual treefall recruitment rate to FB stream nodes:

$$Annual\ treefall\ recruitment\ to\ NF\ channel\ node\ (stems) = \frac{2L_n MH\rho}{\pi}$$

Wood accumulates in NF channels during the period of time between debris flows. During the period of time that wood is accumulating, the accumulated wood is also decaying at an annual rate k. In specifying a decay function we assume that the number of stems decays at the same rate as wood mass, and can be represented as an exponential decay function. The number of stems n_s that accumulate at a channel node over an increment of time dt is:

$$dn_s = \left(\frac{2L_n MH\rho}{\pi}\right) dt$$

The number of stems n_s that decay at a channel node over an increment of time dt is:

$$dn_s = (kn_s)dt.$$

The accumulated number of stems minus stems lost to decay over time dt is therefore:

$$dn_s = \left(\frac{2L_n MH\rho}{\pi} - kn_s\right)dt$$

Integrating over a time increment Rf gives:

$$n_s = \frac{2L_n MH\rho}{\pi k}\left(1 - e^{-kRf}\right)$$

Dividing by Rf, which represents the average number of years between debris flows during which wood accumulates and decays, the average annual number of stems at each NF channel node delivered by debris flow to FB streams, adjusted for delivery efficiency E, is:

$$Net\ annual\ treefall\ recruitment\ to\ NF\ channel\ node\ (stems) = \frac{2EL_n MH\rho\left(1 - e^{-kRf}\right)}{\pi kRf}$$

Along any NF channel, the recurrence interval Rf for traversal by debris flows that travel to the downslope FB channel tends to decrease as the number of contributing initiation sites increases, so the modeled amount of accumulated wood tends to decrease nearer the FB channel. The average annual number of stems delivered to the receiving FB channel node is the sum of stems accumulated, given by the equation above, for all NF nodes tributary to the FB node.

4.4.4 STL to NF streams and subsequent debris flow transport to FB streams

For STL recruitment that is not transported directly (forthwith) to an FB channel (Section 4.4.2), we assume that all standing stems within an area traversed by STL are entrained and deposited downslope to the first encountered NF channel node. The number of stems available for STL recruitment in each cell of the traversal probability raster is ρA_C, where ρ is stem density and A_C is the area of a raster cell. Raster cell value P_{Tnf} is the relative probability that the cell was traversed by a landslide that initiated upslope (or at the subject cell) and deposited in a downslope NF channel node. The recurrence interval Rnf for such events is defined as $Rnf = s/P_{Tnf}$, where s is the scaling factor described in section 4.2.3.

STL inputs from each raster cell are accumulated downslope at the first encountered NF channel node in the delineated stream network. Rnf_i is the recurrence interval for STL traversal of the i^{th} raster cell for all cells tributary to the receiving NF stream channel node. As with treefall recruitment to NF channel nodes, stems recruited by STL to NF channel nodes are subsequently transported to an FB channel at debris flow recurrence interval *Rf*. We assume that, on average, the time period for STL accumulation at a subject NF stream node is one-half of the debris flow recurrence interval Rf at that stream node. Adjusting for delivery efficiency *E*, recruitment by STL tributary to each channel node in the NF stream network that is subsequently delivered by debris flow to an FB channel is thus:

$$Net\ annual\ STL\ recruitment\ to\ NF\ channel\ node\ (stems) = \sum_{i=1}^{n} \frac{\rho EA_C}{Rnf_i}\left(\frac{1 - e^{\left(-\frac{kRf}{2}\right)}}{\frac{kRf}{2}}\right)$$

4.5 Summary of Key Modeling Equations and Parameters

The modeling equations used to estimate annual recruitment to FB and NF stream nodes for each of the four recruitment processes, expressed in terms of $stems \cdot node^{-1} \cdot yr^{-1}$, are summarized below:

$$Treefall\ recruitment\ direct\ to\ FB\ channel = \frac{2L_n MH\rho}{\pi}$$

$$SLT\ recruitment\ direct\ to\ FB\ channel = \sum_{i=1}^{n} \frac{\rho E A_C}{Rf_i}$$

$$Treefall\ recruitment\ to\ NF\ channel = \frac{2EL_n MH\rho\left(1 - e^{-kRf}\right)}{\pi kRf}$$

$$SLT\ recruitment\ to\ NF\ channel = \sum_{i=1}^{n} \frac{\rho E A_C}{Rnf_i}\left(\frac{1 - e^{\left(-\frac{kRf}{2}\right)}}{\frac{kRf}{2}}\right)$$

Parameter values used in these equations are summarized in Table 1.

Table 1. Recruitment modeling parameters.

