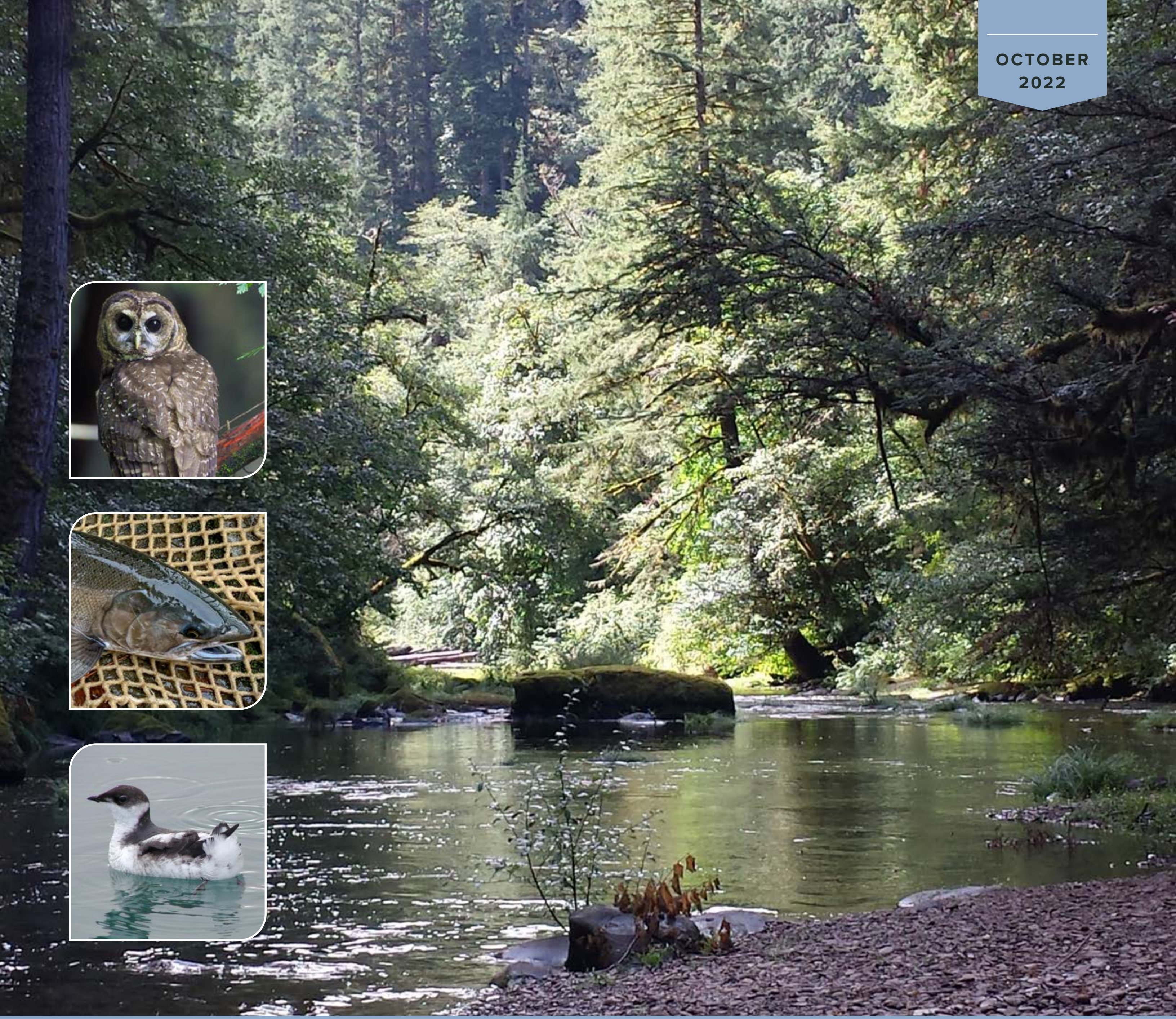


OCTOBER 2022

Elliott State Research Forest HCP

Public Draft Habitat Conservation Plan

PREPARED FOR:

Oregon Department of State Lands

PREPARED BY:

ICF
1200 6th Street, #1800,
Seattle, WA 98101

Contents

Tables

Figures

Acronyms and Abbreviations

°C	degrees Celsius
°F	Degrees Fahrenheit
BLM	U.S. Bureau of Land Management
CCAA	Candidate Conservation Agreement with Assurances
CFR	Code of Federal Regulations
cfs	cubic feet per second
CRW	Conservation Research Watershed
dbh	diameter at breast height
DSL	Oregon Department of State Lands
EFH	essential fish habitat
EIS	environmental impact statement
ESA	federal Endangered Species Act
ESRF	Elliott State Research Forest
ESU	evolutionarily significant unit
FR	*Federal Register*
HCP	Habitat Conservation Plan
ITPs	incidental take permits
Magnuson-Stevens Act	Magnuson-Stevens Fishery Conservation and Management Act
MRW	Management Research Watershed
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
ODF	Oregon Department of Forestry
ODFW	Oregon Department of Fish and Wildlife
OSU	Oregon State University
RCA	Riparian Conservation Area
RMPs	Resource Management Plans
RODs	Records of Decision
Services	USFWS and NMFS collectively
USFWS	U.S. Fish and Wildlife Service

Chapter 1
Introduction

1.1 Overview

The Oregon Department of State Lands (DSL) (the 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 is responsible for reviewing and approving the HCP. The State Land Board is composed of the 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. DSL will manage the forest as the Elliott State Research Forest (ESRF) where forest management activities will be implemented to create a managed landscape where experimentation can occur.

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. Research topics may include, but will not 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.
- 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 towards the extremes of forest conditions—plantations and protected areas—without investigating new approaches for meeting sustainability goals. Forest research to optimize wood production centers on plantations created by repetitive, intense disturbances through clearcutting and rapid tree establishment. 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, and human dimensions.[1] Between these endpoints the goals are to understand how to manage forests to meet resource demands in a manner that emulates natural forest ecosystem function. 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 with the belief this integration is the future of forestry.

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

Sub-watersheds in the ESRF are designated as either a large continuous reserve called the Conservation Research Watershed (CRW), or as part of the Management Research Watershed (MRW). The CRW will be maintained as a contiguous reserve with a one-time thinning of current plantation stands designed to improve habitat associated with complex forest structure over time. In the MRW a *triad* design, which divides the forest into reserves, extensive management, and intensive management areas, will be implemented across the forest.

Watersheds that are wholly contained within the MRW will be managed and receive one of four types of triad treatments—Extensive, Triad-E, Triad-I, reserves with Intensive—with every acre of intensively managed stands matched by an equal acreage of reserves in the same sub-watershed. Intensive and reserve treatment will provide opportunities to study management extremes while variable retention prescriptions established for the extensive treatments will aim to increase forest complexity to achieve multiple values across the landscape.

The Permittee's future timber management of the forest has the potential to adversely affect 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 adverse effects on listed species. This plan is called the ESRF HCP to recognize that it is designed to be implemented by the Permittee as part of their research forest program and will be implemented on what is now the Elliott State Forest to minimize and mitigate the impacts of that authorized incidental take.

1.2 Background

The Elliott State Forest is composed primarily of School Lands. School Lands represent the federal government's contribution to the Oregon public school system. 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 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 the 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 and under contract to 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.[2] 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 by other scientists, was used in subsequent HCP revisions.

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 ODF decided not to pursue revisions to the HCP and no ITPs were issued by USFWS or NMFS. In 2011, DSL and ODF jointly 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 in the forest and the need to avoid adverse effects on the species that might violate the ESA in the absence of ITPs. This harvest limitation has dramatically reduced timber revenue to the point where the cost of managing the Elliott State Forest in 2013 far exceeded its 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 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 April 2022, Oregon Governor Kate Brown signed Senate Bill 1546, which will implement the State Land Board's vision to keep the Elliott State Forest in public ownership and preserve it for future generations for conservation, economic growth, recreation, education, and forest research. The bill established the Elliott State Research Forest with a mission to create an enduring, publicly owned, world class research forest that advances and supports recovery 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 the Elliott State Research Forest Authority to administer the forest as a state agency independent from the DSL. However, because this new agency has not yet been fully established, this HCP still refers to DSL as the manager of the ESRF.

The bill requires that the ESRF be managed to promote collaboration, partnerships, inclusive public processes and equity, consistent with the following.

- The applicable HCP, as approved by the Services.

[2] The 1995 Elliott State Forest HCP did not cover Oregon Coast coho because it had not yet been listed. Listing occurred in 2011.

- A forest management plan, to be approved by the State Land Board.
- The applicable version of Oregon State University's Elliott State Research Forest Proposal (Oregon State University 2021).

Once finalized and approved, these documents, along with the requirements of Senate Bill 1506, will establish the foundation for management of the ESRF over the 80-year permit term.

1.3 Purpose

Section 9 of the ESA prohibits the taking of species listed as threatened or endangered, with *taking* defined as, "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct" (16 U.S. Code [USC] 1532). *Harm* is further defined as including "significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering" (50 Code of Federal Regulations [CFR] 17.3). In the course of research activities, including timber harvest, there is potential to take three species listed as threatened under the ESA: northern spotted owl, marbled murrelet, and Oregon Coast coho. Protection of the northern spotted owl and marbled murrelet falls under the jurisdiction of USFWS; protection of the Oregon Coast coho falls under the jurisdiction of NMFS.

Lawful forestry research activities cannot be conducted without removing or altering habitat for these three listed species. To the extent this alteration injures or kills one or more of these three species including by "habitat modification or degradation that significantly impairs essential behavioral patterns," it amounts to take under Section 9 of the ESA. DSL and the Permittee have taken steps to reduce the adverse effects on the habitats of the listed species, but they are unable to eliminate the effects altogether that may result in take without severely limiting or altogether ceasing the timber harvest and related management activities needed to fully implement the research forest charter.

1.4 Scope of the HCP

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

1.4.1 Plan Area and Permit Area

The Elliott State Forest is composed of two distinct sets of lands with different ownership and mandates. The School Lands (83,458 acres) are overseen by the State Land Board and managed by DSL. The remaining 8,897 acres are Board of Forestry Lands overseen by the State Board of Forestry and managed by ODF. The HCP plan area includes both types of land (School Lands and Board of Forestry Lands) (Figures 1-1 and 1-2, Table 1-1). There are an additional 162 acres of private lands in the plan area.

The permit area, where all covered activities and conservation actions will occur, includes only 83,458 acres of School Lands within the plan area (Table 1-1, Figure 1-2). Board of Forestry Lands within the Elliott State Forest are not covered by this HCP and are therefore not part of the HCP permit area. An additional 915 acres of DSL land is not included in the permit area, due to land management, but is included in the plan area. Board of Forestry Lands are included in the plan area to accommodate any future land exchanges between DSL and ODF within the Elliott State Forest.[3] The intention of the HCP is to cover School Lands within the Elliott State Forest that become part of the ESRF. Hereafter, any reference to the Elliott State Forest is to the School Lands of the forest (i.e., the HCP permit area), unless otherwise stated.

There are several small privately owned parcels within the boundary of the Elliott State Forest (Figure 1-2). These private lands are not part of the HCP plan area or permit area, and therefore are not part of the HCP.

Table 1-1. Elliott State Forest Lands Covered and Not Covered by the Habitat Conservation Plan

Land Type in Elliott State Forest	Amount in Acres (%)	Land Ownership	Land Management	In HCP Plan Area?	Covered by this HCP (in Permit Area)?
School Lands	83,458 (89.3%)	State of Oregon, Common School Fund	State Land Board (by DSL)	Yes	Yes
Other DSL Lands[1]	915 (1.0%)	State of Oregon, Common School Fund	Board of Forestry (by ODF) and DSL	Yes	No
Board of Forestry Lands	8,897 (9.5%)	State of Oregon, Board of Forestry	Board of Forestry (by ODF)	Yes	No[2]
Private Inholdings	162 (0.2%)	Private	Private	Yes	No[2]

[1] Includes the 787-acre East Hakki Ridge parcel. Based on if these properties are decoupled from the Common School Fund this site may be manage under this HCP or the Western State Forests HCP.
[2] Lands could be added to the permit area and covered by the HCP if they were transferred or sold to DSL in the future.

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

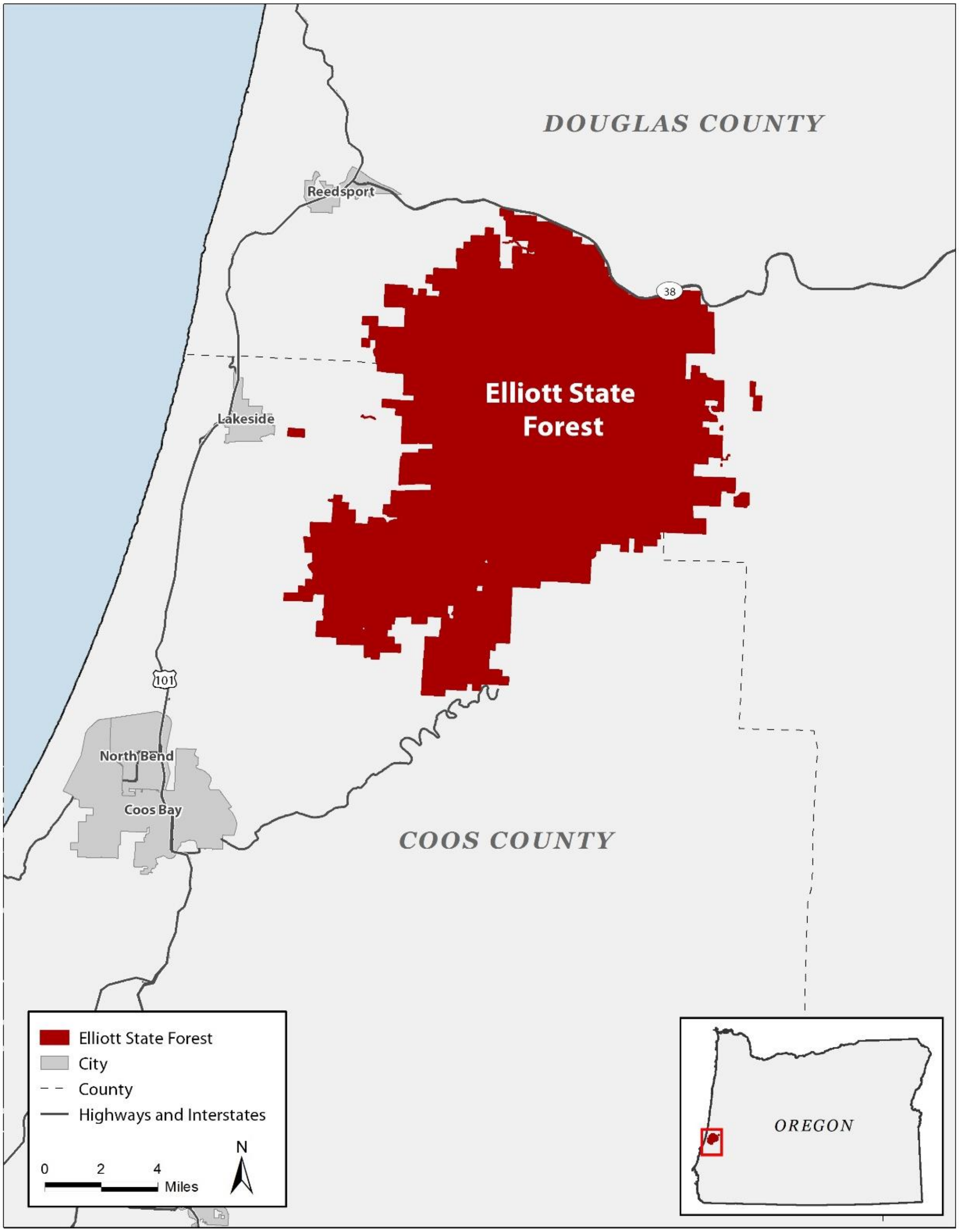


Figure 1-1. Vicinity Map

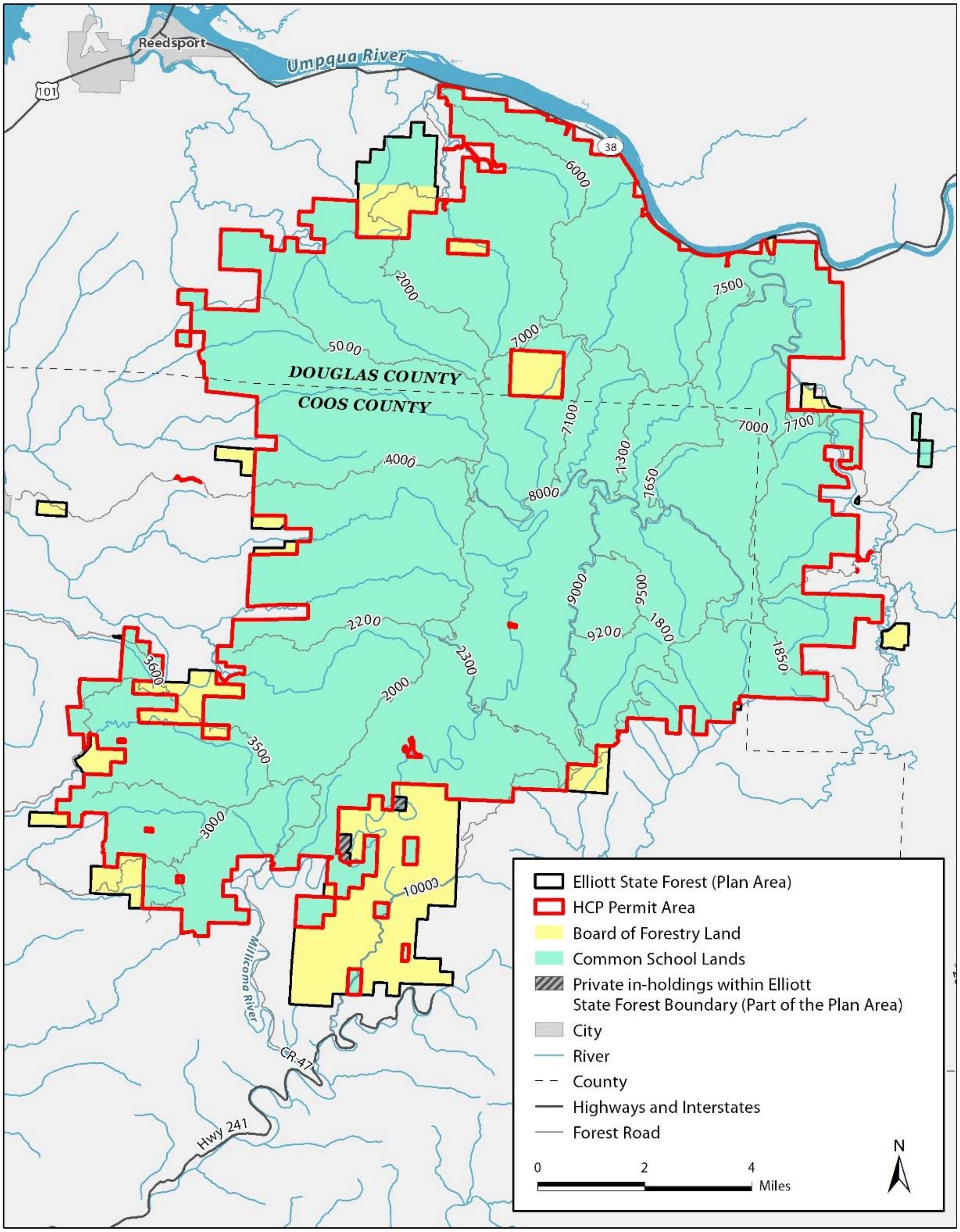


Figure 1-2. Plan Area

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 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 and the associated ITPs will cover and provide incidental take authorization for research 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 research treatment types, are provided in Chapter 3, *Covered Activities*.

- **Stand-Level Research Treatments.** Research actions, harvest activities (intensive, extensive, and reserve), and stand management activities that will be utilized to maintain the research platform.
- **Supporting Management Activities.** Activities used to facilitate stand management activities.
- **Supporting Infrastructure.** Infrastructure needed to facilitate implementation of the research platform and programs, including roads, landings, drainage structures, and quarries.
- **HCP Implementation Activities**. Activities identified in the conservation strategy and monitoring program that may result in short-term effects on covered species.

1.4.4 Covered Species

Covered species are those species for which USFWS and NMFS will provide take authorization to DSL. The plan area provides habitat for a variety of species, including species listed under state and federal endangered species protection laws. DSL selected the covered species for the HCP based on review of all species of conservation concern known or suspected to occur in the plan area during the permit term. These species were then screened for coverage based on four selection criteria (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 plan area (see Appendix B, *Species Considered for Coverage*). To be covered, a species must meet all four criteria.

1.4.4.1 Covered Species Selection Criteria

Range

Species should be known or expected to occur within 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 plan 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.

Table 1-2. Proposed Covered Species

	Status[1]		Federal
Species	**State**	**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

[1] 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 enforcing the provisions of the ESA for most marine and anadromous species. USFWS is responsible for all other terrestrial and aquatic species.

Section 10

Under Section 10(a)(2)(A), a non-federal 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. In addition, the HCP must include a discussion of alternative actions that 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 is 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.

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. 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.

1.5.1.2 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 state 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 must develop an endangered species management plan for marbled murrelet. 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 is likely to affect the human environment must prepare an environmental assessment. If impacts on the human environment are found to be significant and cannot be mitigated to the point of insignificance, the federal agency must then prepare an 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 a draft EIS addressing the proposed issuance of ITPs based on this HCP.

1.5.3 Other Relevant Federal and State Laws

1.5.3.1 Oregon Forest Practices Act

The Oregon Forest Practices Act and its associated rules[4] set standards for all commercial activities involving the establishment, management, or harvesting of trees in Oregon forests. The Forest Practices Act declares it public policy to encourage economically efficient forest practices that ensure the “continuous growing and harvesting of forest tree species and the maintenance of forest land for such purposes as the leading use on privately owned land, consistent with sound

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

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.

1.5.3.2 Oregon Plan for Salmon and Watersheds

In 1997, the Oregon Legislature adopted the Oregon Plan for Salmon and Watersheds, which focused on coho salmon. In 1998, the Steelhead Supplement of the Oregon Plan was added.

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 the implementation of others—an essential principle of the plan involves moving beyond prohibitions and encouraging efforts to improve conditions for salmon through nonregulatory means. This HCP was prepared to be consistent with the Oregon Plan for Salmon and Watersheds.

1.5.3.3 Oregon Fish Passage

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

1.5.3.4 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, fish salvage). 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 (United States Department of Agriculture and Bureau of Land Management 1994) and the associated land and resource management plans of National Forest. Management actions on U.S. 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 (RODs) for the Resource Management Plans (RMPs) for western Oregon (BLM 2016a, 2016b), providing updated management direction 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 the ESRF 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 (U.S. Forest Service 2012), 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 Rouge 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.[5] 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 southern Douglas and northern

[5] 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 the Fall of 2022.

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 also includes in the permit area 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 8,897 acres that are Board of Forestry Lands inside the Elliott State Forest boundary and the 915 acres of other DSL lands adjacent to the ESRF (Figure 1-2). These lands are currently covered by the Western Oregon State Forests HCP. However, if any of the Board of Forestry Lands were transferred to DSL, they could be covered instead by the ESRF HCP.

The Western Oregon State Forests HCP proposes to cover 17 species (including all three species covered under the ESRF HCP) for which USFWS and NMFS will provide take authorization to ODF to conduct their 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 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.

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 a greater amount of land being maintained in spotted owl dispersal habitat. This plan protects existing northern spotted owl nesting sites and dispersal habitats over a large landscape.

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 the 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 Tree Farm 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 (described in Chapter 4, *Effects Analysis and Level of Take*).

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 a barred owl removal experiment that was conducted 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 Barred Owl Removal Experiment (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 to the ESRF where removals were conducted is approximately 25 miles north (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 the 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 percent 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 conduct a barred owl removal 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 non-federal 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 and Levels of Take*, presents the impacts of the covered activities.
- Chapter 5, *Conservation Strategy*, summarizes the conservation strategy and describes the specific avoidance and minimization actions to be implemented to reduce impacts and the mitigation actions to be implemented 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 DSL and the Services. This chapter also describes the regulatory assurances provided to DSL 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 Oregon State University's proposal for transforming the Elliott State Forest into a state research forest managed by the university and its College of Forestry.

Chapter 2
Environmental Setting

The 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 ESRF.

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 (see 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 the 93,181-acre ESRF as described in Section 1.4.1, *Plan Area and Permit Area*.

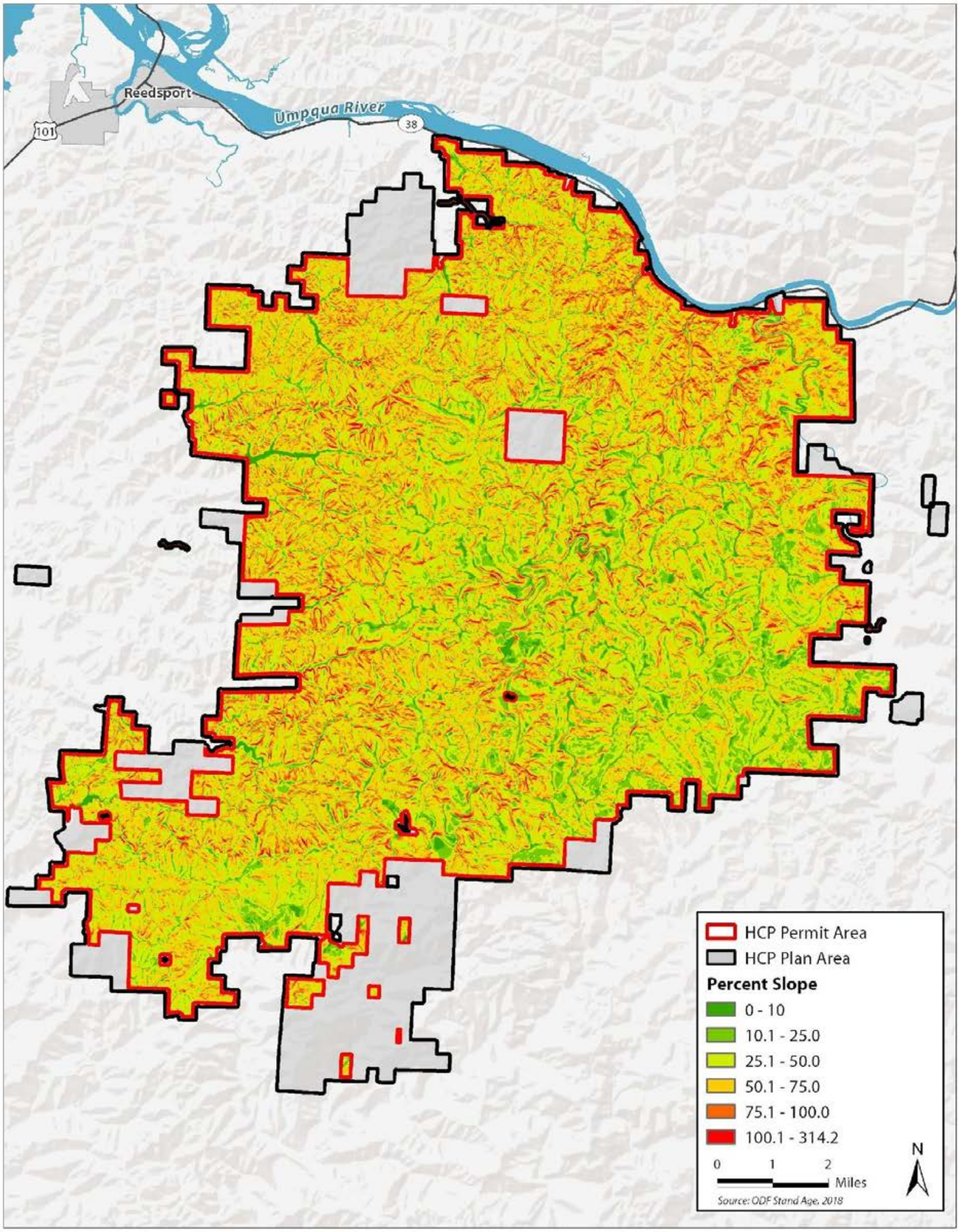
2.1.2 Topography

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 percent. The valley bottoms were formed by alluvial deposits and are gently sloping. Steep colluvial 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 waterbodies. About 47 percent of the plan area drains southwest into Coos Bay, 30 percent drains north to the Umpqua River, and 23 percent drains west to the North and South Tenmile Lakes. 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 to the west of the plan area (Figure 2-2).

The Elliott State Forest has been divided into 13 watersheds based on hydrologic boundaries aggregated up to 5th level (field) hydrologic unit boundaries from the Watershed Boundary Dataset layer for Oregon (U.S. Geological Survey 2020) (Figure 2-2, Table 2-1).



ICF

Figure 2-1. Topography in the Permit Area

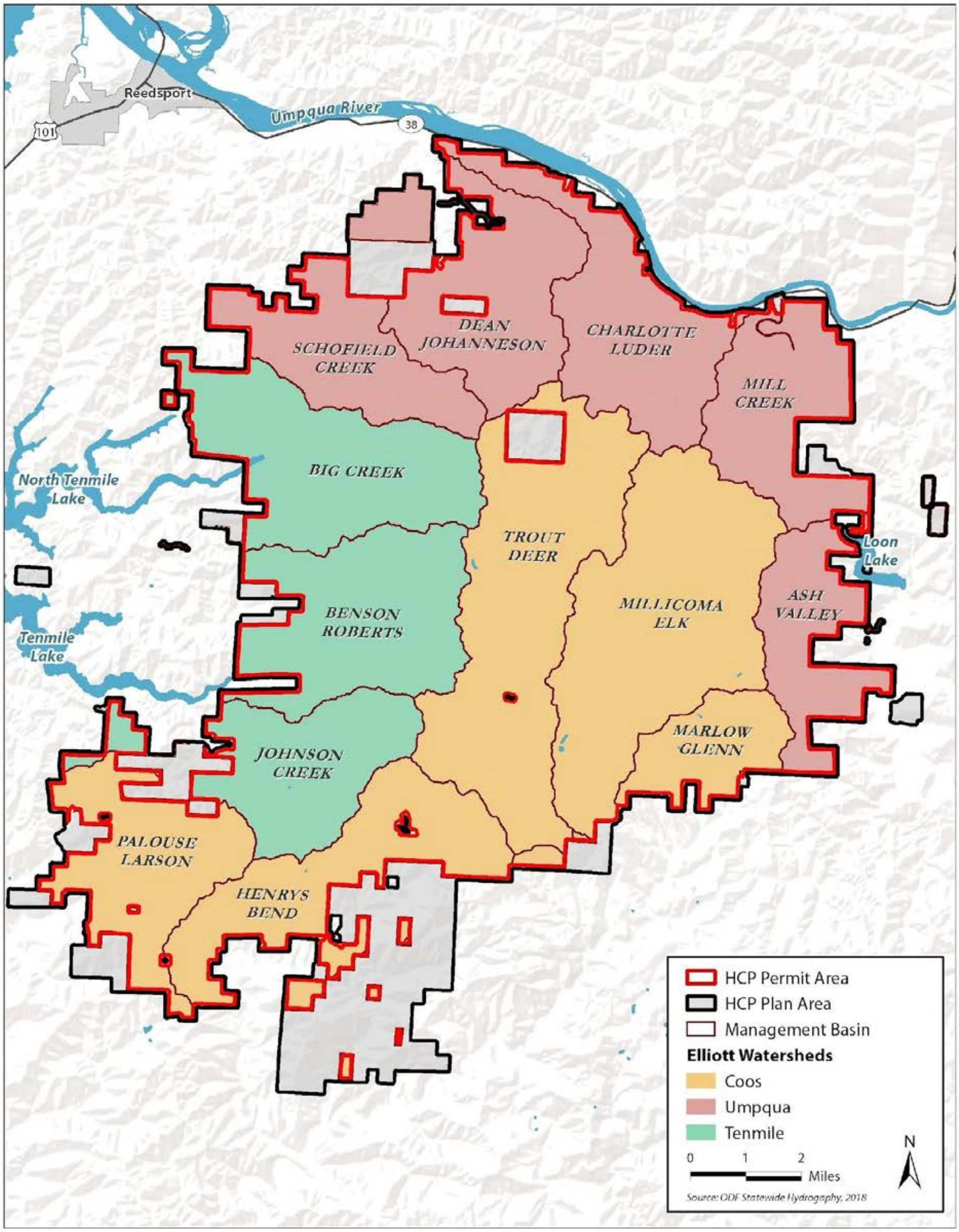


Figure 2-2. Watersheds in the Permit Area

Table 2-1. Elliott State Research Forest Watersheds Within Permit Area

Watershed Name	Size (acres)	Amount in Permit Area (acres)
Mill Creek	5,097	4,944
Charlotte Luder	6,289	6,251
Dean Johanneson	7,323	5,865
Scholfield Creek	5,003	4,772
Big Creek	7,820	7,481
Benson Roberts	7,320	6,972
Johnson Creek	6,295	5,496
Palouse Larson	6,495	5,427
Henry's Bend	8,321	6,569
Marlow Glenn	6,514	3,144
Millicoma Elk	10,924	10,875
Trout Deer	11,341	10,786
Ash Valley	3,905	3,904
Outlying Parcels[1]	391	54
TOTAL	**93,036[2]**	**82,541**

[1] Disjunct permit area lands not within one of the listed basins.

[2] 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.

2.1.4 Soils

The soils in the plan area are composed of several different types: approximately 83 percent of the forest soils are residual soils, approximately 16 percent are alluvial soils found in valley bottoms, and the remaining 1 percent includes agricultural land, rock outcroppings, lakes, ponds, and rivers. Most of the plan area is Site Class II or III, indicating that trees reach heights of 95 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 July temperature is 76°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 ESRF 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.
- Increased winter rain and frequency and severity of winter storms and associated high wind events.

Projected climate effects on forest conditions are described in 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 ESRF and represents slightly more than a third of the entire 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 (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, stream types 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, which encompasses the upper limit of coastal cutthroat trout in stream networks. Cutthroat trout presence generally extends farther into the headwaters of stream networks than any other fish species, even higher than non-game fish such as sculpin. Fish-bearing streams are defined as those with a gradient of 20 percent or less, which is based on environmental DNA data for resident cutthroat trout, and provides a fish-bearing stream network approximately 20 percent longer than that employed by the Oregon Department of Forestry (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 percent of the total stream miles. These streams are critical to maintaining the aquatic ecosystem's productivity by providing cool water, wood, sediment, fish prey, and nutrients to fish-bearing streams. These streams provide habitat for a suite of native amphibians, insects, birds, bats, and other organisms, and function as a corridor for energy and nutrient flux within the watershed. 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 ODF (702 miles) and by the National Hydrography Dataset (747 miles).
- **Perennial streams** (streams that have perennial flow and a contributing area greater than 0.062 square kilometer [Clarke et al. 2008]).
- **Seasonal streams** (streams that have a contributing area less than 0.062 square kilometer [Clark 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).

Wetlands are often near streams or contain trees, but they are ecologically distinct from streams and forests. The Forest Practices Act 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.

Table 2-2. Length of Streams in the Permit Area by HUC-10 (miles)

	Fish-Bearing		Non-Fish-Bearing		
HUC-10	**Perennial**	**Seasonal**	**Perennial**	**Seasonal**	**Total**
Coos Bay-Frontal Pacific Ocean	12.57	N/A	19.75	108.22	127.97
Lower Umpqua River	38.36	N/A	55.94	343.78	399.72
Middle Umpqua River	NA	N/A	0.45	4.83	5.27
Mill Creek	17.59	N/A	32.55	186.98	219.54
Millicoma River	111.38	N/A	74.73	568.34	643.07
Tenmile Creek-Frontal Pacific Ocean	55.63	N/A	60.83	395.85	456.68

HUC = hydrologic unit code
N/A = not applicable

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 that use 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 located 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.

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 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*. For the remainder of this discussion, the term *landslide* will be used to include all of these types of mass-wasting events.

Benda and Dunne (1997) succinctly described the prevalence of landslides 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,[1] 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[2], 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.

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

[2] 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.

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 may make up more than 70 percent of the stream network in the Coast Range and are important contributors of large wood and sediment. Small, non-fish-bearing streams also provide habitat for amphibians and macroinvertebrates that are a food source for coho. 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).

The adjacent riparian forest is similarly important to the stream ecosystem, providing root strength 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 watershed in the Oregon Coast Range. They found that 65 percent of the number of pieces, and 46 percent of the estimated volume, of wood originated from upstream sources delivered by landslides or debris flows more than 300 feet from the channel. The remainder of the wood originated in streamside sources immediately adjacent to the 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 percent 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.

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 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 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 2-3). Most private lands are maintained as commercial timberlands dominated by plantations composed of relatively young, uniform Douglas-fir (*Pseudotsuga menziesii*) forest. Lands in the adjacent private Millicoma Tree Farm are managed under an HCP for northern spotted owl (*Strix occidentalis*) (Weyerhaeuser Company 1995). Federal lands 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 U.S. Bureau of Land Management lands) and Land Management Plans (for U.S. Forest Service lands)). Major conservation elements of these plans include conservation of Late-Successional Reserves and Aquatic Reserves, much of which contain older forest cover. State lands, including the plan area, have a mix of older and recently harvested forests.

Based on these generalities, the plan area is surrounded by young forests 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 Highway 38, the Umpqua River, and some private lands.

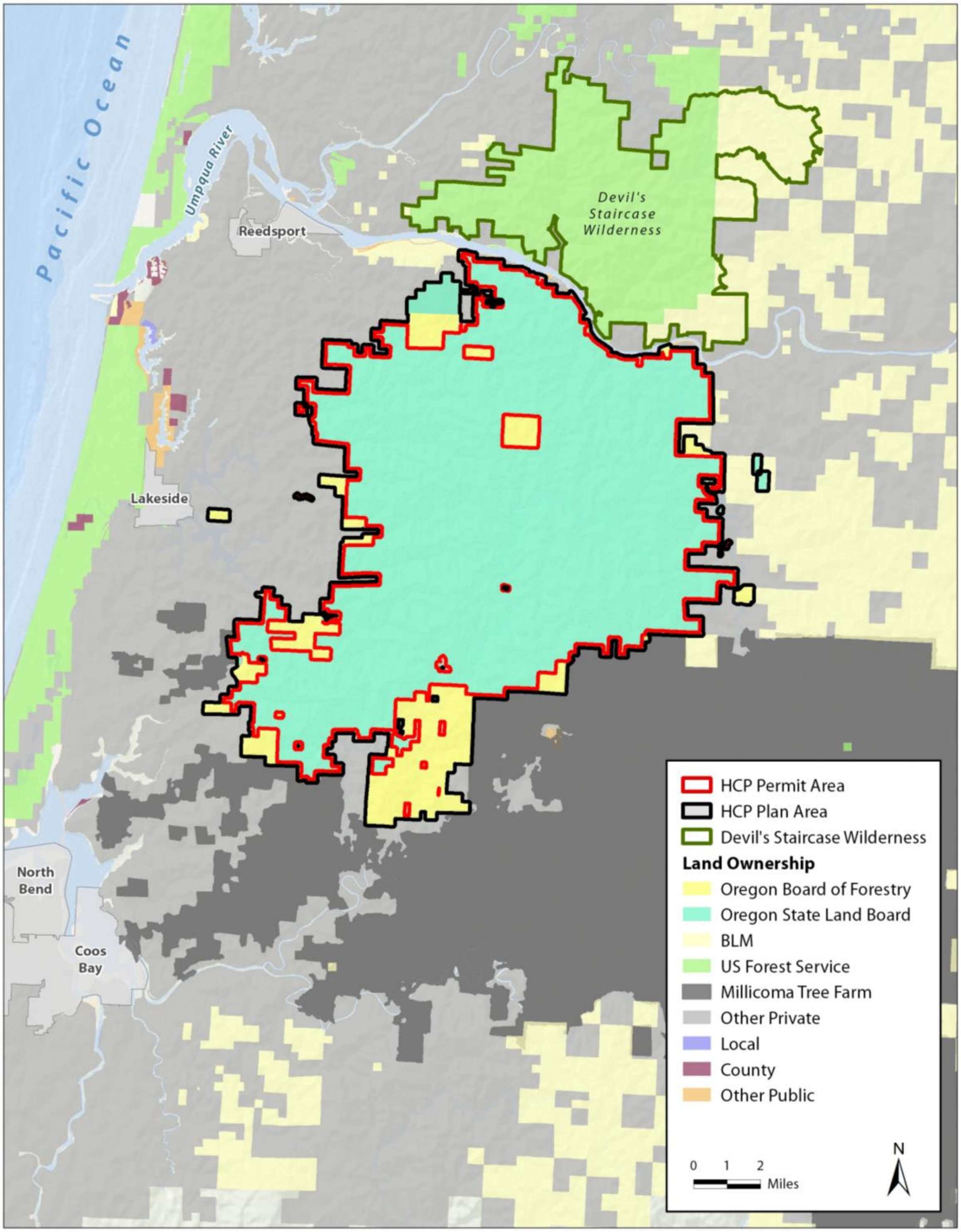


Figure 2-3. Land Ownership Within and Near the Plan Area

2.2.3 Tree Species

More than 90 percent 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*).

2.2.4 Ecological Disturbance and Forest 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.

These disturbances are natural and necessary processes of the forest ecosystem and provide many important components of wildlife habitat. Neither fire nor wind completely removes the forest overstory; both tend to leave patches of trees or individual large dominant trees (residuals) that survive, along with standing and fallen trees from the prior forest cohort. This "legacy" structure may provide habitat used by 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 percent of the plan area was burned during this fire (Figure 2-4), 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.

2.2.4.2 Disturbance Agents: Storms

Severe storm events are relatively common in the plan area (Robison et al. 1999), while the principal storm event that has shaped the current ESRF 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 ESRF. 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.

A more common example of important storm events were 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).

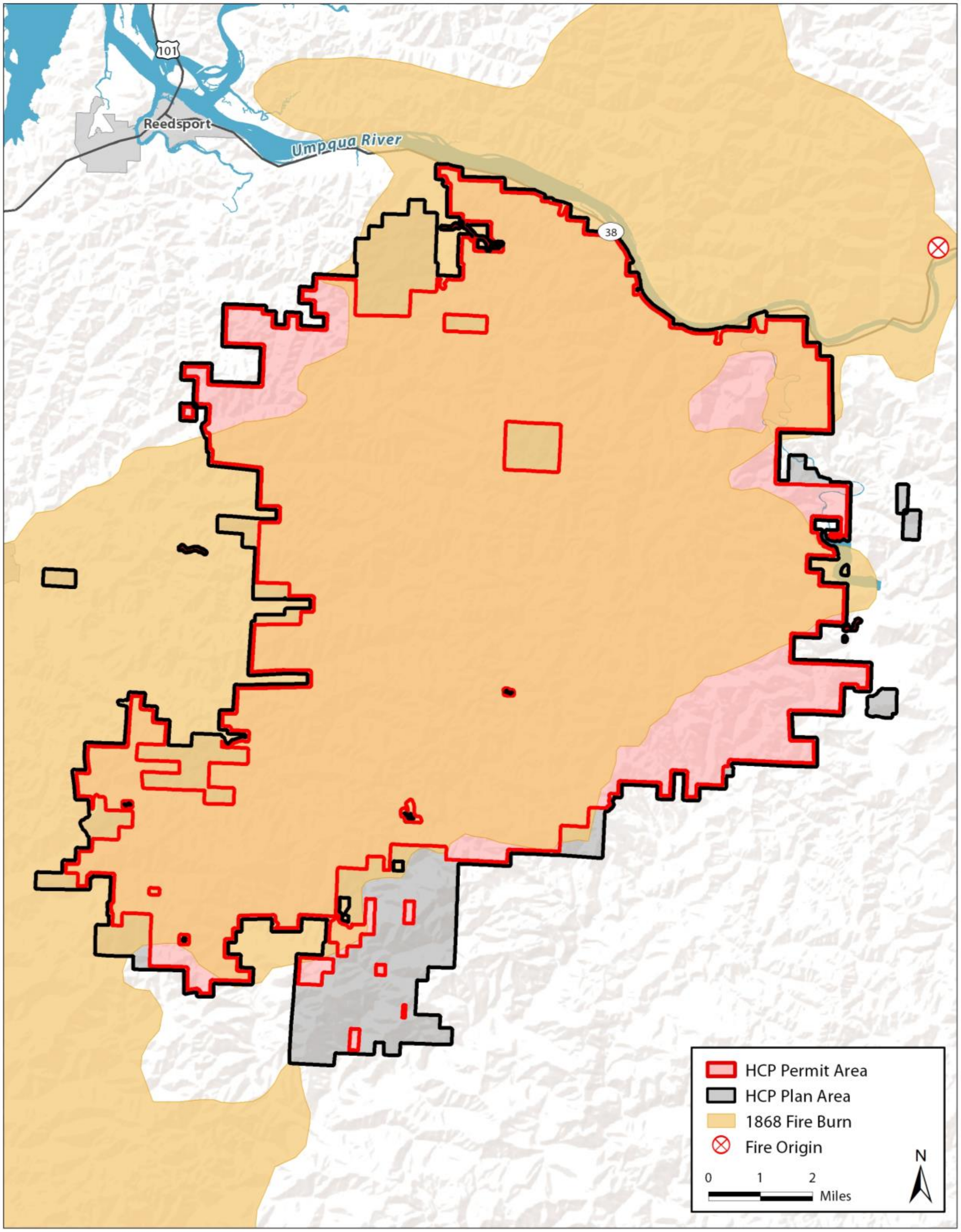


Figure 2-4. Extent of the 1868 Fire on the Elliott State Forest

2.2.4.3 Disturbance Agents: Timber Harvest

In most recent decades, timber harvest has been the primary agent of change. Commercial-scale logging likely commenced in earnest in the plan area around 1955. Any forest stand that originated after this date therefore likely resulted from timber harvest or salvage because there have been no major fires in the plan area after 1955. Forest stands older than 1955 are assumed to have originated from stand-replacing wildfires. Overall, about 50 percent of the Elliott State Forest has been clearcut and regenerated in the past 65 years (Oregon State University 2021).

2.2.4.4 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 (Agnea 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 ESRF 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 ESRF, was projected to have the lowest amount of climate change effects among Pacific Northwest forest regions.

2.2.6 Forest Age

Management of the ESRF 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 (Figure 2-5) that can be explained by three general stand histories: (1) stands less than 65 years old (as of 2020), (2) stands older than 65 years old (between 75 and 125 years, as of 2020), and (3) stands older than 65 years old (between 80 and 230 years, as of 2020). These classes may not represent the stand history of every single stand, but the primary activities in the recent past. Stands under 65 years of age are forest stands that regenerated following a clearcut. Stands over 65 years of age regenerated naturally, primarily following fire.

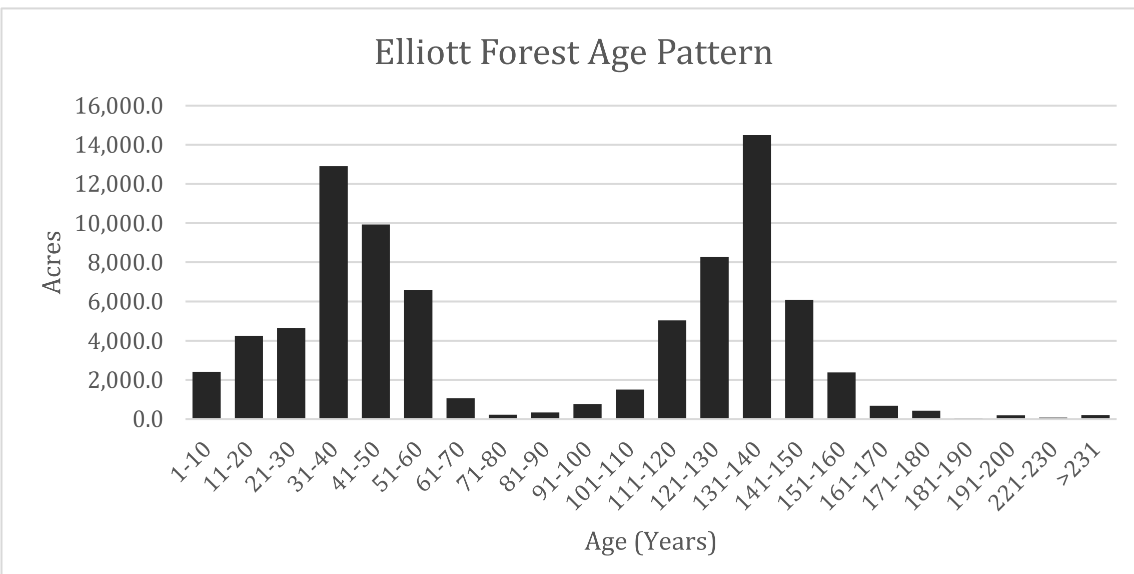


Figure 2-5. Tree Age Distribution on the Elliott State Forest by Age Class as of 2020

2.2.6.1 Forests Less than 65 Years Old (as of 2020)

Overall, about 50 percent of the ESRF 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. These practices resulted in approximately 41,000 acres of young forest in the plan area (approximately 50 percent 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.

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.

Parts of the Permit Area Approximately 65–160 Years Old

Approximately 50 percent of the Elliott State Forest supports forests that regenerated naturally following fire, wind events, or landslides prior to 1955. These forests have not been harvested, with the exception of several thousand acres that were thinned when they were 75 to 125 years old. The purpose of the thinning was to remove approximately 30 percent 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. While records are incomplete, somewhere between 5,000 to 10,000 acres of forests older than 65 years have been partially harvested (Phillips 1997). These stands were primarily 100 to 160 years in 2020.

Parts of the Permit Area Approximately 80–230 Years Old

This category also includes forests that regenerated following natural events. 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 due to spotty historical records. Using the estimates of Phillips (1997) of 5,000–10,000 acres of these older forests being partially harvested, the ESRF contains approximately 30,000–35,000 acres of unmanaged forests. The age range of these forests is from 80 to 230 years, with 71 percent of this forest type between 130 and 160 years. 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. There may be individual trees older than 200 years old as scattered remnants in younger stands.

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.

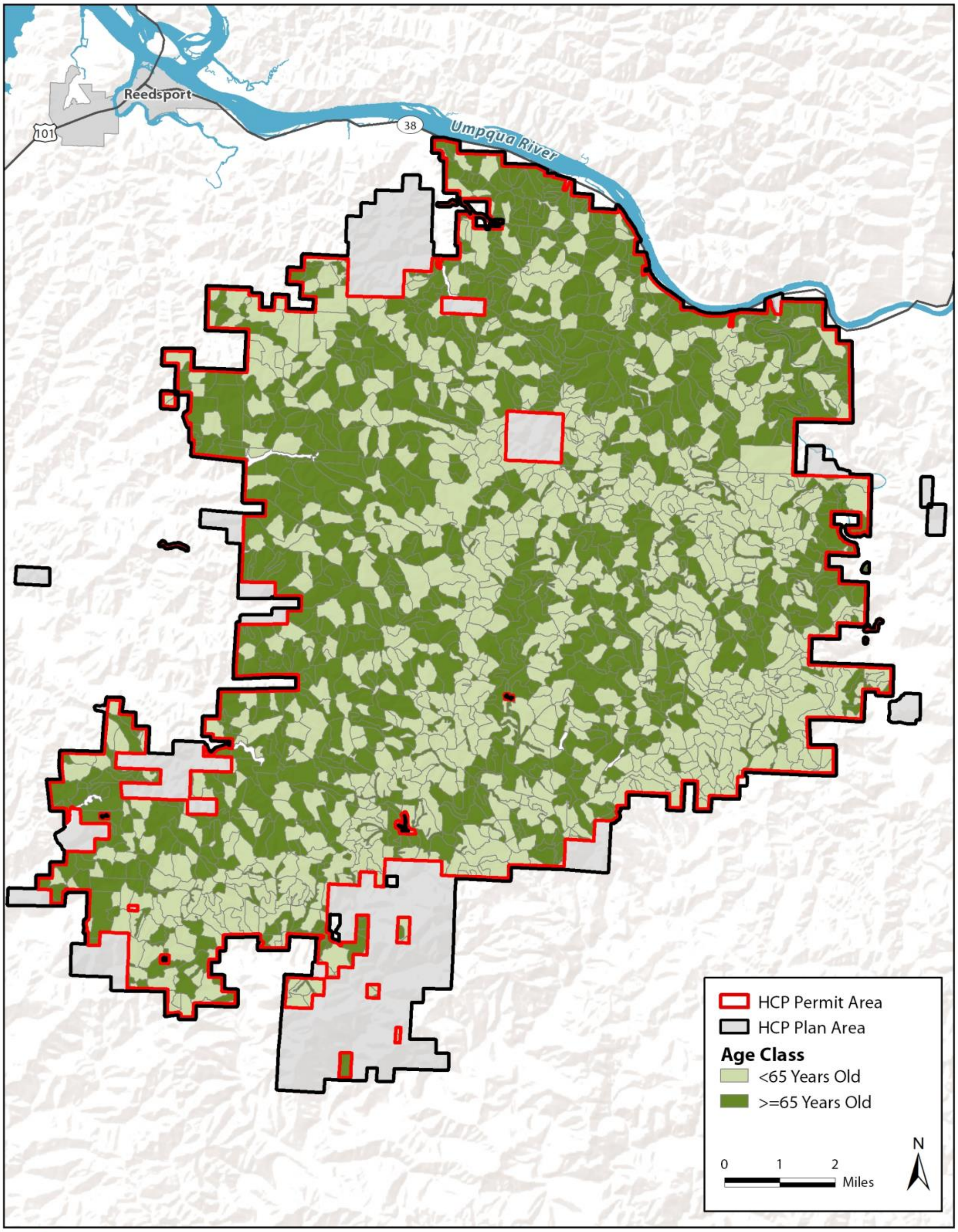


Figure 2-6. Age Class Distribution in the Permit Area

2.2.7 Riparian Forest

Riparian areas include streams and those associated upland forests that interact with the stream in ecologically important ways, such as by affecting microclimate along the stream. 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 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).

Riparian forests are defined as mature if they are older than 99 years (Biosystems et al. 2003). In the Elliott State Forest, riparian forest with a mature forest condition represents from 13 to 52 percent of each major basin (Biosystems et al. 2003). Riparian areas farthest 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, followed by Coos, then Tenmile. On average, forest-wide, 31 percent of streams have mature forest within 150 feet of the stream (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 (U.S. Fish and Wildlife Service 1990). 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 (U.S. Fish and Wildlife Service 2020a). In the finding, the 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

The 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 U.S. Bureau of Land Management 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).

The USFWS revised critical habitat for the northern spotted owl in 2021 by excluding certain areas, which revised the previous 2012 rule (U.S. Fish and Wildlife Service 2012a, 2021). Critical habitat for the northern spotted owl now includes approximately 4.3 million acres in Oregon, including 38,764 acres (approximately 42 percent) of the ESRF plan area (described in more detail in Section 2.3.2, *Population and Habitat Status*). The lands on ESRF were not part of the exclusions identified in the 2021 rule, so critical habitat on the ESRF 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 (U.S. Fish and Wildlife Service 2012a), and the Notice of 12-Month Finding on a petition to list the northern spotted owl as an endangered (U.S. Fish and Wildlife Service 2020a). 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 2020 USFWS 12-Month Finding (U.S. Fish and Wildlife Service 2020a).

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 within 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; Franklin 1992) 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 (U.S. Fish and Wildlife Service 2012a). 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 (U.S. Fish and Wildlife Service 2012a).

USFWS considers the following components important to nesting and roosting habitat (77 *Federal Register* [FR] 71875–72068).

- Moderate to high canopy cover (60 percent to over 80 percent).
- 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 diameters of trees.
- 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 (U.S. Fish and Wildlife Service 2012a). Foraging habitat is the most variable of all habitats used by territorial spotted owls and is closely tied to the prey base (U.S. Fish and Wildlife Service 2012a). Nesting and roosting habitat always also provides foraging habitat, but foraging habitat does not always also provide nesting habitat (U.S. Fish and Wildlife Service 2012a). Owls may forage in younger and more open and fragmented forests if adequate prey is available.

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 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 percent to over 80 percent).
- 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 percent canopy cover.
- Younger and less diverse forest stands than foraging habitat, such as even-aged, pole-sized stands, if such stands contain some roosting structures and foraging habitat to allow for temporary resting and feeding during 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 percent per year due primarily to habitat loss and degradation. Current estimates are in the range of a 3.8 percent annual decline, although there is wide geographic variation (Table 2-3). Lesmeister et al.(2018) found that the Oregon Coast Range population has been declining at approximately 5 percent 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 state-wide by more than 60 percent from 1995 through 2017, with the Oregon Coast Range and Klamath areas declining by more than 75 percent over the same time, with up to a 9 percent 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.

Table 2-3. Estimated Mean Annual Rate of Population Decline of Northern Spotted Owls in 11 Study Areas in Washington, Oregon, and California (Annual Average, 1985–2013)[1]

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.

[1] 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.

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 2020b).

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 percent on federal lands, primarily caused by wildfire, and a net decrease of 8.3 percent on non-federal 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 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 ≥ 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 2012b).

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 Elliott State Forest was estimated to support 51 individual owls on 25 activity centers. By 2016 (i.e., after 25 years), the occupancy estimate was 14 owls on 8 activity centers (Kingfisher 2016; numbers based on the density survey protocol of Forsman 1995).

This decline was accompanied by a corresponding increase in barred owl detections. In 2003, barred owls were detected in only 8 sites where northern spotted owls had been previously found. By 2016, barred owls were detected at 57 such sites (Kingfisher 2016).

As of 2016 (the last year that full surveys were completed), eight northern spotted owl activity centers were found to be occupied by northern spotted owls (this includes one pair in a site centered on adjacent federal lands). Single northern spotted owls were detected at five historic pair activity centers, and two non-territorial floaters were detected.

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, 1 unconfirmed pair site, and 2 resident single sites centered on the Elliott State Forest have been consistently occupied over several years and have had at least 1 northern spotted owl detection between 2011 and 2016 (within 5 years of the last full survey conducted in 2016). In addition, 5 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 1 northern spotted owl detection between 2011 and 2016. Table 2-4 lists the details for these sites and Figure 2-7 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 and Level of Take*.

Table 2-4. Consistent and Recent Northern Spotted Owl Activity Centers in Plan Area

ID	Site Name	Highest Status[1]	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		
36	Murphy Creek	PR	20	1991	Absent	6	2012		
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		2
46	Palouse Creek	PR	18	1991	Absent	5	2003		3
50	Benson Creek	PR	8	1991	Absent	8	2013	1	1
53	Scholfield Creek	PR	6	1990	Absent	1	2011		
54	Johanneson Creek	PR	0	1991	**Pair**	6	2016		
55	Upper Millicoma	PR	6	1991	Single	1	2016		
56	Charlotte Creek	PR	6	1991	Single	3	2016		
57	Cougar Creek	PR	6	1999	Single	2	2016	1	
59	Luder Creek	PR	0	1991	**Pair**	8	2016		
61	Upper Elk	RS	3	2013	Absent	1RS	2013		
62	Footlog Creek	PR	0	2010	**Pair**	5	2016		2
63	Lower Mill Creek	PR	0	1986	**Pair**	21	2016	2	6
64	Marlow Ridge	PR	0	1991	**Pair**	7	2016	1	
65	West Glenn Creek	PR	0	2003	**Pair**	3	2016		
66	Johnson Creek	PR	0	1991	**Pair**	8	2016		4
68	Upper Roberts Creek	PU	5	2011	Absent	1 PU	2014		

ID	Site Name	Highest Status[1]	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
69	Panther Creek	RS	6	2003	Absent	2RS	2011		
70	Salander Creek	PR	25	1991	Absent	7	2015	1	5
2176	Upper Mill Creek*(BLM)	PR	1	1991	Single	5	2016		
2938	Marlow Creek*(Weyerhaeuser)	PR	0	1991	**Pair**	18	2016	1	3
3159	Tom Fool Creek*(BLM)	PR	8	1992	Absent	11	2012	1	2
3531	Lockhart Road* (Weyerhaeuser)	PR	1	1986	Single	9	2016		
4166	Lower West Fork Millicoma*(Weyerhaeuser)	PR	4	1992	Absent	14	2014	2	2

Source: Kingfisher 2016.
[1] PR = Pair, PU = Unconfirmed Pair, RS = Resident Single
* = adjacent lands (centered outside of ESRF, ownership in parentheses; BLM = U.S. Bureau of Land Management)

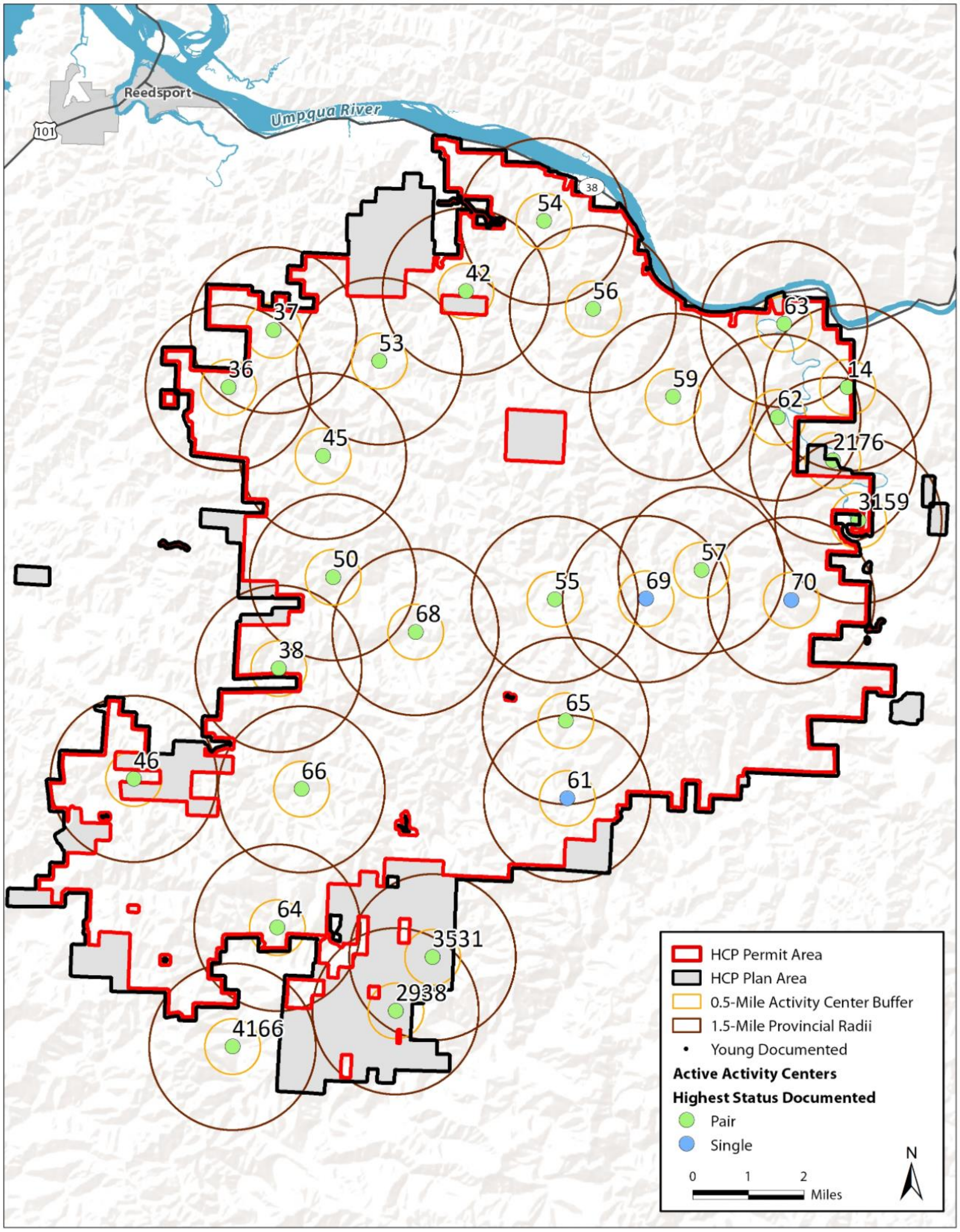


Figure 2-7. Active Northern Spotted Owl Activity Centers in and Adjacent to the Plan Area

Because no northern spotted owl surveys have occurred on the Elliott State Forest since 2016, these consistent and recently active activity centers are assumed to still be active for the purposes of this HCP. However, due to the likely expansion of barred owl on the site, it is likely that some of these activity centers are no longer occupied by northern spotted owls.

In addition to occupancy surveys, the surveys included site visits to determine reproductive success. The cumulative results show that of 20 pair sites summarized above and in Table 2-4, 13 (65 percent) have been determined to have fledged young. No young or nesting attempts were found during the 2016 survey (Kingfisher 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; U.S. Fish and Wildlife Service 2012a). 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 (U.S. Fish and Wildlife Service 2012a, citing 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 percent of the plots where foraging occurred had been thinned 15 to 40 years prior to the study.

One indication of the availability of habitat for northern spotted owl is the federal designation of critical habitat. In 2012, USFWS designated 38,764 acres (approximately 42 percent) of the plan area as critical habitat for northern spotted owl (U.S. Fish and Wildlife Service 2012a; Figure 2-8).

Using the habitat suitability model developed by Davis et al. (2016), approximately 26,501 acres of the plan area (32 percent) rated as highly suitable northern spotted owl habitat (Table 2-5). Combined with the approximately 8,385 acres (10 percent) of the plan area rated as suitable, up to 42 percent of the plan area is considered suitable northern spotted owl nesting and roosting habitat.

Table 2-5 presents the results of the Davis et al. (2016) model as applied to the plan area. The model value ratings do not distinguish between nesting/roosting habitat, foraging, or dispersal habitat. Based on descriptions of the model, highly suitable and suitable nesting/roosting habitat is most likely to provide nesting and roosting habitat, marginal nesting/roosting habitat in the model is more likely to provide foraging habitat, and unsuitable nesting/roosting modeled habitat could be dispersal and/or non-habitat.

Because of inherent uncertainty in the modeling data, 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, 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 located within reserves and other non-commercial forest areas. Factors such as age, patch size, and connectivity have been incorporated in the impact of the taking analysis and determinations presented in Chapter 4.

Table 2-5. Modeled Northern Spotted Owl Habitat

Modeled Value[1]	Permit Area (acres)[1]	%	Plan Area Outside of Permit Area[2]	%	Total Plan Area[1]	%
Highest	26,501	32%	2,034	21%	28,535	31%
Moderately Suitable	8,385	10%	961	10%	9,346	10%
Marginal	18,653	23%	3,060	31%	21,713	24%
Lowest	28,839	35%	3,751	38%	32,590	35%
	82,379		9,806		92,185	

Source: based on Davis et al. 2016; see also Figure 2-9.

[1] Based on Davis et al. 2016. For this assessment, areas rated and mapped as "highly suitable" and "suitable" by Davis were considered suitable roosting and nesting habitat, while areas rated and mapped as "marginal" were considered suitable foraging habitat. Forests classified as "unsuitable" were considered dispersal and/or non-habitat. Marginal nesting/roosting habitat is assumed to be suitable foraging and dispersal habitat (suitable and highly suitable habitats are also considered dispersal habitat). Acres described in text added acres of highly suitable and suitable.

[2] Acreages do not match exactly with permit/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 ESRF.

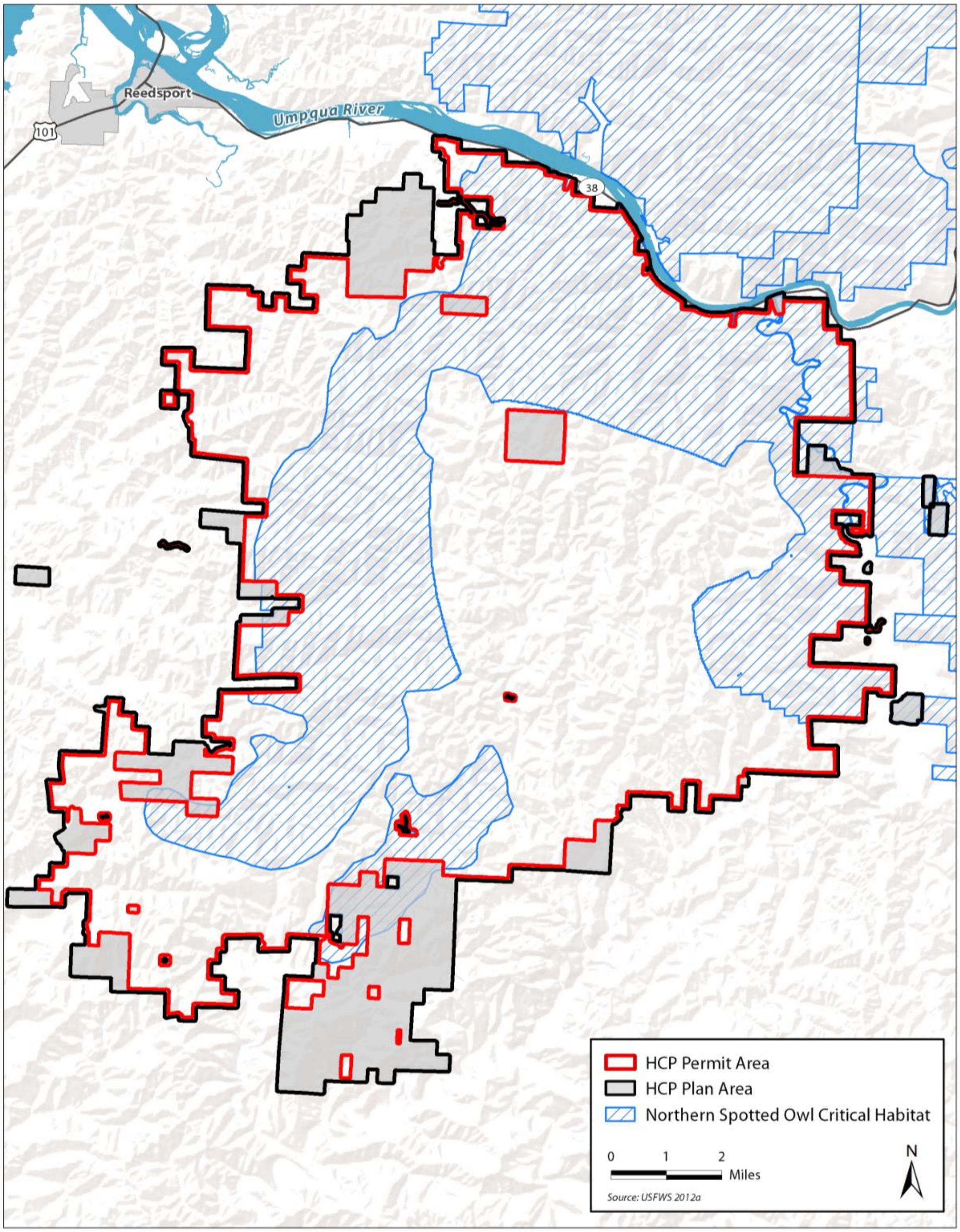


Figure 2-8. Northern Spotted Owl Critical Habitat Within the Plan Area

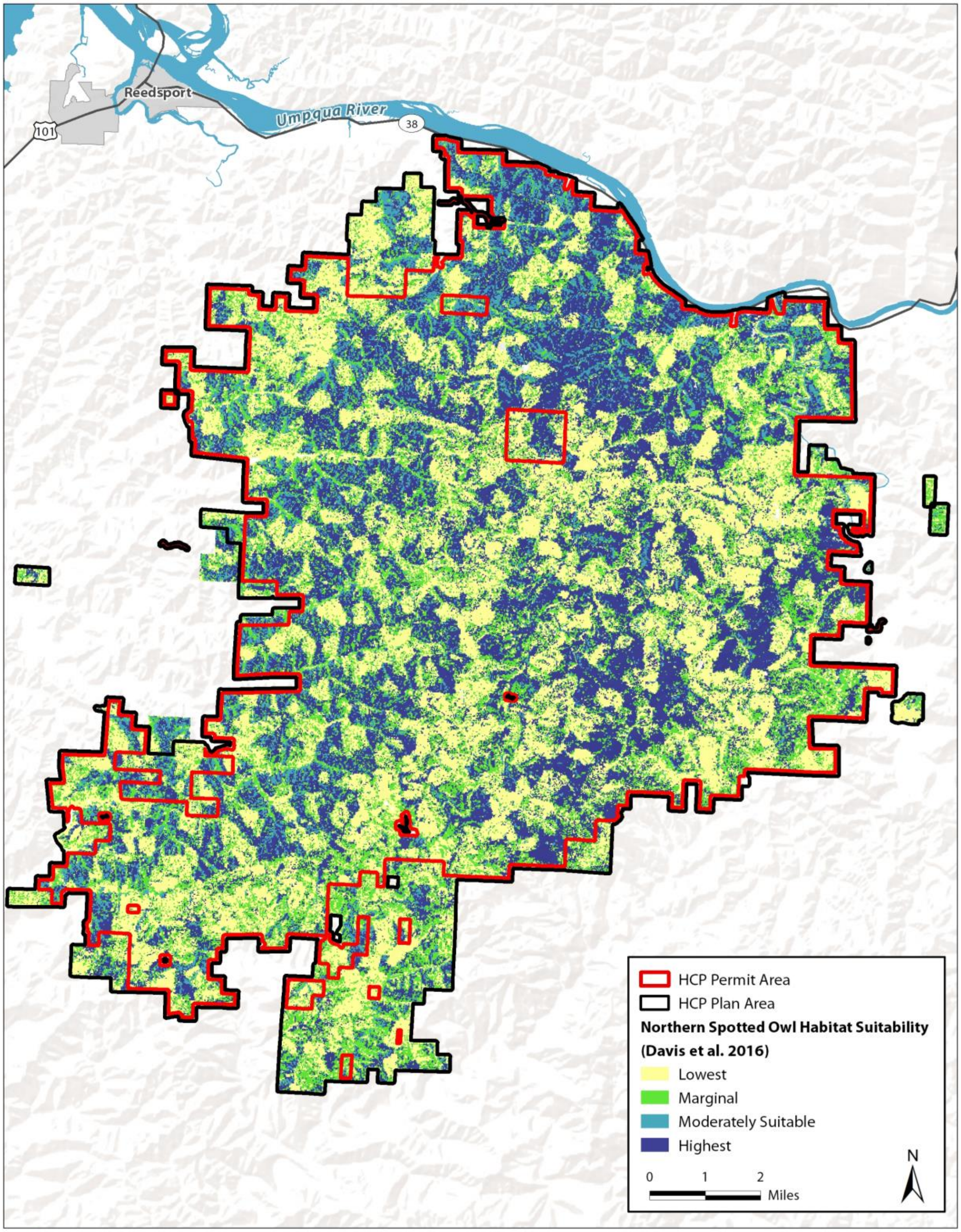


Figure 2-9. Northern Spotted Owl Habitat Suitability (Davis et al. 2016)

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 within the plan area (U.S. Fish and Wildlife Service 2016). 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 the Oregon Department of Fish and Wildlife (ODFW) (2019a), 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). The most recent and 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 inland 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.

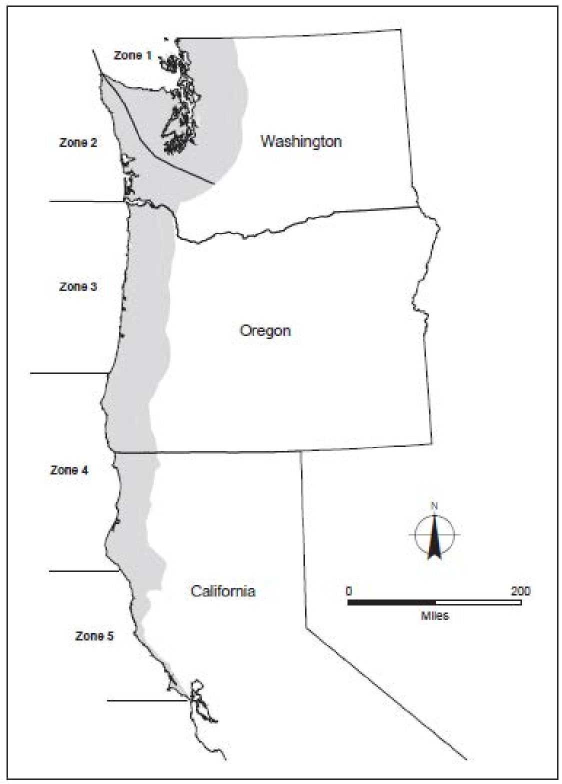
2.4.2 Population and Habitat Status

2.4.2.1 Rangewide Status

Populations

USFWS has designated five recovery zones for marbled murrelet, ranging from San Francisco Bay to the Canada border with Washington State (Figure 2-10). Falxa and Raphael (2016) reported marbled murrelet population estimates in each zone as follows.

- 7,600 marbled murrelets in the Strait of Juan de Fuca, San Juan Islands, and Puget Sound in Washington (Zone 1).
- 2,000 marbled murrelets on the outer coast of Washington (Zone 2).
- 7,600 marbled murrelets from Coos Bay, Oregon, north to the Columbia River (Zone 3, which includes the HCP plan area).
- 6,600 marbled murrelets from Shelter Cove, California, north to Coos Bay, Oregon (Zone 4).
- "Few" marbled murrelets remaining from San Francisco Bay north to Shelter Cove, California (Zone 5).



Source: Falxa and Raphael 2016

Figure 2-10. Marbled Murrelet Recovery Zones

At the state scale, Falxa and Raphael (2016) found populations to be declining in Washington (4.6 percent decline per year), but no evidence of a trend in Oregon or California.

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.

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 percent 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).

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 the Bureau of Land Management. 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 percent 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-approved survey protocol (Evans Mack et al. 2003). The survey data does 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 within 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 2-11).

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 (656 feet) radius 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 percent of the survey sites (5,479), presence was detected in 17 percent of the sites (1,172), and “significant observations” indicating nesting were detected in 4 percent (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 does 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 Oregon State University (OSU), has conducted surveys in the Elliott State Forest using similar protocols (Oregon State University 2021). Based on those surveys, 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 ODF data in a process described in Appendix 11 of the OSU 2021 study. The combined areas where marbled murrelet significant (below-canopy) behaviors were observed were combined into an "occupied" data layer shown in Figure 2-11.

Habitat

The most recent designation of marbled murrelet critical habitat by USFWS only included a few acres (<5) within 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. (2020a) 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, thereby more accurately representing habitat based on actual use within the plan area. The amount of modeled habitat within the permit and plan areas is presented in Table 2-6. Figure 2-11 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 2-6. Modeled Marbled Murrelet Habitat in the Plan Area and Permit Area

Modeled Value	Permit Area (acres)[1]	%	Plan Area Outside of Permit Area[1]	%	Total Plan Area[1]	%
Designated Occupied	21,475	26%	0	0%	21,475	23%
Modeled Potential	16,354	20%	2,651	27%	19,005	21%
Non-Habitat	44,713	54%	7,161	73%	51,874	56%
TOTAL	**82,542**	**100%**	**9,812**	**100%**	**92,354**	**100%**

Source: based on Oregon State University 2021

[1] Acreages do not match exactly with permit/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.

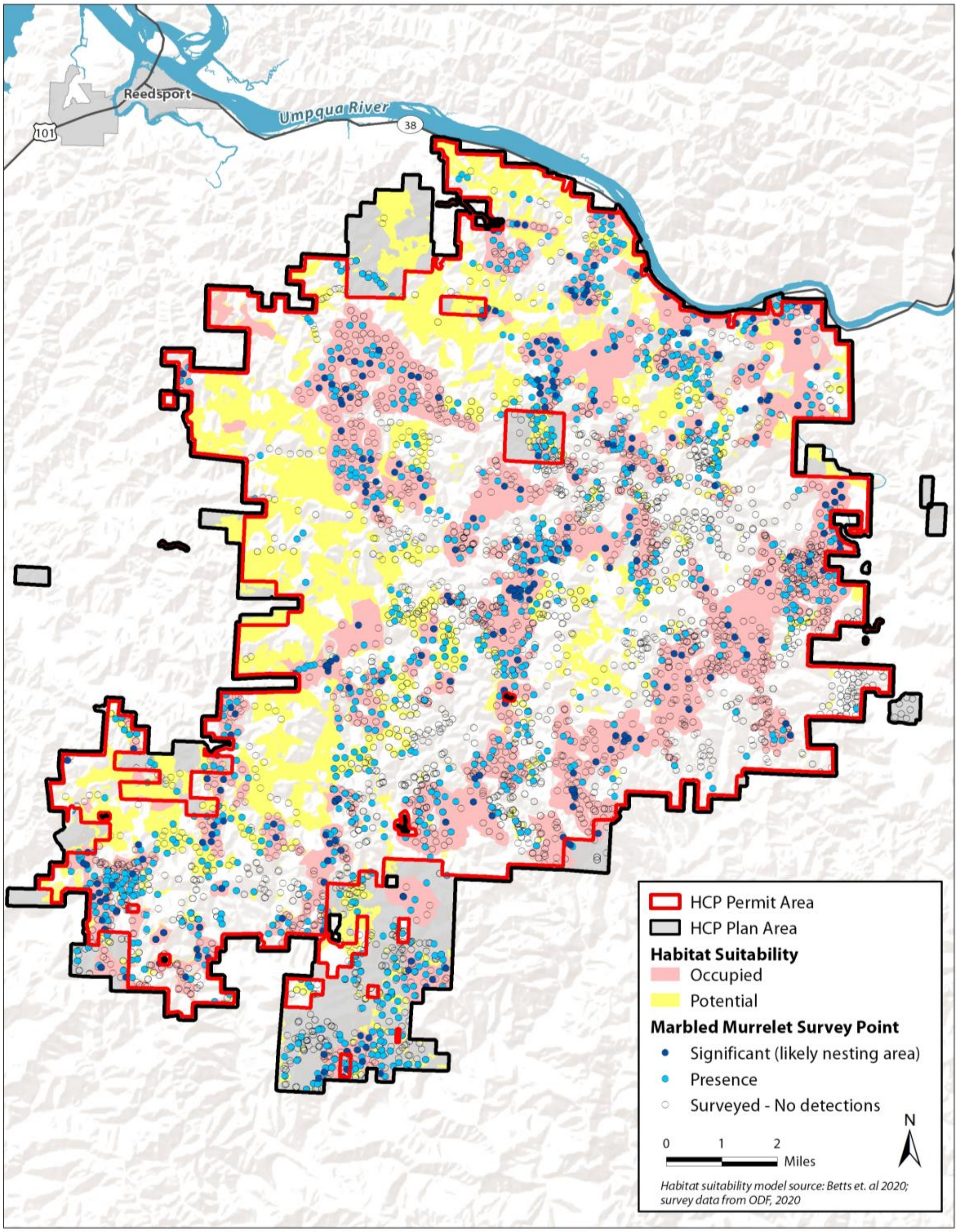


Figure 2-11. Marbled Murrelet Survey Results from 1994 – 2019 and Modeled Habitat*

* As described in OSU's Research Proposal (2021, Appendix 11), historically occupied stands were determined based on marbled murrelet occupancy surveys conducted by S.K. Nelson and ODF.

2.5 Coho Salmon

The Oregon Coast coho salmon (*Oncorhynchus kisutch*) evolutionarily significant unit (ESU) is one of 19 ESUs and distinct population segments of salmon and steelhead in the Pacific Northwest listed as threatened or endangered under the ESA. 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 the adverse effects of natural environmental variability from drought, floods, and poor ocean conditions have been exacerbated by the degradation of habitat by human activities. A subsequent status review by the Northwest Fisheries Science Center in 2015 found that risks posed by hatcheries and fisheries had been greatly remedied (Northwest Fisheries Science Center 2015). NMFS concluded in its 5-year status review that continued threats from habitat degradation and climate change remain factors affecting the ESU's long-term status and, concluded that the Oregon Coast coho salmon ESU should remain listed under the ESA as threatened (National Marine Fisheries Service 2016).

A federal recovery plan for the Oregon Coast coho salmon ESU was finalized in December 2016 (81 FR 90780). The plan provides guidance to improve the viability of the species to the point that it meets the delisting criteria and no longer requires ESA protection. The primary threat identified in the recovery plan is deteriorating freshwater habitat conditions and a concern that existing voluntary and regulatory mechanisms are inadequate to protect and recover Oregon Coast coho salmon (National Marine Fisheries Service 2016).

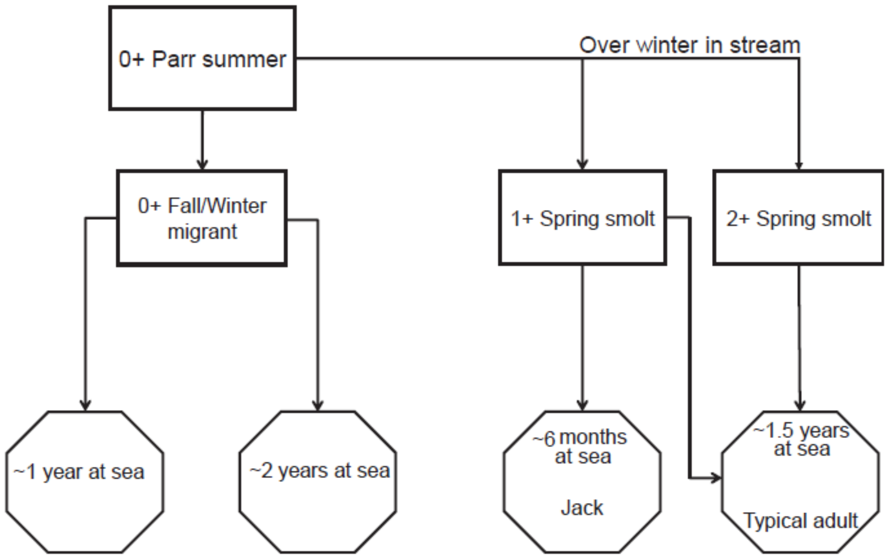
The Oregon State Coast Coho Conservation Plan (Oregon Coho Plan) was approved by the Oregon Fish and Wildlife Commission in 2007 prior to final listing under the ESA (Oregon Department of Fish and Wildlife 2007). The Oregon Coho Plan addresses the legal requirements for conservation planning under Oregon's 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.

