Endangered Species Act Section 7(a)(2) Biological Opinion and Magnuson–Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for the

Issuance of a Section 10 Incidental Take Permit for the Elliott State Research Forest Habitat Conservation Plan

NMFS Consultation Number: WCRO-2024-03430

Action Agency: National Marine Fisheries Service

Affected Species and NMFS' Determinations:

ESA-Listed Species	Status	Is Action Likely to Adversely Affect Species?	If likely to adversely affect, Is Action Likely to Jeopardize the Species?	Is Action Likely to Adversely Affect Critical Habitat?	If likely to adversely affect, is Action Likely to Destroy or Adversely Modify Critical Habitat?
Oregon Coast coho salmon (*Oncoryhnchus kisutch*)	Threatened	Yes	No	Yes	No
Southern Distinct Population Segment Pacific eulachon (*Thaleichthys pacificus*)	Threatened	No	No	No	No
Southern Distinct Population Segment North American Green Sturgeon (*Acipenser medirostris*)	Threatened	No	No	No	No
Southern Resident Killer Whale (*Orcinus Orca*)	Threatened	No	No	No	No

Fishery Management Plan That Identifies EFH in the Project Area	Does Action Have an Adverse Effect on EFH?	Are EFH Conservation Recommendations Provided?
Pacific Coast Salmon	Yes	Yes

Consultation Conducted By: National Marine Fisheries Service, West Coast Region

Issued By:

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Date: May 27, 2025

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1. INTRODUCTION

This Introduction section provides information relevant to the other sections of this document and is incorporated by reference into Sections 2 and 3, below.

1.1. Background

Under Section 10(a)(2)(A) of the Endangered Species Act (ESA), a nonfederal party or entity may apply to the National Marine Fisheries Service (NMFS) for an incidental take permit (ITP) providing authorization to incidentally take ESA-listed species, meaning that the activity taking the species is incidental to, but is not the purpose of, otherwise lawful activities. The application for an ITP must include a habitat conservation plan (HCP) that describes the impacts from incidental take, includes measures to minimize and mitigate incidental take, demonstrates adequate funding to implement said measures, discusses alternative actions that avoid incidental take, provides reasoning as to why said alternative actions are not being used, and includes any other measures required by the Secretary of Commerce as necessary or appropriate for the purpose of the plan. Each issuance of an ITP by NMFS is subject to evaluation under section 7 of the ESA to ensure that permit issuance will not jeopardize the continued existence of ESA-listed species or destroy or adversely modify their designated critical habitats.

The National Marine Fisheries Service (NMFS) prepared the biological opinion (opinion) and incidental take statement (ITS) portions of this document in accordance with section 7(b) of the Endangered Species Act (ESA) of 1973 (16 U.S.C. 1531 et seq.), as amended, and implementing regulations at 50 CFR part 402.

We also completed an essential fish habitat (EFH) consultation on the proposed action, in accordance with section 305(b)(2) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) (16 U.S.C. 1801 et seq.) and implementing regulations at 50 CFR part 600.

We completed pre-dissemination review of this document using standards for utility, integrity, and objectivity in compliance with applicable guidelines issued under the Data Quality Act (DQA) (section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001, Public Law 106-554). The document will be available at the NOAA Library Institutional Repository [https://repository.library.noaa.gov/welcome]. A complete record of this consultation is on file at NMFS' Oregon Washington Coastal Office.

The Oregon State Land Board (OSLB) establishes policies that provide for the stewardship of the Elliot State Forest, including setting harvest levels. From 1930 to 2017, the Elliott State Forest (ESF) was managed by the Oregon Department of Forestry (ODF) through a contract with the Oregon Department of State Lands (ODSL). In 1995, the first HCP for the ESF was developed to support ITP applications to the U.S. Fish and Wildlife Service (USFWS) for Northern spotted owl (*Strix occidentalis*) for 60 years and marbled murrelet (*Brachyramphus marmoratus*) for 6 years. Part of the 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. The 1995 HCP and ITP are no longer in effect.

Early in the 2000s, ODF began preparing a subsequent long-term HCP, which they publicly released in 2010 along with the Services' draft environmental impact statement (DEIS). The HCP included northern spotted owl, marbled murrelet, Oregon Coast (OC) coho salmon (*Oncorhynchus kisutch*), and other non-listed native invertebrate species. The 2010 draft HCP was not finalized because the State of Oregon decided not to pursue further revisions through the HCP development process, and no ITPs were issued by USFWS or NMFS. In 2011, ODSL and ODF released the ESF management plan, which has guided forest practices since then.

Timber harvest on the ESF has been limited due to the presence of ESA-listed species and their habitat and the need to comply with the ESA with regard to incidental take. Following the 2013 lawsuit, the OSLB and ODSL pursued developing solutions for meeting ESA obligations and revenue requirements.

In 2017, the OSLB terminated the management contract with ODF for the ESF. In December 2018, the OSLB directed ODSL to work with Oregon State University to explore the potential for the ESF to become a publicly owned research forest. In December 2020, the OSLB endorsed OSU's research design for the ESF.

In April 2022, the Oregon Governor signed Senate Bill 1546, which established the Elliot State Research Forest (ESRF) along with ten management policy directives. One of which directed the ODSL to manage the ESRF to promote collaboration, partnerships, and inclusive public processes and equity, consistent with an applicable HCP, as approved by the Services as well as a forest management plan, to be approved by the OSLB. At present ESRF is managed by ODSL.

Since 2017 NMFS has been engaged with ODSL and USFWS in development of an HCP to support ODSL's applications for ITPs under ESA section 10(a)(2)(A) for marbled murrelet, northern spotted owl, and OC coho salmon.

1.2. Consultation History

On October 10, 2022, NMFS received an application for an ITP from ODSL for incidental take of OC coho salmon for forest management and research activities conducted on the ESRF. The application included a draft HCP, which has been revised and updated by ODSL in collaboration with the NMFS and USFWS (Services). The ODSL submitted the final ESRF HCP on December 20, 2024, completing their ITP application. NMFS conducts section 7 consultation on its issuance of an ITP to ensure the issuance does not jeopardize the continued existence of ESA-listed species or destroy or adversely modify the critical habitat of ESA-listed species. NMFS initiated ESA section 7 consultation on December 20, 2025.

Updates to the regulations governing interagency consultation (50 CFR part 402) were effective on May 6, 2024 (89 Fed. Reg. 24268). We are applying the updated regulations to this consultation. The 2024 regulatory changes, like those from 2019, were intended to improve and clarify the consultation process, and, with one exception from 2024 (offsetting reasonable and prudent measures), were not intended to result in changes to the Services' existing practice in implementing section 7(a)(2) of the Act. 89 Fed. Reg. at 24268; 84 Fed. Reg. at 45015. We have considered the prior rules and affirm that the substantive analysis and conclusions articulated in this biological opinion and incidental take statement would not have been any different under the 2019 regulations or pre-2019 regulations.

1.3. Proposed Federal Action

Under the ESA, "action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by federal agencies (see 50 CFR 402.02). The proposed action is NMFS' issuance of an ITP pursuant to section 10(a)(1)(b) of the ESA to ODSL for forestry activities related to management of the ESRF for a permit term of 80 years. Issuance of the ITP would require implementation of the ESRF HCP as documented in the FEIS (USFWS 2025).

The ITP would allow incidental take of Oregon Coast (OC) coho salmon (*Oncorhynchus kisutch*), which is the only covered species in the HCP that NMFS has statutory authority over. Oregon Coast coho salmon were most recently listed as threatened by NMFS on January 20, 2011 (76 FR 35755). Critical habitat was designated for the species, and protective regulations were issued on February 11, 2008 (73 FR 7816).

This opinion includes concurrence that the proposed action is not likely to adversely affect Southern Resident (SR) killer whales (*Orcinus orca*), southern distinct population segment (DPS) Northern American green sturgeon (*Acipenser medirostris*) (hereafter referred to as 'green sturgeon'), southern DPS Pacific eulachon (*Thaleichthys pacificus*) (hereafter referred to as 'eulachon'), and designated critical habitat for SR killer whales and green sturgeon (see section 2.12, *Not Likely to Adversely Affect Determinations*, of this opinion). The ODSL is not requesting incidental take coverage under an ITP for SR killer whales, green sturgeon, and eulachon, and incidental take of these species from the proposed activities is not reasonably certain to occur. However, NMFS is required to consult under section 7 of the ESA for any species that may be affected by the proposed action.

1.3.1 Covered Area

The ESRF HCP includes both the permit and plan areas depicted below. As described in the HCP, the plan area consists of common school fund lands, board of forestry lands, and private inholdings managed by ODSL, Oregon Department of Forestry, and private forest landowners (92,504 acres). ODSL has included lands outside the permit area in the broader plan area to accommodate any future potential land exchanges or other potential agreements between ODSL and adjacent landowners.

The permit area is where ITP coverage would apply and is described as all ODSL-managed lands (83,326 acres) where all covered activities and conservation actions will occur (Figure 1). The permit area also includes waters and streams downstream of ODSL lands that would be affected by the covered activities.

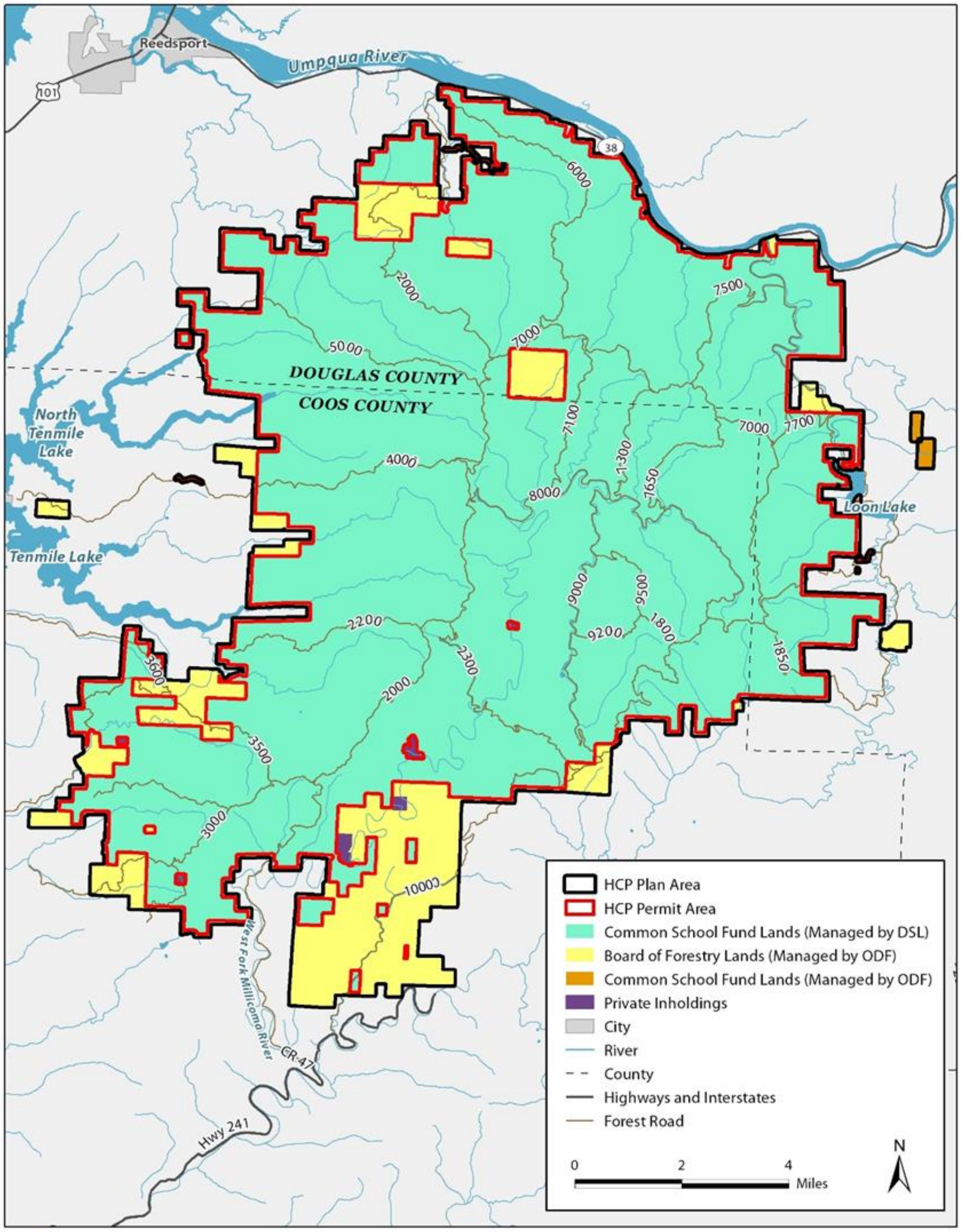

Figure 1. Plan and permit area for the Elliott State Research Forest HCP.

1.3.2 Covered Activities

Chapter 3 of the ESRF HCP describes the projects and activities for which ODSL is seeking take coverage, which are collectively called the covered activities. The covered activities in this HCP broadly correspond to activities regulated through the Oregon Forest Practices Act (OFPA) (Oregon Revise Statutes 527 and Oregon Administrative Rules 629). Chapter 3 of the HCP also describes activities needed to carry out the conservation strategy as described in Chapter 5, *Conservation Strategy,* of the HCP. Below is a summary of the covered activities. For more detail or explanation of the covered activities, see Chapter 3, *Covered Activities*, in the ESRF HCP. Recreational activities and infrastructure, firewood collection, grazing permits, fire suppression, easement use, new water developments, and passive research are activities not covered under the HCP. Application of forest management chemicals such as herbicides or insecticides is also not a covered activity. Therefore, an incidental take exemption is not provided for the application of forest-management chemicals. Use of the ESRF in the permit area by easement holders or other parties (e.g. adjacent landowner's timber harvest and road use, recreational users) for activities not related to or not in support of the HCP are not covered activities because ODSL does not have authority or control over the users actions and when or where they will occur.