Parameter Name	Symbol	Units	Parameter Values	
			Default	Sensitivity Range
Tree Height	H	m	60	50, 60, 70
Treefall (stream-adjacent mortality)	M	$stems \cdot stems^{-1} \cdot yr^{-1}$	0.015	0.005 – 0.05
Stem Density	ρ	$stems \cdot m^{-2}$	.0075	Not evaluated
Wood Decay Rate	k	$stems \cdot stems^{-1} \cdot yr^{-1}$	0.02	0.005 – 0.05
Traversal Raster Cell Area	A_c	m^2	Raster cell size ($2m^2$)	Not evaluated
Traversal Probability (to FB)	P_{Tf}	$events \cdot A_c^{-1}$	From traversal rasters	Not evaluated
Traversal Probability (to NF)	P_{Tnf}	$events \cdot A_c^{-1}$	From traversal rasters	Not evaluated
Scaling Factor	s	$A_c^{-1} \cdot yr$	8.0	6.0, 8.0, 10.0
Recurrence Interval (to FB)	Rf	$event^{-1} \cdot yr$	$= s/P_{Tf}$	Not evaluated
Recurrence Interval (to NF)	Rnf	$event^{-1} \cdot yr$	$= s/P_{Tnf}$	Not evaluated
STL & Debris Flow Delivery Efficiency	E	$stems \cdot stems^{-1}$	0.4	0.0 – 1.0
Node Length	L_n	m	From traversal rasters	Not evaluated

4.5.1 Summary of Model Parameters

1) **Tree Height:** The modeled forest is a uniform, well-stocked native forest with dominant and co-dominant trees that have attained their maximum biological height, given local site conditions. Tree height *H* is a parameter in the equations for treefall to FB and NF channel nodes. We assume that STL recruitment is independent of tree height; thus, tree height is not a parameter for STL input to FB and NF channel nodes. We use a default value of H = 60 meters, which is the estimated average site potential tree height of the study area (OSU, 2021). Sensitivity of model output to tree height is evaluated for values of 50, 60, and 70 meters.

2) **Treefall:** We use a default treefall (mortality) value of 1.5%. This is based on a lower-bounds value of 0.75% suggested by findings of Franklin and DeBell (1988) in a 500-year-old Douglas-fir forest in western Oregon, and presumed higher mortality values that may result from competition in developing stands, or from episodic disturbance. Sensitivity of model output to annual treefall rate is evaluated at values of between 0.5% and 5.0%.
3) **Stem density:** The modeled forest condition is expressed by variables for tree height H and stand density ρ, which we assume to be constant across the area of analysis. Stem density is a parameter in each of the four equations used to calculate recruitment to channel nodes. Because we assume stem density to be spatially and temporally uniform, this parameter could be factored-out of all equations without affecting the relative magnitude of the different recruitment processes (i.e. %NFR). Factoring-out ρ would change the output unit of analysis from *stems* to *meters* however, and leave recruitment quantities undefined. By applying a realistic stem density input value (75 stems/ha) for a mature forest we are able to subjectively evaluate whether model output is plausible.
4) **Wood Decay Rate:** Wood recruited to an NF channel accumulates over time, and accumulated wood decays over time. The total quantity of wood present in an NF channel at the time of debris flow entrainment is a function of the recruitment rate from treefall and STL sources, the accumulation time between debris flows (i.e. recurrence interval), and the annual wood decay rate *k*. We use an annual wood decay rate of 2.0% as our default value based on the ranges of wood decay values reported by Stone et al. (1998), Edmonds et al. (1986), and Benda and Sias (2003a). We evaluate the sensitivity of NF recruitment to annual decay rate using values of between 0.5% and 5.0%. In the literature cited here decay rates are estimated in terms of volume and mass. We assume that over large spatial and temporal scales a percent reduction in accumulated volume or mass is equivalent to a percent reduction in the accumulated number of stems.
5) **Traversal Raster Cell Area:** Grid (cell) size of the traversal probability rasters used in this analysis is $2m^2$. While probability rasters could be recalculated for different resolutions, this value is a constant as applied in this analysis.
6) **Scaling Factor:** Scaling factor is used to convert STL initiation and debris flow traversal probabilities to recurrence intervals (Section 4.3.3). Increasing or decreasing the scaling factor increases and decreases STL and debris flow recurrence intervals proportionately, and was used for model calibration (Section 4.7). We evaluate the sensitivity of model output to changes in recurrence intervals by bracketing the selected scaling factor of 8.0 with scaling factors of 6.0 and 10.0.
7) **Recurrence Interval:** STL and debris flow traversal probabilities are expressed as annual recurrence interval R, in years (Section 4.3.3). We evaluate the sensitivity of model output to changes in recurrence interval through the evaluation of scaling factor.
8) **Delivery Efficiency:** The wood delivered to FB stream channels by STL and debris flow processes can be partitioned between two fractions: (1) wood deposited within the FB channel, including wood that becomes available to the channel over time, and (2) wood deposited in fans and terraces that eventually decays away and never enters the FB channel. Delivery efficiency E represents the proportion of wood delivered to FB streams by STL and debris flow processes that is accounted for as wood recruitment. Delivery efficiency is assumed to be 40%, the same proportion of sediment estimated to be deposited directly in channels (Benda and Dunne 1997;

May and Gresswell 2003). We evaluate the sensitivity of NF recruitment to delivery efficiency values of between 0.0% and 100%.

9) **Node Length:** Delineated stream channels are represented by nodes, with one node per raster cell along traced channel flow paths. The channel length associated with each channel node is one-half of the distance to the upstream node + one-half of the distance to the downstream node. For example, our analysis uses rasters with 2-meter cell size; hence node lengths vary between approximately 2 and 3 meters.