2.5.1 Biology and Ecology

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 2-12 provide a summary.

Coho typically have a 3-year life cycle. The freshwater life cycle in Oregon Coast streams is 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 2-12). 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. 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 percent of the juveniles from a given brood year were fall migrants (migrated to saltwater between early October and end of December).



Source: Bennett et al. 2015.

Figure 2-12. Coho Life History Pathways

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.

Beaver (*Castor canadensis*)-related habitat such as ponds and slow-moving water provide important rearing habitat for juvenile coho. Widespread commercial trapping in the 19th century resulted in declines in the beaver population. Today, beaver populations have rebounded, but are not what they were historically. 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). Pollock et al. (2004) found that smolt production increases significantly in systems where beavers are present. Recent restoration work tends to rely on large wood to create salmon-rearing habitat. A more cost-effective measure that would create the same types of pool habitat required by juvenile coho would be to introduce or promote new or existing populations of beaver (Pollock et al. 2004). Increasing the number of beaver dams in key areas would create high-quality rearing habitat that promotes stream complexity and increases smolt capacity (Oregon Department of Fish and Wildlife 2007).

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[3] 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 habitat 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 will 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) (Mason 1976; Ptolemy 1993; Ward et al. 2003). More productive streams tend to support higher densities of juvenile salmon.

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. However, the effect of summer low flow on survival and freshwater smolt abundance may be overwhelmed by the quantity of favorable overwinter habitat for coho salmon. 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

The presence of wood in streams is loosely correlated to 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.

[3] The ability to sense the presence of a tributary using olfactory, temperature, or velocity gradients.

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 Temperature

Lestelle (2007) summarized several studies on effects of water temperature on juvenile coho. A study in the Mattole River (Northern California) reported coho were not found in streams warmer than a maximum weekly temperature of 18 degrees Celsius (°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). 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. 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.

2.5.2 Population and Habitat Status

2.5.2.1 Rangewide Status

It is estimated that coho have been extirpated from approximately 46 percent of their historic range in North America and 3.5 percent of their original range in western Oregon and northern California (Botkin et al. 1995). 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).

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 2016). Since 2001, the number of adult coho spawners averaged 177,920 fish. There has been a decline in abundance since 2015; from 2015 to 2017 the number of coho salmon spawners across the ESU has been less than 100,000 fish. The recent decline is likely because of low ocean survival and possibly freshwater conditions during egg incubation and juvenile residence (National Marine Fisheries Service 2016).

Primary limiting factors of concern across the ESU are the loss of stream complexity and disconnected floodplains affecting juvenile survival, with special concern for overwinter habitat for juvenile coho (National Marine Fisheries Service 2016). Flitcroft et al. (2017) found that while instream habitat conditions are important, the ability for coho to move between different habitat types required by their life history may be more important for increasing fish density. Also of concern are issues of degraded water quality and water temperature at specific locations and fish passage barriers limiting access to freshwater and estuarine habitats.

2.5.2.2 Independent Populations in the Permit Area

The plan area includes portions of three coho stratums within the Oregon Coast coho ESU: Lakes, Umpqua, and Mid-South Coast (Figure 2-13). Miles of streams with ODFW documented or assumed coho salmon presence within the plan area, by independent population, are summarized in Table 2-7. Stout et al. (2012) calculated an overall ranking of relative health for all five stratums within the Oregon Coast coho ESU. Each complex was reviewed based on viability, abundance, and productivity. For the five stratums reviewed, the top three in this ESU were Lakes, Coos, and Umpqua. The condition of each stratum, as it relates to the overall recover of the ESU, is described below.

- The Lakes stratum consists of three independent coho populations. The Tenmile population is the only population within this stratum that includes portions of the plan area. Approximately 18 stream miles are in the plan 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 plan area encompasses approximately 20 percent of the range of the Tenmile population (Table 2-7), making contribution of coho from the plan area to the overall Tenmile population important for the persistence of this population.
- Monitoring trends analysis done by Kara Anlauf (ODFW) concluded that the ESU's streams are generally pool rich but structurally simple, mean values of the monitored attributes are all low, there are few off-channel habitats or beaver pools, and most streams have low volumes of wood and high fine sediment (Stout et al. 2012).

Table 2-7. Miles of Coho Salmon Known or Presumed Coho Salmon Presence in the Elliott State Research Forest Plan Area

	Stream Miles with Known or Presumed Coho Salmon Presence		
Biogeographic Stratum and Population	**Total Stream Miles in Independent Population**	**Miles Within Plan Area**	**Percent of Total Independent Population Stream Miles Within Permit Area**
Lakes Stratum			
Tenmile Lake	90	18	20%
Umpqua Stratum			
Lower Umpqua River	610	19	3%
Mid-South Coast Stratum			
Coos River	483	54	11%
Total	**1,183**	**91**	**8%**

Source: Oregon Department of Fish and Wildlife 2019b.

- 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 plan area. Approximately 19 stream miles are in the plan area in the Lower Umpqua population (Mill Creek, Charlotte Luder, Dan Johanneson, and Schofield Creek management basins). While the contribution of coho from the plan area to the Lower Umpqua population is relatively small (3 percent; Table 2-7), production of coho in the plan 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 plan area. Approximately 54 stream miles are in the plan area in the Coos population (Palause Larson, Henrys Bend, Marlow Glenn, Millicoma Elk, and Trout Deer management basins). The plan area represents approximately 11 percent of the range of the Coos independent population; production of coho in the plan area will benefit the Coos population and overall ESU.

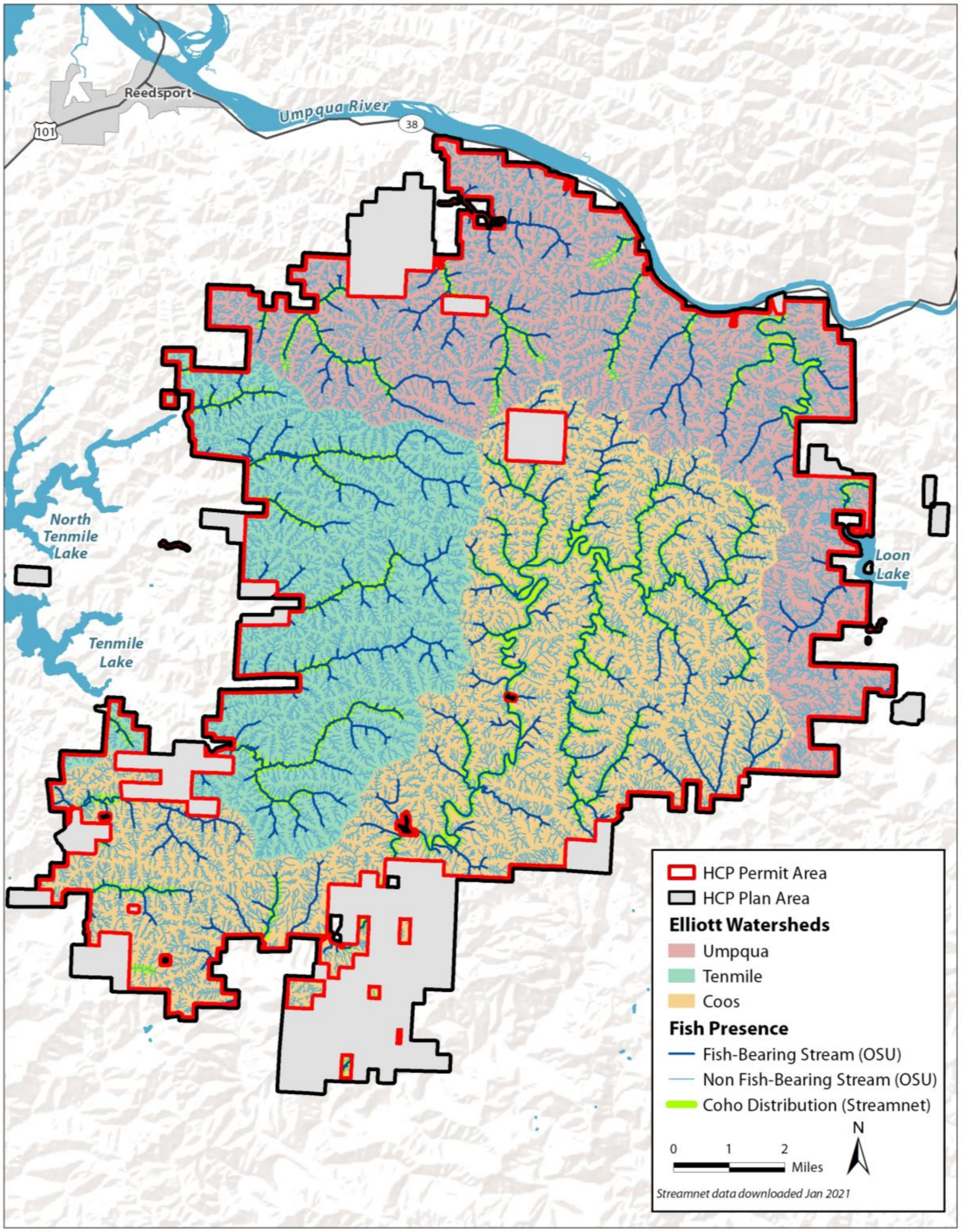


Figure 2-13. Coho Distribution in the Permit Area

2.5.2.3 Contributions of the Permit Area

Spawner abundance data for the independent populations in the permit area indicate that, while the Elliott State Forest is in a unique position to contribute to three independent populations, there is limited capacity to do so based on habitat quality and watershed position. ODFW reports coho spawner abundance by independent population within the ESU (1994–2017; Oregon Department of Fish and Wildlife 2018b). The three independent populations associated with the permit area have ranged from 1 to 21 percent of the total ESU spawner abundance by population. Combined the three populations have ranged from 14 to 44 percent of the total ESU spawner abundance.

Table 2-8 summarizes the average number of coho spawners per mile and range of estimates for the 10 annual survey reaches in the plan area.[4] The number of coho per mile is estimated using the area-under-the-curve technique 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 in management basins that are part of the Coos population ranged from 16 to 135 coho per mile (see Table 2-8). Average densities for the last 10 years (2008–2017) ranged from 11 to 151 coho per mile in the same survey reaches. Surveys were less frequent in management basins that are part of the Tenmile coho population. Average densities 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. Only one management basin that is part of the Lower Umpqua Basin has annual surveys in the plan area. The density 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 reported in Sounhein et al. (2017). Coho densities in management basins that are part of the Tenmile population are high relative to other coastal Oregon streams. Densities in management basins that are part of the Coos and Lower Umpqua populations are approximately the same as reported for other coastal populations.

The ESRF will contribute to the recovery of Oregon Coast coho directly and indirectly. The ESRF has a limited potential to increase numbers of coho salmon that would contribute to the ESU recovery because steep streams and narrow valleys dominate it. Such settings generally have a limited potential to provide productive habitat for coho salmon. However, there are some areas on the ESRF that have habitat conditions where coho salmon numbers are relatively strong. The contribution of these local populations may be important for the associated independent populations (Lower Umpqua, Tenmile, and Coos). The most significant contribution of the ESRF to the recovery of Oregon Coast coho is the production and export of wood, sediment, high-quality water, nutrients, and food to the lower portions of watersheds outside of the ESRF, where the potential for productive habitats and the increases in fish numbers is greatest. The ESRF will support the recovery and conservation efforts for the three independent coho populations that occur within the permit area.

[4] 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.

Table 2-8. Coho Spawner Survey Fish per Mile by Survey Reach Within the Plan Area

		Annual Surveys (1998–2017)		Annual Surveys (2008–2017)	
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)
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 et al. 2017.

Note: 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 the Oregon Department of Fish and Wildlife.

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.

A coho Habitat Limiting Factors Model was used to evaluate potential carrying capacity of streams. The Habitat Limiting Factors Model evaluates the quantity 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. The second model is a HabRate model, which is used to evaluate the quality of habitat for coho. 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. Within 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 quantity and 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 percent forest-wide. Thirty surveyed reaches covering 40 kilometers (~25 miles) in the Tenmile Lakes region averaged 18 percent 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 percent fine sediment, and the Coos basin averaged 13 percent fine sediment in 117 reaches over 206 kilometers.

Kavanagh et al. (2005) concluded barriers do not appear to be major issue to coho in the Elliott State Forest. However, they note that data on migration barriers is limited and recommended additional surveys.

Chapter 3
Covered Activities

3.1 Introduction

This chapter describes the covered activities for which the Permittee (the Oregon Department of State Lands [DSL]) will receive take coverage for management of the Elliott State Research Forest (ESRF).

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

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

The covered activities described in this chapter broadly correspond to activities regulated through the Oregon Forest Practices Act (Oregon Revised Statues 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 the potential to cause incidental take.

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 on the research forest in enough detail that they can be analyzed in Chapter 4, *Effects Analysis and Level of Take*.

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 Section 7.6, *Modifications to the HCP*, for details on the amendment process. The Permittee would also have the option of conducting those activities under take avoidance or under a separate permit under the federal Endangered Species Act (ESL).

DSL will oversee the covered activities and as the Permittee, will be responsible for ensuring activities are implemented in alignment with the HCP and permits. 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 (see Section 7.5, *Adjustments to Stay-Ahead*).

The following sections describe the HCP covered activities in terms of the following categories and topics:

- 3.2, *Foundational Research Design of the Elliott State Research Forest Proposal*
- 3.3, *Stand-Level Operation Standards, by Research Treatment Designation*
- 3.4, *Harvest Timing, Types, and Methods*
- 3.5, *Supporting Management Activities*
- 3.6, *Supporting Infrastructure*
- 3.7, *Potential Research Projects*
- 3.8, *Covered Activities Related to Conservation Measures and Implementation*

For context, the chapter begins with an overview of the research program design and allocation of research treatments across the watersheds of the Elliott State Forest. The chapter ends with a discussion of activities not covered by the HCP (Section 3.9).

3.2 Foundational Research Design of the Elliott State Research Forest Proposal

3.2.1 Overview of Research Proposal and Relationship to Covered Activities

As described in Chapter 1, *Introduction*, the ESRF will be managed under the research design described in the Elliott State Research Forest Proposal (Oregon State University 2021; Appendix D). The research proposal is a foundational document that will direct the transformation of the Elliott State Forest into a publicly owned state research forest.

A key element of the research proposal related to covered activities is that the proposal establishes long-term treatment designations for lands within the permit area. These long-term designations are central to the research design, because holding operational management constant over time creates certainty for researchers and allows for the long-term studies that are essential for understanding long-lived forests. This is something impossible to accomplish using lands that are not designated as research forests.

The treatment designations establish the long-term management direction and associated timber harvest design and resulting forest stand condition and future growth trajectories. Specifically, as described in Section 3.3, *Stand-Level Operations Standards, by Research Treatment Designation*, each treatment designation includes operations standards that will direct timber harvest design specifications within those allocations, with tree retention standards being one of the most important specifications related to habitat effects on covered species.

Details regarding the research design can be found in Appendix D or the research proposal, which is incorporated by reference here. The following sections describe the basic elements of the research proposal and associated covered activities.

3.2.2 Establishment of Conservation and Management Research Watersheds

The experimental units for the research design are subwatersheds 400 to 2,000 acres in size. The 66 subwatersheds present in the permit area are designated to be either Conservation Research Watersheds (CRWs) or Management Research Watersheds (MRWs). These subwatersheds are collectively referred to as "the CRW" and "the MRW." Subwatershed allocations were optimized to avoid known harvesting of stands that predate the 1868 fire. There are approximately 400 acres or 0.5 percent 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.

At 34,140 acres, the CRW anchors the conservation strategy integrated into the research design by establishing a contiguous reserve within an area containing important habitat and presence of covered species on the ESRF. This area is to be 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 research treatment designations (to be described in detail later) totaling 48,380 acres: intensive (14,334 acres), extensive (13,413 acres), reserve (14,096 acres), and Riparian Conservation Areas (6,538 acres). These designations follow attempts to reconcile conservation, production, and other objectives on forest lands that 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 (Oregon State University 2021). These are generally defined as follows.

- **Reserve areas** are managed for biodiversity conservation, which often means no silvicultural interventions or interventions that are limited only to that which will improve biodiversity and related attributes.
- **Extensive forestry operations** are typically characterized by partial retention, minimal use of external inputs, more time between harvests, and reliance on natural tree regeneration.
- **Intensive forestry operations** are those of traditional production forestry commonly applied on private timber lands. Intensive forestry is typically characterized by plantation-based timber production, with shorter time between harvests. Intensive forestry includes tree planting, use of herbicide to control competing vegetation, thinning, and fertilization.
- **Riparian Conservation Areas** (RCAs)are also defined in the research proposal as an additional designation due to the unique management requirements and research needs for riparian habitats.

The research proposal builds on these basic definitions to define more specific definitions and operations standards for each of these treatment designations (described in detail in Section 3.3).

Figure 3-1 illustrates the distribution of these permanent research treatment designations; 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.

The research proposal outlines a "Triad" research design that provides a framework for exploring the complex tradeoffs and synergies between commercial forest production and other public values, including endangered species conservation. The framework operates at the subwatershed level—meaning that subwatersheds within the MRW will be assigned to one of the four following subwatershed research treatment categories.

- **Extensive treatments** would be 100 percent extensive stand management across the entire subwatershed.
- **Triad-E treatments** would have 60 percent of the subbasin acreage in extensive, 20 percent intensive, and 20 percent reserve stand management.
- **Triad-I treatments** would have 20 percent of the subbasin acreage in extensive, 40 percent intensive, and 40 percent reserve stand management.
- **Reserves with intensive treatments** would have 50 percent of the subbasin acreage in intensive and 50 percent reserve stand management.

This framework will only be applied on subwatersheds that are greater than 400 acres and completely contained within the MRW. Approximately 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. These partial watersheds are still designated as intensive, extensive, reserve, and RCA (see Figure 3-1)—and will be managed as such—but are not part of the four subwatershed treatment framework just described (a minor point when considering effects).

The research design allocations are a covered activity that. while purely administrative in nature, will nevertheless drive the stand-level research treatments and associated covered activities that are expected to result in take of covered species. Other covered activities described later in this chapter—such as harvest and supporting management activities like road construction or riparian restoration projects—define and describe the specific covered activities that will result in direct, physical alterations to habitat or otherwise affect covered species.

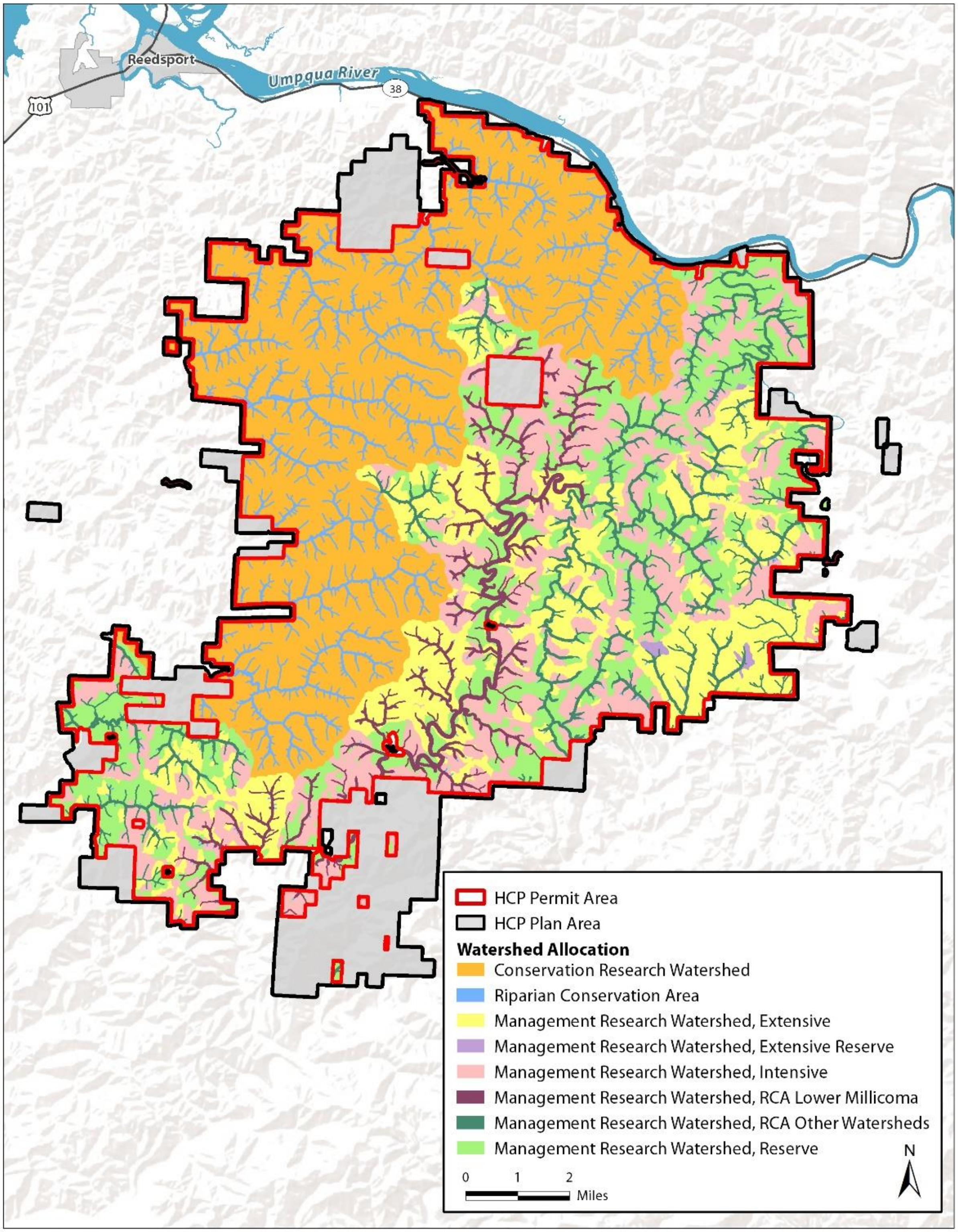


Figure 3-1. Subwatershed Research Treatment Allocations

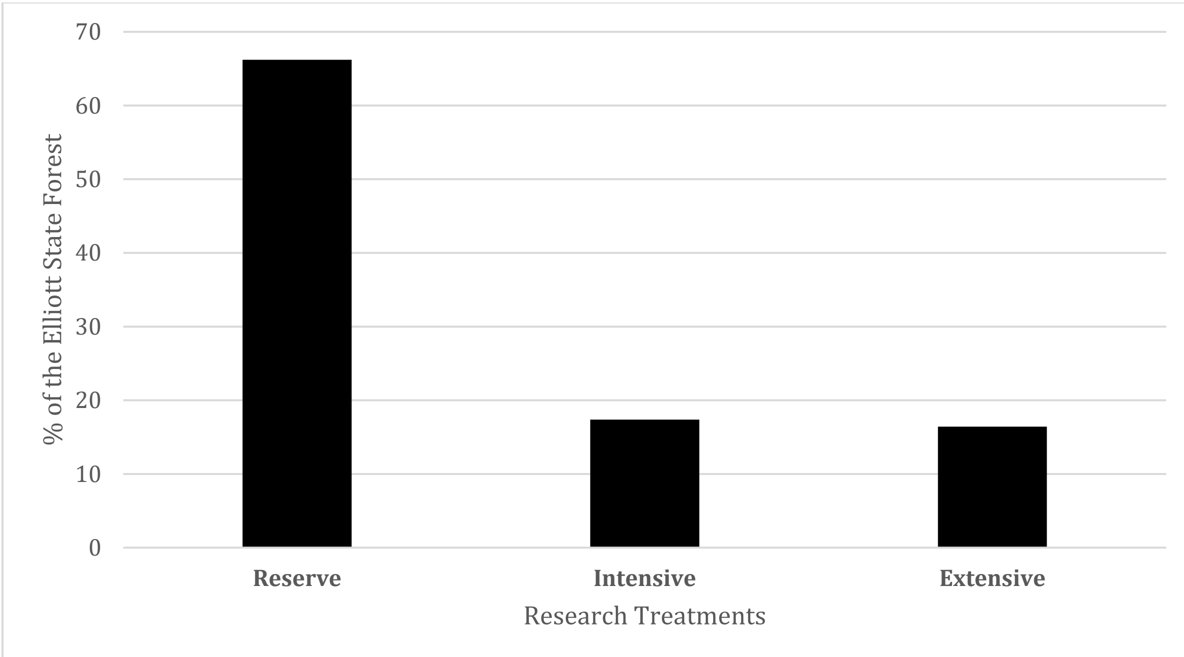


Figure 3-2a. Percentage of Elliott State Research Forest Allocated to Each Stand-Level Research Treatment (Includes CRW and MRW)

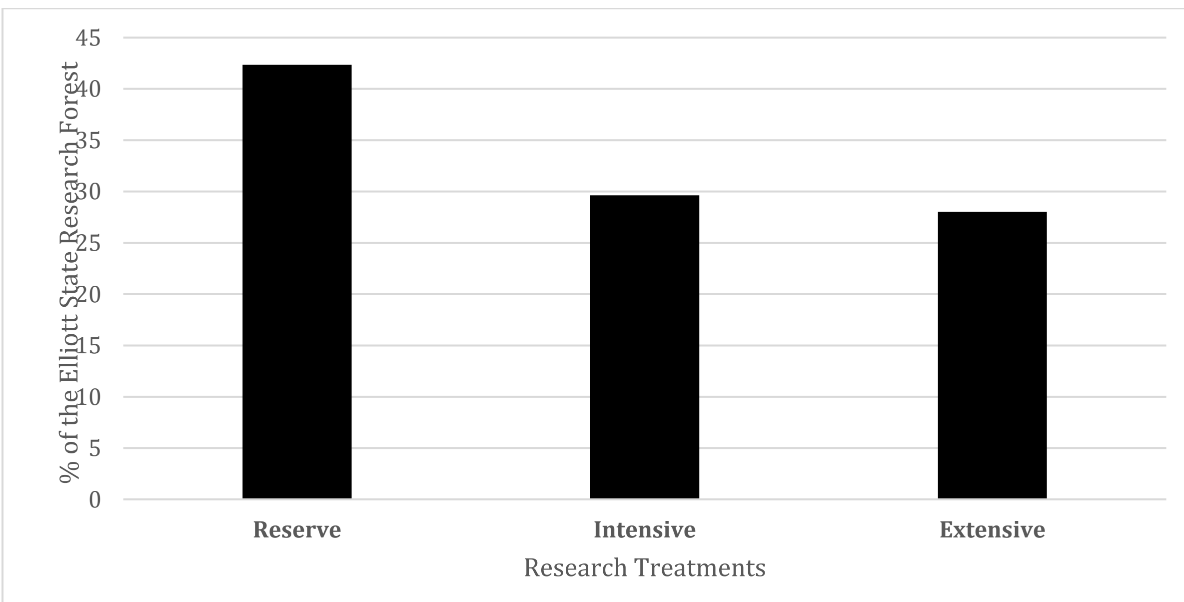


Figure 3-2b. Percentage of Elliott State Research Forest Allocated to Each Stand-Level Research Treatment (MRW only)

3.3 Stand-Level Operations Standards, by Research Treatment Designation

As noted, the research framework will include a Triad design that will test the three experimental treatments (reserve, intensive, extensive) arrayed in various spatial and temporal configurations, together with RCAs. The following provides a more detailed description of activities in each treatment type.

Harvest types and methods used to establish and maintain the research platform will include the full suite of thinning and harvest techniques used in contemporary forestry, as described in Sections 3.4.2 and 3.4.3. In addition, new techniques may be established, even on an experimental basis, as part of the research program. In general, the HCP will cover a variety of harvest types including precommercial and commercial thins, retention harvests, and regeneration harvest. Salvage harvest may be used at times in the MRW, should the research opportunity arise. A more detailed description of management practices in each research treatment is provided below.

3.3.1 Reserve Treatments

Reserve stand-level research treatments are areas that will not be actively harvested and consist of primarily unlogged, naturally regenerated stands. The CRW is an approximately 34,000-acre contiguous blocked reserve, while the MRW reserves (reserve and extensive reserve) and RCAs represent approximately 20,600 acres in total. These reserve treatments represent 54,600 acres, or 65 percent, of the permit area. The reserve treatments do include some former plantations, recognizing the need for a focused effort to recruit future old stands. Thus, reserve treatments will have primarily 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. Several thousand acres of the mature forests had a single-entry thinning approximately 40–60 years ago so not all of the mature reserves are unlogged. The following operational standards will be used to guide management in reserve treatments covered by the HCP (both the CRW and reserves within the MRW).

1. Retain the CRW as a contiguous reserve in the southern Coast Range.
2. Assess plantations (forests 65 years and younger) in the CRW and MRW for conservation and restoration in the first few years of implementation so that management (a single-entry restoration treatment) can be completed in the first 20 years. Management in the CRW that involves Douglas-fir plantations less than 65 years old will be aimed at accelerating late seral forest conditions.
3. Design and implement experiments during the first 20 years of implementation to explore methods for increasing the likelihood of achieving mature forest structure, which includes increasing habitat and native species diversity and creating complex early seral forests from dense single-species plantations. These experiments will take advantage of findings from various studies that investigate the possibility of accelerating development of late-successional stand structures and compositions (Bauhus et al. 2009), including Demonstration of Ecosystem Management, Density Management Study, Young Stand Thinning and Diversity Study, and

others. For a summary of studies, see Monserud (2002), and Poage and Anderson (2007). 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 desirable understory vegetation; planting in gaps or in the understory to encourage species diversity; or removal of invasive species. All activities will follow the other operations standards for reserve treatments.

4. 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.
5. The timing of the treatments will depend upon the experimental design and stand age; however, anticipate the experimental treatments will be completed in the CRW in approximately two decades. The MRW may take longer, given the stepwise implementation, and is anticipated to occur as needed to support research objectives over the permit term.
6. Following initial treatments, no additional logging or development of infrastructure will occur.
7. Natural disturbances such as fire, drought, disease, wind, and insects will occur without salvage. However, if an introduced insect or disease is found in reserves, there may be attempts to control it by removing dead trees.
8. Suppress all fires but will not salvage if mortality does occur.
9. Potentially thin RCAs on a limited basis to reduce density and promote the development of healthy native riparian ecosystems.

Examples of research concepts and outcomes associated with reserve treatments are described by Oregon State University (OSU) (2020: Appendices 2 and 3).

3.3.2 Intensive Treatments

Currently, 42,000 acres of the forest are Douglas-fir plantations, established primarily between 1955 and 2015. These stands reflect conventional even-age forestry practices over the past six decades. Intensive (production-oriented) stand-level research treatments in these forests will allow the investigation of management options that primarily 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. The following operational standards will be used to guide management in intensive treatments covered by the HCP.

1. Even-age management using clearcut harvesting techniques suitable for the terrain. Rotation age of approximately 60 years.
2. Follow all Oregon Forestry Protection Act rules except for the more stringent requirements in the riparian areas in headwalls and all streams (e.g., wider riparian buffers and more miles of streams buffered) as described in Section 3.3.4.2, *Variation in Riparian Conservation Areas*.
3. Post-harvest application of site preparation and vegetation control practices as described in Section 3.5, *Supporting Management Activities*, to ensure seedling establishment and initial growth.
4. Animal control (e.g., mountain beaver) techniques will follow Oregon Department of Fish and Wildlife (ODFW) standards and guidelines and will not involve 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 (e.g., ranges of temperature and precipitation expected).
6. Maintain stand densities at levels that provide vigorous trees and maintain high wood production through thinning operations; with typically one, but possibly two commercial thinning occurring between 30 and 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, intensive treatments may vary in rotation length, type of site preparation, and species planted. Riparian buffers will be a minimum of 120 feet[1] on fish-bearing streams and 50 feet 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. No minimum buffer will be required on XNFB streams.
9. Salvage may occur in stands affected by natural disturbances such as fire, drought, disease, wind, and insects and would follow conservation measures described in Chapter 5.
10. All activities will comply with the Oregon Forest Practices Act, and other applicable state and federal regulations, including compliance with the Endangered Species Act, through this HCP.

Examples of research concepts and outcomes that may be associated with intensive treatments are described by OSU (2020: Appendices 2 and 3).

3.3.3 Extensive Treatments

While reserve and intensive treatments provide opportunities to study management extremes, a third research treatment, extensive research treatments, will increase forest complexity to help achieve multiple values across the landscape. The purpose of these widespread dynamically managed forests will be to explore a new set of alternatives in a continuum between intensive plantation management and unlogged reserves. The research 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. This goal will be accomplished 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 a novel approach to forest management will be tested, reflecting varying social values, needs, and ecosystem function. The following operations standards will be used to guide management in extensive treatments covered by the HCP.

1. On average, extensive treatments will seek to produce harvest volumes that are approximately 50 percent of the fiber production of stands managed according to intensive experimental treatments. This means that some treatments with lower retention (20 percent) will have more than 50 percent relative yield, and those with high retention (80 percent) will have less than

[1] Horizontal distance.

50 percent relative yield. The goal is to have the yield average 50 percent at the subwatershed level as compared to the intensive harvest yields.

2. 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 individuals within younger stands that predate the 1868 fire they will be protected within extensive stands and elsewhere in the permit area. Those stands or individual trees will be identified when research experiments are designed and as research harvest activities are laid out. 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. It is recognized that due to safety issues in camp sites, logging operations, and under other circumstances trees that predate the 1868 fire may need to be removed on rare occasions. However, the Permittee is committed to the protection of the oldest forests and individual trees as part of further planning and project-level implementation of the research platform.
3. The number of live trees needed to meet various experimental goals will be retained. The retention range will be from 20 to 80 percent 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 objectives.
4. The size of the experimental units will represent the ecosystem's natural disturbance, including the appropriate mix of clumps and open patches, snags, and downed 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 classes 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. Retention areas will focus on, and retention preference will be prioritized based on, the following:
   a. A landscape analysis, that will be completed during the forest management planning process, that identifies what is limiting to the covered species as well as a variety of attributes such as biodiversity, species richness, species at risk, genetic diversity, and landscape diversity).
   b. 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. Trees will be prioritized for retention if they have features that typically support covered species.
   c. If the numbers of large standing dead and down trees are low relative to controls, ways to increase their abundance should be tested.
7. Experimental tests will be developed to determine 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.
8. A combination of factors will be used to assess and monitor the spatial pattern of retention areas 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. The variables monitored will be determined by individual research projects designed around extensive retention treatments.

9. The development of riparian forests that emulate their critical roles in natural disturbance, are fully integrated with upland management, and maintain critical ecological processes that will benefit Oregon Coast coho will be promoted.
10. Extensive treatments will be developed based on initial site-specific and landscape-level conditions to ensure each treatment is best suited to support research questions being asked.

Examples of attributes that would **not** characterize an extensive treatment are:

- 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.
- No plan for or monitoring of desired forest, riparian, or wildlife attributes.
- No landscape-level plan.

Examples of research concepts that may be associated with extensive treatments are described by OSU (2020:Appendices 2 and 3).

3.3.4 Riparian Conservation Areas

Riparian forests provide several critical functions, including large wood recruitment, controls on stream temperature, litter input, flow regimes, and reducing stream sediment loads that are important for maintaining native aquatic biota in headwater streams. The Permittee will use observational and experimental research coupled with monitoring across the permit area to explore how different management strategies affect the functions listed above and will inform future forest policy and management practices by private and public agencies across the Pacific Northwest, concerning riparian forests and aquatic ecosystems.

The focus of the 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 fixed riparian buffers, the ESRF will utilize an integrated combination of RCAs, land use allocation, and outcome-based wood delivery potential, across a range of stream types such as fish-bearing or non-fish-bearing perennial or non-perennial steep headwall or defined stream channel. By combining these methods across a range of river and stream sizes and locations in the watershed, the Permittee will provide protection and conservation of key ecological processes essential for aquatic ecosystems

The research design for the forest intends to move beyond examining the degree to which riparian buffers protect aquatic systems from wood fiber extraction and explore restoration actions designed to improve the ecological function of RCAs (including forests and associate streams)and the best size, extent, and arrangement of RCAs, reserves, intensive forest, and high-retention complex forest harvest practices to optimize wood production, aquatic protection, and other important values.

Further, because research in the ESRF is being approached from a whole-system perspective, the riparian and aquatic research program will focus on road restoration and decommissioning, recreation, harvest on steep slopes, earth movement, and natural disturbances. Upslope activities will include components to preserve their integrity and understand the resilience and resistance of associated aquatic ecosystems that are adjacent to reserves, intensively, and extensively managed forests.

3.3.4.1 Designating Riparian Conservation Areas

Research protocols call for RCAs to vary in size and configuration according to stream type and upslope research treatment (Table 3-2). Stream types reflect the presence of fish, timing of flow (perennial versus seasonal), and susceptibility to landslide-associated debris flows that deliver wood and sediment to fish-bearing streams. RCAs are delineated using the horizontal distance from the outer edge of the channel migration zone and in reference to a site potential tree height[2] of 200 feet, per local Bureau of Land Management data. The ESRF research design, in which the RCAs play a critical role, allows for varying, site-specific implementation of RCAs, with a set of standard prescriptions applied, as set forth in the following sections. The NetMap model shows the expected size of the RCA buffers based on modeled stream type and research treatment. The data will be used during harvest review; however, siting of the actual buffers for implementation will be determined by field verification.

Typically, in actively managed private and public forests in Oregon, designated riparian buffers of a given width are delineated and explicitly managed to conserve aquatic and riparian functions. The ESRF and proposed research design scale creates a unique opportunity to measure the long-term effects of varying levels of integration of RCAs with upland forests on species recovery. Approximately 65 percent of the permit area will be in reserves, where restoration thinning of approximately 14,000 acres of existing Douglas-fir (*Pseudotsuga menziesii*) plantations are proposed over the next 10–20 years (described further in Section 5.4.5, *Conservation Measure 5, Research on Northern Spotted Owl, Marbled Murrelet, and Their Habitat*) and where no harvests will occur on roughly 37,000 acres of naturally regenerated older forests. Therefore, in the near term, the aquatic, riparian, and upslope ecosystems within the unlogged reserves will be the same fully integrated system that has been in place since the last significant disturbance over 100 years ago.

RCA designations play a key conservation role in the portion of the MRW. Approximately 17 percent of the permit area will be managed using even-age clearcuts on a 60-year or greater rotation. Over time, the older, more diverse designated linear RCAs will be less well integrated with these young upslope homogenous plantations, resulting in a sharp delineation between riparian and upslope conditions (in essence, creating a linear reserve). In contrast, integration between riparian and upslope forests will be more evident in the extensive treatments on 16.7 percent of the landscape. The upslope forests will have 20–80 percent retention of pre-harvest density, which does not include the RCA, and will have trees from a variety of age and size classes, canopy complexity, and 100-year-plus rotations. This continuous tree cover and presence of an ever-aging cohort will create very different conditions relative to intensive harvest.

The proposed level of RCA protection of riparian and aquatic systems in all non-fish-bearing streams in the permit area was calculated using the number of stream miles adjacent to each land management strategy. Approximately 1,516 miles (or 86 percent) of non-fish-bearing non-perennial

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

(XNFB) streams in the permit area, from headwalls down to fish-bearing streams, are in a protected (e.g., reserves) or increased conservation status (e.g., extensive; Table 3-1), with the remaining 14 percent within intensive forest management activities allocations. All non-fish-bearing perennial (PNFB) streams and the high landslide delivery potential (HLDP) streams[3] have a minimum 50-foot buffer, where wood harvest may occur adjacent to the buffer. For additional details on fish-bearing and non-fish-bearing streams see Table 3-2. This integrated allocation with the research platform on the ESRF uses 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 and between them.

Table 3-1. Stream Miles of Non-Fish-Bearing Stream Within Each Triad Treatment Type

Triad Treatment Adjacent to Non-Fish-Bearing Streams	PNFB	HLDP	XNFB	Total
Reserves (CRW and MRW) without restoration thinning	78	43	737	858
Reserves (CRW and MRW) with restoration thinning	29	21	275	325
Extensive (20–80% retention harvest)	32	7	264	303
Subtotal of conservation and restoration miles	138	71	1,277	1,486
Intensive (clearcut 60-year rotation)	23	7	252	282
Total	**161**	**78**	**1,529**	**1,768**

PNFB = non-fish-bearing perennial streams
HLDP = high landslide delivery potential streams
XNFB = non-fish-bearing non-perennial streams

3.3.4.2 Variation in Riparian Conservation Areas

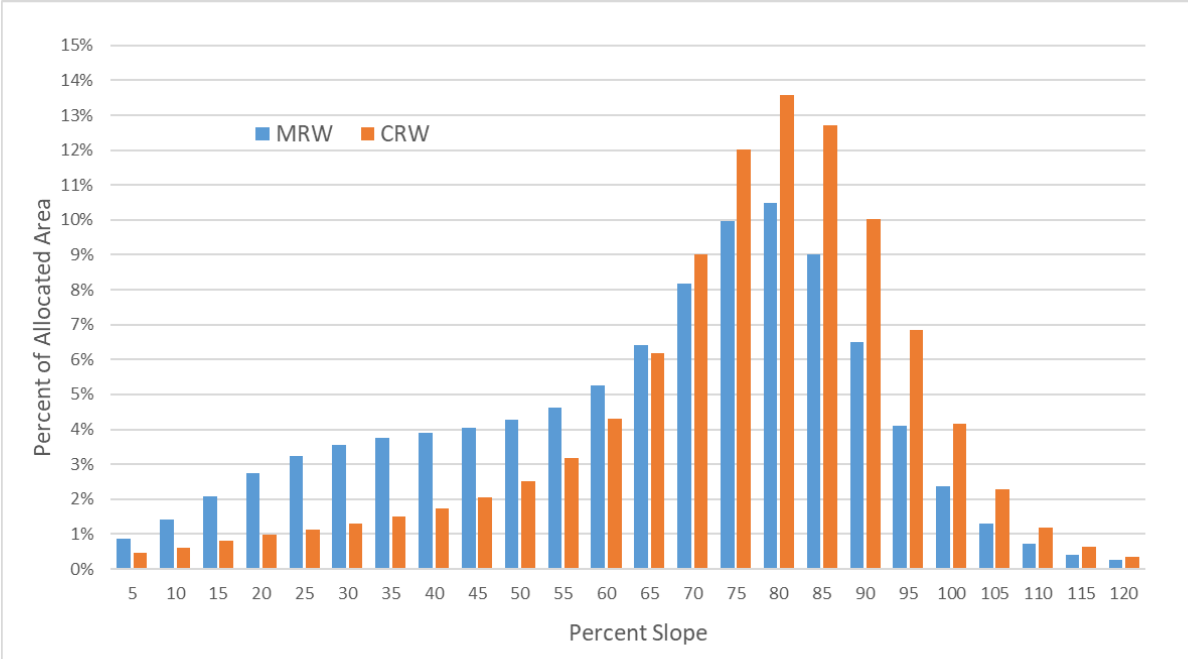
The designated sizes of the RCAs within the MRW treatments are described in Table 3-2. Widths of RCAs on fish-bearing streams range from 200 feet when adjacent to reserve stands (where there are no management activities), to 100 feet in intensive and extensive treatments (clearcut on a 60-year rotation and 20–80 percent forest retention, respectively). RCAs on non-fish-bearing perennial streams and selected landslide-prone channels (Carlson in prep.) with the greatest potential to deliver wood to fish-bearing streams are 200 feet in the reserves and 50 feet alongside intensive and extensive stands, respectively.

The level of wood delivery from RCAs in the CRW is near 100 percent, because harvest will not occur, and management will be aimed at improving forest health and habitat quality. The level of wood delivery provided by RCAs in the MRW subwatersheds is 70 percent plus despite the reduced sizes of the RCA in intensive and extensive treatment areas and limited extent of the non-fish-bearing network. Estimates for wood delivery within each Oregon Coast coho (*Oncorhynchus kisutch*) independent population are summarized in Chapter 4.

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 3-3). The riparian protection strategy is integrated with shallow translational

[3] Non-fish-bearing streams with the potential to deliver wood to fish-bearing streams.

landslide probabilities in non-channel areas and is conceptually based on identifying and prioritizing for protection those slopes and stream channels most likely to initiate and sustain a debris torrent that delivers large wood to fish-bearing streams.



Vertical axis values refer to the percent of MRW area and percent of CRW area, not percent of total ESRF area.

Figure 3-3. Distribution of Classified Hillslope Gradient Across the MRW and the CRW

Initially, specific size and configuration of the different RCA components in the respective stream types will depend on the level of potential wood delivery needed to attain the MRW outcomes-based wood recruitment objective, by independent coho population, as described in *Objective 3.1: Promote Recruitment of Large Woody Debris*, in Chapter 5. Table 3-2 describes the widths and stream miles within each of the four 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, supports the 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 (minimum of 70 percent, which was the estimated potential for the Olympic Experimental State Forest HCP [Washington State Department of Natural Resources 2016]). This is the reason for a range of RCA widths of 100–120 feet for the fish-bearing portion of streams outside the lower Millicoma. In watersheds where RCAs are 100 feet wide, increased riparian protection would be allocated to the HLDP portions of the stream network in order to attain the target level of wood delivery and to ensure areas with a high potential for failure will have trees in place for soil stability and root strength (see Chapter 5). This also provides researchers a means to consider other factors (e.g., wildlife, operational efficiency) in designing an efficient and effective protection network.

Table 3-2. Widths and Approximate Number of Modeled Stream Miles by Stream Protection Zone (measured in horizontal distance)

Stream Protection Class	RCA Width (feet)[1]	CRW[2]	MRW Lower Millicoma Watersheds	MRW Other (full watersheds)	MRW Other (partial watersheds)	Total
		Miles of Stream				
FB[3]	100	0	0	74	0	74
FB[3]	120	0	43	0	15	58
FB[3]	200	87	16	0	0	103
PNFB[4]	50	0	38	49	24	111
PNFB[4]	200	67	0	0	0	67
HLDP[5]	50	0	0	15	5	20
HLDP[5]	120	0	9	0	0	9
HLDP[5]	200	48	0	0	0	48
Total RCA miles		**202**	**106**	**138**	**44**	**490**
XNFB[6]	See note [6]	680	308	434	174	1,596
Grand Total		**882**	**414**	**572**	**218**	**2,086**

[1] As measured from the edge of the aquatic zone. Buffer will be applied to both sides of the channel.

[2] While RCAs in the CRW are reported here as 200 feet, effectively they are buffered even beyond that, as the activities occurring in the CRW and MRW reserves are limited to conservation thinning of stands less than 65 years old.

[3] FB = fish-bearing stream.

[4] PNFB = perennial non-fish-bearing stream not otherwise protected as a non-fish-bearing stream that would not deliver wood to fish-bearing streams.

[5] HLDP = high landslide delivery potential non-fish-bearing stream; may be either perennial or non-perennial.

[6] XNFB = non-fish-bearing streams that are neither HLDP nor PNFB. Approximately 84% of non-fish-bearing streams on the ESRF, from headwalls down to fish-bearing streams, are in a protected or increased conservation status (CRW, MRW reserves, or extensive allocation with ecological forestry). XNFB streams located in the CRW, MRW reserves effectively have a buffer that goes beyond 200 feet, as the activities occurring there are limited to conservation thinning of stands less than 65 years old. The remaining 16% are located in areas where at least one side of the stream is adjacent to an intensive allocation. In those cases the opposite side of the stream may also be in an intensive allocation or it may be in a reserve, MRW reserve, or extensive allocation with ecological forestry.

3.3.4.3 Role of Wood Recruitment

Modeled potential large wood recruitment to fish-bearing streams will be used 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 potential wood recruitment for its specific value as creating habitat for the covered 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 channels, episodic debris flows can deliver substantial quantities of accumulated large wood to fish-bearing streams. However, not every non-fish-bearing tributary has the same potential to deliver wood.

Therefore, treatment of the riparian system will be integrated with the upslope forests' treatments to ensure water quality and fish habitat as follows. Steps 1–3 in the following list were completed during the HCP planning process and Steps 4–7 will be completed during completion of the Forest Management Plan, prior to HCP implementation. These steps will continue to be evaluated during

HCP implementation, as the RCAs are laid out during research projects or ahead of harvested activities. Implementation of these objectives will be summarized in annual reports, as well as subsequent 6-year and 12-year comprehensive reports.

1. Set established wood recruitment goals for each of the three independent coho populations in the permit area (Chapter 5, Objective 3.1).
2. Identify and classify non-fish-bearing streams according to their potential for wood recruitment to fish-bearing streams. Tributaries and headwalls with high potential for wood recruitment and other conservation components were identified (*ElliottSFWood* model).
3. Calculate site potential tree height and width of the riparian buffer needed to ensure a desired level of wood delivery to the fish-bearing stream.
4. Overlay potential reserves, intensive, and extensive treatments, and adjust to better integrate reserves and extensive with non-fish-bearing streams with high potential for wood recruitment. Reserves, extensive treatments, and RCAs 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. See Chapter 6 for monitoring and reporting schedule.
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 fish-bearing streams. This effort will be continuous, as research projects are implemented. Monitoring and reporting will be consistent with that described in Chapter 6.
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.

3.3.4.4 Non-Fish-Bearing Streams Without the Potential to Deliver Wood to Fish-Bearing (XNFB)

While RCAs are not designated alongside XNFB streams, the overall level of protection for aquatic and riparian ecosystems in the ESRF using the Triad approach is very high, as measured by the wood delivery potential and the level of protection on non-fish-bearing and fish-bearing streams. The levels of protection do vary depending on the research designation. In the CRWs, there is complete protection of these ecosystems and their associated ecological processes. In thinned portions of CRWs, the level of protection is expected to range between moderate and high based on level of tree retention.

3.3.4.5 Operations Standards for Riparian Treatments in Reserves

The riparian reserve treatments will follow all operations standards specified for other reserves and will include mostly restoration-based thinning in Douglas-fir plantations. Overplanting of Douglas-fir following previous timber harvest in the riparian areas of the CRW and MRW reserves has created dense plantation stands in some areas, including in riparian zones. Reserves will have two starting points: (a) exploring treatments to restore and enhance conservation value in established plantations by transitioning to more productive forest conditions, including in RCAs; and (b) conserving unmanaged mature forests as they move through natural successional processes.

Because there is no harvesting in the second category (b), there is no need for designated RCAs to protect riparian and instream processes. Thinning treatments in RCAs in the CRW will occur once during the first 20 years of the permit term. Once the thinning is complete there will be no more harvesting in the reserve treatment areas. However, during thinning, RCAs at these locations will be 200 feet horizontal distance on fish-bearing and non-fish-bearing perennial streams, and key debris flow torrents that deliver wood to the fish-bearing streams (Table 3-2).

Thinning to reduce the density of existing plantation stands within RCA 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. The conservation outcome is 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, and increase habitat diversity and stream productivity. No harvest of trees will occur from the RCA if they are determined to be older than 65 years as of 2020, situated on landslide-prone steep or unstable conditions (as defined by OSU modeling), or if there is overlap with designated wildlife habitat (e.g., marbled murrelet). Additional details on riparian thinning are provided in Chapter 5.

3.3.4.6 Operations Standards for Riparian Treatments Outside Reserves

In the MRW, research will utilize a framework including a mix of reserve forests and forests influenced to a varying degree by wood fiber harvests. The MRW will be capable of testing the ability of these strategies to address a broader suite of values and variables. Most importantly, the Triad design allows flexibility in how each subwatershed in the MRW can be arranged to optimize resource protection. The proportions of each stand treatment type (reserve, extensive, intensive) within a subwatershed are fixed. However, the arrangements or locations of each treatment can be flexible, potentially providing protection for older forest-dependent species, unstable slopes, and key riparian habitat for Oregon Coast coho by assigning them to reserves. Steep headwall areas, as defined in OSU modeling, will be prioritized to be allocated to extensive treatments, with a continuous tree retention providing root strength and soil stability, unless part of a targeted research study on the effects of harvest activity on landslide risk. Intensive treatments can be focused on previously logged stands that would not require additional road construction. No subwatershed is 100 percent intensive so there will be the potential to tailor riparian conservation strategies at fine scales to meet conservation goals at the subwatershed and watershed scale.

Table 3-2 describes the minimum buffers that apply to RCAs adjacent to intensive and extensive stand-level treatments in the MRW. No intensive stand replacement management will be conducted within RCAs. Thinning to reduce the density of less than 65-year-old existing plantation stands within RCA buffers will occur, but only in the context of a study to understand how management can enhance long-term ecological functions of the RCA. Thinning in RCAs will occur for restoration purposes following the same guidelines as the CRW, and no removal of trees will occur in the RCA if they are determined to be older than 65 years (as of 2020), situated on landslide-prone steep or unstable conditions, or if there is overlap with designated wildlife habitat (e.g., marbled murrelet).

3.4 Harvest Timing, Types, and Methods

3.4.1 Projected Timing and Amount of Harvest

The initial 20-year period of the permit term includes an emphasis on restoration thinning treatments in young plantation stands in areas designated as reserves and RCAs. The purpose of these thinning treatments is to set the young dense stands in the reserves on a trajectory to develop into older forests with natural variations to benefit the covered species, and for improved riparian functions in the RCAs. However, the distribution of stand age across the reserves that will see the restoration thinning may dictate entry for thinning on an accelerated timeline before stands reach an age and density that will preclude accomplishing the intended conservation purpose. To account for this limitation and to facilitate the intended conservation outcomes for these areas while also maintaining the financial viability of the forest, limits on acres sold during years 1–20 are addressed with more specificity than for the remainder of the permit term.

The following limits would 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), but will not be exceeded in any given year without concurrence of permitting agencies. No more than 80 percent of the intensive/extensive acres below would be harvested intensively unless otherwise agreed upon with the U.S. Fish and Wildlife Service and National Marine Fisheries Service (collectively, the Services).

- Years 1-5
  - Intensive/Extensive = 800 acres per year
  - Restoration Thinning in Reserves and RCA = 800 acres per year
- Years 6–10
  - Intensive/Extensive = 700 acres per year
  - Restoration Thinning in Reserves and RCA = 800 acres per year
- Years 11–15
  - Intensive/Extensive = 700 acres per year
  - Restoration Thinning and RCA = 700 acres per year
- Years 16–20
  - Intensive/Extensive = 800 acres per year
  - Restoration Thinning and RCA = 500 acres per year
- Beyond Year 20
  - Timber sales from all sources (reserve thinning's, extensive, and intensive treatments) will not exceed 1,000 acres in any single year.

This use of acres sold recognizes an important consideration of forest operations. Contracts for sale of timber 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 may be sought by the permit holder in consultation with the agencies when unforeseen circumstances arise related to contractor operations.

3.4.2 Harvest Types

The harvest types described below will be applied to achieve the stand-level research treatments described in Section 3.3. Operational standards for implementation of these harvest types, by research treatment, is described in Section 3.3.

3.4.2.1 Regeneration

The intent of a *regeneration harvest* is to develop a new age cohort. In intensive treatments, residual trees left after a clearcut harvest are intended to remain on the site through the life of the new stand and subsequent stands. In extensive treatments, residual trees remaining after a retention cut may be harvested in the future, while others will be retained and allowed to grow into large trees that will contribute to complex canopy structures intended to be achieved in extensive research treatments.

Clearcut

A *clearcut* removes all (or nearly all) trees in a stand; however, the Oregon Forest Practices Act (FPA) requires that at least a few live trees be retained in each unit. Clearcuts will be used in the intensive treatments to explore approaches and impacts related to maximizing wood production.

Retention Cut

Retention cuts will retain 20–80 percent of the current stand density in extensive treatments. The higher residual densities will differentiate these harvests from a clearcut. In the retention cut harvest type, the goal is to develop multi-age complex stand structures. A retention cut will result in a stand with two or more distinct age classes. Retention cuts will be used in the extensive treatments to explore approaches to integrate ecological restoration with timber production.

3.4.2.2 Thinning

The intent of a thinning is to manage the growth and density of an existing stand with outcomes ranging from restoration of natural conditions to maximizing wood production, depending on stand objectives. A prescription for a thinning may be designed to increase the structural complexity of a stand, maximize volume growth, or capture tree mortality.

Thinning prescriptions are often designed using measures of Stand Density Index (SDI)[4] or Relative Density and 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 will also be used frequently within extensive treatment areas.

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

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

will become more complex relative to a dense, Douglas-fir plantation, although it may reduce habitat suitability for some species.

Thinning will be used in all treatment designations, including intensive, extensive, and—to a limited degree—RCAs and reserves as described below.

Intensive

Intensive thinning will be a commercial thin aimed at maintaining stand densities at levels that provide vigorous tree growth and maintain high wood production. Regeneration harvest and commercial thinning will be determined by growth patterns (mean annual increment), vulnerability to disturbances, and markets. Thinning will typically occur between 25 and 50 years, and meet snag and green tree retention standards as described in the Oregon FPA. No more than 80 percent of the pre-harvest basal area will be thinned. This maximum percentage thinned would not be applied on more the 7,000 acres, with the remaining acres not to exceed 50 percent of the pre-harvest basal area thinned without concurrence from the Services. Intensively thinned stands will maintain a minimum rotation age of approximately 60 years.

Extensive

Multiple-entry commercial and restoration thinnings and regeneration harvests that create multi-aged stands will transition even-aged Douglas-fir stands towards greater diversity in structural composition and species mix. Restoration thinnings will set these even-aged stands, which were planted following clearcut logging, on a trajectory to meet the goals and objectives of extensive treatments on the ESRF. These objectives include providing diverse forest characteristics encompassing a range of stand structures, successional stages, and wildlife habitat features while producing wood products in order to provide a diverse array of ecosystem goods and services across the forest. Thinnings of Douglas-fir plantations in the extensive allocation could include a maximum of 10,300 acres, depending on current relative density. Extensive regeneration harvests with 20 percent retention would not be applied on more the 1,000 acres (stands greater than 65 years old as of 2020 that are outside marbled murrelet and northern spotted owl habitat), with the remaining regeneration harvest acres not to exceed 50 percent retention without concurrence from the Services. Both of these are not to exceed figures, absent concurrence from the Services.

Reserves

Single-entry restoration thinnings in reserves (CRW and MRW) will occur within the first 20 years after establishment of the ESRF in even-age stands less than 65 years of age (as of 2020). Restoration thinnings will set these even-aged stands that have regenerated following prior clearcut logging on their trajectory as older forests with further variations cultivated by natural forest disturbance and successional processes. The goals of these treatments are to enhance forest complexity and habitat by transitioning young, dense plantations in reserves towards greater compositional, successional, and structural diversity to maintain functional habitat networks for the covered species and restore resources of high cultural value as identified by tribal partners. If, after the initial thin, it is determined additional thinning would further benefit the covered species subsequent entries will be permitted contingent on concurrence from the Services.

Stands will receive thinning treatments as part of a restoration research design based on age, topographic template,[5] density, and silvicultural priority to promote ecological processes that support conservation goals. Restoration thinning will be reflective of past conditions, which supported viable populations of the covered species, and will remove 20–80 percent of the basal area (i.e., 12–30 percent early seral, 12–28 percent mid-seral, and 50–82 percent late-successional to old-growth; Wimberly et al. 2000; Spies et al. 2007; Reilly et al. 2021).

Riparian Conversation Areas

Only trees in plantation-like stands replanted after harvest and 65 years or less in age as of 2020 will be considered for RCA thinning. Management in RCAs will be limited to locations where prior management actions have resulted in overstocked plantations or riparian stands of relatively small trees. Potential projects include silvicultural treatments such as reducing the density of conifers, conversion of hardwood stands to conifer species, selective removal of hardwoods from mixed-species stands and establishment of shade-tolerant conifer seedlings, creation of gaps in hardwood stands to establish conifer seedlings (shade-intolerant and shade-tolerant), opening riparian areas to an early seral stage, or other similar practices designed to improve aquatic and riparian conditions within RCAs.

RCA thinning treatments outside of reserves have the potential for multiple-entry treatments, supporting the use of a range of silvicultural treatments and experimentation to reduce short-term impacts. RCA thinning treatments will not exceed 80 square feet of conifer basal areas per acre.

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 be used in reserves (CRW and MRW reserve stands) or RCAs.

Salvage harvest will occur within the extensive allocation consistent with the treatment standards described in Section 3.3.3, *Extensive Treatments*. In addition, salvage operations will consider the biological legacy of the stand prior to the disturbance event, and tree retention standards will be developed to support the maintenance of these legacy characteristics.

3.4.3 Harvest Methods

Timber harvest is central to implementing the research proposal on the ESRF and achieving the goal of becoming a self -sustaining research forest. Timber harvest—in all its various types and methods—is also a primary activity needed to implement research experiments. Harvest methods are associated with the harvest of timber and other forest products and include the felling, bucking, yarding, processing, loading of logs, and hauling. *Felling* means cutting down trees. *Bucking* means cutting felled trees in the field into predetermined log lengths 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.

[5] Slope aspect, substrate, and elevation

- On steep terrain, contractors fell and sometimes buck trees with handheld chain saws and use tethered feller bunchers.
- Mechanical felling is done by a feller-buncher to fell trees. 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 (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 for 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 on the Elliott State Forest 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 are able to grasp the log using powered grapple attachments or wire rope winch lines. Ground yarding generally works on gentle to moderate slopes, but some of the modern ground yarding equipment can work on slopes up to 60 percent.
- 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 techniques typically occurs in areas where access is limited or very expensive. In helicopter yarding, a cable extending from the helicopter is attached to the logs and used to suspend and move them to the landing area. This technique generally does not disturb soil, although large, separate, cleared landing areas are required for helicopter touchdown.

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

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

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

The harvest methods listed above reflect current options used in forest management. As a research forest, the ESRF will be employing and evaluating the impacts of new technologies as they arise.

3.4.4 Harvest Environmental Protections

During timber harvest and site preparation, many techniques are used to protect soils from compaction or from ponding water and causing excessive erosion. Common techniques include limiting ground equipment activity to gentle slopes and to time periods when soil moisture is low and limiting the amount of area on which ground equipment may operate. Cable and ground equipment operations must minimize gouging and soil displacement. Logging systems that minimize disturbance to existing duff, litter, and woody debris, except where disturbance is desirable to facilitate regeneration, may be used during timber harvest. Live and dead tree retention is used to preserve some of the biological legacy of the previous stand. Logging residue (limbs, tops, cull logs, etc.) are 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 research platform and are also covered by the HCP. When used they will be integrated into the research program and done as part of research studies.

- **Mechanical Vegetation Control.** Mechanical vegetation control may be practiced in the permit area, both to control invasive weeds along the road system and in forest lands, 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 and may include grading, hand cutting, using a brush hog–type mechanical device, steaming, and other experimental methods.
- **Prescribed Burning.** Prescribed burns will follow Oregon FPA requirements and include single or multiple prescribed burns that incorporate traditional ecological knowledge (TEK) 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 and broadcast burning of harvest units for site preparation prior to planting will also occur, where appropriate, as part of the research management program. Prescribed burns would not occur 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. Within riparian areas, the most common methods to be used will be hand pile, and burn and slash and scatter.
- **Tree Planting.** Trees may be planted as part of intensive treatments.
- **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 under Section 3.4, *Harvest Timing, Types, and Methods*.
- **Helicopters.** Helicopters are not expected to be regularly required for management of the ESRF. 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 (Cessna 185, etc.).** 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.[6] Hazard tree removal will be done as 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 research treatments.

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 and culverts, and quarries. This category of covered activities also includes the abandonment or decommissioning 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,

[6] Occupational Safety and Health Standards, Code of Federal Regulations, Title 29, Part 1910.266(c)

and it is estimated that, over the course of the permit term, DSL will commit to the construction of no more than 40 miles of new permanent roads. Temporary roads that have not been decommissioned after 5 years will become part of the permanent road network and count toward the 40 miles of new roads constructed over the course of the permit term. There may be some new road spurs constructed to facilitate research-related stand management activities. 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.

Abandonment 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 abandonment 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. The FPA prescribes measures covering the following.

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

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.

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, would depend on the steepness of the terrain, as well as the type of construction used.

The extent of the existing road system is shown in Table 3-3 and on Figure 3-4. This system is stable, with nominal mileages added or removed each year. The principal foreseeable changes to the system would consist of construction of temporary roads to access new cutting units. These roads would typically be decommissioned once the unit was replanted. Similarly, many existing spur roads that served only to access prior cutting units are expected to be decommissioned. No primary or secondary road[7] construction, relocation, or decommissioning is currently proposed, but it is possible that up to 0.5 mile per year of primary or secondary road construction would occur under the HCP, with a total of up to 40 miles of new permanent roads over the permit term. Such construction in the CRW would be accompanied by decommissioning of existing roads at an amount equal to or greater than the amount of primary or secondary road constructed, as described in the conservation strategy (Chapter 5).

Table 3-3. Summary of the Existing Road System

Management Basin	Road Length (miles)	Size of Basin (square miles)	Road Density (miles of road/square mile)
Scattered Tracts[1]	3.59	0.61	5.89
Mill Creek	28.95	7.96	3.64
Charlotte Luder	19.95	9.83	2.03
Dean Johanneson	32.95	11.44	2.88
Schofield Creek	23.41	7.81	3.00
Big Creek	33.78	12.22	2.76
Benson Roberts	34.42	11.44	3.01
Johnson Creek	35.54	9.83	3.62
Palouse Larson	32.65	10.14	3.22
Henrys Bend	49.48	13.00	3.81
Marlow Glenn	50.05	10.18	4.92
Millicoma Elk	94.57	17.07	5.54
Trout Deer	83.23	17.72	4.70
Ash Valley	27.87	6.10	4.57
Total	**550.44**	**145.35**	**3.79**

[1] Disjunct plan area lands not within one of the listed basins.

[7] *Primary roads* are mainline 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.

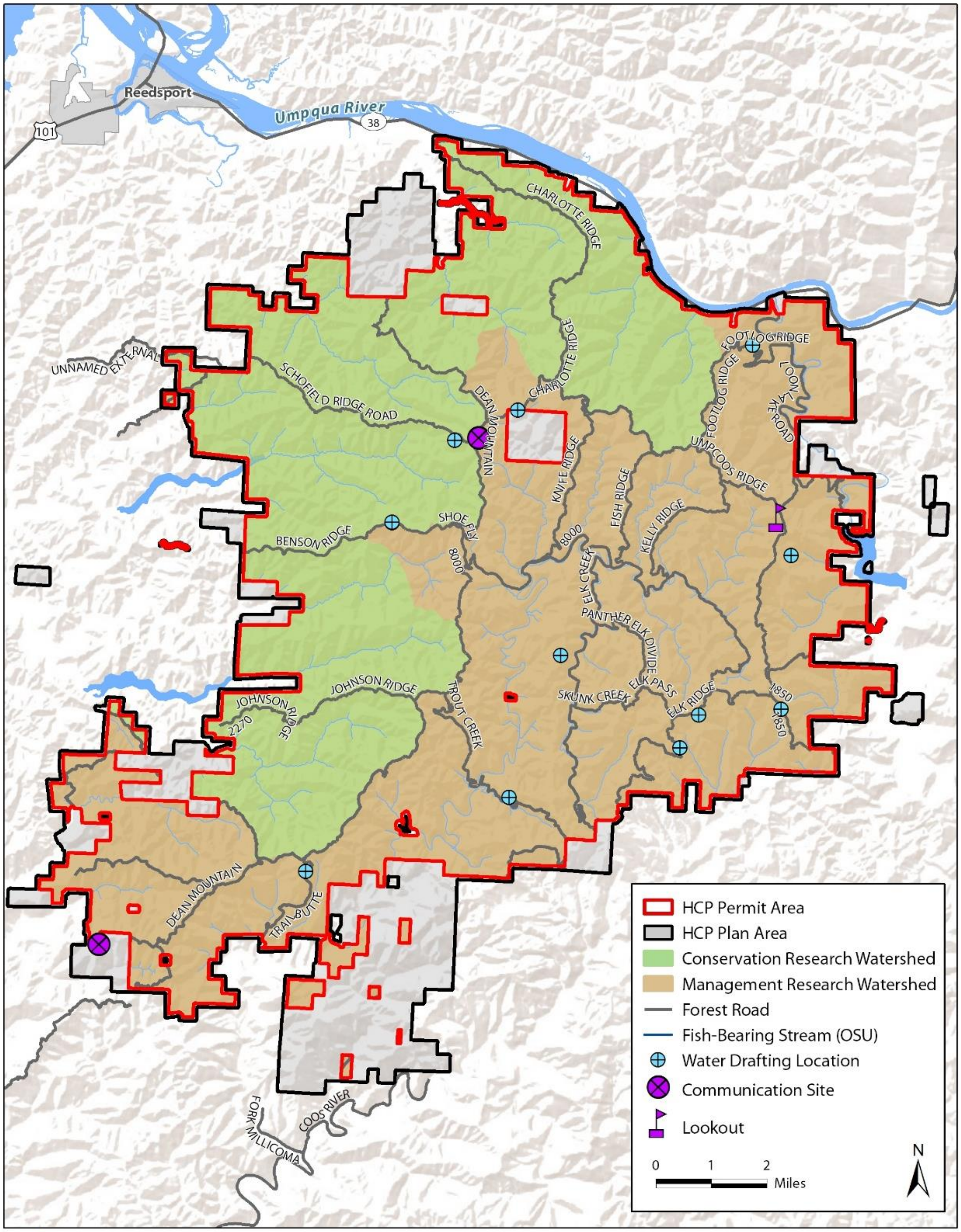


Figure 3-4. Existing Primary Road Network, Water Withdrawal Sites, and Communication and Lookout Sites

3.6.1.2 Road Use

Roads in the plan 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, recreation activities and infrastructure, including OHV and other recreational use of roads, is not a covered activity. Such recreational 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 currently relatively low due to the remote location of the ESRF. However, such use is expected to increase with increased population. DSL has not developed transportation volume estimates for covered road use as part of the research proposal implementation. However, the relative degree and frequency of intensive road use—such as associated with timber harvest—is projected to be infrequent on secondary roads and of greater numbers on main access routes. Based on the even pace of harvest projected, intensive road use would be spread out as mostly temporary, localized use during active harvest and hauling operations.

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, and timber management may include mechanical control of roadside vegetation. Mechanical control may include grading, hand 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 that it is less susceptible to erosion and damage from vehicle traffic. The area along a forest road will have 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 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 percent 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 Abandonment

Road abandonment refers to the process of making a road impassable and effectively closed, including stabilizing the roadbed surface and removing culverts and other drainage structures. The road prism remains otherwise intact. Roads are abandoned if deemed non-essential to near-term future management plans or where access would cause excessive resource damage. The Permittee will determine which roads to abandon or reclaim during project-level analysis. Abandoned roads and reclaimed roads are left in a condition that is stable and provides adequate drainage. All road abandonment is a covered activity under this HCP.

3.6.1.6 Road Decommissioning

Road decommissioning refers to the process of returning a road to its natural state. These roads are "put to bed" with stream crossing drainage structures and fills being excavated and removed, road and landing surfaces permanently drained, and unstable fill slopes stabilized or removed (excavated). The Permittee will determine which roads to decommission during project-level analysis.

3.6.1.7 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.

3.6.1.8 Landings

Landings are the sites to which felled logs are yarded, processed, and loaded onto trucks. Construction, maintenance, and decommissioning of landings is performed using the same techniques, is subject to the same regulatory constraints, and typically occurs at the same times as previously described for road construction, maintenance, use, and abandonment. 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. The standard is no more than 2 percent of a given harvest unit area should be in landings.

3.6.1.9 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 are 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 development, 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 on the forest and is used as a source of rock slope protection material, and up to two such quarries could be built and operational during HCP implementation. New quarries would only occur 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 reserves or RCAs.

3.6.3 Communication Sites and Lookouts

There are three communication sites 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 would be performed by DSL. 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

The stand-level research activities described in this chapter (Section 3.3) will be conducted in accordance with the previously described Triad research design. Researchers will design and implement experiments knowing that timber production and management activities will be held constant at the subwatershed level over time. Some research projects may only focus on one aspect of the Triad design (e.g., reserves), while others may test response variables across all three aspects. Projects and experiments can be scaled from an individual management treatment in one subwatershed to multiple treatments across many subwatersheds. Experiments could also be applied beyond the plan area; for example, comparing results from the ESRF to similar experiments in research forests from around the world.

Research activities are divided into two types: active and passive. Active research would 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 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. Active research is described further in Chapter 4 based on the impact mechanisms associated with the activities as they related to the covered species.

Types of potential short- and long-term research projects, questions, and collaborations that could occur in the permit area are described by OSU (2020:Appendix D). These projects have been defined through 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 is expected to include partnerships and collaborations with local, state, regional, national, and international colleagues.

3.8 Covered Activities Related to Conservation Measures and Implementation

The incidental take permit to be issued under this HCP will permit incidental take caused by mitigation activities, including conservation actions described in Chapter 5 and implementation actions described in Chapter 6.

As described below, most of the activities related to conservation actions (Chapter 5) involve the same covered activities that have already been detailed in previous sections, but applied for conservation purposes. All operations standards previously described for intensive, extensive, reserves, and RCAs will apply to covered activities related to conservation measures and implementation and are not repeated here. Details regarding the conservation actions are presented in Chapter 5; details regarding monitoring and adaptive management are presented in Chapter 6; and details regarding implementation are presented in Chapter 7, *Implementation and Assurances*.

3.8.1 Riparian Restoration and Stream Enhancement

Riparian restoration and stream enhancement projects will generally follow the synthesis and management recommendations presented in the *Elliott Watershed Analysis Implementation Plan* (Biosystems et al. 2003). The majority of projects will include wood placement, which may involve tree cutting for source wood. Such cutting 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. Such activities will occur in areas where large wood and associated channel structure is currently deficient.

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.

Beaver habitat projects may also be implemented to improve riparian habitat functioning in the few areas of unoccupied potential beaver habitat present on the ESRF. 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 non-powered hand tools. As described in Chapter 5, 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 decommissioning and abandonment, which have already been described as part of supporting infrastructure covered activities. Road work specific to both aquatic and upland restoration is also described in the following section.

3.8.2 Road Restoration and Network Reduction

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

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

- Road relocation/redesign.
- Removal of active roads or legacy 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).
- Increase surface material thickness or hardness with crushed rock or paving.

3.8.3 Habitat Enhancement from 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 reserve treatment designations, but will be very limited within intensive designations, and are most likely to occur within reserve treatment designations, with limited use within extensive and RCAs. Habitat enhancement would involve covered activities already described—including commercial and precommercial thinning and associated temporary roads and landings and equipment. All stand-level operations standards described previously will apply.

3.8.4 Research on Coho Salmon and Their Habitat

Potential research focus in the permit area is described in Appendix C 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, as much of the research will be conducted in conjunction with the Triad research design.

Endangered Species Act (ESA) compliance for research that requires handling of coho 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.

3.8.5 Research on Northern Spotted Owls and Marbled Murrelets

Research on northern spotted owls and marbled murrelets will be conducted using the covered activities already described as part of the research design, 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 will also involve tree climbing.

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.

3.8.6 Survey and Monitoring Requirements

Some conservation measures described in Chapter 5 require pre-harvest surveys for northern spotted owls and marbled murrelets prior to harvest. In addition, as detailed in Chapter 6, HCP implementation includes multiple monitoring activities to determine compliance with the HCP and effectiveness of conservation measures.

Turbidity Monitoring. The Permittee will install paired turbidity monitors upstream and downstream of a representative sample of new roads that cross a fish-bearing stream to monitor changes in instream turbidity following the construction of new and maintenance of existing haul roads

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.

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.

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 geographic information systems (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.

Northern Spotted Owl Monitoring. As described in Chapter 5, a third of the 23 northern spotted owl sites in the permit area (described in Chapter 2) will be monitored each nesting season, meaning that all of the historic 23 nesting territories will be monitored every 3 years. Searches for new northern spotted owl nest sites in locations where habitat is improving as a result of the research design 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–approved 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.

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, field survey protocols will be used to verify acoustical surveys or to calibrate automated systems. Monitoring will be prioritized in stands that are developing into habitat for marbled murrelets, either due to active management or passive management.

3.9 Activities Not Covered

Some activities are not covered under the HCP because they do not meet the criteria described in the Section 3.1, *Introduction*, including activities that are outside the control of the permit holder. In addition, for some activities, such as recreational activities and infrastructure, there are insufficient details regarding the intensity, duration, location, and extent of such activities, 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 additional consultations with the Services.

The following summarizes the activities that are not covered under this HCP.

Recreational Activities and Infrastructure. Recreational activities are not a covered activity under this HCP. The ESRF is remote with 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 on a project-specific basis, as needed. 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, 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, ATV permit).

Pesticide[8] Use. Pesticide application using either aerial application methods (i.e., fixed-wing airplane, helicopter, unmanned aerial system) or ground is not a covered activity under this HCP. DSL may still use pesticide application 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 within the moist conditions of the ESRF. The last major wildfire in the plan area occurred in 1868 (Coos Bay Fire), which burned approximately 90 percent 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 within the plan area. Uses of lands within the plan area by easement holders or other parties that are not representatives of or contractors to the Permittee are not covered activities.

Water Developments. Water developments for drafting and other water uses are all located at springs and 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.

[8] As defined by the EPA as 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.

Research Involving Handling or Other Disturbance to Covered Species. For any research that requires capturing covered species 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 U.S. Fish and Wildlife Service as part of the amendment process described in Chapter 7.

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.

Chapter 4
Effects Analysis and Level of Take

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. Section 10 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 quantified, habitat-based take estimates to inform the Service's Section 10 processes, as well as more general cause-and-effect analyses to support the habitat-based take assessment. The approach used in this HCP generally follows the *effects pathway* model described in the HCP Handbook, by which covered activities (Chapter 3) and conservation measures (Chapter 5) 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. Note that 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 effect pathway model helps identify how project 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 harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or to attempt to engage in any such conduct (United States Code, Title 16, Section 1542(b)).

DSL 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 (Code of Federal Regulations, Title 50, Section 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 within the permit area. These same units are used on 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 (U.S. Fish and Wildlife Service 2015). 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 USFWS 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 habitat surrogate units have been established for covered species.

For both northern spotted owl (*Strix occidentalis*) and marbled murrelet (*Brachyramphus marmoratus*), impacts are quantified using modeled habitat as a surrogate. As will be described later under each species' assessment, take due to direct harm (e.g., cutting down a tree containing an active nest) or indirectly due to noise or other disturbances has been minimized, as described in Chapter 5, *Conservation Strategy*. Therefore, habitat loss (i.e., changing forest structure from being habitat to not being habitat) and modification (i.e., changing forest structure in a way that reduces, but does not necessarily eliminate, habitat value, such as changing nesting habitat to foraging habitat) are the sources of take anticipated to occur to these species as the result of covered activities.

For this HCP, habitat is defined for northern spotted owl based on Davis et al. (2016) and for marbled murrelets based on Betts et al. (2020a). Acres of existing habitat (by value classification), as mapped by the models within each research treatment type, have been quantified for each of the two bird species. As with any habitat model, these models only approximate habitat, and on-the-ground conditions may vary from the model results. In addition, localized errors have been identified in the models within areas selected for intensive management. All stands within intensive allocations contain existing Douglas-fir plantations that are less than 65 years old (as of 2020), so while the models identified some of these areas as habitat, many do not actually contain any habitat (other than perhaps dispersal for northern spotted owls) due to stand age. However, some higher-quality remnant habitat patches may be present. Most modeling errors within intensive allocations are suspected to be due to older aerial imagery being used as part of the input data for the models. The practical result of these errors is that take estimates based on modeled habitat within intensive allocations likely overestimate the amount of actual habitat that will be affected. More specific measures of effects will be taken during plan implementation and associated monitoring and reporting.

Acres of habitat were evaluated based on research treatment designations (i.e., intensive, extensive, reserve, Riparian Conservation Area [RCA]). In addition to timber harvest, the quantity of acres affected include all covered activities that will occur within each designation, as described in Chapter 3, *Covered Activities*.

For Oregon Coast coho (*Oncorhynchus kisutch*), take estimate is based on the proportion of each independent population within the permit area and the acres of projected harvest levels within the watersheds that overlap with each evolutionarily significant unit (ESU). With the RCA in place, the potential for take to occur is expected to be largely minimized.

4.3.3 Determining Impact of Take

The impact of the take section considers effects with avoidance and minimization measures in place. Beneficial and net effects of conservation actions are described in Chapter 5. 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 ESU affected for aquatic covered species and the quantity and degree to which habitat will be affected for both terrestrial and aquatic covered species. In addition, 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. 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 and Types of Take

4.4.1.1 Disturbance or Direct Mortality from Covered Activities

The research and other covered activities described in Chapter 3 were designed to minimize effects on listed species, including northern spotted owl. Direct interactions, such as disturbing actively nesting northern spotted owls, will be avoided through seasonal restrictions described in Chapter 5 and, therefore, will not be a source of take. This includes use of fire for slash burning or site preparation, where such seasonal restriction around nesting areas is the avoidance and minimization strategy recommended by the USFWS for effects of smoke on owls (U.S. Fish and Wildlife Service 2013b).

One area where incidental take may occur is through road use associated with covered activities (research, administrative, forest work crews). Direct effects from road use include noise and direct mortality.

Noise from commercial vehicle traffic could disturb nesting spotted owls, although any nest sites near roads would have been established within the presence of roads, as no new roads have been constructed in recent years. The types of reactions that spotted owls could have to vehicle noise are those that the USFWS considers to have a negligible impact, and include flapping of wings, the turning of a head towards 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 percent of the mortality (83), followed by starvation at 26 percent (32) and accidents (6 percent [7]). Of accidental deaths, vehicle collisions accounted for 4 of the 7 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 on the Elliot State Forest, particularly at night. Therefore, based on the rarity of northern spotted owl collisions with vehicles, the low level of use of vehicles, and generally low speeds, vehicle collisions—while possible over the 80-year permit term—are not anticipated to be a significant source of take during operation of the Elliot State Research Forest (ESRF).

4.4.1.2 Habitat Loss and Modification from Stand-Level Treatments and Supporting Management Activities and Infrastructure

As detailed later in this section, the research design and treatments described in Chapter 3, together with conservation measures and conditions on covered activities described in Chapter 5, are intended to maintain core area and home range habitat for existing activity centers (i.e., historic nest sites) and result in a net increase in northern spotted owl 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 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 silvicultural practices used to establish and maintain the research platform, which will include the full suite of thinning and harvest techniques used in contemporary forestry. In addition to effects of thinning and harvest within stands, effects include supporting management and infrastructure activities, including construction of access roads and landings. Other sources of spotted owl habitat modification include any tree removal associated with covered activities such as RCA thinning treatments, 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 research treatments or other covered activities).

The effects projected to occur will be localized losses of nesting, roosting, and foraging habitat, and the associated chain of effects described in the Section 4.4.1.3, *Effects Pathways*. Details regarding the amount of habitat modification and the potential for habitat modification to result in take are described in Section 4.4.2, *Amount of Take.* Note that the acres of habitat impacts described in Section 4.4.2 includes acres that will be disturbed from the other covered activities that will be conducted within the framework of the research design and associated operations standards, conservation measures, and conditions (i.e., habitat effects from all covered activities are counted but not quantified separately).

4.4.1.3 Effects Pathways

As described above, the primary source of take anticipated to occur due to the covered activities is habitat loss and modification from timber harvest and other silvicultural practices used to establish and maintain the research platform. 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, 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.

4.4.1.4 Habitat Effects by Research Treatments

The degree of habitat modification anticipated to occur is closely associated with the research treatments described in Chapter 3, and as detailed in the following subsections.

The conservation strategy (Chapter 5) includes several conditions to protect the 23 northern spotted owl nest sites considered to be "active" due to recent or repeated historic occupancy (see Chapter 2, *Environmental Setting*). These conditions will apply to all treatment types and are central to the avoidance and minimization of effects on northern spotted owl, and include the following.

- Condition 2, which stipulates that a 100-acre nesting core area of the best contiguous habitat will be maintained around the nest tree. There will be 100 percent retention in the nesting core area (i.e., no modification or treatment will occur in the 100-acre nesting core area).
- Condition 3, which stipulates that within "core use areas" (defined as a 0.5-mile-radius circle from the nest tree/activity center), at least 50 percent (more than 251 acres) will be maintained as nesting, roosting, and foraging habitat, at the same or better quality as pre-treatment conditions, at all times.
- Condition 4, which stipulates that at least 40 percent of the home range (defined as a 1.5-mile-radius circle from nest tree/activity center) that is nesting, roosting, and foraging habitat will be retained at the same or better quality as pre-treatment conditions, around the active nesting core areas (see Condition 2).
- Condition 5, which stipulates that at least 40 percent of the Management Research Watersheds (MRW) will be retained as dispersal habitat, which is habitat that both juvenile and adult northern spotted owls use to move across the landscape to establish new territories (note that essentially all of the Conservation Research Watersheds [CRW] will be dispersal habitat).

These avoidance and minimization measures provide important context on the habitat effects described below for each research treatment type, as most of the habitat for intensive treatments described below is likely to be unoccupied (due to the retention of the most likely occupied sites through Conditions 2–5).

Intensive Treatments

Modification of forest stands that meet the definition of northern spotted owl habitat of Davis et al. (2016) will occur within lands allocated for intensive harvest of existing even-aged Douglas-fir (*Pseudotsuga menziesii*) plantations using clearcut harvesting techniques suitable for the terrain. Sources of habitat effects will include timber harvest as well as associated management activities that could disturb habitat, including access roads, landings, and related activities. While specific treatments within intensive treatments may vary slightly in rotation length, leave tree retention, type of site preparation, species planted, and other management techniques, the overall result will be forest stands that lack sufficient forest structure and composition needed by northern spotted owls for nesting, roosting, and foraging.