Research Relationship to Covered Activities

The ODSL will manage the ESRF under a research framework described in Oregon State University's (OSU) research proposal for the ESRF (OSU 2021) as revised over time and reflected in the HCP (ICF 2024). The ODSL adjusted and modified the research framework in developing the HCP commitments to facilitate collaboration with OSU and other unidentified potential research entities. The covered activities were defined to allow research to occur based on the research framework. Under agreement with ODSL, any research entity that will conduct research in the permit area will be required to implement the covered activities and conservation strategy as described in the HCP (ICF 2024).

A key element of the management strategy for the ESRF is the allocation of lands within the permit area such that operational management of lands within the permit area is consistent over the permit term. The treatments and operational standards described below in the subsequent sections for each allocation type will remain the same over time regardless of the potential variation in research partners and research goals and objectives. The treatments and operational standards for each allocation type are described in Section 3.3, *Stand Level Treatments and Operations Standards, by Allocation*, of the ESRF HCP.

Land Allocations

- Land allocations in the permit area will be part of two broader watershed groups called conservation research watersheds (CRWs) and management research watersheds (MRWs) (Figure 2). Mature forests in the CRWs and MRWs will serve as benchmarks for research in the ESRF. The CRWs stand alone as a single allocation type, while the MRWs will be broken into reserve, extensive forestry, and intensive forestry allocation types. The reserve, extensive, and intensive allocations will be broken down in MRW triad watersheds as follows: Extensive subwatersheds will be 100 percent extensive watersheds;

- Triad-E subwatersheds will be 60 percent extensive; 20 percent intensive, and 20 percent reserves;
- Triad-I subwatersheds will be 20 percent extensive, 40 percent intensive, and 40 percent reserves; and
- Reserves with intensive subwatersheds will be 50 percent intensive and 50 percent reserves.

The remaining allocation types include flexible, flexible extensive, and volume replacement (Figure 3). Within these allocation types is the riparian conservation areas (RCAs) allocation. Operational standards in all allocation types, except RCAs, are expected to be implemented in upland stands outside of the specific RCA widths prescribed by stream type for each land allocation.

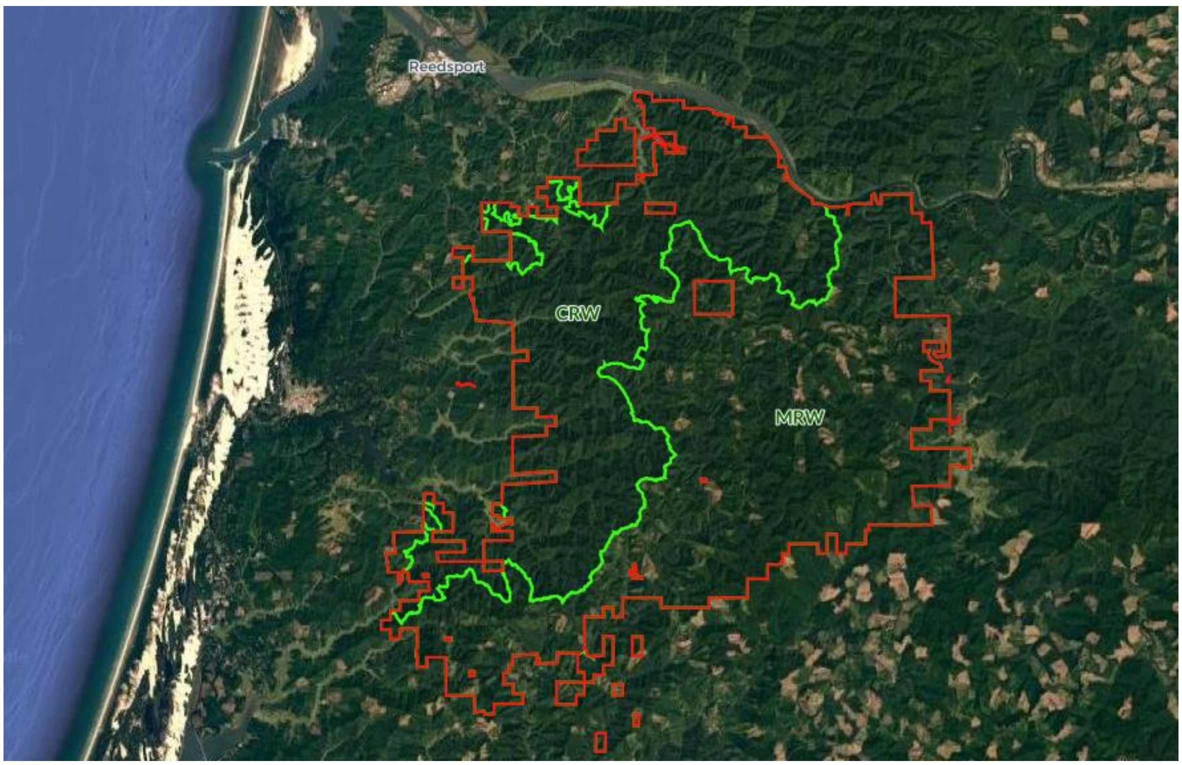

Figure 2. Conservation and Management Research Watershed groups.

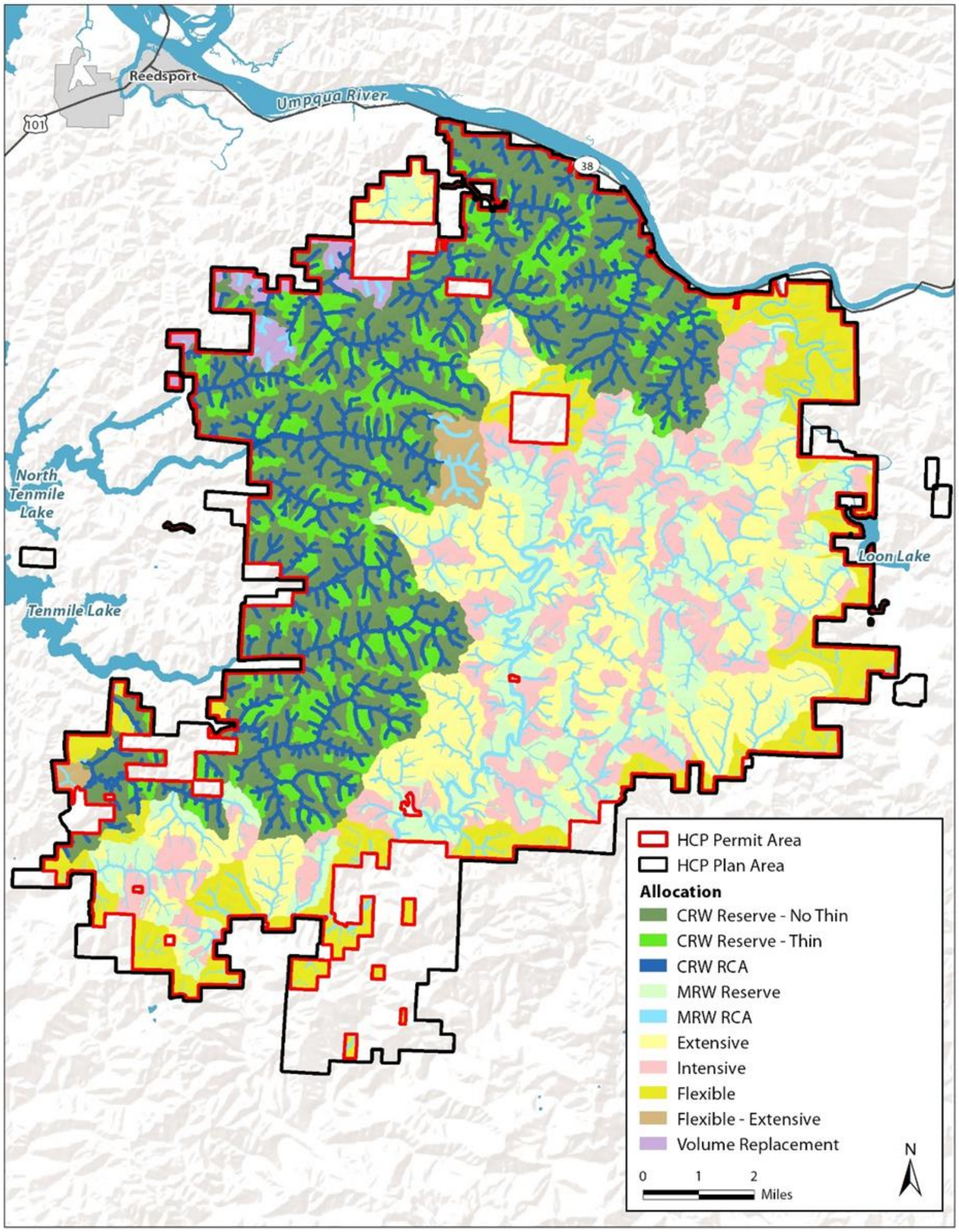

Figure 3. Land allocations in the permit area.

Conservation Research Watersheds. The ODSL will manage the CRWs (33,571 acres) within the context of research with varying thinning treatments across watersheds intended to establish multi-aged stands and improve forest quality and function to support the covered species. However, in the absence of research and a research partner, ODSL will carry out these treatments to meet their commitments in the conservation strategy of the HCP. Depending on conditions, thinning treatments could be composed of one or several of the following treatments: variable-density thinning, including skips and gaps; creating 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 removing invasive species. ODSL will passively manage much of the CRWs (Figure 3; CRW Reserve – No thin). However, ODSL has identified areas within the CRWs where there is a need for focused restoration efforts to enhance the recruitment of mature stands, address legacy effects of management activities (e.g., fish passage barriers, road problems, invasive or reduced native plant diversity), and support natural disturbance dynamics and related resilience (Figure 3; CRW Reserve – Thin). Restoration efforts designed to enhance recruitment of mature stands will consist of thinning of stands 65 years old or younger (as of 2020). ODSL will implement the following operational standards in CRWs:

- In the first few years of implementation, ODSL will assess plantation stands in CRWs that are 65 years old or younger (as of 2020) and design and implement thinning treatments intended to improve forest function and habitat conditions over the permit term. Treatments and controls will be implemented over a range of forest ages (up to 65 years old or younger as of 2020).
- Depending on stand condition prior to harvest, stand age, and experimental design, 20 to 80 percent of the pre-harvest stand density will be removed.
- Thinning will consist of single-entry treatments in the first 20 years of the permit term's 30-year CRW thinning window. Following the initial 20 years of thinning, 3,500 acres of additional thinning treatments (first or second entry) in CRWs may occur up to 30-years into the permit term to allow flexibility in the research design or to meet restoration objectives that were not met during the initial 20 years. Any plantation stand that reaches 80 years old prior to an initial thinning would only be thinned with concurrence from the Services.
- Any second-entry thin or subsequent entries beyond the 3,500 acres of total re-treated stands would only be permitted contingent on ODSL collaborating with the Services and the relevant provisions outlined in Sections 7.6 and 7.2.4 of the HCP (ICF 2024).
- Treatments and controls will be implemented over a range of forest ages (up to 65 years old or younger as of 2020).
- ODSL will manage CRWs for conservation research, habitat restoration and conservation, related and compatible cultural practices, and partnership development.
- Fire suppression in CRWs will occur when fire naturally occurs; however, salvage harvest will not be conducted, unless exempted as described in Section 3.4.2.3, *Salvage Harvest*, of the HCP (ICF 2024), or below in this section of the Opinion.

Management Research Watershed Reserve Allocations. Management in the MRW reserve allocations (11,986 acres) will be the same as that in the CRWs with the exception of when the MRW reserves treatments would occur. Because of the stepwise implementation of restoration thinning in the CRWs and MRW reserves, the MRW reserves will not be subject to the 30-year thinning window cap. Any stand that reaches 80 years old in the MRW reserve allocations prior to thinning will only be thinned with concurrence from the Services.

Management Research Watershed Extensive Forestry Allocations. Management in extensive forestry allocations (10,870 acres) are characterized by partial retention harvest, longer rotation periods between harvests, and reliance on natural tree regeneration. Treatments in extensive forestry allocations will be designed to promote the development of complex forest structure, function, and composition associated with ecological forestry (Franklin et al. 2018). The objectives of management in extensive allocations include promoting new tree growth and the development of a multi-layered canopy structure, accelerating the development of large-diameter trees, fostering understory vegetation development as well as complex early seral habitat, and delaying crown recession.

Factors ODSL will consider during the planning phase for extensive harvest units will include landscape-scale ecological patterns, underlying allocations, the location and arrangement of RCAs, and any related research objectives. Treatments could consist of a combination of thinning for timber production purposes or other stand management objectives, as well as a variable retention regeneration harvest over the permit term. Harvest rotation intervals will depend on monitoring growth and progress towards achieving desired conditions including complex early seral to older forests, with an expected longer rotation age within individual forest stands (average 100-year rotation). Two stand age groups, stands less than 65 years old (as of 2020) and stands between 65 and 150 years old (as of 2020), will be subject to extensive treatments. Stands older than 150 years old will not be treated during the permit term.