4.6 Analyzing Model Output in ArcMap

ElliotSFWood aggregates stream node (GIS points) recruitment values into stream segments (GIS polylines) of approximately 10 meters length. Model output is in the form of a GIS shapefile containing attributes for each polyline stream segment of the delineated stream network. Wood recruitment values for each segment were obtained by summing the wood recruitment outputs for each of the four modeled recruitment processes (summarized in section 4.5), for each channel node within the segment. These values were divided by the segment length to provide recruitment per unit channel length. Subsequent analysis of model output was performed using ArcMap.

The area of analysis evaluated using *ElliotSFWood* included areas beyond the borders of the ESRF so that modeled landslide and debris flow processes would not be truncated at the forest boundary. The *ElliotSFWood* output file was spatially clipped to include only stream segments within the contiguous boundary of the ESRF. The resulting area of analysis comprised 33,200 hectares, and included 337,775 stream segments totaling 3,382 km in length. Approximately 200 hectares of the ESRF in non-contiguous parcels were excluded from this analysis.

Output values of the four recruitment sources are in units of number of stems per meter of channel length; these values are multiplied by segment length L to provide annual recruitment by channel segment for each of the four recruitment sources. Total potential annual wood recruitment (PWR) for a stream segment z is:

$$PWR_z = FB\_treefall_z + FB\_STL_z + NF\_treefall_z + NF\_STL_z$$

Total potential annual wood recruitment for any given set of stream segments A is the sum of recruitment attributable to the four modeled recruitment sources across all segments within the set:

$$PWR_A = \sum_{z=1}^{n} FB\_Treefall_z + \sum_{z=1}^{n} FB\_STL_z + \sum_{z=1}^{n} NF\_Treefall_z + \sum_{z=1}^{n} NF\_STL_z$$

For example, using default model parameter values (Table 1) the sum of modeled potential annual recruitment values for all stream segments and all recruitment sources across the entire contiguous area of the ESRF is 2,481 stems (Table 2).

Table 2. Summed recruitment for all modeled stream segments and recruitment sources of the contiguous ESRF, using default modeling parameters (Table 1). Values displayed are number of stems recruited to the recruitment target (FB streams) annually; percent of total ESRF recruitment is shown in parentheses. All of NF recruitment is through debris flow through NF tributaries to FB channels irrespective of whether it originated in the NF channel as stream-adjacent treefall recruitment or as STL recruitment from adjacent hillslopes.

	Treefall	STL	Total
FB	1,691 *(68.2%)*	10 *(0.4%)*	1,702 *(68.6%)*
NF	590 *(23.8%)*	189 *(7.6%)*	779 *(31.4%)*
Total	2,281 *(92.0%)*	199 *(8.0%)*	2,481 *(100.0%)*

4.7 Model Calibration

Studies by May and Gresswell (2003), May (2002), Bigelow et al. (2007), and Reeves et al. (2002) provide estimates of the proportion of the large wood budget of FB streams that is attributable to debris flow recruitment through NF tributaries (Table 3), thereby providing an empirical basis for determining a target %NFR value to use for model calibration. All of these studies are from the OCR; however, results from these studies are highly variable. Bigelow et al. (2007) report a range of %NFR values from four separate basins of the OCR of between 31% and 85%. The location of the Bigelow et al. (2007) study area is nearest to the ESRF, and is primarily in mature, unmanaged stands, a condition similar to the reference forest we describe in Section 3.1. The authors intentionally selected study basins where they expected the influence of debris flows would be strong, however, and therefore may overestimate %NFR at broader scales. The study by May (2002) covered a wide geographic area that included both managed and unmanaged forests; however, only about 30% of the area studied was in mature forest, and only debris flows resulting from the 1996 storms were evaluated. May (2002) also reports large wood quantities in terms of volume, making it difficult to interpret in terms of piece count, the unit of analysis used in this study. The underlying lithology of the area studied by Reeves et al. (2002) is Yachats basalts, and differs from that of the ESRF (Tyee sedimentary); moreover, the pinnate watershed structure of the studied basin could result in atypical debris flow recruitment values compared to the dendritic watershed patterns more typical of the OCR and the ESRF. Although it is limited in geographic scope, the area studied by May and Gresswell (2003) appears to be very similar to the physiography of the ESRF and to the intended reference forest condition of this study. May and Gresswell (2003) reported that 33% of the wood budget of the subject alluvial mainstem stream came from debris flow through colluvial tributaries. This value is supported by Bigelow et al. (2007) and potentially supported by May (2002); however, debris flow recruitment values from Reeves et al. (2002) suggest a higher value may be more appropriate. Given the collective results of these studies we estimate that a conservative value for %NFR on the ESRF, assuming reference forest conditions, would lie between 30% and 35%. As analyzed across the contiguous area of the ESRF, a modeled %NFR value of 31.4% is achieved using a scaling factor of 8.0 (Table 2), which we use as our default value. Sensitivity of model output to scaling factor was evaluated using scaling factors of 6.0, 8.0, and 10.0 (Figure 4).

Table 3. Studies that estimate the proportion of the large wood budget of fish-bearing streams that is attributable to debris flow recruitment through NF tributaries in the OCR.