As a requirement of the research design, intensive treatments will occur only in stands that are less than 65 years old (as of 2020), and therefore have limited or marginal nesting and roosting habitat potential. Stands on the higher end of that range, closer to 65 years old, may provide foraging habitat. But the majority of stands less than 65 years old—based on low forest structure and generally small patch sizes—are expected to provide dispersal habitat at best, and thus, intensive treatments will have a limited impact on nesting, roosting, and foraging habitat. Some of these stands, however, may not be treated until they have matured into characteristics associated with foraging habitat. As a result, habitat values and associated potential use by northern spotted owls (likely to be foraging and movement/dispersal) may be lost as these stands are treated under the intensive treatment designations. As described above and in Chapter 5, the conservation strategy includes retaining habitat values on 23 historic northern spotted owl territories. As a result, while habitat modification and associated effects pathways will occur when intensive treatments are applied, the effects of the modification will be minimized on nesting northern spotted owls, due to the commitment to habitat retention around nest locations. These effects will be fully offset by the conservation measures and conditions on covered activities described in Chapter 5.

Extensive Treatments

The flexibility provided in the research design for extensive treatments described in Chapter 3, together with the tree retention and other conservation actions described in Chapter 5, are expected to reduce adverse effects on northern spotted owl habitat quality within extensive treatments (compared to intensive treatments) and will also include some beneficial effects, such as gradually increasing legacy components within extensive stands and higher habitat quality over the long term. Within extensive treatments, live trees will be retained as needed to meet various experimental goals, as well as to incorporate existing northern spotted owl habitat into the research design, resulting in patches and blocks of habitat that are expected to remain suitable for northern spotted owl, while habitat values will be lost to varying degrees in more heavily treated areas. As described above and in Chapter 5, the conservation strategy includes retaining habitat values on 23 historic northern spotted owl territories and seasonal restrictions around nest sites.

While operations conditions around nest sites and leave tree retention standards will reduce effects within extensive treatment stands, some adverse effects on habitat within extensive treatment areas (but outside of habitat protected for the 23 historic sites) will be unavoidable. Where extensive areas are treated by variable density regeneration harvests, canopy cover and tree density could fall below that required by northern spotted owls following treatments. Habitat values may remain in leave patches or in areas of high-density retention, 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 the owl to continue 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 harvests within extensive treatment areas will be in Douglas-fir plantations, with the intent to increase over time the forest structure needed by northern spotted owls. Any treatments in forests older than 65 years (as of 2020) will include retention of at least 50 percent pre-harvest density to minimize effects.

Extensive treatments will not be conducted inside the 100-acre nesting core area around known northern spotted owl nest locations. Extensive treatments will only be conducted in the home ranges of known northern spotted owl nesting locations, if at least 40 percent of a home range qualifies as nesting, roosting, or and foraging habitat. Similarly, extensive treatments will only be conducted inside the 502-acre core use areas of known northern spotted owl nest locations if at least 50 percent of the core use area remains nesting, roosting, or and foraging habitat. As a result, while habitat modification is likely to occur, over the short term, it will be minimized and is not likely to result in behavioral changes to nesting northern spotted owls due to the commitment to habitat retention around nest locations. These effects will be fully offset by the conservation measures and conditions on covered activities described in Chapter 5.

In summary, extensive harvest treatments will have at least short-term adverse effects on northern spotted owl habitat values. However, the extensive treatment areas are expected to continue to provide foraging and dispersal habitat within areas of high retention. Overall, forest legacy structure is expected to increase throughout extensive treatment areas over time. As part of the research design, over 10,000 acres of extensive treatment areas will be converted from Douglas-fir plantations into multi-age, legacy filled, complex canopy forests that have trees that continue to age to 125 years, by the end of the permit term. The collective value of these stands is expected to increase habitat for northern spotted owls over time, particularly for foraging habitat. In a study conducted in the Oregon Coast Range (Olson et al. 2004), researchers found that owls used a variety of forest types and concluded that while mid- and late-seral forests are important to owls, a mixture of these forest types with younger forest and nonforest may be best for owl survival and reproduction. Therefore, the mosaic created by extensive treatments is expected to continue to contribute to the overall landscape value of the ESRF for northern spotted owls.

Reserve Treatments

Effects from treatments within reserves 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. No reserve harvest will occur within forests more than 65 years old as of 2020. Some stands within reserves may be treated in the later years of the treatment program for plantations within reserves, which is anticipated to take up to 20 years. In such cases, stands may be as old as 85 years and may be developing into foraging habitat. These habitat values and associated potential use by northern spotted owls may be temporarily lost as plantations are converted to more complex forest structure through time. The specific timing and extent of reserve treatments is not available at the current programmatic level of planning. However, stand data indicates that the CRW contains 12,458 acres of stands less than 70 years old. These are the areas where habitat enhancement treatments will occur, although not all stands will be treated.

Research treatments on younger stands 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, such as avoiding activities during the active nesting season and making commitments to nesting, roosting, and foraging habitat retention for the 23 historic northern spotted owl activity centers will further minimize effects from treatments within reserves.

Riparian Conservation Area Treatments

Treatments within RCAs are expected to be similar to those described for reserves, as the same operations standards will apply. As described in Chapter 3, thinning to reduce the density of existing plantation stands within RCA 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. The conservation outcome is primarily focused around promoting the more rapid development of large trees, so effects may be a temporary reduction in habitat values in lower-quality foraging habitat, with habitat values improving over the remaining portion of the permit term.

Effects of 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 will occur due to previously described covered activities, including thinning of plantations located in reserves, RCAs, and extensive treatment designations and associated covered activities, such as landings and road construction, maintenance, and use.

In addition to previously described 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 less than 65 years old as of 2020 and maintaining habitat commitments for northern spotted owls, including the 23 northern spotted owl historic nesting territories identified for conservation.

Removal of active or legacy roads will 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. Much 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.

Conservation measures to retain habitat within historic northern spotted owl territories (Conditions 2, 3, and 4) allow for habitat removal within the home ranges, core use areas, and core nesting areas, but only in situations where habitat will be retained at the minimum levels defined in Chapter 5.

Effects of Monitoring and Implementation Activities

Northern spotted owl monitoring efforts (described in Chapter 6, *Monitoring and Adaptive Management*) will follow USFWS-approved 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 2012b). Using recorded call playback will likely disrupt the behavior of owls if present. Calling surveys can also attract barred owls and result in interactions between northern spotted owls and barred owls, further disrupting 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 nests trees or looking into nest cavity holes to determine the status of young.

Effects of Other Covered Activities

Also, as previously described for the effects of each research treatment designation (reserve, intensive, extensive, RCAs), 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 research treatment described in Chapter 3, as well as the conservation actions and conditions described in Chapter 5. 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, *Amount of Take*, include acres that will be disturbed from the other covered activities that will be conducted within the framework of the research design and associated operations standards, conservation measures, and conditions (i.e., habitat effects are counted by not quantified separately).

4.4.2 Amount of Take

The unit of impact for northern spotted owl is the number of acres of existing habitat that will be modified by covered activities over the duration of the permit. Acres of existing habitat have been identified and quantified based on the published habitat model and mapping completed by Davis et al. (2016, referred to in this HCP as "the Davis model"), who used multi-factor habitat models to rate and map northern spotted owl nesting and roosting habitat throughout the range of the species. The ratings used in the Davis model were for nesting and roosting habitat only (i.e., it did not rate foraging habitat). Therefore, for this assessment, areas rated and mapped as "highest" and "suitable" by Davis et al. (2016) were considered suitable roosting and nesting habitat, while areas rated and mapped as "marginal" nesting and roosting habitat were considered suitable foraging habitat but not roosting or nesting habitat. Forests classified as "unsuitable" were considered dispersal and/or non-habitat.

The Davis 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. The model outputs mapped habitat within 30-meter square "pixels," classified as either highly suitable, suitable, marginal, or unsuitable nesting and roosting habitat. This "pixelated" coverage adds another layer of potential inaccuracies in the model.

To further inform the habitat impact analysis, Davis model outputs were cross-checked against known stand histories on the ESRF. Specifically, habitat identified within plantations and other stands less than 60 years of age (as of 2020) were quantified separately to provide context, which is considered in Section 4.4.3, *Impact of the Taking*.

In addition, the HCP considers the effects on the active northern spotted owl pair sites described in Chapter 2 (i.e., the 23 occupied territories identified, based on most recent survey data and listed in Table 2-4). The following sections detail whether take is anticipated to occur over the permit term based on these two metrics.

4.4.2.1 Nesting, Roosting, and Foraging Habitat

Based on the Davis model, a total of 6,818 acres of northern spotted owl habitat (combined acres ranked as highly suitable and suitable nesting/roosting habitat) are located within extensive and intensive allocations and, therefore, could be subject to harvest. This represents approximately 20 percent of the total acres of existing modeled highly suitable and suitable habitat currently present within the permit area. In addition, approximately 36 percent (6,825 acres) of the total acres of marginal nesting and roosting habitat (considered to be foraging habitat in this HCP) are located within intensive and extensive allocations.

Because the proposed research design (described in Chapter 3) included placing the oldest stands in reserves, northern spotted owl habitat outside of reserves (and therefore subject to harvest under intensive or extensive treatments) occurs in stands that are on average younger, smaller, and more fragmented (isolated from other habitat) than the stands located within reserves. In terms of age, of the 6,818 acres of modeled highly suitable and suitable habitat that may be subject to harvest, approximately 4,060 acres are located within plantations that are younger than 60 years (61 percent of the highly suitable and suitable habitat that will be affected). The remaining 2,758 acres (39 percent) are located within stands older than 60 years. All of these older stands are located within extensive allocations, where impacts will be lower due to higher retention and increased legacy structure over time (previously described in Section 4.4.1.4, *Habitat Effects by Research Treatments*).

Habitat loss (intensive) or modification (extensive, reserve, and RCA) is most likely to harm northern spotted owls in areas where forest stands are more than 60 years old. Modeled habitat in stands more than 65 years old (as of 2020) will be managed exclusively using ecological forestry practices under the extensive treatment allocations. In those areas pre-harvest density retention will range from 20 to 80 percent. This may result in a short-term modification of habitat and reduction in habitat quality; however, over the long term these managed areas will develop into older forests that will likely have the size of trees and habitat structure preferred by northern spotted owl.

Conditions in Chapter 5 outline protections around nest locations, including seasonal restrictions around nest sites on covered activities that result in loud and sustained noise. In addition, Conditions 2, 3, and 4 (Chapter 5) will retain habitat around 23 historic northern spotted owl activity centers (see Chapter 2). The habitat levels to be retained are based on USFWS estimates of what is required to support a nesting pair of northern spotted owls (U.S. Fish and Wildlife Service 2011), which include a core area, core use area, and a home range area, all centered around each activity center (i.e., the nest tree/grove or otherwise established “activity center”). These conditions and potential effects on individual northern spotted owl activity centers are presented in Section 4.4.2.3, *Northern Spotted Owl Activity Centers*.

Figure 4-1 shows the distribution of modeled northern spotted owl nesting/roosting habitat among the research designations described in Chapter 3. Table 4-1 provides a summary of modeled habitat type across the research treatments. Section 4.4.3 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 development of additional habitat, are described in Chapter 5.

Table 4-1. Northern Spotted Owl Nesting/Roosting Habitat[1] by Research Treatment

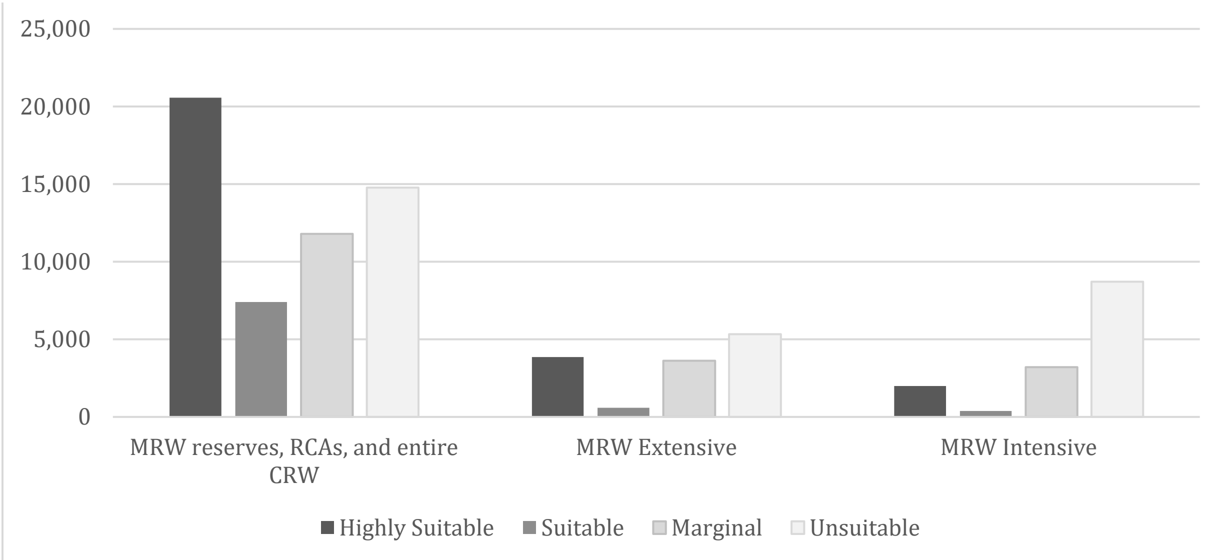
	Nesting/Roosting Habitat				Foraging Only Habitat	
	Highly Suitable		Suitable		Marginal	
Treatment Type[2]	**Acres**	**Percent of Total**	**Acres**	**Percent of Total**	**Acres**	**Percent of Total**
Reserves (MRW reserves, RCAs, and entire CRW)	20,566	78%	7,400	88%	11,795	63%
Extensive	3,856	15%	590	7%	3,615	19%
MRW Extensive >60 years old	2,326	9%	333	4%	853	5%
MRW Extensive <60 years old	1,530	6%	257	3%	2,762	15%
Intensive (all <60 years old)	1,988	8%	384	5%	3,210	17%
Total	**26,410**	**100%**	**8,374**	**100%**	**18,620**	**100%**
TOTALS						
Extensive >60 years old	2,326	9%	333	4%	853	5%
Extensive + Intensive <60 years old	3,518	13%	641	8%	5,972	31%

Source: Davis et al. 2016.

[1] For this assessment, areas rated and mapped as "highly suitable" and "suitable" by Davis et al. (2016) were considered suitable roosting and nesting habitat, while areas rated and mapped as "marginal" were considered suitable foraging habitat. Forests classified as "unsuitable" were considered dispersal and/or non-habitat. Marginal nesting/roosting habitat is assumed to be suitable foraging and dispersal habitat (suitable and highly suitable habitats are also considered dispersal habitat). Acres described in the text added acres of highly suitable and suitable. Also, numbers differ slightly from those presented in Chapter 2 due to some areas within the permit area being unallocated under Oregon State University's research proposal (Oregon State University 2021).

[2] Treatment designations of specific stands within MRWs are either extensive, intensive, or reserve. See Chapter 3 for specifications.

[3] Percent distribution of habitat type among each treatment (e.g., 43% of highest value habitat is located within the CRW treatment area).



Source: Davis et al. 2016.

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

Modeled Habitat Patch Size

To better characterize habitat patch size, habitat model outputs from Davis et al. 2016 were summarized to show which highly suitable or suitable habitat patches were greater or less than 6.5 acres. This was used as a guideline based on the recognition that in order for a potential nest tree to be viable it would likely at least need a 300-foot buffer of legacy trees around it. A potential nest tree with a 300-foot buffer around it equates to 6.5 acres. This is considered the minimum viable amount of habitat needed for a patch of habitat to provide any nesting and roosting value. In reality the patch would need to be even bigger, and the quality will depend on the age of the forest around it, but 6.5 acres was used as a reasonable and conservative threshold to help elucidate the relative value of the modeled habitat patches across research allocations. Figure 4-2 shows a summary of how habitat patch size changes across research allocations.

In terms of habitat patch size, of the 4,447acres of highly suitable and suitable modeled habitat found in extensive allocations, 1,865 acres (42 percent) are composed of modeled habitat patches less than 6.5 acres in size—patches likely too small to support NSO nest sites. And of the 2,372 acres of highly suitable and suitable modeled habitat found in intensive allocations, 2,062 (87 percent) are composed of modeled habitat patches less than 6.5 acres in size.

By contrast, of the 8,884 acres of highly suitable and suitable modeled habitat found in MRW reserve allocations, only 1,122 acres (13 percent) are composed of modeled habitat patches less than 6.5 acres in size, and of the 16,133 acres of highly suitable and suitable modeled habitat found in CRW, only 1,499 acres (9 percent) are composed of modeled habitat patches less than 6.5 acres in size (Figure 4-2). The smaller disconnected patches of modeled habitat in intensive allocations demonstrate the lower quality of habitat provided in those allocations, when compared to the larger, more contiguous patches found in older stands allocated to reserves.

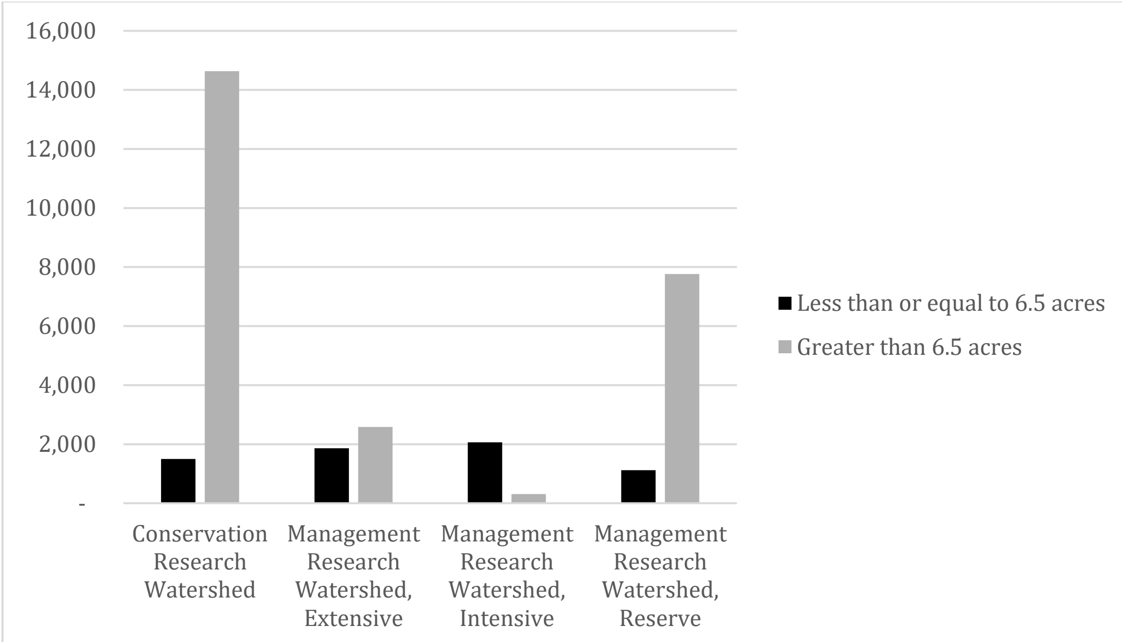


Figure 4-2. Patch Size of Highly Suitable and Suitable Habitat, by Research Allocation

4.4.2.2 Dispersal Habitat

The CRW and MRW reserves are expected to continue 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 percent of the MRW as dispersal habitat is an acknowledgement that habitat quality will be reduced in areas that are intensively harvested, and even in some areas that are extensively harvested, if retention is low. However overall, the MRW will continue to provide nesting, roosting, and foraging habitat in areas managed as extensive and reserve treatments. These areas will continue to support dispersing northern spotted owls. In addition, DSL is committing to retain a minimum of at least 40 percent of the MRW as dispersal habitat (Chapter 5, Objective 1.3) in the permit area. The pace of harvest activities is modest (on average 1,000 acres/year, mostly in intensive, extensive, and plantations within reserves), 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 would change over time. However, due to the mosaic of research treatments included in the research design, and network of riparian habitats, dispersal habitat will be distributed throughout the MRW, as will be confirmed through monitoring.

4.4.2.3 Northern Spotted Owl Activity Centers

Activity Centers Located Within the Permit Area

USFWS (2012b) uses three contexts by which to evaluate effects on specific northern spotted owl sites.

- **Activity centers.** Location or point representing "the best of detections" such as nest stands, stands used by roosting pairs or territorial singles, or concentrated nighttime detections.

- **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.
- **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, which is where the ESRF is located. This results in a 502-acre area around each activity center. In this HCP the 502-acre area is contiguous but does not have to be a circle, specifically.
- **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 that equates to approximately 4,523 acres.

Based on published studies regarding spotted owl home ranges and core use areas, as summarized in the Northern Spotted Owl Recovery Plan (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 percent of the home range (i.e., 40 percent of area within a 1.5-mile radius circle centered on the activity center, which equates to ≥1,809 acres of nesting, roosting, and foraging habitat within the 4,523-acre circle).
- ≥50 percent of the core use area (i.e., ≥251 acres of nesting, roosting, and foraging habitat within the 502-acre area). Habitat within core use areas also contributes to home range thresholds because the home range envelops core use areas.

Table 4-2 summarizes the amount of existing habitat within the permit area and within the core area and home range for the 23 activity centers described in Chapter 2 that are centered within the permit area. Figure 4-3 shows the location of these active activity centers, together with underlying research treatments.

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

- 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 active northern spotted owl nest sites, where at least 50 percent (>251 acres) of the best contiguous habitat will be maintained as nesting, roosting, and foraging habitat, at the same or better quality as pre-treatment conditions, at all times. For core use areas that are currently below the 50 percent threshold no harvest will occur until the minimum habitat threshold is met.
- Under Condition 4, at least 40 percent of the home range will be retained as nesting, roosting, and foraging habitat, at the same or better quality as pre-treatment conditions, around the active nest core areas. For home range areas that are currently below the 40 percent threshold no harvest will occur until the minimum habitat threshold is met.

Many of the core use areas and home range territories of the 23 activity centers centered within the permit area include lands that occur outside the permit area. In these cases, Conditions 2, 3, and 4 apply proportionately to the amount of area contained within the permit area. For example, 38 percent (1,727 acres) of the home range for the Lower Camp Creek activity center falls within the permit area (Table 4-2). Under Condition 4, a minimum of 40 percent 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 23 northern spotted owl activity centers described above and as shown in Figure 2-7. If new owl nest locations are discovered in the future, outside of those shown in Figure 2-7, the Permittee will provide written notice seeking coordination with the USFWS, 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.

"Swapping" of nest sites—if conducted—would maintain protections on at least 23 core use areas and allow the Permittee to focus on the 23 historic nest sites with the highest-quality habitat and documentation of nesting activity at any one time. Removal of protections would occur on nest sites that meet the definition of "inactive," as defined in Chapter 5.[1]

Collectively, these conditions, together with the avoidance already incorporated into the research allocations, will maintain and potentially increase the capacity of the ESRF to support northern spotted owls based on an increased amount of habitat (see Section 5.6, *Beneficial and Net Effects*).

Newly Established Activity Centers

Northern spotted owl pairs may establish nesting territories in areas outside of the 23 activity centers (Figure 2-7) designated for long-term management commitments under Conditions 2, 3, and 4 (Chapter 5). This should be expected for the following reasons.

Owl Movements. There is the potential for dispersing juveniles and non-territorial adults (called "floaters") to move into the ESRF. In addition, while some individual owls and pairs may establish long-term pair bonds and use the same nest site or nest grove, individual owls on the ESRF have been documented changing nest sites and even mates from year to year (Kingfisher 2016).

Habitat Growth Over the Permit Term. Additional spotted owl habitat is projected to grow over the permit term, potentially providing new places for pairs to establish territories.

However, because northern spotted owl populations are declining, there is a declining number of new individuals entering the population, which may reduce the likelihood of new nest sites becoming established.

New owl locations (i.e., in addition to those 23 identified in Figure 2-7) will be identified and documented through the terrestrial monitoring program described in Chapter 6. These owls may include dispersing juveniles, non-territorial adults (floaters), resident singles, and, potentially, newly established territorial pairs.

---

[1] As described in Chapter 5, in order for a northern spotted owl nest site to switch from active to inactive status, consecutive surveys determining unoccupied status will need to be completed for at least 7 consecutive years, or as otherwise determined through coordination with the USFWS.

Any new sites established within the CRW, where much of the future habitat growth is anticipated, would be protected by the reserve status of those watersheds. However, any new sites established within the MRW may be subject to take under the HCP, because the commitments described in Chapter 5 are to retain habitat within reserves and within the core use areas and home ranges of previously established historic activity centers. There is no commitment to protect any new nest site or associated home ranges that may become established (other than seasonal disturbance restrictions), as this requirement would not be practicable due to the need of long-term certainty to support the research platform. As described in Chapter 3, holding operational management constant over time is central to the research design, because it provides certainty for researchers and allows for the long-term studies that are essential for understanding long-lived forests.

However, as described in Chapter 5 (Conditions 2, 3, and 4), if new owl nest locations are discovered in the future, outside of the 23 shown in Figure 2-7, the Permittee, in coordination with USFWS, could choose to remove protections from one of the 23 protected activity centers—if determined to be abandoned—and apply protections to the newly discovered (active) nest site. This “swapping” of activity centers would maintain protections on 23 core use areas with the highest-quality habitat and documentation of nesting activity at any one time.

Should the Permittee decide to not make such a swap, the newly discovered nest site would not be subject to protection other than the seasonal disturbance restrictions. However, the flexibility provided in the research design—particularly for extensive designations—provides the opportunity to adjust treatments within extensive treatments to better accommodate any nesting pairs that may become established. Such situations, should they occur, would provide opportunities to research within extensive treatment areas, which may prompt future harvest designs intended to protect the nest site.

Activity Centers on Adjacent Lands

Five northern spotted owl activity centers are located outside the permit area but within 1.5 miles and thus may rely on the permit area to sustain them at some level. One of these has 46 percent overlap with the core area (0.5-mile-radius circle from the nest site/activity center), one has 19 percent, another 6 percent, and two have no overlap with the core area but some area within the home range (Table 4-3, Figure 4-3).

For these sites, habitat will be retained at the percentages stated in Chapter 5 (Conditions 2, 3, and 4) proportional to the amount of the core area, core use areas, and home ranges that are within the permit area. This is to say that nesting, roosting, and foraging habitat will be maintained to at least 50 percent of the total area inside the portion of the 0.5-mile-radius core use area that is also inside the permit area. Similarly, if the 1.5-mile-radius home range circle includes areas outside the permit area, at least 40 percent of the total area inside the permit area will be maintained as nesting, roosting, and foraging habitat. As a result, the Permittee will contribute to the habitat requirements for historic activity centers located outside the permit area in proportion to the amount of overlap with the permit area and the core use areas and home ranges.

Because the Permittee has no control over lands outside the permit area, take could occur at these five sites should habitat be harvested within the permit area in addition to harvest on adjacent lands, because the acres of habitat proposed to be protected on the permit lands alone will not be sufficient to support a pair of northern spotted owls (using the core use area and home range requirements identified in U.S. Fish and Wildlife Service 2011).

Table 4-2. Northern Spotted Owl Activity Centers and Existing Percent Habitat[1] Within Home Range and Core in Permit Area

ID#	Activity Center Name (pairs)	% Home Range Within Permit Area[2]	Existing Habitat Within Permit Area as % of Total Home Range[3]	% Core Use Area Within Permit Area	Existing Habitat Within Permit Area as % of Total Core Use Area
14	Lower Camp Creek	38%	*27%	61%	*42%
36	Murphy Creek	67%	41%	88%	67%
37	Wind Creek	69%	*37%	96%	42%
38	Roberts Creek	72%	51%	74%	61%
42	Dean Creek	80%	56%	76%	54%
45	Alder Creek	99%	71%	99%	79%
46	Palouse Creek	57%	*35%	59%	*41%
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%	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%

Source: Davis et al. 2016.

[1] Habitat is the sum of areas rated and mapped as "highest," "suitable," and "marginal" habitat, as rated and mapped by Davis et al. 2016. Minimum thresholds are 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 ≥251 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 ≥1,809 acres of habitat). Sites where research design will conserve habitat above these home range and core use area thresholds are expected to be adequate to support nesting owls.

[2] % Home Range Within Permit Area is the proportion of the circle, centered on the activity center, that is within the permit area.

[3] Existing Habitat (all allocations) is the amount of habitat within the permit area portion of the circle. Percentage is the percentage that existing habitat contributes to the total area of the circle (i.e., in and outside the permit area).

* = Currently below threshold, meaning that existing habitat within reserves in the permit area is not sufficient to meet minimum thresholds alone (i.e., habitat on adjacent lands is needed to meet threshold).

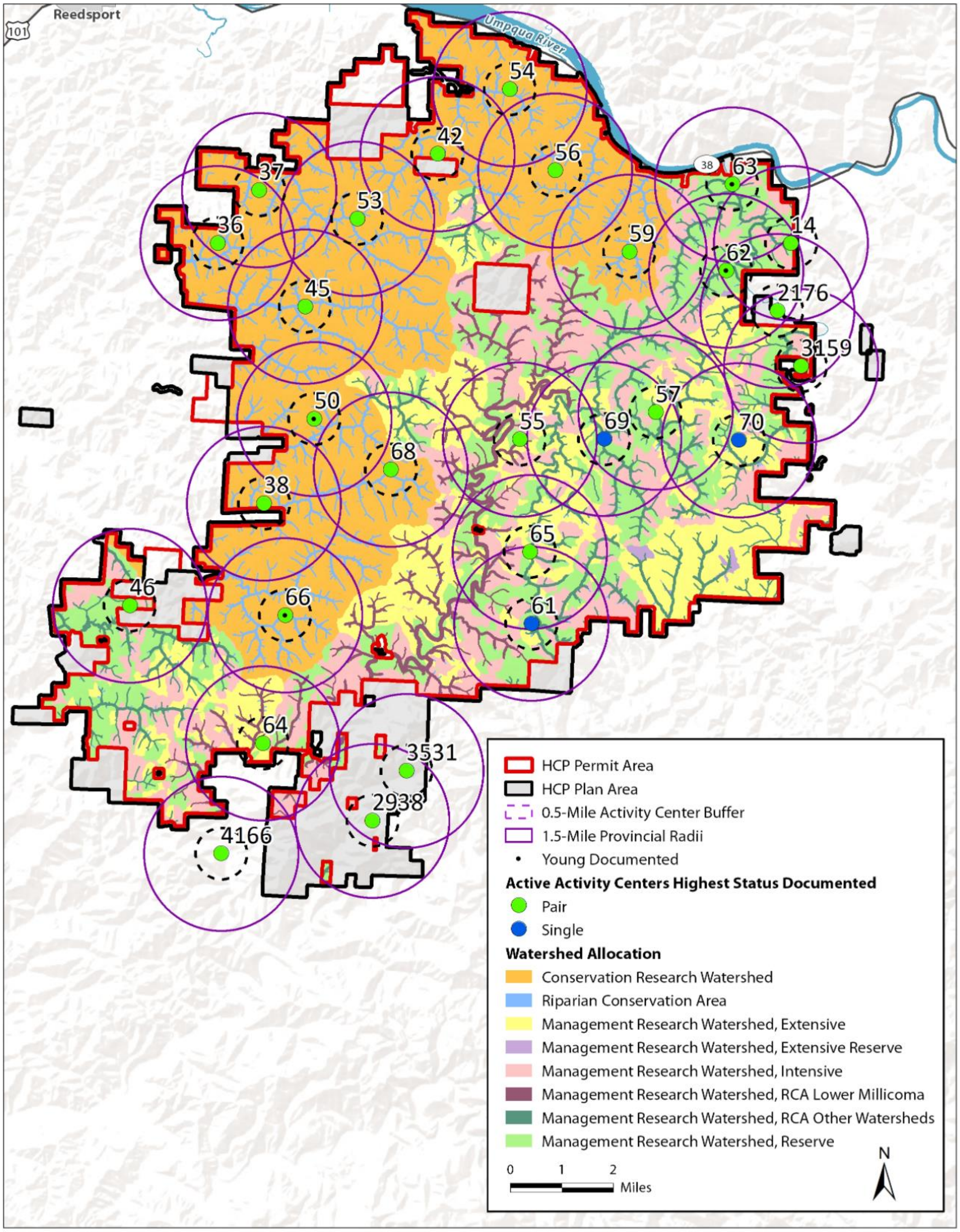


Figure 4-3. Activity Centers and Associated Activity Center Radii Within and Adjacent to the Permit Area

Table 4-3. Northern Spotted Owl Nest Locations with Activity Centers on Adjacent Lands

	Site Name	% Home Range Within Permit Area	Existing Habitat Within Permit Area as % of Total Home Range Circle	% Core Use Area Within Permit Area	Existing Habitat Within Permit Area as % of Total Core Use Area Circle
2176	Upper Mill Creek	53%	30%	19%	14%
2938	Marlow Creek	9%	5%	6%	2%
3159	Tom Fool Creek	40%	27%	46%	24%
3531	Lockhart Road	6%	4%	0%	0%
4166	Lower West Fork Millicoma	11%	6%	0%	0%

[1] 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). Sites where research design will conserve existing habitat above these home range and core use area thresholds are expected to be adequately conserved.

4.4.2.4 Effects on Critical Habitat

USFWS has designated critical habitat totaling 38,746 acres for the northern spotted owl in the permit area (U.S. Fish and Wildlife Service 2012a, 2021). Approximately 50 percent of designated critical habitat within the permit area was modeled as marginal or lowest quality. Approximately 37 percent was modeled as highly suitable and 13 percent is 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 habitat of the critical habitat when the covered activity occurs. Critical habitat quality is variable. The USFWS stated justification for designating much 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 (U.S. Fish and Wildlife Service 2012a, 2021).

In general, designated critical habitat that is located in reserves, RCAs, and other non-harvest areas is expected to increase in habitat value during the permit term. As described in Chapter 3, research management activities in reserves will be focused on improving habitat values through management of even-aged Douglas-fir plantations towards more complex, older, and structurally diverse stands with a mix of ages and tree sizes.

Of the 38,746 acres of designated northern spotted owl critical habitat in the permit area, 3,739 acres are located within extensive treatment areas. Of this, 11 percent (1,191 acres) is modeled as lowest-value habitat, 13 percent (1,161 acres) is modeled as marginal, 4 percent is modeled as suitable (202 acres), and 8 percent is modeled as highly suitable (1,185 acres), see Table 4-4. As described in Section 4.4.1, *Sources and Types of Take*, some stands within extensive treatment areas are expected to continue to provide northern spotted owl foraging and dispersal habitat, with nesting and roosting habitat protected within reserves. While covered activities described in Chapter 3 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.

Designated critical habitat within intensive treatment areas is likely to provide little to no habitat values for northern spotted owls for the duration of the permit as the result of habitat modification from intensive treatments. A total of 3,972 acres of designated critical habitat for northern spotted owl is located in intensive treatment areas. Of this, 22 percent (2,376 acres) is modeled as lowest-value habitat, 11 percent (998 acres) is modeled as marginal, 2 percent is modeled as suitable (115 acres), and 3 percent is modeled as highly suitable (483 acres) (Davis et al. 2016).

Table 4-4 and Figure 4-4 summarize the acres of critical habitat inside and outside of reserves by modeled habitat category.

Table 4-4. Acres of Designated Critical Habitat for Northern Spotted Owl, by Research Treatments and Modeled Nesting/Roosting Habitat Classification

Treatment Type	Highly Suitable		Suitable		Marginal		Dispersal/ Lowest Value		Total
MRW reserves, RCAs, and entire CRW	12,558	88%	4,760	94%	6,570	75%	7,147	67%	31,035
Extensive	1,185	8%	202	4%	1,161	13%	1,191	11%	3,739
Intensive	483	3%	115	2%	998	11%	2,376	22%	3,972
Total	**14,226**		**5,078**		**8,727**		**10,715**		**38,746**

Source: Davis et al. 2016

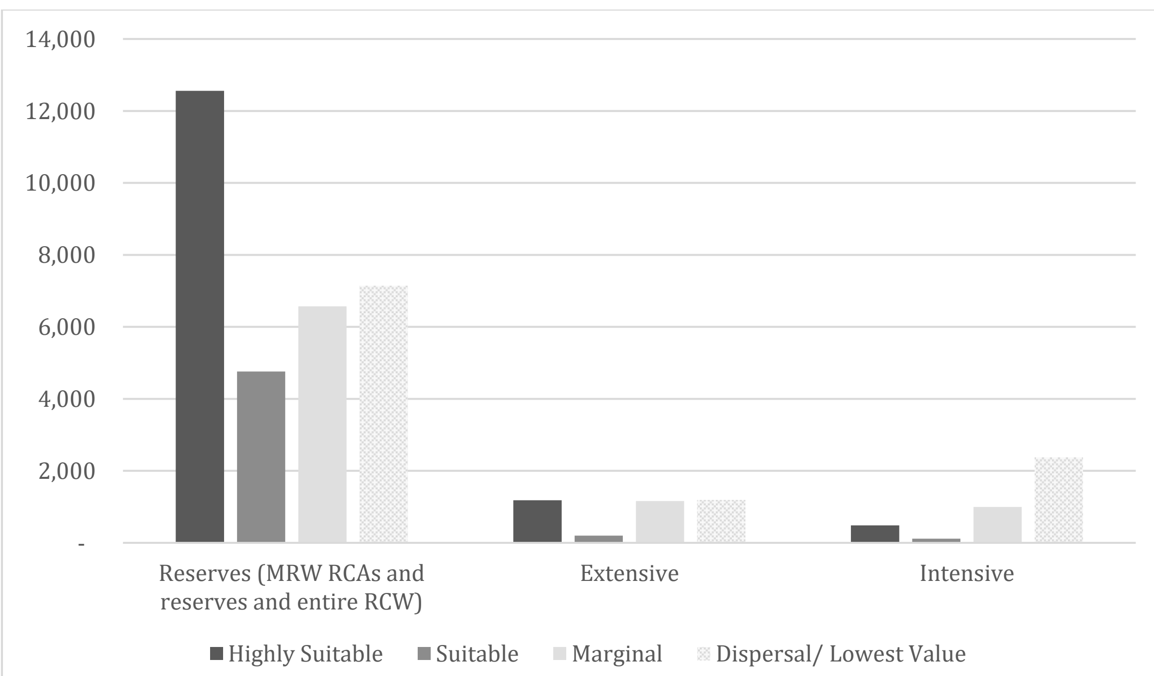


Figure 4-4. Acres of Designated Critical Habitat for Northern Spotted Owl on the Elliott State Forest, by Stand-Level Research Treatments based on 2020 Allocations

4.4.3 Impact of the Taking

As described in Section 4.4.2, approximately 20 percent (6,818 acres) of the total acres of existing northern spotted owl habitat (combined modeled as highly suitable and suitable) is located within extensive and intensive allocations and therefore subject to harvest. While the Davis model identified all of these acres as suitable habitat,[2] 60 percent (4,060 acres) of the 6,818 acres is located within plantations. 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 located outside of reserve allocations occurs in stands that are on average smaller and more isolated than stands located within reserves. While there will be habitat modification in the near term from extensive treatment activities, these areas are expected to have corresponding long-term benefits by increasing the old forest structure required by northern spotted owls.

The remaining 40 percent (2,758 acres) of the 6,818 acres subject to harvest under the HCP consists of stands older than 60 years, all of which are located within extensive allocations, where impacts will be lower than in intensive designations due to the higher tree and habitat retention that will reflect habitat desirability and associated increased legacy structure expected to develop over time (described in Section 4.4.1.2, *Habitat Loss and Modification from Stand-Level Treatments and Supporting Management Activities and Infrastructure*).

As described in Section 4.4.2.3, and as detailed further in Chapter 5, impacts on known northern spotted owl nesting territories and associated reproduction are expected to be minimized through implementation of Conditions 2, 3, and 4. Through these conditions, habitat will be maintained at levels believed to be sufficient to maintain a nesting pair of northern spotted owls at 23 nest sites, a number based on the existing distribution of activity centers evaluated in Section 4.4.2.3.

The northern spotted owl conservation strategy described in Chapter 5 focuses on retaining sufficient habitat to support at least the 23 pairs of northern spotted owls whose home ranges (based on a 1.5-mile-radius circle from the activity center) fall completely within the permit area, and with proportional protections on the five territories that overlap with adjacent ownership. The concept is to retain the capacity of ESRF 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 this habitat, while being authorized to take owls that may occur outside of these areas.

It is important to note that not all of the 23 northern spotted owl home ranges to be protected are likely to be currently occupied. The northern spotted owl population on the ESRF has been declining for decades, most likely due to barred owl displacement (Kingfisher 2016). 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. But by 2016 (the last year that comprehensive surveys were completed), the occupancy estimate was 14 owls on 8 activity centers (Kingfisher 2016). The conservation strategy includes the Permittee's commitment to retain habitat

[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.

values on 23 sites with historic pair occupancy, retaining the areas that are known to have supported northern spotted owls in the past. These areas are most likely to also contain the remaining northern spotted owls on the ESRF, as well as provide future habitat for recolonization, should barred owl removal efforts be successfully implemented. This habitat commitment to retain habitat within currently unoccupied historic territories will retain the capacity of the ESRF to support northern spotted owl populations at recent historic levels.

Considered collectively, habitat to be retained in reserves and RCAs and the additional conditions placed on core use areas and home ranges 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 Section 5.6, *Beneficial and Net Effects*, the net effect on northern spotted owl habitat from covered activities will be beneficial, with long-term habitat gains that will maintain and increase over time the capacity of the ESRF to support nesting pairs of northern spotted owls. It follows that the impact of the taking will not likely impact populations within the context of the Oregon Coast Range or range-wide distributions.

4.5 Effects Analysis for Marbled Murrelet

4.5.1 Sources and Types of Take

4.5.1.1 Disturbance or Direct Mortality from Covered Activities

The covered activities described in Chapter 3 were developed to minimize effects on listed species, including marbled murrelet. Direct interactions, such as disturbing actively nesting marbled murrelets during research treatments, will be avoided through conditions described in Chapter 5.

Smoke disturbance from prescribed burning will also be avoided through seasonal restrictions around occupied murrelet habitat. The Marbled Murrelet Recovery Plan (U.S. Fish and Wildlife Service 1997) speculated that smoke may adversely affect marbled murrelets but that research was needed to confirm and understand such effects. 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 on the ESRF, but the effect is not expected to rise to the level of take.

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 nor 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 on the ESRF 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 morality is also a possibility. 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 1to 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.

Mortality of marbled murrelet eggs or chicks could occur due to nest site depredation facilitated by clearcut or heavy thinning adjacent to occupied nesting habitat. Ravens, crows, and jays are known to prey on marbled murrelet eggs and young (Golightly and Schneider 2011; Flaxa et al. 2016). The Marbled Murrelet Recovery Plan (U.S. Fish and Wildlife Service 2017) recommended 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 publication of 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. Edge creation will be primarily in intensive treatment areas located adjacent to occupied or potential habitat, although similar effects may occur in extensive and reserve treatments where heavy thinning or clearcut harvests are applied within plantations or to create gaps. Additional details on these edge effects—by research treatment designations—are provided in Section 4.5.1.4, *Habitat Effects by Research Treatments*.

4.5.1.2 Habitat Loss and Modification from Stand-Level Treatments and Supporting Management Activities and Infrastructure

As detailed later in this section, the research design and treatments described in Chapter 3, together with conservation measures and conditions on covered activities described in Chapter 5, 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 marbled murrelet 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 silvicultural practices used to establish and maintain the research platform, which will include the full suite of thinning and harvest techniques used in contemporary forestry. In addition to effects of thinning and harvest within stands, effects include supporting management and infrastructure activities, including construction of access roads and landings. Other sources of marbled murrelet habitat modification include any tree removal associated with covered activities, such as RCA thinning treatments 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).

Details regarding the amount of projected take through habitat modification are provided in Section 4.5.2, *Amount of Take*. Note that the acres of habitat impacts described in Section 4.4.2, *Amount of Take*, for northern spotted owl includes acres that will be disturbed from the other covered activities that will be conducted within the framework of the research design and associated operations standards, conservation measures, and conditions (i.e., habitat effects from all covered activities are counted but not quantified separately).

4.5.1.3 Effects Pathways

Modification of habitat through covered activities is anticipated to result in the following categories of stressors on marbled murrelets.

- Eliminate large trees with platforms and associated canopy cover and interior habitat required for nesting.
- Subject interior nesting habitat to forest edge, thus increasing access to nest sites by predators (primarily corvids).

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 one 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 located farther 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.

4.5.1.4 Habitat Effects by Research Treatment

The conservation strategy (Chapter 5) includes several conditions to protect marbled murrelet. These conditions are central to the avoidance and minimization of effects on marbled murrelet and include the following.

- Condition 6, which stipulates that all designated occupied and modeled potential marbled murrelet stands, as defined in this HCP (Figure 2-11), that are subject to intensive or extensive harvest treatments will be examined for presence of marbled murrelet nest sites and habitat protected (described in detail in Chapter 5).
- Condition 7, which limits harvest in designated and modeled potential marbled murrelet habitat to a 1,400-acre cap.
- Condition 8, which stipulates that there will be no temporal loss of the aggregate number of acres of designated occupied or modeled potential habitat as a result of harvest treatments in the permit area.

The degree of habitat modification anticipated to occur is closely associated with the research treatment described in Chapter 3, as detailed in the following subsections.

Intensive Treatments

Some young stands modeled as potential habitat (using Betts et al. 2020a) will be subject to intensive treatments. Intensive treatment areas are located within existing Douglas-fir plantations that are less than 65 years old (as of 2020), so while the model identified these areas as potential habitat, many areas are likely to be unoccupied due to stand age, although some higher-quality remnant habitat patches may be occupied.

Under Condition 8 (Chapter 5), intensive harvest treatments in designated occupied and modeled potential marbled murrelet habitat are prohibited unless they are in areas determined to be unoccupied through the process set forth in Condition 7. When intensive treatment areas overlap with designated occupied or 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. Areas allocated to intensive treatment that are found to be occupied by marbled murrelets will be reallocated to either extensive treatment or reserve.

Harvest of non-habitat within intensive stands may still indirectly affect marbled murrelet nesting habitat in adjacent stands. As described under Effects Pathways, harvest adjacent to marbled murrelet nesting habitat may create a sharp edge that could subject any nesting murrelets to increased risk of nest site predation. This effect could occur at the affected site for several years, until regeneration occurs to create a softer edge and less direct access to nesting stands for predators. In addition to nest site depredation from corvids that may increase with the creation of edge habitat, clearcut harvest and heavy thinning will expose habitat to windthrow by removing wind protection that was provided by the harvested/thinned stand (Raphael et al. 2016). In addition, harvest of adjacent stands can reduce humidity levels within habitat, reducing the extent and future development of mossy branches required for marbled murrelet nest sites (Van Rooyen et al. 2011).

Extensive Treatments

Effects on much of the marbled murrelet nesting habitat in extensive treatment areas will be minimized through retention standards described in Chapter 5 (Condition 8). Even with retention of at least 80 percent pre-harvest density in extensive treatment areas, temporary degradation of habitat is possible to a point where marbled murrelets no longer select nest sites in those locations or experience a higher degree of nest predation due to reduced forest cover and increased exposure to predators.

Condition 8 also specifies that no more than 1,400 acres will be managed in extensive treatment areas in occupied marbled murrelet habitat, all of which will be conducted using the extensive prescriptions based on ecological forestry techniques emphasizing promotion of multiple values in addition to timber production as described in the Oregon State University research proposal (2021). Within that 1,400-acre limit, no more than 500 acres[3] will be managed in the first 10 years of the permit term. Those 500 acres will be part of a research project, which will be developed in

[3] As a first approximation from a scientific perspective, Betts et al. (2020) suggested 10 treatment sites (where extensive harvest occurs) and 10 control sites (stands with no harvest). A site would likely need to be more than 50 acres.

coordination with the USFWS and other stakeholders, to determine whether and when marbled murrelets recolonize those managed areas and whether they experience changes in nest success or depredation rates. The remaining 900 acres will only be managed if the results of the research show benefits to the species and upon review and approval of the USFWS (see Chapter 5, Condition 8).

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 (described in Chapter 3) will provide opportunities to minimize or avoid edge effects and associated risks of predation, but edge effects will still occur.

Murrelet surveys will be conducted—using USFWS-approved protocols—in all potentially occupied habitat stands that are intended for harvest. In the first 10 years of implementation, a total of 500 acres should be sufficient to detect harvest effects on occupancy (with a paired 500–800 acres as controls). Timber harvests in occupied stands will not reduce tree relative density more than 20 percent and will retain the overstory as much as possible. Best management practices will be developed and will involve provisions to limit predation by corvids and other impacts on murrelets as informed by the best available science.

This combination of high pre-harvest retention rates in occupied and potential habitat and limits on the total acres that can be managed in extensive allocations minimizes effects from habitat modification on marbled murrelets. Habitat modification may result in take immediately following harvest treatments, due to a decrease in habitat quality, but habitat quality is expected to recover over time, leaving a temporal effect on habitat quality.

Reserve Treatments

Stand management activities will occur in the CRW, MRW reserves, and RCAs. These activities will primarily be thinning to set these stands on a trajectory to develop old forest structure, which will increase the habitat value for marbled murrelets. These stand management activities will occur in the first 20 years of HCP implementation and will focus on Douglas-fir plantations that are less than 65 years old (as of 2020) and not occupied. Because trees 65 years old (in 2020) and older 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 occupied or potential habitat is present adjacent to thinning treatments in reserves.

Riparian Conservation Area Treatments

Treatments within RCAs are expected to be similar to those described for reserves, as the same operations standards will apply. As described in Chapter 3, thinning to reduce the density of existing plantation stands within RCA 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. The conservation outcome is primarily focused on promoting the more rapid development of large trees, so effects may be a temporary reduction in habitat values. Because such treatments will follow operations standards described in Chapter 3 and conservation measures and conditions described in Chapter 5, RCA treatments will only occur where marbled murrelets have been determined to be absent, and, therefore, direct effects on nesting marbled murrelets will not occur. 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.

Effects of 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 will occur due to previously described covered activities, including thinning of plantations located in reserves, RCAs, and extensive treatment designations and associated covered activities, including landings, and road construction, maintenance, and use.

In addition to previously described thinning in RCAs, riparian restoration and stream enhancement projects will include selective tree harvesting beyond 120 feet from the stream for ecological purposes, which could result in localized habitat reductions, although all operations standards for RCAs will be applied to minimize effects, including limiting such harvest to trees less than 65 years old (as of 2020) and outside of designated habitat for northern spotted owls.

Removal of active or legacy roads will not have adverse habitat effects other than the potential need to remove hazard trees determined to be an unacceptable safety risk for workers or the others. Road daylighting will involve 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 owl habitat.

Effects of Monitoring and Implementation Activities

Marbled murrelet monitoring efforts (described in Chapter 6) will follow USFWS-approved methods, which are currently conducted by trained surveyors watching and listening for marbled murrelets (Evans Mack et al. 2003). This method has no adverse effects on marbled murrelets.

Effects of Other Covered Activities

Also, as previously described under effects of each research treatment designation (reserve, intensive, extensive, RCAs), habitat disturbances will 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, as well as the conservation actions and conditions described in Chapter 5. This includes avoiding disturbance of nesting marbled murrelets through the seasonal restrictions (Condition 1, Chapter 5). The acres of habitat impacts described in Section 4.4.2 includes acres that will be disturbed from the other covered activities that will be conducted within the framework of the research design and associated operations standards, conservation measures, and conditions (i.e., habitat effects are counted by not quantified separately).

4.5.2 Amount of Take

4.5.2.1 Disturbance and Direct Morality

As previously established, disturbance of nesting marbled murrelets from covered activities, including smoke from prescribed burning, is expected to occur, but at levels below the threshold of take due to the seasonal restrictions outlined in Chapter 5. Similarly, noise from road use may result in some behavioral responses, but the overall effect is not likely to significantly disrupt normal behavior patterns or otherwise result in take.

Mortality from collisions with vehicles is possible, but 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, the USFWS has not quantified such take for incidental take permits for road mortality related to forest management operations (e.g., for the Bureau of Land Management's Resource Management Plan for Western Oregon [U.S. Fish and Wildlife Service 2016] and the Washington State Department of Natural Resources Marbled Murrelet Long-term Conservation Strategy [U.S. Fish and Wildlife Service 2019]). As described in Chapter 5, Conservation Measure 3 restricts road development to no more than 40 miles of new roads of the course of the permit term, and several roads are expected to be closed or vacated, particularly in the CRW, where no net increase in permanent road miles will occur.

As previously described, mortality of marbled murrelet eggs or chicks may occur due to nest site depredation facilitated by clearcut or heavy thinning adjacent to occupied nesting habitat. 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.

4.5.2.2 Habitat Modification

Based on the research design and treatments presented in Chapter 3, and on a habitat suitability model developed specifically for the ESRF,[4] a total of 1,417 acres of designated occupied marbled murrelet habitat and 487 acres of modeled potential habitat are present within young Douglas-fir plantations assigned to intensive harvest treatment under the research design. Of the 1,417 acres of designated occupied marbled murrelet habitat allocated to intensive treatments, roughly 450 acres were shown to have some residual large trees or potential habitat structure, based on an air photo and LiDAR review (Oregon State University 2021). The remaining acres are not expected to contain habitat features that marbled murrelet require during nesting, despite being mapped as occupied habitat based on historical survey information. A further assessment of these designated occupied areas or modeled potential areas that are allocated to intensive treatments is required by Condition 7, described in Chapter 5. Surveys of any residual habitat patches larger than 5 acres are also required by the condition, and any areas found to be occupied by marbled murrelets will be reallocated to extensive treatments or reserves. There will be no loss of designated occupied marbled murrelet habitat from intensive treatments unless they are in areas determined to no longer be occupied through the process set forth in Chapter 5 (Condition 7).

Within extensive research treatment areas, 1,910 acres of designated occupied habitat and 1,178 acres of modeled potential habitat are present and will be subject to ecological forestry in extensive treatments. However, Condition 8 specifies that no more than 1,400 acres will be managed using ecological forestry techniques in extensive treatment areas in designated occupied marbled murrelet habitat. Within that 1,400-acre limit, no more than 500 acres will be managed in the first 10 years of the permit term. Those 500 acres will be part of a research project to determine whether and when marbled murrelets recolonize those managed areas and whether they experience changes in nest success or depredation rates. The remaining 900 acres will only be managed if the results of

[4] Betts et al. (2020) used Maxent to model marbled murrelet occupancy data for the ESRF. Maxent is a machine-learning-based presence-only model that is extensively used for modeling species distributions. The model was informed by a combination of marbled murrelet survey data, Landsat spectral analysis, and LiDAR. It identified habitat as occupied or potential, with "occupied" based on known observations and "potential" based solely on habitat.

the research show benefits to the species or as otherwise agreed to with the USFWS. This limit on harvest activities in extensive allocations in occupied habitat will minimize effects on marbled murrelets. The locations where ecological forestry experiments will occur in designated occupied marbled murrelet habitat equate to approximately 5 of the 51 marbled murrelet management areas formerly recognized by the Oregon Department of Forestry. Experiments will occur in locations where designated occupied habitat (former marbled murrelet management areas) overlap with extensive research allocations. Only five such locations exist that are more than 10 acres in size, meaning a patch of designated occupied habitat large enough to conduct an experiment on marbled murrelet use.

Table 4-5 summarizes the acres of marbled murrelet habitat across research treatments. As shown in Table 4-5, most (93 percent) of the oldest habitat (i.e., more than 65 years of age as of 2020) is in reserves and will not be adversely affected by covered activities. Approximately 1,394 acres of designated occupied or potential habitat more than 65 years of age (as of 2020) are in extensive treatment areas and no older habitat is in intensive treatment areas. Based on a review conducted by Oregon State University of stands less than 65 years of age (as of 2020) that were identified as occupied (Oregon State University 2021:Appendix 11), approximately 65 percent of these stands contained no residual trees, and approximately 31 percent contained residual trees. Four percent were adjacent to older stands and could provide buffer habitat.

Figure 4-5 shows the distribution of marbled murrelet habitat among the research treatments described in Chapter 3. Figure 4-6 shows marbled murrelet habitat locations relative to research treatments.

Table 4-5. Marbled Murrelet Habitat, by Research Treatment[1]

Treatment Type	Designated Occupied	Modeled Potential
Reserves (MRW reserves, RCAs and entire CRW)		
Habitat <65 years old (as of 2020)	907	1,236
Habitat >65 years old (as of 2020)	17,241	13,451
Total	**18,148**	**14,687**
MRW Extensive		
Habitat <65 years old (as of 2020)	516	195
Habitat >65 years old (as of 2020)	1,394[2]	983
Total	**1,910**	**1,178**
MRW Intensive (all <65 years old as of 2020)	**1,417[3]**	**487**
Total Existing Habitat Within the Permit Area	**21,475**	**16,351**

[1] Habitat based on Betts et al. (2020a). Reported acreages differ slightly from those presented in Oregon State University's research proposal (2021) because the research proposal was completed before the riparian conservation strategy was finalized. Updated RCAs account for difference in acreages when they occur in occupied or potential marbled murrelet habitat.

[2] No more than 1,400 acres will be managed using ecological forestry techniques in extensive treatment areas in occupied marbled murrelet habitat. Within that 1,400-acre limit, no more than 500 acres will be managed in the first 10 years of the permit term. The remaining 900 acres will only be managed if the results of the research show benefits to the species, subject to agreement with the USFWS.

[3] Surveys of any residual habitat patches larger than 5 acres are also required by the condition, and any areas found to be occupied by marbled murrelets will be reallocated to extensive treatments or reserves.

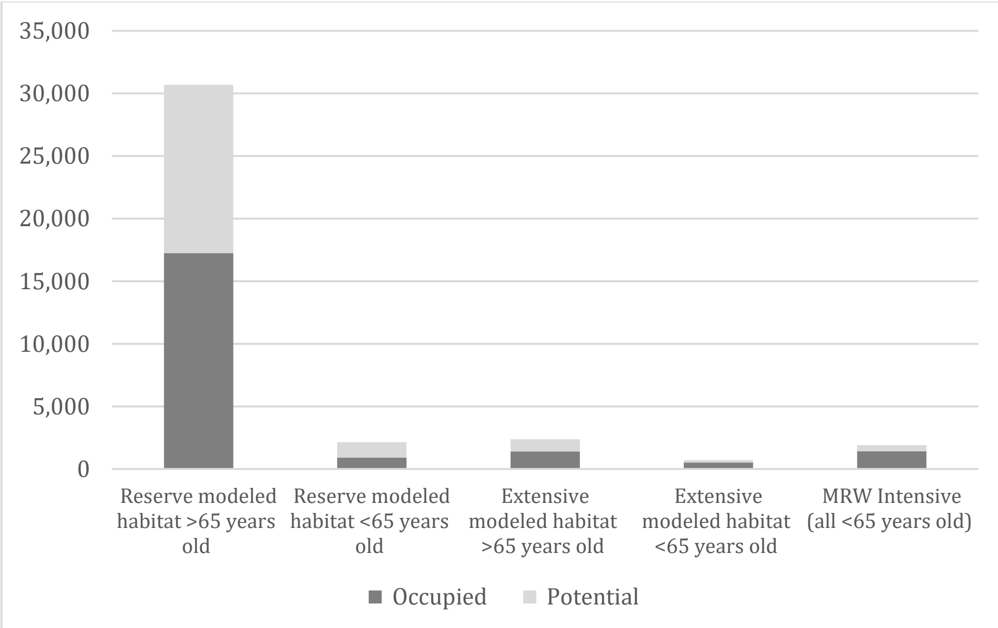


Figure 4-5. Marbled Murrelet Habitat by Research Treatment

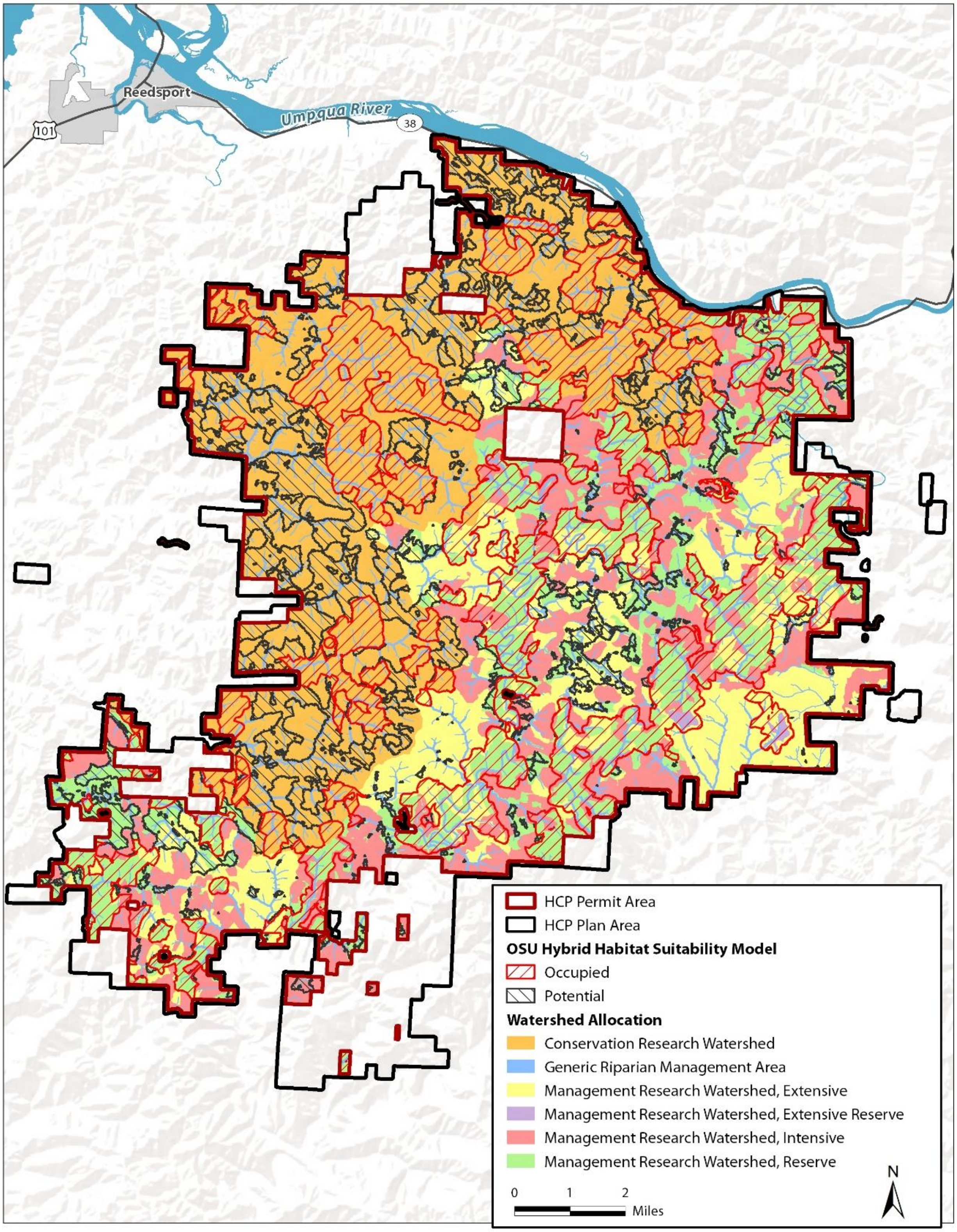


Figure 4-6. Marbled Murrelet Occupied and Potential Habitat by Research Treatment

4.5.2.3 Effects on Individuals

The majority of known occupied marbled murrelet nesting sites (i.e., those with "significant observations," based on USFWS-approved survey protocols) will be in reserves or will be reallocated to reserves detailed under Condition 7 in Chapter 5. No more than 1,400 acres of occupied habitat will be harvested using ecological forestry techniques embodied in the extensive treatment prescriptions. The harvest will include at least 80 percent retention of pre-harvest density in those stands that are harvested. Harvesting could result in some short-term habitat modification that would make that habitat less suitable or less desirable to marbled murrelets. Because marbled murrelets have high site fidelity, this could result in some failed nesting attempts for a period of time, or avoidance of nesting habitat until habitat quality recovers.

Intensive harvest treatments in designated occupied and modeled potential marbled murrelet habitat will be avoided unless they are in areas determined to no longer be occupied through the process set forth in Condition 7 (Chapter 5). Also under Condition 7, all designated occupied and modeled potential marbled murrelet stands subject to intensive or extensive harvest treatments will be examined for presence of marbled murrelet nest sites following a three-step process that includes a desktop survey, field assessment, and, if determined to be needed, marbled murrelet nesting surveys. Furthermore, under Condition 7, where marbled murrelets are determined to be nesting within intensive allocations, the area will be redesignated as a reserve (or expanded RCA) or extensive treatment area, and a replacement amount of intensive treatment areas will be reallocated to another part of the subwatershed. Where nesting marbled murrelets are discovered within extensive treatment areas, stand management will be done consistent with Condition 8, which limits extensive harvest treatments in designated occupied marbled murrelet habitat to no more than 1,400 acres, and must be undertaken consistent with Condition 7.

As previously described, 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.

4.5.2.4 Effects on Critical Habitat

Less than 5 acres of critical habitat overlap with the permit area. These 5 acres will be avoided by covered activities resulting in no effect on critical habitat. The ESRF 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.

4.5.3 Impact of the Taking

The approximately 1,910 acres of designated occupied marbled murrelet habitat and 1,178 acres of modeled potential habitat present within extensive treatment allocations (described in Section 4.5.2) represent 8 percent of the total designated occupied or modeled potential murrelet habitat within the permit area (3,088 acres of 37,826 acres). Within intensive allocations, 1,417 acres of designated occupied marbled murrelet habitat and 487 acres of modeled potential habitat are present, which represents approximately 5 percent (1,904 acres of 37,826 acres) of the total designated occupied or modeled potential habitat in the permit area. Collectively, there are 4,992 acres of designated occupied and modeled potential habitat in extensive and intensive allocations, representing 13 percent of the total designated occupied or modeled potential habitat within the permit area.

Because the best and largest blocks of habitat were retained in reserves, the loss of biological value is likely lower than the proportion of habitat that will be lost. More than three-quarters (77 percent) of the designated occupied and modeled potential habitat that will be subject to harvest under the research design is in even-aged Douglas-fir plantations that contain few or no residual trees suitable for nesting and where modeled habitat is generally fragmented.

The following conditions will minimize effects on marbled murrelets (more detail is provided for each in Chapter 5).

- Condition 6—Seasonal restrictions on covered activities in occupied areas during the nesting season.
- Condition 7—Survey requirements in residual habitat patches in intensive treatment areas or extensive treatment areas that overlap with designated occupied habitat or modeled potential habitat; reallocation of areas found to be occupied to either extensive or reserve allocations.
- Condition 8—Limit of 1,400 acres of designated occupied marbled murrelet habitat that can be managed under extensive allocations, including a limit of 500 acres of management in the first 10 years of the permit term. The remaining 900 acres will only be managed if the results of the research show benefits to the species, subject to agreement with the USFWS.
- Condition 9—No temporal loss of designated occupied or modeled potential marbled murrelet habitat, meaning that new occupied areas need to be discovered or new potential habitat needs to be grown before harvest of designated occupied or modeled potential habitat is allowed. This reduces any temporary loss of habitat function for marbled murrelets from covered activities.

Based on the research design and associated conditions, the amount of habitat loss described in Section 4.5.2 will be fully offset; while there may be short-term impacts associated with research, these will not result in adverse impacts on marbled murrelet populations at the level of the ESRF over the course of the permit term. It follows that the impact of the taking will not likely affect marbled murrelet populations within 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 could result in the following categories of stressors on Oregon Coast coho, each of which has the potential to result in take and is described in more detail in the following subsections.

- Changes to ecological processes that result in a reduction or modification of habitat. These include changes in habitat structure 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 barriers (e.g., undersized culverts, large jump heights).

- Direct injury or mortality of individuals as a result of handling or crushing by equipment, humans, or felled trees.

The stressors listed above are categorized in this manner to facilitate a meaningful assessment of the effect 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, residency 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. The approach 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.

To date, management has almost exclusively used fixed-width buffers (Richardson et al. 2012), which are set as an absolute distance. Such buffers widths are generally less than a site potential tree height and are primarily along fish-bearing streams; there is very limited application to other stream types. This approach is easy to administer and apply and is less costly than developing site-specific recommendations. As described in Chapter 3, RCAs (buffers) on the ESRF will be established on fish-bearing streams and a subset of non-fish-bearing streams to guarantee retention of ecological processes needed to support Oregon Coast coho. The focus of this approach is on maintaining sufficient wood recruitment potential to support needed habitat and environmental conditions, both within the permit area and in downstream areas outside of the permit area. Establishing these RCAs will also provide protection against increased temperatures, manage sediment transfer, and filter chemicals and other pollutants. Overall, the riparian buffering strategy will minimize modification of habitat and likely provide a net benefit for coho over the permit term. Each of these parameters and the potential effects under the HCP are described below.

Large Wood Recruitment

A common issue in fish-bearing streams in western Oregon is a lack of instream wood. Reduced instream wood is the result of removal of trees from within the riparian zone around streams and rivers over time for timber, as well as the long-standing practice of clearing debris and logjams from river channels (Stout et al. 2012). Large living and dead wood in the riparian zone provides important habitat for Oregon Coast coho. Trees that die and fall into and near streams, such as within floodplains and wetlands, regulate sediment and flow routing, influence stream channel complexity and stability, increase pool volume and area, and provide refugia and cover for fish (Bisson et al. 1987; Gregory et al. 1987; Hicks et al. 1991; Ralph et al. 1994; Bilby and Bisson 1998; Reeves et al. 2018). NMFS (2016) identifies the loss of stream complexity, which is created through inputs of large woody material, as a primary limiting factor for the Lower Umpqua and Coos independent populations.

Harvest in riparian areas adjacent to streams eliminates or reduces the amount of wood available for delivery to streams. As described in Chapter 3, RCAs will be maintained to provide a source for large woody material to aquatic ecosystems and includes the non-fish-bearing streams that are estimated to have the greatest potential to reach fish-bearing streams, thus ensuring that the input of wood and sediment and the productive capacity of the instream habitat is maintained, even in the intensive watersheds. The overall level of protection for aquatic and riparian ecosystems in the permit area in this proposed design is high when compared to the Olympia Experimental Research Forest and Oregon Forest Practices Act standards; however, the levels of protection do vary depending on the research designation. In the CRWs, these ecosystems and their associated ecological processes have a high level of protection. Similarly, the level of protection is high in the subwatershed treatment areas that contain extensive stand treatments because of the moderate to high levels of tree retention outside the RCA and alongside high landslide delivery potential streams where a variable-width RCA (50–200 feet) is designated. The designated sizes of the RCAs are most divergent within the intensive subwatershed treatment areas, where up to 50 percent of the subwatershed is in intensive management and 50 percent is in reserve. Widths of RCAs on fish-bearing streams are 200 feet when adjacent to reserve stands. RCAs on non-fish-bearing perennial streams and selected landslide-prone channels with the greatest potential to deliver wood to fish-bearing streams are 200 feet in the reserves and 50 feet alongside the harvested stands, respectively.

Wood recruitment for the ESRF is based on the model *ElliottSFWood*, developed by Dr. Dan Miller of Earth Systems Institute. The model estimates the relative proportions of total wood recruitment attributable to stream-adjacent, landslide, and debris torrent processes (Miller and Carlson in prep.), which was then integrated with the large wood source-distance relationships described by McDade et al. (1990) within a geographic information system (GIS) environment to estimate protected wood recruitment (Carlson et al. in prep.). Model output estimates *potential wood recruitment*, which is the quantity of large wood that could be recruited to a specified aquatic ecosystem, given the existence of certain conditions (Carlson in prep.). Based on model data, RCAs are expected to provide a minimum of 95 percent of potential wood delivery in the permit area. The current level of wood delivery in the permit area is likely much less than 70 percent because of historic harvest activities and the protection afforded to riparian areas from the Oregon Forest Practices Act. Potential wood delivery level will vary across the permit area by management approach but is founded upon 99 percent delivery in the CRW, greatly reducing potential adverse effects on the overall ESU. Delivery in the MRW will be targeted at 70 percent.

In addition to maintaining RCAs, Conservation Measure 1, Targeted Restoration and Stream Enhancement (see Section 5.4, *Conservation Measures*), will be utilized within RCAs where basin-level riparian stand conditions are inconsistent with achieving properly functioning aquatic habitat conditions in a timely manner. Similar to other locations along the Oregon Coast that were previously managed for timber production, riparian areas in the permit area that are characterized by a high density of conifers that restrict the growth and development of desired larger trees and lack hardwood trees need to be managed to promote key aquatic biological objectives (Reeves et al. 2018).

Generally, management in these types of riparian areas has been limited because of concerns about effects on wood recruitment and water temperatures. However, current science indicates that such an approach may actually compromise or retard the restoration 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, which will influence the structure of the aquatic food web (Bellmore et al. 2013). At these locations silviculture measures, such as thinning (Appendix A, *Riparian Thinning*), will be employed to allow faster development of larger trees that will benefit Oregon Coast coho. Thinning to increase tree growth (Dodson et al. 2012) and the purposeful placement of some 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).

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). In reaches where thinning occurs, 15–20 percent of the thinned total volume will be placed in the streams to provide structure for Oregon Coast coho, and all cut logs from within 120 feet of the stream will be retained within the RCA or placed within the stream channel (Conservation Measure 1). Introducing 15–20 percent of the volume of thinned trees to the stream will result in increased instream structure over time when compared to unthinned stands (Benda et al. 2015). The predicted increases in the volume of instream wood due to retaining portions of thinned trees within RCAs and their instream placement as a mitigation measure that could offset concerns about reductions of instream wood delivery and near-term impacts on fish habitat during a thinning operation (Beechie et al. 2000; Benda et al. 2016). Additionally, manual felling increases the amount of instream wood immediately rather than being delayed for 25–50 years in a no treatment, unmanaged stand, which will benefit Oregon Coast coho.

Wood recruitment is the function that occurs across the greatest expanse of the riparian area. Other functions such as root strength and litter fall occur very close to the stream, generally within equal to one-half a site potential tree height. Negative effects of the HCP on large wood recruitment are expected to be minor. Covered activities and Conservation Measure 1 will retain enough riparian forest to allow large wood to be recruited into fish-bearing streams in the permit area. Construction of new roads and cable corridors adjacent to streams will result in minor reductions in the amount of wood available for recruitment at some locations in the permit area. This action will be governed by Conservation Measure 3, Reduced Forest Road Network in CRW, and Condition 12, that will both limit new and reduce existing road construction in the permit area. Condition 12 will:

- Ensure hydrologically disconnection when constructing new roads, and
- Reduce erosion and stream sedimentation during road maintenance activities.

The minor reduction in available large wood and the habitat alterations associated with removal of wood for roads and cable corridors will be unlikely to result in take due to the conservation measures and conditions on covered activities. In addition, conservation measures and conditions in the RCAs will result in development of larger trees over time, leading to higher-quality wood being available for recruitment into the aquatic system throughout the permit term.

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, as much as or perhaps more than shade from riparian forests (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, perennial non-fish-bearing streams that flow into fish-bearing streams, particularly in stream reaches immediately above fish-bearing streams. Given the permit area's steep topography and proximity to the coast (Chapter 2), water temperatures are projected to be relatively favorable (Figure 4-7) over the course of the permit term, however, there are locations where modeling projects warming later in the permit term (Figure 4-8). In addition, the steep topography means there are limited locations where vegetation has an influence on water temperatures (Figure 4-9). Vegetation and topographic effects specific to each independent population are described in Section 4.6.2, *Impacts of the Taking*.

Wood recruitment in the permit area is being used as a surrogate for shade retention. The hypothesis is that the effectiveness of canopy cover for temperature regulation is closely correlated to wood delivery rates. Data collected during monitoring efforts will be analyzed to test whether riparian thinning to enhance tree growth will adequately protect stream temperature 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. The research plan objective is to attain 99 percent of potential wood recruitment in the CRW and reserve watersheds located in the MRW, and a minimum of 70 percent in the portions of the MRW that are not in reserves.

Under Conservation Measure 4, Research on Coho Salmon and Their Habitat, temperature monitoring will be employed in conjunction with harvest activities outside RCAs to determine how the size and vegetative composition of the RCAs interact with stream size to affect key aquatic characteristics and processes such as water temperature. The continued evaluation of the RCAs associated with harvest provides feedback on how alternative 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.

Potential effects on water temperature from harvest activities in the permit area are minimized by creating RCAs adjacent to the stream or wetland (see Chapter 3 for full RCA description). Stream shading and instream temperature protection will be maintained by retaining vegetation in riparian areas during adjacent harvest activities as described in Chapter 3. Absent an unforeseen circumstance such as flooding or fire, vegetation in the riparian buffers 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. Thinning activities in RCAs include Conservation Measure 1 to increase wood recruitment in the near and long terms. RCA thinning may result in localized increases in water temperature; however, relatively few studies have examined the effects of riparian thinning on stream-water temperature.

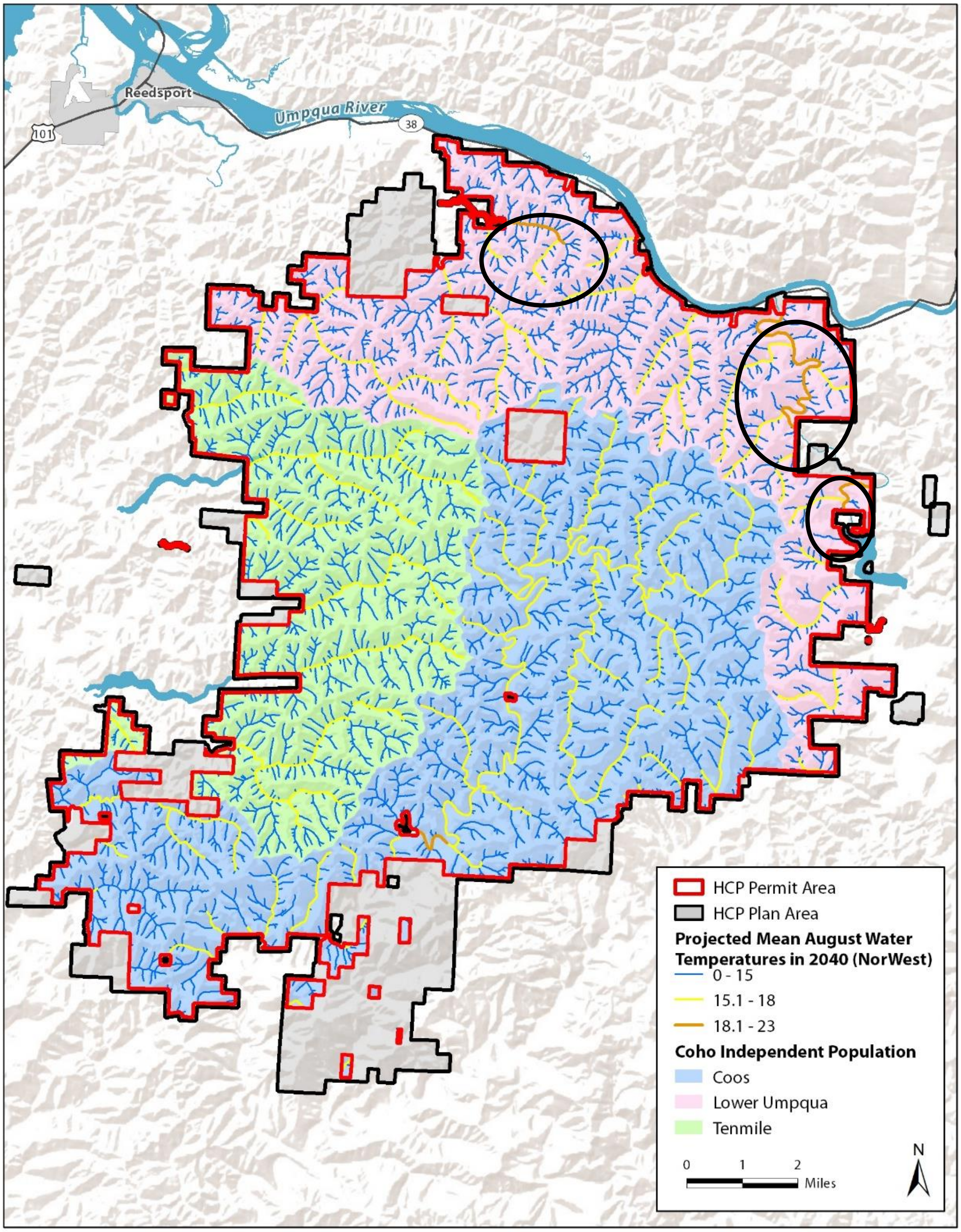


Figure 4-7. Projected Mean August Water Temperatures (°C) in 2040 (NorWest)

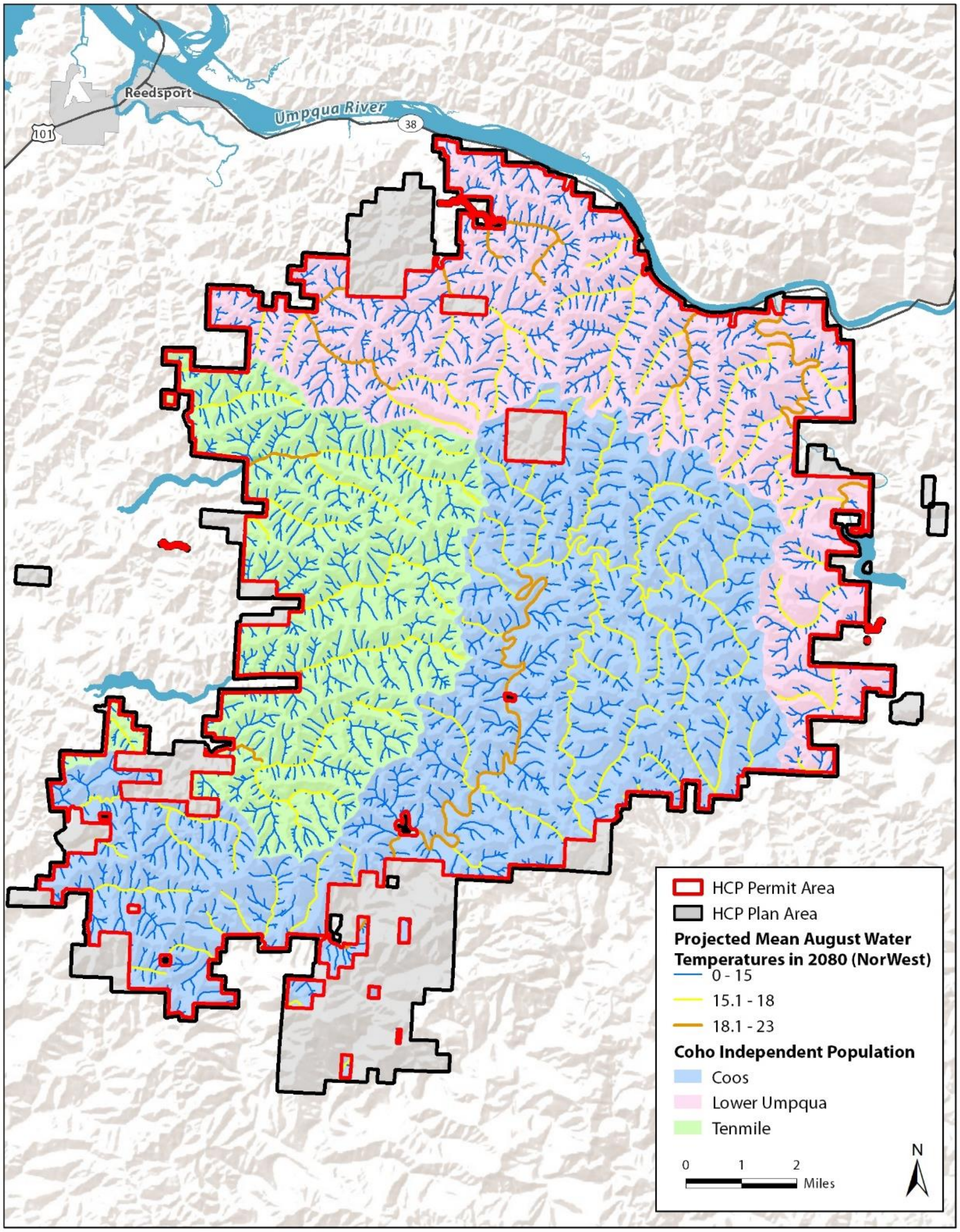


Figure 4-8. Projected Mean August Water Temperatures (°C) in 2080 (NorWest)

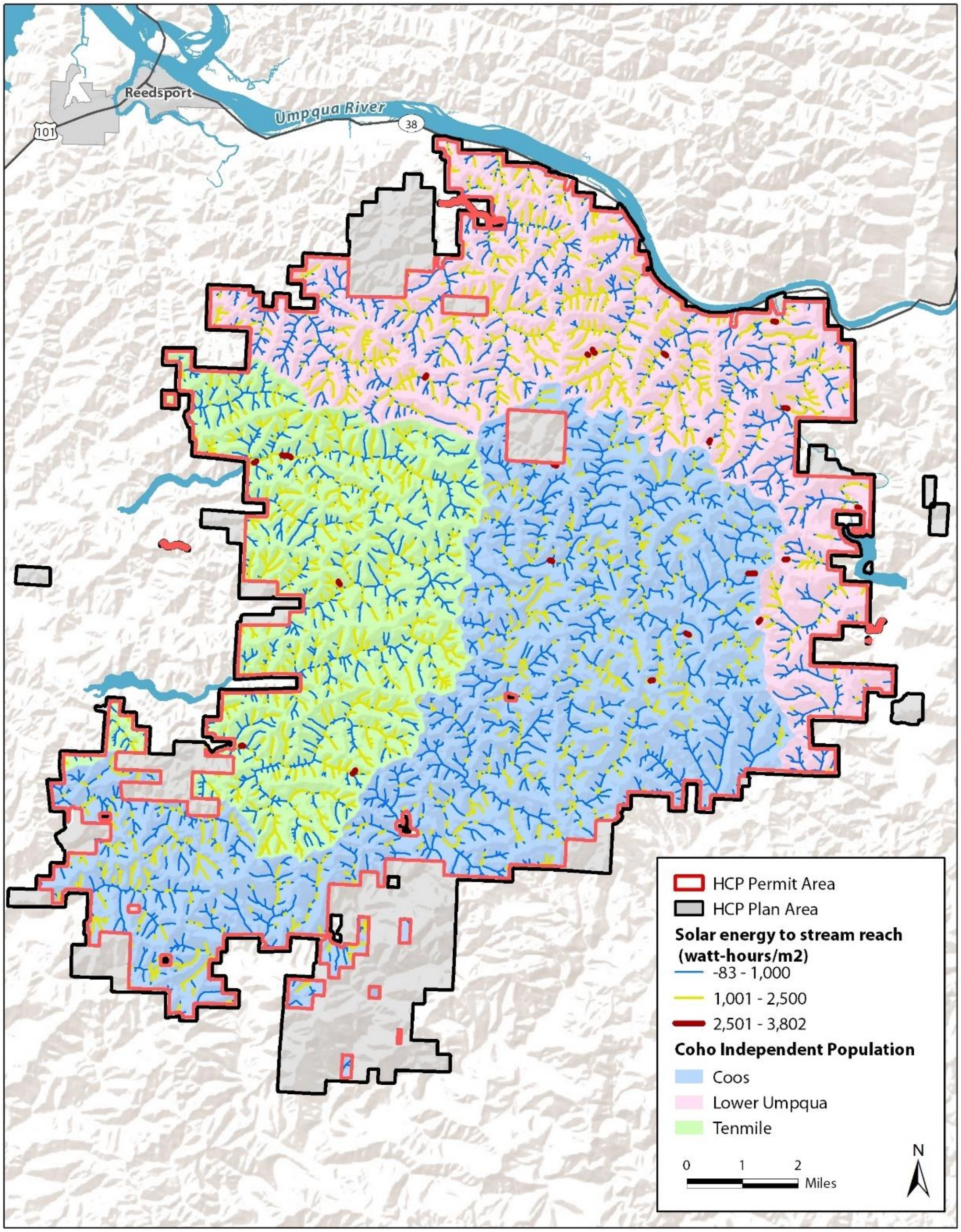


Figure 4-9. Stream Reaches Where Riparian Vegetation Exerts the Most Influence on Water Temperatures

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).