Tree retention in extensive allocations will range from 20 to 80 percent of pre-harvest stand density over a variety of spatial and age-class patterns and through a combination of dispersed and aggregated retention approaches described as follows and shown in Figure 4:

- Dispersed – includes uniform and irregular distribution of leave trees within the stand's boundaries; and
- Aggregated – includes retention of trees grouped in patches of the stand boundary coupled with patches of regeneration harvest.

Figure 4. Examples of dispersed (left) and aggregated (right) variable retention harvest in ecological forestry (Franklin et al. 2018) that may be subject of research in extensive allocations.

When conducting treatments in extensive forestry allocations, ODSL will maintain a minimum 20 percent retention of pre-harvest stand density at the sub-watershed level excluding the RCA allocations (described below). At the stand level, ODSL will maintain a 20 percent minimum retention level of pre-harvest stand density including the RCA allocations. The size of harvest units will be determined by operational constraints and treatment objectives. The number of entries and nature of treatments for each stand will be developed as part of biennial operations plans consistent with the HCP (ICF 2024) and the ESRF Forest Management Plan.

ODSL will ensure implementation of the following operational standards to guide stand-level management in extensive forestry allocations:

- Stands aged 65 to 150 years (as of 2020) will receive a single variable retention regeneration harvest, where a portion of the stand will be converted into openings to promote new stand establishment. The remaining portion of the stand will be retained in dispersion or aggregates. Harvest in these stands will be capped at 3,200 acres for the permit term.
    - Regeneration harvest portion:
        - <u>Retention commitments</u> - The ODSL will retain a minimum of 20 percent of the pre-harvest stand density including the RCAs and an average of at least 50 percent (ranging from 20 to 80 percent) of pre-harvest stand density across the totality of extensively managed stands aged 65 to 150 years (as of 2020) over the permit term.
        - The ODSL will conduct up to three entries (not associated with the single variable retention regeneration harvest) across the regeneration portion of the stand. Thinning treatments may occur before or after the variable retention regeneration harvest. Once the ecological forestry stand objective is met, subsequent thinning treatments will not occur.
        - Thinning treatments will not be subject to the 3,200-acre limit as long as they occur on the same acres as that harvest but remain subject to meeting the retention commitments stated above.
    - Retention portion:
        - The stand area that is retained will not be eligible at a later date for variable retention regeneration harvest and would generally be grown forward *in situ*. However, this part of the stand will be eligible for up to three thinning entries in order to achieve extensive forestry objectives described above, but will also be subject to meeting the retention commitments above.
        - The ODSL may conduct harvest in the retention portion of a stand to achieve a minimum of 25 percent in the aggregated pattern (Figure 4, right)
- Stands aged 65 years or younger (as of 2020): The ODSL may thin these stands up to three times prior to or following variable retention regeneration harvest to promote increased tree size diversity, accelerate the development of large-diameter trees, or to maintain complex early seral or other desired conditions associated with extensive forestry objectives.

    - Harvest and thinning activities will be based on an average 100-year rotation for extensively managed stands across the permit area, with longer rotation ages expected within individual forest stands.
    - Retention commitment - For stands aged 65 years or younger (as of 2020), the ODSL will retain from 20 to 80 percent of pre-harvest stand density including RCAs adjacent to the stand.

In addition to the stand-specific standards above, the following general standards will be implemented during extensive allocation management planning and implementation:

- In retention areas, ODSL will conserve existing multi-layered mature or old-growth forests already functioning according to extensive forestry objectives. The ODSL will prioritize retention in aggregated and dispersed retention areas consistent with the following:
    - Retention of large, mature trees prioritized based on a combination of factors, including diameter at breast height, bole and bark characteristics, tree height, and crown and branching characteristics that are underrepresented across the stand or that typically support covered species.
    - The development of riparian forests that emulate their critical roles in natural disturbance, fully integrate with upland management, and maintain critical ecological processes that benefit OC coho salmon.
- At the subwatershed level, retention maintains a minimum of 20 percent pre-harvest density, not including any RCA allocations already present in the subwatershed.
- Salvage may occur in stands affected by natural disturbances such as fire, drought, disease, wind, and insects as described in Section 3.4.2.3 of the HCP (ICF 2024).

Management Research Watershed, Intensive. Management in intensive allocations (9,858 acres) will emphasize wood fiber production at rotations of 60 years or longer and emulate conventional even-aged forestry practices. Treatment methods will consist of regeneration harvest in the form of clear-cuts and commercial thinning intended to develop a new age cohort in a stand. ODSL will use clear-cut harvest treatments to research approaches and impacts related to maximizing wood production. After clear-cut harvest, stands will be replanted at densities sufficient to ensure stand establishment. Clear-cuts and commercial thinning in intensive allocations will meet snag and green tree retention standards as described in the OFPA. ODSL will implement the following operational standards in intensive allocations:

- Harvest will only occur in stands that are 65 years old or younger (as of 2020).
- Even-aged management will follow a 60-year rotation cycle.
- Post-harvest site preparation and vegetation control practices will ensure seedling establishment and initial stand growth.
- One to two commercial thinning treatments will be conducted 25 to 50 years after harvest activities to maintain stand densities at levels that provide vigorous tree growth and high wood production.
- No more than 7,000 acres would be thinned to the maximum percentage thinned (80 percent of the original pre-harvest stand density). Thinning would not exceed 80 percent of the original pre-harvest stand density without concurrence from the Services and in accordance with Section 7.6, *Modifications to the HCP*, of the HCP (ICF 2024).

- Salvage may occur in stands affected by natural disturbances such as fire, drought, disease, wind, and insects as described in Section 3.4.2.3, *Salvage Harvest*, in the ESRF HCP (ICF 2024).

Volume Replacement. With one exception, stands in these allocations (943 acres) will be managed the same as reserves. If modeled potential marbled murrelet habitat within extensive allocations is found to be occupied and ineligible for harvest an equivalent acreage of volume replacement allocations would become available for extensive allocation treatment. ODSL did not specify which acres of volume replacement allocation acres would be potential marbled murrelet habitat to be managed as extensive or which acres would be managed as reserves. Thus, for the purposes of our analysis, we will assume that all acres of volume replacement will be managed as extensive allocations.

Flexible. The ODSL will manage stands in flexible allocations based on their age. ODSL proposes that stands aged 65 years and younger (as of 2020) will be available for intensive, extensive, tribal holistic, longer rotation forestry, or other treatment types. Stands greater than 65 years old (as of 2020) will be available for extensive, tribal holistic, or longer rotation forestry treatments. Flexible allocations are shown in Figure 3 and are primarily located at the outer edges of the permit area. Figures 5 and 6 show the stand ages and the treatment types that will apply across the permit area and in the flexible allocations (intensive or extensive). Flexible allocations managed as intensive will be subject to the operational standards described above for intensive allocations and those managed as extensive will be subject to the operational standards described above for extensive allocations. Harvest in flexible allocation stands greater than 65 years old (as of 2020) will count toward the 3,200-acre harvest cap described above for stands in extensive allocations between 65 and 150 years old (as of 2020). Salvage may occur in flexible allocation stands affected by natural disturbances such as fire, drought, disease, wind, and insects as described in Section 3.4.2.3 of the HCP (ICF 2024).

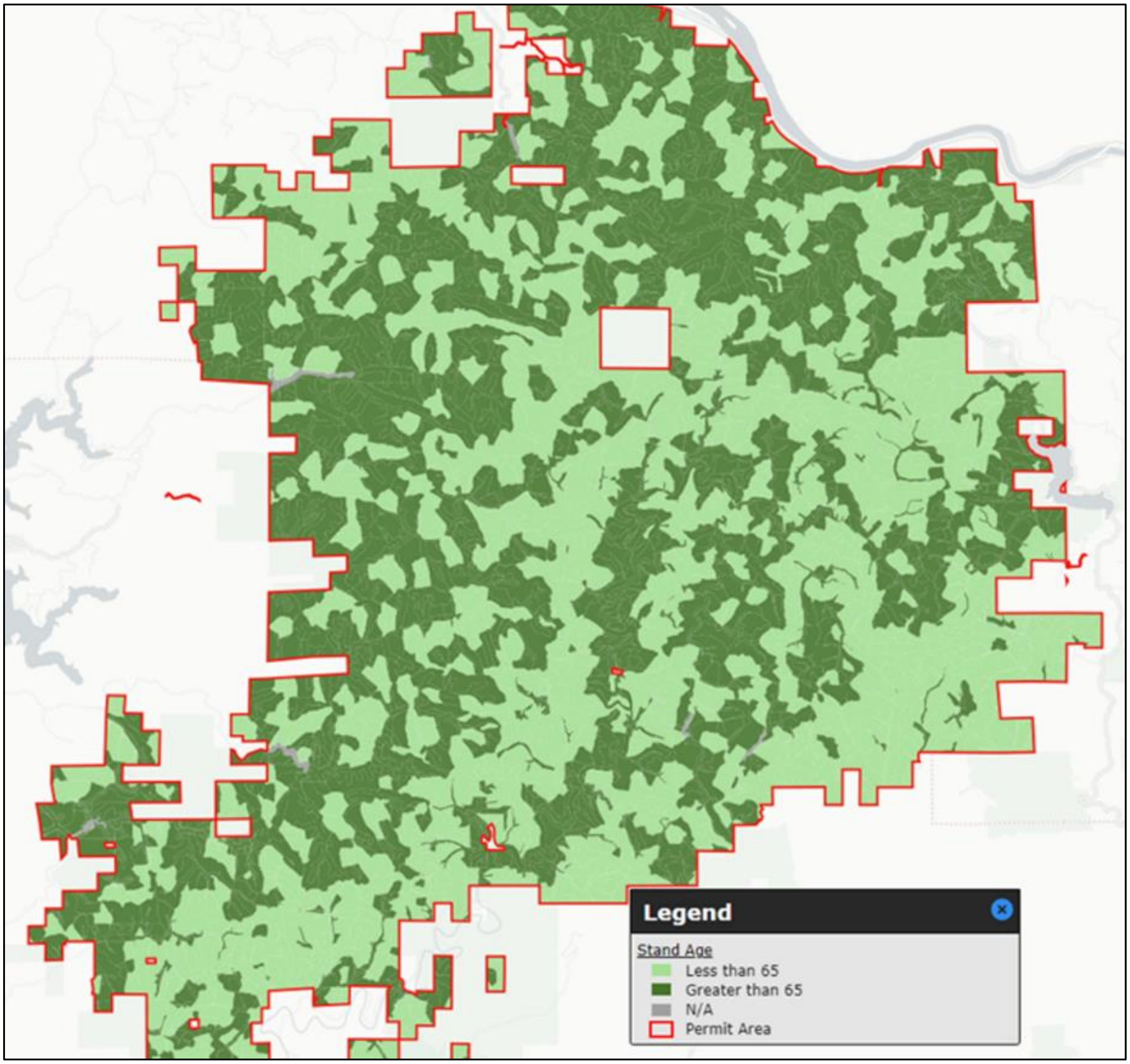

Figure 5. Timber stands in the permit area that are 65 years or younger or greater than 65 years old as of 2020.

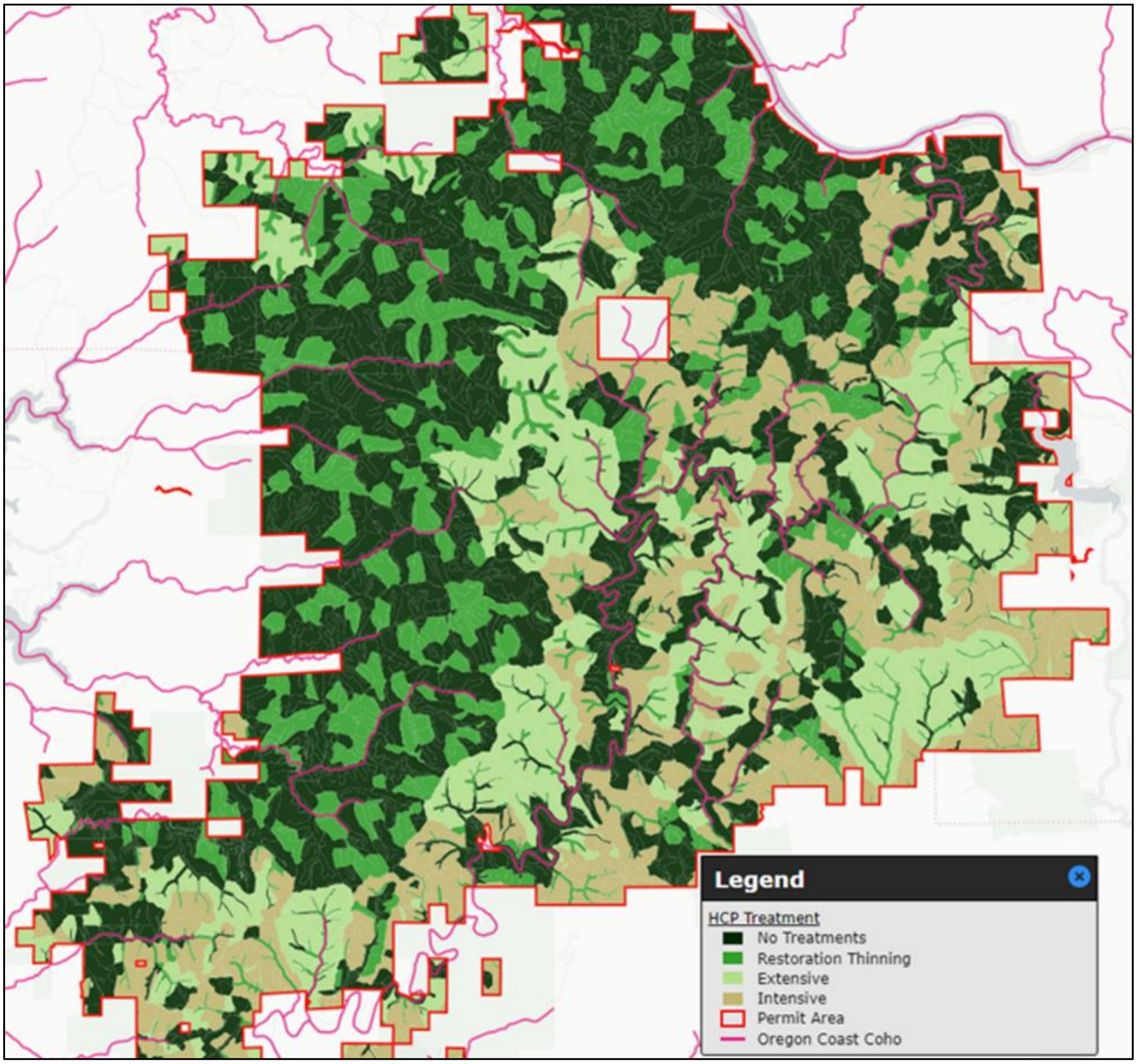

Figure 6. Stand treatments across the permit area. Violet lines indicate OC coho salmon distribution in the permit area.