Study	Location	Distance to ESRF	FB study length	%NFR	Unit of Analysis	Geology	Notes
May and Gresswell (2003)	Southern OCR	40km south	2.1km	33%	Pieces	Tyee sedimentary	Single basin study.
May (2002)	Central OCR	60km north	39.6km	34%	Volume	Tyee sedimentary	34% value is based on weighted average of reported values. Eleven mid-order streams studied. %NFR (volume) varied between 11% and 59%. Only debris flows from 1996 storms were evaluated.
Bigelow et al. (2007)	Central OCR	15km north	6.5km	58%	Pieces	Tyee sedimentary	Four separate basins studied. %NFR varied between 31% and 85%
Reeves et al. (2002)	Central OCR	70km north	8.7km	65%	Pieces	Yachats basalt	Study distinguished between streamside and upslope sources.

5. Sensitivity Analysis Results

Sensitivity of %NFR to five parameter values (Table 1) was evaluated. All stream segments within the contiguous area of the ESRF, including all full and partial watersheds (Figure 4), were included in model evaluation.

5.1 Annual Treefall Rate

Treefall is a primary source of large wood recruited directly to FB streams and recruited indirectly to FB streams via debris flow through NF channels; thus, changes in the annual treefall rate affect the quantity of treefall recruitment attributable to both FB and NF streams (Figure 6). The interaction between STL recruitment, which is independent of treefall rate (dotted lines, Figure 6), and treefall recruitment, which is directly proportional to treefall rate (dashed lines, Figure 6), results in an increase in %NFR with decreasing treefall rates (Figure 7a, 7c, and 7d). This increase in %NFR is attributable to two factors: 1) STL recruitment is constant with respect to treefall rate, and so comprises a larger fraction of the total recruitment budget with decreasing treefall rates, and 2) STL recruitment to FB streams is negligible in comparison to STL recruitment through NF streams. Thus, as the treefall rate decreases the proportion of STL recruitment in the total wood recruitment budget increases, and because nearly all STL recruitment is attributable to NF sources, %NFR also increases.

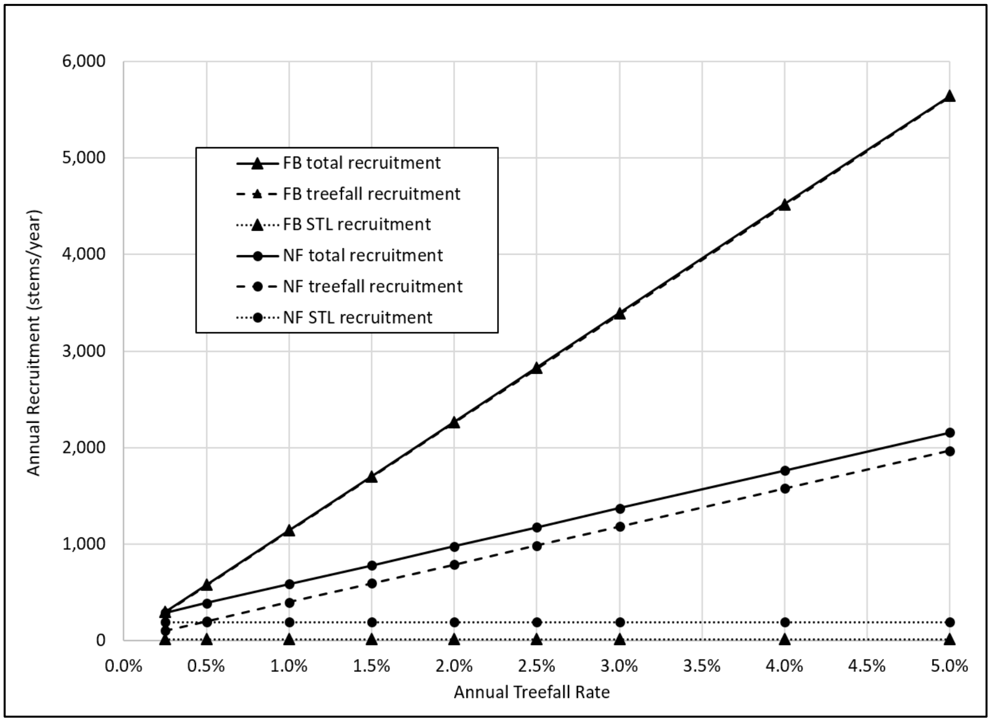

Figure 6. Treefall, STL, and total recruitment as a function of annual treefall rate. Markers are at evaluated treefall rate values; other parameters are default values (Table 1). The quantity of treefall recruitment increases proportionally with increases in the annual treefall rate, while the quantity of STL recruitment remains constant.

5.2 Tree height

Modeled treefall recruitment is a function of tree height (Equations 1 and 3), whereas modeled STL recruitment is not (Equations 2 and 4). Increasing [decreasing] tree height therefore has the effect of increasing [decreasing] treefall recruitment, while at the same time STL recruitment remains constant. Because treefall is the primary source of large wood to both FB and NF streams (Table 4), changes in tree height affect the wood budgets of both FB and NF streams; as a result, %NFR shows little sensitivity to changes in tree height, especially at annual treefall rates of greater than 1.5% (Figure 7a). As treefall rates decrease treefall become a proportionally smaller part of the total wood budget (Figure 6), and because treefall recruitment is a much smaller fraction of the NF recruitment than of FB recruitment (Table 2), increases (decreases) in treefall recruitment attributable to increases (decreases) in tree height disproportionately affect FB recruitment. Hence, a reduction in tree height and corresponding reduction in treefall recruitment results in an increase in %NFR, especially at low annual treefall rates (Figure 7a).