In general, 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 amount of shade lost 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 increases from riparian thinning are temporary because riparian forest canopies eventually close after thinning (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 the riparian buffer, the buffer size, the pre-thinned riparian forest attributes (Leinenbach et al. 2013), the thinning prescription (*see* Section 3.4.1), and the thermal sensitivity of the stream (Janisch et al. 2012). Further research is needed to improve understanding of the impacts of thinning.

The existing road network in the Elliott State Forest is primarily located on ridge tops, with 0.5 percent of the existing road network occurring within 100 feet of a waterbody. This road network is extensive and new road construction in RCAs is expected to be negligible. If roads are constructed in proximity to a stream, right-of-way clearing can permanently remove an average width of 45 feet of vegetation within the new road's right-of-way that would reduce stream shading due to a reduction in tree density. Conservation Measure 3 will limit new road construction such that roads will only occur in RCAs when other options are not viable, which limits temperature effects on adjacent streams. However, some circumstances will require new road construction in the RCAs for harvest in areas outside the RCAs to occur. Due to the limited number of roads that are expected to be constructed in the RCAs, impacts on stream shading and temperature are expected to be localized and minor.

Road maintenance and decommissioning activities could require brushing, removal of hazard trees, culvert cleaning, road resurfacing (e.g., rocking), and drainage improvements. These actions could require that trees and brush be removed, with vegetation removal occurring primarily from the understory while the removal of hazard trees could affect overstory vegetation. These actions will occur infrequently (see Chapter 3) and will not affect vegetation composition in one location enough to cause more than a minor localized impact.

Due to the steep topography of the permit area, creation of RCAs, and limited potential for road construction in RCAs, temperature effects on Oregon Coast coho are likely to be minor and localized.

Sediment Transfer and Suspended Sediment

As described in NMFS (2016), increased levels of fine sediments loads, which can result from forest management, agricultural operations, and road building, can allow sediments to enter streams. Increased sedimentation can affect coho habitat and production by reducing spawning habitats, smothering reeds, decreasing pool depth, and decreasing available substrate used by fry. The RCAs provide a forested buffer that will trap sediment before it enters the aquatic environment. The riparian vegetation that is maintained inside the RCA will also stabilize streambanks, limiting the potential for introductions of fine sediment into the aquatic environment. In addition, increased wood recruitment into the streams, due to the RCAs, will provide channel complexity that will sort and store large sediment.

Landslides and other geologic processes can have significant effects on watersheds, including aquatic and riparian areas. Steep slopes present challenges for land managers, particularly in regard to timber harvest. The removal of trees can increase the frequency of the landslides and deep seated earthflows (Roering et al. 2003; Schanz and Colee 2022). Additionally, roads can exert a strong influence on them (Swanson and Dyrness 1975; Sessions et al. 1987; Miller and Burnett 2007). Concerns are particularly high where there is infrastructure or concern about human safety but also arise where landslides and debris flows may occur in areas used by salmonids, such as coho salmon.

Within the permit area the CRW, MRW reserves, and RCAs combined comprise 67 percent of the total area of the ESRF and 72 percent of the area of the ESRF with hillslope gradients greater than 65 percent (Figure 4-10). The balance of these steep slopes is in the extensive treatment areas (13 percent) and in the intensive treatment areas (16 percent). The prevalence of headwater streams with gradients greater than 50 percent shows a similar distribution pattern to steep slopes relative to reserve, extensive, and intensive treatments. Thus, at the scale of the entire ESRF, extensive and reserve treatments (CRW, MRW reserve, and RCAs) provide an appreciable level of protection to steep slopes and headwater streams. Reserve treatments (dark green) are non-harvest areas that are protected[5] from the effects of forest harvest. Intensive treatment areas (green) are intended to be representative of lands managed primarily under an industrial timber production approach within Oregon Forest Practices Act requirements and the additional ESRF intensive approach overlays. Extensive treatment areas (orange) represent alternative forest management strategies and will be managed to transition even-aged Douglas-fir stands towards greater diversity in structural composition and species mixture. The minimum relative density remaining after thinning will be 15–20 percent. This minimum density will be applied to a portion of the forests being converted from Douglas-fir plantations to create low-density stands that will be suitable for a rotation age more than 100 years while maintaining stand and crown complexity.

Mass wasting events, like shallow-rapid landslides, are a natural occurrence in the permit area, given the steep topography and highly dissected channel network. Landslides reaching stream channels can provide a source of coarse and fine sediments and woody debris to the channel network. The influence of landslides on a watershed scale, without the development of associated debris flows or dam-break floods, is generally localized. Aquatic habitats can be either beneficially or adversely influenced, depending on the level of sediment deposition. Fish spawning habitat in particular is dependent on gravel deposits and a well-sorted supply of gravels 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. Channels need streambed structure such as large boulder clusters or large wood to store and stabilize the bedload of sediment inputs. Channel structure to retain the existing level of sediment inputs in the permit area is currently lacking but will be improved through the creation of RCAs and the conservation measures.

Factors that influence slope stability in the permit area include, but are not limited to, slope steepness, root strength, roads, stand age, and rainfall intensity. A large majority of the steep slopes and non-fish-bearing non-perennial (XNFB) streams will be in reserve, RCA, or extensive treatment areas (72 percent). A relatively small portion of the ESRF's steep slopes and XNFB streams are in intensive treatment areas (Figure 4-10). Of that portion, some are in locations that will not put the

[5] Once restoration thinning of Douglas-fir plantations is complete.

anadromous fish-bearing network at risk (e.g., no anadromy above Loon Lake, where intensive treatment areas exist). Tools used to assess slope stability 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. RCAs on non-fish-bearing streams will integrate shallow translational landslide probabilities and will identify and prioritize protection for those slopes and stream channels most likely to initiate and sustain a debris torrent that delivers large wood to fish-bearing streams. No harvest of trees will occur in an RCA if they are situated on landslide-prone steep slopes or unstable conditions; however, silviculture management could occur to accelerate the development of larger trees on landslide-prone slopes. High landslide hazard locations are specific sites that are subject to initiation of shallow, rapidly moving landslides. Timber harvesting and road construction operations will be assessed for 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.

Risk-based management principles and best management practices described in Chapter 5 will minimize road-related landslides and chronic erosion (sedimentation to streams). Hazard assessment and risk-based management, in conjunction with the creation of RCAs will ensure available wood in the permit area will remain in RCAs, making large wood available in the track of potential debris slides and torrents. Vegetation management on steep slopes will vary by allocation and independent population. Management in RCAs is limited and all wood will be available for recruitment. In RCAs that are thinned (Conservation Measure 1) to promote the development of larger trees, all wood from the thinning will be retained within the first 120 feet from the stream, and 15–20 percent of the total volume thinned (0–200 feet) will be placed in the stream channel. This volume will come from the trees cut in the first 120 feet. If that amount is not available in that zone, the balance will be taken from areas ranging between 120 and 200 feet. RCA thinning could result in short-term sediment increase, but over the long term will promote properly functioning conditions for future aquatic habitat inputs to support Oregon Coast coho.

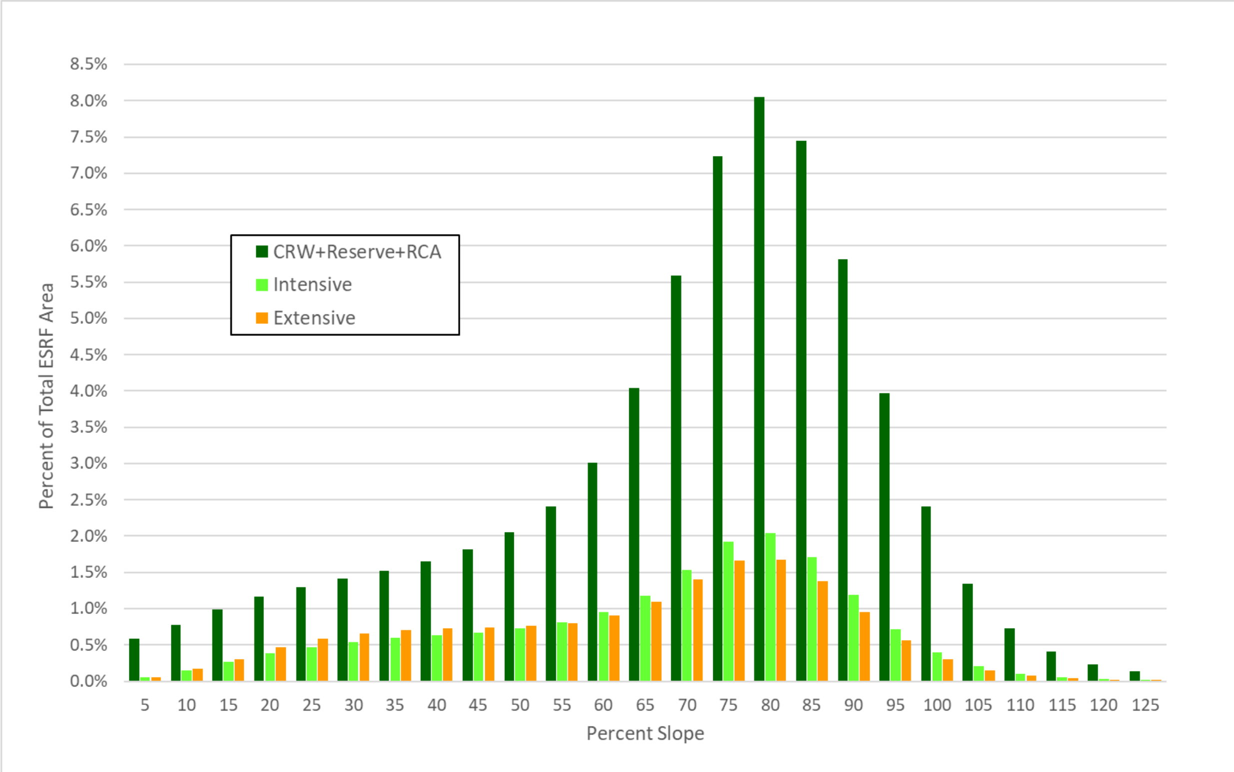


Figure 4-10. Distribution of Classified Hillslope Gradient by Treatments

The road system in the permit area is relatively old and in place. The majority of the road system in the permit area is on ridgelines, with approximately 0.5 percent of the roads within 100 feet of a fish-bearing stream and 9 percent of stream crossings traversing a fish-bearing stream. Ridgeline roads are generally good locations to minimize fill failure hazards and the hydrologic connectivity between the road system and the stream system; sediment from upslope roads does not move beyond the road prism (Wemple et al. 2001). No more than 40 miles of road will be built over the permit term to serve new landings or harvest sites (Section 3.6.1, *Road System Construction and Management*). Roads in the permit area will be managed in accordance with Condition 12 to minimize the disruption of natural drainage patterns. 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. Roads that cannot be fixed will be decommissioned as described in Conservation Measure 3.

Construction of new logging roads in RCAs will be a rare occurrence. 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 stream bank stability (Kaufmann et al. 2009). The indirect effects of increased access could result in increased deposition of fine sediment on the streambed and degrade spawning areas, reduce pool refuge habitat, decrease winter refuge areas for juveniles, and impede feeding visibility. These effects are expected to be nominal because new road construction will not exceed 0.5 mile per year and will likely occur outside RCAs, limiting the creation of new human access points.

Research activities and habitat restoration activities implemented under Conservation Measure 4 and Conservation Measure 1 could result in harm to covered species. 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., cut bank improvement of road drainage systems), road closure, and/or road decommissioning. These activities may temporarily affect covered fish species through temporary increases in sedimentation but will ultimately be beneficial and will follow the conditions on covered activities to reduce short-term impacts. Research activities, as described by Oregon State University (2021:Appendices 2 and 3) may cause aquatic habitat alterations that could have both short-term and long-term effects on Oregon Coast coho. Research efforts will include extensive data collection and monitoring programs to track the effects of landscape management on the aquatic ecosystem.

The creation of RCAs and implementation of Conservation Measure 3 and Condition 12 will limit effects on Oregon Coast coho in the permit area to minor, localized increases in sedimentation associated with new road construction, existing road and culvert maintenance, road use, and habitat restoration activities. While these conservation measures will minimize management-related erosion and sedimentation, complete elimination of management and public-related inputs is not possible.

Chemical Contaminants

If not sited properly, forest roads can direct and increase the runoff of soils into waterbodies, increasing sedimentation and exposure to potential chemical spills (Gucinski et al. 2001). Stormwater runoff from impervious surfaces delivers a wide variety of pollutants to aquatic ecosystems, such as metals (e.g., copper, 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). 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 the laboratory to affect fish behavior even at very low concentrations. Accidental introduction of contaminants associated with timber harvest activities (e.g., fuel spills from timber harvest equipment) could result in mortality or inhibit normal behaviors of covered species that encounter these contaminants. The introduction of contaminants associated with maintenance-related activities will have similar effects.

The majority of the road system in the permit area is on ridgelines, which are generally good locations to minimize the hydrologic connectivity between the road system and the stream system, reducing the potential for introduction of chemical contaminants into the aquatic system. Construction of new roads, while expected to be nominal over the course of the permit term, will follow Condition 12 and be hydrologically disconnected if possible. Roads that cannot be disconnected, or are unsuitable for wintertime haul, will be closed to logging trucks during wet weather. Staging and storage areas associated with construction activities in the RCAs 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

Forests influence water yield through the interception of precipitation and transpiration by trees. Increased coarse sediment following logging can increase the effect of low flows by shallowing and widening stream channels (Hicks et al. 1991). If more than approximately 20 percent of a watershed is clearcut at any given time, elevated peak flows become measurable; with these effects diminishing as the watershed becomes larger (Grant et al. 2008; Stednick 1996). Harvest outside of the RCAs is not expected to affect watershed process as intensive harvest blocks will be limited. Therefore, it is unlikely that 20 percent of any Hydrologic Unit Code 10 will be in the young forest stage (0–10 years) at any given time. Furthermore, the creation of RCAs addresses potential effects on water quantity from harvest activities in the permit area by maintaining riparian forests adjacent to the aquatic zone. Segura et al. (2020) found that riparian areas in fact partially mitigated the effect of clear cutting. As of this writing, the Permittee has not examined the widths of the buffers in these study areas in Segura et al. (2020), but given the study locations it is highly likely they were substantially less in size and extent than those proposed for the ESRF. This riparian vegetation will provide bank stability and prevent the shallowing and widening of a stream that can occur in its absence.

Access to Suitable Habitat

Fish passage for anadromous salmon 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. A number of natural barriers exist in the forest that prevent or delay fish passage. Fishways have been constructed at two of these sites—Elk Creek and Stulls Falls—to facilitate fish passage at a greater range of stream flows. It is unlikely that any additional fishways will be constructed to address natural barriers, though it could be something the Permittee collaborates on with regional partners.

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 12, 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 life and or when otherwise due for an upgrade.

Culvert replacement 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* (Oregon Department of Fish and Wildlife 2008) or will obtain appropriate approvals from the Oregon Department of Fish and Wildlife (ODFW) if it needs to occur outside appropriate windows. Effects of instream work associated with vegetation removal and increased sedimentation are described above.

4.6.1.2 Effects on Individuals

Direct mortality of the Oregon Coast coho could occur if they contact 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 the covered fish species. As described in Condition 12, in-water work will follow the established *Oregon Guidelines for Timing of In-Water Work to Protect Fish and Wildlife* (Oregon Department of Fish and Wildlife 2008) or will obtain appropriate approvals from ODFW if it needs to occur outside appropriate windows. The ODFW work windows will minimize impacts on Oregon Coast coho and its habitat by having work occur during times that avoid the vulnerable life stages of fish, including migration, spawning, and rearing.

4.6.2 Impacts of the Taking

Oregon Coast coho consists of 27 independent and dependent populations and is distributed across 4,227,104 acres. Three independent populations occur in the permit area—Tenmile, Coos, and Lower Umpqua—each of which encompasses only a portion of the overall ESU (Table 4-6). The ESRF has limited potential to increase numbers of coho salmon that would contribute to the ESU recovery because steep streams and narrow valleys dominate it. Such settings generally have limited potential to provide productive habitat for coho salmon. However, there are some areas in the permit area that have habitat conditions where coho numbers are relatively strong, and the contribution of these local populations may be important for the associated independent populations (Tenmile, Coos, and Lower Umpqua; Figure 2-13). The most 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 greatest. The permit area can be the foundation of comprehensive recovery and conservation efforts for the three independent coho populations that it supports. Table 4-6 summarizes the stream miles for each independent coho population across the research treatment areas. The following sections describe the variation in effects on these populations based on the type and extent of covered activities expected to occur in each.

Table 4-6. Fish Distribution by Independent Population and Treatment Type (Miles)[1]

Treatment Type	Tenmile	Lower Umpqua	Coos
Conservation Research Watershed	16.6 (95%)	11.7 (54.2%)	--
Management Research Watershed, Extensive	--	0.1 (0.5%)[2]	0.2 (0.5%)
Management Research Watershed, Lower Millicoma	--	--	26.9 (48%)
Management Research Watershed, Intensive	--	9.8 (45.3%)	28.3 (51%)
Management Research Watershed, Reserve	0.8 (5%)	--	0.3 (0.5%)
Total	17.4(100%)	21.6 (100%)	55.7 (100%)

[1] Stream miles based on species distribution in StreamNet (Oregon Department of Fish and Wildlife 2019b), not representative of all stream miles receiving RCAs in the permit area.
[2] Area upstream of Loon Lake not accessible.

4.6.2.1 Tenmile

The primary limiting factor in the Tenmile population is competition with nonnative species. However, NMFS recognizes that the lake stratum, which includes Tenmile, has been the strongest in terms of sustainability and persistence despite the presences of non-indigenous fish (National Marine Fisheries Service 2016). The rate at which nonnative fish are preying on Oregon Coast coho salmon in the lakes populations (Tenmile) and the Umpqua and Coquille Rivers populations, and the level of impact nonnative fish predation is having on these populations is unknown (National Marine Fisheries Service 2016). The occurrence of nonnative fish is outside the permit area, and therefore is not addressed as a conservation measure under this HCP.

Large Wood Recruitment

Stream complexity has been identified by NMFS (2016) as a secondary limiting factor for the Tenmile independent population. The permit area comprises 20 percent of the Tenmile independent population’s range. Within the permit area the Tenmile population occurs entirely within the CRW, which is expected to recruit 99 percent of available wood. Thinning in the Tenmile RCAs is expected to occur during the first 20 years. These thinning activities are aimed at achieving properly functioning aquatic habitat conditions in a timely manner. In reaches where thinning occurs, 15–20 percent of the trees removed from the RCA, and 100 percent from 120 feet of the stream (Conservation Measure 1) will be dropped in the streams to provide structure for Oregon Coast coho. If there is enough wood in the first 120 feet of the RCA to meet the 15–20 percent leave requirement, the remaining wood may be removed from between 120 and 200 feet. The recruitment of riparian wood over the course of the permit term will help with pool development and sediment retention, provide cover and spawning habitat, potentially increase floodplain connection, and promote nutrient cycling. Given that almost all riparian wood is available for recruitment in the CRW, wood enhancement projects in Tenmile will be limited to those that are deemed necessary to immediately improve local habitat conditions in the permit area. In addition, larger-scale targeted restoration projects such as side channel reconnection could be employed in this watershed to increase off-channel habitat.

Sediment Transfer

The Tenmile population is almost entirely in the CRW, with approximately 72 percent of the total acreage classified as steep slopes (slopes >65 degrees). Given the location in the CRW these slopes would not be harvested except for those RCA locations that have been identified for single-entry restoration thinnings (Conservation Measure 1) to improve aquatic and riparian conditions. These treatments would occur during the first 20 years of HCP implementation with the goal of enhancing forest complexity and habitat by transitioning young, dense plantations in reserves towards greater compositional, successional, and structural diversity to maintain functional habitat networks for the covered species and restore resources of high cultural value as identified by tribal partners. While restoration thinning will occur in RCAs, no trees will be removed from the first 120 feet of the RCA and limited equipment is expected to enter this area. The removal of riparian vegetation and presence of heavy equipment in the RCA will temporarily remove vegetative structure and compact the soil, which could increase erosion and sedimentation in adjacent waterbodies. Therefore, thinning activities that occur in RCAs during the first 20 years of the permit term may result in minor, localized short-term increases in fine sediment inputs.

Water Temperature

As described in Section 4.6.1.1, *Habitat Modification,* the permit area has steep topography that shades much of the stream network. While there are some locations in Tenmile where stream temperatures are strongly influenced by riparian vegetation this area is entirely in the CRW. The forests will be maintained as a reserve, and riparian ecosystems will be left intact except for restoration thinning (Conservation Measure 1) in the RCAs. Thinning in the RCAs will occur as a covered activity, and thinning strategies operate with the goal of improving aquatic conditions. This includes the retention of felled trees within 120 feet of streams (Conservation Measure 1). These projects could have short-term effects on stream segments that rely on vegetation to provide shading because in these areas instream temperatures may increase until crown closure occurs. 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 riparian thinning on stream temperatures will be a function of the amount of shade lost. These effects are expected to be localized and short term.

Suspended Sediment

The construction of new roads will be limited to temporary roads to facilitate conservation management activities. Road construction will be implemented consistent with Condition 12, minimizing the potential for increased sedimentation. The existing road network will be inventoried during the first 12 years of HCP implementation. Segments of the road network that pose a risk to the aquatic system will prioritized and upgraded or closed/vacated to reduce anthropogenic inputs of sediment that could affect coho (Conservation Measure 3). It is expected the overall road network within the bounds of the Tenmile population will not increase over the permit term and roads that remain will be hydraulically disconnected.

Chemical Contaminants

As described in Section 4.6.1.1 under *Chemical Contaminants,* 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.

Water Quantity

Given the Tenmile is almost entirely within a CRW, harvest-related changes to water quantity are not expected to occur. There would be limited silviculture activities associated with restoration during the first 20 years of the permit term. Based on this low level of silviculture work, at no point during the permit term will enough acres within the Tenmile independent population be 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 above for suspended sediment, hydraulic connections between roads and streams will be corrected wherever possible, and 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.

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 12, which requires that new and replacement culverts meet the most recent passage criteria (currently NMFS [2014] and ODFW [2015]) to ensure culverts are designed to maintain hydraulic conditions, including hydrology, velocities, and slopes that pass juvenile and adult fish. Effects on the Tenmile population from culvert replacement projects will be the same as described in Section 4.6.1.1.

Effects on Individuals

Effects on individuals can occur as described in Section 4.6.1.2, *Effects on Individuals*. These effects are expected to be limited for the Tenmile population due its designation as a CRW.

4.6.2.2 Coos

Large Wood Recruitment

The primary limiting factor in the Coos is stream complexity and the secondary limiting factor is water quality (National Marine Fisheries Service 2016). The permit area comprises 11 percent of the Coos independent population's range. Within the permit area the Coos population occurs entirely within the MRW, which will have harvest activities. Under Conservation Measure 2, Expanded RCAs on Lower Millicoma River, and considering the reserves associated with the intensive treatment areas, wood recruitment in the Coos is projected to be at least 89 percent. The Millicoma River's main channel will be bordered by 68 percent reserves, 26 percent extensive treatment areas, and 6 percent intensive treatment areas. Because 68 percent of the river will be bordered by reserves, the RCAs in these locations will exceed 200 feet because adjacent land will not be harvested. To further minimize the potential for adverse impacts on this ecologically and recreationally valuable region, as described in Conservation Measure 2, the approximately 30 percent of the Lower Millicoma watershed in reserves and 30 percent of the area in extensive treatment areas can be integrated with the non-fish-bearing streams identified as high potential for debris flow torrents that deliver wood to fish-bearing streams. Leaving standing wood along selected debris flow tracks ensures that wood will be incorporated into the landslide, which would not normally be the case with the Oregon Forest Practices Act. It also provides for a different legacy, modifying the potential of how the stream responds to the landslide.

Thinning in the Coos RCAs is expected to occur during the first 20 years. These thinning activities are aimed at achieving properly functioning aquatic habitat conditions in a timely manner. In reaches where thinning occurs, 15–20 percent of the trees cut in the RCA, and 100 percent from 120 feet of the stream (Conservation Measure 1) will be placed in the streams to provide structure for Oregon Coast coho. If there is enough wood in the first 120 feet of the RCA to meet the 15–20 percent leave requirement, the remaining wood may be removed from between 120 and 200 feet. The recruitment of riparian wood over the course of the permit term will help with pool development and sediment retention, provide cover and spawning habitat, potentially increase floodplain connection, and promote nutrient cycling.

Riparian and aquatic research will occur within the Coos with the goal of developing a better scientific understanding of the effects and biological response of natural and human-made disturbances in forest landscapes on water quality and quantity. Several different wood recruitment strategies, all of which meet the biological goals and objectives, will allow experimentation to test buffer effectiveness and tradeoffs with other values. Research activities may result in changes to the aquatic ecosystems. These effects will be tied to reporting and adaptive management requirements to ensure that the biological goals and objectives are met.

Sediment Transfer

Within the Coos, 55 percent of the total acreage is classified as steep slopes (slopes >65 degrees), with approximately 35 percent of that occurring within an intensive allocation that will be regeneration harvested on a 60-year rotation. The remaining 65 percent of steep slopes occurs in extensive or reserves. Upland harvest activities are expected to be spread out over space and time. While harvest will occur in the Coos it is unlikely to affect large contiguous swaths of the landscape simultaneously because all harvest activities will at least meet Oregon Forest Practices Act standards. As described in Section 4.6.1.1;most roads in the ESRF are located on ridgetops, and new road construction will be limited and occur at least 35 feet away from streams. Furthermore, under Conservation Measure 2, the RCAs along the Lower Millicoma River will be expanded to 200 feet horizontal distance on either side of the river mainstem and 120 feet 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. The forested buffer provided by the RCAs should be wide enough to sediment from surface erosion before it enters the aquatic environment and stabilize streambanks, limiting the potential for introductions of fine sediment into the aquatic environment.

Thinning in RCAs is a covered activity that will occur to promote the development of large-diameter conifers and varied tree sizes (including hardwoods) and create standing and down deadwood for recruitment into streams to increase habitat diversity and stream productivity. While this action will have a long-term benefit to the covered species, short-term direct impacts associated with ground disturbance from felling trees within 120 feet of streams (Conservation Measure 1) could result from sediment transfer to streams. The removal of riparian vegetation and presence of heavy equipment in the RCA will temporarily remove vegetative structure and compact the soil, which could increase erosion and sedimentation in adjacent waterbodies (U.S. Forest Service n.d.). The indirect effects of increased access could result in increased deposition of fine sediment on the stream bed, but effects are expected to be localized and short term.

Water Temperature

The secondary limiting factor in the Coos is water quality (National Marine Fisheries Service 2016). While the Coos is almost entirely in an MRW, 50 percent of that has expanded RCAs under Conservation Measure 2 (Table 4-7). As described in Section 4.6.1.1, the permit area has steep topography that shades the stream network in the Coos, protecting stream temperatures (Figure 4-8). Therefore, while harvest activities will occur, they are unlikely to cause increases in stream temperature.

Thinning in the RCAs will occur as a covered activity, and thinning strategies operate with the goal of improving aquatic conditions. This includes the retention of felled trees within 120 feet of fish-bearing streams (Conservation Measure 1) and 50 feet along perennial non-fish-bearing streams and high landslide delivery potential areas. These projects could have short-term effects on stream segments that rely on vegetation to provide shading because in these areas instream temperatures may increase until crown closure occurs. For example, Groom et al. (2011) found a 50 percent reduction in shade increased stream temperatures (3.6°F) as a result of riparian thinning. Reach-scale studies demonstrate that solar radiation is the primary factor affecting stream-water temperatures during summer (Leinenbach et al. 2013). Thus, the likely effect of riparian thinning 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 partial retention of forested riparian buffers tends to reduce these effects, as does thinning rather than clearcutting outside the buffer. These effects are expected to be localized and short term. Further, any shade loss and stream-temperature increase from riparian thinning will be temporary because riparian forest canopies can close relatively quickly after thinning (Chan et al. 2006; Yeung et al. 2017).

However, the amount of shade lost from a given thinning treatment can be highly variable, and the small number of scientific studies makes it difficult to draw strong generalities. The amount of shade lost 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).

Suspended Sediments

The construction of new roads will be limited to temporary roads to facilitate research-related harvest activities or conservation management activities. Road construction will be implemented consistent with Condition 12, minimizing the potential for increased sedimentation. The existing road network will be inventoried during the first 12 years of HCP implementation. Segments of the road network that pose a risk to the aquatic system will prioritized and upgraded or closed/vacated to reduce anthropogenic inputs of sediment that could affect coho (Conservation Measure 3).

Chemical Contaminants

As described in Section 4.6.1.1 under *Chemical Contaminants,* 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.

Water Quantity

On average, less than 1 percent of the permit area will be harvested in any 1 year and only a portion of that will include intensive harvest. Based on this low level of harvest 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 (10–30 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 above for suspended sediment, hydraulic connection will be corrected. 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.

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 12, which requires that new and replacement culverts meet the most recent passage criteria (currently NMFS [2014] and ODFW [2015]) to ensure culverts are designed to maintain hydraulic conditions, including hydrology, velocities, and slopes that pass juvenile and adult fish. Effects on the Coos population from culvert replacement projects will be the same as described in Section 4.6.1.1.

Effects on Individuals

Effects on individuals can occur as described in Section 4.6.1.2.

4.6.2.3 Lower Umpqua

Large Wood Recruitment

The primary limiting factor in the Lower Umpqua is stream complexity and the secondary limiting factor is water quality (National Marine Fisheries Service 2016). The permit area comprises 3 percent of the Umpqua independent population's range. Within the permit area approximately 66 percent of the Lower Umpqua independent population is contained within a CRW, which is expected to recruit approximately 99 percent of available wood. Thinning in the CRW RCAs is expected to occur during the first 20 years. These thinning activities are aimed at achieving properly functioning aquatic habitat conditions in a timely manner and will not remove wood from the first 120 feet of RCAs (Conservation Measure 1). 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. Given that almost all riparian wood is available for recruitment in the CRW, wood enhancement projects in Lower Umpqua will be limited to those that are deemed necessary to immediately improve local habitat conditions in the permit area. In addition, larger-scale targeted restoration projects such as side channel reconnection could be employed in this watershed to increase off-channel habitat. The remaining 34 percent of the Lower Umpqua is in the MRW, part of which is above Loon Lake and inaccessible to coho. The research design will allow flexibility in how each subwatershed in the MRW can best be arranged to optimize resource protection. The proportions of each stand treatment type (i.e., reserve, extensive, intensive) within a subwatershed are fixed. However, the arrangements or locations of each treatment are flexible, so treatments will be assigned to provide protections for older forest-dependent species, unstable slopes, and key riparian habitat for amphibians by assigning them to reserves. Approximately 95 percent of total wood is expected to be recruited in the Lower Umpqua.

Riparian and aquatic research will occur within the MRW of the Lower Umpqua, with the goal of developing a better scientific understanding of the effects and biological response of natural and human-made disturbances in forest landscapes on water quality and quantity. Several different wood recruitment strategies, all of which meet the biological goals and objectives, will allow experimentation to test buffer effectiveness and tradeoffs with other values. Research activities may result in changes to the aquatic ecosystems. These effects will be tied to reporting and adaptive management requirements to ensure that the biological goals and objectives are met.

Sediment Transfer

Within the Lower Umpqua 78 percent[6] of the total acreage is classified as steep slopes (slopes >65 degrees), with approximately 8 percent of that occurring within an intensive allocation that will be regeneration harvested on a 60-year rotation. The remaining 92 percent of steep slopes occur in extensive or reserves. Upland harvest activities are expected to be spread out over space and time. While harvest will occur in the Lower Umpqua, it is unlikely to affect large contiguous swaths of the landscape simultaneously. Landscape changes could affect instream habitat, as described in Section 4.6.1.1; however, given most roads in the ESRF are located on ridgetops and new road construction will be limited and occur at least 35 feet away from the stream, RCAs will provide a forested buffer

[6] This does not include the area above Loon Lake for the Lower Umpqua population, which is inaccessible to Coho salmon and other anadromous salmonids.

that will trap sediment before it enters the aquatic environment and stabilize streambanks, limiting the potential for introduction of fine sediment into the aquatic environment.

Thinning in RCAs is a covered activity that will occur to promote the development of large-diameter conifers and varied tree sizes (including hardwoods) and create standing and down deadwood for recruitment into streams to increase habitat diversity and stream productivity. While this action will have a long-term benefit to the covered species, short-term direct impacts associated with ground disturbance from felling trees within 120 feet of streams (Conservation Measure 1) could result from sediment transfer to streams. The removal of riparian vegetation and presence of heavy equipment in the RCA will temporarily remove vegetative structure and compact the soil, which could increase erosion and sedimentation in adjacent waterbodies (U.S. Forest Service n.d.). The indirect effects of increased access could result in increased deposition of fine sediment on the stream bed, but effects are expected to be localized and short term.

Water Temperature

The secondary limiting factor in the Lower Umpqua is water quality (National Marine Fisheries Service 2016). The Lower Umpqua is divided between CRW and MRW. As described in Section 4.6.1.1, the permit area has steep topography that shades the stream network in the Lower Umpqua, protecting stream temperatures. Furthermore, reaches within the CRW will have complete protection of the riparian ecosystems and changes to water quality and quantity are not expected to occur.

Thinning in the RCAs will occur as a covered activity, and thinning strategies operate with the goal of improving aquatic conditions. This includes the retention of felled trees within 120 feet of streams (Conservation Measure 1) and 50 feet along perennial non-fish-bearing streams and high landslide delivery potential areas These projects could have short-term effects on stream segments that rely on vegetation to provide shading because in these areas instream temperatures may increase until crown closure occurs. For example, Groom et al. (2011) found a 50 percent reduction in shade increased stream temperatures (3.6°F) as a result of riparian thinning. 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 riparian thinning 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 partial retention of forested riparian buffers tends to reduce these effects, as does thinning rather than clearcutting outside the buffer. These effects are expected to be localized and short term.

Suspended Sediment

Construction of new roads will be limited to temporary roads to facilitate research-related harvest activities or conservation management activities. Road construction will be implemented consistent with Condition 12, minimizing the potential for increased sedimentation. The existing road network will be inventoried during the first 12 years of HCP implementation. Segments of the road network that pose a risk to the aquatic system will be prioritized and upgraded or closed/vacated to reduce anthropogenic inputs of sediment that could affect coho (Conservation Measure 3). It is expected that the overall road network within the CRW will be reduced, and roads that remain will be hydraulically disconnected.

Chemical Contaminants

As described in Section 4.6.1.1 under *Chemical Contaminants,* 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.

Water Quantity

Over half of the Lower Umpqua is in the CRW. There will be no clearcuts in the CRW; however, restoration harvest (Conservation Measure 1) will occur during the first 20 years. On average, less than 1 percent of the permit area will be harvested in any 1 year and only a portion of that will include intensive harvest. Based on this 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 population 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 above for suspended sediment, the road network in the CRW is expected to decrease in total miles, and hydraulic connection will be corrected. 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.

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 12, which requires that new and replacement culverts meet the most recent passage criteria (currently NMFS [2014] and ODFW [2015]) to ensure culverts are designed to maintain hydraulic conditions, including hydrology, velocities, and slopes that pass juvenile and adult fish. Effects on the Lower Umpqua population from culvert replacement projects will be the same as described in Section 4.6.1.1.

Effects on Individuals

Effects on individuals can occur as described in Section 4.6.1.2.

4.6.3 Effects on Critical Habitat

A small portion of the designated critical habitat for Oregon Coast coho is in the permit area (Table 4-7). While the covered activities could have minor, localized effects on critical habitat, it is expected that the RCAs and conservation measures identified in Chapter 5 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.

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. 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 12). 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. Thinning (Conservation Measure 1) will set riparian forests on a trajectory that will benefit Oregon Coast coho and other aquatic organisms in the permit area.

Table 4-7. Miles of Critical Habitat by in the Permit Area

ESU	Total Miles of Designated Critical Habitat	Miles of Critical Habitat in Permit Area	Percent
Oregon Coast Coho	**1,064.5**	**84.6**	**1.4%**
Tenmile Independent Population	**78.7**	**16.1**	**19.4%**
Coos Independent Population	**453.2**	**55.5**	**11.4%**
Millicoma River	115.6	50.6	43.8%
Coos Bay–Frontal Pacific Ocean	189.7	4.9	2.3%
South Fork Coos River	153.9	0	0%
Lower Umpqua Independent Population	**532.6**	**13**	**3.5%**
Lower Umpqua River	85.1	13	15.3%
Middle Umpqua River	74	0	0%
Lower Smith River	197	0	0%
Upper Smith River	176.5	0	0%

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 and Level of Take*, specifies the take that is predicted to occur by carrying out the proposed covered activities (Chapter 3, *Covered Activities*), the impacts of such taking, and the net effects following consideration of the proposed conservation actions described in this chapter. Chapter 6, *Monitoring and Adaptive Management*, specifies the monitoring and adaptive management program that will be implemented to 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, *Conservation Strategies Integrated into the Research Design*, describes the specific components of the research design (Chapter 3) that the Permittee will use—in part—to achieve biological goals and objectives.
- Section 5.4, *Conservation Measures*, includes additional conservation measures that will be implemented—in addition to the avoidance and minimization measures integrated into the research design—to achieve biological goals and objectives.
- Section 5.5, *Conditions on Covered Activities*, includes additional conservation measures in the form of specific conditions under which covered activities will be implemented to further minimize effects 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 (Oregon Coast coho [*Oncorhynchus kisutch*], northern spotted owl [*Strix occidentalis*], marbled murrelet [*Brachyramphus marmoratus*]), considering implementation of the research proposal and all additional conservation strategies described in this chapter.

The following terms are central to the organization of this chapter and the conservation strategy itself.

- **Biological Goal:** Broad guiding principles based on the conservation needs of the covered species. A biological goal is included for each covered species.
- **Biological Objective:** 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 Measure:** Actions that DSL will implement to achieve the objectives in support of the Habitat Conservation Plan's (HCP) goals.
- **Condition on Covered Activities:** 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 summarizes the potential for take to occur as a result of habitat modification or effects on individuals from the covered activities presented in Chapter 3. The habitat protections and enhancement inherent in the research design and implementation described in Chapter 3 are considered in the effects analysis. These habitat protections and enhancements mostly, but not entirely, avoid and minimize effects on the three covered species. The conservation strategy in this chapter is designed to mitigate residual impacts from the covered activities and ensure that those impacts are fully offset and mitigated.

The conservation strategy defines specific biological goals and objectives, as required 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). The conservation strategy presented in this chapter incorporates and builds upon the research design described in Chapter 3 along with conservation measures and conditions on covered activities that will further avoid, minimize, or mitigate any effects that cannot be avoided or offset by the research design itself.

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 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 research activities described in Chapter 3, most of which reflect the Elliott State Research Forest (ESRF) research goals of exploring management strategies to ensure the conservation of aquatic and terrestrial ecosystems as an integrated system. For clarity, biological goals and objectives for each species integrate the components of the research proposal described in Chapter 3 with the conservation measures described in this chapter (i.e., they are additive).

[1] The requirement for biological goals and objectives in HCPs was first published by the U.S. Fish and Wildlife Service and National Marine Fisheries Service in 2001 in what was then called the "5-Point Policy" (65 *Federal Register* 35242).

Biological goals and objectives are provided in the sections below 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 below.

5.2.1.1 Goal 1: Retain and enhance existing northern spotted owl nesting, roosting, and foraging habitat and increase the availability of these habitat types in the ESRF.

Objective 1.1: Retain and enhance 28,000 acres of nesting/roosting habitat, and 11,000 acres of foraging habitat in the permit area.

Rationale

Northern spotted owl was listed under the ESA in 1990 (U.S. Fish and Wildlife Service 1990) because of widespread habitat loss across the range of the species. Past habitat 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 ESRF and surrounding areas continue to be a stronghold for northern spotted owl on the southern Oregon Coast (Kingfisher 2016).

Protecting existing northern spotted owl habitat in the permit area will help sustain survival and reproduction of northern spotted owls in currently occupied habitat, support and potentially improve persistent low densities in the central Coast Range, and retain sufficient unoccupied 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 28,000 acres of habitat that are modeled as high or moderately suitable nesting/roosting habitat by Davis et al. (2016) that are located in the Conservation Research Watershed (CRW), Management Research Watershed (MRW) reserves, or Riparian Conservation Areas (RCAs)—and these areas will be retained throughout the permit term. An additional 11,000 acres are modeled as marginally suitable nesting/roosting habitat, which likely supports foraging, will also be retained throughout the permit term. These habitats are located within stands generally greater 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 less as of 2020. Collectively, this 39,000 acres of nesting, roosting, and foraging habitat will be retained and enhanced in the CRW, reserves, and RCAs as described in the research design in Chapter 3. In addition, Section 5.5 outlines additional conditions on covered activities intended to achieve Objective 1.1 (particularly Conditions 2, 3, and 4), which includes commitments to retain habitat around the 23 historic northern spotted owl nests centered within 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 recovery plan (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 research treatment areas.

In addition to conserving 39,000 acres of known nesting, roosting, and foraging habitat, DSL will increase the amount of nesting, roosting, and foraging habitat that is available by 14,000 acres over the permit term to offset habitat lost due to research treatments.

The areas that will be managed to enhance the development and maintenance of northern spotted owl habitat will primarily be in the CRW and in the MRW reserves, though areas managed under extensive treatments with high retention rates are also expected to retain habitat value for northern spotted owls. Management that occurs in the CRW or reserves in the first 20 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 takes decades, particularly in stands that have little residual legacy structure and that lack large trees (Lindenmayer and Franklin 2002; Dodson et al. 2012), which is the case over much of the permit area. This objective is intended to provide benefits during the middle to later periods of the permit term.

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 non-habitat into habitat. Stands with any residual large trees would be particularly likely to develop into habitat. Approximately 11,000 acres in the CRW are between 30 and 60 years old, and these stands are most likely to become habitat within the permit term. Other habitat will develop within MRW reserves and RCAs, either naturally or through treatments intended to accelerate the development of old forest structure and associated habitat values for northern spotted owl.

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

There are currently 14,000 acres of habitat that are modeled as having low or no suitability for nesting/roosting habitat (Davis et al. 2016) that are located in the CRW, MRW reserves, or RCAs. Because the intention of the active and passive management in those areas is to develop old forest conditions, including habitat features and structure that will function as nesting, roosting, and foraging habitat for northern spotted owl, it is anticipated that all of those acres will become at least moderately suitable, if not highly suitable nesting/roosting habitat by the end of the permit term.

Depending on initial stand conditions, some of these areas will also provide foraging and dispersal habitat in both the near and long term.

Objective 1.3: Maintain at least 40 percent 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 *Federal Register* 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. DSL's commitment to retaining at least 40 percent of the MRW as dispersal habitat is an acknowledgement that habitat quality will be reduced in areas that are intensively harvested, and even in some areas that are extensively harvested, if retention is low. On the whole, however, the MRW will continue to provide some nesting, roosting, and foraging habitat and the remainder will provide at least a base level of dispersal habitat. This objective will ensure that that a large portion of the ESRF 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 biological goals and objectives below.

5.2.2.1 Goal 2: Increase occupied and potential marbled murrelet nesting habitat in the ESRF.

Objective 2.1: Retain and enhance 18,000 acres of occupied and 14,000 acres of potential marbled murrelet nesting 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 disturbance 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 incorporated into the research design described in Chapter 3. There are currently 18,000 acres of habitat that are designated as occupied and 14,000 acres modeled as potential marbled murrelet habitat in the CRW, MRW reserves, or RCAs. Collectively these 32,000 acres of designated occupied and potential habitat will be retained for the duration of the permit term in the CRW, MRW reserves, and RCAs as described in the research design in Chapter 3 (except: see Conditions 7 and 8 in Section 5.5).

Objective 2.2: Increase suitable marbled murrelet nesting habitat in the permit area by 21,000 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 research design described in Chapter 3, such as designated reserves and operation standards for extensive and reserve research treatments, which include several standards intended to increase old forest structure and associated habitat values. Within the CRW, MRW reserves, and RCAs there are currently 21,000 acres that are not designated occupied or modeled as providing habitat potential for marbled murrelets. It is anticipated that those acres will grow into habitat suitable for occupancy by the end of the permit term, although site-specific conditions and research treatments, disturbance, or other factors may result in some of these stands not achieving habitat objectives. As described in Chapter 6, marbled murrelet monitoring will be prioritized in stands that are developing into habitat for marbled murrelets, either due to active or passive management.

Stand management will be strategically focused in the CRW and reserves in locations that currently do not support habitat for marbled murrelet (i.e., generally those stands less than 65 years old). 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 potential nest trees to increase height and stimulate tree branch growth to increase nesting platforms (Raphael et al. 2018). Treatments may vary with research objectives, as this work will be conducted as part of research treatments. Per the research design (Oregon State University 2021), selective tree harvests and thinning within extensive allocations will retain 20 to 80 percent of the pre-harvest forest density during harvest cycles.

With the exception of the 1,400 acres allowed to be managed under extensive treatments, management activities within intensive and extensive allocations will not occur in occupied habitat that is verified following surveys described under Condition 7 in Section 5.5. This eventual expansion of habitat suitable for occupancy will allow colonization of new habitat and support the potential expansion of the nesting population over time. It will also improve the value of existing habitat by reducing edge effects through the creation of larger blocks of suitable nesting habitat.

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 ESRF as well as those in downstream reaches outside the permit area.

The strategy is further guided by the following principles.

- The role of the ESRF in supporting the 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: Promote recruitment of large woody debris.

Rationale

This objective promotes the development of streamside vegetation to improve freshwater habitat conditions for Oregon Coast coho through the contribution of large woody debris, and will be measured by long-term trends for each independent population.

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 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 riparian vegetation within 0.6 site potential tree height[2] (Spies et al. 2013) creates material to be recruited as instream large wood.

Objective 3.2: Support continual 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. Much of the instream shade in the permit area is associated with topography. The restoration of riparian function through implementation of RCAs in the permit area will benefit discrete locations where vegetation is the major influence on shading and will reduce stream temperature increases by adding shading (Beechie et al. 2012). This will benefit coho across the permit area and provide longer-term climate change resilience.

[2] Site potential tree height is approximately 200 feet in the permit area.

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 34 percent of the roads in the permit area are within 100 feet of a stream,[3] and only 0.5 percent of roads occur within 100 feet of areas that have been identified as high landslide delivery potential non-fish-bearing streams. Also, most roads in the permit area are on ridge tops, which are generally the most stable and the least problematic with regards to aquatic ecosystems because sediment from such roads does not move beyond the road prism (Wemple et al. 2001). As a result, this configuration greatly reduces the potential for roads in the permit area to contribute to chronic sedimentation.

Water quantity on the ESRF 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 percent over the course of the twenty-first century. Downscaled projects for the ESRF suggest that the reduction of summer flows will be on the low end of these projections (no more than approximately 7percent; 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 percent; Figure 5-2).

Reduction in summer low flows can negatively affect the covered salmon species by reducing the availability of rearing habitat in the permit area (Woelfle-Erskine et al. 2017). Forest management on the ESRF is not likely to decrease water quantity on the ESRF. Forests affect water yield through the interception of precipitation and transpiration by trees, with younger forest having higher rates that older forests. Perry and Jones (2016) found declining streamflow can result from the conversion of old growth to Douglas-fir plantations, with greater reductions correlated with larger harvested area. However, this is not likely to occur on the ESRF. First, no watersheds or subwatersheds will be totally clearcut. Intensive treatments in the MRW will be limited to no more than 50 percent of the watershed because for every acre of intensive management there is an acre of reserve. In addition, only those stands that are less than 65 years old will be harvested in intensive treatments, thereby 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. Additionally, Segura et al. (2020) found that riparian areas partially mitigated the effect of clear cutting on water yield. The extensive nature of the RCAs will thus further reduce the potential of management and research activities to affect summer flows. Implementation of RCAs will minimize sediment transfer to fish-bearing stream channels. Limits on new roads in, near, and across streams, including conditions described in Section 5.5, will minimize new sources of sediment and rectify existing sources from roads and other infrastructure.

Water quality and quantity will be protected through the designation of RCAs, as described in Chapter 4, as well as the management of RCAs, as described in Conservation Measure 2, Expanded RCAs on Lower Millicoma River; and Conservation Measure 3, Reduced Forest Road Network in CRW.

[3] Based on the Oregon State University synthetic stream layer developed of Oregon Coast coho.

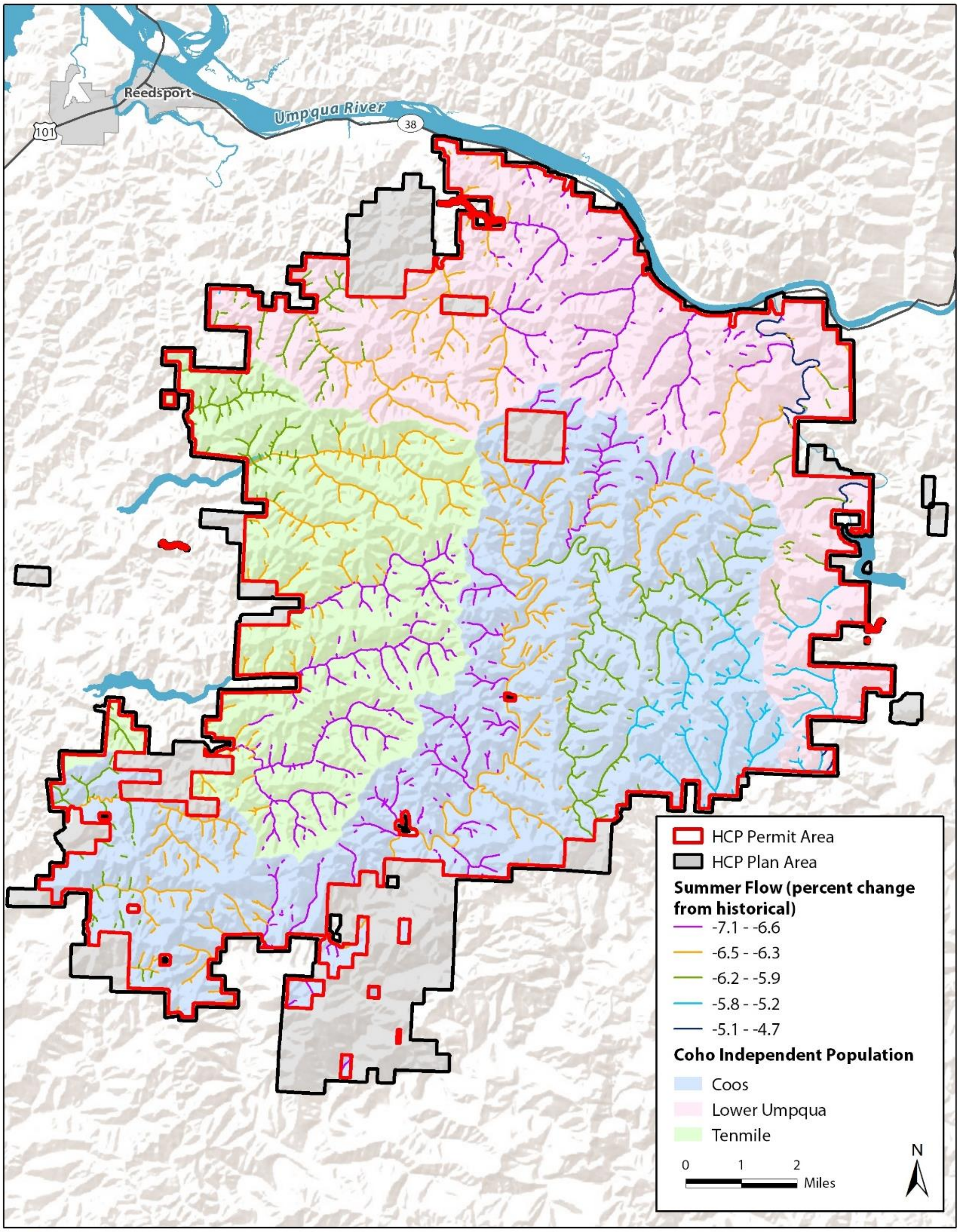


Figure 5-1. Downscale Climate Projections for Reductions in Summer Flow in the Permit Area

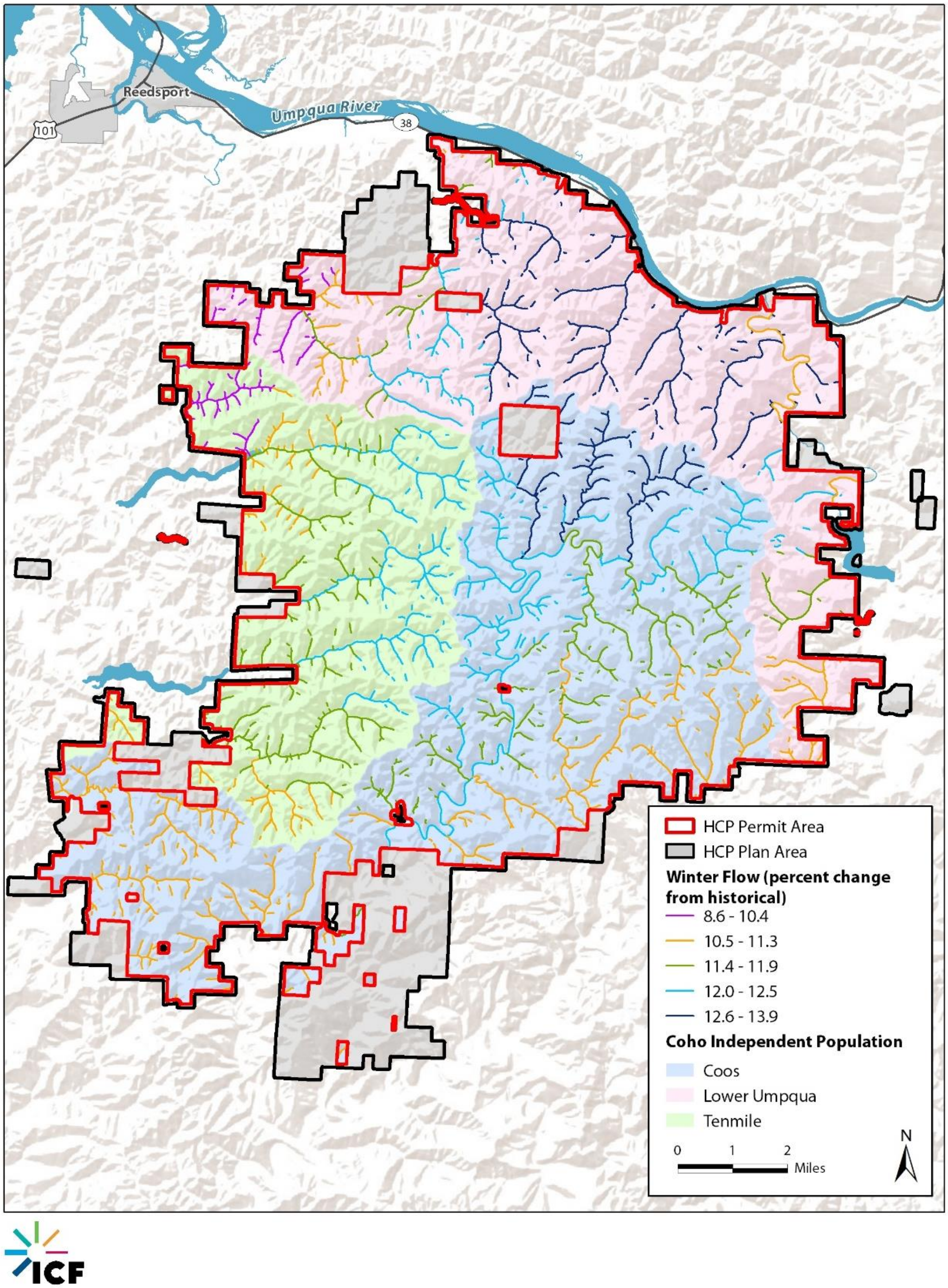


Figure 5-2. Downscale Climate Projections for Increases in Winter Flow in the Permit Area

5.3 Conservation Strategies Integrated into the Research Design

The research design and allocations described in Chapter 3 incorporate land designations that are designed, in part, to conserve the covered species and their habitats. These land designations and the forest management and research regimes associated with them are an integral part of the research forest proposal. In other words, the designation and management of the CRW and RCAs, and the subwatershed treatments in the MRW (see Section 3.2, *Foundational Research Design of the Elliott State Research Forest Proposal*, and Section 3.3, *Stand-Level Operations Standards, by Research Treatment Designation*) 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 avoidance and minimization measures that are integrated into the research design and associated covered activities described in Chapter 3.

5.3.1 Conservation Strategies for the Conservation Research Watershed

A major component of the avoidance and minimization measures integrated into the research design and associated covered activities described in Chapter 3 is the 34,148 acres that will be set aside as a single "blocked" reserve called "Conservation Research Watersheds." This set aside will be exclusively managed to promote and establish mature, complex forest stands providing significant habitat benefiting all three covered species. These 34,148 acres will constitute one of the largest dedicated conservation reserves in the Oregon Coast Range.

5.3.2 Conservation Strategies for the Management Research Watershed

Several avoidance and minimization measures have been integrated into the research design and associated covered activities described in Chapter 3 for the MRW.

Of the 48,382 acres allocated within the MRW, 14,096 acres will be designated as reserves and 6,538 acres will be designated and managed as riparian buffers for fish-bearing and non-fish-bearing streams. Called "Riparian Conservation Areas," these areas have been estimated based on stream layer data that includes 20 percent more fish-bearing stream miles than would be identified for protection using historical criteria for stream buffers set forth in prior decision documents of the listing agencies. These RCAs will also provide 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 "blocked" reserve and riparian set asides, a total of 66 percent of the entire permit area is being managed exclusively for conservation purposes benefiting the covered species.

The remaining 27,747 acres (or 34 percent) of the forest are available for harvest, but with operations standards designed to provide significant conservation benefits. These include the following.

- **Avoid Harvest of Oldest Trees.** Trees pre-dating the 1868 stand replacement fire on the Elliott will be protected.
- **Minimize Harvest of Older Stands.** No more than 3,400 acres of trees older than 65 years as of 2020 will be harvested over the 80-year term of the permit, and these will not be subject to intensive forest management practices.
- **Minimize Effects Through Ecological Forestry Within Extensive Allocations.** Approximately 16 percent (13,000 acres) of the total permit area will be managed according to principles of ecological forestry. Of these approximately 13,414 acres, only 3,400 acres are in stands 65 years or older, with the remainder in young, previously managed plantation stands. The 13,414 acres will be subject to "extensive" management protocols that dictate harvest treatments in 90-year rotation cycles (rotation cycles are the timing between commercial regeneration harvests) that retain between 20 and 80 percent of the stand density in order 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 Harvests to that Needed for Research.** While more than 42,000 acres (over 50 percent) of the permit area are currently characterized by stands younger than 65 years as of 2020, the research forest design calls for less than 14,500 acres to be "intensively" managed. These are the only acres in the permit area that will continue to be managed as plantations, and (significantly) the typical 40-year rotation will be extended to a 60-year rotation to establish a more mature forest across the Elliott State Forest landscape. Here again, all management will occur outside the acres set aside as RCAs, every area managed intensively is matched by creation of an equal amount of reserve in the same subwatershed, and no stands greater than 65 years old as of 2020 will be intensively managed.

5.3.3 Species-Specific Conservation Strategies

The following species-specific avoidance and minimization measures have been integrated into the research design and associated covered activities described in Chapter 3.

5.3.3.1 Northern Spotted Owls

80 percent of modeled nesting, roosting, and foraging habitat is located in designated reserves.

Only 7 percent of modeled habitat is included in areas subject to intensive treatments, where the HCP establishes specific retention requirements in Conditions 2, 3, and 4 to protect nesting, roosting, and foraging habitat (see Section 5.5).

The remaining 13 percent of modeled habitat is within extensive allocations, where habitat enhancement and retention will occur as part of research objectives for ecological forestry (although the amount of such habitat to be enhanced or retained remains to be decided during site-specific research design that will occur during HCP implementation).

Of the 23 known nest locations for northern spotted owl centered on the ESRF, 12 are in the CRW and 11 are in the MRW. Of those 11, 7 are in areas designated as reserves, and 2 are in protected RCAs. Two are in areas that could be subject to extensive treatments (but under the Conservation Strategy, will be managed consistent with Conditions 2, 3, and 4).

5.3.3.2 Marbled Murrelets

84 percent of designated occupied and 90 percent of modeled potential marbled murrelet habitat will be placed in designated reserves.

5.3.3.3 Oregon Coast Coho

A total of 66 percent of the entire permit area is in designated reserves based on the combination of CRW, reserve set asides in areas being actively managed (MRW), and RCAs.

A total of 86 percent of non-fish-bearing, non-perennial streams (XNFB) are located in reserves or areas subject to variable retention harvest characterized by ecological forestry principles that provide significant flexibility when establishing appropriate harvest layouts to reflecting site-specific characteristics. This also includes steep slopes and landslide-prone areas.

Areas set aside from active management and those in the variable retention harvest characterized by ecological forestry principles comprise 84 percent of the area that has hillslope gradients greater than 65 percent in the permit area. The balance of these steep slopes occur in intensive allocations (16 percent), and will undergo a geotechnical review as part of establishing harvest layouts in order to minimize effects on coho salmon prior to harvest.

RCAs were designated for the following purposes.

- To focus on fish-bearing streams (up to 20 percent 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).

Wood recruitment percentages for each of the areas defining the three independent populations of coho has been modeled at the following percentages.

- 99 percent for the Tenmile independent population.
- 94 percent for the Lower Umpqua independent population.
- 88 percent for the Coos independent population.

RCAs portions in the Millicoma are larger in order to support an increase in habitat quality for the Coos independent population.

Table 5-1 Summarizes how operations standards described in Chapter 3 help achieve the biological objectives and associated goals listed in Section 5.2.

Table 5-1. Operation Standards and Associated Biological Objectives[1]

	Northern Spotted Owl Objectives			Marbled Murrelet Objectives		Coho Objectives	
Operations Standards (Chapter 3)	**1.1 Retain Habitat**	**1.2 Increase Habitat**	**1.3 MRW Dispersal Habitat[2]**	**2.1 Retain Habitat**	**2.2 Increase Habitat**	**3.1 Recruit Large Woody Debris**	**3.2 Water Quality and Quantity**
R1. Manage CRW as contiguous reserve	X	X		X	X	X	X
R2. Assess plantations in reserves for treatment; treat suitable stands within 20 years		X			X	X	X
R3. Experiment to increase structure and diversity		X			X	X	X
R4. Explore methods for increased structure and diversity		X			X	X	X
R5. Prohibit treatments in forest older than 65 years (as of 2020)	X			X			X
R6. Treat all CRW within two decades		X			X	X	
R7. Prohibit logging (following initial treatments, if used)	X	X		X	X		
R8. Prohibit salvage	X			X		X	X
R9. Suppress fires	X			X			X
R10. Allow only limited riparian thinning		X			X	X	X
E-1. Maintain 50% retention average of harvest		X	X			X	X
E-2. Prohibit extensive treatments in stands dating to 1868 fire or earlier	X			X			
E-3. Retain live trees from 20 to 80% pre-harvest density	X	X	X			X	X
E-4. Maintain variable unit size			X				X

	Northern Spotted Owl Objectives			Marbled Murrelet Objectives		Coho Objectives	
Operations Standards (Chapter 3)	**1.1 Retain Habitat**	**1.2 Increase Habitat**	**1.3 MRW Dispersal Habitat[2]**	**2.1 Retain Habitat**	**2.2 Increase Habitat**	**3.1 Recruit Large Woody Debris**	**3.2 Water Quality and Quantity**
E-5. Maintain variable tree age, with target of minimum two canopy position age classes		X	X				
E-6. Prioritize retention where most needed		X	X			X	X
E-7. Test aggregating retention on unstable slopes						X	X
E-8. Limit planting to only where needed							
E-9. Assess and monitor spatial patterns of retention areas		X	X				
E-10. Integrate riparian forest management with upland management	X	X	X	X	X	X	X
E-11. Tailor extensive treatments to site-specific and landscape-level conditions			X			X	X

[1] This table crosswalks the operations standards (see Chapter 3) with biological goals and objectives. Other conservation strategies and relationship to biological goals and objectives are discussed in the text.
[2] Objective 1.3 is to retain dispersal habitat within the MRW. There is no need for a CRW objective for dispersal due to the reserve status of all stands within the CRW.

5.4 Conservation Measures

5.4.1 Conservation Measure 1, Targeted Restoration and Stream Enhancement

As described by the National Marine Fisheries Service (NMFS) (2016), historic 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, 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 within 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, replacement of stream-crossing structures (i.e., culverts) that block fish passage, relocation or redesign of improperly located roads, stabilization of sediment sources (i.e., cut banks), improvement of road drainage systems, road closure and/or road abandonment, and riparian vegetation management.

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[4] 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). This instream habitat is critical to produce enough juvenile survival 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 aquatic habitat maintenance or improvement strategies are intended to correct conditions in the permit area that may contribute to aquatic habitat deficiencies, or that may limit desired aquatic habitat conditions and affect the covered species. These strategies will promote aquatic habitat conditions that support the short- and long-term survival needs of Oregon Coast coho and other aquatic organisms, as well as providing additional places for habitat for northern spotted owl and marbled murrelet to develop over the permit term. Strategic enhancement projects will make it more likely that properly functioning aquatic habitat conditions will be attained in a timely manner. Finally, these strategies will encourage forest conditions that support the ecological processes necessary to naturally create and maintain complex aquatic habitats on a self-sustaining basis.

This comprehensive stream restoration and enhancement approach applies both short- and long-term management actions. These strategies 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 toward desired conditions), while at the same time creating self-sustaining habitats over the long term. The following strategies and actions will be implemented as part of the aquatic habitat maintenance or improvement strategy.

The *Elliott Watershed Analysis Implementation Plan* (Biosystems et al. 2003) identified 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 the watershed analysis implementation plan, along with other opportunistic projects associated with harvest operations. These projects will occur when there is a need, and the opportunity exists to take 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 (see Chapter 6) and the operation contains wood meeting size requirements for the intended stream.

[4] Factors that constrain a population's size and slow or stop population growth.

The following guidelines will be considered when planning 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 consider 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 re-establish 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 utilize 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. Reliance on 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.

5.4.1.1 Riparian Vegetation Management in RCAs

Riparian vegetation management treatments are primarily designed to address recruitment of vegetation to riparian areas and to supply downed wood to streams for the purpose of improving fish habitat and contributing to aquatic food webs.

The rationale for implementing vegetation management within RCAs is described in Appendix A, *Active Management of Riparian Conservation Areas*. Management in RCAs will be limited to locations where prior management actions have resulted in overstocked plantations or stands of relatively small trees. Potential projects include silvicultural treatments such as reducing the density of conifers, converting hardwood stands to conifer species, creating gaps in hardwood stands to establish conifer seedlings (shade-intolerant and shade-tolerant), opening riparian areas to an early seral stage, or other similar practices designed to improve aquatic and riparian conditions through the felling of trees and retention of downed wood. These riparian treatments will create down deadwood specifically for recruitment into streams to increase habitat diversity, including channel complexity, and stream productivity.

Although these projects will be designed to achieve properly functioning aquatic habitat conditions during the permit term, improvement of riparian forests may also indirectly benefit terrestrial species, including northern spotted owl and marbled murrelet. 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 utilized as nesting habitat for species such as marbled murrelets. Treatments will utilize planting, natural regeneration, or both within gaps and thinned areas to promote the regeneration of diverse vegetative communities (Puettmann and Tappeiner 2014).

The activity may occur throughout the entire width of the RCA with the objective of improving ecological conditions. As discussed under *Riparian Conservation Areas* in Section 3.4.2.2, *Thinning*, of Chapter 3, only trees in plantation-like stands replanted after harvest and 65 years or less in age as of 2020 will be considered for thinning and tree retention treatments. Single-entry riparian thinnings in reserve RCAs are scheduled to be completed within the first 20 years following establishment of the ESRF in coordination with the single-entry restoration thinnings in reserves (CRW and MRW). Riparian treatments in RCAs outside of reserves have the potential for multiple-entry treatments, supporting the use of a range of silvicultural treatments and experimentation to reduce short-term impacts.

The HCP recognizes that these treatments are experimental actions, and that, over time, managers will gain additional knowledge and experience through monitoring and research. These projects will be monitored and evaluated (as described in Section 6.3.4, *Riparian Restoration Monitoring*) to ensure that the objectives are being achieved, and that undesirable effects are being minimized. 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.

The vegetation management strategies will apply silvicultural approaches in riparian areas where it is determined management activities could be implemented to help meet the coho biological goals and objectives. Vegetation management treatments in riparian areas on the ESRF will devote 15 to 20 percent of the thinned total volume within the first 120 feet to the stream channel. Log volume may be removed from 120 to 200 feet within the RCA to support the financial requirements of riparian vegetation treatments.

Vegetation management treatments will be implemented according to the following conservation measure.

- **Within 120 feet of stream channel:**
  - Cut logs within the first 120 feet from the stream channel must be retained within the RCA or placed within the stream channel unless an alternative approach is agreed upon with the Services.
  - The 15–20 percent of the total volume thinned that is devoted to the channel placement will come from the first 120 feet, provided there is sufficient volume in this area and financial resources to do so.
  - No commercial harvest (sale of logs) will occur from within this area.
- **Areas from 120 to 200 feet of stream channel**
  - Commercial harvest (sale of logs) from within this area may occur to offset cost of treatments

5.4.1.2 Beaver-Related Habitat Management

Beaver 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 rebounded, with populations occupying most of their former range (Naiman et al. 1998). The presence of beavers can strongly influence salmon populations in the side channels of large alluvial rivers by building dams that create pond complexes (Malison et al. 2016). Beaver ponds and slow-water habitat created by beaver provide important summer rearing and overwintering habitat (Castro et al. 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 percent of the habitat, but support 88 percent of the coho that were found in this habitat (Nickelson et al. 1992).

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 ESRF are in narrow valleys, bordered by steep side slopes with gradients on the side slopes that commonly exceed 65 percent, limiting potential beaver habitat. 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 percent

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 the covered species. 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 beaver in the permit area will improving floodplain connectivity, stream complexity, and slow-moving rearing habitat that would benefit the covered salmon and steelhead. The Permittee will coordinate this work with regional partners, ODFW, USFWS, and NMFS to ensure beaver management actions fit into the larger context of salmonid recovery and statewide beaver management principles.

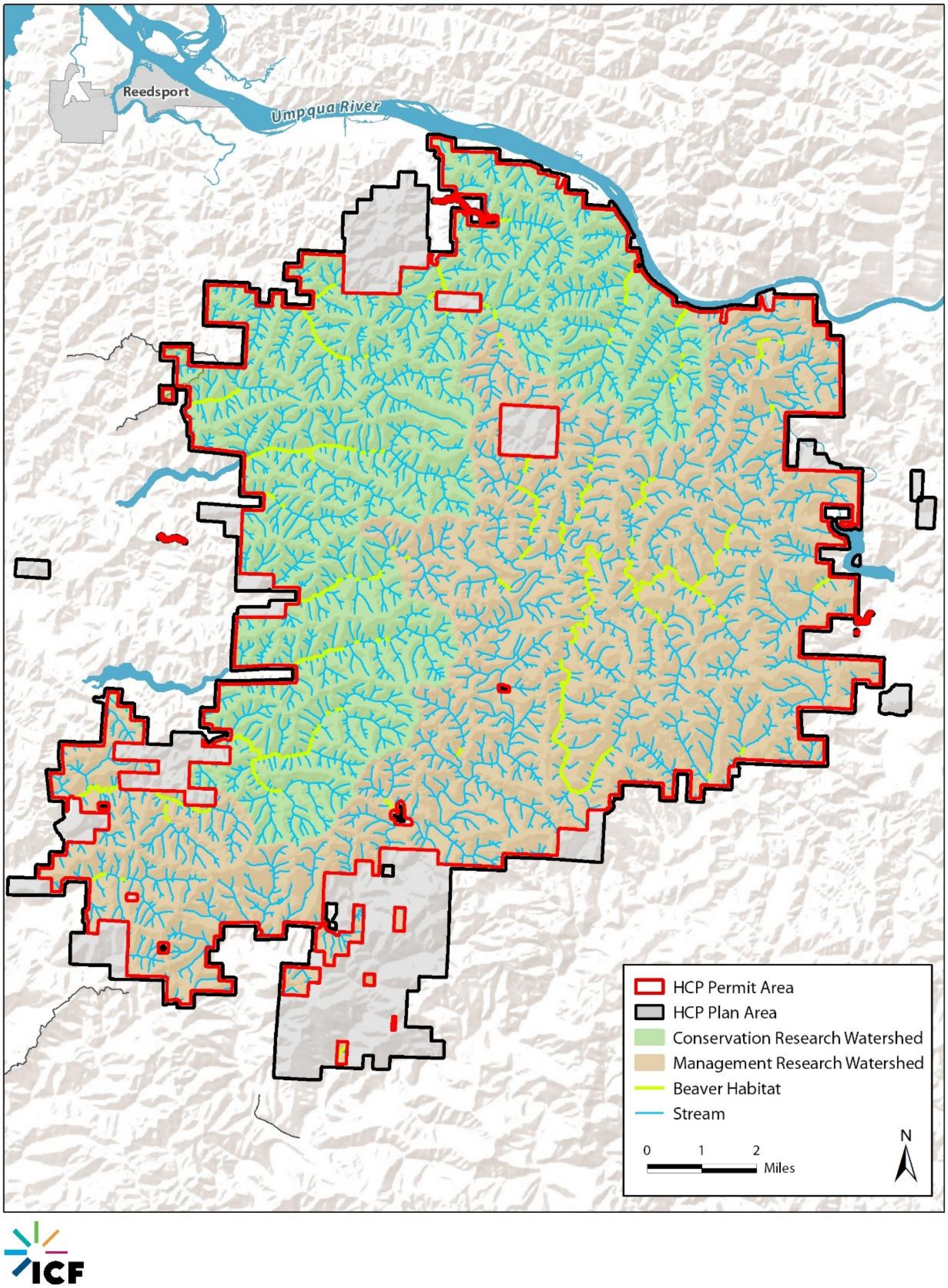


Figure 5-3. Potential Beaver Habitat in the Permit Area

5.4.2 Conservation Measure 2, Expanded RCAs on Lower Millicoma River

In recognition of the distinct relative values the Millicoma system provides to Coos independent population and the Oregon Coast coho salmon evolutionarily significant unit (ESU), the designated RCAs for the Lower Millicoma River from its entry into the permit area in the southwest portion of the permit area through the confluence with Elk Creek will include 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 (Carlson in prep.). 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 will have more variable RCA widths when compared to the Tenmile and Lower Umpqua independent populations. With the expanded RCAs on the Lower Millicoma River, the expected wood recruitment within the Coos independent population would increase to 89 percent. The expanded RCAs also ensure that the recruitment occurs in a location where it is most beneficial to coho.

5.4.3 Conservation Measure 3, Reduced Forest Road Network in CRW

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, minimizing road networks can have direct and indirect positive benefits on northern spotted owls and marbled murrelets.

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, 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. As described in Section 3.2, most roads in the permit area are on ridge tops, which are generally the most stable and protective the aquatic resource and water quality.

For the ESRF transportation system, the vision is a road network that will provide effective access for all necessary activities taking place in the forest. The transportation system will be actively managed to minimize effects on natural resources. The road network throughout the permit area will not expand more than 40 miles of permanent new roads over the course of the permit term. There will be no net increase in permanent road miles in the CRW by the end of the permit term. In order to meet that commitment in the CRW, roads not necessary to facilitate the research program, recreation activities, or emergency management will be abandoned or decommissioned.

Any new roads will be constructed in the best locations for minimizing impacts on aquatic and riparian systems. Any expansions will be kept to the minimum needed to achieve forest management objectives. Barriers to fish passage created by road crossings will be constructed to meet NMFS and ODFW fish passage requirements. Roads will be constructed, maintained, and vacated following the restrictions outlined in Section 3.6.1, *Road System Construction and Management*. 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. The roads will be effectively maintained to minimize degradation to other natural resources.

All road construction, maintenance, and abandonment will be performed in accordance with restrictions placed by the Oregon Forest Practices Act (Oregon Administrative Rule 629) and other applicable statutes as described in Chapter 3. 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 5-2 and will be implemented when designing new roads and improving existing road systems in the permit area to benefit the covered salmonids.

Table 5-2. 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 active roads or legacy roads that are degrading the aquatic environment	X	X	X
Culvert or stream-crossing upgrades (repair unstable crossings)		X	X
Sidecast removal or reduction		X	X
Reduced road drainage to stream[1]	X	X	
Increased surface material thickness or hardness with crushed rock or paving		X	
Traffic reduction (unpaved roads)		X	

Source: Roni et al. 2002.
[1] Drainage reduced through increased crossings and by diverting water onto forest floor.

While roads can 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, in the ESRF the majority of the road system is on ridgelines, with approximately 0.5 percent of the roads within 100 feet of a fish-bearing stream and 9 percent of stream crossings traversing a fish-bearing stream.

During the first 12 years of HCP implementation a study on the degree of hydrologic connections of current and legacy roads and their primary locations in the permit area will be developed. 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, an inventory of the road networks will be maintained 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.

Roads that pose an ecological risk may be decommissioned, depending on their utility. This effort will be mindful of providing access for firefighting and recreation consistent with reserve goals and multiple management objectives associated with this publicly owned forest. The road network in the CRW and MRW will decline over time, and new, permanent roads may be constructed as part of a strategy to decommission road segments that are a problem. Any road decommissioning strategy must be developed and implemented within the context of a forest management plan.

5.4.3.1 Barrier Upgrade and Removal

There are currently 12 impassable fish barriers and 22 partial barriers identified in the permit area, with most of the barriers overlapping the Coos independent population (Oregon Department of Fish and Wildlife 2019b; Table 5-3). Over the course of the permit term some of these barriers may need to be upgraded or removed when they reach their end of life. All new and replacement stream crossings will be designed to meet current NMFS and ODFW passage criteria to maintain upstream and downstream passage for the covered fish species.

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). While fish passage is not identified as a primary limiting factor for the ESU/independent populations of covered salmonids in the permit area, removing or improving fish-passage barriers in the permit area could benefit the covered species by increasing access to previously unavailable or underutilized habitat.

Table 5-3. Fish-Passage Barriers in the Permit Area by Independent Population

Independent Population	Partial	Blocked	Unknown Anadromous	Unknown
Tenmile	5	3	9	2
Coos	14	6	16	16
Lower Umpqua	3	3	10	6
Total	**22**	**12**	**35**	**24**

5.4.4 Conservation Measure 4, Research on 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-made disturbances in forest landscapes. Research conducted in the permit area will be tailored to account for this important and unique opportunity to study the effects of different forest treatments on Oregon Coast coho ESU health, its populations, and habitat parameters important to the species. Potential research focus in the permit area is described in Appendix A and may include, but not be limited to, water quality and quantity (Objective 3.2), and landscape disturbances such as landslides, debris flows, fires, and different types of harvest regimes (Objective 3.1) to determine how these actions affect Oregon Coast coho ESU and its habitat. These actions play a crucial role in the health and productivity of forest landscapes and their ability to provide habitat for Oregon Coast coho ESU in the permit area, and have broader benefits for the management of forest and fish across the Pacific Northwest.

As described in Section 3.3.4.2, *Variation in Riparian Conservation Areas*, specific size and configuration of the different RCA components in the respective stream types will depend on the level of potential wood delivery needed to attain the MRW outcomes-based wood recruitment objective, by independent coho population. Modeling and monitoring will ensure that the RCAs employed in the MRWs are adequate to achieve Objective 3.1 for each independent population of Oregon Coast coho ESU. The use of riparian systems will 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, will allow experimentation to test buffer effectiveness and tradeoffs with other values, and their effects on and benefits to Oregon Coast coho ESU.

An interagency stakeholder advisory committee will be developed to participate in research and monitoring planning conversations as they pertain to coho and their habitat. This committee will be created and managed by the Permittee and will include, but is not limited to, participants from DSL, Oregon State University (OSU), USFWS, NMFS, ODFW, and two members of the Board of Directors of the Elliott State Research Forest Authority (or its equivalent stakeholder advisory body should the Authority not become operational). NMFS and USFWS (the Services) may recommend other federal, state, tribal, and local governments and non-governmental organizations be invited to participate in informing the advisory committee on research needs.

5.4.5 Conservation Measure 5, Research on Northern Spotted Owl, Marbled Murrelet, and Their Habitat

This conservation measure includes research to determine the best methods for increasing old forest structure that will benefit northern spotted owls and marbled murrelets. The research effort will include initiatives to explore methods for increasing the likelihood of achieving old forest structure, increasing species diversity, and creating complex early seral forests from dense, young (less than 65-year-old), single-species plantations. This approach 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 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). An interagency stakeholder advisory committee will be developed to participate in research and monitoring planning conversations as it pertains to northern spotted owl, marbled murrelet, and their habitat. This committee will be created and managed by the Permittee and will include, but not be limited to, participants from DSL, OSU, USFWS, NMFS, ODFW, and two members of the Board of Directors of the Elliott State Research Forest Authority (or its equivalent stakeholder advisory body should the Authority not become operational). The Services may recommend other federal, state, tribal, and local governments and non-governmental organizations be invited to participate in informing the advisory committee on research needs.

Depending on conditions, thinning treatments, if necessary, could be composed of one or several of the following treatments: variable-density thinnings, 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 desirable understory vegetation; planting in gaps or in the understory to encourage species diversity; or removal of invasive species.

Habitat monitoring described in Chapter 6 will allow DSL to track changes in habitat quality over time. Species response monitoring will determine if species are using habitat that is developed during the permit term.

5.4.6 Conservation Measure 6, Barred Owl Research

Barred owl populations have grown rapidly and achieved particularly high densities in older forest of Washington and western Oregon, which has exacerbated northern spotted owl population declines (U.S. Geological Survey Forest and Rangeland Ecosystem Science Center 2018). Lethal removal of barred owl 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 owl that allowed populations to stabilize in the areas with removals (Wiens et al. 2021). These promising results are being incorporated into the USFWS' development of a Barred Owl Management Strategy.

The ESRF is uniquely suited to provide additional experimental data collection in support of barred owl management strategies. 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. In addition, ESRF will provide additional 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. Research initiatives will be integrated into monitoring and data collection related to northern spotted owl identified in Chapter 8, *Cost and Funding*, to the greatest extent possible, and will include a statistically-valid approach to management of barred owls from the ESRF; the timing and extent of which will be determined as part of the experimental design. The research initiative associated with this mitigation measure will be designed and budgeted by January 2025 and begin no later than the appropriate field season of 2026.

5.5 Conditions on Covered Activities

The conservation strategy includes several conditions on covered activities. Conditions, as defined for this HCP, are conservation measures that define specific take avoidance and minimization measures that the Permittee has committed to apply to the covered activities described in Chapter 3. These conditions will apply throughout the permit term.

5.5.1 Definitions Used in Conditions

The following definitions are for 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 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.

Active vs. 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 early nesting period, 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 non-survey years. In order for a nest site to switch from active to inactive status, surveys will have to be completed per USFWS protocols or as otherwise determined to be inactive by the USFWS.

Nest Site: The nest tree and other trees within 300 feet of the nest tree.

Nesting Core Area: 100 acres of the best contiguous habitat that surrounds a northern spotted owl nest site.

Core Use Area: 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: 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.

5.5.1.2 Marbled Murrelet Definitions

Designated Occupied Habitat: Areas mapped as occupied by marbled murrelets based on historical survey data. These areas are a combination of those formerly designated as marbled murrelet management areas by the Oregon Department of Forestry and those mapped as occupied by OSU researcher Kim Nelson. This is further explained in Section 2.4.2.2, *Plan Area Status*, and shown on Figure 2-11.