Flexible Extensive. Flexible extensive allocations will be subject to the same operational standards described above for extensive allocations except that rotation ages may exceed 100 years on average. Salvage may occur in Flexible allocation stands affected by natural disturbances such as fire, drought, disease, wind, and insects as described in Section 3.4.2.3 of the HCP (ICF 2024).

Riparian Conservation Areas. The focus of management activities in RCAs is to restore and maintain key ecological processes that influence the productivity of aquatic ecosystems and associated resources. Research will consider the size, extent, and arrangement of RCAs and adjacent treatments to optimize wood production, aquatic protections, restoration potential, and other important values. Thinning will only occur in the RCAs and the sale of logs that are not left on-site as part of the restoration design may occur to offset the cost of thinning treatments. The RCA widths vary in size and configuration according to stream type and upslope allocation. Stream types were delineated using methodology described in OSU (2020). For fish bearing streams, OSU (2020) defined the upper extent of fish distribution as having a gradient of 20% or less. This resulted in a fish-bearing network that is approximately 20 percent (70 miles) longer than that previously defined on the ESRF by the OFPA. RCA widths are delineated as the horizontal distance from the outer edge of the channel migration zone and in reference to a site potential tree height of 200 feet, per local Bureau of Land Management data.

The ESRF HCP defines stream types as fish bearing (FB), perennial non-fish bearing (PNFB), high landslide delivery potential (HLDP),[1] and non-fish-bearing non-perennial (XNFB)[2] streams. The RCA widths by stream type for each allocation are shown in Table 1. Within the MRWs in the Millicoma River watershed, expanded RCAs are proposed because of the distinct relative values of the Millicoma River to the Coos River population of OC coho salmon.

Table 1. Widths of RCAs by stream type and adjacent allocation. Widths are measured in horizontal distance (feet) from the outer edge of the channel migration zone.

Stream Type	CRW Reserves	MRWs			Volume Replacement	Flexible	Flexible Extensive	WF Millicoma River
		MRW Extensive	MRW Intensive	MRW Reserves				
FB	200	100	100	100	200	120	200 (Big Cr.)[a] 120 (outside Big Cr.)	200 (mainstem) 120 (non-mainstem)
PNFB	200	50	50	50	200	50	200 (Big Cr.)	50
HLDP	200	50	50	50	200	50	200 (Big Cr.)	120
XNFB	0	0	0	0	0	0	0	0

[a] Big Creek subwatershed

Potential RCA thinning projects include silvicultural treatments such as reducing the density of conifers, 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, restoration of cedar in suitable habitat areas, or other similar practices designed to improve aquatic and riparian conditions within RCAs. Operational standards for restoration thinning that will apply in RCAs include:

- The ODSL may conduct restoration thinning in RCAs that are 65 years old or younger (as of 2020) as part of a research project.
- The ODSL may conduct thinning treatments in up to 1,200 acres of RCAs across the permit area.
- Up to two restoration thinning entries per RCA unit may occur on up to 50 percent of the 1,200 acres of RCAs over the permit term whereas the remaining 50 percent will be single entry thins.

[1] HLDP streams are non-fish-bearing streams with the highest modeled potential to deliver wood to fish-bearing streams and were identified using models based on Benda and Dunne (1997) and Miller and Burnett (2008).
[2] XNFB streams are non-fish-bearing, seasonal or intermittent streams that have low potential to deliver wood to coho salmon habitat streams. XNFB streams are often located in the headwalls of stream networks.

- Variable thinning will be designed to retain the largest trees in the RCA unit and a minimum density of 40 square feet of conifer basal area per acre.
- No intensive stand-replacement management will occur within RCAs.
- Restoration thinning in RCAs on slopes greater than 40 percent will be completed predominantly with hand felling methods, but ground-based equipment may be used on slopes less than 40 percent.
- Thinning in RCAs in CRWs will be subject to the 30-year restoration thinning window described above in the *MRW, extensive forestry allocation* section. However, it is expected that 60 to 70 percent of the potential sites, concentrated in the CRW, will be treated in the first 20-years of the permit term.
- RCA stands older than 80 years (at the time of any considered thinning) will not be eligible for thinning without prior discussion with and concurrence of the Services pursuant to Section 7.6 of the HCP.
- Thinning of RCAs in the MRW will not be subject to the 30-year limitation (see Section 3.4.2.2, *Riparian Conservation Areas* of the HCP [ICF 2024]) but would adhere to the limitation on number of entries and 80-year stand age limit.

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

Equipment Limitation Zones. Equipment Limitation Zones (ELZ) along OFPA designated stream types (OAR 629-600-0100; Type F, SSBT, N, Np, and Ns streams) are intended to protect ecological functionality by limiting ground disturbance from ground-based and cable yarding equipment operation, tethered equipment, shovel-logging, ground- skidding, or similar equipment directly within these zones. The OFPA limits equipment operations but does not exclude the direct cutting and removal of trees from these zones. ELZs apply to the area that is within 35 feet (measured horizontally from the stream channel edge) of the stream channel edge on both sides. ODSL will comply with the following measures to minimize ground disturbance in ELZs:

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

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

Harvest Timing

ODSL has proposed limits on the amount of commercial harvest by treatment type and timeframe, which will apply to acres sold (contracted) for commercial harvest. Timber sales from all treatments will not exceed 1,000 acres per year based on a 4-year rolling average of contracted sales. Of these 1,000 acres, no more than 480 acres per year will be from regeneration (clearcuts or retention cuts) harvest as part of intensive treatments in Intensive and Flexible allocations. The 1,000-acre limit will include a mix of intensive, extensive, and restoration treatments.

The 1,000-acre limit does not apply to restoration thinning., ODSL may conduct restoration thinning in plantation stands in CRW and MRW reserves and RCAs on up to 300 acres per year for the first 20 years of the permit term and 200 acres per year during years 21 to 30 of the permit term to enhance covered species habitat needs. While this additional restoration thinning may not occur on an annual basis, NMFS will assume that the sale of 300 additional acres for restoration thinning for the first 20 years of the permit term and 200 additional acres for years 21 to 30 will occur annually for the purposes of our effects analysis. While this additional restoration thinning allowance beyond the 1000-acre limit will expire after the initial 30 years of the permit term, it should be noted that restoration thinning outside the CRW (i.e., MRW Reserves and MRW RCAs) are not subject to the 30-year time limit, as noted in Section 3.3.1. However, as also noted in Section 3.3.1 and elsewhere in the HCP (ICF 2024), restoration thinning may occur in stands that have reached 80 years old (at the time of any contemplated thinning) with prior concurrence from the Services.

RCA thinning may occur in 1,200 acres across the permit area and may occur in the first 30 years of the permit term. The ODSL will conduct the first RCA thinning project in the first 5-7 years of the permit term in 160 acres of an MRW.

The use of acres sold (contracted) recognizes that timber sale contracts routinely allow actual harvest to occur over a 3-year period following the sale, at the discretion of the contractor. This standard practice can (and often does) result in a variable number of acres harvested in any given year of a contract.

Salvage Harvest

Salvage harvest is the removal of timber in the aftermath of a natural disturbance event that affects forest health, such as insect infestations, 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 clear-cut harvest, depending on the magnitude of the disturbance event and forest management goals. Salvage harvest may occur in intensive, extensive, volume replacement, flexible-extensive, and flexible allocations consistent with the treatment standards described and in Section 3.3, *Stand-Level Treatments and Operation*

Standards by Allocation, of the ESRF HCP (ICF 2024). Salvage harvest will not occur in CRW and MRW Reserve stands or RCAs, with the following exceptions:

- Limited roadside tree removal needed to maintain public access and forest operations
- Selective removal of cedar trees for indigenous cultural practices
- If an introduced, non-native insect or disease is found and removal of trees can help control it

Harvest Methods

Harvest methods include felling, bucking, yarding, processing, loading of logs, and hauling. Felling means cutting down trees. Bucking means cutting felled trees in the field into predetermined log lengths to maximize tree value. Trees may also be felled and yarded to be processed and manufactured into logs on a landing or road. Equipment used for felling and bucking trees includes:

- Handheld chainsaws.
- Feller-bunchers, which are functionally like tracked hoes and use an articulated attachment to grab, fell, and bunch trees or logs for subsequent skidding or transport to a landing.
- Cut-to-length machines, which are used to grab, fell, delimb, and buck trees into logs using processer 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.
- Ground-based yarding involves tracked or rubber-tired tractors (skidders) skidding logs to the landing. Machines can grasp the log using powered grapple attachments or wire-rope winch lines. Ground 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 technique typically occurs in areas where access is limited or very expensive. In helicopter yarding, a cable extending from the helicopter is attached to the logs and used to suspend and move them to the landing area. This technique generally does not disturb soil, although large, separate, cleared landing areas are required for helicopter touchdown.

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

During harvest, ODSL will require contractors to use best management practices for timber harvest. Common techniques include limiting ground equipment activity to gentle slopes and times when soil moisture is low and limiting the amount of area on which ground equipment may operate. Cable and ground equipment operations must minimize gouging and soil displacement. Logging systems that minimize disturbance to existing duff, litter, and woody debris, except where disturbance is desirable to facilitate regeneration, may be used during timber harvest. Live and dead tree retention is used to preserve some of the biological legacy of the previous stand. Logging residue (e.g. limbs, tops, cull logs) is retained to levels that do not prohibit reforestation and do not create an unacceptable fire hazard.

Supporting Management Activities

The ODSL may conduct the following forestry activities within the ESRF:

- 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 OFPA and may include grading, hand-cutting, using a brush-hog-type mechanical device, steaming, and other experimental methods.

- Prescribed burns will follow OFPA requirements. Activities will include single or multiple prescribed burns that incorporate indigenous knowledge to manage fuels and increase or maintain suitable conditions for species of cultural value to local tribal communities. Prescribed burning of slash piles on landings following harvest, broadcast burning of harvest units for site preparation prior to planting, and/or use of prescribed fire for maintenance of meadows or other habitat may also occur, where appropriate, as part of the research management program. Prescribed burns will not be conducted inside RCAs.
- Yard and burn slash are the residual woody debris that results from timber harvest and thinning. Methods of slash removal include piling and burning, mastication (chipping), and scattering. Piles may be gathered using heavy equipment or by hand. Slash burning will not occur in RCAs.
- While natural reseeding is likely to be pursued as part of research treatments across significant portions of the permit area, trees or shrubs may be planted as part of intensive treatments or when deemed important to restoring native plant diversity, tribal cultural practices, or habitat resilience in the permit area.
- Animal (e.g., mountain beaver [*Aplodontia rufa*]) control techniques will follow ODFW standards and guidelines and will not involve use of rodenticides.
- Precommercial thinning involves thinning where the trees cut are not sold commercially. Precommercial thinning will be generally conducted in stands between 10 and 20 years old to manipulate the density, structure, or species composition of dense stands. Felled trees are typically left on-site, although slash may be burned, as described under yard and burn slash.
- Timber harvest requires landings for log hauling, as described above in the *Harvest Methods* section of this opinion.
- Helicopters are not expected to be regularly required for management in the permit area. However, helicopters may be used as part of riparian restoration projects or other projects in remote locations where movement of heavy objects, such as large wood, is required.
- Fixed-wing aircraft may be used infrequently for a variety of purposes, including collection of remote sensing imagery and related data.
- Heavy equipment use 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.
- Trees may be climbed as part of research and, potentially, as part of monitoring.
- Hazard trees (or "danger trees") are defined as a standing tree that presents a hazard to employees because of 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. 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.
- Chainsaw use and tree felling will be conducted as part of all treatment types.