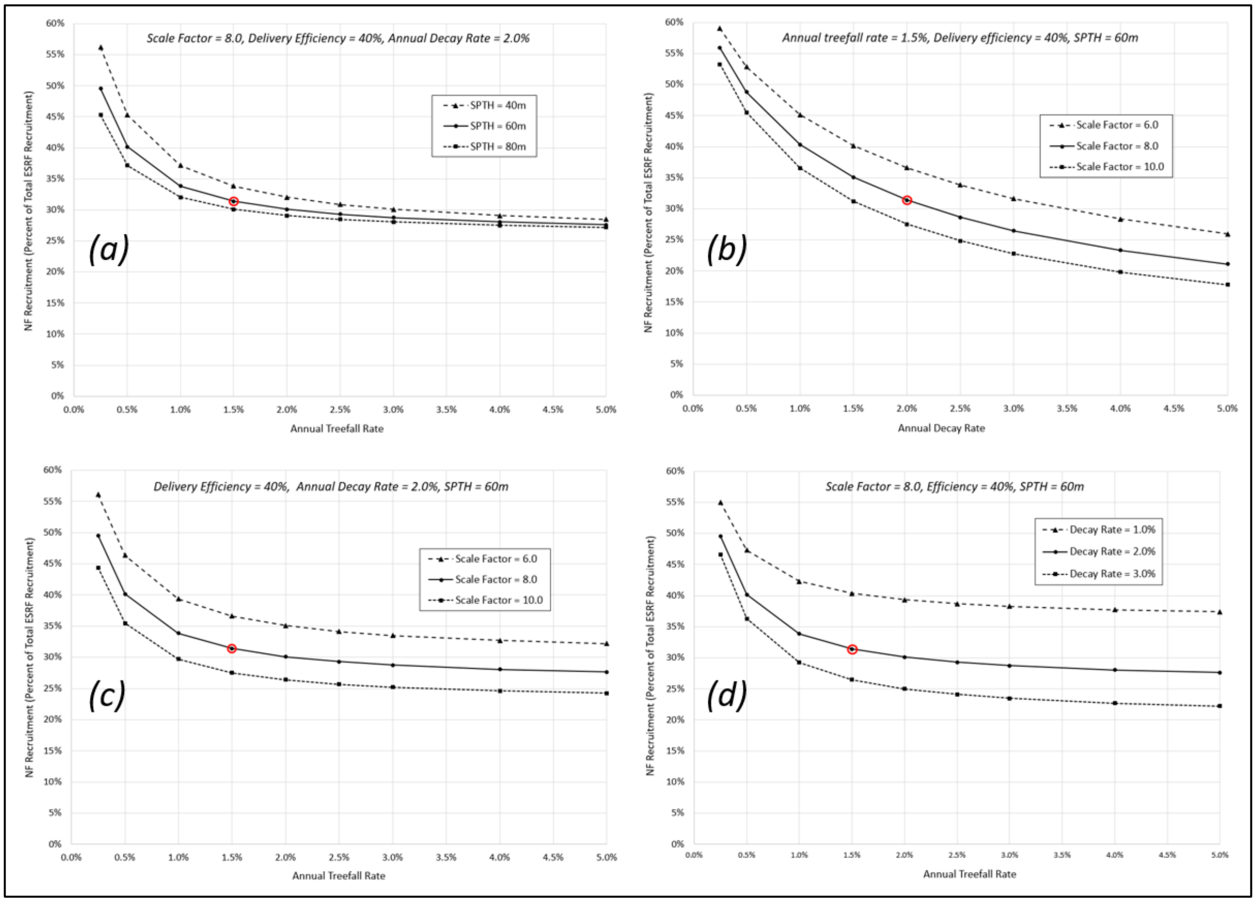

Figure 7. Sensitivity analysis of key parameters with respect to %NFR. Default parameter values are circled in red.

5.3 Annual Decay Rate

Annual decay rate affects only accumulated wood in NF stream channels, and therefore affects only NF recruitment (Equations 3 and 4). At higher decay rates there is less wood available for debris flow recruitment; thus, as we might expect, %NFR decreases with an increase in decay rate (Figure 7b, 7d). Notably, sensitivity of %NFR to changes in annual decay rate is much greater than changes in annual treefall rate (Figure 7a and 7c) and changes in tree height (Figure 7a).

5.4 Scaling Factor

Scaling factor is used to convert empirical STL and debris flow densities derived from field surveys to STL and debris flow recurrence intervals, with recurrence interval being directly proportional to the scaling factor (Section 4.3.3). Scaling factor is a variable used to calculate STL recruitment directly to FB channels, STL recruitment to NF channels, and treefall recruitment to NF channels (Equations 2, 3, and 4). Increases in the scaling factor increase STL and debris flow recurrence intervals, therefore decreasing STL recruitment directly to FB channels, STL recruitment to NF channels, and treefall recruitment to NF channels. Because STL contributions directly to FB streams are negligible compared to total NF recruitment (Table 4), changes to the scaling factor disproportionately affect NF recruitment values. Thus, as would be expected, %NFR is sensitive to changes in the scaling factor (Figure 7b, 7c; Figure 8).