Modeled Potential Habitat: Habitat that is modeled as having potential to be occupied by marbled murrelets by OSU researchers. Methods are described in Section 2.4.2.2 and shown on Figure 2-11.

Nest Site: The nest tree and other trees within 300 feet of the nest tree.

5.5.2 Condition 1: Seasonal Restrictions Around Northern Spotted Owl Nest Sites

To minimize adverse effects on nesting northern spotted owl, covered activities will follow USFWS-recommended seasonal disturbance distances (USFWS 2020c; Table 5-3). Seasonal disturbance restrictions will apply to the 23 northern spotted owl activity centers (20 pair sites, 1 unconfirmed pair site, and 2 resident single sites) centered on the Elliott State Forest that had historic occupancy 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; see Chapter 2, *Environmental Setting*, for details).

The operational restrictions described in this condition also apply to actively nesting northern spotted owls located outside the permit area that may become established within the permit area outside of protected historic activity centers. Activities will be restricted during the critical nesting season for active single and pair sites, and within the distances given in Table 5-4, unless it is determined that no nesting is occurring, or has failed, or until July 15, whichever is sooner. Determination of absence of nesting will be made following USFWS-approved 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 5-4. Seasonal Distance Restrictions for Active Northern Spotted Owl Nest Sites During the Nesting Season[1,2]

Covered Activity	Critical Breeding Season (March 1–July 7)[3]	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[4]	0.25 mile	100 yards
Helicopter: Chinook 47d	265 yards[5]	100 yards (hovering only)
Helicopter: Boeing Vertol 107, Sikorsky S-64 (SkyCrane)	150 yards[5]	50 yards (hovering only)
Helicopters: K-MAX, Bell 206 L4, Hughes 500	110 yards[5]	50 yards (hovering only)
Small fixed-wing aircraft (Cessna 185, etc.)	110 yards[5]	No restrictions
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 2020c.

[1] Active sites are based on nest tree locations or designated activity center if nest site is not known. Suitable northern spotted owl nesting habitat is assumed to contain active nest unless verified non-nesting through surveys conducted following protocols approved by the USFWS.

[2] 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.

[3] As measured from the edge of the active nest site to the limit of the activity performed, unless DSL determines that young are not present, based on USFWS-approved survey methods, at which point distance restrictions may be lifted on a case-by-case basis.

[4] 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.
[5] 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.
N/A = not applicable

5.5.3 Condition 2: Retention of Northern Spotted Owl Nesting Core Areas

A 100-acre nesting core area of the best contiguous habitat will be maintained around the nest tree (or designated activity center if nest site unknown) for the 23 northern spotted owl activity centers described in Condition 1 above (see Chapter 2 for details). There will be 100 percent retention 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 and the distance between the nest tree and the edge of the nesting core will be no less than 300 feet. The location of the nest tree will be determined by northern spotted owl experts. Designation of the nesting core area will be done prior to any harvest activities occurring in the surrounding approximately 502-acre core use area.

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 active northern spotted owl nest sites. The 502 acres does 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 percent (more than 251 acres) of the highest-quality contiguous habitat will be retained as nesting, roosting, and foraging habitat 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 percent of the total area inside the core use area (which is also inside the permit area).

The 50 percent amount is based on the *Revised Recovery Plan for Northern Spotted Owl*, which identifies sites currently with >50 percent nesting, roosting, and foraging habitat within 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 (USFWS 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, or marginal nesting and roosting habitat. Based on descriptions of the Davis model, highly suitable and suitable nesting/roosting habitat is most likely to provide nesting and roosting habitat, marginal nesting/roosting habitat in the model is more likely to provide foraging habitat, and unsuitable nesting/roosting modeled habitat could be dispersal and/or non-habitat. Habitat that supports nesting, roosting, and foraging in the context of this HCP is distinguished from habitat that only supports foraging. For this HCP, “nesting, roosting, and foraging habitat” (sometimes referred to as “NRF” in consultation documents), is habitat that contains all of the elements of nesting, roosting, and foraging habitat, and these elements should not be considered in isolation.

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 percent threshold. Retention and long-term application of ecological forestry practices within extensive allocations may contribute to the maintenance of 50 percent nesting, roosting, and foraging habitat in core use areas.

This standard will be applied to at least 23 northern spotted owl core use areas at any one time. Initially, this condition will apply to northern spotted owl activity centers shown in Figure 2-7. If new owl nest locations are discovered in the future, outside of those shown in Figure 2-7, the Permittee, in coordination with USFWS, could choose 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 23 core use areas and allow the Permittee to focus on the 23 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 coordination with the USFWS, 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 percent of the home range (a 1.5-mile-radius circle centered on the activity center) as nesting, roosting, and foraging habitat around the active nest core areas described in Condition 2. For a 1.5-mile-radius circle, 40 percent equates to 1,809 acres. For areas within the home range but outside of the core use area, the “highest-quality 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 nesting, roosting, and foraging habitat. A home range will be recognized for each northern spotted owl nest location that also has a nesting core area and core use area. The definition of nesting, roosting, and foraging habitat is the same as that described in Condition 3. Similar to the requirements in core use areas, if the 1.5-mile buffer around a nest site, which defines the home range, includes areas outside of the permit area, the Permittee is only responsible for retaining at least 40 percent of the total area that is inside the permit area, and therefore in the Permittee’s control.

The 40 percent amount is based on the *Revised Recovery Plan for Northern Spotted Owl*, which identifies sites currently with >40 percent 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 (USFWS 2011).

5.5.6 Condition 5: Maintenance of Northern Spotted Owl Dispersal Landscape

This conservation measure establishes the commitment to retain at least 40 percent 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 probably 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 within 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 the USFWS (2011). The standard is met when forests—at a landscape level—are composed of at least 50 percent of trees with 11 inches diameter at breast height (dbh) or greater, and with roughly a minimum 40 percent canopy cover.

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 percent of the MRW as dispersal habitat is an acknowledgement that habitat quality will be reduced in areas that are intensively harvested, and in some areas that are extensively harvested, if retention is low.

Under Conservation Measure 6, a minimum of 40 percent of the MRW will be maintained as dispersal habitat in the permit area, using the definition provided above (Thomas et al. 1990).

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 to September 15). Seasonal restrictions prohibit certain covered activities from occurring within a set distance of occupied habitat, using distances approved as adequate by the USFWS. Recommended distances identified by USFWS (2020c) for marbled murrelet—as applied to covered activities—are listed in Table 5-5. Some activities can have daily restrictions as well, which avoid disturbance during certain times of day later in the nesting season.

Table 5-5. Seasonal Restriction Distances for Marbled Murrelet Occupied Habitat[1]

Covered Activity	Critical Breeding Season (April 1–August 5)[3]	Late Breeding Season (August 6–September 15)
Light maintenance of roads, campgrounds, and administrative facilities	No restrictions[4]	No restrictions
Log hauling on open roads	No restrictions	No restrictions
Chainsaws (includes felling hazard/danger trees), Drones	110 yards	Time-of-day restrictions[2]
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[3]	0.25 mile	0.25mile
Helicopter: Chinook 47d (described as a large helicopter in the rest of this document)	265 yards[5]	100 yards (hovering only)
Helicopter: Boeing Vertol 107, Sikorsky S- 64 (SkyCrane)	150 yards[5]	50 yards (hovering only)
Helicopters: K-MAX, Bell 206 L4, Hughes 500	110 yards[5]	50 yards (hovering only)
Small fixed-wing aircraft (Cessna 185, etc.)	110 yards[5]	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

[1] 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.
[2] No disturbance from 2 hours before sunset until 2 hours after sunrise.
[3] 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.
[4] Disturbances with no likely adverse effects and associated no restrictions needed are based on conclusions presented in USFWS 2016.
[5] 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.

5.5.8 Condition 7: Survey Requirements for Designated Occupied and Modeled Potential Marbled Murrelet Habitat

The designated occupied and modeled potential marbled murrelet habitat (see definitions in Section 2.4.2.2) that were allocated to intensive or extensive harvest treatments included some stands that are less than 65 years old, some of which may have no or very few residual large-diameter trees (>20 inches dbh) that remained in place subsequent to stand replacement harvests conducted in the past. When large-diameter trees (residual or otherwise) occur in these stands, there remains potential for marbled murrelets to occur. The following protocol will be followed in recognition of potential occurrences.

In order to minimize effects, and regardless of stand age, all designated occupied and modeled potential marbled murrelet stands, as defined in this HCP (Figure 2-11), that are subject to intensive or extensive harvest treatments—or restoration treatments within the CRW and MRW reserves—will be examined for presence of marbled murrelet nest sites prior to treatments utilizing the following three-step process.

1. **Desktop Review**—All intensive or extensive treatments in designated occupied or modeled potential marbled murrelet habitat will be reviewed using the most current air photos and Lidar imagery to determine which have contiguous patches of trees older than 65 years (estimated current age at time of review) that are 5 acres or larger. Contiguous potential habitat is that which contains no gaps in suitable forest cover wider than 328 feet (Evans Mack et al. 2003). Stands that do not have contiguous patches of trees older than 65 years can be harvested as an intensive or extensive treatment. Those that do have contiguous patches of trees older than 65 years will undergo a field assessment.

2. **Field Assessment—**Intensive or extensive treatments in designated occupied or modeled potential marbled murrelet habitat that have contiguous stands of residual trees 5 acres or larger that are likely older than 65 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 (Evans Mack et al. 2003).

3. **Marbled Murrelet Nesting Survey**—Those stands that are determined in the Desktop Review to have habitat and in the Field Assessment to have characteristics that support nesting marbled murrelets will be surveyed for murrelets. Surveys will follow survey methods approved by the USFWS (currently Evans Mack et al. 2003). Surveys may also be modified to meet the needs of ongoing marbled murrelet research projects, upon approval from the USFWS. At a minimum, all survey protocols will include survey information sufficient to make occupancy determinations

and to make comparisons across the permit area and across survey years (e.g., surveying during "favorable" and "unfavorable" ocean condition years). A determination of presence/absence of nesting will follow stipulations described in Evans Mack et al. (2003), or methods otherwise mutually agreed to between the Permittee and the USFWS. This may include acoustic detection at some point during the permit term, as defined by future protocols.

Ultimately presence/absence is what will influence decisions around how a stand is managed. In areas allocated to intensive treatments where nesting marbled murrelets are discovered the continuous habitat where the marbled murrelets were found will be designated as a reserve (or expanded RCA) or extensive treatment area, and the intensive treatment will be reallocated to another part of the subwatershed not occupied by marbled murrelets. In areas allocated to extensive treatments where nesting marbled murrelets are discovered, stand management will be done consistent with Condition 8.

5.5.9 Condition 8: Limits on Harvest in Designated Occupied and Modeled Potential Marbled Murrelet Habitat

Intensive harvest treatments in designated occupied and modeled potential marbled murrelet habitat are prohibited unless they are in areas determined to no longer be occupied through the process set forth in Condition 7.

Extensive harvest treatments in designated occupied and modeled potential marbled murrelet habitat, which are found to be occupied pursuant to the process in Condition 7, will not exceed 1,400 acres. In both designated occupied and modeled potential marbled murrelet habitat, management activities subject to the 1,400-acre cap are those occurring in locations found to be occupied by marbled murrelets pursuant to the process in Condition 7. In addition, locations that were previously determined to be occupied will continue to be considered occupied, regardless of survey results, if there have been no changes to habitat condition since the last marbled murrelet detections were made (e.g., pre-HCP harvest or stand management activities, changes in habitat quality due to natural events such as storms, fire, or disease). This condition only applies to designated occupied habitat and modeled potential habitat as defined in this HCP (Figure 2-11). Any areas outside of designated occupied or modeled potential habitat, as shown in Figure 2-11, are not subject to the 1,400-acre cap, and can be managed as described in Chapter 3. This includes stands that may develop into habitat within extensive allocations if such habitat is not designated by the Permittee for use in meeting biological objectives. Such areas may be harvested consistent with Conditions 6 and 7. Changes in determinations of occupancy within designated occupied or modeled potential habitat will be coordinated with the USFWS.

Of the 1,400 acres of extensive treatments allowed in designated occupied and modeled potential marbled murrelet habitat (as defined in Figure 2-11), no more than 500 acres will occur in at least the first 10 years of HCP implementation. In those treatments, stand density will be retained at 80 percent or greater of pre-harvest density.

Consistent with adaptive management, further harvesting (beyond the initial 500 acres) will be contingent on the outcome of the experiments (testing for both statistical and biologically meaningful effects). If experiments find that (1) murrelets do not return to, or colonize, ecological forestry treatments, or (2) nesting birds suffer high rates of nest failure, the Permittee will not proceed with harvest in the remaining 900 acres. Treatments in the remaining 900 acres, if they occur, will be informed by the findings of research on the initial 500 acres and undertaken subject to review and concurrence by USFWS. In all of these locations there would be 80 percent or greater retention of pre-harvest density. Further, any known nest trees or trees within 300 feet of known nest trees will be included in those retained.

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 or modeled potential habitat as a result of harvest treatments in the permit area. The Permittee will demonstrate that at least as many acres of designated occupied or modeled potential habitat proposed for extensive harvest will have been replaced by habitat in the CRW or MRW reserves that is first determined to be occupied during the permit term. This condition only applies to designated occupied habitat and modeled potential habitat as defined in this HCP (Figure 2-11). Any areas outside of designated occupied or modeled potential habitat, as shown in Figure 2-11, are not subject to this requirement and can be managed as described in Chapter 3.

Newly occupied areas, which could be used to offset any habitat loss, would be locations in the CRW or MRW reserves where surveys have been conducted in the past and no occupancy was documented. In order for newly occupied habitat to count as replacement habitat, it must already be allocated as a reserve (within the CRW, MRW reserve, or RCA) or—if located outside of reserves—reallocated as a reserve.

New potential habitat would be areas that are deemed potential habitat following additional modeling or field surveys in the CRW or MRW reserves that are located in areas that were not previously modeled as potential habitat (Figure 2-11). This would mean these areas have effectively grown into habitat that is suitable for occupancy since modeling was completed for this HCP in 2020. Acres of occupied and potential modeled habitat will be accounted for annually and summarized in annual reports along with 6-year summary and 12-year comprehensive reports, including the newly discovered locations in the CRW or MRW reserves, in order to demonstrate compliance with this condition.

5.5.11 Condition 10: Retention Standards for Intensive Treatments

Retention standards in intensive treatment areas will meet or exceed the Oregon Forest Practices Act, with the exception of riparian buffers. RCAs are more expansive than those required by the Oregon Forest Practices Act.

5.5.12 Condition 11: Management on Steep Slopes

Combined, the CRW, MRW reserves, RCAs, and extensive allocations comprise 84 percent of the area of the ESRF with hillslope gradients greater than 65 percent. The balance of these steep slopes is in intensive allocations (16 percent). The areas that will be managed in intensive allocations have slopes with a gradient greater than 65 percent and have been harvested at some point in the past, and therefore have some existing road infrastructure and are accessible. Of all the intensive allocations, 57 percent are in areas with slopes with an average gradient greater than 65 percent. Harvest plans in these areas will be reviewed by a geotechnical specialist, who would advise on harvest layouts to minimize the risk of sediment transfer or increased risk of landslides in ways that may have a negative effect on coho salmon. This includes not just stream segments, as shown in Figure 5-4, but any areas within harvest units with an average gradient greater than 65 percent. If it is determined that management activities would increase the risk of landslides or sediment transfer in ways that would have a negative impact on streams that support coho salmon, stand management activities will be modified to reduce that risk.

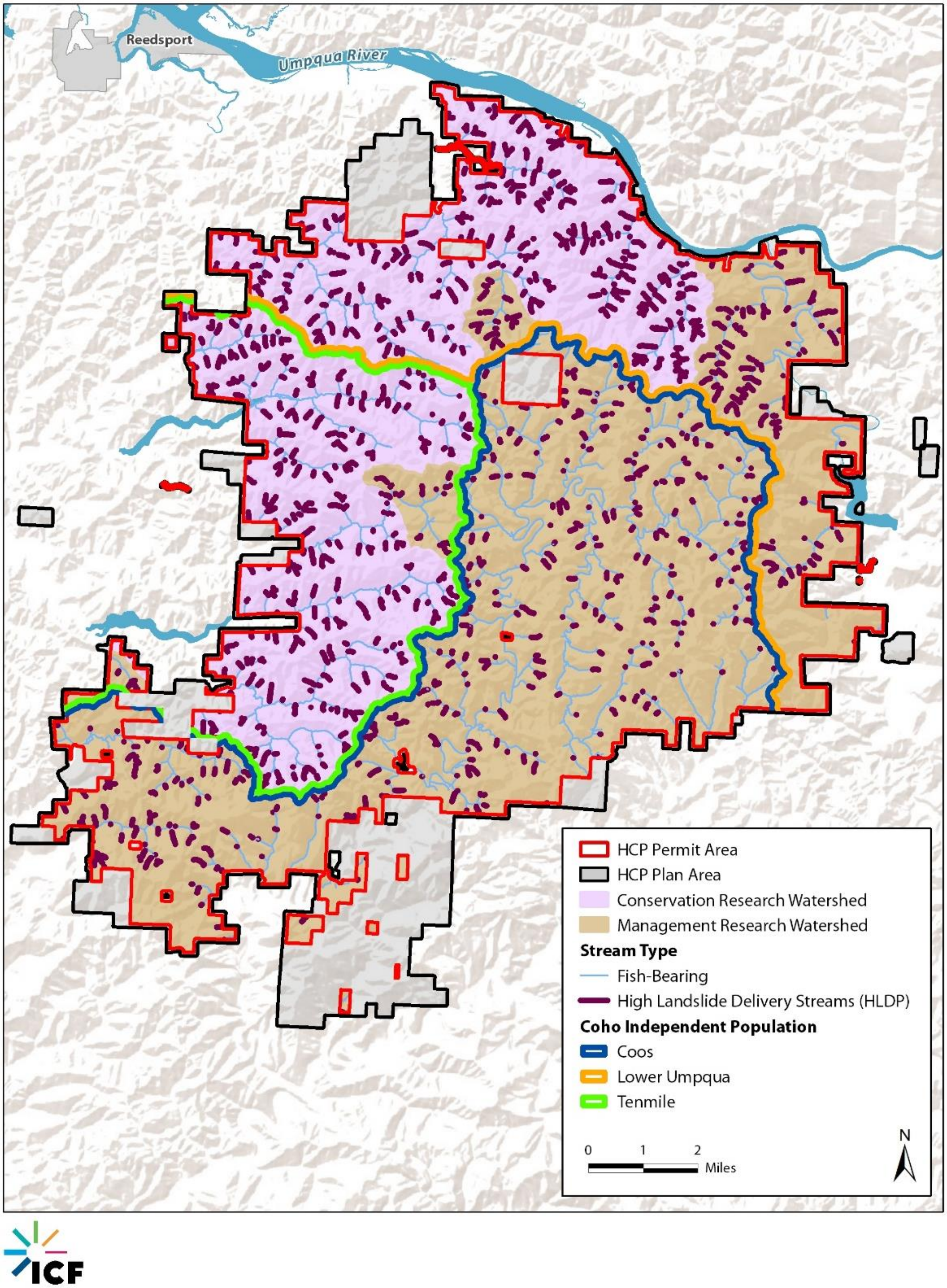


Figure 5-4. High Landslide Delivery Streams with the Potential to Deliver to Fish-Bearing Streams

5.5.13 Condition 12: Road Construction and Maintenance

5.5.13.1 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 ridgetops, 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 operations and recreational access, the impacts of road construction and maintenance can be minimized.

Geotechnical specialists will be consulted as needed while designing roads and harvest units. 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 forest land management decisions. The use of geotechnical analysis in management decisions makes it possible to minimize the number or magnitude of management activity–induced soil movements and protect Oregon Coast coho.

Road design measures that will be implemented to minimize potential impacts on the covered aquatic species are identified below. The intent of these road design measures is to hydrologically disconnect the road system from streams.

- Temporary and permanent roads and landings will be located on stable locations (e.g., ridge tops, stable benches, or flats) and gentle to moderate side slopes, and will be constructed at least 35 feet from the edge of the aquatic zone.
- Roads that have a history of failure or of contributing sediment to streams will be vacated, consistent with valid existing rights, provided that the act of vacating the road does not do more ecological damage than leaving it in place.
- New roads will be located away from streams, wetlands, unstable areas, and sensitive resource sites, including sensitive wildlife habitats.
- 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.
- Road development within the RCAs will only occur when other alternatives are not operationally feasible and economically viable.
- Where crossings of fish-bearing streams occur, bridges and culverts will be designed to meet current standards (National Marine Fisheries Service 2022; ODFW fish-passage laws [Oregon Revised Statute 509.580 through 910 and Oregon Administrative Rules 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 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.

5.5.13.2 Maintenance

As described in 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. The Permittee may use the Geomorphic Road Analysis and Inventory Package, or a similar tool, to identify existing roads that pose a sediment delivery risk to streams in the permit area.

The following guidelines will be followed during road maintenance activities.

- Roads within or adjacent to RCAs will be closed to logging trucks during wintertime wet weather.
- 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 2008) 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.
- Construction activities will be conducted during the dry season (generally April 1 through October 31). Outside this period, construction may occur through a written waiver obtained from the Permittee during prolonged periods of dry weather. 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 construction resumes.

- 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 percent.
- 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.
- Areas of bare soil that could deliver sediment to waters will have effective drainage established or will be mulched and/or seeded before the start of the rainy season to reduce surface erosion. These areas include, but are not limited to, unsurfaced road grades, cut slopes, fill slopes, waste areas, borrow areas, and rock pits.
- When a road construction project is partially completed at the start of the rainy period (mid-October), the project will be left in a condition that will minimize erosion and the sedimentation of streams during the rainy period. Drainage measures will be performed on uncompleted subgrades, such as surface smoothing, outsloping, water-barring, and dip installation. Mulching and/or grass seeding will be done on all cut slopes, unarmored fill slopes, and on any other areas of bare soil where erosion and sedimentation could affect water quality. Silt fences and/or 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.

5.5.13.3 Barrier Upgrade or Removal

As described in Section 5.4.3.1, *Barrier Upgrade and Removal*, culverts that need to be replaced in the permit area due to reaching their end of life will be designed to meet current NMFS and ODFW passage criteria to maintain upstream and downstream passage for the covered fish species.

5.6 Beneficial and Net Effects

5.6.1 Northern Spotted Owl

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.

While habitat increases alone will not necessarily result in increase in spotted owl populations due to many factors, including barred owl competition, the CRW and MRW areas are projected to collectively increase the *capacity* of the ESRF to support northern spotted owl territories and provide important demographic support for the Coast Range population. Based on the research design and areas of protected habitat (reserves), the net effect on northern spotted owls from covered activities and implementation of the conservation measures of the HCP will be beneficial, with long-term habitat conservation commitments and anticipated growth of new habitat that will maintain and potentially increase the capacity of the ESRF to contribute to the recovery of spotted owl populations within the Coast Range. In addition, with the inclusion of the conditions on covered activities described above, the adverse impacts on the 23 historic northern spotted owl nest locations and the surrounding habitat (nesting core, core use, and home range) are expected to be minimal.

The 34,000-acre CRW will provide a large block of habitat that will continue to improve over time through a combination of natural growth and silvicultural treatments intended to accelerate development of late-successional stand structures and compositions. 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: (1) exploring treatments to restore and enhance conservation value in established plantations that will transition to reserves; and (2) conserving unmanaged mature forests as they move through natural successional processes. Harm to northern spotted owl from such experimental treatments will be minimized through the conservation strategies and conditions described above.

Over time, the research design and associated covered activities described in Chapter 3 are projected to increase habitat within the CRW over the permit term. Of the 54,800 acres included in the CRW, MRW reserves, and RCAs, 39,000 acres (71 percent) are currently modeled as highly or moderately suitable nesting/roosting habitat (Davis et al. 2016; Table 5-5). Protection and management of this existing habitat provides an immediate stronghold of nesting habitat for the species.

Forest stands within the CRW, MRW reserves, and RCAs will continue to develop into higher-quality habitat over time, likely increasing the capacity to support northern spotted owls. Over the 80-year permit term, many of these designated reserve areas that are not currently highly or moderately suitable nesting/roosting habitat are expected to increase in their older forest characteristics, including stand structure that will benefit northern spotted owls by providing foraging habitat and potentially nesting and roosting habitat. Based on the Davis model, approximately 11,000 acres within the CRW are marginal habitat and 8,000 acres currently not habitat. An additional 6,000 acres of marginal and 6,000 acres of non-habitat are present within MRW reserves (Table 5-6). If all of these areas developed into moderately or highly suitable nesting, roosting, and foraging habitat, this would result in an additional 31,000 acres of highly and moderately suitable nesting/roosting habitat in the permit area. The actual amount of marginal habitat and non-habitat that will develop into habitat within reserves is expected to be lower due to many factors, including site-specific forest growth and disturbance from wind, disease, and fire. Coupled with the portions of the CRW and reserves that are already habitat, there could be over 54,000 acres of northern spotted owl highly or moderately suitable nesting/roosting habitat in the permit area by the end of the permit term, roughly 65 percent of the ESRF, compared to the current 35,000 acres (42 percent).

Table 5-6. Current Habitat Conditions, including Reserve Areas Currently Not Habitat (acres)

Treatment Designation	Highly Suitable	Moderately Suitable	Marginal	Not Habitat
Conservation Research Watersheds (CRW)	11,345	4,789	6,099	8,180
Management Research Watersheds (MRW)				
Reserves	7,291	1,596	3,030	1,993
RCAs and Other Non-Harvest Areas	1,930	1,015	2,666	4,603
Extensive	3,856	590	3,615	5,334
Intensive	1,988	384	3,210	8,708
Total	**26,502**	**8,384**	**18,652**	**28,829**

5.6.2 Marbled Murrelet

Collectively, both the CRW and MRW areas are projected to increase the capacity of the ESRF to support marbled murrelet nesting and reproduction, thereby continuing to contribute to the recovery of the Oregon Coast Range population of marbled murrelets. The research design and associated covered activities described in Chapter 3 are projected to increase habitat within the permit area over time. While all forests in reserves that are currently not habitat are not expected to become occupied habitat over the permit term, the area suitable to support nesting marbled murrelets is expected to increase substantially. Over the 80-year permit term, many of the 21,900 acres of forest within the CRW, reserves, and RCAs that are not currently designated occupied or modeled potential habitat are expected to develop into an old forest condition, including stand structure that will benefit marbled murrelet.

As described in Section 4.5.3, *Impact of the Taking*, over 65 percent of the forest will be in reserve, with approximately 34,000 contiguous acres in the northwest portion of the forest set aside. Of the remaining 20,600 acres of MRW reserve and MRW RCA, 77 percent are in areas protecting older trees (i.e., stands greater than 65 years old) and associated habitat for marbled murrelets. Of the 54,800 acres included in the CRW, reserves, and RCAs, 32,800 acres (60 percent) are currently designated occupied or modeled potential marbled murrelet habitat. Protection and management of these areas provides an immediate stronghold of potential nesting habitat for the species. Further, the CRW will develop into a large block of habitat capable of supporting some of the highest density of nesting pairs of marbled murrelets within the species' range, with a high proportion of interior habitat and minimal habitat edge.

Under the research design, the ESRF is expected to provide demographic support to marbled murrelet populations along the Oregon Coast. Habitat within the CRW will continue to improve over time, either through natural growth or through experimental treatments intended to accelerate development of late-successional stand structures and compositions. Harm to nesting marbled murrelets from such experimental treatments will be minimized through the conservation strategies above.

Within MRWs, where most of the harvest would occur, reserves will provide multiple locations suitable to support nesting pairs of marbled murrelets, including protection of 85 percent of known designated occupied marbled murrelet nesting locations. In addition, as previously described, marbled murrelet designated occupied habitat in extensive harvest allocations will involve retention of at least 80 percent of the pre-harvest density, resulting in some short-term changes in habitat quality, but likely resulting in longer-term increases in habitat quality, as the results from the near-term stand management activities lead to larger-diameter trees over time. The value of this habitat will continue to increase over time.

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 implementation of the covered activities are physical habitat quality and quantity and water quality associated with land management. A recovery plan has been developed for the Oregon Coast coho ESU, with a goal of improving the viability of the species to the point that they meet the delisting criteria and no longer require ESA protection.

Full implementation of the HCP will result in a net increase in quality of available habitat for the Oregon Coast coho ESU. 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 within 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, and improved functioning of riparian forest, which would address limiting factors for the Oregon Coast coho, and improve conditions for them over the course of the permit term.

The potential impacts of climate change in the permit area will be addressed by the proposed HCP. Water temperatures (NorWest Stream Temperature Model) are projected to remain within suitable levels for salmonids in the ESRF except for some small stream segments (Figure 4-7). Riparian zones of a size similar to that being proposed for the HCP can potentially offset temperature increases. However, because of the effect of topographic shading and stream orientation, opportunities to use riparian zones to reduce water temperatures are limited to small, disconnected reaches primarily in the Coos independent population (Figure 4-8). Therefore, the primary protection of instream temperatures in the permit area is topographic shading, which will not be affected by implementation of the HCP.

Reduction in summer flows (Figure 5-1) and increases in winter flows (Figure 5-2) are projected to be relatively small in the permit area. One potential consequence of increased winter flows is an increase in landslides. The establishment of riparian areas along headwater streams with the greatest potential to deliver wood to fish-bearing 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. These types of debris flows are more likely to negatively affect fish-bearing channels, as compared to the potentially favorable effects that result from the presence of wood. 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).

Chapter 6
Monitoring and Adaptive Management

This chapter describes the monitoring and adaptive management framework for the Elliott State Research Forest (ESRF) Habitat Conservation Plan (HCP), including guidelines, and specific recommendations that will help 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, to assess the status of covered species habitat, and to 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, and monitoring will inform and change management actions to continually improve outcomes for covered species. This chapter provides an overview of the program, monitoring and management actions, and data and reporting requirements.

The goal of this chapter is to provide standards to ensure that the program designed during implementation will be operated in compliance with the Endangered Species Act.

6.1 Regulatory Context

An HCP must provide for the establishment of a monitoring program that generates information necessary to assess compliance and verify progress toward achieving the biological goals and objectives of the HCP (50 Code of Federal Regulations [CFR] 17.22(b)(2)(A-F), 50 CFR 17.32(b)(2)(i-iii), and 50 CFR 222.307(b)(5)). Adaptive management programs are generally recommended for large, programmatic plans and those with data gaps and scientific uncertainty that could affect how species are managed and monitored in the future. The *Habitat Conservation Planning and Incidental Take Permit Processing Handbook* (HCP Handbook) (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 towards 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 U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) (together, the Services). All data collected will be utilized 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 provision will be completed. The reporting requirements and stay-ahead provision are described in Chapter 7, *Implementation and Assurances*.

6.2 Types of Monitoring

Recent 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 standards, and effectiveness monitoring to determine if conservation measures are having the intended effect of improving conditions for covered species. 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 annually to the Services, who will verify the HCP remains in compliance. As defined by the HCP, compliance monitoring will at least track the components listed below. Where applicable, these components will also be tracked by the underlying research design designations, including Conservation Research Watershed (CRW) and Management Research Watershed (MRW) designations and, for the MRW, research design designations (i.e., intensive, extensive, reserve, Riparian Conservation Area [RCA]).

- Location, extent, and timing of loss of covered species habitats to ensure the proposed maximum extent of take is not exceeded and to ensure that increases in the quantity and quality of habitat are appropriately balanced with loss of habitat from covered activities. 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 Section 2.3, *Northern Spotted Owl*).
- Types, acres, and location of silvicultural activities conducted in the permit area, including thinning.
- 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 roads built and vacated, including those in reserves and RCAs.
- Number and location of culverts upgraded or removed.
- Acres of upland restoration activities completed.
- Miles of stream and acres of riparian habitat thinned.
- Location of harvest and width of RCAs implemented in treatment areas.
- Aquatic restoration projects completed.
- Reporting of conservation measures and monitoring activities (e.g., what monitoring activities were implemented and resulting reports produced).
- 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 implementing the conservation strategy described in Chapter 5 are consistent with the assumptions and predictions made during development of the conservation strategy, including achieving the HCP's biological goals and objectives described in Chapter 5 (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).

To conduct effectiveness monitoring, it is necessary to first develop thresholds of success for management actions. The thresholds most important to effectiveness monitoring for this HCP are the quantitative commitments specified in the biological goals and objectives described in Chapter 5. Quantifying conditions before and after management is the basis for judging success. In most cases, success will not be immediately apparent, and monitoring must be conducted over a sufficient period for results to manifest. Effectiveness monitoring is focused on covered species habitat improvement as described in the biological objectives.

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 desired outcomes, to provide information and mechanisms for altering management if necessary, and to evaluate whether the conservation strategy described in Chapter 5 is successful.

The biological goals and objectives will inform success criteria so that it is clear whether progress is being made toward biological goals and objectives during the permit term. The baseline for individual criteria may come from existing known conditions and trends (i.e., from existing monitoring programs) or from modeled conditions. 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.

6.3 Aquatic and Riparian Monitoring

As the forests in the permit area age and research progresses, monitoring data will be collected across the permit area to track long-term habitat trends. The research treatments applied to the CRW and MRW, and the data collected, will be used to improve knowledge around forestry and its effects on salmonids.

The aquatic monitoring program focuses on monitoring long-term trends in aquatic habitat quality and quantity in the permit area. It is not intended to be a measure of production (i.e., number of fish) of Oregon coast coho (*Oncorhynchus kisutch*) in the permit area. A rotating panel design where one stream in each of the independent populations, which will be determined in consultation with NMFS, will be sampled once every 3 years (Table 6-1). Trends in habitat quality will be summarized in the 6-year Summary Report (Section 7.3.2, *6-Year Summary Report*) and a more comprehensive assessment will be completed during the 12-year Comprehensive Review (Section 7.3.3, *12-Year*

Comprehensive Review). During the 12-year Comprehensive Review more in-depth analysis of long-term trends will be analyzed, particularly as the permit term progresses and more years of monitoring are completed. The intention is to track trends in covered species habitat quality and quantity over time and relate the trends back to the management activities and conservation measures in the permit area. The 12-year Comprehensive Review will allow the compilation of four monitoring cycles for each of the three independent populations. The 3-year cycle coincides with the life history of coho in western Oregon and coho salmon in the Oregon Coast Range. This design allows monitoring in each independent population through time, with a focus on one location, reducing potential variability introduced by multiple cohorts. Over time the association between returning cohorts and habitat quality can be tracked.

Table 6-1. Coho Stream Habitat Sampling Regime

Independent Population	Year Sampled											
	1	2	3	4	5	6	7	8	9	10	11	12
Tenmile	✓			✓			✓			✓		
Lower Umpqua		✓			✓			✓			✓	
Coos			✓			✓			✓			✓

6.3.1 Turbidity Monitoring

The Permittee will install paired turbidity monitors upstream and downstream of a representative sample of roads that cross fish-bearing streams and/or RCA thinning units to monitor changes in instream turbidity following the construction of new, and maintenance of existing roads. Monitors will be placed in locations that allow the Permittee to report on trends in turbidity over a 12-year period. These monitors will predominantly occur lower in the watershed, in perennial fish-bearing streams, to detect potential changes to stream turbidity in locations where covered species occur. These data will be used in conjunction with the road monitoring data to determine if changes in fine sediment inputs associated with road activities are occurring. Additional turbidity monitoring may occur on locations that are determined to be "problem" areas during the road network baseline evaluation that occurs in the first 5 years. Monitoring will attempt to determine the degree to which those locations contribute sediment to prioritize when and how to address those road segments. Further, monitoring will occur both before and after those road segments are addressed or RCA thinning occurs to determine whether there is a measurable difference in sediment delivery to the stream. This data will inform how the Permittee addresses future road segments and RCA thinning activities that contribute sediment to aquatic environments.

Reporting of turbidity data will be 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, under Conservation Measure 3, *Reduce Forest Road Network in CRW*, and be prioritized for improvement/decommissioning.

6.3.2 Water Temperature Monitoring

The Permittee will implement a long-term temperature monitoring program to track trends in water temperature across the permit area. Recording thermographs will be placed in key watersheds where data will help address water temperature questions at the coho independent population level. The Permittee will collect data year-round for analysis and tracking in monitoring reports. Water temperature monitoring under the HCP will be integrated with research projects that will likely also collect stream temperature data as well as with a planned network of 20 climate stations established across the ESRF to collect long-term measurements of ambient temperature, precipitation, relative humidity, soil moisture, and radiation. This research will provide information on how management influences temperature and inform management decisions in the permit area. Monitoring locations will be maintained as described in Table 6-1. Data collected will enable the Permittee to report on trends in temperature change for each independent population.

6.3.3 Instream Habitat Monitoring

The Permittee will collect and monitor data on instream habitat variables annually. The collection methods and sampling regime will generally be consistent with Hankin and Reeves (1988) and will be conducted to allow comparison with Oregon Department of Fish and Wildlife Aquatic Inventories Project data, both in the ESRF and in watersheds outside the ESRF. This protocol is a continuous survey of habitat units along the entire length of the sampled stream. Each habitat unit is identified to type, and the length, width, and mean depth are estimated visually. At a predetermined interval, the length, width, and mean depth are measured as well as estimated, which allows the visual estimates to be corrected for any observer bias. This also results in an accurate representation of the size and location of habitat on the stream of interest, providing the opportunity to examine changes in the distribution and abundance of habitat units over time. This sampling methodology provides a census (i.e., complete count) of habitat and wood, allowing identification of trends by comparing numbers among surveys, and does not require the construction of statistical confidence intervals. However, fine sediment will be sampled in a probabilistic manner (i.e., systematically at given intervals along the stream), allowing calculation of the measure of error to statistically compare sites among years.

The same watershed will be monitored throughout the life of the permit. The frequency and distribution of monitoring will be such that the Permittee will be able to report on trends in instream habitat quality over a 12-year period, with 4 monitoring years for each independent population. For the purposes of this HCP the following variables will be tracked over time to represent the long-term trends in streams for a given independent population.

- Wood (size classes to be determined); total count.
- Pools; number and size.
- Fine sediments at pool tail crests; at systematically determined intervals.
- 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.

Riparian data will in large part be gathered using remote sensing technologies (e.g., 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. Non-riparian parameters will be collected as described in Hankin and Reeves (1988) or other applicable methodology.

An in-depth landscape analysis of the permit area will be completed in the first 5 years of the permit term to characterize baseline conditions. This will include baseline data collection on instream aquatic habitat parameters, listed above. Changes in habitat quality are not expected to be linear due to the stochastic nature of natural events in instream habitat (e.g., landslides). There will be an ongoing assessment of instream habitat quality, and changes that occur will be compared to baseline conditions. When natural events occur that change instream habitat quality, a new baseline may need to be established to inform the monitoring program going forward.

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 in the 12-year Comprehensive Review. Monitoring changes in riparian and aquatic conditions will provide information for tracking status and trends based on implementation of the covered activities and natural disturbance. Any changes to monitoring and/or enhancement will be documented, and rationale for the change will be provided in the 6-year Summary Reports or 12-year Comprehensive Review.

6.3.4 Riparian Restoration Monitoring

Given the novel approach of managing the entire RCA the effectiveness and potential consequences of will be assessed in a limited area before proceeding with a full-fledged restoration effort. Initial RCA thinnings and assessment will occur on up to 100 acres of RCAs along fish- and non-fish-bearing streams in all allocation types of the MRW. Assessments will occur over a 5-year period and include 2 years of pre-restoration assessment and 3 years of post-restoration assessment. 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. Any changes to RCA thinning protocols will be documented, and rationale for the change will be provided in the 6-year Summary Reports. Upon completion of the initial 5-year assessment of RCA thinning, this monitoring will conclude; future habitat conditions will be captured as part of the instream habitat monitoring descried above.

6.3.5 Landslide Monitoring

The Permittee will develop a landslide monitoring program, which will include maintaining a landslide inventory for the ESRF throughout the permit term. Results of the landslide monitoring and inventory program will provide information on how management activities influence natural processes in the permit area and will inform future management decisions. Reporting of landslide data will be included in the annual report, and will be summarized and reviewed during the 6-year Summary Report and 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 in order 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 the most current scientifically accepted protocols, as approved for use by the USFWS. Over time the intent is to pair those field-based protocols with automated monitoring and, once automated monitoring becomes scientifically accepted as a way to monitor habitat condition, species presence, and species use, it will be the primary tool. Use of remote sensing tools will allow the Permittee to track changes in habitat quality for northern spotted owls (*Strix occidentalis*) and marbled murrelets (*Brachyramphus marmoratus*). Bio-acoustic monitoring will allow the Permittee to track presence of covered species across various research designations and habitat types.

In line with the aquatic and riparian monitoring program, the terrestrial monitoring program will cover one-third of the forest 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, per USFWS approved protocols. 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. Marbled murrelet occupied and potential habitat will generally be monitored—following USFWS approved protocols—on the same cycle, with one-third of the habitat monitored every year, and all habitat monitored at least once every 3 years; however, the location of marbled murrelet monitoring will also be tailored to those areas where timber management is expected (but still conducted in all habitat at least once every 3 years). Condition 7 in Chapter 5 outlines the marbled murrelet monitoring requirements in designated occupied and modeled potential habitat. Trends in habitat quality will be summarized in the 6-year Summary Report, and a more comprehensive assessment will be completed during the 12-year Comprehensive Review, as described in Section 7.3, *Reporting*. Northern spotted owls and marbled murrelets' long-term trends in species presence in the permit area will provide a stable and long-term dataset upon which an assessment can be completed, connecting the pace and scale of forest management activities to species response.

6.4.1 Habitat Monitoring

Habitat monitoring will be conducted annually, but the results will be summarized and reported in the 6-year Summary Reports. The Permittee will report acres of habitat harvested versus acres of habitat grown for northern spotted owls and marbled murrelets. Notable incidents of habitat loss due to other disturbances, such as fire, will also be tracked and reported.

The commitment to increase the quantity and quality of habitat over time will be monitored using the acreage metric, tracking habitat loss versus gain. The primary way that habitat quality will improve over time is simply through forest growth. In that way, the stand age and tree height are two 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 owl and marbled murrelet use for nesting. However, the simple metrics of stand age, average tree height, 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 remote sensing capabilities.

Conversely, if a stand is harvested, those same metrics will be used to determine that the habitat quality in that stand has reduced due to a covered activity. Changes in habitat quality that result from covered activities will be tracked with administration of those activities (e.g., acres of habitat lost at the time of research harvest). The baseline number of acres of species habitat is described using published habitat models in Chapter 2, *Environmental Setting*, and the acres of habitat loss expected from covered activities were estimated based on those habitat models and the covered activities that are anticipated in those locations (i.e., whether intensive, extensive, or reserve 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 HCP and permits still authorize habitat loss based on the analysis in the HCP and its proper implementation. 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.

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 and NMFS to determine whether the HCP needs to be amended to reflect those changes. Any amendments would be subject to approval by the Services.

6.4.2 Monitoring Stand-Level Operations

The Permittee will implement stand-level operations, as described in Chapter 3, *Covered Activities*, to accelerate the growth and improve the quality of habitat. Within the CRW, these activities will occur during the first 20 years of HCP implementation. 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. These stands will be monitored in conjunction with other habitat monitoring described above, on a 3-year cycle, 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, tracking where management occurred, 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 utilize adaptive management to adjust management practices in other locations to minimize short-term habitat degradation and maximize long-term habitat improvement.

6.4.3 Monitoring Retention of Legacy Features

Chapter 5 outlines standards for retention in stands that are harvested. The retention standards for extensive and intensive treatment areas are described in Chapter 3. 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 research harvest activities. Demonstration of compliance with these standards will be summarized in the annual report.

6.5 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 other than for purposes of compliance with the permit, 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.

6.5.1 Northern Spotted Owl

The monitoring goal for northern spotted owl is to determine site status at the 23 historic sites described in Chapter 2, 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 23 historic nest sites in the permit area will be monitored each nesting season, meaning that all of the historic sites will be monitored every 3 years. The purpose of monitoring 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, but the USFWS survey protocols that will be used include 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 autonomous recording units that have been shown to be effective in detecting the presence of both northern spotted owls and barred owls (*Strix varia*) (Duchac et al. 2020), and use of such equipment may allow for more efficient and thorough monitoring of spotted owl nesting activities. Use of passive acoustic monitoring will be implemented in coordination with regional efforts for using passive monitoring, including monitoring being conducted as part of regional northern spotted owl demography studies.

All moderately and highly suitable nesting/roosting habitat within the permit area will be surveyed every 3 years so that surveys will cover essentially one-third of all moderately and highly suitable nesting/roosting habitat each year. Searches for new northern spotted owl nest sites in locations where habitat is improving as a result of the research design will be completed in the same one-third of the forest where nesting activity surveys are being completed in a given year. Distribution of automated monitoring units in additional locations, beyond known activity centers, will allow the Permittee to determine when northern spotted owl begin to use new locations and to generally track long-term trends in nesting activity in the permit area.

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 are reestablishing in locations that they historically used. Monitoring will be prioritized in locations where habitat quality is improving and northern spotted owls are expected to colonize or recolonize an area. Within a research context the monitoring program will be designed to sample enough of an area that is treated or not in order to determine if management activities are having an effect. Monitoring of the effectiveness of management treatments on species habitat quality will include a sufficient number of sites and replication that the results will have sufficient statistical power to meaningfully inform future management decisions. This intent may influence where and how monitoring occurs.

6.5.2 Marbled Murrelet

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 acoustic sampling accurately detects occupied areas, and until such protocols for such passive surveys are approved by the USFWS, field surveys following standard USFWS approved survey protocols (currently Evans Mack et al. 2003) will be used to verify acoustical surveys or to calibrate automated systems. Monitoring will be prioritized in stands that are developing into habitat for marbled murrelets, either due to active management or passive management. Monitoring will include a sufficient number of sites and replication that the results will have enough statistical power to meaningfully inform future management decisions. As with monitoring for northern spotted owl and Oregon coast coho, one-third of occupied and potential marbled murrelet habitat will be monitored in a given year, meaning that a representative sample of all habitat areas in the permit area will be monitored every 3 years. Note that determinations of absence for marbled murrelets for management purposes will still follow the USFWS protocol requirements, which currently require 2 consecutive years of surveys determining absence.

6.6 Adaptive Management

This section describes how the Permittee will use adaptive management to respond to monitoring results and new information. Chapter 7 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 programs that are related to or support implementation of the HCP. The Permittee strives for efficiency and effectiveness on all fronts and all programs, including how HCP implementation will adhere to that objective.

For the purposes of this HCP, adaptive management is a decision-making process used to examine alternative strategies (e.g., conservation 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 as assumptions change. Monitoring and learning from the outcomes of past actions are the foundation of adaptive management (Williams et al. 2007). Unlike most HCPs, the Permittee will be conducting research on many natural resource topics, including the covered species, in the permit area. Adaptive management in the permit area will be informed by more information than is described in the HCP or permits. Conservation measures will also be modified in response to research findings, if it would improve implementation of the HCP conservation strategy.

The conservation strategy in this HCP is based on the best scientific information currently available, and it is expected that the conservation measures will effectively achieve the biological goals and objectives as stated in Chapter 5. Future improvements in forest inventory methods and increased accuracy or precision of important metrics, or improvements in species habitat models, may result in different estimations of current and projected habitat trends. Results of effectiveness monitoring may indicate that some management techniques are more or less effective than anticipated, resulting in an increase or decrease in their use, or modifications 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 implementation of strategies on the landscape. Monitoring strategies themselves may change, as they are improved to better quantify or describe specific habitat metrics.

To address these uncertainties, the monitoring and adaptive management program allows the Permittee to learn from experience and reevaluate and revise the type, extent, and location of conservation measures when necessary 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 in effect.

6.6.1 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). Much of the first 10–20 years will be spent collecting baseline data on the forest and on harvest techniques related to the research platform. As that information is gathered adjustments will be made to the research design, including how harvest treatments are deployed. This section is specific to how adaptive management will be utilized within the context of the HCP to refine implementation of the conservation strategy.

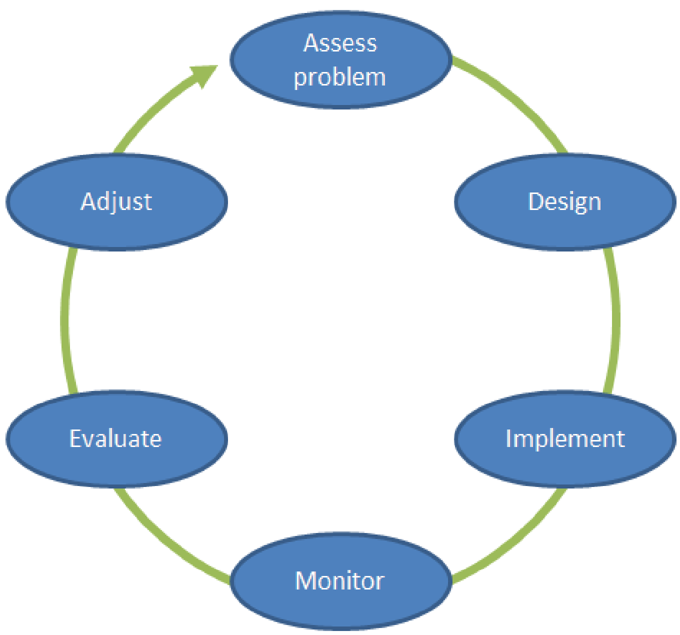


Figure 6-1. Adaptive Management Process

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 conservation measures, as written in Chapter 5, will ultimately achieve the biological goals and objectives.
    b. Determine if conservation measures are not moving the HCP toward meeting the biological goals and objectives set in the HCP.
2. **Design**
    a. In order to test new management actions or techniques, thoughtful consideration must be given to how changes in management are made, so that it is evident what is working and what is not. Because the permit area will all be one large experiment, designing adequate experiments or tests of new approaches will be inherent in implementation 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 to determine whether HCP amendment and associated approval is necessary to comply with permit terms. 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 Section 7.3.
    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.
5. **Evaluate**
    a. The ESRF Manager (see Section 7.2.1, *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 state and federal agencies to confirm adjustments meet the standards of the HCP and permits.

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) 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 for implementation 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.

6.6.2 Adaptive Management Triggers

Adaptive management responses will be triggered when monitoring or other information indicates either of the following.

- Existing practices are under- or over-achieving the biological goals and objectives as illustrated in Table 6-2.
- 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 adaptive management triggers and associated responses will also vary on the specific monitoring metric indicating potential deficiencies. Table 6-2 provides examples of the range of conservation actions expected to be potential areas for adaptive management and associated metrics, triggers, and adaptive management responses. All adaptive management responses will begin with a determination of the underlying causes of the identified deficiencies and triggers. While the examples in Table 6-2 focus on deficiencies, the same rationale can be applied where desired outcomes are overachieved, resulting in allowance for increased management flexibility. If monitoring identifies the need to adapt management, revised management approaches would be developed, with review and input provided by the Services and the interagency stakeholder advisory committee. Any revisions to management approaches will be evaluated to determine if they conflict with meeting stay-ahead provisions described in Chapter 7.

Additional triggers may be identified as part of routine annual reporting, 6-year check-ins, or as part of the 12-year HCP comprehensive reviews. New triggers may also be added in response to new science or emerging issues that influence biological outcomes in the permit area. New triggers can be added at any time during implementation—as approved by the Services—and will be set to provide a warning of trends in the wrong direction in enough time to make adjustments.

Table 6-2. Potential Triggers for Adaptive Management

Actions	Potential Trigger	Adaptive Management Response Example
Aquatic Actions		
Wood recruitment in streams	Trend in large wood frequency/volume in streams is not increasing in watersheds where wood is a limiting factor for covered fish species.	Revise near-term annual harvest plans to increase riparian management in order to incorporate additional wood enhancement in deficient stream reaches.
Stream temperature	Temperature increases or shade reduction are detected in perennial streams within or above fish-bearing streams despite implementation of riparian conservation areas.	Consider targeted riparian conservation strategy adjustments in locations where temperature increases are detected and there are similar stream segments in the permit area. Potentially revise decadal harvest plan in particular watersheds to modify amount of harvest in an affected watershed.
Riparian enhancement	Riparian enhancement projects are not being completed or 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.
Riparian buffers	Over time, debris flow studies show that riparian buffers are insufficient at capturing debris, 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.	Apply lessons learned to selection and design of passage upgrades 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.	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.
Douglas-fir 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.

6.6.3 Adaptive Management and Climate Change

In terms of adaptive management, climate change effects may be detected through monitoring results that will 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 a state and federal level with other major forest land owners in western Oregon, including private industrial forest land owners, federal land managers (the Bureau of Land Management and U.S. Forest Service), and tribal governments and natural resource agencies. Climate change research will be central to everything that occurs on the ESRF so adapting to new information that emerges from that research is part of 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

The Oregon Department of State Lands (DSL) will be 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) (collectively, 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).

7.2.1 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 will oversee and provide support for the following tasks.

- Develop and maintain annual budgets and work plans for HCP implementation.
- Coordinate communication and decision-making within the DSL on HCP implementation and between the Permittee, USFWS, and NMFS, as needed.
- Prepare and submit annual reports to USFWS and NMFS, including 6-year Summary Reports and 12-year Comprehensive Reviews (Section 7.3, *Reporting*).
- Coordinate compliance and effectiveness monitoring activities (Chapter 6, *Monitoring and Adaptive Management*).
- Maintain effectiveness and compliance monitoring and survey data reports and archives, including monitoring results, and incorporate results into the annual report.
- Coordinate the development of policies needed to communicate HCP expectations and requirements to staff.
- Coordinate updates to existing policies, guidelines, and business practices to align with HCP requirements, as needed.
- Ensure adequate training on HCP implementation, including all compliance requirements.

7.2.2 Staff and Other Specialists

The ESRF Manager will be supported by several staff during HCP implementation. A research technician will have the primary duty of managing the implementation of conservation measures and monitoring activities. The research technician will oversee and facilitate implementation to ensure that the Permittee remains in compliance with the terms of the HCP and permits.

The research technician will also collect information from other staff in order to complete the annual compliance report, 6-year Summary Reports on biological effectiveness, and 12-year Comprehensive Reviews on biological effectiveness. The research technician will work closely with a biology technician and forest technician to coordinate HCP-related activities on the forest, track those activities, and make sure they are appropriately reported. It is anticipated that this work will be maintained and tracked in a database managed by a data analyst. 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*.

7.2.3 U.S. Fish and Wildlife Service and National Marine Fisheries Service

USFWS and NMFS oversee HCP implementation, including the following expected tasks.

- Receive and review annual reports, 6-year Summary Reports, and 12-year Comprehensive Reviews submitted by the Permittee.
- Attend annual meeting on HCP implementation.
- Determine if the Permittee is properly implementing the HCP in compliance with the HCP and any additional terms and conditions of each permit, based on the annual report, other information provided by the Permittee, and site visits as necessary.
- Respond to requests by the Permittee for HCP amendments (see Section 7.6, *Modifications to the HCP*).
- 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*.
- Enforce the provisions of the ITPs, as needed.

7.2.4 Public Engagement

Senate Bill (SB) 1546, which established the ESRF, includes a mandate to "maintain a high level of public accountability and transparency in forest management decisions and operations" and establishes the ESRF Authority as a public agency subject to all state laws requiring meetings of the oversight board and written documents to be made available to the public. In addition, SB 1506 has additional transparency requirements for availability of documents to the public prior to forest management decisions. These requirements will encompass all materials related to ongoing 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 for any HCP amendments is also required as part of SB 1506 requirements, including authorization by the state Land Board after consideration and action at a public meeting. These requirements are in addition to the process 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, but is not limited to, the Permittee providing the Elliott State Research Forest Advisory Committee with 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 Elliott State Research Forest Advisory Committee is integral to the sustainability and success of the ESRF. The Advisory Committee will provide input and advice to the Permittee 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. 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 for the duration of the permit term detailing, among other things, compliance, habitat loss, conservation actions, and monitoring activities. The annual reports will summarize the previous state fiscal year's implementation activities (July 1–June 30) and be provided to the Services by November 15 of each year. Annual reports will require synthesis of data and reporting on important trends. A due date of November 15 will allow time for the data to be assembled, analyzed, and presented in a clear and concise format. If the Permittee requires more time to prepare and submit the annual report, the Permittee may request from USFWS and NMFS 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.

The goals of the annual reports are to demonstrate to USFWS, NMFS, and the public that the HCP is being implemented properly. If any implementation problems have occurred, they will be disclosed with a description of corrective measures planned or measures that have been taken to address the problems. The reports will also identify past and expected future changes to the management and monitoring program, through adaptive management, and remedial actions needed to address changed circumstances.

The required content of the annual reports is as follows.

- Description of covered activities implemented during the reporting year as well as cumulative total (i.e., from the start of the permit term).
    - Acres and location of timber harvested by harvest type, and description of research and management objectives and prescriptions.
    - Details associated with experimental treatments and associated prescriptions for treatments within intensive and extensive harvest allocations, within the Conservation Research Watershed (CRW) and Management Research Watershed (MRW) reserves and Riparian Conservation Areas (RCAs).

  - 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.
  - Acres treated or harvested and dates of operations in modeled terrestrial species habitat. Habitat data will include modeled quality ratings (e.g., marginal, suitable, high – See Table 2-5) for stand conditions prior to and after treatment. For extensive treatments, habitat data will also include pre- and post-treatment stand density conditions.
  - Acres treated in RCAs.
  - Aquatic restoration projects completed.
  - Roads constructed or vacated.
  - Road management actions performed.
  - Barriers to fish passage upgraded or removed.
- Documentation of any known instances of direct mortality of covered species.
- 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.
- Summary of the implementation of conditions on covered activities.
- Documentation and justification of any instances where deviations/exceptions from conditions on covered activities occur (Chapter 5, *Conservation Strategy*).
- Summary of all conservation measures implemented.
- Progress toward achieving the biological goals and objectives by implementation of conservation actions (including avoidance, minimization, and mitigation).
- Compliance with the Stay-Ahead provision, including an assessment of whether the loss of habitat quality from disturbed acres caused the Permittee to fall behind the Stay-Ahead provision, as described in Section 7.4, *Stay-Ahead Provision*.
- Monitoring actions conducted in the reporting year (monitoring results will be reported every 6 years as part of the 6-year Summary Report or 12-year Comprehensive Review).
- Summary of surveys conducted through the monitoring program in the reporting year, including a description of surveys conducted, protocols used, and survey results.
- Discussion of possible changes to the monitoring and research program based on interpretation of monitoring results and research findings, if applicable.
- Documentation of any changed circumstances described in Section 7.7.1, *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.
- If changed circumstances were triggered in prior years, document ongoing responses to those past changed circumstances in the current reporting year, and the ongoing results of remedial measures.

- Discussion of possible changes in forest management practices relevant to HCP implementation that are a result of the adaptive management decisions during the reporting year, as applicable. This description will include the information that triggered the change, the rationale for the planned responses, and the results of any applicable monitoring actions.
- Any administrative changes or amendments proposed or implemented during the reporting year (see Section 7.6).
- Summary of any substantive coordination between the Permittee and local, state, federal, and tribal governments and other stakeholders regarding implementation of the HCP.
- Total costs associated with HCP implementation for the reporting year, as well as budget projections for the next fiscal year.

7.3.2 6-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 there will still be an accounting of activities 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.

- A summary of monitoring efforts and activities and relative trends in aquatic and riparian habitat parameters.
- 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.
- 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.
- Amount and general location (e.g., subwatershed) of CRW and reserve treatments (i.e., treated with conservation thinning) and a 6-year projection of additional thinning that will occur.
- Amount and general location (e.g., subwatershed) of RCAs treated with conservation thinning and a 6-year projection of additional thinning that will occur.
- Updated wood recruitment modeling with known buffer widths included to gauge progress towards biological objectives for each independent population of Oregon Coast coho (*Oncorhynchus kisutch*).
- Compliance with the Stay-Ahead provision as described in Section 7.4.

7.3.3 12-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. Information gathered for the 12-year Comprehensive Review will largely be the same as described in Section 7.3.2, *6-Year Summary*

Report, except it will contain a more comprehensive analysis as described in Sections 6.3, *Aquatic and Riparian Monitoring*, and 6.4, *Terrestrial Monitoring*.

7.4 Stay-Ahead Provisions

The Endangered Species Act (ESA) requires that HCPs minimize and mitigate the impacts of the taking to the maximum extent practicable (ESA Section 10(a)(2)(B)(ii)). 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 conservation strategy is that terrestrial habitat quality will improve over time, as the forest grows, and that more acres of habitat and, more importantly, more acres of higher-quality habitat will grow than will be lost to covered activities. The designation of the CRW and reserve treatments in the MRW at the outset of the program will immediately provide conservation benefits to covered species. The lack of regeneration harvest in those areas will allow habitat to develop gradually over time. By maintaining the boundaries of the research allocations through the permit term, the Permittee provides certainty that the total acres of covered species habitat will not be reduced.

It is important to note that “replacing” habitat for northern spotted owl and marbled murrelet 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.

- Acres of existing habitat commitments established as part of the conservation strategy.
- Acres of new ingrowth of habitat (using modeled suitability values).
- Acres of restoration treatments of plantation completed.
- Acres of habitat retention and improvement treatments within extensive and intensive allocations.

These metrics, in turn, will be weighed 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 of 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 within reserves (i.e., within the CRW and reserve treatments within the MRW).

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.

- Acres of existing habitat conserved as part of the conservation strategy, including occupied and unoccupied habitat (based on monitoring data).
- Acres of habitat improvement treatments of plantations.
- Acres of habitat retention and improvement treatments within extensive and intensive allocations.
- Acres of new habitat ingrowth within the CRW, MRW reserves, RCAs, and home ranges of the 23 activity centers included in the conservation strategy.
- Acres of habitat ingrowth within extensive allocations.

The determination of whether conservation actions and accomplishments are collectively on track to meeting the biological goals and objectives and associated Stay-Ahead provisions will be made by the Permittee in consultation with USFWS as part of the 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 23 historic sites identified for protection in this HCP, as specified in Chapter 5 (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 above=minimum levels, per Condition 5 (Chapter 5).

7.4.2 Marbled Murrelet Stay-Ahead Provisions

For marbled murrelet, per Condition 9 in Chapter 5, there will be no temporal loss of the aggregate number of acres of designated occupied or modeled potential 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. 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 covered aquatic species habitat quality improvement through the monitoring of habitat condition in RCAs and aquatic habitat trends (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. 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). Because the only harvest activities occurring in RCAs will be those aimed at transitioning Douglas-fir (*Pseudotsuga menziesii*) plantations to more dynamic ecosystems, the Stay-Ahead provisions for the aquatic strategy will be centered on ensuring that riparian management activities do not reduce habitat quality for Oregon Coast coho along a given stream reach. For example, thinning of trees to improve riparian habitat quality and to provide wood into the stream system cannot increase stream temperature to a level that would begin to have an effect on fish habitat quality. 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 7.8.3, *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 conceivable that the reserves (i.e., CRW and reserve treatments within the MRW, 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 towards those commitments will be linear, due to these stochastic events. The potential for these events to occur in the future is described in Section 7.8.3.2*, 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.

When these natural events occur, the Permittee will respond as described in Section 7.8.3. In the CRW and reserve treatments in the MRW and RCAs, the response will include an assessment of damage to covered species habitat and the potential for regeneration of healthy forests following the event. In some cases, restoration activities, such as reforestation, will occur to speed the recovery of species habitat, but in many cases natural succession will be allowed to proceed.

When these natural disturbances occur in reserve areas, 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.

In many cases, the Stay-Ahead measurement will exclude areas subject to extreme disturbance. In others, however, the Permittee may decide to retain the area in the Stay-Ahead calculation if it will continue to provide habitat for covered species. These determinations will be species-specific and require approval of the Services. Many factors, including the variation in severity of disturbance, will influence those determinations.

Those acres affected by natural disturbance will continue to be reported in annual, 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 in reserve treatments within the MRW 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, change the habitat quality in a stream section very quickly. From that point forward that section of stream would be monitored with the new condition in mind, and habitat quality would be tracked from that point forward, with the new stream condition, created by the episodic event, as the reference point.

7.6 Modifications to the HCP

The HCP and associated ITP may be modified in accordance with the ESA, USFWS and NMFS implementing regulations, and the provisions outlined in this section. HCP or permit modifications are expected to be rare. Modifications to the HCP or ITPs may be requested by 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) Section 13.23(b) and the No Surprises assurances described in the HCP. The modifications will fall into one of two categories: corrective revisions or amendments, each of which is described in the following subsections.

7.6.1 Corrective Revisions and Plan Clarifications

Corrective revisions or Plan clarifications are changes that do not affect the effects assessment or conservation strategy described in the HCP and do not affect the ability of the Permittee to achieve the biological goals and objectives of the Plan. USFWS and NMFS will be notified when corrective revisions and Plan clarifications occur via written description, as described below. These revisions and changes do not require an amendment to the ITP. Examples are listed below.

- Correcting insignificant mapping errors.
- Slightly modifying conservation measures or conditions on covered activities.
- Modifying annual reporting protocols.
- Making minor changes to monitoring protocols.
- Changing funding sources.
- Changing the names or addresses of responsible officials.

To modify the HCP without amending the ITP, the Permittee will submit a written description of the proposed change to the Services as well as an explanation of why its effects are not believed to be significantly different from those described in the original HCP or analyzed under the National Environmental Policy Act (NEPA). If the Services concur with the Permittee's assessment the modification to the Plan will be considered effective on the date of the USFWS's and NMFS's concurrence.

7.6.2 Amendments

An amendment is a change in the HCP that may affect the effects analysis or conservation strategy. Amendments to the HCP may require an amendment to the ITP through generally the same formal review process as the original HCP and ITP, including NEPA review, *Federal Register* notices, and an internal ESA Section 7 consultation with the Services. To obtain the USFWS and NMFS approval of a proposed amendment, the Permittee must submit the proposed amendment to USFWS and NMFS in a report that includes a description of the need for the amendment, an assessment of its impacts, and any alternatives by which the objectives of the proposal might be achieved.

Examples of changes that would require an amendment include, but are not limited to, those listed below.

- Addition of new species, either listed or unlisted.
- Increased level or different form of take for covered species.
- Changes to funding that affect the ability of the Permittee to implement the HCP.
- Changes to covered activities not previously addressed.
- Changes to covered lands.
- Significant changes to the conservation strategy, including changes to the conservation actions and conditions.

- Extending the ITP term.[1]
- Any other changes in Plan implementation that are not described as corrective measures.

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 requests regulatory assurances (No Surprises) for all covered species in the HCP. In accordance with No Surprises, the Permittee will be responsible for implementing and funding measures in response to any changed circumstances, as described in this chapter. The Permittee will not be obligated to address unforeseen circumstances but will work with the Services to address them within the funding and other constraints of the HCP should they occur.

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 Sections 13.27, 13.28, and 17.32 and other applicable laws and regulations) in force at the time of such suspension (see Section 7.9, *Permit Suspension or Revocation*).

7.8 Changed and Unforeseen Circumstances

Changed circumstances are defined in the federal No Surprises regulation.[2] 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[3] 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 bound the Permittee's commitment.

[1] Regulations allow an ITP extension for time only as part of a simple approval by the USFWS and NMFS if there is take authorization remaining at the end of the permit term and the HCP Permittee requests no other changes to the Plan and ITP.

[2] 63 *Federal Register* 35 (1998) (amending 50 CFR 17.22(b)(5) and 222.307(g)).

[3] 50 CFR Sections 17.22(b)(2),17.32(b)(2), and 222.307

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)."[4] 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.

If a changed circumstance, as defined in this section, occurs within the plan area, the Permittee will implement the responsive actions prescribed in this section. The Services will not require any conservation and mitigation measures to respond to changed circumstances, except those provided for in this section, as long as the HCP is being properly implemented. *Properly implemented* means the Permittee has been implementing the HCP in accordance with the terms and conditions of the ITPs.

7.8.2 Unforeseen Circumstances

Unforeseen circumstances are defined by federal regulation as "changes in circumstances affecting a species or geographic area covered by a conservation plan that could not reasonably have been anticipated by plan developers and the 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. The following describes the procedures to be used 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 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 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 (see, e.g., 50 CFR 17.22(b)(5)(iii) and 50 CFR 222.307(g)(3)(iii)), upon determining that unforeseen circumstances exist, the Services will inform the Permittee of any additional avoidance, minimization, or mitigation measures that may be warranted. While the Permittee will not be required to provide additional resources or funds to remedy unforeseen circumstances, the Permittee will work with the Services to determine an appropriate response within the original resource commitments identified in the HCP. 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.

[4] 50 CFR Section 17.3.

7.8.3 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 of the Plan 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 a description of responsive actions to address changed circumstances. The Permittee has allocated a portion of the HCP implementation budget for the responsive actions.

Climate change poses the most uncertainty and risk to state forests. Warmer, drier summers with more extreme heat events, and more extreme precipitation events in winter are expected in western Oregon (Spies et al. 2018). Climate change will likely be a driver for many of the changed circumstances described below, increasing the potential for these events to occur. For example, weather pattern changes may affect forest productivity and health and biodiversity in unforeseen ways, as well as have large but variable effects on species and ecosystems, including increased frequency and severity of drought, fire, invasive species outbreaks, or other disturbances. These more frequent and intense disturbances may quickly change habitat conditions for covered species in the plan area.

Climate change resulting from increased concentrations of atmospheric carbon dioxide is expected to result in warmer temperatures and changed precipitation regimes during this century. Climate change is expected to diminish tree health and improve conditions for some highly damaging pathogens (Kliejeunas et al. 2009). 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 northwest 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).

7.8.3.1 New Species Listed

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.

Response

If a noncovered species is listed, the Permittee will take the following responsive actions.

1. **Determine the potential for permitted 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 agency-provided 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 provided by USFWS or NMFS to avoid take of the species. The Permittee will implement the interim take or adverse modification avoidance guidelines 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 is amended or take authorization is granted through a separate permitting process.

If new critical habitat is designated in the permit area the Permittee and Services will review the new designation(s) in light of the ongoing research and management under the HCP obligations.

7.8.3.2 Temporary Change in Species Habitat Quality from Natural Events

Some natural events can cause significant temporary changes in terrestrial species habitat quality. Natural events that occur in a forested landscape in western Oregon, including the permit area, include the following.

- Fire
- Storms (e.g., ice, wind, snow)
- Floods
- Invasive species and disease

The following sections summarize how these natural events have affected forests within the permit area historically. That information provides context for the thresholds defined for this HCP and used to determine what would be considered a changed circumstance versus an unforeseen circumstance. The proposed responses to these changed circumstances are described after the summary of these natural events.

Fire

Fire is the primary coarse-scale disturbance agent of forests in the western hemlock (*Tsuga hererophylla*) 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 percent 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 stand to an earlier developmental state by killing many plants, thereby favoring the establishment of early seral species. Since the 1868 fire, the Elliott State Forest has been spared any major catastrophic fire event (Section 2.2.4.1, *Disturbance Agents: Fires*). Small-scale fires are rare in the permit area because of its proximity to the coast and generally wet condition, which greatly reduces fire risk except in extreme weather conditions (as occurred in 1868).

The permit area is located within 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). Climate change may increase the frequency and severity of such fires in the permit area as late seasonal drought and incidents of drying east winds are expected to increase seasonal risks of stand-replacing fires (Hagmann et al. 2021; Hessburg et al. 2021).

Storm Events

Storm events (e.g., ice storms, severe wind, heavy snow) can lead to under-productive forest conditions and susceptibility to insects and disease. 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 a more common example 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 torrents. 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 (Teensma et al. 1991; Wimberly et al. 2000). 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.

Invasive Species or Disease

Invasive species and diseases currently occur in the plan area. Several diseases have reached noticeable levels of damage in the Elliott State Forest in recent decades (Section 2.2.4.4, *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 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 plan area that have the potential to spread into the plan 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 plan area in the permit term is a foreseeable event. If a disease or nonnative species spreads beyond the thresholds identified below, however, it will be considered a catastrophic event, and the Services will not require the Permittee to fund remedial actions to address it.

The conservation strategy (Chapter 5) includes measures to reduce existing, and prevent future, infestations of nonnative invasive species and diseases. The monitoring program will identify and map existing diseases and nonnative species in the ESRF so that new ones can be identified quickly and a control or eradication plan can be put into place.

Changed Circumstance

If more than 5,000 acres of conservation areas for terrestrial covered species (reserves, northern spotted owl habitat for the 23 historic nest sites, or occupied or modeled potential marbled murrelet habitat) are collectively affected by any combination of the events described above in one 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 species habitat due to natural events following the steps listed below. The steps are aimed at determining whether the changed circumstance from natural events would potentially undermine the Permittee's ability to successfully maintain conservation values from the research forest design, as described in Chapters 3 and 5.

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) 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 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 and NMFS, as described in Section 7.5. 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 requirement 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 Oregon Department of Fish and Wildlife and federal permitting agencies 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 extensive or intensive areas, but within the same watershed where the natural disturbance occurred, that is not part of an operation currently under contract.
3. Defer harvest in extensive or intensive areas 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.

7.8.3.3 Aquatic Invasive Plants, Nonnative Fish, and Disease/Parasites

Nonnative aquatic plant species, disease, and warmwater predatory fishes may currently occur in portions of the plan area as well as outside the plan area. Aquatic invasive plant species like knotweeds (*Polygonum* spp.) can inundate streamside habitat in open areas, where it displaces native vegetation and can increase streambank erosion (Oregon State University 2013).

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 plan area in accordance with the biological goals and objectives to ensure the riparian and aquatic habitat are maintained (e.g., riparian forests, shading, no harvest) to benefit the covered species. If an invasive aquatic plant were to expand its range within the permit area, to the point at which it becomes a limiting factor for habitat quality for covered species, the Permittee will work with the Oregon Department of Agriculture to identify measures necessary to eradicate the plant. Similarly, if expansions of nonnative fish (warm or cold water) into the permit area begin to outcompete 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 the Oregon Department of Fish and Wildlife 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.

Changed Circumstance

Aquatic invasive plants, nonnative fish, and disease/parasites will be considered a changed circumstance if the spread of aquatic invasive plant species within a reserve affects up to 25 percent of stream miles within any given hydrologic unit code–10 independent population of Oregon Coast coho within a 3-year time period. Any new invasion that expands beyond 25 percent within a 3-year time period will be considered an unforeseen circumstance. A baseline of current aquatic invasive plants will be completed early in the permit term, upon which this measurement will be based.

Response

The Permittee will address changed circumstances using manual, mechanical, cultural, chemical, and biological treatments to manage new occurrences of aquatic invasive plant infestations within the plan area.

For unforeseen circumstances the Permittee will coordinate a response with Oregon Department of Fish and Wildlife 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.

7.8.3.4 Stream Temperature Changes

Climate change is projected to raise temperatures and alter the flow regimes of streams and rivers within the plan area, which will have consequences for physical processes and aquatic organisms, including covered fish species and their habitats. Water temperature plays a critical role for fish and other aquatic organisms in rivers and streams because their biological processes are directly controlled by ambient water temperatures (Neuheimer and Taggart 2007; Buisson et al. 2008; Pörtner and Farrell 2008; Durance and Ormerod 2009). As climate change continues to 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, stream temperatures across the Pacific Northwest averaged 58 degrees Fahrenheit (°F) (14.2 degrees Celsius [°C]) from 1993 to 2011 (Isaak et al. 2018). Based on climate change model scenarios water temperature in streams and rivers can be expected to increase on average by 2°F and 3.5°F (0.73°C and 1.4°C) by 2040 and 2080, respectively (Isaak et al. 2017).

Based on this modeled climate scenario, average annual water temperatures rising more than 3.5°F (1.4°C) during the permit term would be considered unforeseen.

Response

In response to potential changes in water temperature and flow from climate change, the Permittee will take preventative measures for streams and rivers in the plan area. 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 despite use of stream buffers thought to be adequate.
- Reconnect streams to floodplains and protect seeps, springs, and wetlands to facilitate flow.
- Increase the potential of large wood production to the streams through the buffers within the reserves. 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 watersheds and subwatersheds to manage stream flow over the long term.
- Consider adjustments in upland timber management (e.g., rotation/stand age).

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)) or if the Permittee does not comply with the conditions of their permits (50 CFR 13.27, 13.28).

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 new owner(s) will submit to the Services written documentation providing assurances pursuant to 50 CFR Section 13.25 (b)(2) that the new owner(s) will provide sufficient funding for the HCP and will implement the relevant terms and conditions of the ITP, including any outstanding minimization and mitigation. The new owner(s) will commit to all remaining requirements regarding the take authorization and mitigation obligations of this HCP unless otherwise specified in writing and agreed to in advance by USFWS and NMFS.

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)). 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 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 the following subsections.

- Administration and Conservation Strategy
- Monitoring and Reporting
- Adaptive management 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 was unavailable (e.g., HCP costs that are new), costs were estimated based on similar actions conducted by other entities in the state, or with data from comparable HCPs in other states.

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 2021 dollars. These costs are not adjusted for inflation because funding is expected to increase at the same rate as costs are expected to increase due to inflation. All revenue sources that fund 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. These day-to-day research operations and management will be paid for by the Permittee from revenues derived from harvest operations consistent with the HCP and the experimental design as outlined in the Oregon State University (OSU) research proposal. 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). Therefore, only those costs directly related to the HCP are estimated in this section.

8.2.1 HCP Administration and Conservation Strategy

8.2.1.1 HCP Administration

Research forest operation includes implementation of the harvest and habitat management program, including road system management, and HCP implementation. The ESRF management, staffed by the Permittee, will be responsible for oversight of all administration including contract management and leading coordination efforts with USFWS and NMFS on HCP implementation. Table 8-1 summarizes ESRF operation costs associated with the HCP, including personnel, equipment and supplies, and maintenance and other related costs.

Table 8-1. Elliott State Research Forest Annual Operation Costs Associated with the HCP

Category	Annual Cost	FTE on HCP	Annual Cost for HCP
Operations Personnel (Salary + Benefits)			
Forester (Lead/Manager)	$180,000	0.05	$9,000
GIS/Inventory	$115,000	0.05	$5,750
Technician	$102,000	0.10	$10,200
Forester	$146,000	0.10	$14,600
Research Personnel (Salary + Benefits)			
Executive Director	$297,000	0.10	$29,700
Data Specialist	$130,000	0.10	$13,000
Professorial Research Faculty (combined for three staff)	$468,000	0.09	$14,040
Research Technicians (combined for four staff)	$408,000	0.20	$20,400
Graduate Research Assistants (combined for three staff)	$174,000	0.15	$8,700
Student Interns (combined for three)	$39,000	0.30	$3,900
Subtotal	*$2,059,000*		*$129,290*
Equipment and Supplies	**Annual Cost**	**% for HCP**	**Annual Cost for HCP**
Material and Office Supplies	$25,000	3	$750
Trucks/Other Vehicles/Accessories	$56,000	5	$2,800
Shop Equipment	$6,000	3	$180
Subtotal	*$87,000*		*$3,730*

Maintenance and Other Expenses	Annual Cost	% for HCP	Annual Cost for HCP
HCP Monitoring in Excess of Research Monitoring	$100,000	100	$100,000
Research Monitoring and Equipment Replacement	$377,000	5	$18,850
Research Equipment Maintenance	$50,000	20	$10,000
Vehicle Maintenance and Fuel	$54,000	5	$2,700
Rent	$30,000	5	$1,500
Road Operations and Maintenance	$391,500	5	$19,575
Facilities Operations and Maintenance	$195,000	5	$9,750
IT/Data Storage/Software/QA/QC	$600,000	5	$30,000
Subtotal	*$1,797,500*		*$92,375*
Total	***$3,943,500***		**$325,395**

FTE = fulltime employment; GIS = geographic information system; IT = information technology; QA/QC = quality assurance/quality control.

8.2.1.2 Conservation Strategy

The research forest treatments themselves will provide conservation benefits to the covered species. In order to utilize the research forest design to implement the conservation strategy the costs to complete those actions must be identified and assured.

As stated in Chapter 5, the conservation program implements the conservation measures to fulfill the HCP requirement to avoid, minimize, and mitigate impacts of the taking. Estimated costs associated with the conservation strategy include the following conservation measures. The staff expected to support the research treatments, and thus the research activities that are described in the conservation strategy, are listed in Table 8-1. Funding for individual research projects is not included here. Funding for research projects will come from other sources, such as grants, foundations, other public or private funding sources. Note that the availability of funding for individual research projects will not affect implementation of the conservation measures.

1. **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 the aquatic and riparian management strategies, to change the vegetative community so that the HCP's aquatic and riparian habitat objectives can be more easily achieved. It is assumed that there will be HCP-related costs associated with applying alternative vegetation treatments. In the Conservation Research Watershed (CRW) and reserves, timber that is felled outside of the 120-foot RCA between 120 and 200 feet can be sold for revenue, provided wood volume is increased in the stream by 20 percent (see Conservation Measure 3). The intention of selling this wood outside of the 120-foot RCA is to generate enough revenue to offset the costs of completing thinning treatments in the RCA. These costs are accounted for in the operations budget shown in Table 8-1.
2. **Conservation Measure 2: Expanded RCAs on Lower Millicoma River**. This conservation measure will establish and maintain a designated RCA for Lower Millicoma River from its entry into the permit area in the southwest portion of the permit area through the confluence with Elk Creek. This conservation measure addresses the lower amount of wood recruitment expected in the Coos independent population, as it is entirely within the Management Research Watershed (MRW), and will have variable RCA widths when compared to the Tenmile and Lower Umpqua

independent populations. There is no cost for Conservation Measure 2, but the revenue lost from this expansion is captured in the timber harvest and financial modeling results shown in Table 8-3.

3. **Conservation Measure 3: Reduced Forest Road Network in CRW**. 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 problems 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. There will be no net increase in permanent road miles in the CRW by the end of the permit term. In order to facilitate that, roads unnecessary to support the research program or emergency management will be closed or vacated. Any new roads will be constructed in the best locations for minimizing impacts on aquatic and riparian systems. These costs are accounted for in the operations budget shown in Table 8-1.

4. **Conservation Measure 4: Research on Coho Salmon and Their Habitat**. This conservation measure is aimed at research towards a better scientific understanding of the effects and biological response of natural and human-made disturbances in forest landscapes on water quality and quantity. Researchers will test the effectiveness of buffer combinations relative to tradeoffs with other economical and ecological attributes, such as habitat, accessibility, and fiber yield in riparian systems. It is assumed that the costs for riparian and aquatic research will be funded as research projects. The operational costs related to creating the research platform, upon which those studies can be completed, is included in the HCP conservation strategy costs. The operational costs associated with management in order to set up these experiments is accounted for in the operations budget shown in Table 8-1. The research activities themselves will be paid for through outside funding sources, including funding from grants, foundations, and other public and private sources.

5. **Conservation Measure 5: Research on Northern Spotted Owl, Marbled Murrelet, and Their Habitat**. This conservation measure includes the design and implementation of experimental methods for increasing the likelihood of achieving old forest structure, increasing species diversity, and creating complex early seral forests from dense single-species plantations. Depending on conditions, thinning treatments could be composed of one or several of the following: variable density thinnings, including skips and gaps, creation of snags and downed wood, retaining unique tree forms and structures, retaining and/or encouraging a 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. The operational costs related to creating the research platform, upon which those studies can be completed, is included in the HCP conservation strategy costs below. The operational costs associated with management in order to set up these experiments is accounted for in the operations budget shown in Table 8-1. The research activities themselves will be paid for through outside funding sources, including funding from grants, foundations, and other public and private sources.

   Conservation Measure 6: Barred Owl 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 recovery. In addition, ESRF will provide additional 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 research initiative associated with this mitigation measure will be designed and budgeted by January 2025 and begin no later than the 2026 field season.

8.2.2 HCP Monitoring and Reporting

The HCP monitoring program is described in Chapter 6. Reporting requirements are described in Chapter 7. Monitoring the outcomes of conservation measures is the foundation of the HCP's conservation program and adaptive management approach and can help advance scientific understanding to better achieve the HCP's biological goals and objectives. The monitoring actions will result in the estimated costs shown in Table 8-2. Reporting is critical to demonstrating compliance with the HCP and permits and progress.

Table 8-2. Estimated Costs for Monitoring Actions Annually

	Estimated Annual Cost
Effectiveness Monitoring for Oregon Coast coho	$50,000
Effectiveness Monitoring for Northern Spotted Owl	$85,000
Effectiveness Monitoring for Marbled Murrelet	$85,000
Compliance Monitoring	Included in staff time in operational budget in Table 8-1
Annual Reporting	Included in staff time in operational budget in Table 8-1
Total cost of monitoring program	**$210,000**

8.2.3 Adaptive Management and Remedial Measures

Chapter 6 describes the processes for addressing the specific uncertainties associated with the conservation strategy, and the adaptive management measures and potential responses associated with those measures. 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. 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 or remedial measures would not result in additional costs to the Permittee or the need to hire additional staff, but would rather be absorbed into the operational costs described in Table 8-1. For example, if harvest patterns are modified through adaptive management, that would be accommodated through the ongoing management planning that is already funded. 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.

8.2.4 Total HCP Costs

Table 8-3 summarizes all costs for the HCP program over the 80-year permit term. Details for each cost category can be found in Section 8.2, *Implementation Cost*.

Table 8-3. Total Estimated Costs for the Elliott State Research Forest HCP

Cost Category	Average Annual HCP Cost	HCP Cost Over 80-Year Permit Term[1]
HCP Administration and Conservation Strategy	$325,395	$22,777,650
Monitoring and Reporting	$210,000	$16,800,000
Adaptive Management	Included in operations costs	--
Remedial Measures	Included in operations costs	--
Total	**$535,395**	**$39,577,650**

[1] Totals over permit term are in 2021 dollars and do not include inflation.

8.3 Implementation Funding

To fund the costs to implement the HCP (i.e., costs summarized in Table 8-3), the Permittee will rely on revenue from the sale of timber harvests in the permit area and conducted consistent with the HCP.

8.3.1 Timber Sale Revenue

Operations of the ESRF (including HCP implementation) will be financially self-sufficient based on revenue generated through harvesting operations. Timber harvests occur on the ESRF to implement the research platform design in allowable harvest areas and implement the HCP. The Permittee modeled potential timber harvesting required to fund management of the ESRF. Modeling of anticipated harvest revenue included constraints and commitments contained in the OSU Proposal as well as those set forth in the HCP (Table 8-4) (Oregon State University 2021).