Road System Construction and Management

Road system management activities are those associated with construction, use, and maintenance of forest roads and associated facilities, mainly landings, drainage structures such as bridges and culverts, and quarries. This category of covered activities also includes the vacating of such facilities. The permit area currently has an extensive road network. Over the course of the permit term, ODSL may construct up to 40 miles of new permanent roads or up to 1.0 mile per year. The ODSL may also construct up to 2.0 miles of temporary roads per year. Temporary roads that have not been vacated after 5 years will be considered part of the permanent road network and count toward the 40-mile limit. There may be some new road spurs constructed to facilitate stand-management activities. There may also be some road relocation to hydrologically 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.

Except in those instances described in Chapter 5, *Conservation Strategy*, of the ESRF HCP (ICF 2024), road construction, maintenance, and vacating will be performed in accordance with the OFPA (OAR 629) and other applicable statutes. The OFPA prescribes the following measures:

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

Road Construction. Roads are most commonly constructed by felling and yarding timber along a predetermined road alignment; excavating or filling hillslope areas using tractors or excavators; constructing watercourse crossings that use culverts, bridges, and fords; and constructing vehicle turnouts and log landings. Road construction also involves surfacing soil roads with rock, lignin, pavement, or other surface treatments.

The principal foreseeable additions to the existing road system include temporary spur roads to access new cutting units. ODSL will construct spur roads with a subgrade width of approximately 16 feet and a 3-foot-wide ditch, for a total typical width of 19 feet. The total disturbance area of the road, including cut-slopes and fill-slopes, will depend on the steepness of the terrain as well as the type of construction used. These roads will typically be vacated once the associated harvest unit is replanted.

Similarly, many existing spur roads that served only to access prior cutting units are expected to be vacated. [3] Up to 1 mile per year of primary or secondary road construction may occur under the HCP, with a total of up to 40 miles of new permanent roads over the permit term. All new roads will be sited in the best locations for carrying out anticipated activities and minimizing impacts on aquatic and riparian systems. The location and design for new forest roads will be suitable for the terrain and type of access needed. Any road expansions will be kept to the minimum needed to achieve forest management objectives. Road stream crossings will be constructed to meet NMFS (2022 or most recent) and ODFW fish-passage requirements.

Road Use. Roads in the permit area will be used for transportation associated with the covered activities and other activities not covered under this HCP (e.g., recreation, infrastructure). The ODSL did not develop transportation volume estimates for road use associated with the covered activities. However, ODSL did estimate the number of truckloads of timber associated with timber harvest as 3,400 truckloads per year assuming an annual harvest of 17 million board feet of timber. Based on even pace of harvest projected, intensive road use would be spread out as mostly temporary, localized use during active harvest and hauling operations.

Road Maintenance. Road maintenance is the maintenance and repair of existing roads that are accessible to motorized vehicle use. Road maintenance includes surface grading, clearing bank slumps, repairing slumping or sliding fills, clearing ditches, repairing or replacing culverts and bridges, adding surface material, dust abatement, and installing or replacing surface-drainage structures. Road maintenance for fire prevention, public access, safety, and timber management also includes mechanical control of roadside vegetation. Mechanical control may include grading, hand or mechanical cutting, using a brush-hog-type mechanical device, steaming, and other experimental methods.

Road Daylighting. The objective of road daylighting is to allow for sunlight exposure that evaporates moisture from the road so it is less susceptible to erosion and damage from vehicular traffic. Areas along forest roads 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 provides vegetation for use by wildlife. The open canopy minimizes roadside crown and ladder fuels, thereby reducing wildfire risk and improving line-of-sight visibility for public safety. Road daylighting will not remove stream-adjacent trees providing riparian shade.

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

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[3] 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 an 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.

ODSL will vacate roads if they deem them non-essential to near-term future management plans, where access would cause excessive resource damage, or where existing resource concerns or ecological values, including hydrological connectivity, can be improved. ODSL will use the road study to determine which roads to vacate. Vacated roads will be left in a condition that is stable and provides adequate drainage.

Drainage Structures. Drainage structures are normally associated with roadways and include channel-spanning structures (culverts and bridged), roadside drainage ditches, and cross-slope drainage culverts. All new drainage structures will be installed and maintained in accordance with applicable laws and regulations. Maintenance or replacement of stream-channel-spanning structures may include work area isolation and fish salvage (capture, handling, and relocation). The ODSL will design and construct stream crossing replacements to be consistent with NMFS fish passage design criteria (NMFS 2022a or most recent). If adhering to fish passage standards is not feasible due to site-specific constraints, ODSL will coordinate with NMFS to design an acceptable fish passage solution.

Under certain conditions natural hazard response may be needed to complete an unplanned, immediate, or short-term repair of a road or culvert. These include in-water repairs that must be made before the next in-water work period to resolve critical conditions that, unless corrected, are likely to cause loss of human life, unacceptable loss of property, or natural resources. Natural hazards in this context may include, but are not limited to, a flood that causes scour erosion and significantly weakens the foundation of a road or bridge; culvert failure due to blockage by fluvial debris, overtopping, or crushing; and ground saturation that causes debris slide, earth flow, or rock fall to cover a road. These actions could be taken outside of ODFW defined in-water work windows (ODFW 2024 or most recent) to prevent damage to property and life. To the extent practicable, measures will be taken prior to any response to limit impacts on coho and its habitat including, but not limited to, removal and relocation efforts. The NMFS will be notified as soon as possible prior to any hazard response and a post-action report will be provided that includes a description of the work performed as well as an assessment of its effects on coho and its critical habitat. If actions in response to natural hazard conditions do not meet NMFS or ODFW fish passage design standards or OFPA road design standards at the time of the emergency repair, then follow-up actions will occur so that the structure meets design standards once the appropriate in-water work window is available.

Barrier Upgrade and Removal. There are currently three blocked culverts and two partially blocked culverts identified in the permit area, with most of these overlapping the Coos independent population. Approximately 2 miles of additional modeled fish habitat is available in the permit area upstream of impassable culverts and 3.5 miles upstream of partially blocked culverts. Over the course of the permit term artificial barriers will be upgraded or removed to increase the amount of habitat accessible to OC coho salmon. Over the course of the permit term up to 50 culverts or bridges are expected to be repaired, replaced, or constructed, resulting in in-water work. No more than three bridges or culverts will be installed/upgraded in a single year. Any new and replaced stream crossings will be designed to meet current NMFS and ODFW passage criteria to maintain upstream and downstream fish passage. Culverts will be located and inventoried as part of the roads study and encountered during harvest, riparian, or thinning treatments. The location of barrier improvement(s) will be informed by the road assessment and determined in conjunction with the Services, watershed councils, and Implementation and Adaptive Management Committee (HCP Section 7.2.4) (ICF 2024).

Landings. Landings are the sites where logs are yarded, processes, 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 those described for road construction, maintenance, use, and vacating. Because of the proximity of reserves to extensive and intensive allocations, landings may be located in reserves to conduct harvest in adjacent harvest units. Typically, a landing area takes up less than 2 percent of a given harvest unit.

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

Quarries

One quarry currently exists in the permit area and is used as a source of rock-slope protection material; up to two such quarries could be built and operational during the permit term. New quarries would only be developed in the MRWs. 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 complaint with requirements of the OFPA (OAR 629-625-0500) and other applicable statutes. Any new quarries would be constructed outside of CRW and MRW reserves and RCAs.

Communication Sites and Lookouts

Throughout the permit term, ODSL will oversee the periodic maintenance of three communication sites that exist within the permit area. Maintenance will include clearing of vegetation, including trees and shrubs. 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 southwestern end of the permit area.

Research

Research activities conducted by ODSL and a research partner include passive and active research. Active research would include physical manipulation of the landscape or resources that may result in altering habitat for covered species. ODSL's research activities will include capturing and handling juvenile OC coho salmon (e.g., surveys and sampling) that is likely to result in the harm and/or harassment of OC coho salmon individuals.

The coho-related potential research focus in the permit area is described in Appendix C of the HCP 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.

Indigenous Cultural Use of Cedar Trees

Cultural use of cedar trees includes the removal or selective use of individual cedar trees over 65 years old (as of 2020) over the course of the permit term. Cedar tree uses include bark peeling and/or tree removal. The following are specific restrictions for removal or selective use of cedar trees for cultural practices:

- This activity would be permitted based on receipt of an application to ODSL from a tribal government or related indigenous entities with ancestral connections to the permit area demonstrating compliance with the activity's intent and condition.
- The geographic scope of this covered activity includes all harvest allocations across the entire permit area.
- Cedar use and removal would not be for the purposes of harvest objectives or revenue related to commercial sale of timber.
- Over the permit term, up to 80 trees could be removed from RCAs, and additional trees from outside the RCAs could be removed if consistent with the following:
    - Sustainability and forest structure objectives for cedar in the permit area (including cedar inventory data development)
    - Location within areas or instances of:
        - Blowdown/windthrow, tree mortality from wildfire or other factors
        - Roadside clearing, construction, or maintenance
        - Management to address human safety
        - Planned research or other treatments within the allocations in the permit area (e.g., extensive, intensive, restoration thinning) where the tree removal would not be inconsistent with retention or other objectives for the planned treatment
    - Exclusion from removal if a tree is:
        - Within marbled murrelet occupied habitat or northern spotted owl core area
        - Situated on landslide-prone slopes or likely to destabilize conditions and promote landslide effects
        - Leaning or situated in a manner that is likely to become an instream log in the near future
- To address the range of potential cultural uses, tree size would not be limited, but tree selection would be limited by compliance with the above criteria.

Conservation Strategy

The conservation strategy includes categories of actions and the following covered activities intended to minimize and mitigate the take of OC coho salmon.

Targeted restoration and stream enhancement. This will include wood placement in stream reaches, which will occur directly in stream channels and adjacent floodplains using equipment such as helicopters, excavators, dump trucks, front-end loaders, full-suspension yarders, and similar equipment. This may involve tree cutting for source wood, which may be conducted in conjunction with upland harvest project. Tree cutting may also be conducted locally for site-specific needs, following all applicable allocation operational standards. Activities under this conservation action may also include beaver habitat improvement projects and road vacating. These projects will occur directly in stream channels and adjacent floodplains.

Road restoration and network reduction. Activities under this conservation action include road vacating, daylighting, and drainage improvement; road relocation and/or design; vacating of roads that are degrading the aquatic environment; road-barrier upgrade and removal; reduction of road drainage to stream; culvert or stream crossing upgrades; traffic reduction; and road surfacing with either crushed rock or paving.

Habitat enhancement for northern spotted owls and marbled murrelets. Habitat enhancement will include commercial and pre-commercial thinning and all stand-level operational standards to improve habitat for northern spotted owls and marbled murrelets. These activities are intended to improve habitat by transitioning established plantation stands to older and more complex forests and accelerate the development of northern spotted owl and marbled murrelet habitat. While this conservation measure is intended for these terrestrial species, where these stands overlap with RCAs or are within one site potential tree height of streams, there is potential that the desired condition of the stands, where achieved, will help minimize and mitigate the impacts of incidental take on OC coho salmon.

1.3.3 Conservation Strategy

The conservation strategy is integrated into the covered activities through the establishment of CRWs and MRWs; establishment of riparian RCAs, operational standards for extensive, intensive, reserve, and RCA allocations; and conservation measures and conditions to minimize effects of forest management (timber harvest, road management, etc.) and research activities on OC coho salmon and their designated critical habitat (section 1.3.2 of this opinion). As stated above, ODSL will manage the permit area consistent with the research framework described in the Elliot State Research Forest Proposal (OSU 2021). As such, ODSL's management of the ESRF aims to investigate the best landscape-scale approaches to providing society with sustainable wood resources without compromising biodiversity, ecosystem function, climate resilience, and social benefits while conserving, enhancing, and sustaining habitats for the covered species and other wildlife. Because of this, the research framework, covered activities, and conservation strategy all tier off of the biological goals and objectives for OC coho salmon described in Section 5.2.3 of the ESRF HCP (ICF 2024). Additional conservation actions not described in section 1.3.2, *Covered Activities*, of the HCP (ICF 2024) are intended to offset the impacts of any take of OC coho salmon that cannot be avoided.

Biological Goals and Objectives

The biological goals and objectives broadly describe the desired future conditions of the ESRF. Each goal steps down to one or more objectives that define how to achieve these conditions in measurable terms. ODSL will measure the success of the HCP against whether these objectives are met on an ongoing basis as regularly reported throughout the permit term. For OC coho salmon, the biological goal and objectives include:

- Goal – Contribute to the persistence of the OC coho salmon ESU directly and indirectly by restoring ecological attributes and processes that benefit multiple life histories of the Tenmile, Coos, and Lower Umpqua independent populations in the permit area and in downstream reaches outside the permit area.
    - Objective 3.1 – Improve the complexity and physical structure within streams by recruiting large wood to OC coho salmon habitat; and
    - Objective 3.2 – Support improvement in water quality and quantity conditions most important to coho salmon as measured by long-term trends in fine sediments in riffles, summer low flows, and stream temperature in the permit area.

Conservation Measures for OC coho salmon

ODSL will implement four conservation actions to minimize and mitigate the impacts of take caused by the covered activities on OC coho salmon and achieve the biological goal and objectives described above. There are three additional conservation measures identified for terrestrial wildlife species that may affect OC coho salmon and their designated critical habitat, but will not be applicable to achieving biological goals objectives for OC coho salmon that are defined in Section 5.4, *Conservation Measures*, of the HCP (ICF 2024).