We calibrated the recruitment model to a scaling factor of 8.0 (Section 4.7), and evaluated scaling factors of 6.0 and 10.0, which correspond to a decrease and an increase (respectively) of 25% in modeled debris flow and STL recurrence intervals. Because %NFR is also sensitive to annual decay rate, changes in the default annual decay rate would force a corresponding change in the scaling factor in order to maintain the target calibration range of 30% to 35% debris flow recruitment. If we assume plausible annual decay rates of between 1.5% and 3.0%, these would require corresponding scaling factors of ~10.0 and ~6.0, respectively (Figure 7b).

5.5 Delivery Efficiency

Delivery efficiency exerts a primary control on the quantity of wood delivered to FB streams by STL and debris flow processes. At $\mathrm{E} = 0\%$ no wood is delivered to FB streams through NF sources, and results in a %NFR value of zero (Figure 8). At $\mathrm{E} = 100\%$ the most possible wood is delivered to FB streams through NF sources, given the value of other model parameters (Figure 8). There are few data available upon which to base a value for delivery efficiency, which underscores the importance of model calibration.

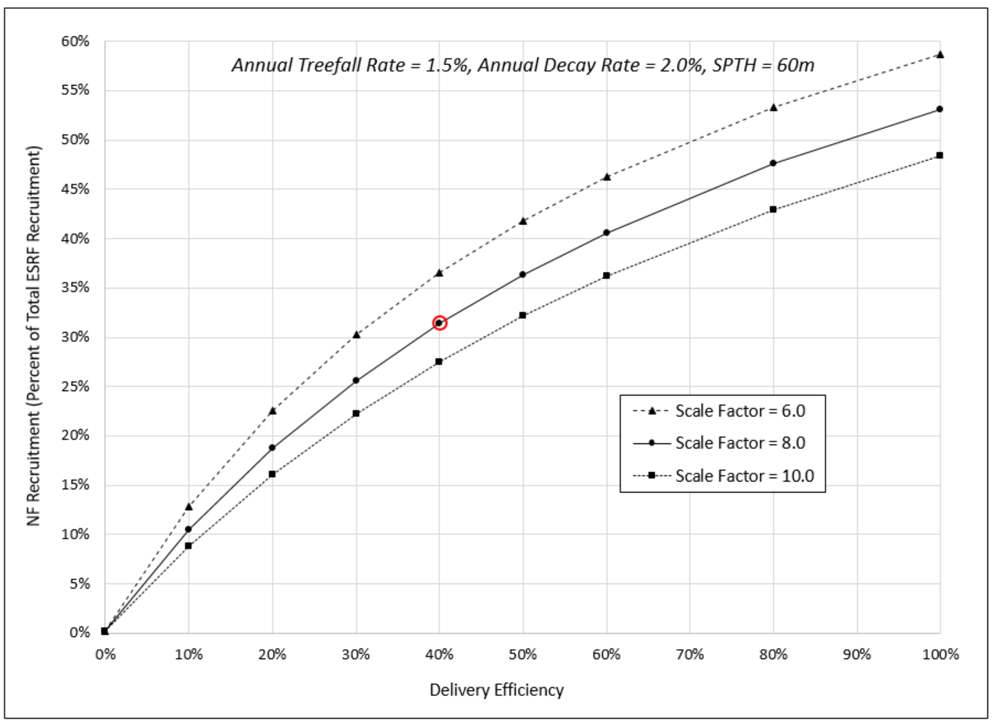

Figure 8. Percent NF recruitment as a function of delivery efficiency. Default parameters circled in red.

6. Conclusion

Large wood is a key element in the physical structure, biophysical processes, and ecological function of streams of the Pacific Northwest. Federal, state, and local forest policies reflect the social, economic, and ecological values that large wood contributes to forest streams, especially fish-bearing streams, and in particular streams deemed to be important to the viability of federally protected fish species, notably coho salmon. Empirical evidence suggests that, in the Oregon Coast Range, wood recruitment attributable to debris flow through colluvial tributaries contributes a sizable fraction of the total large wood budget of low-order alluvial streams. Identifying colluvial tributaries most likely to contribute large wood to the fish-bearing stream network provides policymakers a means of protecting these sources of large wood where doing so helps achieve policy objectives.

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Appendix F

Glossary

Appendix F
Glossary

Term	Definition
activity center	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. Activity centers are a location or point representing the best of detections such as nest stands, stands used by roosting pairs or territorial singles, or concentrated nighttime detections. Activity centers are within the core use area and are represented by this central location.
adaptive management	A system of evaluating management included in the HCP's covered activities and conservation strategy. Systematic approach to learning from actions, improving management, and accommodating change during the HCP permit term.
allocation	Areas that the permit area is divided into (Figure 3-1). Each allocation has specific treatments that would be conducted within them under the HCP.
areas restricted for covered species	Areas encumbered by conservation measures and conditions on covered activities (Chapter 5, *Conservation Strategy*). These areas have limited or no availability for timber harvest because of species-related encumbrances.
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.
biological goals	Broad principles for covered species conservation; describe the desired future conditions of an HCP.
biological objectives	Specific, measurable conservation targets that clearly state a desired result.
board foot	The amount of wood equivalent to a piece of wood 1 foot wide by 1 foot high by 1 inch thick.
carbon sequestration	Capture and storage of atmospheric carbon dioxide (CO_2) in carbon sinks.
changed circumstances	"Changes in circumstances affecting a species or geographic area covered by [an HCP] that can reasonably be anticipated by [HCP] developers and the Services and that can be planned for (e.g., the listing of new species, or a fire or other natural catastrophic event in areas prone to such events)" (50 Code of Federal Regulations 17.3).
clearcut	See "*intensive (treatment)*"
commercial thinning	Thinning in a stand that occurs between intensive treatments (clearcuts) to maintain stand densities at levels that provide vigorous tree growth and maintain high wood production.
Common School Fund Lands	Forestlands in Oregon granted to the State for the purpose of providing revenue to public schools.
compliance monitoring	Tracks the status of HCP implementation and documents that the requirements of the HCP and permits are being met, including information on avoidance, minimization, and mitigation measures.