The harvesting model results in an average harvest of approximately 17 million board feet per year to maintain a consistent revenue stream over time (Table 8-4). This is an average of 1,000 acres per year in active harvests (regeneration and thinning). The initial periods will be higher than average as restoration harvests are conducted in the reserves to set them on their future trajectory as older forests with natural variations, and the later periods will likely drop to below 800 acres per year in active harvests. These average annual harvest acreages and volumes may change because they are based on even-flow assumptions in a financial feasibility analysis and may not reflect actual operations on the forest over time. The ESRF timber harvest is expected to generate over $5.6 million in revenue annually (Table 8-4). Estimated annual HCP costs (Table 8-3) represent approximately 10 percent of this revenue. Therefore, the 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.

Table 8-4. Estimated Average Annual Harvest Volumes, Acreage, and Revenue to the ESRF

Category	Harvests in Intensive Treatments	Harvests in Extensive Treatments	Harvests in Reserves[1]	Harvest Total
Estimated Average Annual Harvest (million board feet)	10.6	3.9	2.1	16.6
Estimated Average Annual Harvest (acres)	470	300	230	1,000
Estimated Average Annual Net Revenue[2]	$3.69 million	$1.28 million	$0.65 million	$5.62 million

[1] Harvests in reserves are for restoration thinning and are scheduled to be completed within the first 20 years. These include the CRW.

[2] Revenue was estimated in 2019 based on expected average annual timber prices and the expected volume generated from harvest activities.

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 (HCP).

- 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 all of the previous chapters of this HCP. This proposed approach represents the Permittee's best attempt to minimize take of the covered species while allowing research-related 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 than the alternatives described in the environmental impact statement (EIS) that accompanies this HCP. The EIS alternatives serve a broader purpose than the alternatives here, which are narrowly focused on alternatives that may eliminate or reduce take of one or more of the covered species. To distinguish the alternatives here from the EIS alternatives, alternatives in the HCP are called *alternatives to take*.

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 below. 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 research and forest management activities that result in the take of any of the covered species, thereby removing the need for ITPs from USFWS or NMFS. This alternative was not selected because the Permittee would like to conduct 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. In order to accomplish those objectives, it is imperative forestry practices be developed that balance those benefits through careful scientific inquiry, and the Elliott State Research Forest (ESRF) offers that landscape and opportunity. Implementation of a research forest requires the flexibility to sustain an evolving set of research priorities, which could cause habitat modifications that may result in the take of listed species. Therefore, research in the forest cannot be congruent with a no take alternative.

In addition to being a platform for this research, the ESRF provides Oregonians with access to forest education and recreation, as well as jobs in forest products, forestry, and forest research. The Permittee believes that this HCP and the take authorization it will provide is essential to ensure that the Permittee can successfully conduct this 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 environmental effects (as opposed to prioritizing take avoidance of listed species).

Covering these activities under this HCP will lead to a more comprehensive, large-scale conservation strategy that will provide greater conservation benefit to covered species. 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 habitat, or inside known northern spotted owl 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 result in a net reduction in timber volume and harvest revenue from the forest, and in turn would result in the inability to meet the economic needs of the research forest. Beyond the economic infeasibility of this alternative, it would also 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 plantations), habitat quality is expected to be less, in the future, than it would be if management were to occur.

Further, one of the primary objectives of the research forest is to conduct experiments in forest management to gain a better understanding of how marbled murrelets, northern spotted owls, and Oregon coast coho 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 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 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, net reduction of timber volume and resulting harvest revenue would jeopardize the forest's ability to be self-sustaining financially because the wood production is a derivative of the experimental design. Therefore, this alternative was rejected.

Chapter 10
References

Agee, J. K. 1993. *Fire ecology of Pacific Northwest forests.* Island Press, Washington, D.C.

Agnea, Michelle C., Peter A. Beedlowb, David C. Shawa, David R. Woodruffc, E. Henry Leeb, Steven P. Clineb, and Randy L. Comeleob. 2018. Interactions of Predominant Insects and Diseases with Climate Change in Douglas-Fir Forests of Western Oregon and Washington, U.S.A. *Forest Ecology and Management* 409:317–332.

Allen, J.D. 1995. *Stream Ecology: Structure and Function of Running Waters*. Chapman & Hall, New York.

Anthony, R.G., M.C. Hansen, K. Swindle, and A. Ellingson. 2000. *Effects of Forest Stand Manipulations on Spotted Owl Home Range and Use Patterns: A Case Study. Final Draft.* Oregon Cooperative Fish and Wildlife Research Unit, Department of Fisheries and Wildlife, Oregon State University, Corvallis, Oregon. 27 pp. Submitted to: Oregon Department of Forestry, Salem, OR.

Atkinson, A. J., P. C. Trenham, R. N. Fisher, S. A. Hathaway, B. S. Johnson, S. G. Torres, and Y. C. Moore. 2004. *Designing Monitoring Programs in an Adaptive Management Context for Regional Multiple Species Conservation Plans*. U.S. Geological Survey, California Department of Fish and Game, and U.S. Fish and Wildlife Service.

Barnett, T.P., D.W. Pierce, H.G. Hidalgo, C. Bonfils, B.D. Santer, T. Das, G. Bala, A.W. Wood, T. Nozawa, A.A. Mirin, D.R. Cayan, and M.D. Dettinger. 2008. Human Induced Changes in the Hydrology of the Western United States. *Science* 319:1080–1083.

Bauhus J., K. Puettmann, and C. Messier. 2009. Silviculture for Old-Growth Attributes. *Forest Ecology and Management* 258:525–537.

Becker B.H., M.Z. Peery, and S.R. Beissinger. 2007. Ocean Climate and Prey Availability Affect the Trophic Level and Reproductive Success of the Marbled Murrelet, an Endangered Seabird. *Mar Ecol Prog Ser* 329:267–279.

Beechie, T.J., G. Pess, P. Kennard, R. Bilby, and S. Bolton. 2000. Modeling Recovery Rates and Pathways for Woody Debris Recruitment in Northwestern Washington Streams. *North American Journal of Fisheries Management* 20:436–452.

Beechie, T, G. Pess, S. Morley, L. Butler, P. Downs, A. Maltby, P. Skidmore, S. Clayton, C. Muhlfeld, and K. Hanson. 2012. Watershed Assessments and Identification of Restoration Needs. In P. Roni and T. Beechie (eds.), *Stream and Watershed Restoration: A Guide to Restoring Riverine Processes and Habitats.* Wiley-Blackwell.

Behnke, R.J. 2002. *Trout and Salmon of North America*. Free Press, Simon and Shuster, Inc. New York, NY.

Bellmore, J.R., C.V. Baxter, K. Martens, and P.J. Connolly. 2013. The Floodplain Food Web Mosaic: A Study of its Importance to Salmon and Steelhead with Implications for Their Recovery. *Ecological Applications* 23(1):189–207.

Benda L., and Dunne, T. 1997. Stochastic Forcing of Sediment Supply to Channel Networks from Landsliding and Debris Flow. *Water Resources Research* 33:2865–2880.

Benda, Lee Litschert, S.E., Reeves, G., and Pabst, R.. 2016. Thinning and In-Stream Wood Recruitment in Riparian Second Growth Forests in Coastal Oregon and the use of Buffers and Tree Tipping as Mitigation. *Journal of Forestry Research*. 27(4):821–836.

Bennett, T. R., P. Roni, K. Denton, M. McHenry, and R. Moses. 2015. Nomads No More: Early Juvenile Coho Salmon Migrants Contribute to the Adult Return. *Ecology of Freshwater Fish* 24:264–275.

Betts, M., J. Rivers, K. Nelson, D. Roby, and Z. Yang. 2020a. *Potential Marbled Murrelet Habitat Distribution and Research Strategy at the Elliott State Forest*. Oregon State University. Corvallis, OR.

Betts, M.G., J. M. Northrup, J.A. Bailey Guerrero, LJ. Adrean, S.K. Nelson, J.L. Fisher, B.D. Gerber, M.S. Garcia-Heras, Z. Yang, D.D. Roby, and J.W. Rivers. 2020b. Squeezed by a Habitat Split: Warm Ocean Conditions and Old-Forest Loss Interact to Reduce Long-Term Occupancy of a Threatened Seabird*. Conservation Letters* 13: e12745.

Bilby, R.E., and P.A. Bisson. 1998. Function and Distribution of Large Woody Debris. Pages 324–326 in R. J. Naiman and R. Bibly (eds.), *River Ecology and Management: Lessons from the Pacific Coastal Ecoregion.* Springer-Verlag, New York.

Bilby, Robert E., and James W. Ward. 1991. Characteristics and Function of Large Woody Debris in Streams Draining Old-Growth, Clear-Cut, and Second-Growth Forests in Southwestern Washington. *Canadian Journal of Fisheries and Aquatic Sciences* 48(12):2499–2508.

Bingham, B., and B.R. Noon. 1997. Mitigation For Habitat "Take": Application to Habitat Conservation Planning. *Conservation Biology* 11:127–139.

Biosystems, Waterwork Consulting, Coos Watershed Association, Alsea Geospatial, Inc. and Karen Bahus. 2003. *Elliott State Forest Watershed Analysis*. Prepared for the Oregon Department of Forestry. October 2003. 14pp. Available: http://egov.oregon.gov/ODF/STATE_FORESTS/watershed.shtml#Elliott_State_Forest_Analysis.

Bisson, P.A., R.E. Bilby, M.D. Bryant, C.A. Dolloff, G.B. Grette, R.A. House, M.L. Murphy, K.V. Koski, and J.R. Sedell. 1987. Large Woody Debris in Forested Streams in the Pacific Northwest: Past, Present, and Future. Pages 143–190 in E.O. Salo and T.W. Cundy (eds.), *Streamside Management: Forestry and Fishery Interactions*. University of Washington, Institute of Forest Resources, Seattle. Contribution 57.

Borker, A.L., P. Halbert, M.W. McKown, B.R. Tershy, and D.A. Croll. 2015. A Comparison of Automated and Traditional Monitoring Techniques for Marbled Murrelets Using Passive Acoustic Sensors. *Wildl. Soc. Bull.* 39:813–818.

Boston, K. 2016. The Potential Effects of Forest Roads on the Environment and Mitigating Their Impacts. *Current Forestry Reports* 2:215–222.

Botkin, D.B., K. Cummins, T. Dunne, H. Regier, M. Sobel, and L. Talbot. 1995. *Status and Future of Salmon of Western Oregon and Northern California: Findings and Options*. The Center for the Study of the Environment, P.O. Box 6945, Santa Barbara, CA 93160, Research Report 951002.

Brown, G.W., and J.T. Krygier. 1970. Effects of Clear-Cutting on Stream Temperature. *Water Resources Research* 6:1133–1139.

Buchanan, J.B., L.L. Irwin, and E.L. McCutchen. 1993. Characteristics of Spotted Owl Nest Trees in the Wenatchee National Forest. *Journal of Raptor Research* 27:1–7.

Buckler, D.R., and G.E. Granato. 1999. *Assessing Biological Effects from Highway Runoff Constituents.* U.S. Department of Interior and U.S. Geological Survey Open-File Report 99–240.

Buffler, Susan. 2005. *Synthesis of Design Guidelines and Experimental Data for Water Quality Function in Agricultural Landscapes in the Intermountain West*.

Buisson L., W. Thuiller, S. Lek, P. Lim, and G. Grenouillet. 2008. Climate Change Hastens the Turnover of Stream Fish Assemblages. *Global Change Biol.* 14:2232–2248

Bunn, J.T., and D.R. Montgomery. 2004. Patterns of Wood and Sediment Storage Along Debris-Flow Impacted Headwater Channels in Old-Growth and Industrial Forests of the Western Olympic Mountains, Washington. Pages 99–112 in S.J. Bennet and A. Simon (eds.), *Riparian Vegetation and Fluvial Geomorphology: Hydraulic, Hydrologic, and Geotechnical Interactions.* American Geophysical Union, Washington, DC.

Burger, Alan E. 2002. *Conservation Assessment of Marbled Murrelets in British Columbia: A Review of the Biology, Populations, Habitat Associations, and Conservation*. Technical Report Series Number 387, Canadian Wildlife Service Pacific and Yukon Region, British Columbia. Available: http://www.sfu.ca/biology/wildberg/bertram/mamurt/PartA.pdf.

Burnett, K. M., G. H. Reeves, D. J. Miller, S. Clarke, K. Vance-Borland, and K. R. Christiansen. 2007. Distribution of Salmon-Habitat Potential Relative to Landscape Characteristics and Implications for Conservation. *Ecol. Appl*. 17:66–80.

Campbell, E.Y., Dunham, J.B. and Reeves, G.H. 2020. Linkages Between Temperature, Macroinvertebrates, and Young-of-Year Coho Salmon Growth in Surface-Water and Groundwater Streams. *Freshwater Science* 39(3):447–460.

Campbell, S., and L. Liegel. *1996. Disturbance and Forest Health in Oregon and Washington*. USDA Forest Service, Pacific Northwest Research Station, Portland, OR; Oregon Department of Forestry; and Washington Department of Natural Resources. General Technical Report PNW-GTR-381. 105 pp.

Carlson in prep. – *To Come*

Carlson et al. in prep. – *To Come*

Castro, J., M. M. Pollock, C. Jordan, G. Lewallen, and K. Woodruff. 2017. *The Beaver Restoration Guidebook: Working with Beaver to Restore Streams, Wetlands, and Floodplains, Version 2.0.* U.S. Fish and Wildlife Service, Portland, OR.

Chan, S.S., D.J. Larson, K.G. Maas-Hebner, W.H. Emmingham, S.R. Johnston, and D.A. Mikowski. 2006. Overstory and Understory Development in Thinned and Underplanted Oregon Coast Range Douglas Fir Stands. *Canadian Journal of Forest Research*. 36:2696–2711.

Chen, J., J.F. Franklin, and T.A. Spies. 1995. Growing-Season Microclimatic Gradients from Clearcut Edges into Old-Growth Douglas-Fir Forests. *Ecological Applications* 5:74-86.

Clarke, S.E., Burnett, K.M. and Miller, D.J. 2008. Modeling Streams and Hydrogeomorphic Attributes in Oregon from Digital and Field Data. *JAWRA Journal of the American Water Resources Association* 44(2):459–477.

Colman, J.A., K.C. Rice, and T.C. Willoughby. 2001. *Methodology and Significance of Studies of Atmospheric Deposition in Highway Runoff*. U.S. Geological Survey Open-File Report 01-259, Northborough, Massachusetts, 63 pp.

Courtney, S.P., J.A. Blakesley. R.E. Bigley, M.L. Cody, J.P. Dumbacher, R.C. Fleishcher, A.B. Franklin, J.F. Franklin, R.J. Gutiérrez, J.M. Marzluff, and L. Sztukowski 2004. *Scientific Evaluation of the Status of the Northern Spotted Owl.* Portland, OR: Sustainable Ecosystems Institute. 498 pp. Available: https://www.fws.gov/oregonfwo/species/data/northernspottedowl/BarredOwl/Documents/CourtneyEtAl2004.pdf.

Crozier, L. 2016. *Impacts of Climate Change on Salmon of the Pacific Northwest. A Review of the Scientific Literature Published in 2015*.

Davis, R.J., B. Hollen, J. Hobson, J.E. Gower, and D. Keenum. 2016. *Status and Trends of Northern Spotted Owl Habitats. Northwest Forest Plan. The First 20 Years (1994–2013).* Pacific Northwest Research Station. General Technical Report. PNW-GTR-929. Portland, OR.

Decker, M., S. Jaensch, A. Pozniakovsky, A. Zinke, K.F. O'Connell, W. Zachariae, E. Myers, and A.A. Hyman. 2011. Limiting Amounts of Centrosome Material Set Centrosome Size in C. elegans Embryos. *Curr Biol* 21:1259–1267.

DeMeo, T., R. Haugo, C. Ringo, J. Kertis, S. Acker, M. Simpson, and M. Stern. 2018. Expanding Our Understanding of Forest Structural Restoration Needs in the Pacific Northwest. *Northwest Science* 92:18–35.

Dodson, E.K., A. Ares, and K.J. Puettmann. 2012. Early Responses to Thinning Treatments Designed to Accelerate Late Successional Forest Structure in Young Coniferous Stands of Western Oregon, USA. *Canadian Journal of Forest Research* 42(2):345–355. DOI: 10.1139/x11-188.

Driscoll, E.D., P.E. Shelley, and E.W. Strecher. 1990. *Pollutant Loadings and Impacts from Highway Runoff, Volume III: Analytical Investigation and Research Report*. FHWD-RD- 88-0088. Federal Highway Administration, Office of Engineering and Highway Operations Research and Development, McLean, Virginia.

Duchac, L.S., D.B. Lesmeister, K.M. Dugger, Z.J. Ruff, and R.J. Davis. 2020. Passive Acoustic Monitoring Effectively Detects Northern Spotted Owls and Barred Owls Over a Range of Forest Conditions. *The Condor* 122:1–22.

Dugger, K. M., R.G. Anthony, and L.S. Andrews. 2011. Transient Dynamics of Invasive Competition: Barred Owls, Spotted Owls, Habitat, and the Demons of Competition Present. *Ecological Applications* 21(7).

Dugger, K.M., E.D. Forsman, A.B. Franklin, R.J. Davis, G.C. White, C.J. Schwarz, K.P. Burnham, J.D. Nichols, J.E. Hines, C.B. Yackulic, P.F. Doherty Jr., L.L. Bailey, D.A. Clark, S.H. Ackers, L.S. Andrews, B. Augustine, B.L. Biswell, J.A. Blakesley, P.C. Carlson, M.J. Clement, L.V. Diller, E.M. Glenn, A. Green, S.A. Gremel, D.R. Herter, J.M. Higley, J. Hobson, R.B. Horn, K.P. Huyvaert, C. McCafferty, T.L. McDonald, K. McDonnell, G.S. Olson, J.A. Reid, J. Rockweit, V. Ruiz, J. Saenz, and S.G. Sovern. 2016.

The Effects of Habitat, Climate and Barred Owls on the Long-Term Population Demographics of Northern Spotted Owls. *Condor* 118:57–116. doi:10.1650/CONDOR-15-24.1.

Dunk, J. R., B. Woodbridge, N. Schumaker, E.M. Glenn, B. White, D.W. LaPlante, R.G. Anthony, R.J. Davis, K. Halupka, P. Henson, B. Marcot, M. Zwartjes, B.R. Noon, M.G. Raphael, J. Caicco, D. Hansen, M.J. Mazurek, and J. Thrailkill. 2019. Conservation Planning for Species Recovery Under the Endangered Species Act: A Case Study with the Northern Spotted Owl. *PLoS ONE* 14(1).

Durance, I., and S. Ormerod. 2009. Trends in Water Quality and Discharge Confound Long-Term Warming Effects on River Macroinvertebrates. *Freshw Ecol* 54:388–405.

Ebersole J.L., P.J. Wigington, J.P. Baker, M.A. Cairns, M.R. Church, E. Compton, S.G. Leibowitz, B. Miller, and B. Hansen. 2006. Juvenile Coho Salmon Growth and Across Stream Network Seasonal Habitats. *Transactions of the American Fisheries Society* 135:1681–1697.

Evans Mack, D., W. P. Ritchie, S. K. Nelson, E. Kuo-Harrison, P. Harrison, and T. E. Hamer. 2003. *Methods for Surveying Marbled Murrelets in Forests: A Revised Protocol for Land Management and Research.* Pacific Seabird Group unpublished document. Available: http://www.pacificseabirdgroup.org.

Everest, F.H. and G.H. Reeves. 2007. *Riparian and Aquatic Habitats of the Pacific Northwest and Southeast Alaska: Ecology, Management History, and Potential Management Strategies*. Gen. Tech. Rep. PNW-GTR-692. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 130 pp.

Falxa, Gary A., and Martin G. Raphael. 2016. *Northwest Forest Plan-the First 20 years (1994–2013): Status and Trend of Marbled Murrelet Populations and Nesting Habitat.* Gen. Tech. Rep. PNW-GTR-933. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 132 pp.

Flitcroft, R.L., K.M. Burnett, G.H. Reeves, and L.M. Ganio. 2012. Do Network Relationships Matter? Comparing Network and Instream Habitat Variables to Explain Densities of Juvenile Coho Salmon (*Oncorhynchus kisutch*) in Midcoastal Oregon, USA. *Aquat. Conserv.* 22:288–302.

Forest Ecosystem Management Team. 1993. *Forest Ecosystem Management: An Ecological, Economic, and Social Assessment*. Report of the FEMAT. U.S. Government Printing Office, Washington, DC.

Forsman, E.D. 1995. *Spotted Owl Monitoring Protocols for Demographic Studies*. U.S. Department of Agriculture. Pacific Northwest Research Station. Corvallis, OR. 11 pp.

Forsman, E.D., E.C. Meslow, and H.M. Wight. 1984. Distribution and Biology of the Spotted Owl in Oregon. *Wildlife Monograph* 87:1–64.

Forsman, E.D., R.G. Anthony, J.A. Reid, P J. Loschl, S.G. Sovern, M. Taylor, B.L. Biswell, A. Ellingson, E.C. Meslow, G.S. Miller, K.A. Swindle, J.A. Thrailkill, F.F. Wagner, and D.E. Seaman. 2002. *Natal and Breeding Dispersal of Northern Spotted Owls.* Wildlife Monographs:1–35.

Forsman, E.D., R.G. Anthony, K.M. Dugger, E.M. Glenn, A.B. Franklin, G.C. White, C.J. Schwarz, K.P. Burnham, D.R. Anderson, J.D. Nichols, J.E. Hines, J.B. Lint, R.J. Davis, S.H. Ackers, L.S. Andrews, B.L. Biswell, P.C. Carlson, L.V. Diller, S.A. Gremel, D.R. Herter, J.M. Higley, R.B. Horn, J.A. Reid, J. Rockweit, J. Schaberl, T.J. Snetsinger, and S.G. Sovern. 2011. *Population Demography of Northern Spotted Owls: 1985–2008.* Studies in Avian Biology. Cooper Ornithological Society.

Franklin, A.B. 1992. Population Regulation in Northern Spotted Owls: Theoretical Implications for Management. Pages 815–830 in D. R. McCullough, and R. H. Barrett (eds.), *Wildlife 2001: Populations.* Elsevier Applied Science, London, United Kingdom

Franklin, Jerry F., and C. T. Dyrness. 1988. *Natural Vegetation of Oregon and Washington*. OSU Press.

Franklin, Katie M. Dugger, Damon B. Lesmeister, Raymond J. Davis, J. David Wiens, Gary C. White, James D. Nichols, James E. Hines, Charles B. Yackulic, Carl J. Schwarz, Steven H. Ackers, L. Steven Andrews, Larissa L. Bailey, Robin Bown, Jesse Burgher, Kenneth P. Burnham, Peter C. Carlson, Tara Chestnut, Mary M. Conner, Krista E. Dilione, Eric D. Forsman, Elizabeth M. Glenn, Scott A. Gremel, Keith A. Hamm, Dale R. Herter, J. Mark Higley, Rob B. Horn, Julianna M. Jenkins, William L. Kendall, David W. Lamphear, Christopher McCafferty, Trent L. McDonald, Janice A. Reid, Jeremy T. Rockweit, David C. Simon, Stan G. Sovern, James K. Swingle, Heather Wise. 2021. Range-Wide Declines of Northern Spotted Owl Populations in the Pacific Northwest: A Meta-Analysis. *Biological Conservation* 259: 109168, ISSN 0006-3207, https://doi.org/10.1016/j.biocon.2021.109168. (https://www.sciencedirect.com/science/article/pii/S0006320721002202)

Furniss, M.J., T.D. Roelofs, and C.S. Yee. 1991. Influences of Forest and Rangeland Management on Salmonid Fishes and Their Habitats. *American Fisheries Society Special Publications* 19:297–232.

Glenn, E.M., M.C. Hansen, and R.G. Anthony. 2004. Spotted Owl Homerange and Habitat Use in Young Forests of Western Oregon. *Journal of Wildlife Management* 68:33–50.

Goetz, J.N., R.H. Guthrie, R. H., and A. Brenning, 2015. Forest Harvesting Is Associated with Increased Landslide Activity During an Extreme Rainstorm on Vancouver Island, Canada. *Nat. Hazards Earth Syst. Sci.* 15:1311–1330. Available: https://doi.org/10.5194/nhess-15-1311-2015.

Grant, R.F., H.A. Margolis, A.G. Barr, T.A. Black, A.L. Dunn, P.Y. Burnier, and O. Bergeron. 2008. Changes in Net Ecosystem Productivity of Boreal Black Spruce Stands in Response to Changes in Temperature at Diurnal and Seasonal Time Scales. *Tree Physiol*. 29(1):1–17.

Gregory, S.V., G.A. Lamberti, D.C. Erman, K.V. Koski, M.L. Murphy, and J.R. Sedell. 1987. Influence of Forest Practices on Aquatic Production. Pages 233–255 in E.O. Salo and T.W. Cundy (eds.), *Streamside Management: Forestry and Fishery Interactions*. University of Washington, Institute of Forest Resources Contribution 57, Seattle.

Gregory, Stanley V., Frederick J. Swanson, W. Arthur McKee, and Kenneth W. Cummins. 1991. An Ecosystem Perspective of Riparian Zones. *BioScience* 41(8):540–551. Available: https://doi.org/10.2307/1311607.

Groom et al. 2011 recent add to Chapter 4– *To Come*

Gucinski, H., M.J. Furniss, R.R. Ziemer, and M.H. Brooks. 2001. *Forest Roads: A Synthesis of Scientific Information.* General Technical Report PNW-GTR-509. U.S. Forest Service. Portland, OR.

Guthrie, Richard. 2002. The Effects of Logging on Frequency and Distribution of Landslides in Three Watersheds on Vancouver Island, British Columbia. *Geomorphology*. 43:273–292. 10.1016/S0169-555X(01)00138-6.

Gutiérrez, R.J., A.B. Franklin, and W.S. LaHaye. 1995. Spotted Owl (*Strix occidentalis*). In A. Poole and F. Gill (eds.), *The Birds of North America No. 179*. The Academy of Natural Sciences, Philadelphia, PA and The American Ornithologists' Union, Washington, DC.

Gutiérrez R, M. Cody, S. Courtney, and D. Kennedy. 2004. Assessment of the Potential Threat of the Northern Barred Owl. In *Final Report: Scientific Evaluation of the Status of the Northern Spotted Owl.* Sustainable Ecosystems Institute, Portland, OR

Hagmann, R. K., et al. 2021. Evidence for widespread changes in the structure, composition, and fire regimes of western North American forests. Ecological Applications

Hance, D.J., L.M. Ganio, K.M. Burnett, and J.L. Ebersole. 2016. Basin-Scale Variation in the Spatial Pattern of Fall Movement of Juvenile Coho Salmon in the West Fork Smith River, Oregon. *Transactions of the American Fisheries Society* 145(5):1018–1034.

Hankin, D.G., and G.H. Reeves. 1988. Estimating Total Fish Abundance and Total Habitat Area in Small Streams Based on Visual Estimation Methods. *Can.J. Fish. Aquat. Sci.* 45:834–844.

Hessburg, P.F., C.L. Miller, N.A. Povak, A.H. Taylor, P.E. Higuera, S.J. Prichard, M.P. North, B.M. Collins, M.D. Hurteau, A.J. Larson, and C.D. Allen. 2019. Climate, Environment, and Disturbance History Govern Resilience of Western North American Forests. *Frontiers in Ecology and Evolution* 7:239.

Hessburg, P. F., S. J. Prichard, R. K. Hagmann, N. A. Povak, and F. K. Lake. 2021. Wildfire and climate change adaptation of western North American forests: a case for intentional management. Ecological Applications

Hibbs, D.E., and P.A. Giordano. 1996. Vegetation Characteristics of Alter-Dominated Riparian Buffers Strips in the Oregon Coast Range. *Northwest Science* 70(3) 213–222.

Hicks, Brendan J., Robert L. Beschta, and R. Dennis. Harr. 1991. Long-Term Changes in Streamflow Following Logging in Western Oregon and Associated Fisheries Implications. *Journal of the American Water Resources Association* 27(2):217–226. Available: https://doi.org/10.1111/j.1752-1688.1991.tb03126.x.

Huff, M.H., M.G. Raphael, S.L. Miller, S.K. Nelson, and J. Baldwin. 2006. *Northwest Forest Plan—The First 10 Years (1994–2003): Status and Trends of Populations and Nesting Habitat for the Marbled Murrelet.* Gen. Tech. Rep. PNW-GTR-650. U.S. Forest Service, Pacific Northwest Research Station, Portland, OR.

Isaak, D., S. Wollrab, D. Horan, and G. Chandler. 2012. Climate Change Effects on Stream and River Temperatures Across the Northwest U.S. from 1980–2009 and Implications for Salmonid Fishes. *Climatic Change* 113:499–524.

Isaak, D., S. Wenger, E. Peterson, J. Ver Hoef, D. Nagel, C. Luce, S. Hostetler, J. Dunham, B. Roper, S. Wollrab, G. Chandler, D. Horan, and S. Parkes-Payne. 2017. The NorWeST Summer Stream Temperature Model and Scenarios for the Western U.S.: A Crowd-Sourced Database and New Geospatial Tools Foster a User Community and Predict Broad Climate Warming of Rivers and Streams. *Water Resources Research* 53:9181–9205. Available: https://doi.org/10.1002/2017WR020969.

Isaak, D.J., C. Luce, D. Horan, G. Chandler, S. Wollrab, and D. Nagel. 2018. Global Warming of Salmon and Trout Rivers in the Northwestern U.S.: Road to Ruin or Path Through Purgatory? *Transactions of the American Fisheries Society* 147. DOI:10.1002/tafs.10059.

Jacobs, S., J. Firman, G. Susac, D. Stewart, and J. Weybright. 2002. *Status of Oregon Coastal Stocks of Anadromous Salmonids, 2000–2001 and 2001–2002*. Oregon Plan for Salmon and Watersheds Monitoring Report Number OPSW-OSFW-2002-3, September 2002.

Jakob, M. 2000. The Impacts of Logging on Landslide Activity at Clayoquot Sound, Vancouver Island, British Columbia. *Catena* 38:279–300.

Janisch, J.E., Wondzell, S.M., and W.J. Ehinger. 2012. Headwater Stream Temperature: Interpreting Response After Logging, With and Without Riparian Buffers, Washington, USA. *Forest Ecology and Management* 270:302–313.

Johnson, S.L. 2004. Factors Influencing Stream Temperatures in Small Streams: Substrate Effects and a Shading Experiment. *Canadian Journal of Fisheries and Aquatic Sciences* 61:913–923.

Kaufmann, Phillip K., Larsen, D. P., and J. M Faustini. 2009. Bed Stability and Sedimentation Associated with Human Disturbances in Pacific Northwest Streams. *Journal of American Water Resources Association*. Vol. 45. Issue 2. https://doi.org/10.1111/j.1752-1688.2009.00301.x

Kavanagh P.S., K.K. Jones, C.H. Stein, and P.S. Jacobsen. 2005. *Fish Habitat Assessment in the Oregon Department of Forestry Elliott Study Area.* Conservation and Recovery Program, Oregon Department of Fish and Wildlife, 28655 Highway 34, Corvallis OR 97333.

Kayhanian, M., A. Singh, C. Suverkropp, and S. Borroum. 2003. The Impact of Annual Average Daily Traffic on Highway Runoff Pollutant Concentrations. *Journal of Environmental Engineering* 129(11):975–990.

Kingfisher Ecological, Inc. 2016. *Final Report: Northern Spotted Owl Surveys on the Elliott State Forest.* Prepared for: Oregon Department of Forestry Salem, Oregon. Coos Bay District, Coos Bay, Oregon . Prepared by: Kingfisher Ecological, Inc. Corvallis, Oregon

Kliejeunas, J.T, B.W. Geils, J.M. Glaeser, E.M. Goheen, P. Hennon, M. Kim, H. Kope, J. Stone, R. Sturrock, and S.J. Frankel. 2009. *Review of Literature on Climate Change in Western North America*. Gen. Tech. Rep. PSW-GTR-225. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest research Station. 54 pp.

Koski, K. 2009. The Fate of Coho Salmon Nomads: The Story of an Estuarine-Rearing Strategy Promoting Resilience. *Ecology & Society* 14(1).

Kreutzweiser et al. 2009– *To Come*

Kuehne, C., A.R. Weiskittel, S. Fraver, and K.J. Puettmann. 2015. Effects of Thinning-Induced Changes in Structural Heterogeneity on Growth, Ingrowth, and Mortality in Secondary Coastal Douglas-Fir Forests. *Can. J. For. Res.* 45:1448–1461.

Kuletz, K.J. 2005. *Foraging Behavior and Productivity of a Non-Colonial Seabird, The Marbled Murrelet, Relative To Prey And Habitat.* University of Victoria, Victoria, Canada.

Lancaster, S.T., and N.E. Casebeer. 2007. Sediment Storage and Evacuation in Headwater Valleys at the Transition Between Debris-Flow and Fluvial Processes. *Geology* 35:1027–1030.

Lancaster, S.T., S.K. Hayes, and G.E. Grant. 2003. Effects of Wood on Debris Flow Runout in Small Mountain Watersheds. *Water Resource Research* 39(6):1168.

Leinenbach, P., G. McFadden, and C. Torgersen. 2013. *Effects of Riparian Management Strategies on Stream Temperature*. Science Review Team Temperature Subgroup. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 22 pp. On file with: U.S. Forest Service, Pacific Northwest Research Station, 3200 SW Jefferson Way, Corvallis, OR 97331.

Lesmeister, D.B., R.J. Davis, P.H. Singleton, and J.D. Wiens. 2018. Northern Spotted Owl Habitat and Populations: Status and Threats. Chapter 4, pages 374-624 in T.A. Spies, P.A. Stine, R. Gravenmier, J.W. Long, and M.J. Reilly (tech. coords.).*Volume 2-Synthesis Of Science to Inform Land Management Within the Northwest Forest Plan Area*. Gen. Tech. Rep. PNW-GTR-966. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Lestelle, Lawrence C. 2007. *Coho Salmon (*Oncorhynchus kisutch*) Life History Patterns in the Pacific Northwest and California*. Final report submitted to the U.S. Bureau of Reclamation, Klamath Area Office, Klamath Falls, OR.

Lestelle, L.C., G.R. Blair, and S.A. Chitwood. 1993. Approaches to Supplementing Coho Salmon in the Queets River, Washington. Pages 104-119 in L. Berg and P.W. Delaney (eds.), *Proceedings of the Coho Workshop.* British Columbia Department of Fisheries and Oceans, Vancouver, BC.

Lindenmayer, D., and J. Franklin. 2002. *Conserving Forest Biodiversity: A Comprehensive Multiscaled Approach*. Island Press.

Littell, J.S., D.L. Peterson, K.L. Riley, Y. Liu, and C.H. Luce. 2016. A Review of the Relationships Between Drought and Forest Fire in the United States. *Global Change Biology* 22:2353–2369. Available: https://doi.org/10.1111/gcb.13275.

Luce, C.H., J.T. Abatzoglou, and Z.A. Holden. 2013. The Missing Mountain Water: Slower Westerlies Decrease Orographic Enhancement in the Pacific Northwest USA. *Science* 342(6164):1360–1364, doi:10.1126/science.1242335.

Macdonald, J.S., MacIsaac, E.A., and H.E. Herunter. 2003. The Effect of Variable-Retention Riparian Buffer Zones on Water Temperatures in Small Headwater Streams in Sub-Boreal Forest Ecosystems of British Columbia. *Canadian Journal of Forest Research*. 33:1371–1382.

Maguire, D.A., J.A. Kershaw Jr., and D.W. Hann. 1991. Predicting the Effects of Silvicultural Regime on Branch Size and Crown Wood Core in Douglas-Fr. *Forest Science* 37:1409–1428.

Mahoney, K., D. Swales, M.J. Mueller, M. Alexander, M. Hughes, and K. Malloy. 2018. An Examination of an inland-Penetrating Atmospheric River Flood Event Under Potential Future Thermodynamic Conditions. *Journal of Climate* 31(16):6281–6297.

Malison, R.L., K.V. Kuzishchin, and J.A. Stanford. 2016. Do Beaver Dams Reduce Habitat Connectivity and Salmon Productivity in Expansive River Floodplains? *PeerJ* 4:e2403; DOI 10.7717/peerj.2403.

Malt, J., and D. Lank. 2007. Temporal Dynamics of Edge Effects on Nest Predation Risk for the Marbled Murrelet. *Biological Conservation* 140(1-2):160–173. Available: https://www.sciencedirect.com/science/article/pii/S000632070700328X.

Manning, T., J.C. Hagar, and B.C. McComb. 2012. Thinning of Young Douglas-Fir Forests Decreases Density of Northern Flying Squirrels in the Oregon Cascades. *Forest Ecology and Management* 264:15–124.

Mason, J.C. 1976. Response of Underyearling Coho Salmon to Supplemental Feeding in a Natural Stream. *Journal of Wildlife Management* 40:775–778.

May, C.L., and D.C. Lee. 2004. The Relationships Among In-Channel Sediment Storage, Pool Depth, and Summer Survival of Juvenile Salmonids in Oregon Coast Range Streams. *North American Journal of Fisheries Management* 24:761–774.

McDade, M.H., F.J. Swanson, W.A. McKee, J.F. Franklin, and J. Van Sickle. 1990. Source Distances for Coarse Woody Debris Entering Small Streams in Western Oregon and Washington. *Canadian Journal of Forest Research* 20:326–330.

McIntyre, P.J., J.H. Thorne, C.R. Dolanc, A.L. Flint, L.E. Flint, M. Kelly, and D.D. Ackerly. 2015. Twentieth-Century Shifts in Forest Structure in California: Denser Forests, Smaller Trees, and Increased Dominance of Oaks. *Proc. Natl. Acad. Sci*. 201410186.

Meehan, William R. 1996. *Influence of Riparian Canopy on Macroinvertebrate Composition and Food Habits of Juvenile Salmonids in Several Oregon Streams*. U.S. Department of Agriculture USFS. Available: https://www.fs.usda.gov/treesearch/pubs/2877.

Meiman, S., Anthony, R., Glenn, E., Bayless, T., Ellingson, A., Hansen, M., and C. Smith. 2003. Effects of Commercial Thinning on Home-Range and Habitat-Use Patterns of a Male Northern Spotted Owl: A Case Study. *Wildlife Society Bulletin* 31:1254-1262. 10.2307/3784476.

Melillo, J.M., T.C. Richmond, and G.W. Yohe (eds.). 2014. *Climate Change Impacts in the United States: The Third National Climate Assessment*. U.S. Global Change Research Program, 841 pp. Available: https://doi.org/10.7930/J0KW5CXT.

Mellina, E., R.D. Moore, S.G. Hinch, J.S. Macdonald, and G. Pearson. 2002. Stream Temperature Responses to Clearcut Logging in British Columbia: The Moderating Influences of Groundwater and Headwater Lakes. *Canadian Journal of Fisheries and Aquatic Sciences* 59:1886–1900.

Miller, B.A., and S. Sadro. 2003. Residence Time and Seasonal Movements of Juvenile Coho Salmon in the ecotone and Lower Estuary of Winchester Creek, South Slough, Oregon. *Transactions of the American Fisheries Society* 132:546–559.

Miller, D.J., and K.M. Burnett. 2007. Effects of Forest Cover, Topography, and Sampling Extent on the Measured Density of Shallow, Translational Landslides: Forest Cover and Topographic Effects on Landslides. *Water Resources Research* 43(3):23p.

Miller and Carlson in prep. – *To Come*

Miller, R.R. 2010. *Is the Past Present? Historical Splash-Dam Mapping and Stream Disturbance Detection in the Oregon Coastal Province*. Masters Thesis, Oregon State University.

Monserud, R.A. 2002. Large-Scale Management Experiments in the Moist Maritime Forests of the Pacific Northwest. *Landscape Urban Plan* 59(3):159–180.

Moore, G.W., B.B. Bond, J.A. Jones, N. Phillips, and R.C. Meinzer. 2004. Structural and Compositional Controls on Transpiration in 40- and 450-Year-Old Riparian Forests in Western Oregon, USA. *Tree Physiology* 24: 481–491.

Moore, R.D., D.L. Spittlehouse, and A. Story. 2005. Riparian Microclimate and Stream Temperature Response to Forest Harvesting. *Journal of the American Water Resources Association.* 41:813–834.

Mote, P.W., A.F. Hamlet, M.P. Clark, and D.P. Lettenmaier. 2005. Declining Mountain Snowpack in Western North America. *Bull. Am. Meteorol. Soc.* 86(1):39–49, doi:10.1175/BAMS-86-1-39.

Moyle, P.B. 2002. *Inland Fishes of California*. University of California Press, Berkeley, CA.

Naiman, Robert J., Kevin L. Fetherston, Stephen J. McKay, and Jiquan Chen. 1998. Riparian Forests. Chapter 12, pp. 289–323 in *Ecology and Management of Streams and Rivers in the Pacific Northwest Coastal Ecoregion*. New York: Springer-Verlag.

National Marine Fisheries Service. 2011. *Anadromous Salmonid Passage Facility Design*. NOAA Fisheries, Northwest Region. Portland, Oregon.

National Marine Fisheries Service. 2014. *Anadromous Salmonid Passage Facility Design*. NOAA Fisheries, Northwest Region. Portland, Oregon.

National Marine Fisheries Service. 2016. *Final ESA Recovery Plan for Oregon Coast Coho Salmon (*Oncorhynchus kisutch*) Evolutionarily Significant Unit.* National Marine Fisheries Service, West Coast Region, Portland, Oregon. Available: http://www.westcoast.fisheries.noaa.gov/protected_species/salmon_steelhead/recovery_planning_and_implementation/oregon_coast/oregon_coast_salmon_recovery_domain.html

National Marine Fisheries Service. 2022. *Guidelines for Salmonid Passage at Stream Crossings in Oregon, Washington, and Idaho.* WCR. Portland, Oregon

Nelson, K.S. 1997. Marbled Murrelet (*Brachyramphus marmoratus*). In A. Poole and F. Gill (eds.), *The Birds of North America*, No. 276. Philadelphia, PA: The Birds of North America, Inc.

Nelson, S. Kim, and Amanda K. Wilson. 2002. *Marbled Murrelet Habitat Characteristics on State Lands in Western Oregon*. Unpublished Report, submitted to Oregon Department of Forestry, Oregon Department of Fish and Wildlife, U.S. Fish and Wildlife Service, and National Council for Air and Stream Improvement.

Newton, M., and L. Cole 2015. Overstory Development in Douglas-Fir-Dominant Forests Thinned to Enhance Late-Seral Features. *Forest Science*. 61:809–816.

Maguire, D.A., J.A. Kershaw Jr., and D.W. Hann, 1991. Predicting the Effects of Silvicultural Regime on Branch Size and Crown Wood Core in Douglas-Fir. *Forest Science* 37:1409-1428.

Neuheimer, A.B., and C.T. Taggart. 2007. The Growing Degree-Day and Fish Size-at-Age: The Overlooked Metric. *Can J Fish Aquat Sci* 64:375–385.

Nickelson, T.E., Rodgers, J.D., Johnson. S.L., and Solazzi, M.F. 1992. Seasonal Changes in Habitat Use by Juvenile Coho Salmon (*Oncorhynchus kisutch*) in Oregon Coastal Streams. *Canadian Journal of Fisheries and Aquatic Sciences* 49:783–789.

Northwest Fisheries Science Center. 2015. *Status Review Update for Pacific Salmon and Steelhead Listed Under the Endangered Species Act: Pacific Northwes*t.

O'Hanley J.R., and D. Tomberlin. 2005. Optimizing the Removal of Small Fish Passage Barriers. *Environmental Modeling and Assessment* 10:85–98.

Oliver, Chadwick, and Bruce Larson. 1996. *Forest Stand Dynamics*. Wiley.

Olson, Deanna, and K.M. Burnett. 2009. Design and Management of Linkage Areas Across Headwater Drainages to Conserve Biodiversity in Forest Ecosystems. *Forest Ecology and Management*. 258S:S117–S126.

Olson, Deanna, and M.R. Kluber. 2014. Plethodontid Salamander Distributions in Managed Forest Headwaters in Western Oregon, USA. *Herpetological Conservation and Biology* 9(1):76–96.

Olson, G.S., E.M. Glenn, R. G. Anthony, E.D. Forsman, J.A. Reid, P.J. Loschl, and W.J. Ripple. 2004. Modeling Demographic Performance of Northern Spotted Owls Relative to Forest Habitat in Oregon*. Journal of Wildlife Management* 68(4).

Oregon Department of Fish and Wildlife. 2005. *Oregon Native Fish Status Report, Volume I: Species Management Unit Summaries*. ODFW Fish Division, Salem, OR.

Oregon Department of Fish and Wildlife. 2007. *Oregon Coast Coho Conservation Plan for the State of Oregon.* Available: http://www.oregon.gov/OPSW/cohoproject/coho_proj.shtml.

Oregon Department of Fish and Wildlife. 2008. *Oregon Guidelines for Timing of In-Water Work to Protect Fish and Wildlife*. Available: https://www.dfw.state.or.us/lands/inwater/Oregon_Guidelines_for_Timing_of_%20InWater_Work2008.pdf.

Oregon Department of Fish and Wildlife. 2013. *Fish Passage Priority List. Fish Screening and Passage Program*. February 1. 65 pp.

Oregon Department of Fish and Wildlife 2018a. *Status Review of the Marbled Murrelet (*Brachyramphus marmoratus*) in Oregon and Evaluation of Criteria to Reclassify the Species from Threatened to Endangered under the Oregon Endangered Species Act.* Report prepared for the Oregon Fish and Wildlife Commission, January 2018. Oregon Department of Fish and Wildlife, Salem, Oregon.

Oregon Department of Fish and Wildlife. 2018b. *Oregon Adult Salmonid Inventory and Sampling Project*. Available: https://odfw.forestry.oregonstate.edu/spawn/index.htm.

Oregon Department of Fish and Wildlife 2019a. *Marbled Murrelet Technical Report*. Oregon Department of Fish and Wildlife, Salem, Oregon.

Oregon Department of Fish and Wildlife. 2019b. *Oregon Fish Passage Barriers*. Available: https://nrimp.dfw.state.or.us/nrimp/default.aspx?pn=fishbarrierdata#:~:text=Oregon%20Fish%20Passage%20Barriers,that%20is%20stewarded%20by%20ODFW.

Oregon Department of Fish and Wildlife. 2021. *Biological Assessment of the Marbled Murrelet (*Brachyramphus marmoratus*) in Oregon and Evaluation of Criteria to Reclassify the Species from Threatened to Endangered Under the Oregon Endangered Species Act*. Report prepared for the

Oregon Fish and Wildlife Commission, June 2021. Oregon Department of Fish and Wildlife, Salem, Oregon.

Oregon Department of Fish and Wildlife. n.d. Salmon and Steelhead Recovery Tracker. Available: http://odfwrecoverytracker.org/.

Oregon Department of State Lands and Oregon Department of Forestry. 2011. *Elliott State Forest Management Plan. Final Plan*. November 2011. Salem, OR.

Oregon State University 2013– *To Come*

Oregon State University. 2021. *Elliott State Research Forest Proposal*. College of Forestry. Oregon State University. Corvallis, OR. Available: https://www.forestry.oregonstate.edu/sites/default/files/041421_esrf_proposal.pdf. Accessed: September 18, 2022.

Perry, T.D., and J.A. Jones. 2016. Summer Streamflow Deficits from Regenerating Douglas-Fir Forest in the Pacific Northwest, USA. *Ecohydrology* 10(2):1–13.

Peters, R.J. 1996. *An Evaluation of Habitat Enhancement and Wild Fry Supplementation as a Means of Increasing Coho Salmon Production of the Clearwater River, Washington*. Ph.D. Thesis, University of Washington, Seattle, WA.

Phillips, Jerry. 1997. *Caulked Boots and Cheese Sandwiches. A Forester's History of the Oregon's First State Forest "The Elliott" (1912–1996).* 426 pp.

Plissner, J.H., B.A. Cooper, R.H. Day, P.M. Sanzenbacher, A.E. Burger, and M.G. Raphael. 2015. *A Review of Marbled Murrelet Research Related to Nesting Habitat Use and Nest Success.*

Poage, N.J., and P.D. Anderson. 2007. *Large-Scale Silviculture Experiments of Western Oregon and Washington*. USDA Forest Service, General Technical Report PNWGTR-713, Portland, OR, 44 pp.

Poage, N.J., and J.C. Tappeiner. 2002. Long-Term Patterns of Diameter and Basal Area Growth of Old-Growth Douglas-Fir Trees in Western Oregon. *Canadian Journal of Forest Research* 32: 1232–1243.

Pollock, M.M., G.R. Pess, T.J. Beechie, and D.R. Montgomery. 2004. The Importance of Beaver Ponds to Coho Salmon Production in the Stillaguamish River Basin, Washington, USA. *North American Journal of Fisheries Mgt.* 24(3):749–760.

Pörtner H. and A. Farrell. 2008. Physiology and Climate Change. *Science* 322:690–692.

Ptolemy, R.A. 1993. Maximum Salmonid Densities in Fluvial Habitats in British Columbia. Pages 223–250 in L. Berg and P.W. Delaney (eds.), *Proceedings of the Coho Workshop.* British Columbia Department of Fisheries and Oceans, Vancouver, BC.

Puettmann, K.J., A. Ares, J.I. Burton, and E.K. Dodson. 2016. Forest Restoration Using Variable Density Thinning: Lessons from Douglas-Fir Stands in Western Oregon. *Forests* 2016:7, 310. doi:10.3390.

Puettmann and Tappeiner 2014– *To Come*

Ralph, S.C., G.C. Poole, L.L. Conquest, and R.J. Naiman. 1994. Stream Channel Morphology and Woody Debris in Logged and Unlogged Basins of Western Washington. *Canadian Journal of Fisheries and Aquatic Sciences* 51(1):37–51.

Raphael, M.G., G.A. Falxa, and A.E. Burger. 2018. Marbled Murrelet. Chapter 5 in T.A. Spies, P.A. Stine, R. Gravenmier, J.W. Long, and J.W. Reilly (eds.), *Synthesis of Science to Inform Land Management in the Northwest Forest Permit Area.* General Technical Report PNW-GTR-966. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Reeves, Gordon H., Kelly M. Burnett, and Edward V. McGarry. 2003. Sources of Large Wood in the Main Stem of a Fourth-Order Watershed in Coastal Oregon. *Canadian Journal of Forest Research* 33(8):1363-1370. Available: https://doi.org/10.1139/x03-095.

Reeves, G. H., J. D. Sleeper, and D.W. Lang. 2011. Seasonal Changes in Habitat Availability and the Distribution and Abundance of Salmonids Along a Stream Gradient from Headwaters to Mouth in Coastal Oregon. *Transactions of the American Fisheries Society* 140:537–548.

Reeves, G. H., D.H. Olson, S.M. Wondzell, P.A. Bisson, S. Gordon, S.A. Miller, and M.J. Furniss. 2018. The Aquatic Conservation Strategy of the Northwest Forest Plan-A Review of the Relevant Science After 23 Years. Pages 461–624 and 966 in T.A. Spies, P.A. Stine, R. Gravenmier, J.W. Long, and M.J. Reilly (tech. coords.), *Synthesis of Science to Inform Land Management Within the Northwest Forest Plan Area.* Gen. Tech. Rep. PNW-GTR-966. Portland, OR: US Department of Agriculture, Forest Service, Pacific Northwest Research Station: 461–624, 966.

Reilly, M. J, T. A. Spies, J. Littell, R. Butz, and J. B. Kim. 2018. Climate, Disturbance, and Vulnerability to Vegetation Change in the Northwest Forest Plan Area. Chapter 2 in T.A. Spies, P.A. Stine, R. Gravenmier, J.W. Long, and M.J. Reilly (tech. coords.), *Synthesis of Science to Inform Land Management Within the Northwest Forest Plan Area.* USDA Forest Service PNW Research Station, Portland, Oregon.

Reilly et al. 2021– *To Come*

Richardson, J.S., R.J. Naiman, and P.A. Bisson. 2012. How Did Fixed-Width Buffers Become Standard Practice for Protecting Freshwaters and Their Riparian Areas from Forest Harvest Practices? *Freshwater Science* 31(1):232–238.

Roberts and Harrington 2008– *To Come*

Robison, Dr E. George, Keith A. Mills, Jim Paul, and Liz Dent. 1999. *Storm Impacts and Landslides of 1996.* Oregon Department of Forestry.

Roering, J.J., K.M. Schmidt, J.D. Stock, W.E. Dietrich, and D.R. Montgomery. 2003. Shallow Landsliding, Root Reinforcement, and the Spatial Distribution of Trees in the Oregon Coast Range. *Canadian Geotechnical Journal* 40.

Roni, P.l., T.J. Beechie, R.E. Bilby, F.E. Leonetti, M.M. Pollock, and G.R. Pess. 2002. A Review of Stream Restoration Techniques and Hierarchical Strategy for Prioritizing Restoration in Pacific Northwest Watersheds. *North American Journal of Fisheries Management* 22:1–20.

Roni, P., T. Bennett, R. Holland, G. Pess, K. Hanson, R. Moses, M. McHenry, W. Ehinger, and J. Walter. 2012. Factors Affecting Migration Timing, Growth, and Survival of Juvenile Coho Salmon in Two Coastal Washington Watersheds. *Transactions of the American Fisheries Society* 141(4):890–906.

Sandercock, F.K. 1991. Life History of Coho Salmon (*Oncorhynchus kisutch*). Pages 396–445 in C. Groot and L. Margolis (eds.), *Pacific Salmon Life Histories*. University of British Columbia Press, Vancouver, B.C.

Segura, C., K. Bladon, J.A. Hatten, J.A. Jonse, V.C. Hale, and G.G. Ice. 2020. Long-Term Effects of Forest Harvesting on Summer Low Flow Deficits in the Coast Range of Oregon. *Journal of Hydrology* 585:1274.

Schanz, S.A., and A.P. Colee. 2022. Controls on Earthflow Formation in the Teanaway River Basin, Central Washington State, USA. *Earth Surface Dynamics* 10:761–774.

Sessions et al. 1987 (new in Chapter 4) – *To Come*

Solazzi, M.F., T.E. Nickelson, S.L. Johnson, and J.D. Rodgers. 2000. Effects of Increasing Winter Rearing Habitat on Abundance of Salmonids in Two Coastal Oregon Streams. *Canadian Journal of Fisheries and Aquatic Sciences* 57:906–914.

Sounhein, B., E. Brown, M. Lewis and M. Weeber. 2017. *Status of Oregon Stocks of Coho Salmon, 2016.* Monitoring Program Report Number OPSW-ODFW-2017-3, Oregon Department of Fish and Wildlife, Salem, Oregon.

Spies, T.A., D.E. Hibbs, J. Ohmann, G. Reeves, R. Pabst, F. Swanson, C. Whitlock, J. Jones, B.C. Wemple, L. Parendes, and B. Schrader, B. 2003. *The Ecological Basis of Forest Ecosystem Management in the Oregon Coast Range.* Forestry Research Laboratory, Corvallis, OR.

Spies et al. 2007– *To Come*

Spies, T., M. Pollock, G. Reeves, and T. Beechie. 2013. *Effects of Riparian Thinning on Wood Recruitment: A Scientific Synthesis*. Science Review Team Wood Recruitment Subgroup, USDA Forest Service, PNW Research Station, Portland, OR.

Spies, T.A., P.A. Stine, R. Gravenmier, J.W. Long, M.J. Reilly, and R. Mazza. 2018. *Synthesis of Science to Inform Land Management in the Northwest Forest Permit Area*. General Technical Report PNW-GTR-970. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Stednick, J.D. 1996. Monitoring the Effects of Timber Harvest on Annual Water Yield. *Journal of Hydrology* 176:79–95.

Stewart, I., D. Cayan, and M. Dettinger. 2005. Changes Toward Earlier Streamflow Timing Across Western North America. *J. Clim.* 18(8):1136–1155, doi:10.1175/JCLI3321.1.

Stout, H.A., P.W. Lawson, D.L. Bottom, T.D. Cooney, M.J. Ford, C.E. Jordan, R.G. Kope, L.M. Kruzic, G.R. Pess, G.H. Reeves, M.D. Scheuerell, T.C. Wainwright, R.S. Waples, L.A. Weitkamp, J.F. Williams, and T.H. Williams. 2012. *Scientific Conclusions of the Status Review for Oregon Coast Coho Salmon* (Oncorhynchus kisutch). NOAA Technical Memorandum NMFS-NWFSC-118. U. S. Department of Commerce, Northwest Fisheries Science Center, Seattle.

Suzuki, Nobuya, and W. C. Mccomb. 1988. Habitat Classification Models for Beaver (Castor canadensis) in the Streams of the Central Oregon Coast Range. *Northwest Science* 72:102–110.

Swanson and Dyrness 1975 (new in Chapter 4) – *To Come*

Swanson, M.E., J.F. Franklin, R.L. Beschta, C.M. Crisafulli, D.A. DellasSala, R.L. Hutto, D.B. Lindenmayer, and F.J. Swanson. 2011. The Forgotten Stage of Forest Succession: Early-Successional Ecosystems on Forest Sites. *Frontiers in Ecology and Environment* 9:117–125.

Tappeiner, J., T. Nierenberg, J. Bailey, and N. Poage. 2000. *Characterizing Northern Spotted Owl Habitat on State Forest Lands in the Oregon Coast Range*. Report to Oregon Department of Forestry. 114 pp.

Teensma, P.D.A., J.T. Rienstra, and M.A. Yeiter. 1991. *Preliminary Reconstruction and Analysis of Change in Forest Stand Age Classes of the Oregon Coast Range from 1850 to 1940.* Technical Note T/N OR-9, U.S. Department of Interior, Bureau of Land Management, Portland, Ore.

Thomas, J.W., E.D. Forsman, J.B. Lint, E.C. Meslow, B.R. Noon, and J. Verner. 1990. *A Conservation Strategy for the Northern Spotted Owl: Report of the Interagency Scientific Committee to Address the Conservation of the Northern Spotted Owl*. Portland, Oregon. U.S. Department of Agriculture, Forest Service; U.S. Department of the Interior, Bureau of Land Management, Fish and Wildlife Service, National Park Service. 427 pp. Available: https://www.fws.gov/wafwo/species/Fact%20sheets/NSO%20Interagency%20Conservation%20Strategy.pdf.

Thomas, J.W., J.F. Franklin, J. Gordon, and K.N. Johnson. 2006. The Northwest Forest Plan: Origins, Components, Implementation Experience, and Suggestions for Change. *Conservation. Biology*. 20:277–287.

Thompson, M.S., S.J. Brooks, C.C. Sayer, G. Woodward, J.C. Axmacher, D.M. Perkins, and C Gray. 2018. Large Woody Debris "Rewilding" Rapidly Restores Biodiversity in Riverine Food Webs. *J Appl Ecol*. 55:895–904.

Torgersen, C., J. Ebersole, and D. Keenan. 2012. *Primer for Identifying Cold-Water Refuges to Protect and Restore Thermal Diversity in Riverine Landscapes*. Region 10, U.S. Environmental Protection Agency, Seattle, Washington under EPA Interagency Agreement No. DW-14-95755001-0.

U.S. Bureau of Land Management. 2016a. *Northwestern & Coastal Oregon. Record of Decision and Resource Management Plan*. Oregon State Office. Portland, OR.

U.S. Bureau of Land Management. 2016b. *Southwestern Oregon Record of Decision and Resource Management Plan*. Oregon State Office. Portland, OR.

U.S. Department of Agriculture and Bureau of Land Management. 1994. *Record of Decision for Amendments to Forest Service and Bureau of Land Management Planning Documents Within the Range of the Northern Spotted Owl and Standards and Guidelines for Management of Habitat for Late-Successional and Old-Growth Forest Related Species Within the Range of the Northern Spotted Owl.* USDA Forest Service, Portland, Oregon, and BLM, Moscow, Idaho.

U.S. Fish and Wildlife Service. 1990. 50 CFR Part 17. Endangered and Threatened Wildlife and Plants; Determination of Threatened/ Status for the Northern Spotted Owl; Final Rule. *Federal Register* 55(123 I). Tuesday, June 26, 1990 / Rules and Regulations. Department of the Interior. Fish and Wildlife Service.

U.S. Fish and Wildlife Service. 1997. *Recovery Plan for the Threatened Marbled Murrelet (*Brachyramphus marmoratus*) in Washington, Oregon, and California*. Portland, OR.

U.S. Fish and Wildlife Service. 2011. *Revised Recovery Plan for the Northern Spotted Owl (*Strix occidentalis caurina*).* U.S. Fish and Wildlife Service, Portland, OR, USA.

U.S. Fish and Wildlife Service. 2012a. Endangered and Threatened Wildlife and Plants; Designation of Critical Habitat for the Northern Spotted Owl. 50 CFR Part 17. *Federal Register* 77(233). Tuesday, December 4, 2012.

U.S. Fish and Wildlife Service. 2012b. *Protocol for Surveying Proposed Management Activities that May Impact Northern Spotted Owls*. February 2, 2011. Revised January 9, 2012.

U.S. Fish and Wildlife Service. 2013a. *Experimental Removal of Barred Owls to benefit Threatened Northern Spotted Owls: Final EIS*. U.S. Fish and Wildlife Service, Portland, Oregon, USA.

U.S. Fish and Wildlife Service. 2013b. *Programmatic Biological Opinion for Aquatic Restoration Activities in the States of Oregon, Washington, and Portions of California, Idaho, and Nevada*. (ABRO II) FWS reference: 01EOFW00-2013-F-0090. Portland, OR.

U.S. Fish and Wildlife Service. 2015. 50 CFR Part 402. Interagency Cooperation—Endangered Species Act of 1973, as Amended; Incidental Take Statements; Final Rule. *Federal Register* 80(90). Monday, May 11, 2015. Rules and Regulations. Department of the Interior. Fish and Wildlife Service.

U.S. Fish and Wildlife Service. 2016. Endangered and Threatened Wildlife and Plants; Determination of Critical Habitat for the Marbled Murrelet. 50 CFR Part 17. *Federal Register* 81(150). Thursday, August 4, 2016.

U.S. Fish and Wildlife Service. 2019. *Endangered Species Act - Section 7 Consultation. Biological Opinion. Washington State Department of Natural Resources Marbled Murrelet Long-term Conservation Strategy Amendment to the 1997 Habitat Conservation Plan.* Reference: 0IEWFW00-2019-F-1650. x-reference: 1-3-96-FW-594. U.S. Fish and Wildlife Service Washington Fish and Wildlife Office. Lacey, Washington

U.S. Fish and Wildlife Service. 2020a. 50 CFR Part 17. Endangered and Threatened Wildlife and Plants; 12-Month Finding for the Northern Spotted Owl. Notice of 12-month finding. *Federal Register* 85(241). Tuesday, December 15, 2020.

U.S. Fish and Wildlife Service. 2020b. *Barred Owl Study Update*. U.S. Fish and Wildlife Service, Oregon Fish and Wildlife Office, Portland, OR. Available: https://www.fws.gov/oregonfwo/articles.cfm?id=149489616. Accessed: September 1, 2020.

U.S. Fish and Wildlife Service. 2020c. *Biological Opinion on Northwest Oregon District, Bureau of Land Management Harvest and Routine Activities (TAILS: 0lEOFW00-2020-F-0170).* January 31, 2020. Oregon Fish and Wildlife Office. Portland, Oregon.

U.S. Fish and Wildlife Service. 2021. Critical Habitat Designation U.S. Department of the Interior, Fish and Wildlife Service [USFWS]. Endangered and Threatened Wildlife and Plants: Revised Critical Habitat for the Northern Spotted Owl. *Federal Register* 86(10):4820–4860.

U.S. Fish and Wildlife Service and National Marine Fisheries Service. 1998. *Endangered Species Act Consultation Handbook. Procedures for Conducting Section 7 Consultations and Conferences*. March 1998. Final.

U.S. Fish and Wildlife Service and National Marine Fisheries Service. 2016. *Habitat Conservation Planning and Incidental Take Permit Processing Handbook*. December 21, 2016.

U.S. Fish and Wildlife Service and National Marine Fisheries Service. 2019. Endangered and Threatened Wildlife and Plants; Regulations for Interagency Cooperation. *Federal Register* 84(166). August 27, 2019.

U.S. Forest Service. 2012 from Chapter 1– *To Come*

U.S. Forest Service. 2021a. *Siuslaw National Forest Land and Resource Management Plan and Forest Plan Amendments.* Available: https://www.fs.usda.gov/detail/siuslaw/landmanagement/planning/?cid=fsbdev7_007211.

U.S. Forest Service. 2021b. *Umpqua National Forest Planning*. Available: https://www.fs.usda.gov/main/umpqua/landmanagement/planning.

U.S. Forest Service 2021c. *Rogue River-Siskiyou National Forest Planning*. Available: https://www.fs.usda.gov/main/rogue-siskiyou/landmanagement/planning.

U.S. Forest Service and Bureau of Land Management. 1994. *Final Supplemental Environmental Impact Statement on Management of Habitat for Late-Successional and Old Growth Forest Related Species Within the Range of the Northern Spotted Owl.* Vol. 1-2 + Record of Decision.

U.S. Geological Survey. 2018. USGS 14324500 West Fork Millicoma River near Allegany, Oreg. National Water Information System: Web Interface, August 21, 2018.

U.S. Geological Survey. 2020. National Hydrography Watershed Boundary Dataset. Available: https://www.usgs.gov/core-science-systems/ngp/national-hydrography/watershed-boundary-dataset?qt-science_support_page_related_con=4#qt-science_support_page_related_con.

U.S. Geological Survey Forest and Rangeland Ecosystem Science Center. 2018. *Effects of Experimental Removal of Barred Owls on Population Demography of Northern Spotted Owls in the Pacific Northwest*. Available: Effects of Experimental Removal of Barred Owls on Population Demography of Northern Spotted Owls in the Pacific Northwest | U.S. Geological Survey (usgs.gov).

Wainwright T.C. and L.A. Weitkamp. 2013. Effects of Climate Change on Oregon Coast Coho Salmon: Habitat and Life-Cycle Interactions. *Northwest Science* 87(3):219–242.

Walsh, J., D. Wuebbles, K. Hayhoe, J. Kossin, K. Kunkel, G. Stephens, P. Thorne, R. Vose, M. Wehner, J. Willis, D. Anderson, S. Doney, R. Feely, P. Hennon, V. Kharin, T. Knutson, F. Landerer, T. Lenton, J. Kennedy, and R. Somerville. 2014. Our Changing Climate. Climate Change Impacts in the United States: The Third National Climate Assessment. Pages 19–67 in J. M. Melillo, T. C. Richmond, and G. W. Yohe (eds.), U*.S. Global Change Research Program Report*. Available: https://doi.org/10.7930/J0KW5CXT.

Wan, H.Y., J.L. Ganey, C.D. Vojta, and S.A. Cushman. 2018. Managing Emerging Threats to Spotted Owls. *Journal of Wildlife Management* 82:682–697.

Ward, B.R., D.J.F. McCubbing, and P.A. Slaney. 2003. Evaluation of the Addition of Inorganic Nutrients and Stream Habitat Structures in the Keogh River Watershed for Steelhead Trout and Coho Salmon. Pages 127–147 in J.G. Stockner (ed.), *Nutrients in Salmonid Ecosystems: Sustaining Production and Biodiversity*. American Fisheries Society, Symposium 34, Bethesda, MD.

Washington State Department of Natural Resources. 2016. *Olympic Experimental State Forest Habitat Conservation Plan (HCP) Planning Unit Forest Land Plan.* Prepared by Washington State Department of Natural Resources. September 2016. Olympia, Washington.

Wemple, B.C., F.J. Swanson, and J.A. Jones. 2001. Forest Roads and Geomorphic Process Interactions, Cascade Range, Oregon. *Earth Surface Processes and Landforms. The Journal of the British Geomorphological Research Group* 26(2):191–204.

Westerling, A.L., H.G. Hidalgo, D.R. Cayan, and T.W. Swethaml. 2006. Warming and Earlier Spring Increase Western U.S. Forest Wildlife Activity. *Science* 313(5789):940–943

Weyerhaeuser Company. 1995. *Habitat Conservation Plan for the Northern Spotted Owl on the Millicoma Tree Farm*. North Bend, OR.

Wiens, J.D., K.M. Dugger, J.M. Higley et al. 2021. *Invader Removal Triggers Competitive Release in a Threatened Avian Predator.* Available: https://www.google.com/search?q=Invader+removal+triggers+competitive+release+in+a+threatened+avian+predator+%7C+PNAS&rlz=1C1GCEB_enUS887US887&oq=Invader+removal+triggers+competitive+release+in+a+threatened+avian+predator+%7C+PNAS&aqs=chrome..69i57.1424j0j4&sourceid=chrome&ie=UTF-8.

Wilkerson, E., J.M. Hagan, D. Siegel, and A.A. Whitman. 2006. The Effectiveness of Different Buffer Widths for Protecting Headwater Stream Temperature in Maine. *Forest Science*. 52:221–231.

Williams, B.K., R.C. Szaro, and C.D. Shapiro. 2007. *Adaptive Management: The U.S. Department of the Interior Technical Guide*. Adaptive Management Working Group, U.S. Department of the Interior, Washington, DC.

Wilson, T.M., and E.D. Forsman. 2013. Thinning Effects on Spotted Owl Prey and Other Forest-Dwelling Small Mammals. Pages 79–90 in P.D. Anderson and K.L. Ronnenberg (eds.), *Density Management for the 21st Century: West Side Story.* For. Serv., Gen. Tech. Rep. PNW-GTR-880, Pacific Northwest Research Station, Portland, OR.

Wimberly, M.C., T.A. Spies, C.J. Long, and C. Whitlock. 2000. Simulating Historical Variability in the Amount of Old Forest in the Oregon Coast Range. *Conservation Biology* 14(1):167–180.

Woelfle-Erskine, C., L.G. Larsen, and S.M. Carlson. 2017. Abiotic Habitat Thresholds for Salmonid Over-Summer Survival In Intermittent Streams. *Ecosphere* 8(2):e01645.

Yeung, A.C.Y., A. Lecerf, and J.S. Richardson. 2017. Assessing the Long-Term Ecological Effects of Riparian Management Practices on Headwater Streams in a Coastal Temperate Rainforest. *Forest Ecology and Management*. 384:100–109.

Zhang, C., S. Li, J. Qi, Z. Xing, and F. Meng. 2017. Assessing Impacts of Riparian Buffer Zones on Sediment and Nutrient Loadings into Streams at Watershed Scale Using an Integrated REMM-SWAT Model. *Hydrological Processes*. 31:916–924.

Zybach, Bob. 2003. *The Great Fires: Indian Burning and Catastrophic Forest Fire Patterns of the Oregon Coast Range, 1491–1951*. PhD Thesis, Oregon State University.

Appendix A
Active Management of Riparian Conservation Areas

Appendix A
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).

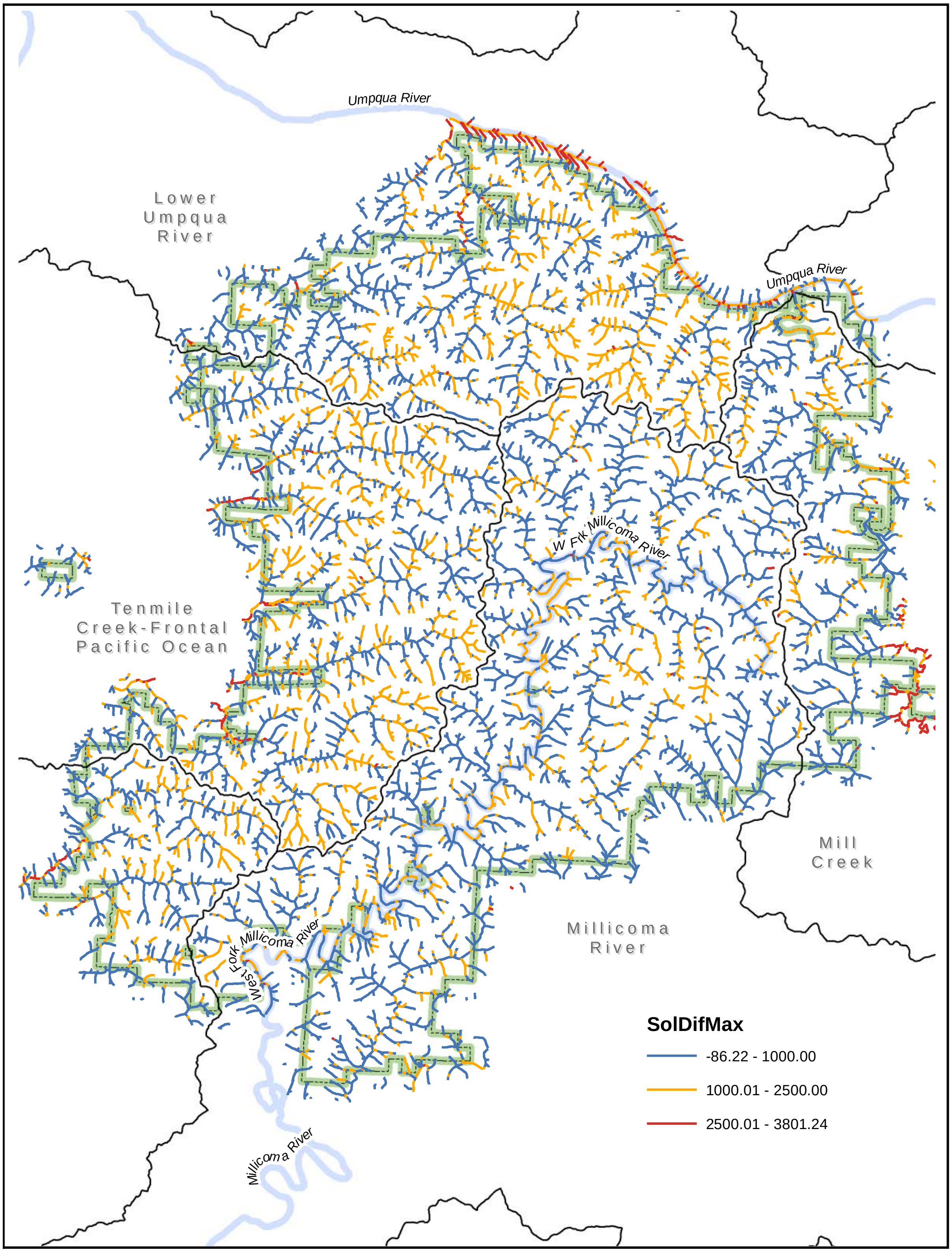


Figure 1. Influence of Solar Radiation on Water Temperature on Streams (SolDifMax) in the Elliott State Research Forest

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.

References

Acker, S.A., S.V. Gregory, G. Lienkaemper, W.A. McKee, F.J. Swanson, and S.D. Miller. 2003. Composition, Complexity, and Tree Mortality in Riparian Forests in the Central Western Cascades of Oregon. *Forest Ecology and Management* 173: 293–308.

Beechie, T, G. Pess, S. Morley, L. Butler, P. Downs, A. Maltby, P. Skidmore, S. Clayton, C. Muhlfeld, and K. Hanson. 2012. Watershed Assessments and Identification of Restoration Needs. In P. Roni and T. Beechie (eds.), *Stream and Watershed Restoration: A Guide to Restoring Riverine Processes and Habitats.* Wiley-Blackwell.

Bellmore, J.R., C.V. Baxter, K. Martens, and P.J. Connolly. 2013. The Floodplain Food Web Mosaic: A Study of its Importance to Salmon and Steelhead with Implications for Their Recovery. *Ecological Applications* 23(1):189–207.

Benda, Lee, S.E. Litschert, G. Reeves, and R. Pabst. 2016. Thinning and In-Stream Wood Recruitment in Riparian Second Growth Forests in Coastal Oregon and the use of Buffers and Tree Tipping as Mitigation. *Journal of Forestry Research*. 27(4):821–836.

Bisson, P.A., R.E. Bilby, M.D. Bryant, C.A. Dolloff, G.B. Grette, R.A. House, M.L. Murphy, K.V. Koski, and J.R. Sedell. 1987. Large Woody Debris in Forested Streams in the Pacific Northwest: Past, Present, and Future. Pages 143–190 in E.O. Salo and T.W. Cundy (eds.), *Streamside Management: Forestry and Fishery Interactions*. University of Washington, Institute of Forest Resources, Seattle. Contribution 57.

Bisson, P.A., J.B. Dunham, and G.H. Reeves. 2009. Freshwater Ecosystems and Resilience of Pacific Salmon: Habitat Management Based on Natural Variability. *Ecology and Society* 14(1):45. Available: http://www.ecologyandsociety.org/ vol14/iss1/art45/.

Burton, J.I., L.M. Ganio, and K.J. Puettmann, K.J. 2014. Multiscale Spatial Controls of Understory Vegetation in Douglas-Fir–Western Hemlock Forests of Western Oregon, USA. *Ecosphere*. 5(12): art151.

Carah, J.K., C.C. Blencowe, D.W. Wright, and L.A. Bolton. 2014. Low-Cost Restoration Techniques for Rapidly Increasing Wood Cover in Coastal Coho Salmon Streams. *North American Journal of Fisheries Management* 34:1003–1013.

Carey, A.B. 2003. Biocomplexity and Restoration of Biodiversity in Temperate Coniferous Forest: Inducing Spatial Heterogeneity with Variable-Density Thinning. *Forestry* 76:127–136.

Carey, A.B., and R.O. Curtis. 1996. Conservation of Biodiversity: A Useful Paradigm for Forest Ecosystem Management. *Wildlife Society Bulletin* 24:610–620.

Chan, S.S., D.J. Larson, K.G. Maas-Hebner, W.H. Emmingham, S.R. Johnston, and D.A. Mikowski. 2006. Overstory and Understory Development in Thinned and Underplanted Oregon Coast Range Douglas-fir Stands. *Canadian Journal of Forest Research* 36:2696–2711.

Cristea, N., and J. Janisch. 2007. *Analysis of Factors Affecting Stream Temperature to Assist the Development of Hardwood Conversion Guidelines for Small Forest Landowners*. Report. Olympia, WA: Washington Department of Ecology.

D'Amore, D.V., K.L. Oken, P.A. Herendeen, E.A. Steel, and P.E. Hennon. 2015. Carbon Accretion in Unthinned and Thinned Young-Growth Forest Stands of the Alaskan Perhumid Coastal Temperate Rainforest. *Carbon Balance and Management* 10:25. Available: https://link.springer.com/ content/pdf/10.1186%2Fs13021-015-0035-4.pdf.

Dale, V.H., S. Brown, R.A. Haeuber, N.T. Hobbs, N. Huntly, R.J. Naiman, W.E. Riebsame, M.G. Turner, and T.J. Valone. 2000. Ecological Principles and Guidelines for Managing the Use of Land. *Ecological Applications* 10:639–670.

Everest, F.H., and G.H. Reeves. 2007. *Riparian and Aquatic Habitats of the Pacific Northwest and Southeast Alaska: Ecology, Management History, and Potential Management Strategies*. Gen. Tech. Rep. PNW-GTR-692. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 130 p.

Franklin, J.F., T.A. Spies, R. Van Pelt, A.B. Carey, D.A. Thornburgh, D.R. Berg, D.B. Lindenmayer, M.E. Harmon, W.S. Keeton, D.C. Shaw, and K. Bible. 2002. Disturbances and Structural Development of Natural Forest Ecosystems with Silvicultural Implications, Using Douglas-Fir Forests as an Example. *Forest Ecology and Management* 155:399–423.

Frissell, C.A., W.J. Liss, R.E. Gresswell, R.K. Nawa, and J.L. Ebersole. 1997. A Resource in Crisis: Changing the Measure of Salmon. Pages 411–446 in D.J. Stouder, P.A. Bisson, and R.J. Naiman (eds.), *Pacific Salmon and Their Ecosystems: Status and Future Options.* New York: Chapman and Hall.

Goetz, J.N., R.H. Guthrie, and A. Brenning. 2015. Forest Harvesting is Associated with Increased Landslide Activity During an Extreme Rainstorm on Vancouver Island, Canada. *Natural Hazards Earth Systems Science* 15:1311–1330.

Gregory, S.V. 1997. Riparian Management in the 21st Century. Pages 69–85 in K.A. Kohm and J.F. Franklin (eds.), *Creating a Forestry for the 21st Century*. Washington, DC: Island Press: 69–85.

Guthrie, R.H. 2002. The Effects of Logging on Frequency and Distribution of Landslides in Three Watersheds on Vancouver Island, British Columbia. *Geomorphology* 43:273–292.

Hagar, J.C., W.C. McComb, and W.H. Emmingham. 1996. Bird Communities in Commercially Thinned and Unthinned Douglas-Fir Stands of Western Oregon. *Wildlife Society Bulletin* 24:353–366.

Hibbs, D.E., and P.A. Giordano. 1996. Vegetation Characteristics of Alder-Dominated Riparian Buffer Strips in the Oregon Coast Range. *Northwest Science* 70:213–222.

Hiers, J.K., S.T. Jackson, R.J. Hobbs, E.S. Bernhardt, and L.E. Valentine. 2016. The Precision Problem in Conservation and Restoration. *Trends in Ecology & Evolution* 31:820–830. Available: https://doi.org/10.1016/j. tree.2016.08.001.

Holling, C.S., and G.K. Meffe. 1996. Command and Control and the Pathology of Natural Resource Management. *Conservation Biology* 10:328–337.

Jakob, M. 2000. The Impacts of Logging on Landslide Activity at Clayoquot Sound, British Columbia. *Catena* 38:279–300.

Janisch, J.E., S.M. Wondzell, and W.J. Ehinger. 2012. Headwater Stream Temperature: Interpreting Response After Logging, With and Without Riparian Buffers, Washington, USA. *Forest Ecology and Management* 270:302–313.

Johnson, S.L. 2004. Factors Influencing Stream Temperatures in Small Streams: Substrate Effects and a Shading Experiment. *Canadian Journal of Fisheries and Aquatic Sciences* 61:913–923.

Kreutzweiser, D.P., S.S. Capell, and S.B. Holmes. 2009. Stream Temperature Responses to Partial-Harvest Logging in Riparian Buffers of Boreal Mixed Wood Forest Watersheds. *Canadian Journal of Forest Research* 39:497–506.

Leinenbach, P., G. McFadden, and C. Torgersen. 2013. *Effects of Riparian Management Strategies on Stream Temperature. Science Review Team Temperature Subgroup*. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 22 p. On file with: U.S. Forest Service, Pacific Northwest Research Station, 3200 SW Jefferson Way, Corvallis, OR 97331.

Lyons, J.K., and R.L. Beschta. 1983. Land Use, Floods, and Channel Changes: Upper Middle Fork Willamette River, Oregon (1936–1980). *Water Resources Research* 19:463–471.

McIntyre, P.J., J.H. Thorne, C.R. Dolanc, A.L. Flint, L.E. Flint, M. Kelly, and D.D. Ackerly. 2015. Twentieth Century Shifts in Forest Structure in California: Denser Forests, Smaller Trees, and Increased Dominance of Oaks. *Proceedings of the National Academy of Sciences of the United States of America* 112:1458–1463.

Moore, R.D., D.L. Spittlehouse, and A. Story. 2005. Riparian Microclimate and Stream Temperature Response to Forest Harvesting. *Journal of the American Water Resources Association* 41:813–834.

Muir, P.S., R.L. Mattingly, J.C. Tappeiner, II, J.D. Bailey, W.E. Elliott, J.C. Hagar, J.C. Miller, E.B. Peterson, and E.E. Starkey. 2002. M*anaging for Biodiversity in Young Douglas-Fir Forests of Western Oregon.* Biol. Science Rep. USGS/BRD/BSR—2002-0006. Corvallis, OR: U.S. Department of the Interior, Geological Survey, Forest and Rangeland Ecosystem Science Center. 76 p. Available: https://fresc.usgs.gov/products/papers/mang_bio.pdf.

Naiman, R.J., R.E. Bilby, and P.A. Bisson. 2000. Riparian Ecology and Management in the Pacific Coastal Rain Forest. *BioScience* 50:996–1011.

Pabst, R.J., and T.A. Spies. 1999. Composition and Structure of Unmanaged Riparian Forests in the Coastal Mountains of Oregon. *Canadian Journal of Forest Research* 29:1557–1573.

Pollock, M.M., and T.J. Beechie. 2014. Does Riparian Forest Restoration Thinning Enhance Biodiversity? The Ecological Importance of Large Wood. *Journal of the American Water Resources Association* 50:543–559.

Reeves, G.H. 2006. The Aquatic Conservation Strategy of the Northwest Forest Plan: An Assessment After Ten Years. Chapter 9, pages 181–217 in R.W. Haynes, B.T. Bormann, D.C. Lee, and J.R. Martin (tech. eds.), *Northwest Forest Plan—The First 10 Years (1994– 2003): Synthesis of Monitoring and Research Results*. Gen. Tech. Rep. PNW-GTR-651. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Reeves, G.H., J.E. Williams, K.M. Burnett, and K. Gallo. 2006. The Aquatic Conservation Strategy of the Northwest Forest Plan. *Conservation Biolo*gy 20:319–329.

Reeves, G.H., B.R. Pickard, and K.N. Johnson. 2016. *An Initial Evaluation of Potential Options for Managing Riparian Reserves of the Aquatic Conservation Strategy of the Northwest Forest Plan*. Gen. Tech. Rep. PNWGTR-937. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 97 p.