Conservation Measure 1: Targeted restoration and stream enhancement. Targeted restoration and stream enhancement includes actions to address short-term deficiencies and functional losses in aquatic habitats that support OC coho salmon because of the covered activities. These actions are also intended to improve riparian function to increase aquatic habitat quality and function to support OC coho salmon later in the permit term. These actions will typically occur as part of a larger project but within the project completion timeline. Restoration and stream-enhancement projects within the permit area can be grouped into three categories including in-channel restoration, riparian vegetation management in RCAs, and beaver-related habitat management. Restoration actions will include in-stream placement of logs or whole trees in streams to create pools and to retain spawning gravels, creation or re-creation 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 vacating, and riparian vegetation management.

<u>In-channel Restoration</u>. The Elliott State Forest Watershed Analysis (Biosystems et al. 2003) identified recommendations for restoration projects in the permit area that would address limiting factors for OC coho salmon. During HCP implementation, ODSL will focus on key restoration actions identified in the watershed analysis implementation plan, along with other opportunistic projects, when needed. ODSL will take advantage of existing equipment onsite during harvest operations to conduct restoration actions. 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 and the operation contains wood meeting size requirements for the intended stream. The following guidelines will be considered when planning in-channel restoration and

enhancement projects. These guidelines largely focus on design and implementation of projects to ensure success in achieving the desired outcomes for each project.

- ODSL will coordinate with ODFW and local watershed councils to plan design projects that mimic natural processes and minimize the use of engineered approaches to stream enhancement.
- Project planning and design will consider habitat conditions and stream processes such that project types will be appropriate to address conditions and processes specific to the site and watershed.
- ODSL will design projects so that they reflect the natural dynamics and geomorphology of the site and in consideration of the way in which introduced materials may cause changes to the stream channel. Projects will be implemented in a manner that minimizes potential negative effects on riparian areas.
- Priority will be placed on projects that supplement large wood that is lacking because of previous disturbance events and/ or management activities.
- ODSL will design restoration projects 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 use materials that are expected to be relatively stable yet functional in these dynamic stream systems. The intent is to maximize the functional attributes of large wood and minimize potential conflicts with public safety in downstream reaches. Reliance on artificial anchoring methods (e.g., cables) will be minimized and will only be used in cases of significant concern for public safety.

Riparian Vegetation Management in RCAs. Section 3.3.7, *Riparian Conservation Areas*, and the discussion of RCAs in section 1.3.2, *Covered Activities*, of the HCP (ICF 2024) describes management that ODSL will conduct in RCAs during the permit term and RCA widths by stream type. The intent of the RCAs with respect to OC coho salmon is to minimize effects on individuals and their designated critical habitat, while managing the RCAs with restoration thinning to improve long-term riparian function to increase the quality of aquatic and terrestrial habitats for the covered species. ODSL intends to contribute to the offset of the remaining effects of restoration thinning in RCAs and management treatments outside RCAs, by implementing the following:

- All trees cut within the first 50 feet of all RCAs will be left on the ground, tipped toward or placed into the stream; no trees will be removed; and
- Outside 50 feet, 0 to 20 percent of the volume of cut logs within RCAs will be left on the ground, felled toward, or placed in the stream channel. These will consist of the largest cut trees to provide the greatest ecological benefit to OC coho salmon.

Beaver habitat management. Over the permit term, ODSL may decide that a beaver restoration project should be implemented to benefit OC coho salmon. According to ODSL, 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. ODSL intends to coordinate this work with regional partners, ODFW, USFWS, and NMFS to ensure beaver management actions fit into the larger context of

OC coho recovery and statewide beaver management principles. For Section 7 purposes, in this Opinion we analyze the effects of the implementation of these activities for potential take that could occur from their implementation during the permit term.

Conservation Measure 2: Expanded RCAs on Select MRW Streams.

West Fork Millicoma River. The designated RCAs for the West Fork Millicoma River - from its entry into the permit area in the southwest portion of the permit area through the confluence with Elk Creek (16 miles) - will be 200 feet measured as the horizontal distance from each side of the channel migration zone and 120 feet measured as horizontal distance along any HLDP stream (total of 9 miles) and fish-bearing streams (total of 45 miles) (Miller and Carlson 2024). ODSL included this conservation measure to address the lower amount of wood recruitment expected in the Coos independent population of OC coho salmon, as it is entirely within the MRWs, and thus, the West Fork of the Millicoma River will have more variable RCA widths when compared to rivers on the Tenmile and Lower Umpqua and their independent populations of OC coho salmon.

Volume Replacement Allocations. As described in Chapter 3 of the HCP (ICF 2024) and, *Volume Replacement*, in section 1.3.2 of this Opinion, volume replacement allocations would be available for extensive treatments in the event that extensive allocations become unavailable for harvest because of marbled murrelet occupancy. In these areas, the designated RCAs will be 200 feet (measured as the horizontal distance from each side of the channel migration zone) on fish-bearing streams, HLDP streams, and PNFB streams.

Flexible Extensive Allocations in Big Creek and Palouse Creek Subwatersheds. Flexible Extensive allocations in the Big Creek and Palouse subwatersheds will have designated RCAs that are the same as in the CRW, including a 200-foot RCA (measured as the horizontal distance from each side of the channel migration zone) on fish-bearing streams, HLDP streams, and PNFB streams.

Conservation Measure 3: Reduce Density of Forest Road Network. ODSL's objectives for managing the forest road systems are to keep as much forestland 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.

During the first 12 years of HCP implementation, ODSL will develop a formal assessment of the degree of hydrological connections of current and legacy roads and their primary locations in the permit area. This assessment and monitoring will identify candidate roads for modification to test methods for reducing hydrological connections, restoring ecological function, and long-term monitoring of subsequent habitat impacts. In support of this, ODSL will maintain an inventory of the road networks to identify current and legacy roads that present a risk (e.g. sedimentation, landslide frequency, erosivity, habitat fragmentation) 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. This inventory will also be used to track current and future road density during the permit term.

In addition to the commitment to not exceed construction of 40 miles of permanent new roads over the course of the permit term (Chapter 3), existing roads will be vacated in 10-year increments to reduce net density (relative to current density) by the end of the permit term. The location, method, specific timing, and rate of road-density decreases will be based on actions set forth in biennial operations plans consistent with the HCP, the forest management plan, and 10-year planning projections reviewed and adopted by forest managers in coordination with the HCP implementation and adaptive management committee (described in Section 7.2.4, *Implementation and Adaptive Management Committee of the HCP*) (ICF 2024). The first 10-year planning period will begin after completion of the required road system assessment discussed above. Thus, activities to decrease road densities should commence in the mid to late 2030s. ODSL will emphasize decreases in the road network in CRWs. ODSL will monitor the miles of road vacated and the locations as part of tracking the commitment not to exceed 40 miles of new permanent road construction over the permit term.

Conservation Measure 5: Harvest and Thinning Adjacent to Occupied Marbled Murrelet Habitat. Outside, but overlapping and adjacent to, some RCAs, are forested areas occupied or potentially occupied by marbled murrelets. This conservation measure contains harvest and thinning prescriptions that, when adjacent to RCAs, can affect shading and wood recruitment to streams and improve riparian function to influence stream habitat and processes over the permit term.

<u>Restoration Thinning in CRWs and MRWs</u>. In the CRW and MRW reserves, modeled potential habitat that is adjacent to occupied marbled murrelet habitat will receive a 150-foot buffer if thinning is proposed adjacent to occupied habitat. The buffer will be managed at 100 percent retention unless the modeled potential habitat is surveyed and determined not to support marbled murrelet occupancy, in which case retention could range from 60 to 100 percent of pre-harvest density. In addition, at least 20 percent of stands identified for the CRW restoration experiment (CRW stands 65 years old or younger as of 2020) will be allocated as statistical controls (no thinning).

<u>Harvest in MRWs</u>. Modeled potential marbled murrelet habitat that exists immediately adjacent to occupied marbled murrelet habitat, and is outside of MRW Reserves, will be buffered as follows:

- 164-foot harvest buffer extending outwards from the border of occupied habitat polygons
- 328-foot harvest buffer extending outwards from either side of the borders of adjacent occupied habitat polygons that are 656 feet apart or less.

Buffers will be maintained at 100 percent retention of pre-harvest stand density unless the adjacent modeled potential marbled murrelet habitat is surveyed (per Condition 7) and (a) occupancy is determined and the area is included as part of the 1,400-acre marbled murrelet experiment, in which case no buffer will apply; or (b) no occupancy is found, in which case the buffer will remain but retention can range from 60 to100 percent of pre-harvest density.

Conditions on Covered Activities. The conservation strategy includes 12 conditions on the covered activities. Conditions, as defined for the HCP, are specific take avoidance and minimization measures that ODSL has committed to apply to the covered activities described in section 1.3.2 of this opinion above and Section 5.5, *Conditions on Covered Activities*, of the HCP. These conditions will apply throughout the 80-year permit term. The five conditions that have potential to affect and improve riparian function and OC coho salmon habitat throughout the permit term are described below.

Condition 2: Retention of Northern Spotted Owl Nesting Core Areas. There are 22 100-acre nesting core areas in the permit area that overlap with RCAs of different widths and stream types (Figure 7). A nesting core area is defined as 100 acres of the best contiguous habitat that surrounds a northern spotted owl nest site and is inside and a part of the core use area. Nest sites are defined as the nest tree and other trees within 300 feet of the nest tree. ODSL will retain 100 percent of trees in the nesting core areas (i.e., no modification or treatment will occur in the 100-acre nesting core area).

Condition 3: Retention of Northern Spotted Owl Core Use Areas. Core use areas overlap with RCAs of different widths and stream types and are defined as 502 acres of the best contiguous habitat that surrounds a northern spotted owl nest site. The edge of the core use area will be no less than 300 feet from the nest location. In 22 core use areas, ODSL will retain at least 50 percent of the highest quality contiguous habitat as nesting, roosting, and foraging habitat at all times. For core use areas that extend beyond the permit area, ODSL will retain 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).

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 treatment areas 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 22 northern spotted owl core use areas at any one time. Initially, this condition will apply to the current northern spotted owl activity centers. If new owl nest locations are discovered in the future, ODSL, 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 22 core use areas and allow ODSL to focus on the 22 nest sites with the highest-quality habitat and documentation of nesting activity at any one time.

In addition, if a nesting area were to shift from the designated activity center, the Permittee would have the option to shift the protection areas within core use areas in collaboration with USFWS, in accordance with the relevant provisions outlined in Chapter 7, Section 7.6, *Modifications to the Habitat Conservation Plan* (ICF 2024), 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.

Condition 4: Retention of Habitat in Northern Spotted Owl Home Ranges. The ODSL 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. 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, ODSL is only responsible for retaining at least 40 percent of the total area that is inside the permit area, and, therefore, in ODSL's control.

If new owl nest locations are discovered in the future, the Permittee will collaborate with USFWS, in accordance with the relevant provisions outlined in Chapter 7, Section 7.6, *Modifications to the Habitat Conservation Plan*, to determine whether to remove protections from another (inactive) home range and apply protections to the home range of the newly discovered (active) nest site. This "swapping" of home ranges would maintain protections on at least 22 home ranges and allow the Permittee to focus on the 22 nest sites with the highest-quality habitat and documentation of nesting activity at any one time. For a 1.5-mile-radius circle, 40% equates to 1,809 acres. For areas within the home range but outside of the core use area, the contiguous habitat requirement will not apply to the broader home range area, although any habitat grown and used as replacement habitat must meet the requirements of the highest-quality nesting, roosting, and foraging habitat. The definition of highest-quality nesting, roosting, and foraging habitat is the same as that described in Condition 3. Similar to the requirements in core use areas, activity centers for which the home range radius (1.5 miles) extends outside of the permit area, the Permittee is only responsible for retaining at least 40% of the total area that is inside the permit area and, therefore, in the Permittee's control.

Condition 5: Maintenance of Northern Spotted Owl Dispersal Landscape. This condition 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). The standard for dispersal habitat (USFWS 2011) is met when forests, at the 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.