Term	Definition
conservation measures	Specific actions included in an HCP to offset impacts on the covered species, tiering from the biological goals and objectives (also see *biological goals* and *biological objectives*).
conservation research watersheds (CRW)	The CRWs anchor the conservation strategy by establishing a contiguous conservation block that combines aquatic and terrestrial habitat protection to benefit the covered species.
core use area	For northern spotted owls, 502 acres of the best contiguous habitat area that surround a northern spotted owl nest site. While often mapped as a concentric circle around the nest location, the core use area can be any shape, as long as the edge of the core use area is a minumum of 300 feet from the nest location. The nesting core area is inside, and part of, the core use area. Also see *nesting core area*.
covered species	Species for which an applicant seeks to receive incidental take permits. Covered species in the ESRF HCP are the marbled murrelet (*Brachyramphus marmoratus*), northern spotted owl (*Strix occidentalis*), and Oregon coast coho (*Oncorhynchus kisutch*).
critical habitat	As defined by the Services, habitat that is needed to support recovery of listed species, which can consist of: • Specific areas within the geographical area occupied by the species at the time of listing that contain physical or biological features essential to conservation of the species and that may require special management considerations or protection; and • Specific areas outside the geographical area occupied by the species if the agency determines that the area itself is essential for conservation. Critical habitat is designed to protect the essential physical and biological features of a landscape and essential areas in the appropriate quantity and spatial arrangement that a species needs to survive and reproduce and ultimately be conserved.
debris flow	Geological phenomena in which water-laden masses of soil and fragmented rock rush down mountainsides, funnel into stream channels, entrain objects in their paths, and form thick, muddy deposits on valley floors.
debris torrent	Rapid downslope movement descending steep pre-existing drainage channels of water-saturated soil and debris.
designated occupied habitat	Areas mapped as occupied by marbled murrelets based on historical survey data. This includes areas formerly designated as marbled murrelet management areas by the ODF and those mapped as occupied by Oregon State University researcher Kim Nelson, with refinements based on 2021 LiDAR data. This is further explained in Section 2.4.2.2, *Plan Area Status*, and shown on Figure 2-13.
edge effect	For marbled murrelet, edge effects occur where existing marbled murrelet habitat is located adjacent to harvest treatments. Of particular concern for marbled murrelets are hard edges created by clearcuts adjacent to nesting areas.
effects analysis	In an HCP, evaluation of the impacts of the covered activities on the covered species.
effectiveness monitoring	Assesses the biological success of the HCP. Effectiveness monitoring evaluates whether the effects of implementing the conservation strategy are achieving the HCP's biological goals and objectives.

Term	Definition
Elliott State Research Forest (ESRF)	Forest for research and sustainable management.
Endangered Species Act (ESA)	Federal law governing endangered species protection. 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.
equipment limitation zone (ELZ)	Area extending 35 feet on either side of Oregon FPA-defined streams in which measures are applied to limit equipment use and minimize ground disturbance and associated impacts on Oregon coast coho.
even-age management	See intensive (treatment); clearcut
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. 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.
extensive (allocation)	Extensive allocations are characterized by partial retention, more time between harvests, and reliance on natural tree regeneration.
extensive (treatment)	Extensive treatments are intended to increase forest complexity to help achieve multiple values across the landscape. These treatments are intended to research management approaches that fall along the continuum between intensive treatments (i.e., clearcuts) and unlogged reserves.
fish-bearing stream	Per Oregon Administrative Rules 629-600-0100, stream Fish-bearing streams are defined as having a gradient of 20 percent or less, which is based on maximum gradient threshold determined from resident cutthroat trout data (Fransen et al. 2006).
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 metadata.
habitat conservation plan (HCP)	A plan developed to meet specific requirements identified in section 10(a)(2)(A) of the ESA and its implementing regulations, which, among other requirements, must specify the impacts that are likely to result from the taking, the measures the permit applicant will undertake to minimize and mitigate such impacts, and the funding that will be available to implement such measures.
highest quality habitat	For northern spotted owls, the highest value/rating of the highly suitable, suitable, and marginal nesting and roosting habitat, based on the specific habitat model adopted for northern spotted owl by the ESRF.
home range area	For northern spotted owls, 4,522 acres that surround a northern spotted owl nest site. This area is generated by observing a 1.5-mile buffer from the known nest site. The home range area includes both the core use area and nesting core area.
incidental take	Also see *take*. Take of any federally listed wildlife species that is incidental to, but not the purpose of, otherwise lawful activities.