Reeves, G.H., D.H. Olson, S.M. Wondzell, P.A. Bisson, S. Gordon, S.A. Miller, J.W. Long, and M.J. Furniss. 2018. The Aquatic Conservation Strategy of the Northwest Forest Plan—A Review of the Relevant Science After 23 years. Pages 461–624 in T.A. Spies, P.A. Stine, R. Gravenmier, J.W. Long, and M.J. Reilly (tech. coords.), *Synthesis of Science to Inform Land Management Within the Northwest Forest Plan Area*. Gen. Tech. Rep. PNW-GTR-966. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Rieman, B., J. Dunham, and J. Clayton. 2006. Emerging Concepts for Management of River Ecosystems and Challenges to Applied Integration of Physical and Biological Sciences in the Pacific Northwest, USA. *International Journal of River Basin Management* 4:85–97.

Roon D.A., J.B. Dunham, and J.D. Groom. 2021. Shade, Light, and Stream Temperature Responses to Riparian Thinning in Second-Growth Redwood Forests of Northern California. *PLoS ONE* 16(2): e0246822. https://doi.org/10.1371/journal.

Russell, W. 2009. The Influence of Timber Harvest on the Structure and Composition of Riparian Forests in the Coastal Redwood Region. *Forest Ecology and Management* 257:1427–1433.

Spies, T., M. Pollock, G. Reeves, and T. Beechie. 2013. *Effects of Riparian Thinning on Wood Recruitment: A Scientific Synthesis. Science* Review Team Wood Recruitment Subgroup. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 46 p. On file with: Pacific Northwest Research Station, 3200 SW Jefferson Way, Corvallis, OR 97331.

Swanson, M., J.F. Franklin, R.L. Beschta, C.M. Crisafulli, D.A. DellaSala, R.L. Hutto, D.B. Lindenmayer, and F.J. Swanson. 2011. The Forgotten Stage of Forest Succession: Early-Successional Ecosystems on Forest Sites. *Frontiers in Ecology and the Environment* 9:117–125.

Tappeiner, J.C., II, D.W. Huffman, D. Marshall, T.A. Spies, and J.D. Bailey. 1997. Density, Ages, and Growth Rates in Old-Growth and Young-Growth Forests in Coastal Oregon. *Canadian Journal of Forest Research* 27:638–648.

Villarin, L.A., D.M. Chapin, and J.E. Jones. 2009. Riparian Forest Structure and Succession in Second-Growth Stands of the Central Cascade Mountains, Washington, USA. *Forest Ecology and Management* 257:1375–1385.

Warren, D.R., S.M. Collins, E.M. Purvis, M.J. Kaylor, and H.A. Bechtold. 2016. Spatial Variability in Light Yields Colimitation of Primary Production by Both Light and Nutrients in a Forested Stream Ecosystem. *Ecosystems*. 1: 198–210.

Welty, J.J., T. Beechie, K. Sullivan, D.M. Hyink, R.E. Bilby, C. Andrus, and G. Pess. 2002. Riparian Aquatic Interaction Simulator (RAIS): A Model of Riparian Forest dynamics for the Generation of Large Woody Debris and Shade. *Forest Ecology and Management* 162:299–318.

Wilkerson, E., J.M. Hagan, D. Siegel, and A.A. Whitman. 2006. The Effectiveness of Different Buffer Widths for Protecting Headwater Stream Temperature in Maine. *Forest Science*. 52:221–231.

Wilzbach, M.A., B.C. Harvey, J.L. White, and R.J. Nakamoto. 2005. Effects of Riparian Canopy Opening and Salmon Carcass Addition on the Abundance and Growth of Resident Salmonids. *Canadian Journal of Fisheries and Aquatic Sciences* 62:58–67.

Wimberly, M.C., and T.A. Spies. 2001. Influences of Environment and Disturbance on Forest Patterns in Coastal Oregon Watersheds. *Ecology* 82:1443–1459.

Wondzell, S.M., A. Przeszlowska, D. Pflugmacher, M.A. Hemstrom, and P.A. Bisson. 2012. Modeling the Dynamic Responses of Riparian Vegetation and Salmon Habitat in the Oregon Coast Range with State and Transition Models. Pages 173–196 in B.K. Kerns, A.J. Shlisky, and C. J. Daniel (eds.), *Proceedings of the First Landscape State-and-Transition Simulation Modeling Conference.* Gen. Tech. Rep. PNW-GTR-869. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Yeung, A.C.Y., A. Lecerf, and J.S. Richardson. 2017. Assessing the Long-Term Ecological Effects of Riparian Management Practices on Headwater Streams in a Coastal Temperate Rainforest. *Forest Ecology and Management* 384:100–109.

Zhang, C.; S. Li,; J. Qi, Z. Xing, and F. Meng. 2017. Assessing Impacts of Riparian Buffer Zones on Sediment and Nutrient Loadings into Streams at Watershed Scale Using an Integrated REMM-SWAT Model. *Hydrological Processes*. 31:916–919.

Appendix B
Species Considered for Coverage

Fish and Wildlife Species Considered for Permit Coverage

	Status[1]		Criteria[2]						
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	Y	Y	Y	N	N	N	Southern Distinct Population Segment listed as Threatened in 2010

	Status[1]		Criteria[2]						
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.

[1] **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

[2] **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

This page intentionally left blank.

Appendix C
Elliott State Research Forest Proposal

COLLEGE OF FORESTRY

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

This proposal was developed, reviewed, and revised through nearly two years of work by a number of individuals and committees. OSU would like to acknowledge their many contributions to this process and the development of a comprehensive proposal for an Elliott State Research Forest.

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
Amy Delahanty	Project Manager
Jennah Stillman	Project Associate

Oregon Department of State Lands

Vicki Walker	Director
Geoff Huntington	Project Advisor
Meliah Masiba	Senior Policy and Legislative Analyst
Ryan Singleton	Forester
Bill Ryan	Operations Deputy Director
Ali Hansen	Communications Manager
Robert Underwood	Project Manager

OSU's College of Forestry Elliott Project Team

Tom DeLuca	Dean of the College of Forestry
Katy Kavanagh	Associate Dean of Research (Exploratory Committee Chair)
Randy Rosenberger	Associate Dean of Student Success and Special Projects
Michael Collins	Director of External Relations
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
Gordie Reeves	Aquatic Biologist
Deanne Carlson	Graduate Researcher, Forest Ecosystems and Society

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

Jennifer Allen, Chair	Environmental/natural resource public policy, Portland State University
Cassandra Moseley	Community-based forestry, rural development, University of Oregon
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
Matt Sloat	Ecology of pacific salmon watersheds, Wild Salmon Center
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:

Stephen Fitzgerald	Professor and Extension Specialist and Director of College of Forestry Research Forests
Dana Warren	Associate Professor, Forest Ecosystems and Society and Fisheries and Wildlife
Kevin Bladon	Associate Professor, Forest Engineering, Resources and Management
Catalina Segura	Associate Professor, Forest Engineering, Resources and Management
Ariel Muldoon	Senior Faculty Research Assistant, Forest Ecosystems and Society
Jim Rivers	Assistant Professor, Forest Engineering, Resources and Management
Jennifer Elston	Executive Assistant to the Dean of the College of Forestry
Adrienne Wonhof	Director of Administration and Operations, College of Forestry Dean's Office
Scott Harris	Graduate Research Fellow, Forest Ecosystems and Society
Lauren Rennan	Art Director, College of Forestry
Taal Levi	Associate Professor, Department of Fisheries and Wildlife
Mark Harmon	Professor Emeritus, Forest Ecosystems and Society
Chris Wolf	Research Associate (Post-doc), Forest Ecosystems and Society
Kim Nelson	Senior Faculty Research Assistant, Department of Fisheries and Wildlife
Zhiqiang Yang	Courtesy Faculty, Forest Ecosystems and Society
Dan Roby	Professor Emeritus, Department of Fisheries and Wildlife

Scientists

We thank the following scientists for their honest feedback on the research design and ESRF proposal:

David Lindenmayer	Fenner School of Environment and Society, Australian National University
John M. Marzluff	School of Environmental and Forest Sciences, University of Washington
Bernard T. Bormann	School of Environmental and Forest Sciences, College of the Environment, University of Washington
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

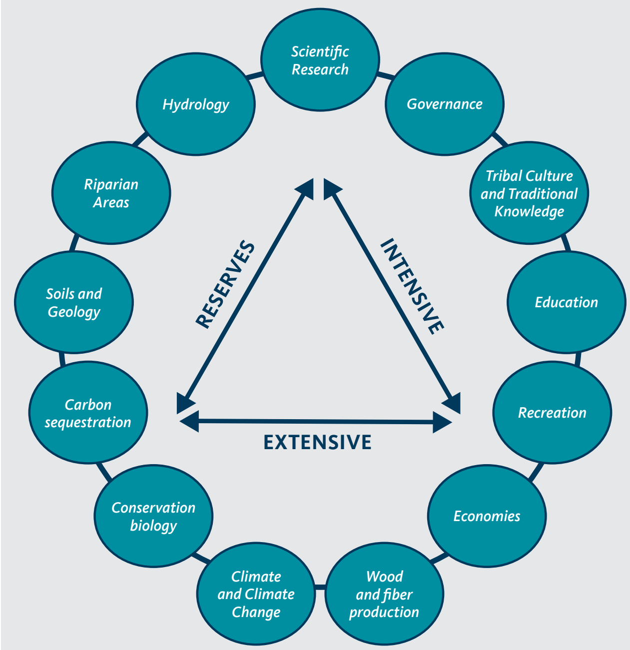


Figure 1. *Conceptualizing the Elliott State Research Forest as a dynamic system with an array of interconnected elements. Note that our research is embedded within the ecological and social systems.*

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

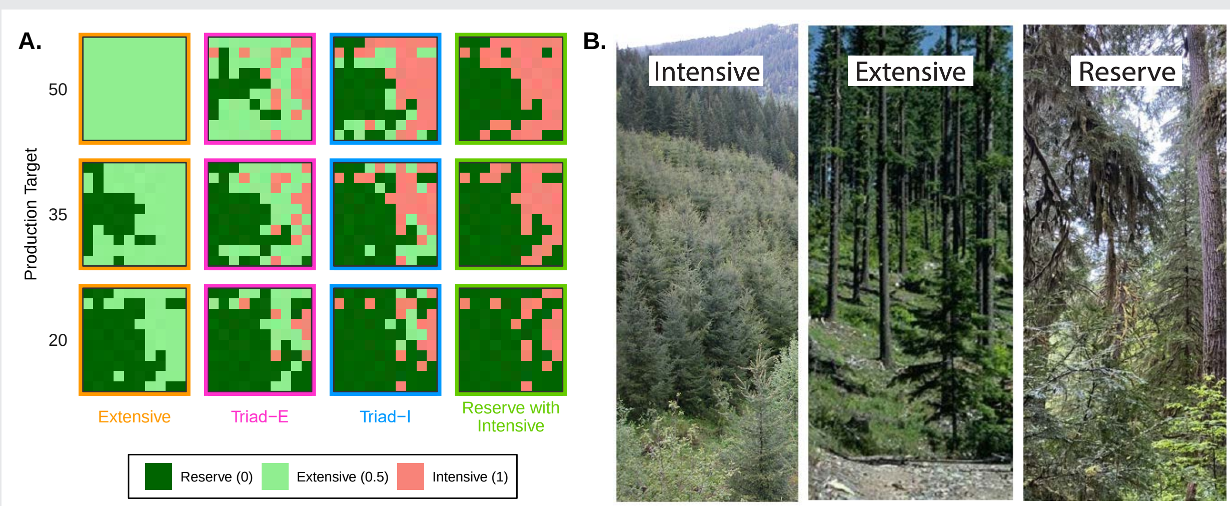
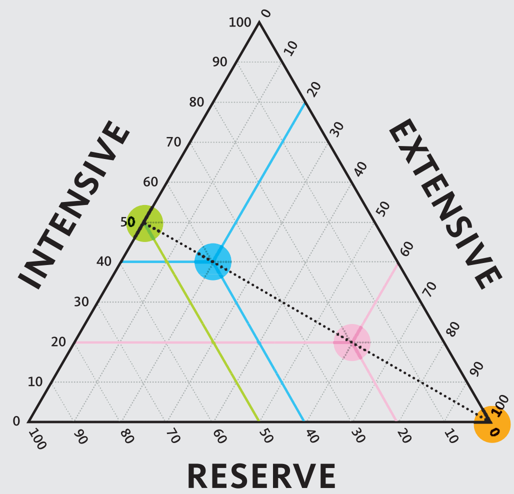


Figure 2. *Conceptual illustration of contrasting approaches to managing landscapes for timber production and biodiversity conservation in mixed-wood yield landscapes along a continuum from where extensive (ecological) forestry dominates to landscapes comprised of reserves and intensive management. In (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



Triad TREATMENTS

- **Extensive** — *0% Reserve, 100% Extensive*
- **TRIAD-E** — *20% Reserve, 20% Intensive, 60% Extensive*
- **TRIAD-I** — *40% Reserve, 40% Intensive, 20% Extensive*
- **Reserve with Intensive** — *50% Reserve, 50% Intensive*
- .... **Equal wood supply**

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

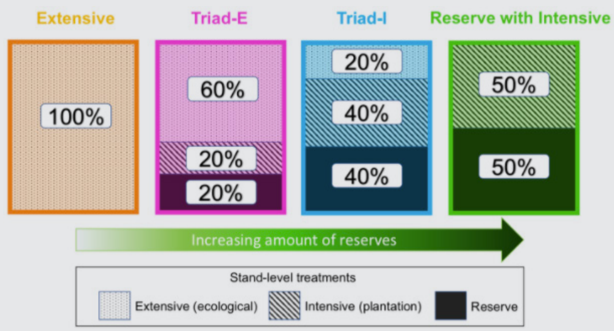


Figure 4. *The four Triad treatments that we will apply at the subwatershed scale at the ESRF. All of the subwatersheds (400-2000 ac) in the Management Research Watersheds will receive one of these four treatments. Treatments are designed to produce approximately equivalent wood yields using different 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

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.*

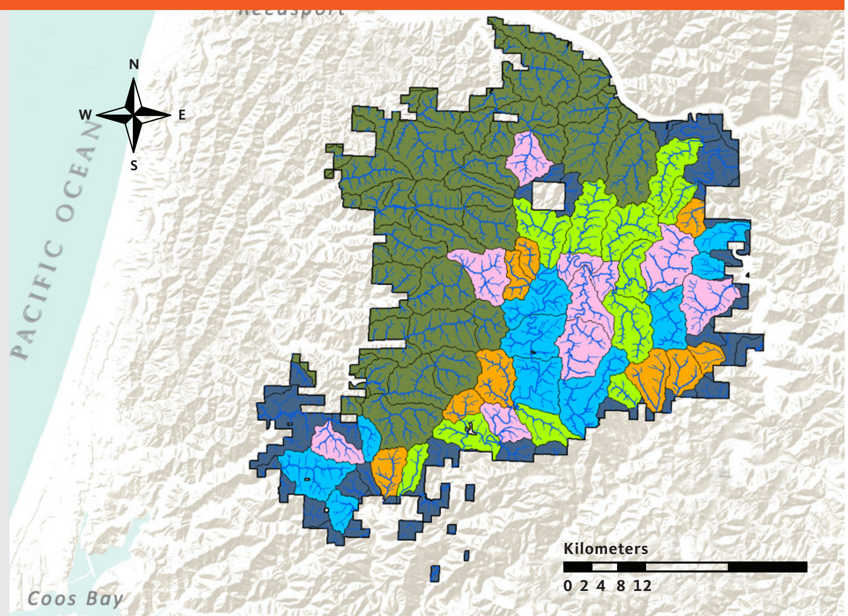
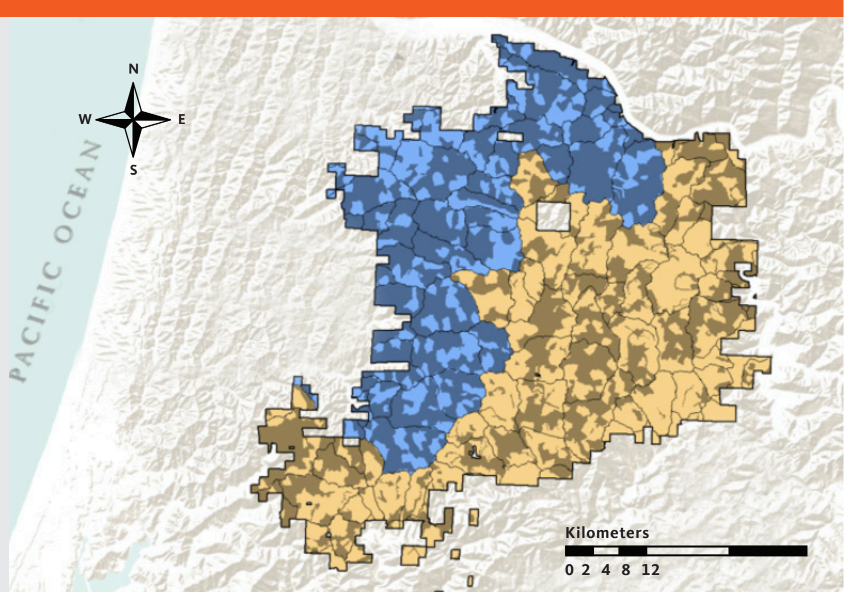


Figure 6. Age class distribution in the Conservation Research Watershed and the Management Research Watershed

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.*



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*

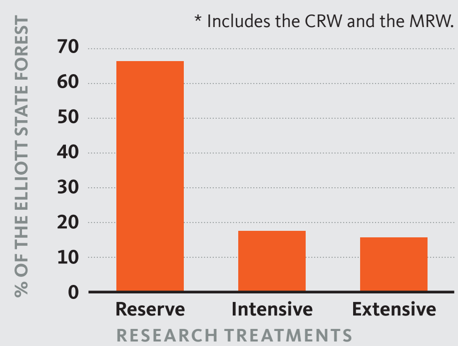


Figure 8. Proposed stand level allocation of extensive, instensive and reserve treatments

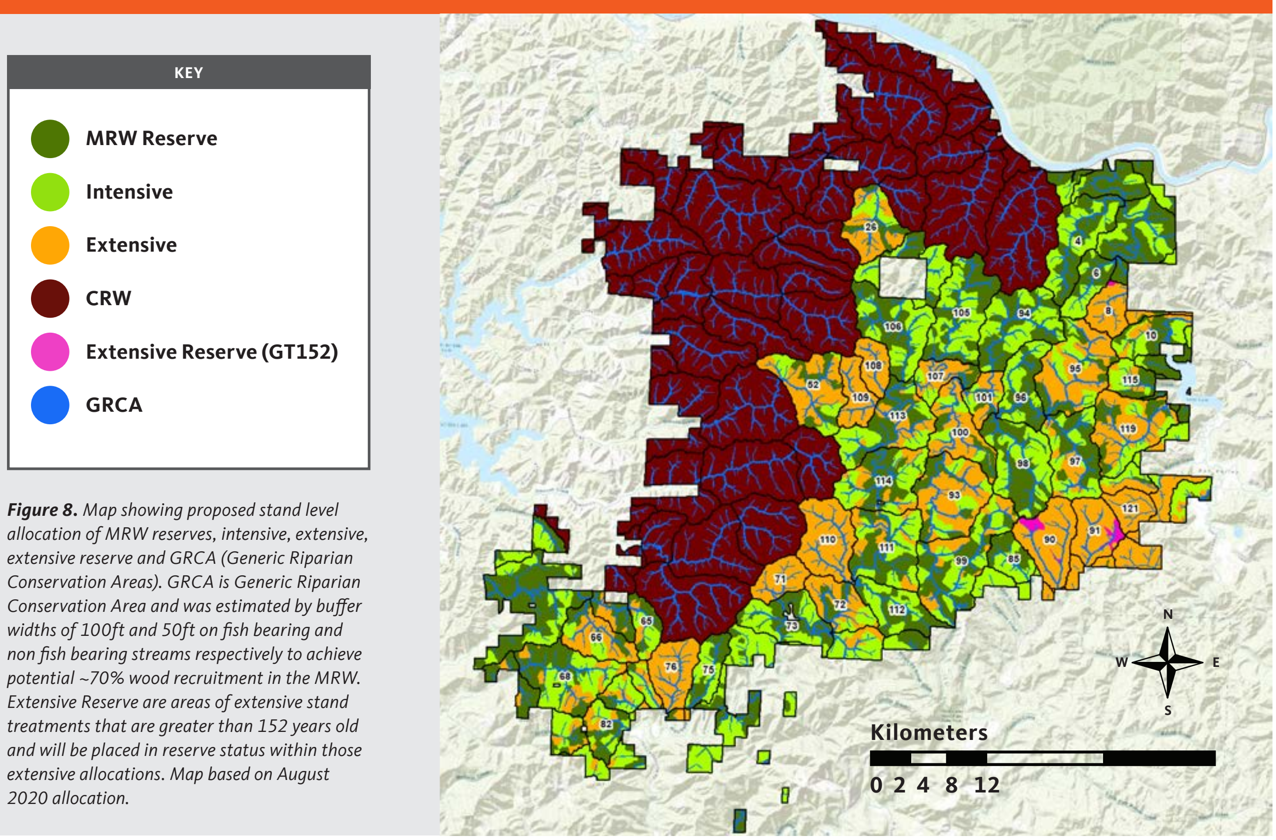


Figure 8. *Map showing proposed stand level allocation of MRW reserves, intensive, extensive, extensive reserve and GRCA (Generic Riparian Conservation Areas). GRCA is Generic Riparian Conservation Area and was estimated by buffer widths of 100ft and 50ft on fish bearing and non fish bearing streams 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.

LITERATURE CITED

Dalton, M., Mote, PW, Snover, AK. 2013. Climate Change in the Northwest: Implications for our Landscapes, Waters, and Communities. Island Press, Washington, DC. 271 pp.

May C., Luce, C, Casola, J, Chang, M, Cuhaciyan, J, Dalton, M, Lowe, S, Morishima, G, Mote, P, Petersen, A, Roesch-McNally, G, and York, E. 2018: Northwest. In: Reidmiller, D.R., Avery, CW, Easterling, DR, Kunkel, KE, Lewis, KLM, Maycock, TK, and Stewart, BC (eds.). Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II. U.S. Global Change Research Program, Washington, DC, USA, pp. 1036–1100. doi: 10.7930/NCA4.2018.CH2

Nagel, LM, Palik, BJ, Battaglia, MA, D'Amato, AW, Guldin, JM, Swanston, CW, Janowiak, MK, Powers, MD, Joyce, LA, Millar, CI, Peterson, DL, Ganio, LM, Kirschbaum, C, and Roske, MR. Adaptive silviculture for climate change: a national experiment in manager-scientist partnerships to apply an adaptation framework. Journal of Forestry. 115(3): 167-178.

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.

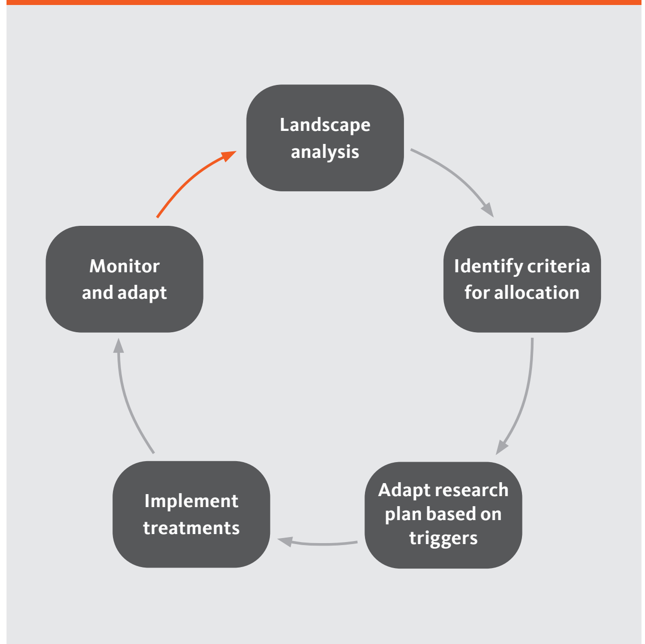
C Based on these data, allocate treatments to each stand within the subwatershed in proportion to the initial experimental design.

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

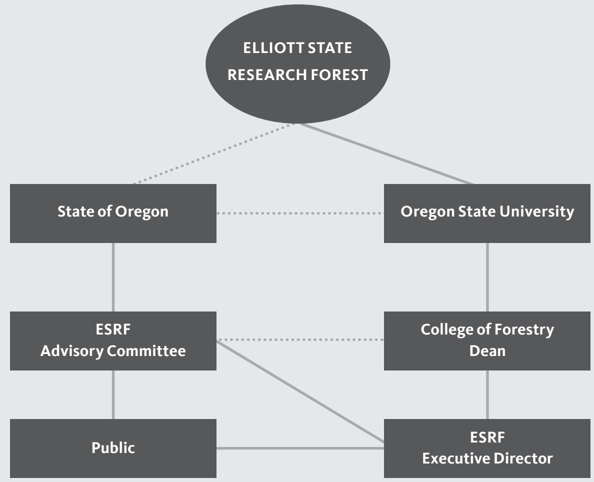


Figure 10. *Governance structure for the ESRF. Solid lines show direct relationships and the dashed lines show indirect relationships.*

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.

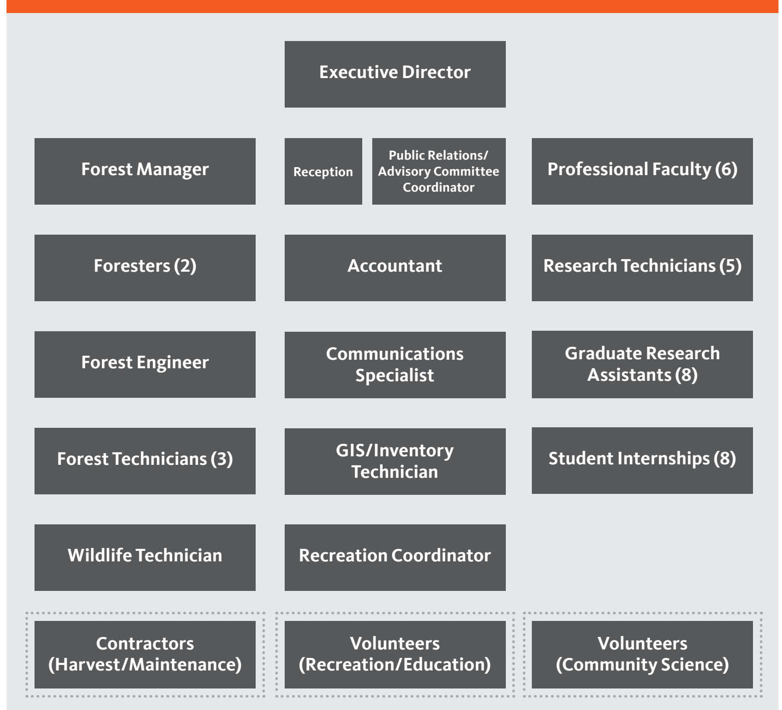
5. Formal processes and structures for advance public review and comment are to be developed, including public notices, comment periods, a website that provides the management plans and updates, and annual local open public meetings.

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

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**

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).

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 (CO2e) 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

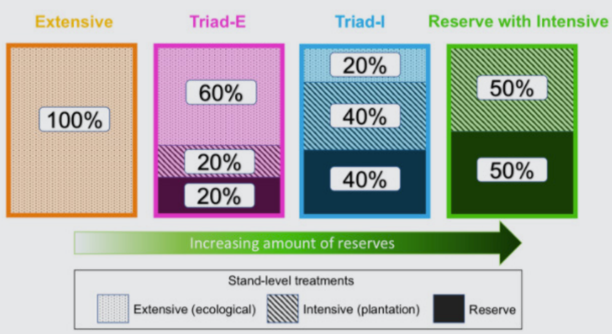
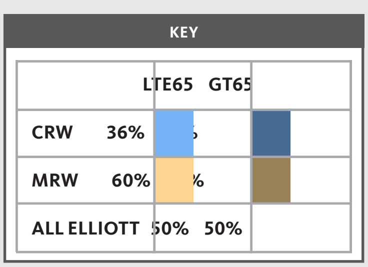


Figure 4. *The four Triad treatments that we will apply at the subwatershed scale at the ESRF. All of the subwatersheds (400-2000 ac) in the Management Research Watersheds will receive one of these four treatments. Treatments are designed to produce approximately equivalent wood yields using different 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



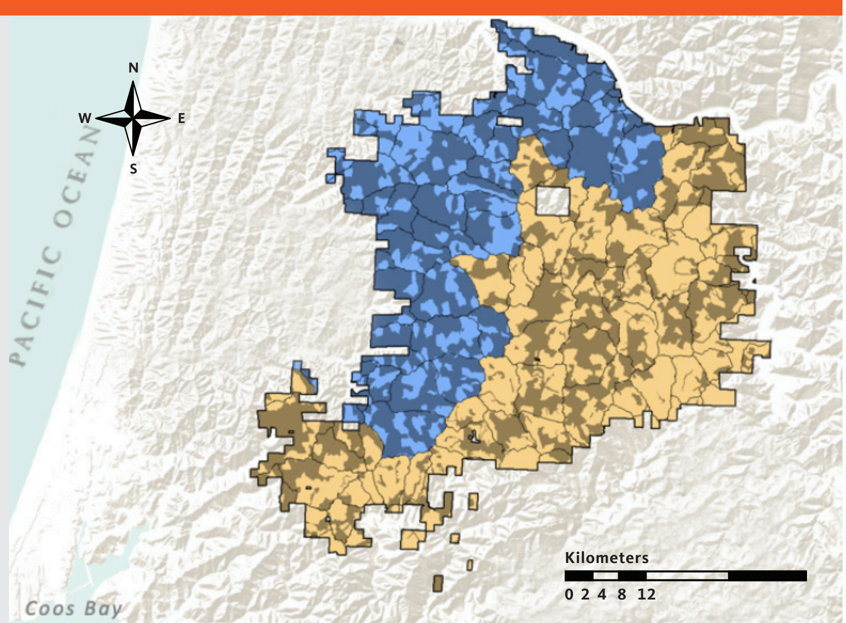


Figure 6. *Subwatersheds of the Elliott State Research Forest color coded by classification into the Conservation Research Watersheds (CRW) and Management Research Watersheds (MRW) and color coded by stand age greater than 65 years (GT65) and less than 65 years (LTE65). Uncolored regions indicate this 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.

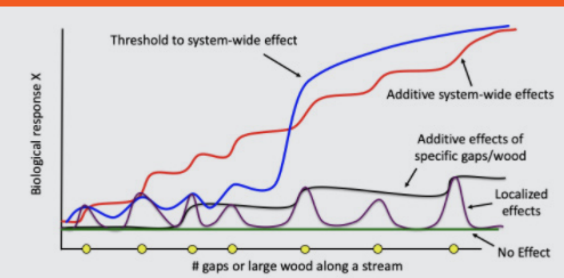
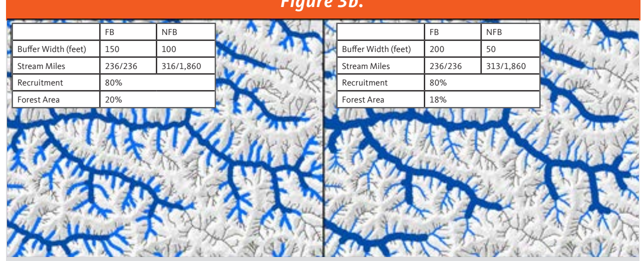


Figure 3a. *Alternative hypothesis for how biological processes or biota in streams will respond to increasing frequency of large wood or canopy gaps along a stream. Each dot on the x-axis represents a hypothetical gap or piece of large wood (or both since they often occur together).*

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

Matt Betts
Oregon State University, College of Forestry, Dept. of Forest Ecosystems & Society

Jim Rivers
Oregon State University, College of Forestry, Dept. of Forest Engineering, Resources and Management

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

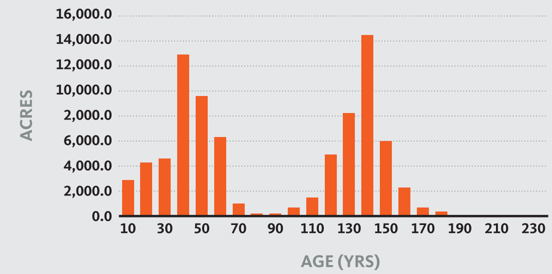


Figure 4a. *Age distribution on the Elliott State Forest by age class as of 2020. Under 65 years of age are forests that regenerated following a clearcut. Stands over 65 years of age regenerated naturally primarily from wildfire.*

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

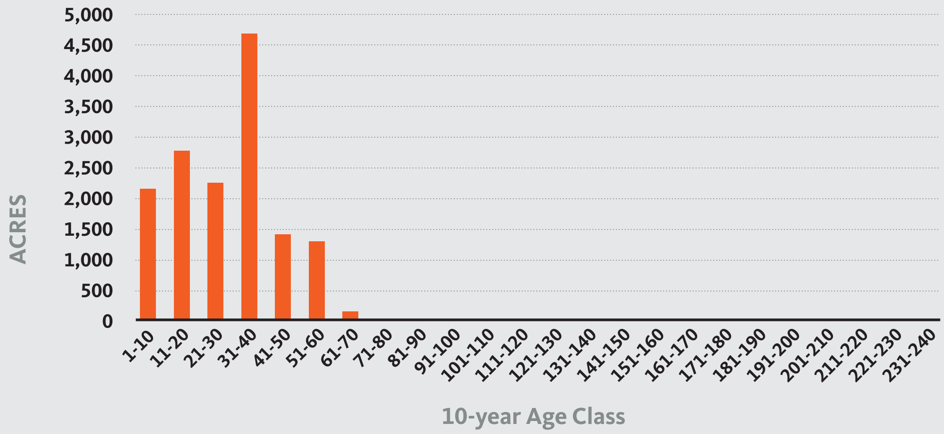


Figure 4b. *Proposed acres of forest in intensive treatment in the MRW by age class as of 2020. Allocation based on August 2020 draft allocation. We assume that stands under 65 years are forests that regenerated after clearcuts and those over 65 years regenerated from natural disturbance, primarily from wildfire.*

Figure 4c. Stand-level Triad Reserve

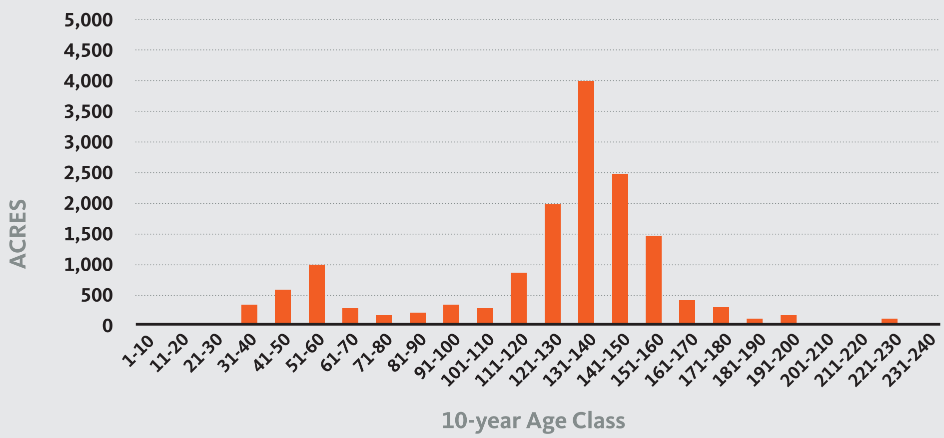


Figure 4c. *Proposed acres of forest in reserve treatment in the MRW by age class as of 2020. Allocation based on August 2020 draft allocation. We assume that stands under 65 years are forests that regenerated after clearcuts and those over 65 years regenerated from natural disturbance, primarily from wildfire.*

Figure 4d. Stand-level Extensive

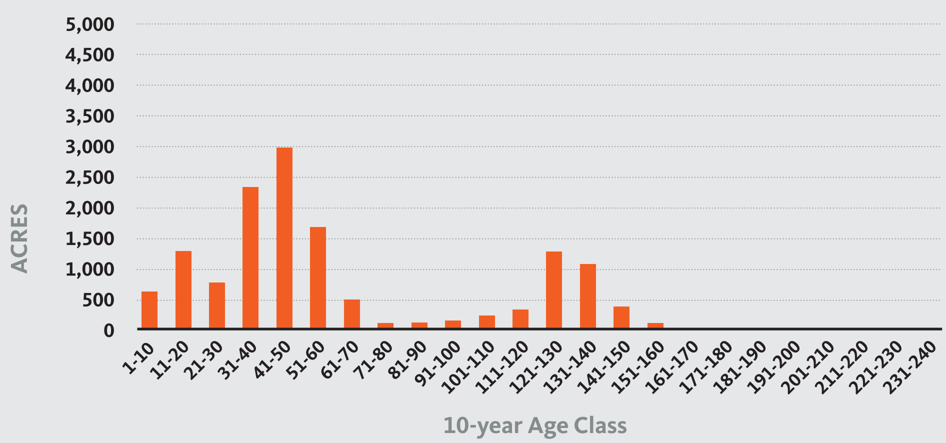


Figure 4d. *Proposed acres of forest in extensive treatment in the MRW by age class as of 2020. Allocation based on August 2020 draft allocation. We assume that stands under 65 years are forests that regenerated after clearcuts and those over 65 years regenerated from natural disturbance, primarily from 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

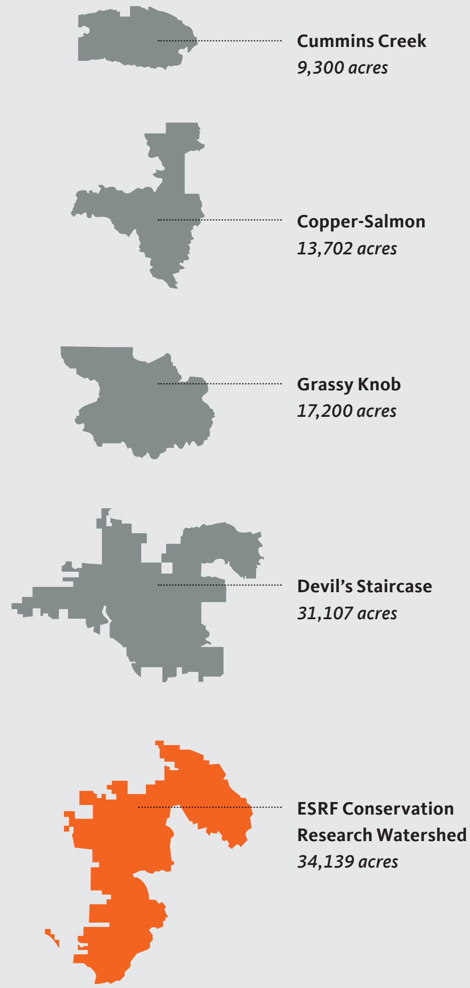


Figure 5a. *Size of the four largest wilderness areas in the Oregon Coast as compared to the Conservation Research Watershed. The CRW and Devil's Staircase Wilderness Area are adjacent and represent a 65,246 acre reserve, the largest in the Oregon Coast Range.*

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

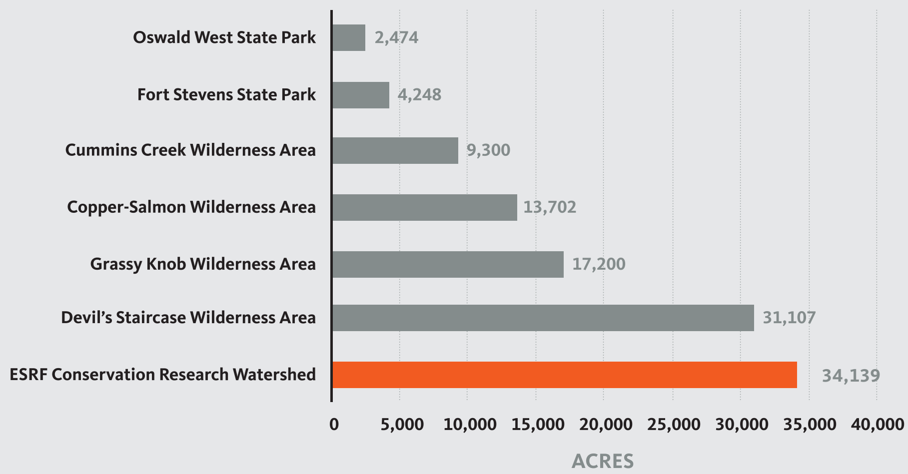


Figure 5b. *Number of acres of the largest state parks and wilderness areas in the Oregon Coast Range as compared to the proposed Conservation Research Watershed in an Elliott State Research Forest.*

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

REFERENCES

Bauhus, J., K. Puettmann, and C. Messier. 2009. Silviculture for old-growth attributes. Forest Ecology and Management 258(4):525-537.

Monserud, R.A. 2002. Large-scale management experiments in the moist maritime forests of the Pacific Northwest. Landscape and Urban Planning 59:159-180.

Poage, N.J., and P.D. Anderson. 2007. Large-scale silviculture experiments of western Oregon and Washington. USDA Forest Service, General Technical Report PNW-GTR-713(Portland, OR):44 pp.

Puettmann, K.J., A. Ares, J.I. Burton, and E.K. Dodson. 2016. Forest restoration using variable density thinning: Lessons from Douglas-fir stands in western Oregon. Forests 7(12):310.

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

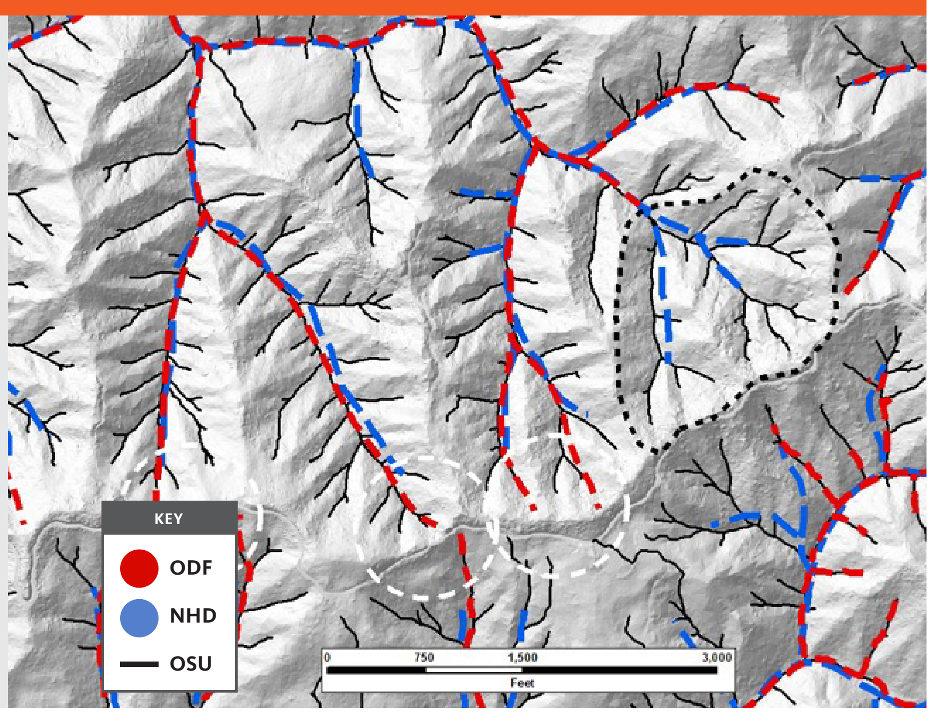


***Figure 6a.** Example comparison of stream delineations for the ESRF. The OSU stream layer is based on a LiDAR-derived DEM, and in nearly all cases extends further into headwall areas than do ODF and NHD stream layers. The ODF layer is less consistent than either the OSU layer or the NHD layer. For 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

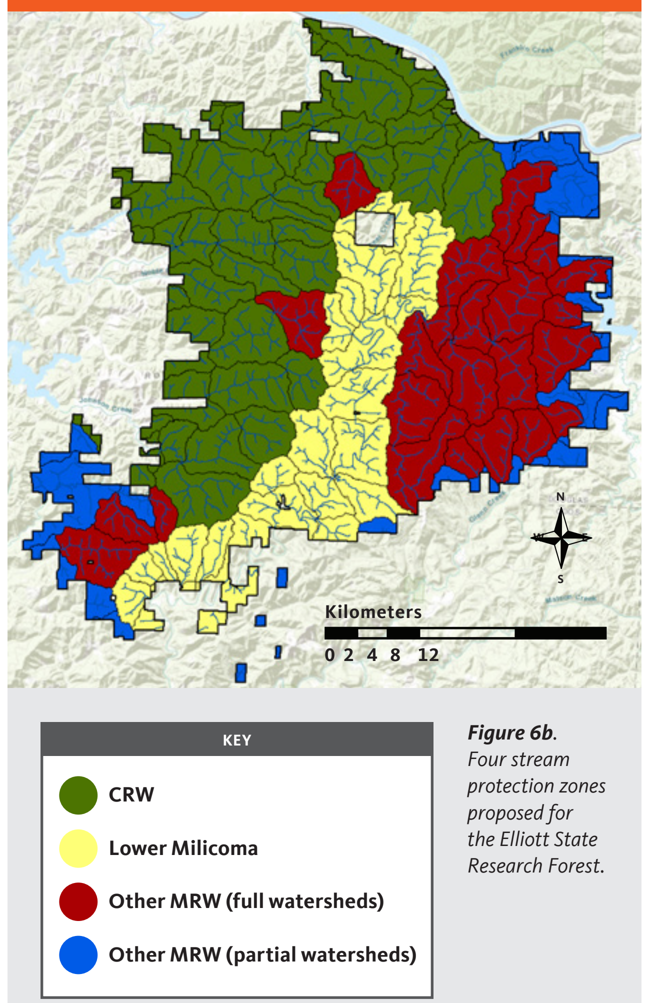


Figure 6b*.* *Four stream protection zones proposed for the Elliott State Research Forest.*

[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

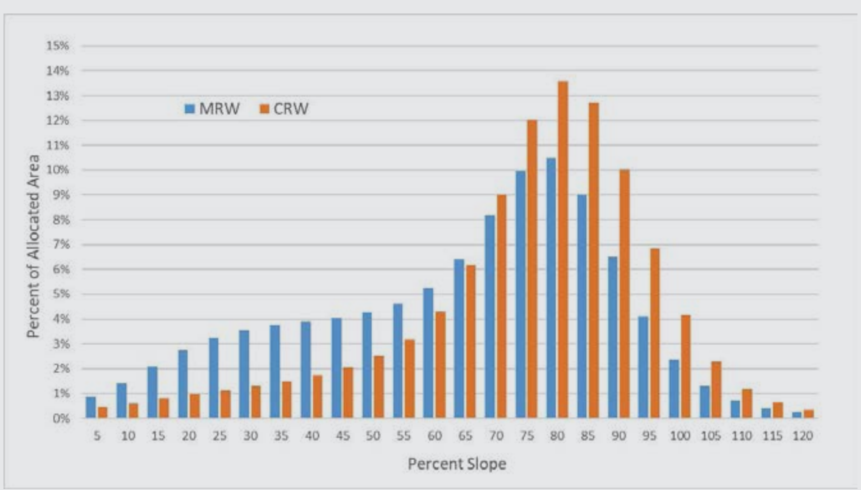


Figure 6c. *Distribution of classified hillslope gradient across the MRW and the CRW. Both the CRW and MRW have areas of very steep slopes, but the MRW and CRW exhibit some generalized topographic differences. Vertical axis values refer to the percent of MRW area and percent of CRW area, not percent 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

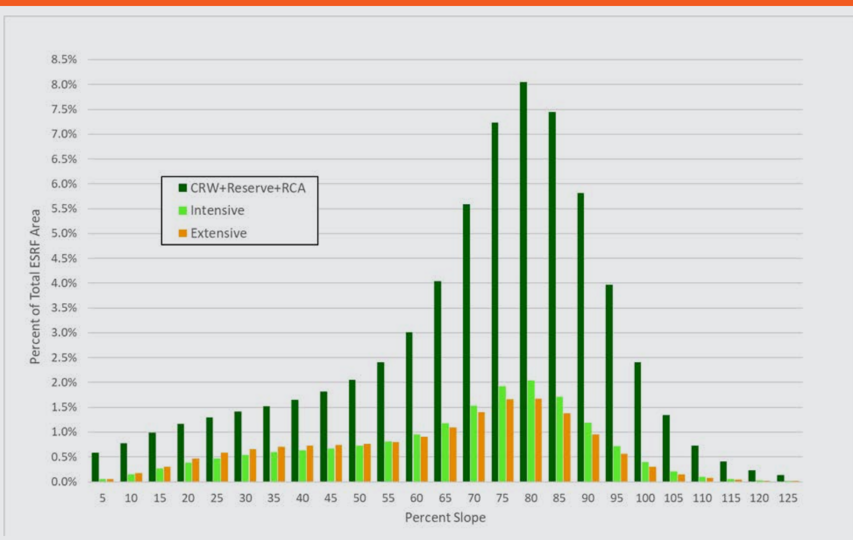


***Figure 6d.** Distribution of classified hillslope gradient by allocation. Reserve treatments (red) are non-harvest areas that are protected* from the effects of forest harvest. Intensive treatments (green) are intended to be representative of lands managed primarily under an industrial timber production 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.

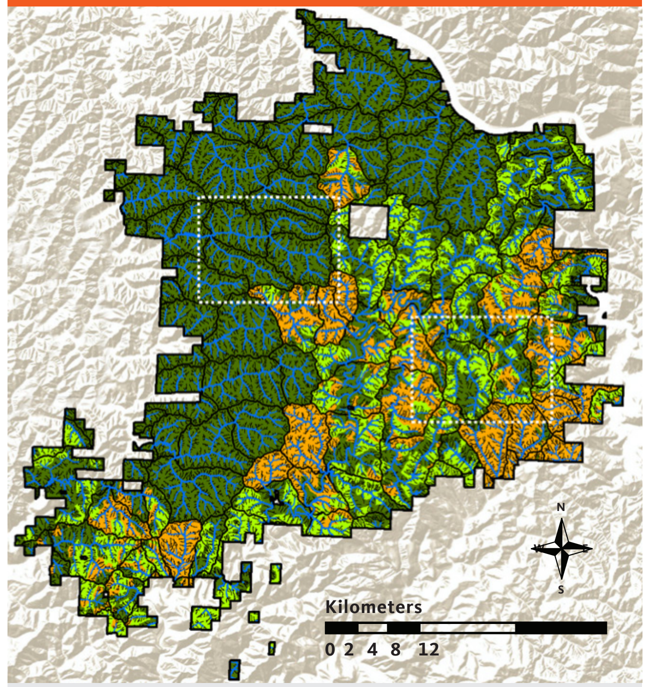
The intent of intensive treatments is to explore management practices relevant to industrial forestland management. Protective mechanisms that apply to industrial forestland in Oregon are the Oregon Forest Practices Rules (OFPR); therefore, OFPR will provide the minimum regulatory standards for practices 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.

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

Figure 6e. Lidar-based stream network for the ESRF



KEY

- **CRW, MRW Reserve, RCA**
- **Extensive treatment**
- **Intensive treatment**
- **RCA-protected stream network**
- **XNFB streams**
- **Sub-watershed boundary**

***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.*

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.*

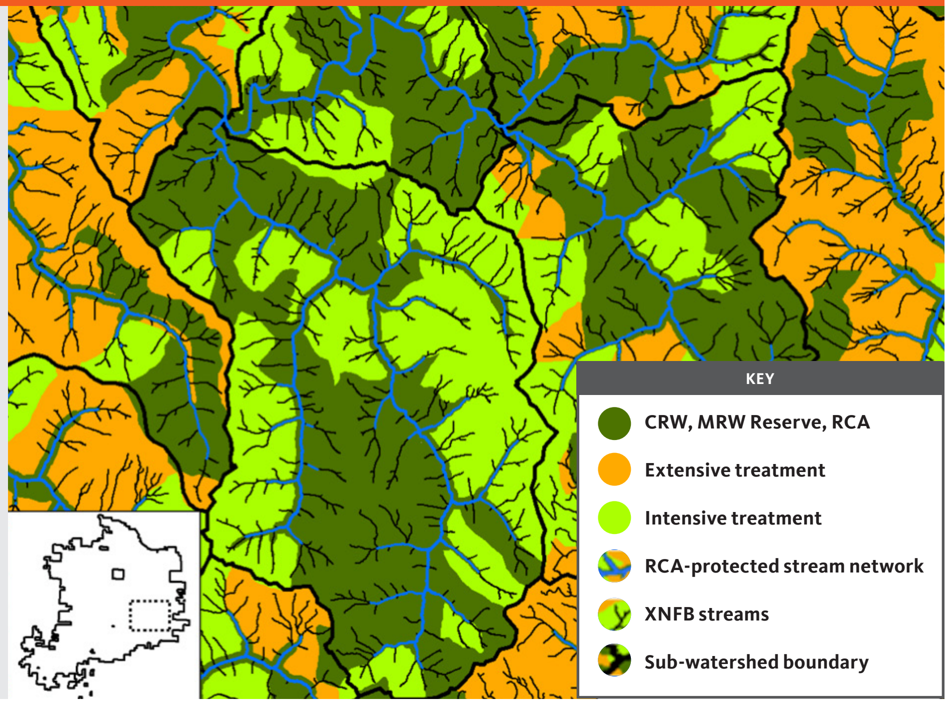
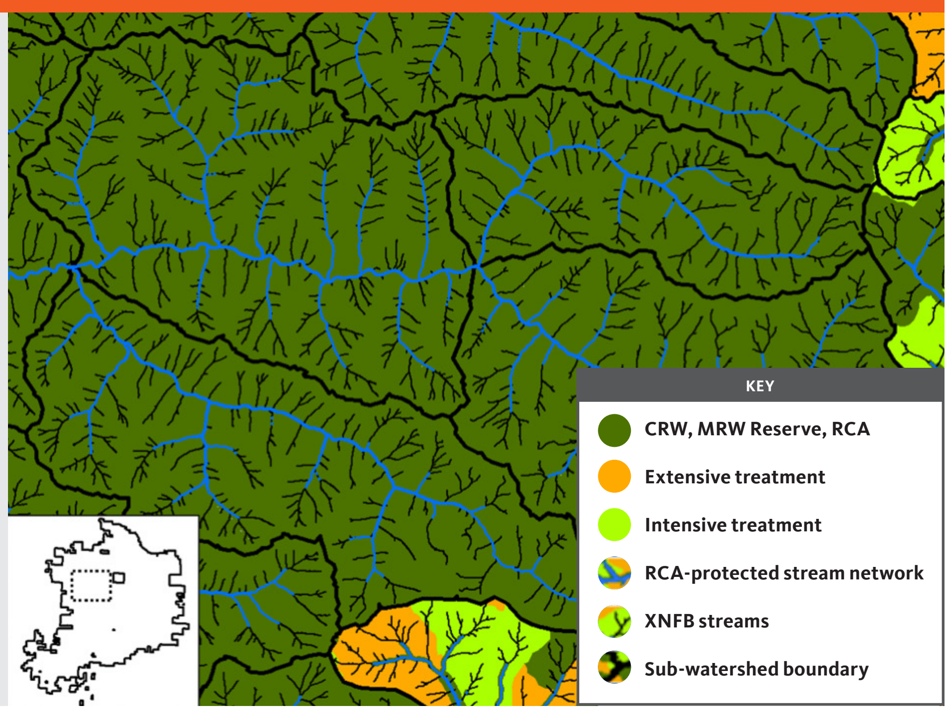


Figure 6g. Portion of the CRW primarily in the CRW reserve on the ESRF illustrating density of/the level of riparian conservation relevant

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).

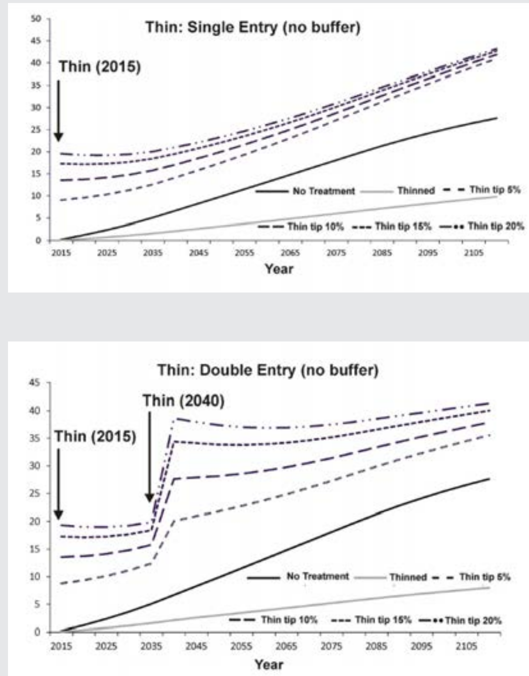


Figure 6h. *Predictions from the reach scale wood model showing cumulative wood volume over time (included decay) for a single and double entry thinning, without a 10 m buffer, simultaneously on both sides of the channel. Also shown are results from tree tipping from 5 to 20% of the thinned trees into 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.

LITERATURE CITED

Alroy, J., 2015. Current extinction rates of reptiles and amphibians. Proceedings of the National Academy of Sciences 112(42): 13003-13008.

Alexander, L.C.; Hawthorne, D.J.; Palmer, M.A.; Lamp, W.O. 2011. Loss of genetic diversity in the North American mayfly Ephemerella invaria associated with deforestation of headwater streams. Freshwater Biology. 56: 1456–1467. doi:10.1111/j.1365-2427.2010.02566.x.

Argerich, A.; Haggerty, R.; Johnson, S.L.; Wondzell, S.M.; Dosch, N.; Corson-Rikert, H.; Ashkenas, L.R.; Pennington, R.; Thomas, C.K. 2016. Comprehensive multiyear carbon budget of a temperate headwater stream. Journal of Geophysical Research Biogeoscience. 121: 1306–1315.

Beckman, N.D.; Wohl, E. 2014. Carbon storage in mountainous headwater streams: the role of oldgrowth forest and logjams. Water Resources Research. 50: 2376–2393.

Beechie T., Pess G.R., Kennard P., Bilby P.R., and Bolton, S. 2000. Modeling recovery rates and pathways for woody debris recruitment in northwestern Washington streams. North American Journal of Fisheries Management 20:436–452.

Benda, L.E., Litschert, S.E., Reeves, G. and Pabst, R., 2016. Thinning and in-stream wood recruitment in riparian second growth forests in coastal Oregon and the use of buffers and tree tipping as mitigation. Journal of Forestry Research 27: 821-836.

Benda, L.; Dunne, T. 1997a. Stochastic forcing of sediment supply to channel networks from landsliding and debris flow. Water Resources Research. 33: 2849–2863.

Benda, L.; Dunne, T. 1997b. Stochastic forcing of sediment routing and storage in channel networks. Water Resources Research. 33: 2865–2880.

Benda, L., Hassan, M.A., Church, M. and May, C.L., 2005. Geomorphology of steepland headwaters: the transition from hillslopes to channels 1. JAWRA Journal of the American Water Resources Association, 41(4), pp.835-851.

Bigelow, P.E.; Benda, L.E.; Miller, D.J.; Burnett, K.M. 2007. On debris flows, river networks, and the spatial structure of channel morphology. Forest Science. 53: 220–238.

Boisjolie, B.A., Flitcroft, R.L. and Santelmann, M.V., 2019. Patterns of riparian policy standards in riverscapes of the Oregon Coast Range. Ecology and Society, 24(1).

Clarke, S.E., Burnett, K.M. and Miller, D.J., 2008. Modeling Streams and Hydrogeomorphic Attributes in Oregon From Digital and Field Data 1. JAWRA Journal of the American Water Resources Association, 44(2), pp.459-477.

Dybala, K.E., Matzek, V., Gardali, T. and Seavy, N.E., 2019. Carbon sequestration in riparian forests: A global synthesis and meta-analysis. Global change biology, 25(1), pp.57-67.

Dodson, E.K., Ares, A., and Puettmann, K.J. 2012. Early responses to thinning treatments designed to accelerate late successional forest structure in young coniferous stands of western Oregon, USA. Canadian Journal of Forest Research 42:345–355

Downing, J.A.; Cole, J.J.; Duarte, C.A.; Middelburg, J.J.; Melack, J.M.; Prairie, Y.T.; Kortelainen, P.; Striegl, R.G.; McDowell, W.H.; Tranvik, L.J. 2012. Global abundance and size distribution of streams and rivers. Inland Waters. 2: 229–236.

Everest, F.H.; Reeves, G.H. 2007. Riparian and aquatic habitats of the Pacific Northwest and southeast Alaska: ecology, management history, and potential management strategies. Gen. Tech. Rep. PNW-GTR-692. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 130 p.

Forest Ecosystem Management Assessment Team (FEMAT). 1993. Forest ecosystem management: an ecological, economic, and social assessment. Portland, OR: U.S. Department of Agriculture; U.S. Department of the Interior[and others]. [irregular pagination].

Goetz, J.N.; Guthrie, R.H.; Brenning, A. 2015. Forest harvesting is associated with increased landslide activity during an extreme rainstorm on Vancouver Island, Canada. Natural Hazards Earth Systems Science. 15: 1311–1330.

Gomi, T.; Sidle, R.C.; Richardson, J.S. 2002. Understanding processes and downstream linkages of headwater systems: headwaters differ from downstream reaches by their close coupling to hillslope processes, more temporal and spatial variation, and their need for different means of protection from land use. BioScience. 52: 905–916.

Guthrie, R.H. 2002. The effects of logging on frequency and distribution of landslides in three watersheds on Vancouver Island, British Columbia. Geomorphology. 43: 273–292.

Hibbs, D.E.; Giordano, P.A. 1996. Vegetation characteristics of alder-dominated riparian buffer strips in the Oregon Coast Range. Northwest Science. 70: 213–222.

Kelsey, K.A.; West, S.D. 1998. Riparian wildlife. In: Bilby, R.E.; Naiman, R.J., eds. River ecology and management: lessons from the Pacific coastal ecoregion. New York: Springer-Verlag: 235–260.

Jakob, M. 2000. The impacts of logging on landslide activity at Clayoquot Sound, British Columbia. Catena. 38: 279–300.

Latterell, J.J., Naiman, R.J., Fransen, B.R. and Bisson, P.A., 2003. Physical constraints on trout (Oncorhynchus spp.) distribution in the Cascade Mountains: a comparison of logged and unlogged streams. Canadian Journal of Fisheries and Aquatic Sciences 60: 1007-1017.

May, C.L.; Gresswell, R.E. 2003. Large wood recruitment and redistribution in headwater streams of the Oregon Coast Range, U.S.A. Canadian Journal of Forest Research. 33: 1352–1362.

May, C.L.; Gresswell, R.E. 2004. Processes and rates of sediment and wood accumulation in headwater streams of the Oregon Coast Range, U.S.A. Earth Surface Processes and Landforms. 28: 409–424.

May, C.L.; Lee, D.C. 2004. The relationships among in-channel sediment storage, pool depth, and summer survival of juvenile salmonids in Oregon Coast Range streams. North American Journal of Fisheries Management. 24: 761–774.

McIntyre, P.J.; Thorne, J.H.; Dolanc, C.R.; Flint, A.L.; Flint, L.E.; Kelly, M.; Ackerly, D.D. 2015. Twentieth century shifts in forest structure in California: denser forests, smaller trees, and increased dominance of oaks. Proceedings of the National Academy of Sciences of the United States of America. 112: 1458–1463.

Meyer, J.L.; Strayer, D.L.; Wallace, J.B.; Eggert, S.L.; Helfman, G.S.; and Leonard, N.E. 2007. The contribution of headwater streams to biodiversity in river networks. Journal of the American Water Resources Association. 43: 86–103.

Naiman, R.J.; Bilby, R.E.; Bisson, P.A. 2000. Riparian ecology and management in the Pacific coastal rain forest. BioScience. 50: 996–1011.

Olson, D.H.; Anderson, P.D.; Frissell, C.A.; Welsh, H.H., Jr.; Bradford, D.F. 2007. Biodiversity management approaches for stream–riparian areas: perspectives for Pacific Northwest headwater forests, microclimates, and amphibians. Forest Ecology and Management. 246: 81–107.

Olson, D.H. and Burnett, K.M., 2009. Design and management of linkage areas across headwater drainages to conserve biodiversity in forest ecosystems. Forest Ecology and Management 258: pp. S117-S126.

Olson, D.H. and Kluber, M.R., 2014. Plethodontid salamander distributions in managed forest headwaters in western Oregon, USA. Herpetological Conservation and Biology 9:76-96.

Penaluna, B.E., Allen, J.M., Arismendi, I., Levi, T., Garcia, T.S. and Walter, J.K., 2021. Better boundaries: identifying the upper extent of fish distributions in forested streams using eDNA and electrofishing. Ecosphere, 12(1), p.e03332

Reeves, G.H.; Burnett, K.M.; McGarry, E.V. 2003. Sources of large wood in the main stem of a fourthorder watershed in coastal Oregon stream. Canadian Journal of Forestry Research. 33: 1363–1370.

Reeves, G.H., D.H. Olson, S.M. Wondzell, P.A. Bisson, S. Gordon, S.A. Miller, J.W. Long, and M.J. Furniss. 2018. The aquatic conservation strategy of the Northwest Forest Plan—A review of the relevant science after 23 years. In: Spies, TA; Stine, PA; Gravenmier, R.; Long, JW; Reilly, MJ, tech. coords. 2018. Synthesis of science to inform land management within the Northwest Forest Plan area. Gen. Tech. Rep. PNW-GTR-966. Portland, OR: US Department of Agriculture, Forest Service, Pacific Northwest Research Station P. 461-624.

Reid, A.J., Carlson, A.K., Creed, I.F., Eliason, E.J., Gell, P.A., Johnson, P.T., Kidd, K.A., MacCormack, T.J., Olden, J.D., Ormerod, S.J. and Smol, J.P. 2019. Emerging threats and persistent conservation challenges for freshwater biodiversity. Biological Reviews 94: 849-873.

Richardson, J.S.; Naiman, R.J.; Bisson, P.A. 2012. How did fixed-width buffers become the standard practice for protecting water from forestry? Freshwater Science. 31: 232–238.

Spies, T., Pollock, M., Reeves, G. and Beechie, T. 2013. Effects of riparian thinning on wood recruitment: a scientific synthesis. Science Review Team Wood Recruitment Subgroup, USDA Forest Service, PNW Research Station, Portland.

Strayer, D.L. and Dudgeon, D. 2010. Freshwater biodiversity conservation: recent progress and future challenges. Journal of the North American Benthological Society 29(1): 344-358.

Swanson, M.; Franklin, J.F.; Beschta, R.L.; Crisafulli, C.M.; DellaSala, D.A.; Hutto, R.L.; Lindenmayer, D.B.; Swanson, F.J. 2011. The forgotten stage of forest succession: early-successional ecosystems on forest sites. Frontiers in Ecology and the Environment. 9: 117–125.

Vörösmarty, C.J., McIntyre, P.B., Gessner, M.O., Dudgeon, D., Prusevich, A., Green, P., Glidden, S., Bunn, S.E., Sullivan, C.A., Liermann, C.R. and Davies, P.M. 2010. Global threats to human water security and river biodiversity. Nature 467(7315): 555-561.

Wipfli, M.S.; Baxter, C.V. 2010. Linking ecosystems, food webs, and fish production: subsidies in salmonid watersheds. Fisheries. 35: 373–387.

Wipfli, M.S.; Gregovich, D.P. 2002. Export of invertebrates and detritus from fishless headwater streams in southeastern Alaska: implications for downstream salmonid production. Freshwater Biology. 47: 957–969.

Wipfli, M.S.; Richardson, J.S.; Naiman, R.J. 2007. Ecological linkages between headwaters and downstream ecosystems: transport of organic matter, invertebrates, and wood down headwater channels. Journal of the American Water Resources Association. 43: 72–85. doi:10.1111/j.1752-1688.2007.00007.x.

Zimmerman, A.; Church, M. 2001. Channel morphology, gradient profiles and bed stresses during a flood in a step-pool channel. Geomorphology. 40: 311–327.

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

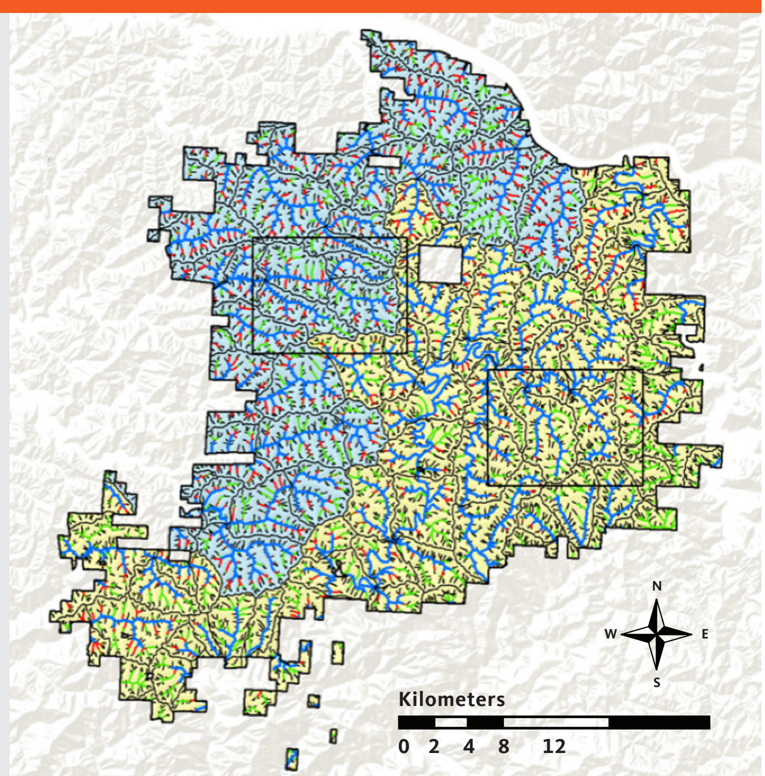


Figure 7a. *The Lidar-based 2087-mile stream network on the Elliott State Research Forest (for visual purposes not all non-fish streams are shown). There are approximately 235 miles of fish bearing and 1852 miles of non-fish perennial streams and non-fish non-perennial streams identified. The high landslide 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
- Intensive
- Extensive
- RCA
- Fish-bearing stream
- HLDP non-fish stream (perennial and non-perennial)
- Perennial non-fish stream
- Other non-perennial, non-fish stream

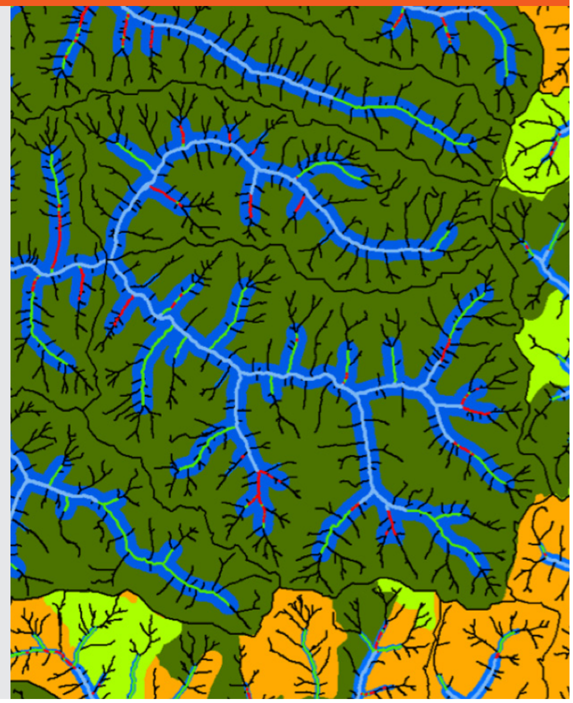


Figure 7b. *A portion of the CRW on the Elliott State Forest illustrating the level of riparian conservation in the CRW. See Table 8b for details of RCA widths. Given that CRW thinning will be limited to existing dense Douglas fir plantations < 65 years old (as of 2020), the research design will result in nearly 100% of the potential wood recruitment within the CRW.*

Figure 7c. MRW Example Area Full Stream Network

KEY

- CRW/Reserve
- Intensive
- Extensive
- RCA
- Reserve Recruitment
- Fish-bearing stream
- HLDP non-fish stream (perennial and non-perennial)
- Perennial non-fish stream
- Other non-perennial, non-fish stream

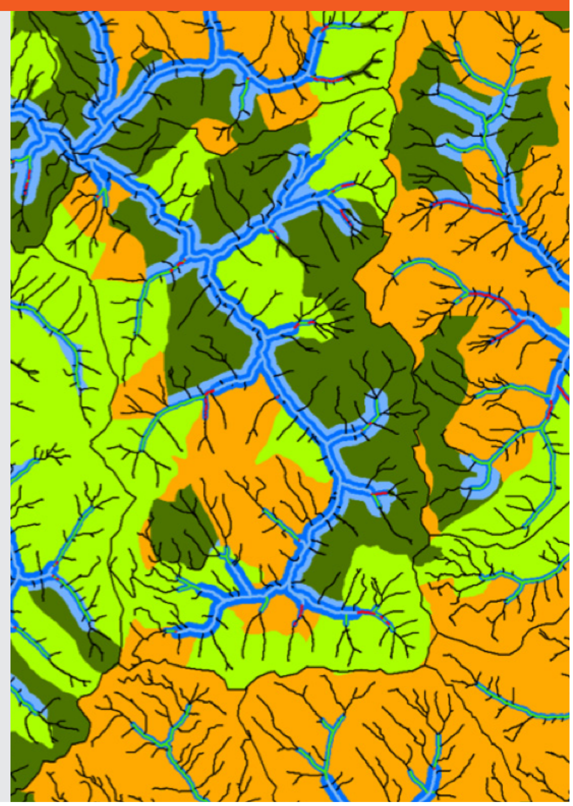


Figure 7c. *A portion of the MRW on the Elliott State Forest illustrating the range of riparian conservation strategies. See Table 8b for details of RCA widths. Note that the size of the RCA will vary depending on research designation and may differ on each side of the stream where there is a reserve 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

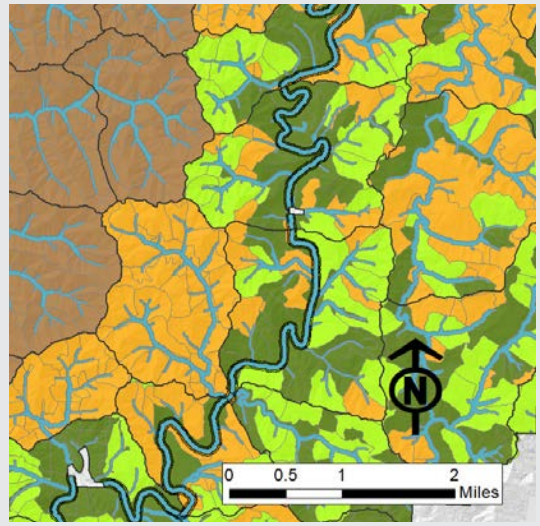
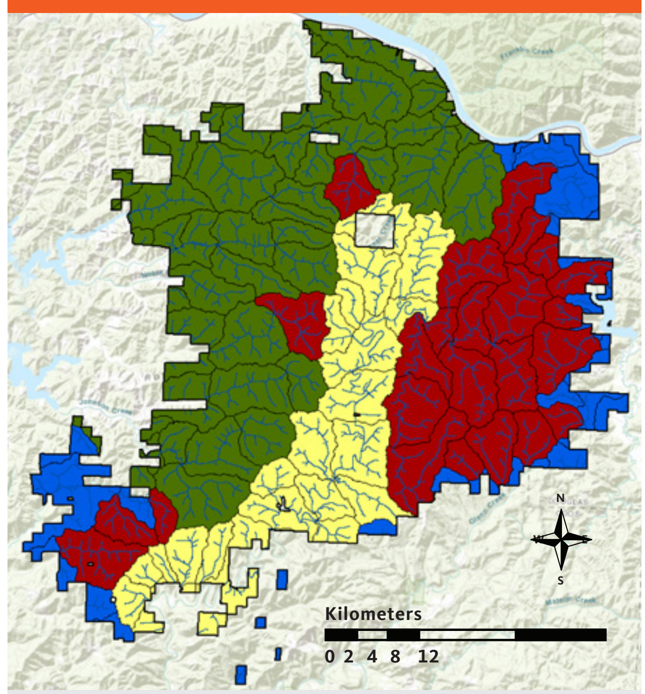


***Figure 7d.** Example of the first step in integrating riparian and upslope treatments along the West Fork of the Millicoma River on the ESRF. The goal is to ensure the presence of large trees where wood recruitment is most likely to occur from riverside to headwall. The current percentage of each 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

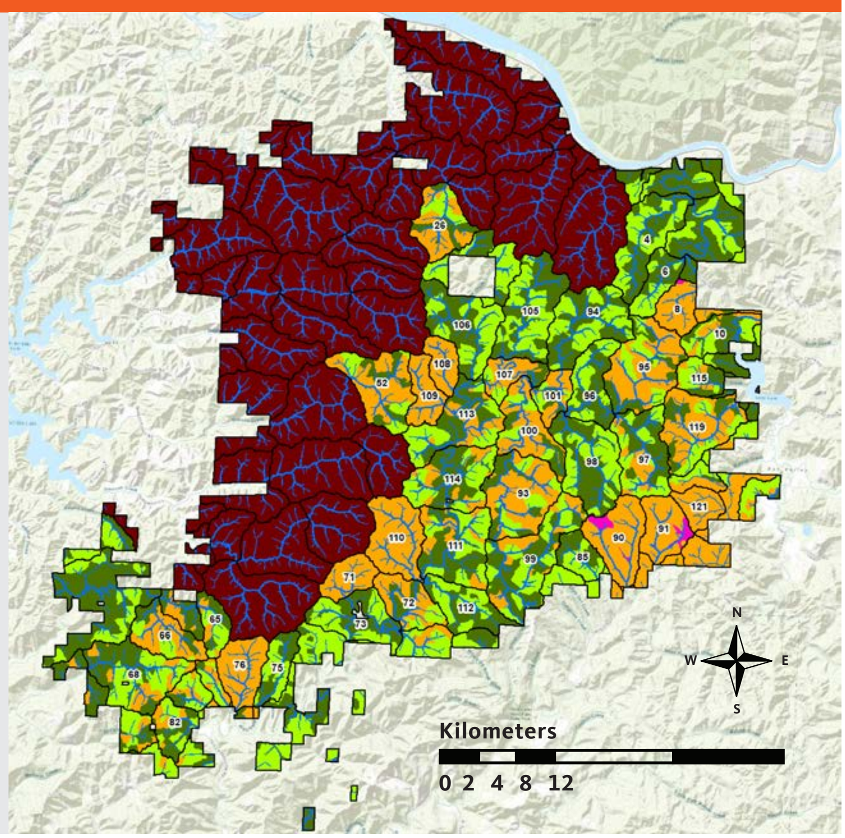


Figure 8. *Map showing proposed stand level allocation of MRW reserves, intensive, extensive, extensive reserve and GRCA (Generic Riparian Conservation Areas). GRCA is Generic Riparian Conservation Area and was estimated by buffer widths of 100ft and 50ft on fish bearing and non fish bearing streams 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

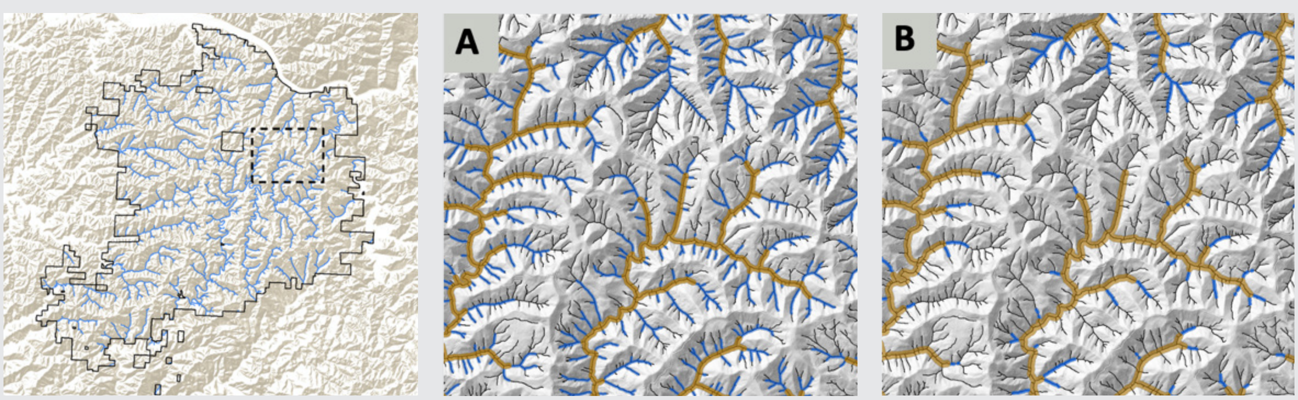


Table 8a. Two example riparian buffer width scenarios attaining ~70% wood recruitment

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

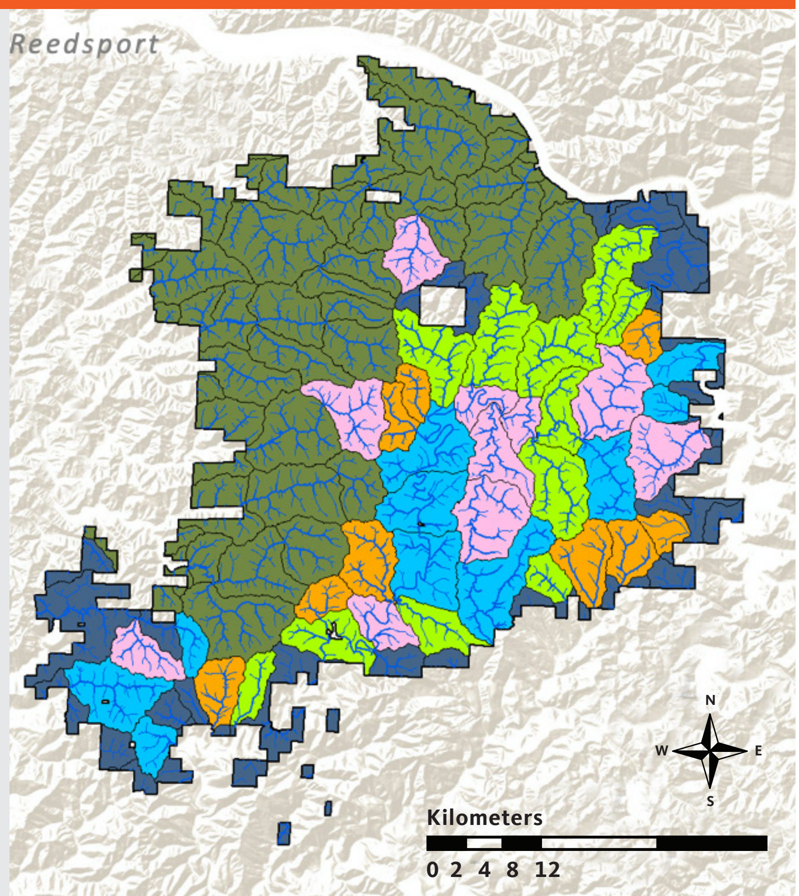


Figure 5. *Map illustrating the proposed western reserve area (Conservation Research Watershed; CRW, in dark green) and the potential allocation of subwatershed-scale Triad treatments in the ESRF's eastern part. Partial watersheds (dark blue) are only partly contained in the ESRF, so they will not have 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

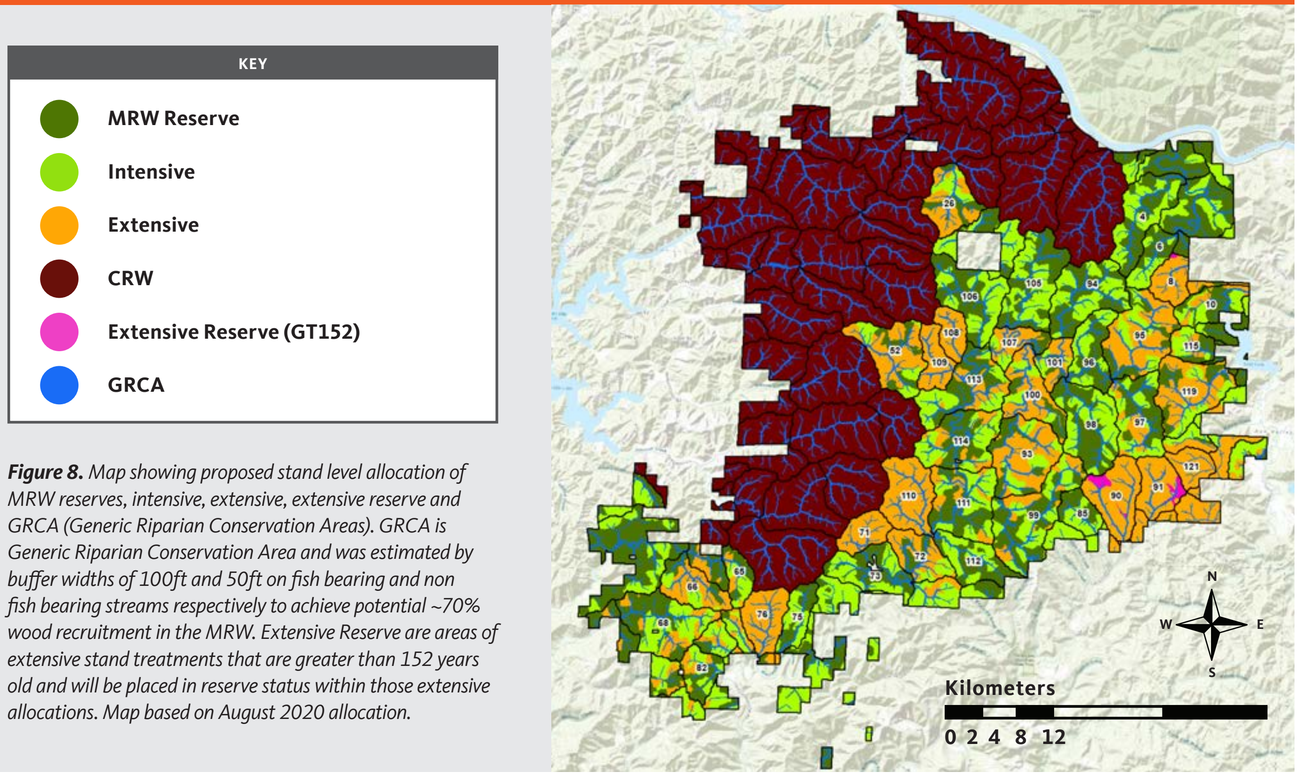


Figure 8. *Map showing proposed stand level allocation of MRW reserves, intensive, extensive, extensive reserve and GRCA (Generic Riparian Conservation Areas). GRCA is Generic Riparian Conservation Area and was estimated by buffer widths of 100ft and 50ft on fish bearing and non fish bearing streams 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.