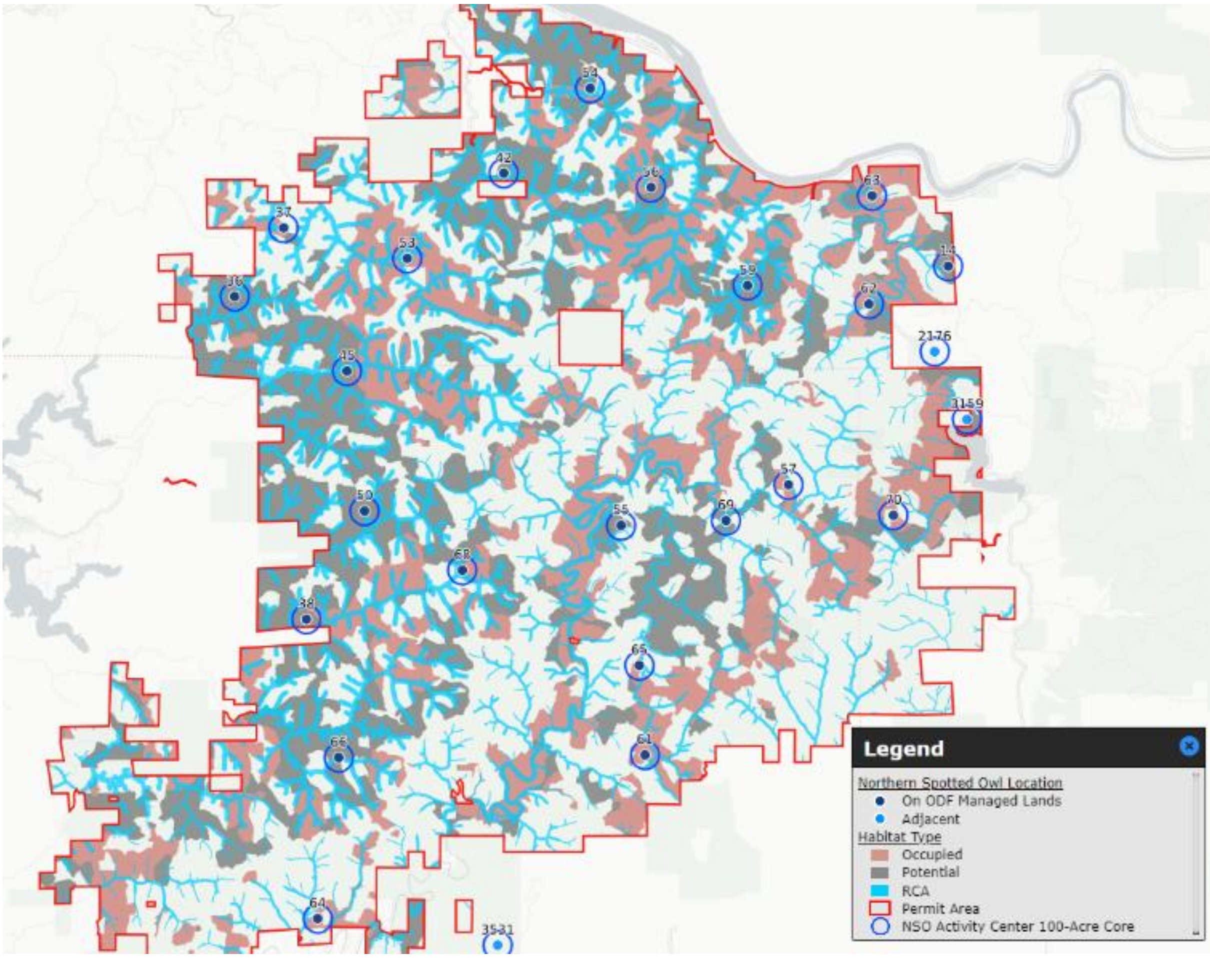

Figure 7. Overlap of RCAs, northern spotted owl core areas, and marbled murrelet occupied and potential habitat in the permit area.

Condition 10: Management on Steep Slopes. The permit area will be managed such that research into the effects of a suite of forestry management strategies on steep-slope stability can be evaluated along with the ecological consequences of any resulting slope failures. Research in the permit area will examine key processes leading to the production and delivery of large trees and sediment/nutrient pulses to aquatic systems and how specific forestry actions affect those processes.

Given the extent of steep topography in the permit area, a high proportion of treatments in the MRW may occur on slopes greater than 65%. During harvest planning and layouts, intensive harvests will avoid slopes identified to be unstable by the Slope Stability Analysis tool (TerrainWorks 2021) unless field surveys reveal that areas are suitable for harvest. Moreover, in the full subwatersheds associated with the Triad research design, each acre slated for intensive harvest will be matched with an equal amount of acreage placed in Reserves in the same subwatershed designation. This approach is intended to ensure that ODSL will manage at least 50% of any given intensively managed subwatershed as a Reserve. Also, across treatment types, cable or tethered logging systems will primarily be used on slopes >40%, new road construction (temporary and permanent) will be located in stable locations (ridgetops, stable benches, or flats). Additionally, treatments in stands <65 years (as of 2020) will be focused on previously logged stands where construction of new roads will be minimal.

Condition 11: Road Construction and Management. The ODSL will consult with their geotechnical specialists, as needed, while designing roads with the intent to minimize the risk of road-construction induced soil movements and their delivery to fish-bearing streams.

The ODSL will implement the following road construction design measures intended to minimize potential impacts on the covered aquatic species. The intent of these road construction design measures is to hydrologically disconnect the road system from streams and supplement the OFPA restrictions included in Section 3.6.1, *Road System Construction and Management*, of the HCP (ICF 2024).

- The ODSL will locate temporary and permanent roads and landings on stable locations (e.g., upper, slope, midslope, or flats) and gentle to moderate side slopes and roads will be constructed at least 35 feet from the edge of the aquatic zone.
- The ODSL will locate all new roads away from streams, wetlands, unstable areas, and sensitive resource sites, including sensitive wildlife habitats. Road development in RCAs will only occur when other alternatives are not operationally feasible or economically viable.
- The ODSL will avoid the removal of trees older than 150 years old (as of 2020) or trees with structures known to be important to the covered species (e.g., potential murrelet nesting platforms, in retained northern spotted owl core areas).
- The ODSL will design bridges and culvert stream crossings to meet NMFS fish-passage criteria (NMFS 2022a or most recent) and ODFW fish-passage laws (Oregon Revised Statute 509.580 through 910 and OAR 635, Division 412).
- New roads will use the minimum practical design standards with respect to road width, radius, and gradient. This will minimize road width and the resultant cut and fill slopes, minimizing effects on the covered aquatic species from new road construction.
- Road designs will provide for proper drainage of surface water and will not introduce runoff into streams. These measures could include the use of grade breaks, outsloping, insloping, ditching, road dips, water bars, and relief culverts.
- Cross drains will not discharge onto unstable slopes, and full bench construction (no sidecast fill) will be used on steep slopes to avoid sidecast failure.
- The ODSL will install rock fill over culverts to reduce the risk of erosion and failure, in case culverts become plugged or overtopped.
- The ODSL will disconnect road runoff to the stream channel by outsloping the road approach. If outsloping is not possible, ODSL will use runoff control, erosion control, and sediment containment measures such as 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.
- The ODSL will armor surface-drainage structures to maintain functionality in areas of erosive and low-strength soils.

- To reduce surface erosion, vegetation removal, soil disturbance, and clearing and grubbing will be limited to the minimum needed to construct the road.
- Excess road-excavation materials will be disposed of at a stable site outside the 100-year floodplain that will not contribute to sedimentation or otherwise degrade covered species habitat.
- The ODSL will rock roads with high erosion potential. 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.

Once roads are constructed, these or existing roads will require periodic maintenance to minimize erosion and sedimentation discharge to streams. ODSL will implement the following maintenance measures to minimize sediment discharge.

- The ODSL will close roads that are in or adjacent to RCAs that cannot be hydrologically disconnected, or are otherwise unsuitable for winter haul, to logging trucks during wet weather as specified by ODSL. This includes all native-surface roads.
- The ODSL will vacate roads that have a history of failure or of contributing sediment to streams, consistent with valid existing rights, provided that the act of vacating the road does not do more ecological damage than leaving it in place.
- The ODSL will suspend commercial road use where the road surface is deteriorating because of vehicular rutting or where standing water and turbid runoff is likely to reach waters of the state.
- In-water work to replace or repair stream crossings will follow the established *Oregon Guidelines for Timing of In-Water Work to Protect Fish and Wildlife* (ODFW 2024 or most recent).
- The ODSL will site storage and staging areas for road construction, harvest activities, and HCP-management and restoration projects at least 150 feet away from a waterbody or wetland. 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 ODSL.
- The ODSL will conduct maintenance activities outside of winter wet weather as specified by ODSL. If rainy weather occurs, ODSL will implement and reinforce erosion and sediment control measures. Soils that are saturated with water, that would become muddy when disturbed, will be allowed to drain before maintenance or construction resumes.
- The ODSL will establish effective drainage or mulch and/or seed bare soil (e.g., unsurfaced road grades, cut slopes, fill slopes, waste areas, borrow areas, rock pits) before the start of the rainy season to reduce surface erosion.
- When a road construction or maintenance project is partially completed at the start of the rainy period (mid-October), the project will be left in a condition that 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 ODSL will effectively drain road surfaces 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 surface waters 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 streams will be seeded with native species and mulched with weed-free mulch.
- Undercutting of cut slopes will be avoided when cleaning ditch lines.

1.3.4 Monitoring and Adaptive Management

The HCP includes the monitoring and adaptive management framework for the ESRF, including guidelines and specific recommendations that will help ODSL develop a detailed program during the initial years of implementation. ODSL’s stated purposes for this framework and the monitoring program are to ensure compliance with the HCP, assess the status of covered species and their habitat, and evaluate the effects of management actions such that the conservation strategy described in Chapter 5 of the HCP, *Conservation Strategy*, including the biological goals and objectives, is achieved. The ODSL will conduct compliance monitoring to ensure adherence to the HCP and the ITP. The ODSL will also conduct 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.

Compliance Monitoring

Compliance monitoring is intended to track the status of HCP implementation and document that the requirements of the HCP and permits are being met, including information on avoidance, minimization, and mitigation measures. ODSL 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 their occurrence in the CRWs or MRWs as well as by the allocations described in Chapter 3 of the HCP, *Covered Activities* (ICF 2024).

- 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
- Types, acres, and location of silvicultural activities conducted in the permit area, including thinning
- Location of removal of cedar trees for Indigenous cultural use
- Details regarding removal of any trees that predate the 1868 fire, including number, location, species, dimensions, age, forest stand conditions and context, and reason for removal
- Miles and locations of permanent and temporary roads built and vacated, including those in reserves and RCAs
- Number and location of fish-passage barriers upgraded or removed
- Acres of upland restoration activities completed
- Miles of stream and acres of riparian habitat thinned, percent retention, and resulting stand density in relation to the 40 square feet basal area per acre minimum
- Location and harvest and width of RCAs implemented in treatment areas by allocation type
- Location and percentage of steep slopes purposely avoided pursuant to Condition 10 in all treatment types
- Type, number and location of stream miles treated of aquatic restoration projects completed
- Monitoring the number of OC coho salmon taken during fish salvage or fish surveys associated with the research plan
- Reporting of conservation measures and monitoring activities (e.g., what monitoring activities were implemented and resulting reports produced)
- Any modifications to the proposed actions, conservation measures, and conditions, as well as documentation of any required pre-approvals by the Services.

Effectiveness Monitoring

Effectiveness monitoring is intended to assess the biological success of the HCP and ascertain the success of management in achieving desired outcomes to provide information and mechanisms for altering management, if necessary, and evaluate whether the conservation strategy is successful. 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.

Aquatic and Riparian Monitoring. Throughout the permit term, ODSL will collect aquatic and riparian monitoring data to track the effectiveness of the conservation strategy in achieving goals and objectives related to aquatic habitat and riparian function in reserve, intensive, and extensive allocations. The aquatic monitoring program focuses on monitoring trends in the permit area; it is not intended to be a measure of production (i.e., number of fish) of OC coho salmon in the permit area.

Instream habitat monitoring will occur on up to five, 200-meter reaches in each treatment type (reserve, extensive, intensive; up to 15 reaches total) based on where potential high-quality coho habitat has been mapped and where harvest treatments or other ground-disturbing actions are expected to occur within the first 5 years of HCP implementation. The 200-meter reach length is consistent with OSU's research study design and would facilitate coordination and comparisons across the HCP, associated ESRF research programs, and potentially with monitoring efforts advanced by other entities the area (e.g., ODFW, watershed associations). Each site will be established at least 1 year prior to harvest treatment or related activities, and will be maintained for at least 9 years and includes monitoring pre- and post-harvest treatment and related covered activities (e.g., road maintenance or construction). Monitoring data collection for turbidity and temperature will tier to these monitoring sites as described below, whereas monitoring of RCA thinning will occur independently as described below.

Instream habitat monitoring sites may be moved after their 9-year cycle to capture additional treatment areas and effects elsewhere on the ESRF. Establishment of new sites will be coordinated with the implementation and adaptive management committee (HCP Chapter 7, Section 7.2.5, *Implementation and Adaptive Management Committee* [ICF 2024]).

Research-related monitoring would occur in addition to the HCP monitoring program. A central component of OSU’s research proposal (OSU 2021) for the ESRF is evaluating the effects of restoration thinning in previously managed RCAs on coho habitat and abundance. Oregon State University is actively engaged in developing rigorous study plans to evaluate the effects of RCA thinning on coho habitat quality in the permit area. The data and findings from OSU research will be made fully available to the HCP team and will be incorporated into HCP monitoring reports submitted to the Services. The RCA thinning prescriptions and monitoring plans will be shared with the Implementation and Adaptive Management committee for review prior to implementation. RCA thinning would only occur as part of a designed and ODSL-funded research study that has been reviewed by the Implementation and Adaptive Management Committee.

Habitat monitoring data will be collected at all instream habitat monitoring sites every third year. Data loggers collecting temperature and turbidity data will be download yearly. Completed monitoring activities will be reported in annual reports, while trends in habitat quality will be summarized in a 6-year summary report and a more comprehensive assessment will be completed during a 12-year comprehensive review (Reporting discussed below).

Trends in habitat quality will be summarized in the 6-year summary report (HCP Section 7.3.2), and a more comprehensive assessment will be completed during the 12-year comprehensive review (HCP Section 7.3.3). During the 12-year review, more in-depth analysis of long-term trends will be completed, particularly as the permit term progresses and more years of monitoring are completed. The intention is to track trends in covered species habitat quality over time and relate the trends back to the management activities and conservation measures in the permit area. The 12-year 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 OC coho salmon.

Turbidity Monitoring. The ODSL will install paired turbidity monitors at the 15 in-stream habitat monitoring reaches described above. The intent is to position loggers to capture changes in turbidity conditions caused by extensive, intensive, and reserve treatments. This will allow ODSL to report on trends in turbidity at relevant reporting intervals.