Term	Definition
incidental take permit (ITP)	A federal exemption to the take prohibition of Section 9 of the ESA; an ITP is issued by FWS or NMFS pursuant to Section 10(a)(1)(B) of the federal Endangered Species Act. An ITP is also referred to as a Section 10 Permit or Section 10(a)(1)(B) Permit.
intensive (allocation)	Intensive allocations are those of traditional production forestry (i.e., clearcutting) commonly applied on private timber lands. Intensive forestry is typically characterized by plantation-based timber production, with shorter time between harvests.
intensive (treatment)	See *clearcut*; treatments that remove all or nearly all trees in a stand (per Oregon FPA requirements about live tree retention). Intensive treatments are intended to maximize timber production.
intermittent stream	Streams that have surface flow for only part of the year; also referred to as non-perennial streams.
lease area	The Oregon Department of State Lands grants a permit to external landowners for the purpose of grazing cattle.
Management research watersheds (MRW)	The MRW is the portion of the permit area that is available for varying degrees of treatments (including restoration thinning treatments, intensive treatments, and extensive treatments). It is divided into the "triad" research allocations, other allocations, and riparian conservation areas (RCAs).
modeled potential habitat	Habitat that is modeled as having potential to be occupied by marbled murrelets by Oregon State University researchers.[1] The modeled potential habitat layer originated from a 2020 model (Betts et al. 2020) and has been subsequently updated using 2021 LiDAR data and an improved 2022 model (Betts and Yang 2022). Methods are described in Section 2.4.2.2 and shown on Figure 2-13.
monitoring and adaptive management	In HCPs, monitoring programs are required to assess compliance with HCP requirements and progress towards biological goals and objectives. Adaptive management programs are included in HCPs to address uncertainty in natural resource management and allow for changes in management to continue to achieve the HCP's biological goals and objectives.
nest site	For northern spotted owl and marbled murrelet, the nest tree and other trees within 300 feet of the nest tree.
nesting core area	For northern spotted owls, 100 acres of the best contiguous habitat that surrounds a northern spotted owl nest site.
operational standards	Specific management requirements that apply within the treatment types
Oregon Department of State Lands (DSL)	The HCP applicant (once ITPs are issued, the Permittee)
perennial stream	Streams with year-round surface flow.
permit area	The area in which the ITP applies; encompasses the Elliott State Forest.
permit term	The duration for which the requested incidental take permit is valid
plan area	Encompasses the Elliott State Forest, adjacent Board of Forestry lands managed by the Oregon Department of Forestry, and several adjacent, privately owned parcels.
pre-harvest stand density	Stand density prior to treatment; unit used to establish a threshold for the amount of tree removal permitted in a given treatment type.

Term	Definition
redd	Location selected by a female salmon or trout for laying eggs; female digs a "nest" in the stream gravels with her tail.
regeneration harvest	See also, *variable retention regeneration harvest*.
research design	Framework guiding ESRF research, developed by OSU (Appendix C).
Reserve allocations	Reserve allocations are managed for biodiversity conservation, which means no silvicultural interventions or interventions that are limited only to that which will improve biodiversity and related attributes.
retention harvest	Silvicultural method that retains forest structural elements, such as large living and dead trees, at the time of harvest to serve as biological legacies in the resulting forest or cohort.
restoration thinning	Treatments intended to alter stands towards more complex forest structure. Goals include increasing forest resilience, addressing legacy effects (e.g., road sedimentation, invasives or reduced native plant diversity), and supporting disturbance dynamics that would naturally result in multi-aged stands. Also see *thinning*.
riparian conservation area (RCA)	In the permit area, protective corridors of prescribed widths along each side of specified stream classes where timber harvest and other site-disturbing activities are restricted or prohibited.
salvage harvest	The removal of dead trees or trees damaged or dying in the aftermath of a disturbance event, 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.
The Services	The U.S. Fish and Wildlife Service and the National Marine Fisheries Service, referred to collectively.
stand	A contiguous community of trees sufficiently uniform in composition, structure, age, size, distribution, spatial arrangement, condition, or location on a site of uniform quality to distinguish it from adjacent communities.
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-level inventory	An inventory of physical characteristics recorded for a given stand of trees that serves as the information source on forest conditions within one or more comparable stands.
supporting infrastructure	Structures for forest management.
supporting management activities	Activities supporting forest management goals.
take	To harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct (Section 3(18) of the federal Endangered Species Act). Federal regulations provide the same taking prohibitions for threatened wildlife species (50 Code of Federal Regulations 17.31(a)).

Term	Definition
thinning	Thinning prescriptions remove a portion of the trees from a stand in a generally uniform pattern, with the exception of restoration thinning and extensive treatments, where variable density thinning is used.
treatment	Treatments define what harvest types and methods will be permitted in the permit area allocations and consist of four broad categories: • Intensive treatments • Extensive treatments • Restoration thinning treatments • No treatment
triad	See *research design*.
unforeseen circumstances	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 Services at the time of the negotiation and development of the plan, and that result in a substantial and adverse change in the status of the covered species (50 Code of Federal Regulations 17.3).
variable-density thinning	A silvicultural strategy designed to accelerate development of late-successional habitat by applying a variety of harvest intensities within a stand.
variable retention regeneration harvest	The method of ecological forestry used in extensive treatments where a portion of the stand is converted into openings to promote new stand establishment. The remaining portion of the stands are also retained in dispersion or aggregates using variable-density thinning.
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.