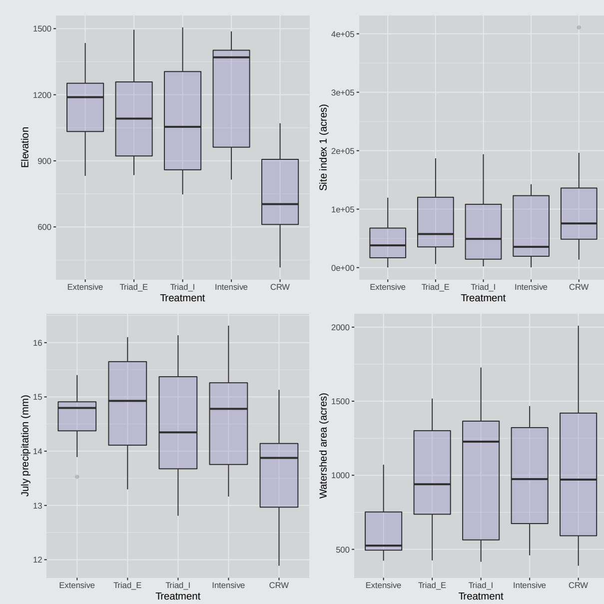


Figure 9a. *Analysis of subwatershed treatments for bias in elevation, July precipitation, site index and watershed area on the Elliott State Forest.*

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:
Scott H. Harris, Matthew G. Betts, John Sessions, Ariel Muldoon
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

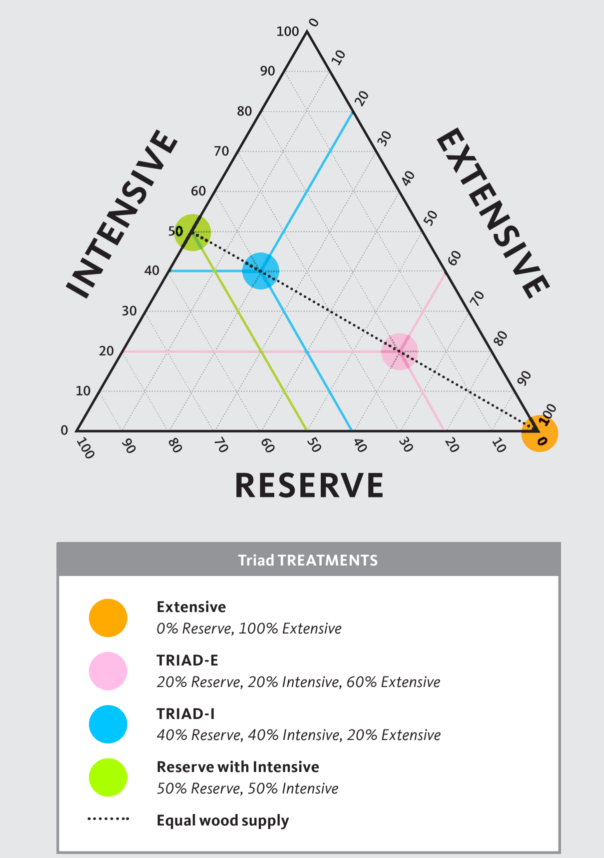


Figure 3. *Conceptualizing the four different Triad Treatments. Each colored dot represents a subwatershed level Triad treatment. The text below specifies the proportions of stand level research treatments (intensive, extensive, reserve).*

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.

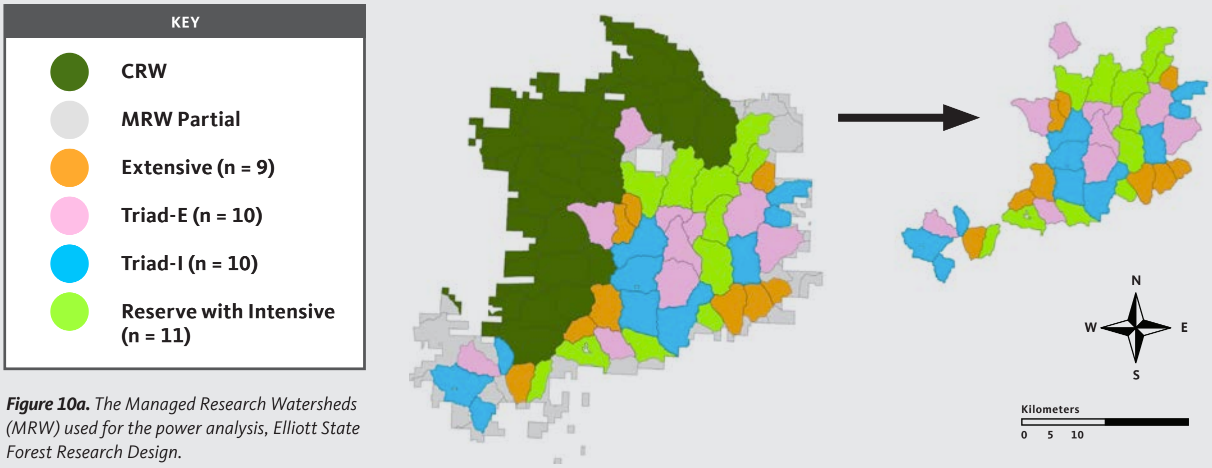


Figure 10a. *The Managed Research Watersheds (MRW) used for the power analysis, Elliott State Forest Research Design.*

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.

Figure 10b.

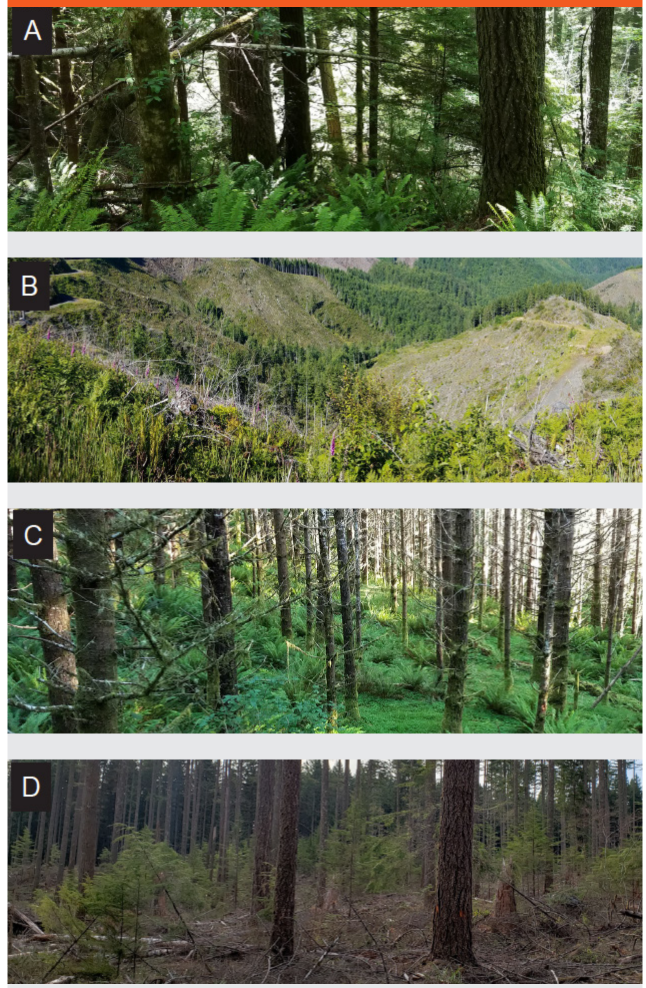


Figure 10b. *Representative examples of stand-level treatments. A) Reserve, 169 years. B) Intensive, 3 years. C) Intensive, 47 years. D) Extensive, 1 year. A, B, and C are stands in the Elliott State Research Forest. D is a BLM stand in the west Oregon Cascades (BLM photo).*

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:

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.

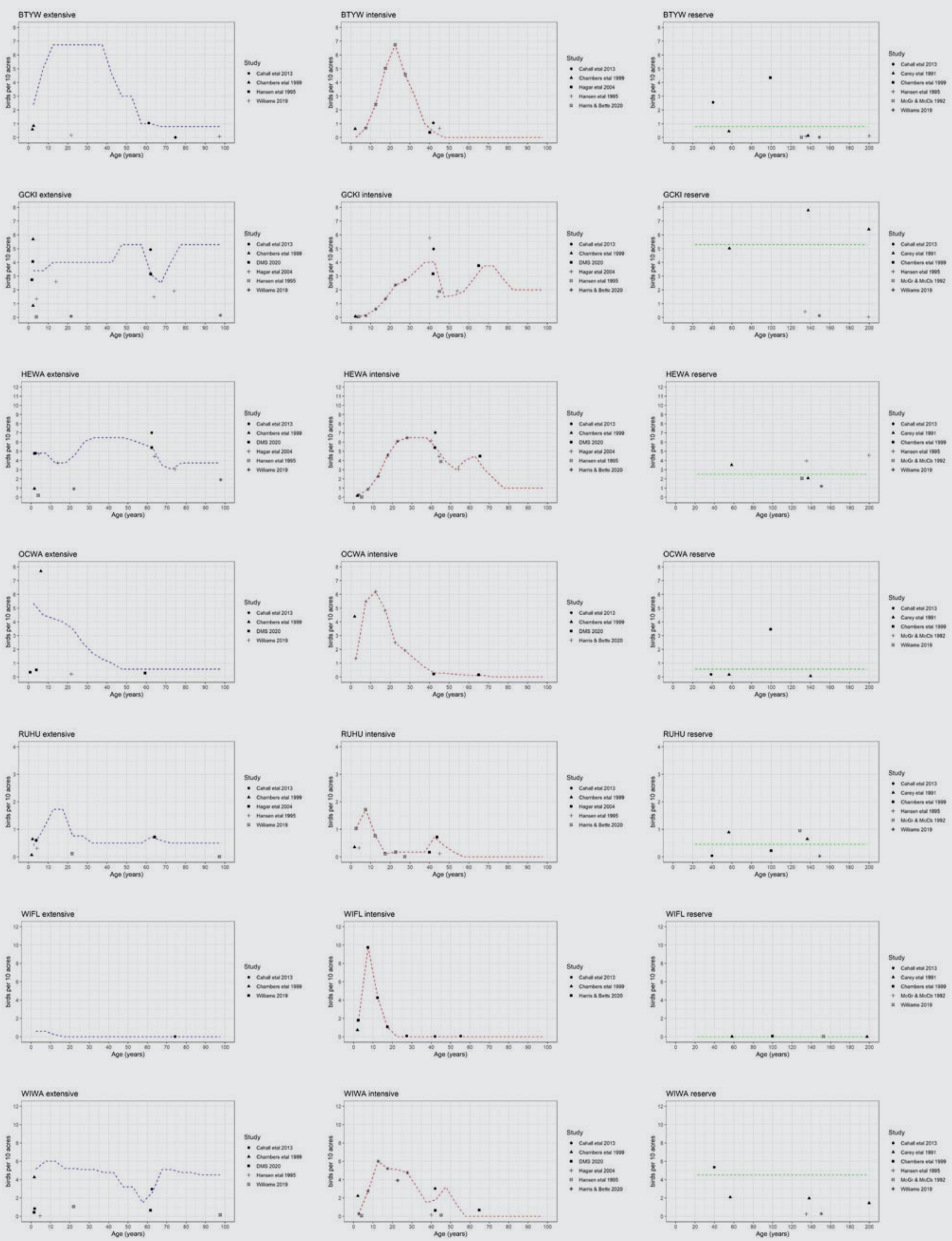


Figure 10c. *Estimated responses of the density of 7 early-seral songbird species as a function of stand age, for the three stand-level treatments of the Elliott State Forest Research Design. Estimated responses are indicated by the dashed lines. Empirical data and sources are indicated by the symbols.*

Table 10a.

Study	STAND LEVEL RESEARCH TREATMENTS			Study Area
	Intensive	Extensive	Reserve	
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.*

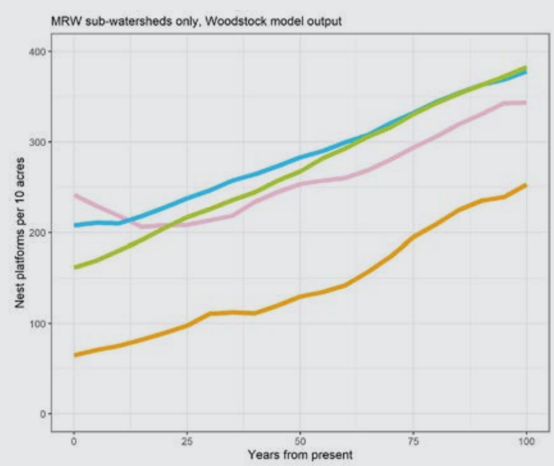
NESTING PLATFORMS FOR MARBLED MURRELET

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.

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.

Figure 10d. Estimates of Potential nesting platforms for Marbled Murrelets



KEY

- Extensive
- Triad-E
- Triad-I
- Reserve with Intensive

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."*

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

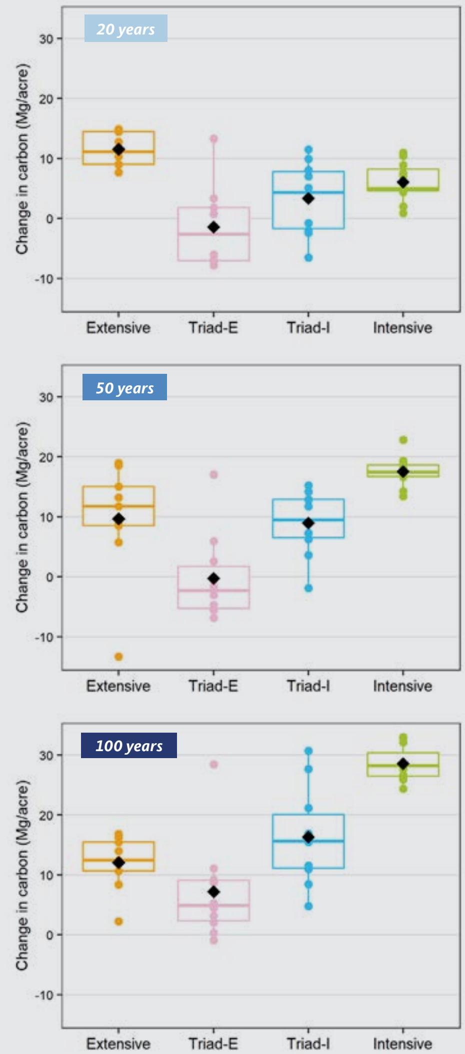


Figure Set 1. Boxplots (above). *Estimates of the change in stored carbon (standing live and dead trees including coarse roots) between the specified time and initial carbon stores at the beginning of the forest planning model (year 2020), for the complete sample of the four subwatershed treatments, 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).*

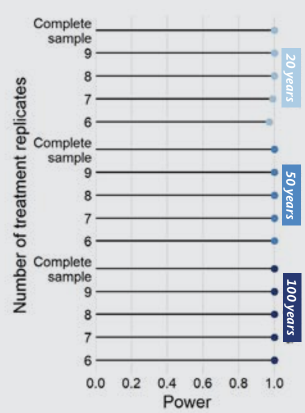


Figure Set 1. Power plot (left). *The estimated power to detect a difference among the treatment means, for different sample sizes (number of subwatershed treatment replicates) at 20, 50, and 100 years.*

Figure Set 2. Orange-crowned warbler

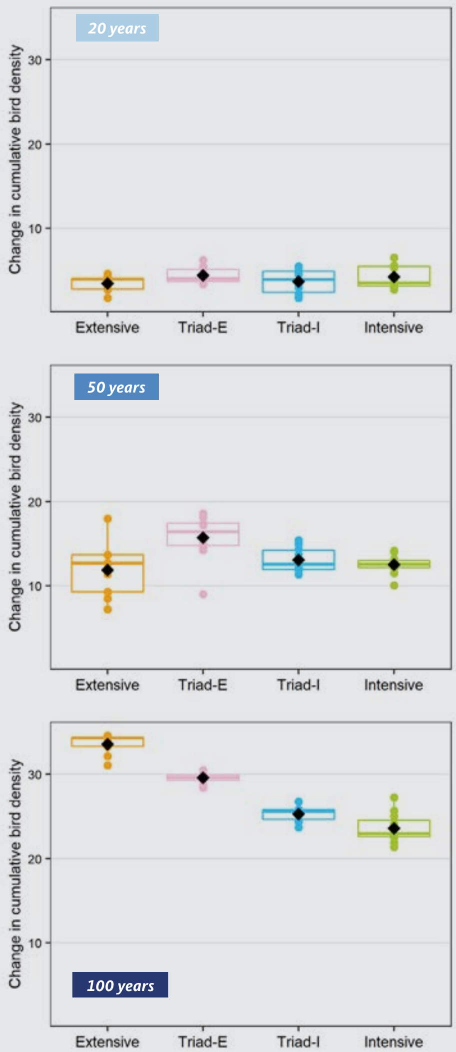


Figure Set 2. Boxplots (above). *Estimates of the change in cumulative density (birds per 10 acres) of orange-crowned warblers between the specified time and initial density at the beginning of the forest planning model (year 2020), for the complete sample of the four subwatershed treatments, Elliott 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).*

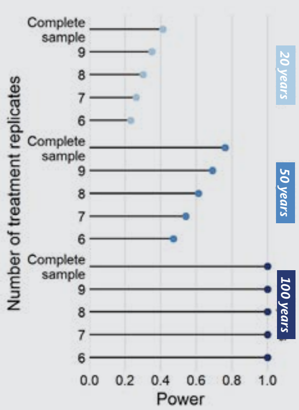


Figure Set 2. Power plot (left). *The estimated power to detect a difference among the treatment means, for different sample sizes (number of subwatershed treatment replicates) at 20, 50, and 100 years.*

Figure Set 3. Marbled murrelet

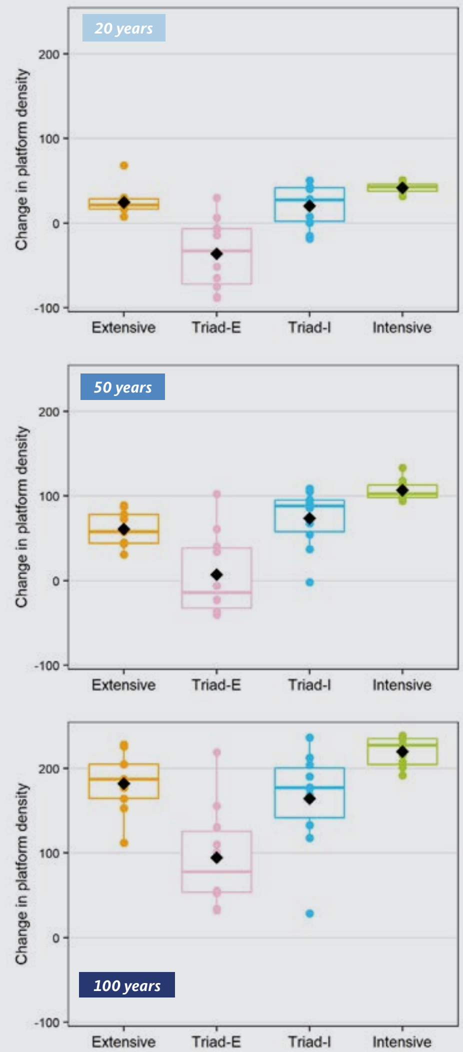


Figure Set 3. Boxplots (above). *Estimates of the change in density (platforms per 10 acres) of potential nesting platforms for marbled murrelets between the specified time and the initial density at the beginning of the forest planning model (year 2020), for the complete sample of the four subwatershed 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).*

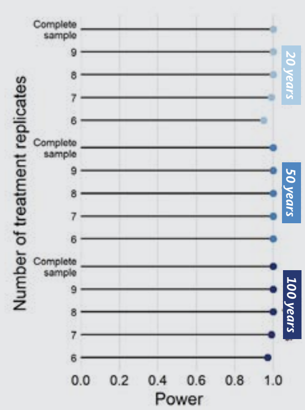


Figure Set 3. Power plot (left). *The estimated power to detect a difference among the treatment means, for different sample sizes (number of subwatershed treatment replicates) at 20, 50, and 100 years.*

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

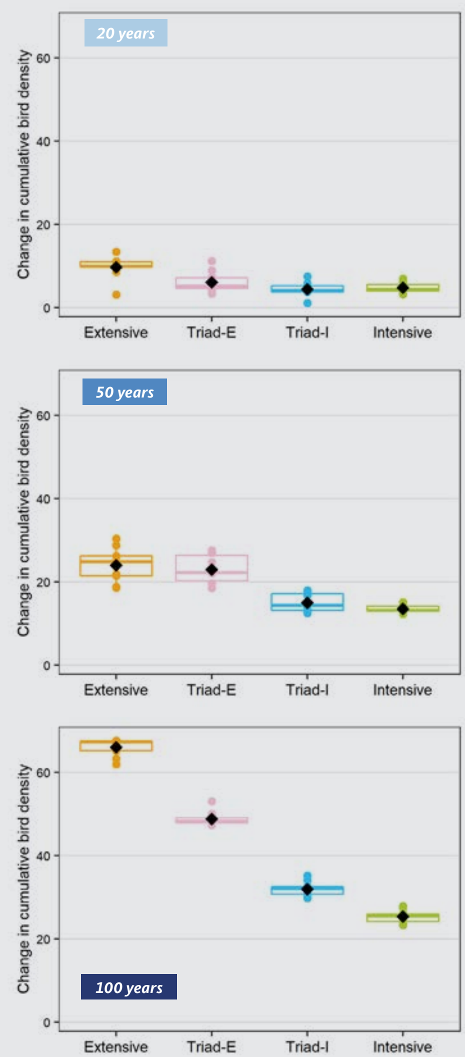


Figure Set 4. Boxplots (above). *Estimates of the change in cumulative density (birds per 10 acres) of black-throated gray warblers between the specified time and initial density at the beginning of the forest planning model (year 2020), for the complete sample of the four subwatershed treatments, Elliott 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).*

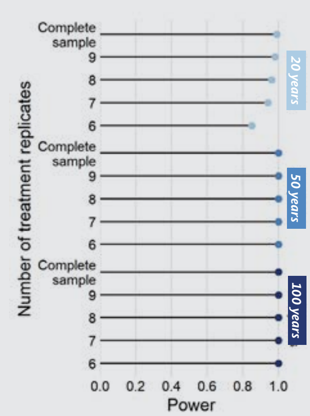


Figure Set 4. Power plot (left). *The estimated power to detect a difference among the treatment means, for different sample sizes (number of subwatershed treatment replicates) at 20, 50, and 100 years.*

Figure Set 5. Golden-crowned kinglet

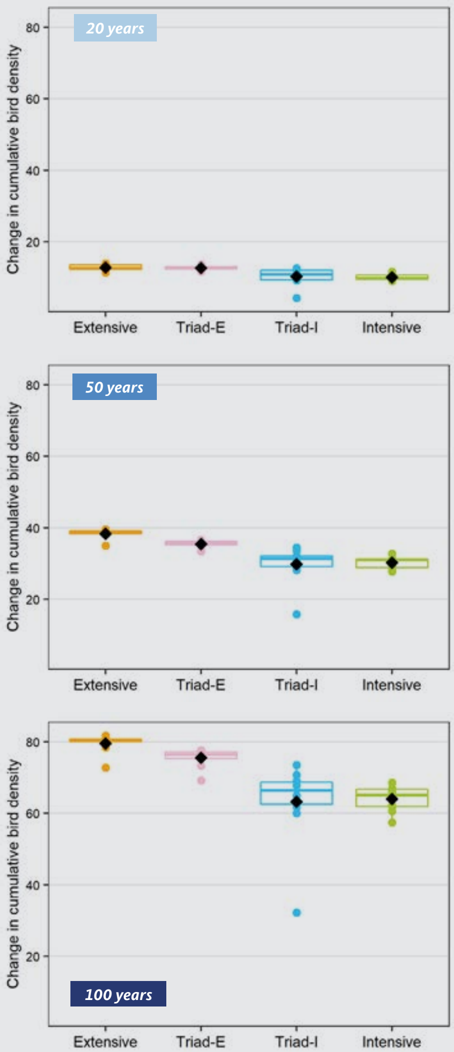


Figure Set 5. Boxplots (above). *Estimates of the change in cumulative density (birds per 10 acres) of golden-crowned kinglets between the specified time and initial density at the beginning of the forest planning model (year 2020), for the complete sample of the four subwatershed treatments, Elliott 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).*

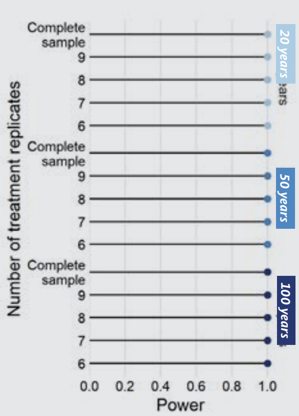


Figure Set 5. Power plot (left). *The estimated power to detect a difference among the treatment means, for different sample sizes (number of subwatershed treatment replicates) at 20, 50, and 100 years.*

Figure Set 6. Hermit warbler

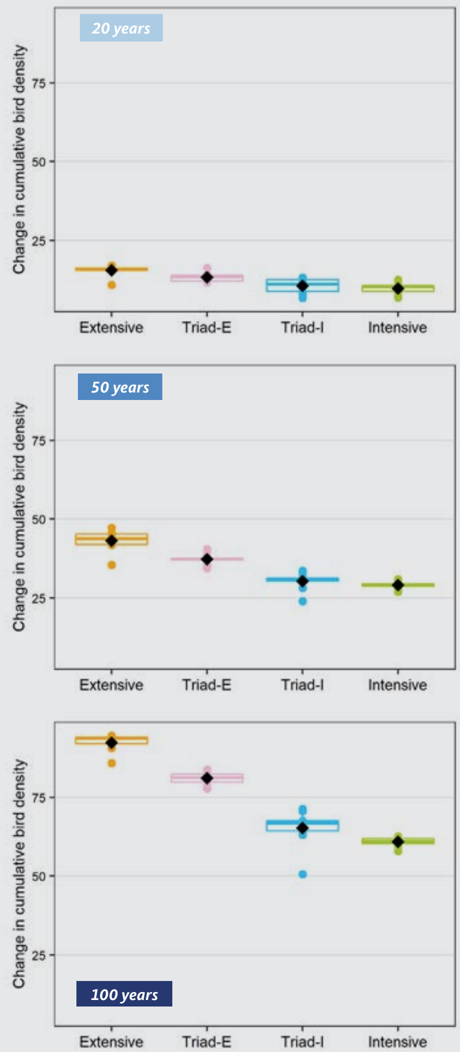


Figure Set 6. Boxplots (above). *Estimates of the change in cumulative density (birds per 10 acres) of hermit warblers between the specified time and initial density at the beginning of the forest planning model (year 2020), for the complete sample of the four subwatershed treatments, Elliott State Forest 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).*

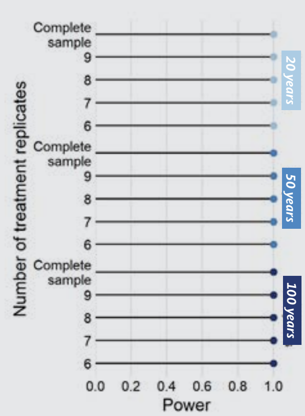


Figure Set 6. Power plot (left). *The estimated power to detect a difference among the treatment means, for different sample sizes (number of subwatershed treatment replicates) at 20, 50, and 100 years.*

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).

REFERENCES

Bahn, V. 1998. Habitat Requirements and Habitat Suitability Index for the Marbled Murrelet (Brachyramphus marmoratus) as a Management Target Species in the Ursus Valley, British Columbia.:168.

Burger, A.E., Ronconi, R.A., Silvergieter, M.P., Conroy, C., Bahn, V., Manley, I.A., Cober, A., Lank, D.B., 2010. Factors affecting the availability of thick epiphyte mats and other potential nest platforms for Marbled Murrelets in British Columbia. Can. J. For. Res. 40, 727–746. https://doi.org/10.1139/X10-034

Cahall, R. E., J. P. Hayes, and M. G. Betts. 2013. Will they come? Long-term response by forest birds to experimental thinning supports the "Field of Dreams" hypothesis. Forest Ecology and Management 304:137–149.

Carey, A. B., M. M. Hardt, S. P. Horton, and B. L. Biswell. 1991. Spring bird communities in the Oregon Coast Range. Pages 123–142 Wildlife and Vegetation of Unmanaged Douglas-fir Forests. USFS Pacific Northwest Research Station, Portland, OR, USA.

Chambers, C. L., W. C. McComb, and J. C. Tappeiner. 1999. Breeding bird responses to three silvicultural treatments in the Oregon Coast Range. Ecological Applications 9:171–185.

Hagar, J., S. Howlin, and L. Ganio. 2004. Short-term response of songbirds to experimental thinning of young Douglas-fir forests in the Oregon Cascades. Forest Ecology and Management 199:333–347.

Hamer, T. E., D. E. Varland, T. L. McDonald, and D. Meekins. 2008. Predictive Model of Habitat Suitability for the Marbled Murrelet in Western Washington. Journal of Wildlife Management 72:983–993.

Hansen, A. J., W. C. McComb, R. Vega, M. G. Raphael, and M. Hunter. 1995. Bird Habitat Relationships in Natural and Managed Forests in the West Cascades of Oregon. Ecological Applications 5:555–569.

Jenkins, J. C. et al. 2003. National scale biomass estimators for United States tree species. Forest Science 49:12–35.

MacLean, D. A., P. Etheridge, J. Pelham, and W. Emrich. 1999. Fundy Model Forest: Partners in sustainable forest management. The Forestry Chronicle 75:219–227.

Figure Set 7. Rufous hummingbird

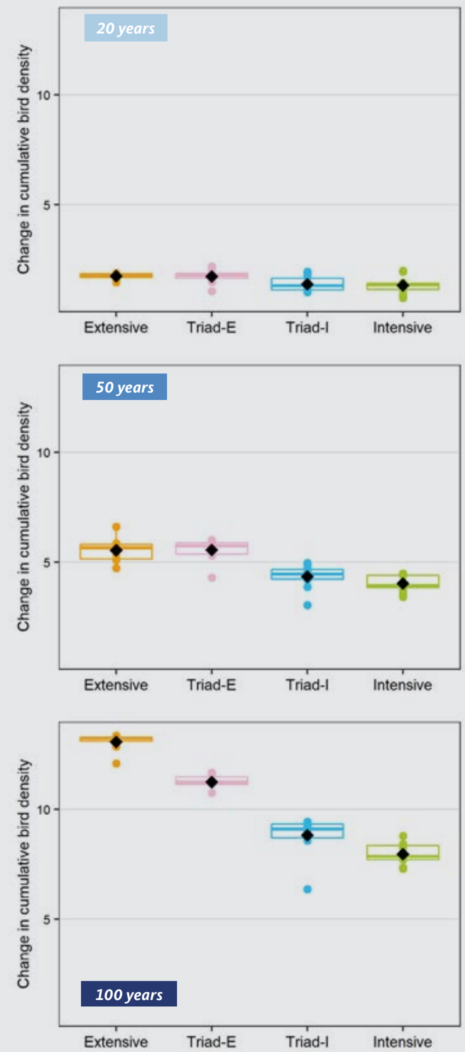


Figure Set 7. Boxplots (above). *Estimates of the change in cumulative density (birds per 10 acres) of rufous hummingbirds between the specified time and initial density at the beginning of the forest planning model (year 2020), for the complete sample of the four subwatershed treatments, Elliott State 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).*

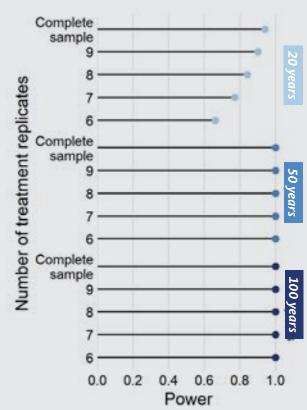


Figure Set 7. Power plot (left). *The estimated power to detect a difference among the treatment means, for different sample sizes (number of subwatershed treatment replicates) at 20, 50, and 100 years.*

Figure Set 8. Willow flycatcher

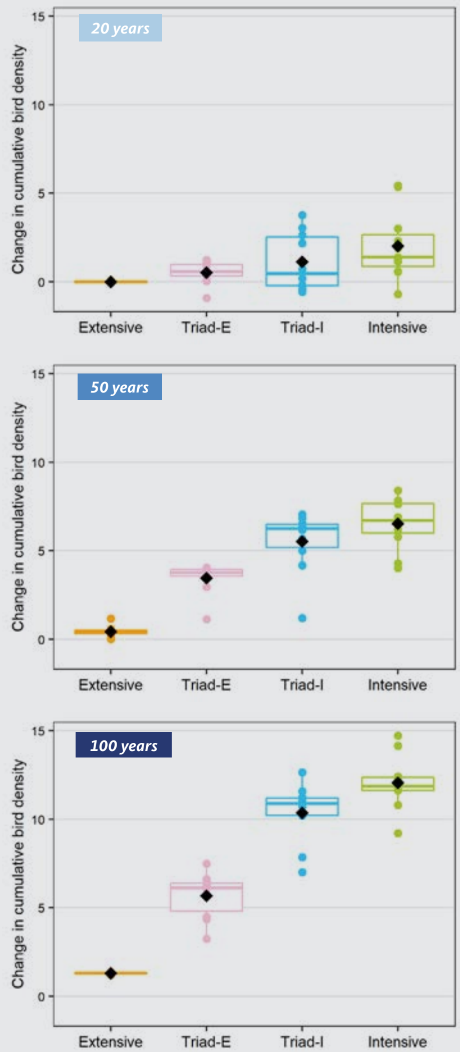


Figure Set 8. Boxplots (above). *Estimates of the change in cumulative density (birds per 10 acres) of willow flycatchers between the specified time and initial density at the beginning of the forest planning model (year 2020), for the complete sample of the four subwatershed treatments, Elliott State 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).*

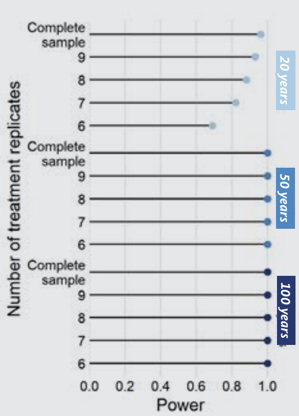


Figure Set 8. Power plot (left). *The estimated power to detect a difference among the treatment means, for different sample sizes (number of subwatershed treatment replicates) at 20, 50, and 100 years.*

Figure Set 9. Wilson's warbler

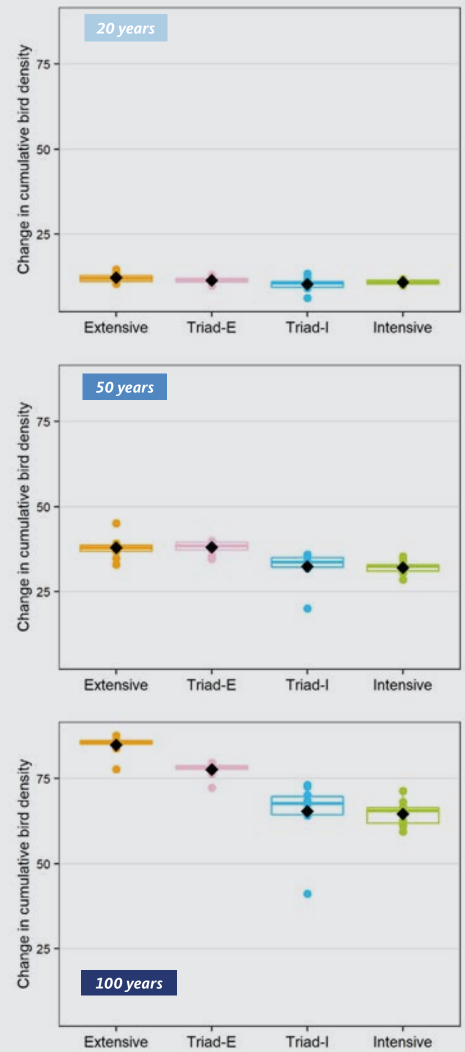


Figure Set 9. Boxplots (above). *Estimates of the change in cumulative density (birds per 10 acres) of Wilson's warblers between the specified time and initial density at the beginning of the forest planning model (year 2020), for the complete sample of the four subwatershed treatments, Elliott State 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).*

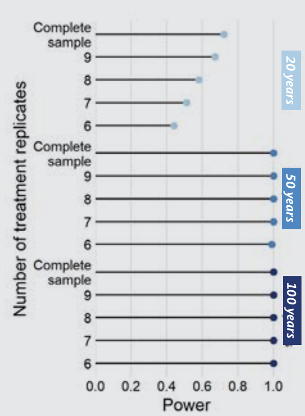


Figure Set 9. Power plot (left). *The estimated power to detect a difference among the treatment means, for different sample sizes (number of subwatershed treatment replicates) at 20, 50, and 100 years.*

Malt, J. M., and D. B. Lank. 2009. Marbled Murrelet nest predation risk in managed forest landscapes: dynamic fragmentation effects at multiple scales. Ecological Applications 19:1274–1287.

McComb, W. C., M. T. McGrath, T. A. Spies, and D. Vesely. 2002. Models for Mapping Potential Habitat at Landscape Scales: An Example Using Northern Spotted Owls. Forest Science 48:203–216.

McGarigal, K., and W. C. McComb. 1992. Streamside versus Upslope Breeding Bird Communities in the Central Oregon Coast Range. The Journal of Wildlife Management 56:10.

Oregon Dept. of State Lands and Oregon Dept. of Forestry. 2011. Elliott State Forest Management Plan. 406p.

Partners in Flight. 2020a. Avian Conservation Assessment Database, version 2020. Available at http://pif.birdconservancy.org/ACAD.

Partners in Flight. 2020b. Population Estimates Database, version 3.1. Available at http://pif.birdconservancy.org/PopEstimates.

Schlesinger, W.H. (1991). Biogeochemistry, an Analysis of Global Change. New York, USA, Academic Press.

Raphael, M.G., Falxa, G.A., Dugger, K.M., Galleher, B.M., Lynch, D., Miller, S.L., Nelson, S.K., Young, R.D., 2011. Status and Trend of Nesting Habitat for the Marbled Murrelet. PNW-GTR-848. USDA Forest Service Pacific Northwest Research Station.

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.

Smith, J. E., L. S. Heath, and J. C. Jenkins. 2003. Forest volume-to-biomass models and estimates of mass for live and standing dead trees of U.S. forests. Page NE-GTR-298. U.S. Department of Agriculture, Forest Service, Northeastern Research Station, Newtown Square, PA.

Spies, T. A., B. C. McComb, R. S. Kennedy, M. T. McGrath, K. Olsen, and R. J. Pabst. 2007. Potential effects of forest policies on terrestrial biodiversity in a multi-ownership province. Ecological Applications 17:48–65.

Ward, C., and T. Erdle. 2015. Evaluation of forest management strategies based on Triad zoning. The Forestry Chronicle 91:40–51.

Welch, B. L. 1951. On the Comparison of Several Mean Values: An Alternative Approach. Biometrika 38:330–336.

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.

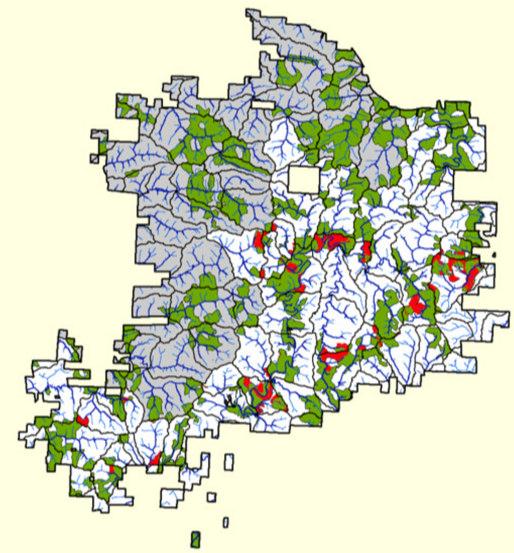


Figure 11a. *Extent of historically occupied stands according to S.K. Nelson and ODF data (green). Occupied stands currently designated as the 'extensive' treatment are highlighted in red. This area totals 1457 acres (7.8% of the historically occupied stands across the entire Elliott State Forest; Table 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.

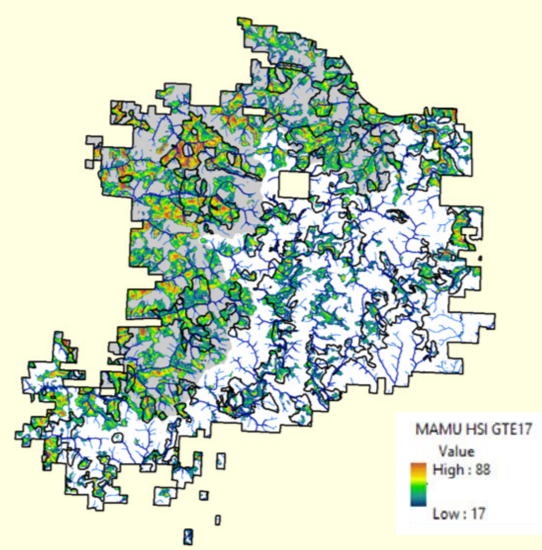


Figure 11b. *Extent of modeled Marbled Murrelet habitat across the Elliott. Occupancy data from Betts et al (2020) [117 points from Nelson and ODF data with known survey dates] were modeled with time-matched 6 visible Landsat TM bands along with 2014 Lidar data. Areas with canopy disturbance were removed. 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.

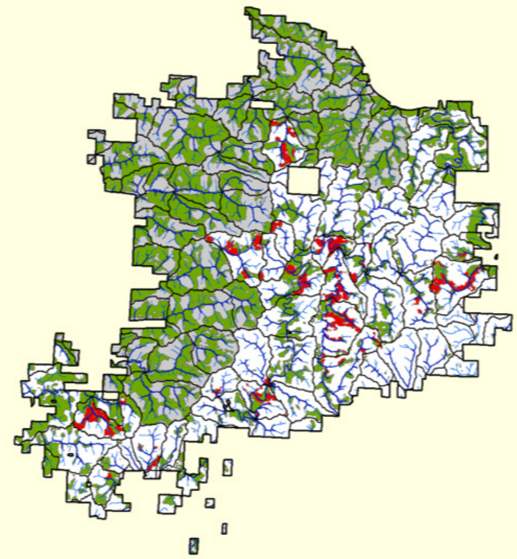


Figure 11c. *Extent of model predicted murrelet occupied stands (green) according to the Yang and Betts (unpublished) species distribution model. Predicted occupied stands currently designated as in the 'extensive' treatment are highlighted in red. This area totals 1676 acres (9% of the historically 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.

LITERATURE CITED

Betts, M.G., J.M. Northrup, J.A. Bailey Guerrero, S.K. Nelson, J.L. Fisher, B.D. Gerber, M-S. Garcia-Heras, Z. Yang, D.D. Roby, J.W. Rivers 2020. Squeezed by a habitat split: Warm ocean conditions and old-forest loss interact to reduce long-term occupancy of a threatened seabird. Conservation Letters 13: e12745.

Cahall, R., J. Hayes, and M.G. Betts. 2013. If you build it will they come? Long-term response by forest birds to experimental thinning supports the "Field of Dreams" hypothesis. Forest Ecology and Management 304: 137–149

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).

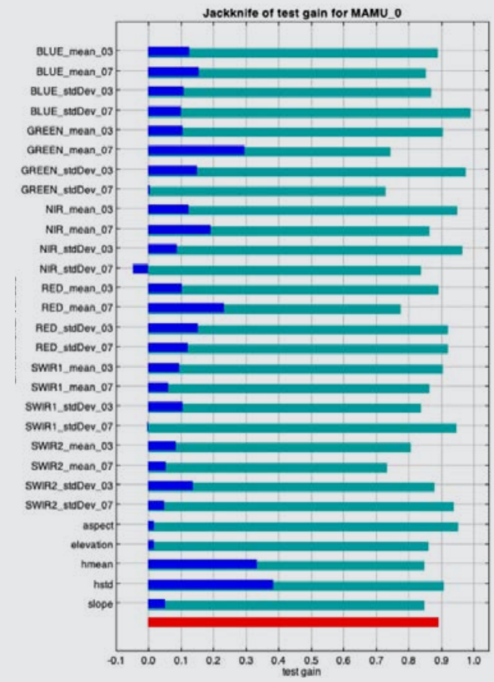
We used murrelet occupancy data 2008-2018 (N=117). Data are available at https://figshare.com/articles/dataset/Squeezed_by_a_habitat_split_warm_ocean_conditions_and_old-forest_loss_interact_to_reduce_long-term_occupancy_of_a_threatened_seabird_data_and_code_/12743762. Occupied areas disturbed by harvesting 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.

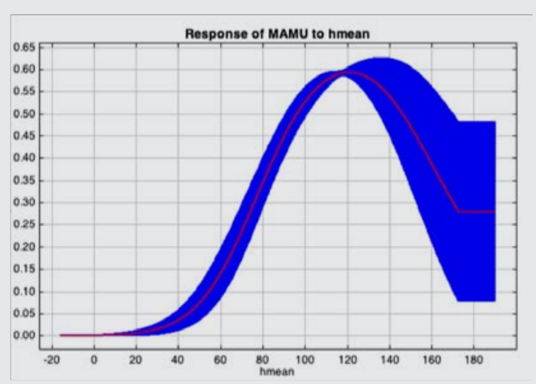


Figure 11e. *Fitted relationship between canopy height (hmean; derived from Lidar) at a 100 m scale and probability of murrelet occupancy. Note high confidence bands at tall tree heights reflect model uncertainty.*

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.

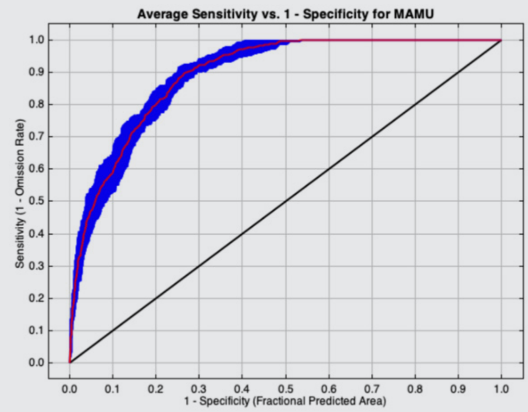
Literature cited

Falxa, G.A., and M. G. Raphael. 2016 Status and trend of Marbled Murrelet populations and nesting habitat. PNW-GTR-933 https://www.fs.fed.us/pnw/pubs/pnw_gtr933.pdf

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

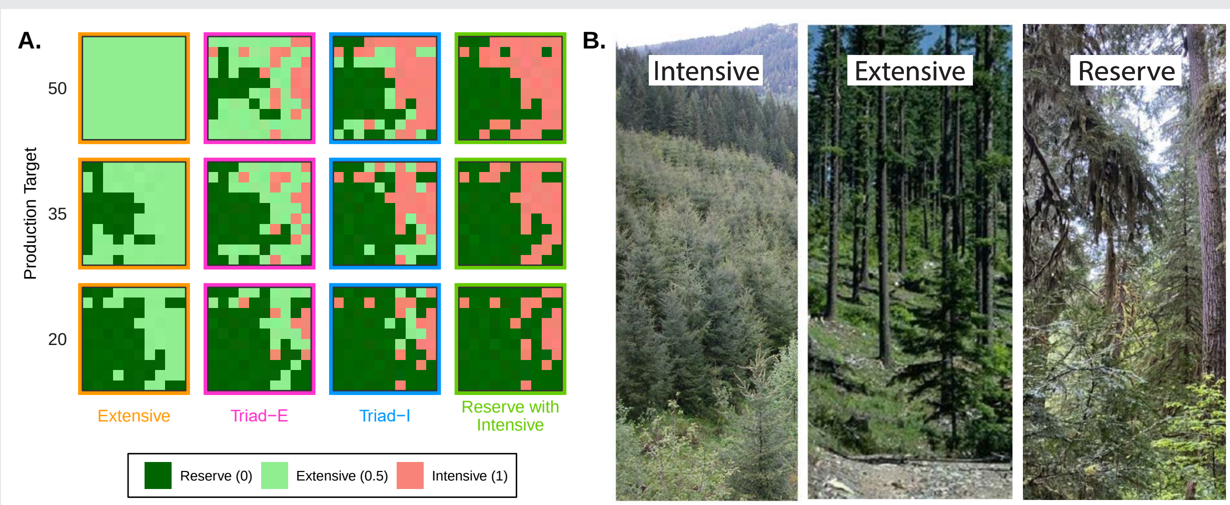


Figure 2. *Conceptual illustration of contrasting approaches to managing landscapes for timber production and biodiversity conservation in mixed-wood yield landscapes along a continuum from where extensive (ecological) forestry dominates to landscapes comprised of reserves and intensive management. In (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.

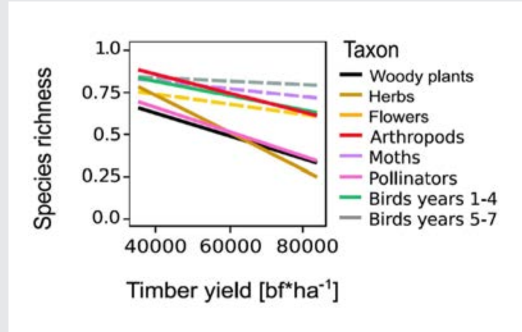


Figure 12a. Results of a recent study (Kormann et al. In Press) demonstrating tradeoffs between species richness of biodiversity taxa (normalized to 1) and timber production. Statistically significant tradeoffs (solid lines) occur for arthropods, pollinators, woody & herbaceous plants, and birds in the 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

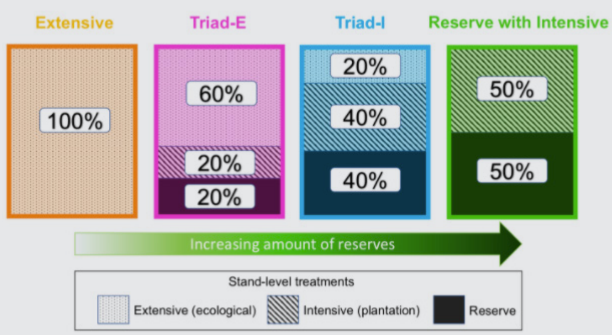


Figure 4. The four Triad treatments that we will apply at the subwatershed scale at the ESRF. All of the subwatersheds (400-2000 ac) in the Management Research Watersheds will receive one of these four treatments. Treatments are designed to produce approximately equivalent wood yields using different 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%

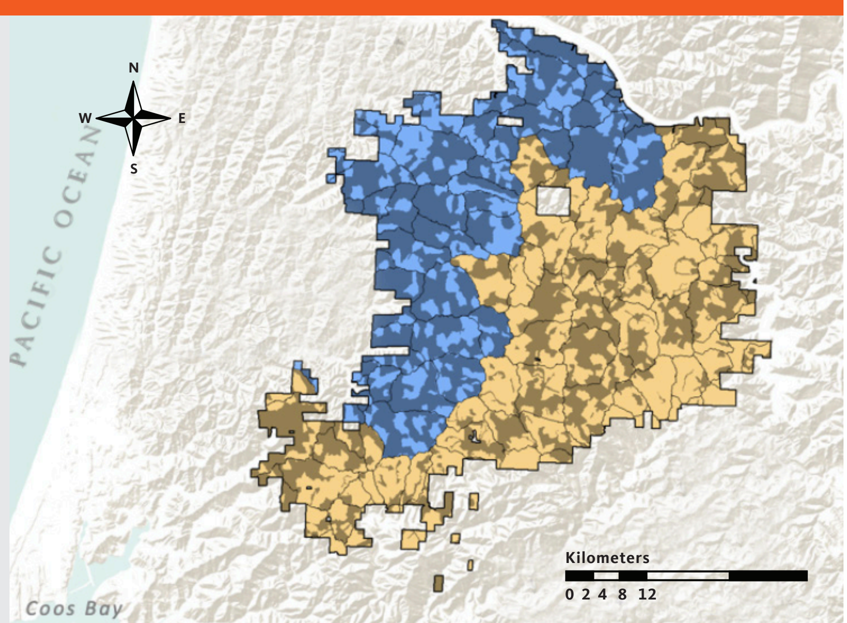


Figure 6. Subwatersheds of the Elliott State Research Forest color coded by classification into the Conservation Research Watersheds (CRW) and Management Research Watersheds (MRW) and color coded by stand age greater than 65 years (GT65) and less than 65 years (LTE65). Uncolored regions indicate this 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

KEY

- CRW
- Extensive
- Triad-E
- Triad-I
- Reserve with Intensive
- MRW Partial

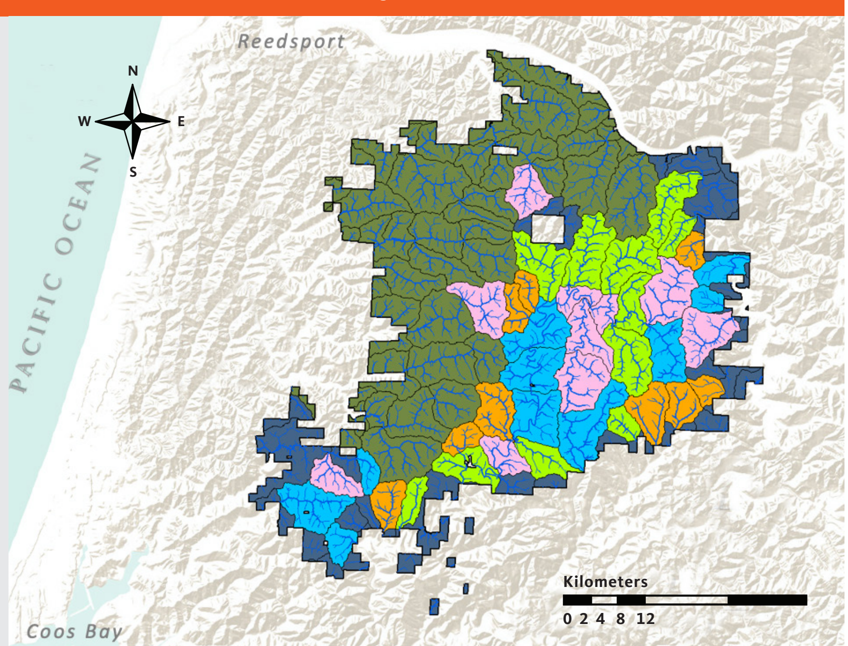


Figure 5. *Map illustrating the proposed western reserve area (Conservation Research Watershed; CRW, in dark green) and the potential allocation of subwatershed-scale Triad treatments in the ESRF's eastern part . Partial watersheds (dark blue) are only partly contained in the ESRF, so they will not have a formal subwatershed Triad treatment assigned. Map is based on August 2020 allocation.*

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.

LITERATURE CITED:

Balmford, A., K. J. Gaston, S. Blyth, A. James, and V. Kapos. 2003. Global variation in terrestrial conservation costs, conservation benefits, and unmet conservation needs. Proceedings of the National Academy of Sciences 100:1046–1050.

Barlow, J., T. A. Gardner, I. S. Araujo, T. C. Ávila-Pires, A. B. Bonaldo, J. E. Costa, M. C. Esposito, L. V.

Ferreira, J. Hawes, M. I. Hernandez, and others. 2007. Quantifying the biodiversity value of tropical primary, secondary, and plantation forests. Proceedings of the National Academy of Sciences 104:18555–18560.

Betts, M., and G. Forbes (eds). 2005. Forest management guidelines to protect native biodiversity in the Greater Fundy Ecosystem, 2nd edition. New Brunswick Cooperative Fish and Wildlife Research Unit. University of New Brunswick.

Betts, M. G., G. J. Forbes, and A. W. Diamond. 2007. Thresholds in Songbird Occurrence in Relation to Landscape Structure. Conservation Biology 21:1046–1058.

Betts, M. G., N. L. Rodenhouse, T. Scott Sillett, P. J. Doran, and R. T. Holmes. 2008. Dynamic occupancy models reveal within-breeding season movement up a habitat quality gradient by a migratory songbird. Ecography 31:592–600.

Betts, M. G., and M.-A. Villard. 2009. Landscape thresholds in species occurrence as quantitative targets in forest management: generality in space and time? Pages 185–206 Setting conservation targets for managed forest landscapes, ed. MA Villard, and BG Jonsson. Cambridge University Press.

Betts, M. G., J. C. Hagar, J. W. Rivers, J. D. Alexander, K. McGarigal, and B. C. McComb. 2010. Thresholds in forest bird occurrence as a function of the amount of early-seral broadleaf forest at landscape scales. Ecological Applications 20:2116–2130.

Betts, M. G., J. Verschuyl, J. Giovanini, T. Stokely, and A. J. Kroll. 2013. Initial experimental effects of intensive forest management on avian abundance. Forest Ecology and Management 310:1036–1044.

Betts, M. G., C. Wolf, W. J. Ripple, B. Phalan, K. A. Millers, A. Duarte, S. H. M. Butchart, and T. Levi. 2017. Global forest loss disproportionately erodes biodiversity in intact landscapes. Nature 547:441–444.

Betts, M. G., Christopher Wolf, Marion Pfeifer, Cristina Banks-Leite, Victor Arroyo-Rodríguez, Danilo Bandini Ribeiro, Jos Barlow, Felix Eigenbrod, Deborah Faria, Robert J. Fletcher Jr., Adam S. Hadley, Joseph E. Hawes, Robert D. Holt, Brian Klingbeil, Urs Kormann, Luc Lens, Taal Levi, Guido. F. Medina-Rangel, Stephanie L. Melles, Dirk Mezger, José Carlos Morante-Filho, David Orme, Carlos A. Peres, Benjamin T. Phalan, Anna Pidgeon, Hugh Possingham, William J. Ripple, Elenor M. Slade, Eduardo Somarriba, Joseph Tobias, Jason M. Tylianakis, J. Nicolás Urbina-Cardona, Jonathon J. Valente, James I. Watling, Konstans Wells, Oliver R. Wearn, Eric Wood, Richard Young, and Robert M. Ewers. 2019a. Extinction filters mediate the global effects of habitat fragmentation on animals. Science 366:1236–1239.

Betts, M. G., J. Gutiérrez Illán, Z. Yang, S. M. Shirley, and C. D. Thomas. 2019b. Synergistic effects of climate and land-cover change on long-term bird population trends of the western USA: A test of modeled predictions. Frontiers in Ecology and Evolution 7:186.

Betts, M. G., B. T. Phalan, C. Wolf, S. C. Baker, C. Messier, K. J. Puettmann, R. Green, S. H. Harris, D. B. Lindenmayer, and A. Balmford. 2020. Producing wood at least cost to biodiversity: integrating Triad and sharing-sparing approaches to inform forest management. Submitted to Biological Reviews.

Brockerhoff, E. G., H. Jactel, J. A. Parrotta, C. P. Quine, and J. Sayer. 2008. Plantation forests and biodiversity: oxymoron or opportunity? Biodiversity and Conservation 17:925–951.

Brockerhoff, E. G., L. Barbaro, B. Castagneyrol, D. I. Forrester, B. Gardiner, J. R. González-Olabarria, P. O. Lyver, N. Meurisse, A. Oxbrough, H. Taki, I. D. Thompson, F. van der Plas, and H. Jactel. 2017. Forest biodiversity, ecosystem functioning and the provision of ecosystem services. Biodiversity and Conservation 26:3005–3035.

Brower, J. E., J. H. Zar, and C. N. von Ende. 1998. Field and Laboratory Methods for General Ecology, 4th Edition. WCB McGraw-Hill, Boston, MA.

Brown, E. R. 1985. Management of wildlife and fish habitats in forests of western Oregon and Washington. Pages 192–1985. U.S. Department of Agriculture.

Butchart, S. H., M. Walpole, B. Collen, A. Van Strien, J. P. Scharlemann, R. E. Almond, J. E. Baillie, B.

Bomhard, C. Brown, J. Bruno, and others. 2010. Global biodiversity: indicators of recent declines. Science 328:1164–1168.

Cahall, R. E., J. P. Hayes, and M. G. Betts. 2013. Will they come? Long-term response by forest birds to experimental thinning supports the “Field of Dreams” hypothesis. Forest Ecology and Management 304:137–149.

Ceballos, G., P. R. Ehrlich, A. D. Barnosky, A. García, R. M. Pringle, and T. M. Palmer. 2015. Accelerated modern human–induced species losses: Entering the sixth mass extinction. Science Advances 1:e1400253.

CIPS. 2020. CIPSANON User’s Manual, version 4.0. Center for Intensive Planted-forest Silviculture. http://cips.forestry.oregonstate.edu/cipsanon.

Convention on Biological Diversity. 2010. The strategic plan for biodiversity 2011– 2020 and the Aichi biodiversity targets. UNEP/CBD/COP/DEC/X/2. Secretariat of the Convention on Biological Diversity, Nagoya, Japan.

Côté, P., R. Tittler, C. Messier, D. D. Kneeshaw, A. Fall, and M.-J. Fortin. 2010. Comparing different forest zoning options for landscape-scale management of the boreal forest: possible benefits of the Triad. Forest Ecology and Management 259:418–427.

Crookston, N. L., and G. E. Dixon. 2005. The forest vegetation simulator: a review of its structure, content, and applications. Computers and Electronics in Agriculture 49:60–80.

Cushman, S. A., and K. McGarigal. 2004. Hierarchical analysis of forest bird species–environment relationships in the Oregon coast range. Ecological Applications 14:1090–1105.

Díaz, S., J. Settele, E. S. Brondízio, H. T. Ngo, J. Agard, A. Arneth, P. Balvanera, K. A. Brauman, S. H. M. Butchart, K. M. A. Chan, L. A. Garibaldi, K. Ichii, J. Liu, S. M. Subramanian, G. F. Midgley, P. Miloslavich, Z. Molnár, D. Obura, A. Pfaff, S. Polasky, A. Purvis, J. Razzaque, B. Reyers, R. R. Chowdhury, Y.-J. Shin, I. Visseren-Hamakers, K. J. Willis, and C. N. Zayas. 2019. Pervasive human-driven decline of life on Earth points to the need for transformative change. Science 366:1-10.

Dooley E., and S. Fairweather. 2016. Elliott State Forest cruise report for Oregon Department of State Lands. Prepared for Oregon Department of State Lands by Mason, Bruce, and Girard. Portland, Oregon. March 9, 2016. 39 pp.

Duraiappah, A. K., S. Naeem, T. Agardy, N. Ash, H. Cooper, S. Diaz, and et al. 2005. Ecosystems and human well-being: biodiversity synthesis; a report of the Millennium Ecosystem Assessment. World Resources Institute.

Edwards, D. P., J. J. Gilroy, P. Woodcock, F. A. Edwards, T. H. Larsen, D. J. Andrews, M. A. Derhé, T. D.

Docherty, W. W. Hsu, S. L. Mitchell, and others. 2014. Land-sharing versus land-sparing logging: reconciling timber extraction with biodiversity conservation. Global change biology 20:183–191.

Ellis, T. M., and M. G. Betts. 2011. Bird abundance and diversity across a hardwood gradient within early seral plantation forest. Forest Ecology and Management 261:1372–1381.

Ellis, T. M., A. J. Kroll, and M. G. Betts. 2012. Early seral hardwood vegetation increases adult and fledgling bird abundance in Douglas-fir plantations of the Oregon Coast Range, USA. Canadian Journal of Forest Research 42:918–933.

Fahrig, L. 1998. When does fragmentation of breeding habitat affect population survival? Ecological Modelling 105:273–292.

Fahrig, L. 2003. Effects of Habitat Fragmentation on Biodiversity. Annual Review of Ecology, Evolution, and Systematics 34:487–515. Food and Agriculture Organization of the United Nations. 2015. Global Forest Resources Assessment 2015: How are the World's Forests Changing?. Food and Agriculture Organization of the United Nations. 2019. FAOSTAT Statistical Database. Rome, Italy.

Franklin, J. F., and D. C. Donato. 2020. Variable retention harvesting in the Douglas-fir region. Ecological Processes 9:1–10.

Franklin, J. F., and K. N. Johnson. 2012. A restoration framework for federal forests in the Pacific Northwest. Journal of Forestry 110:429–439.

Franklin, J. F., K. N. Johnson, and D. L. Johnson. 2018. Ecological forest management.

Gray, A. N., T. R. Whittier, and M. E. Harmon. 2016. Carbon stocks and accumulation rates in Pacific Northwest forests: role of stand age, plant community, and productivity. Ecosphere 7.

Greenfield, P., N. Tran-Dinh, and D. Midgley. 2019. Kelpie: generating full-length 'amplicons' from wholemetagenome datasets. PeerJ 6:e6174.

Gunn, J. S., M. J. Ducey, T. Buchholz, and E. P. Belair. 2020. Forest carbon resilience of Eastern Spruce Budworm (Choristoneura fumiferana) salvage harvesting in the northeastern United States. Frontiers in Forests and Global Change 3:14.

Hagar, J. C. 2007. Wildlife species associated with non-coniferous vegetation in Pacific Northwest conifer forests: A review. Forest Ecology and Management 246:108–122.

Hall, B. 2019, May 19. The fight for a forest: OSU's bid to manage Elliott for research still faces questions. Corvallis Gazette Times.

Hall, M. 2018. Blue and yellow vane traps differ in their sampling effectiveness for wild bees in both open and wooded habitats: Blue vane traps better for bee sampling. Agricultural and Forest Entomology 20:487–495.

Hansen, A. J., W. C. McComb, R. Vega, M. G. Raphael, and M. Hunter. 1995. Bird Habitat Relationships in Natural and Managed Forests in the West Cascades of Oregon. Ecological Applications 5:555–569.

Harris, S. H., U. G. Kormann, T. D. Stokely, J. Verschuyl, A. J. Kroll, and M. G. Betts. 2020. Do birds help trees grow? An experimental study of the effect of land-use intensification on avian trophic cascades. Ecology. In press.

Hayes, J. P., S. P. Cross, and McIntire, P.W. (n.d.). Seasonal variation in mycophagy by the western redbacked vole, Clethrionomys californicus, in southwestern Oregon. Northwest Science 60:250–257.

Helm, D. J., and B. R. Mead. 2004. Reproducibility of vegetation cover estimates in south-central Alaska forests. Journal of Vegetation Science 15:33–40.

Homan, R. N., B. S. Windmiller, and J. M. Reed. 2004. Critical thresholds associated with habitat loss for two vernal pool-breeding amphibians. Ecological Applications 14:1547–1553.

International Union for Conservation of Nature. 2017. The IUCN Red List of Threatened Species. Version 2016.3.

Jones, J. E., A. J. Kroll, J. Giovanini, S. D. Duke, T. M. Ellis, and M. G. Betts. 2012. Avian Species Richness in Relation to Intensive Forest Management Practices in Early Seral Tree Plantations. PLoS ONE 7:e43290.

Jürgensen, C., W. Kollert, and A. Lebedys. 2014. Assessment of industrial roundwood production from planted forests. Planted Forests and Trees Working Papers (FAO) eng no. FP/48/E.

Kelly, R. M., J. Kitzes, H. Wilson, and A. Merenlender. 2016. Habitat diversity promotes bat activity in a vineyard landscape. Agriculture, Ecosystems & Environment 223:175–181.

Kéry, M., and J. A. Royle. 2016. Applied Heirarchical Modeling in Ecology, Vol. 1. Elsevier, New York, NY.

Kéry, M., J. A. Royle, and H. Schmid. 2005. Modeling Avian Abundance from Replictated Counts Using Binomial Mixture Models. Ecological Applications 15:1450–1461.

Kimmins, J. P. 1997. Balancing Act. UBC Press, Vancouver, British Columbia, Canada.

Kok, M. T. J., R. Alkemade, M. Bakkenes, M. van Eerdt, J. Janse, M. Mandryk, T. Kram, T. Lazarova, J. Meijer, M. van Oorschot, H. Westhoek, R. van der Zagt, M. van der Berg, S. van der Esch, A.-G. Prins, and D. P. van Vuuren. 2018. Pathways for agriculture and forestry to contribute to terrestrial biodiversity conservation: A global scenario-study. Biological Conservation 221:137–150.

Kormann, U. G., T. D. Stokely, J. Verschuyl, A. J. Kroll, S. H. Harris, D. A. Maguire, D. B. Mainwaring, J. W. Rivers, and M. G. Betts. In Press. Reconciling biodiversity with timber production and revenue. Ecological Applications.

Kroll, A. J., J. Verschuyl, J. Giovanini, and M. G. Betts. 2017. Assembly dynamics of a forest bird community depend on disturbance intensity and foraging guild. Journal of Applied Ecology 54:784–793.

Lahey, W. 2018. An Independent Review of Forest Practices in Nova Scotia. Halifax, Nova Scotia.

Law, B. E., T. W. Hudiburg, L. T. Berner, J. J. Kent, P. C. Buotte, and M. E. Harmon. 2018. Land use strategies to mitigate climate change in carbon dense temperate forests. Proceedings of the National Academy of Sciences 115:3663–3668.

Lindenmayer, D.B. & Laurance, W.F. 2012. A history of hubris–Cautionary lessons in ecologically sustainable forest management. Biological Conservation 151: 11–16.

Lindenmayer, D., J. Franklin, A. Lõhmus, S. Baker, J. Bauhus, W. Beese, A. Brodie, B. Kiehl, J. Kouki, G. M. Pastur, and others. 2012. A major shift to the retention approach for forestry can help resolve some global forest sustainability issues. Conservation Letters 5:421–431.

MacKenzie, D. I. 2005. What are the issues with presence-absence data for wildlife managers? Journal of Wildlife Management 69:849–860.

MacLean, D. A., P. Etheridge, J. Pelham, and W. Emrich. 1999. Fundy Model Forest: Partners in sustainable forest management. The Forestry Chronicle 75:219–227.

MacLean, D., R. Seymour, M. Montigny, and C. Messier. 2009. Allocation of conservation efforts over the landscape: the Triad approach. Pages 283–303 Setting conservation targets for managed forest landscapes, ed. MA Villard, and BG Jonsson. Cambridge University Press.

Matthews, G. 1993. The carbon content of trees. Forestry Commission Technical Paper 4. Forestry commission, Edinburgh, Scotland.

Mehrabi, Z., E. C. Ellis, and N. Ramankutty. 2018. The challenge of feeding the world while conserving half the planet. Nature Sustainability 1:409–412.

Messier, C., R. Tittler, D. D. Kneeshaw, N. Gélinas, A. Paquette, K. Berninger, H. Rheault, P. Meek, and N. Beaulieu. 2009. Triad zoning in Quebec: Experiences and results after 5 years. The forestry chronicle 85:885–896.

Muggeo, V. M. R. 2003. Estimating regression models with unknown break-points. Statistics in Medicine 22:3055–3071.

Nelson, E., G. Mendoza, J. Regetz, S. Polasky, H. Tallis, Dr. Cameron, K. M. Chan, G. C. Daily, J. Goldstein, P. M. Kareiva, E. Lonsdorf, R. Naidoo, T. H. Ricketts, and Mr. Shaw. 2009. Modeling multiple ecosystem services, biodiversity conservation, commodity production, and tradeoffs at landscape scales. Frontiers in Ecology and the Environment 7:4–11.

Newton, M., and L. Cole. 2015. Overstory development in Douglas-fir-dominant forests thinned to enhance late-seral features. Forest Science 61:809–816.

Ohmann, J. L., and M. J. Gregory. 2002. Predictive mapping of forest composition and structure with direct gradient analysis and nearest- neighbor imputation in coastal Oregon, U.S.A. Canadian Journal of Forest Research 32:725–741.

Oregon Forest Practices Act. 2017. Page ORS 197.277.

Paquette, A., and C. Messier. 2010. The role of plantations in managing the world's forests in the Anthropocene. Frontiers in Ecology and the Environment 8:27–34.

Parrish, M. C., S. Demarais, T. B. Wigley, P. D. Jones, A. W. Ezell, and S. K. Riffell. 2017. Breeding bird communities associated with land cover in intensively managed pine forests of the southeastern U.S. Forest Ecology and Management 406:112–124.

Pasari, J. R., T. Levi, E. S. Zavaleta, and D. Tilman. 2013. Several scales of biodiversity affect ecosystem multifunctionality. Proceedings of the National Academy of Sciences 110:10219–10222.

Phalan, B., M. Onial, A. Balmford, and R. E. Green. 2011. Reconciling food production and biodiversity conservation: land sharing and land sparing compared. Science 333:1289–1291.

Phalan, B. T., J. M. Northrup, Z. Yang, R. L. Deal, J. S. Rousseau, T. A. Spies, and M. G. Betts. 2019. Impacts of the Northwest Forest Plan on forest composition and bird populations. Proceedings of the National Academy of Sciences of the United States of America: 116 (8) 3322-3327.

Pirard, R., L. Dal Secco, and R. Warman. 2016. Do timber plantations contribute to forest conservation? Environmental Science & Policy 57:122–130.

Pommerening, A., and S. Murphy. 2004. A review of the history, definitions and methods of continuous cover forestry with special attention to afforestation and restocking. Forestry 77:27–44.

Puettmann, K. J., K. D. Coates, and C. C. Messier. 2008. A Critique of Silviculture: Managing for Complexity. First edition.

Puettmann, K. J., S. M. Wilson, S. C. Baker, P. J. Donoso, L. Drössler, G. Amente, B. D. Harvey, T.

Knoke, Y. Lu, S. Nocentini, and others. 2015. Silvicultural alternatives to conventional even-aged forest management-what limits global adoption? Forest Ecosystems 2:8.

Radford, J. Q., and A. F. Bennett. 2004. Thresholds in landscape parameters: occurrence of the whitebrowed treecreeper Climacteris affinis in Victoria, Australia. Biological Conservation 117:375–391.

Ralph, C. J., S. Droege, and J. S. Sauer. 1995. Monitoring Bird Populations by Point Counts. Page 191. General Technical Report, U.S. Department of Agriculture, Forest Service, Albany, CA, USA.

Rametsteiner, E., and A. Whiteman. 2014. State of the world's forests; enhancing the socio-economic benefits from forests. Food and Agriculture Organization of the United Nations, Rome, Italy.

Ricketts, T. H., K. B. Watson, I. Koh, A. M. Ellis, C. C. Nicholson, S. Posner, L. L. Richardson, and L. J. Sonter. 2016. Disaggregating the evidence linking biodiversity and ecosystem services. Nature Communications 7:1-8.

Rivers, J. W., A. L. Liebl, J. C. Owen, L. B. Martin, and M. G. Betts. 2012. Baseline corticosterone is positively related to juvenile survival in a migrant passerine bird. Functional Ecology 26:1127–1134.

Rivers, J. W. 2014. The intensive forest management study: avian demography crewbook. Page 106.

Rivers, J. W., C. L. Mathis, A. R. Moldenke, and M. G. Betts. 2018. Wild bee diversity is enhanced by experimental removal of timber harvest residue within intensively managed conifer forest. GCB Bioenergy 10:766–781.

Rivers, J. W., J. Verschuyl, C. J. Schwarz, A. J. Kroll, and M. G. Betts. 2019. No evidence of a demographic response to experimental herbicide treatments by the White-crowned Sparrow, an early successional forest songbird. The Condor 121:duz004.

Root, H. T., and M. G. Betts. 2016. Managing Moist Temperate Forests for Bioenergy and Biodiversity. Journal of Forestry 114:66–74.

Root, H. T., J. Verschuyl, T. Stokely, P. Hammond, M. A. Scherr, and M. G. Betts. 2016. Plant diversity enhances moth diversity in an intensive forest management experiment. Ecological Applications 27: 134–142.

Rota, C. T., R. J. Fletcher Jr, R. M. Dorazio, and M. G. Betts. 2009. Occupancy estimation and the closure assumption. Journal of Applied Ecology.

Royle, J. A. 2004. N-Mixture Models for Estimating Population Size from Spatially Replicated Counts. Biometrics 60:108–115.

Runting, R. K., B. W. Griscom, M. J. Struebig, M. Satar, E. Meijaard, Z. Burivalova, S. M. Cheyne, N. J. Deere, E. T. Game, F. Putz, and others. 2019. Larger gains from improved management over sparing–sharing for tropical forests. Nature Sustainability 2:53.

Saatchi, S. S., N. L. Harris, S. Brown, M. Lefsky, E. T. Mitchard, W. Salas, B. R. Zutta, W. Buermann, S. L. Lewis, S. Hagen, and others. 2011. Benchmark map of forest carbon stocks in tropical regions across three continents. Proceedings of the national academy of sciences 108:9899–9904.

Sedjo, R. A. 1999. Planted Forests: Contribution to the Quest for Sustainable Societies. New Forests 17:339–359.

Seymour, R. S., and M. L. Hunter. 1992. New forestry in eastern spruce-fir forests: principles and applications to Maine.

Sickinger, T. 2019, November 20. Oregon loses $1 billion timber lawsuit to rural counties. The Oregonian.

Spies, T. A., J. W. Long, S. Charnley, P. F. Hessburg, B. G. Marcot, G. H. Reeves, D. B. Lesmeister, M. J. Reilly, L. K. Cerveny, P. A. Stine, and M. G. Raphael. 2019. Twenty-five years of the Northwest Forest Plan: what have we learned? Frontiers in Ecology and the Environment 17:511–520.

Stan Development Team. 2015. 2015. Stan Modeling Language User's Guide and Reference Manual, Version 2.9.0.

Stokely, T. D. 2014. Interactive effects of silvicultural herbicides and cervid herbivory on early seral plant communities of the northern Oregon Coast Range. Oregon State University.

Stokely, T. D., and M. G. Betts. 2019. Deer-mediated ecosystem service versus disservice depends on forest management intensity. Journal of Applied Ecology 57:31-42.

Stokely, T. D., U. G. Kormann, and M. G. Betts. 2020. Synergistic effects of wild ungulates and management intensification suppress native plants and promote exotics. Forest Ecology and Management 460: 117772.

Stokely, T. D., J. Verschuyl, J. C. Hagar, and M. G. Betts. 2018. Herbicides and herbivory interact to drive plant community and crop-tree establishment. Ecological Applications 28: 2011–2023.

Swanson, M. E., J. F. Franklin, R. L. Beschta, C. M. Crisafulli, D. A. DellaSala, R. L. Hutto, D. B. Lindenmayer, and F. J. Swanson. 2011. The forgotten stage of forest succession: earlysuccessional ecosystems on forest sites. Frontiers in Ecology and the Environment 9:117–125.

Tallis, H. M., P. L. Hawthorne, S. Polasky, J. Reid, M. W. Beck, K. Brauman, J. M. Bielicki, S. Binder, M. G. Burgess, E. Cassidy, and others. 2018. An attainable global vision for conservation and human well-being. Frontiers in Ecology and the Environment 16:563–570.

Tang, M., C. J. Hardman, Y. Ji, G. Meng, S. Liu, M. Tan, S. Yang, E. D. Moss, J. Wang, C. Yang and C. Bruce. 2015. High-throughput monitoring of wild bee diversity and abundance via mitogenomics. Methods in Ecology and Evolution 6(9):1034-1043.

Tilman, D., and M. Clark. 2014. Global diets link environmental sustainability and human health. Nature 515:518–522.

Tittler, R., E. Filotas, J. Kroese, and C. Messier. 2015. Maximizing conservation and production with intensive forest management: it's all about location. Environmental management 56:1104–1117.

Tittler, R., C. Messier, and A. Fall. 2012. Concentrating anthropogenic disturbance to balance ecological and economic values: applications to forest management. Ecological Applications 22:1268–1277.

Tittler, R., C. Messier, and R. C. Goodman. 2016. Triad forest management: local fix or global solution. Pages 33–45 Ecological Forest Management Handbook.

Ung, C.H., P. Bernier, and X.J. Guo. 2008. Canadian national biomass equations: new parameter estimates that include British Columbia data. Canadian Journal of Forest Research 38: 1123-1132.

Ure, D. C., and C. Maser. 1982. Mycophagy of red-backed voles in Oregon and Washington. Canadian Journal of Zoology 60:3307–3315.

USFWS (US Fish and Wildlife Service). 2012. Endangered and threatened wildlife and plants; designation of revised critical habitat for the Northern Spotted Owl: final rule. Pages 71876–72068.

Villard, M.-A., and B. G. Jonsson. 2009. Tolerance of focal species to forest management intensity as a guide in the development of conservation targets. Forest Ecology and Management 258:S142–S145.

Wagner, R. G., K. M. Little, B. Richardson, and K. Mcnabb. 2005. The role of vegetation management for enhancing productivity of the world's forests. Forestry 79:57–79.

Walters, K. R., U. Feunekes, A. Cogswell, and E. Cox. 1999. A forest planning system for solving spatial harvest scheduling problems. Page 8. Remsoft.

Ward, C., and T. Erdle. 2015. Evaluation of forest management strategies based on Triad zoning. The Forestry Chronicle 91:40–51.

Wiens, J. A. 1989. Spatial Scaling in Ecology. Functional Ecology 3:385–397.

Wilsey, B. J., and C. Potvin. 2000. Biodiversity and ecosystem functioning: importance of species evenness in an old field. Ecology 81:887–892.

Wilson, B. T., C. W. Woodall, and D. M. Griffith. 2013. Imputing forest carbon stock estimates from inventory plots to a nationally continuous coverage. Carbon Balance and Management 8:15.

With, K. A., and T. O. Crist. 1995. Critical thresholds in species' responses to landscape structure. Ecology 76:2446–2459.

Yamaura, Y., D. Lindenmayer, Y. Yamada, H. Gong, T. Matsuura, Y. Mitsuda, and T. Masaki. 2019. A spatially explicit empirical model of structural development processes in natural forests based on climate and topography. Conservation Biology.

Yamaura, Y., Y. Shoji, Y. Mitsuda, H. Utsugi, T. Tsuge, K. Kuriyama, and F. Nakamura. 2016. How many broadleaved trees are enough in conifer plantations? The economy of land sharing, land sparing and quantitative targets. Journal of applied ecology 53:1117–1126.

Yegorova, S., M. G. Betts, J. Hagar, and K. J. Puettmann. 2013. Bird-vegetation associations in thinned and unthinned young Douglas-fir forests 10years after thinning. Forest Ecology and Management 310:1057–1070.

Yoshii, C., Y. Yamaura, M. Soga, M. Shibuya, and F. Nakamura. 2015. Comparable benefits of land sparing and sharing indicated by bird responses to stand-level plantation intensity in Hokkaido, northern Japan. Journal of forest research 20:167–174.

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.

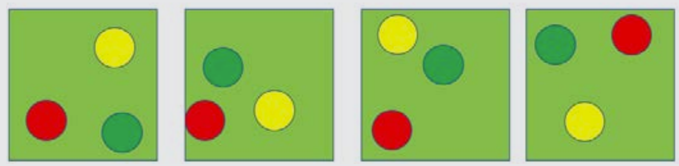


Figure 13a. *Nested study design for the question of whether ecological forestry techniques result in similar habitat quality in old versus young stands, both in relation to unharvested controls. This research is relevant because ecological forestry is being implemented on BLM land in stands up to 150 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.

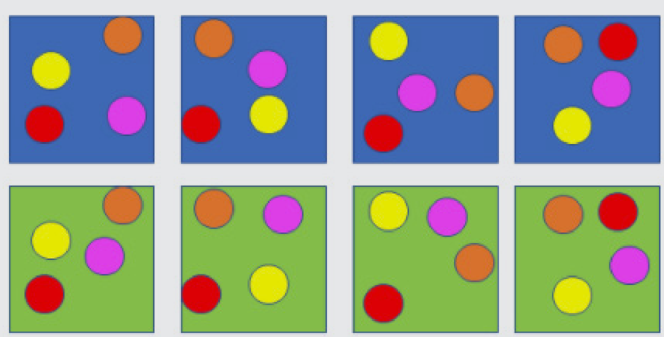


Figure 13b. *Nested study design for the examination of how plantations of different tree species diversity effects yield. These sorts of experiments are of particular importance over the long term to determine whether the current prevalent approach of Douglas-fir monocultures is a risky strategy in 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.

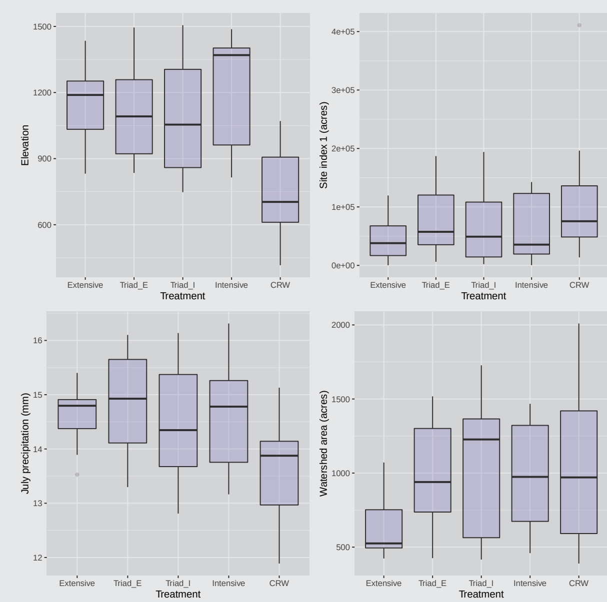


Figure 9a. *Tests for whether lack of fully random subwatershed-scale treatments at the Elliott resulted in any substantial confounding between treatments and other underlying features at the Elliott State Forest. If this were the case, it would be possible to misattribute treatment effects when in fact 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.