Additional turbidity monitoring may occur in locations that are identified during the road analysis, where the 15-instream monitoring reaches would not otherwise detect turbidity impacts. Additional monitoring will attempt to determine the degree to which those locations contribute sediment in order to prioritize when and how to address those road segments. Monitoring will occur both before (6-12 months prior to work occurring) and after those road segments are addressed to determine whether there is a measurable difference in sediment delivery to the stream. These data will inform how ODSL addresses future road segments that can contribute sediment to the aquatic environments.

Reporting of turbidity data will be provided in the annual reports and summarized and reviewed during the 6-year Summary Report and 12-year Comprehensive Review. Road issues that are identified during monitoring activities will be added to the road inventory described in Chapter 5, Section 5.4.3, *Conservation Measure 3, Reduce Density of the Forest Road Network in the Permit Area*, and be prioritized for improvement or vacating.

Water Temperature Monitoring. The ODSL will implement a year-round monitoring program to track water temperature trends across the permit area. The ODSL will place recording thermographs in the 15 in-stream habitat monitoring reaches, which will be distributed between the treatment types to ensure adequate data is collected to evaluate effects of HCP implementation. Data collected will be provided to the Services in annual reports, 6-year summary reports, and 12-year comprehensive reviews to show trends in temperature change. If trends show management related temperature increases that result in watershed exceedances of greater than 0.3 degrees Celsius (°C) for more than 5 years post-harvest, ODSL will work with the Services to determine the appropriate adaptive management response.

For RCA thinning, water temperature changes will be quantified through a paired watershed approach to control for environmental variability to detect effects on water temperature caused by RCA thinning. Temperature trends will be evaluated in relation to the Biologically Based Numeric Criteria (BBNC) and the Protecting Cold Water (PCW) criterion (Oregon Administrative Rule 340-041-0028(4) and 340-041-0028(11)).

Instream Habitat Monitoring. The ODSL will collect and monitor data on instream habitat variables annually consistent with the overarching approach to sites described for aquatic and riparian monitoring above. The collection methods and sampling regime will generally be consistent with techniques set by ODFW Aquatic Inventories Project data, to monitor trends in physical habitat attributes in the permit area over the permit term.

For the purposes of the HCP, the following variables will be tracked over time to represent the trends in habitat quality.

- Total count of wood (size classes to be determined)
- Number, depth, and size of pools
- Fine sediments at pool tail crests at systematically determined intervals
- Summer low flow; 30-day average water flow; length of dry channels and/or distance of dry channels between pools
- Extent of multiple channels by number of channels and total length
- Number of active beaver sites and the estimated area affected
- Vegetative conditions (metrics to be determined)
- Amount of solar radiation reaching the channel

Vegetation data may be gathered using remote-sensing technology (e.g., LIDAR) and other automated monitoring methods. Automation provides more consistent application of methodologies and therefor more repeatable sampling. The methods and technologies will evolve during the permit term as technological advances are made.

Habitat monitoring data will be collected at all sites every third year. The monitoring activities that are completed each year will be summarized in the annual report, and monitoring results will be summarized in the 6-year summary report and the 12-year comprehensive review. Monitoring changes in riparian and aquatic conditions will provide information for tracking status and trends based on the covered activities and natural disturbance. Any potential changes to monitoring or enhancement will be made in coordination with the Services.

Riparian Restoration Monitoring. Before proceeding with a full-fledged restoration effort of restoration thinning in RCAs, ODSL will assess the effectiveness and potential consequences of these treatments in a limited area. Initial RCA thinning and assessment will occur on up to 100 acres of RCAs along fish-bearing and non-fish-bearing streams in 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, which will be similar to those described above for instream habitat monitoring, will be summarized in the annual report, and monitoring results will be summarized in the 6-year summary report.

Landslide Monitoring. Oregon State University created a baseline landslide inventory for the ESRF, which ODSL will update as landslides occur during the permit term. During HCP implementation, ODSL will monitor and report any landslides at harvest sites and/or sites associated with road system work, for 5 years post-harvest. In addition, the Permittee will report any direct landslide observation from forest managers. All reported landslides will include location, site photos, and if the slide reached a fish-bearing stream.

In the event that the 15 designated habitat monitoring reaches are deemed insufficient for capturing the impact of landslides on habitat for the covered species, paired turbidity monitors will be installed at up to 10 additional sites within the permit area. The intent of this monitoring effort is to support the adaptive management program and evaluate the effectiveness of the conservation measures and conditions. Parameters that will be monitored include the ability to achieve wood and sediment delivery objectives; to evaluate the effectiveness of RCAs on HLDP streams and other stream types to reduce debris-flow runout path length to limit adverse effects on fish-bearing streams; and the accurate designation of non-fish-bearing streams with the highest modeled potential to deliver wood to fish-bearing streams (HLDP streams) to improve complexity and physical structure through large wood recruitment.

Adaptive Management

Adaptive management is a systematic approach for improving resource management by learning from management outcomes (Williams et al. 2009), which, in the context of HCPs, NMFS considers a tool to address uncertainty in the conservation of a species covered by an HCP (USFWS and NMFS 2016). To address uncertainties or limitations of current knowledge, the monitoring and adaptive management program is intended to allow ODSL to learn from experience, reevaluate and revise the approach (i.e., type, extent, and location) to improving conservation measures, conditions, and covered activities when necessary, in coordination with the Services and implementation and adaptive management committee, to meet the biological goals and objectives of the HCP. Table 2 below identifies the triggers and potential adjustments/responses that could occur under adaptive management relative to habitat parameters for aquatic habitat.

Table 2. Triggers for adaptive management and potential adjustment/responses for

Actions	Trigger	Adaptive Management Response Example
Aquatic Actions		
Wood recruitment in streams	Trend in large wood frequency/ volume in streams is not meeting the anticipated wood recruitment goals.	Alter riparian management in order to incorporate additional wood enhancement in deficient stream reaches (e.g., additional large wood placement, riparian thinning prescriptions).
Stream temperature	Harvest related temperature increases that result in watershed exceedances of greater than 0.3°C for more than 5 years post-harvest as measured by thermographs as described in Section 6.3.2, *Water Temperature Monitoring*.	Implement targeted riparian conservation strategy adjustments in locations where temperature increases are detected and there are similar stream segments in the permit area. Revise harvest plans or modify amount of riparian thinning in an affected watershed and minimize changes to water temperatures.
Riparian enhancement	Riparian enhancement projects are not achieving expected results. RCA thinning activities are having unintended negative consequences to development of instream habitat.	Identify and capture additional opportunities to fund and implement riparian enhancement. Increase number of riparian enhancement projects identified in near-term harvest plans. Apply lessons learned to selection and design of riparian enhancement projects to improve efficiency and effectiveness. Modify riparian restoration thinning treatments to reduce or eliminate unintended negative consequences to instream habitats.
Debris-flow derived wood	Over time, debris-flow studies show that riparian buffers are insufficient at capturing debris that is detrimental to aquatic system health, when slides occur.	Reconsider buffering strategy on specific stream types or in specific locations, to address debris-flow issues based on best available scientific information.
Road improvement and vacating	Sediment and flow impacts from roads identified within a catchment.	Implement road improvement to treat problem areas through adjustments to budgets and operations. Continually prioritize road locations causing ecological damage to address the most impactful first.
Fish passage	Passage enhancement projects do not achieve intended results of effective fish passage.	Apply lessons learned to selection and design of where fish-passage upgrades should be applied to improve efficiency and effectiveness of fish-passage improvement projects.

1.3.5 Assurances

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." 50 CFR 222.102. This section describes the procedures to deal with unforeseen circumstances that may arise during implementation of the HCP.

The procedure outlined in the HCP for dealing with unforeseen circumstances begins with the identification of any such circumstances or as part of ongoing compliance reporting and coordination with the Services. Either the Services or the Permittee may initiate the process for declaring and documenting unforeseen circumstances. Once initiated by either the Services or the Permittee, the Permittee will provide available information to the Services regarding the circumstances and associated adverse changes to covered species and their habitat in the plan area. If applicable, the Permittee will identify specific biological goals and objectives of the HCP that are or will be affected by the circumstances.

Pursuant to implementing regulations 50 CFR 222.307(g)(3), upon determining that unforeseen circumstances exist, the Services will inform ODSL of any additional avoidance, minimization, or mitigation measures that may be warranted and ODSL will work with the Services to determine an appropriate response in accordance with federal regulations and Section 7, *Federal No Surprises Assurances*, of the HCP (ICF 2024). Responses may include additional mitigation, which may be implemented at the option of ODSL or by third-party stakeholders under the direction of ODSL. The ODSL will document and track any unforeseen circumstances and – and associated metrics and mitigation – as part of the HCP monitoring and reporting program. The ODSL will engage the implementation and adaptive management committee in conversations related to unforeseen circumstances and any effort to address them.

Changed and Unforeseen Circumstances

"Changed circumstances" are defined in 50 CFR 222.102 as changes in circumstances affecting a species or geographic area covered by an HCP that can reasonably be anticipated by HCP developers and NMFS that can be planned for (e.g., the listing of new species, or a fire or other natural catastrophic event in areas prone to such events). The ODSL has identified the changed circumstances that could arise in the permit area and they are listed below, as described by ODSL in the HCP. If a changed circumstance occurs within the permit area, ODSL will implement the responsive actions prescribed in this section. ODSL will engage the implementation and adaptive management committee in conversations related to changed circumstances and any effort to address them.

New species listed or designation/revision of Critical Habitat. If NMFS or USFWS were to list a new species or designate/revise critical habitat for a listed species not included in the HCP, ODSL will take the following actions:

- Coordinate with the Services to evaluate and determine the distribution of the newly listed species on ODSL managed lands in the ESRF and how the covered activities may affect the species
- If the newly listed species is present in the permit area and the covered activities may result in take of said species, ODSL will implement any necessary measures to avoid take of the species until an ITP amendment is completed or an alternate ITP is issued by the Services

- Apply for permit amendment or alternative take coverage.

If new critical habitat is designated or existing critical habitat is revised in the permit area, ODSL and the Services will review the new or revised designation(s) in light of the ongoing as well as permitted future research and management under the HCP obligations. If implementation of the HCP will result in effects to newly designated or revised critical habitat the Services may re-initiate consultation.

Temporary Change in Species Habitat Quality from Natural Events. Some natural events can cause significant temporary changes in terrestrial and aquatic species habitat quality. Natural events that occur in a forested landscape in western Oregon, including the permit area, include fire, storms (rain, ice, wind, snow), floods, drought, and invasive species and diseases. Because conservation areas for terrestrial areas overlap with riparian habitat the changed circumstances and responses for terrestrial species habitat are relevant to riparian areas that influence aquatic habitat. For terrestrial covered species, if more than 5,000 acres of suitable habitat in conservation areas (suitable is defined here as northern spotted owl or marbled murrelet habitat within CRW or MRW Reserves, northern spotted owl habitat for the 22 historic nest sites, or occupied or modeled potential marbled murrelet habitat) are collectively affected by any combination of the events described above in 1 calendar year, that will be considered an unforeseen circumstance.

No changed circumstances for a temporary change in species habitat quality from natural events are defined for RCAs. The ODSL 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.

Aquatic Invasive Plants, Non-native aquatic species, and Disease/Parasites. Non-native invasive plants, non-native fish, and disease and parasites currently occur in portions of the permit area. Effects from invasive plants on habitat range from competition and displacement of native vegetation and increased streambank vegetation (OSU 2014). Non-native fish (*Micropterus spp., Salvelinus spp.*) and other aquatic organisms compete with covered OC coho salmon for spawning, rearing, and foraging habitat and may prey upon juvenile OC coho salmon. As stream temperatures change due to climate change, the range of predatory warmwater fish that prey upon juvenile OC coho salmon will likely expand (NMFS 2016a). 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).

Aquatic invasive plants, nonnative fish, and disease/parasites will be considered a changed circumstance under the following conditions. A changed circumstance will be considered if the spread of aquatic invasive plant species affects up to 25% of stream miles in any given subwatershed for an independent population of Oregon Coast coho in a 3-year time period. If this occurs, ODSL will work with the Oregon Department of Agriculture and ODFW 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 OC coho salmon to a point where it becomes a limiting factor for covered species populations in the permit area, ODSL will coordinate with ODFW and NMFS on what measures, if any, should be taken to address the species expansion that would be consistent with the terms of the HCP and permits.

Any new invasion that expands beyond 25% of stream miles within any given watershed (fifth-field HUC or HUC10) for an independent population of OC coho salmon within a 3-year time period will be considered an unforeseen circumstance.

The ODSL will address changed circumstances using manual, mechanical, cultural, chemical, and biological treatments to manage new occurrences of aquatic invasive plant infestations in the permit area.

Stream Temperature Change. Climate change is projected to raise temperatures and alter the flow regimes of streams and rivers in the permit area, which will have consequences for physical processes and aquatic organisms, including covered fish species and their habitats. Water temperature plays a critical role for fish and other aquatic organisms in rivers and streams because their biological processes are directly linked to ambient water temperatures (Neuheimer and Taggart 2007; Buisson et al. 2008; Pörtner and Farrell 2008; Durance and Ormerod 2009). While water temperature varies over time based on location, time of day, and season, the mean August water temperatures across the Pacific Northwest averaged 58 degrees Fahrenheit (°F) (14.2 degrees Celsius [°C]) from 1993 to 2011 (Isaak et al. 2017). Based on climate change model scenarios, water temperature in streams and rivers can be expected to increase on average by 2°F and 3.5°F (0.73°C and 1.4°C) by 2040 and 2080, respectively (Isaak et al. 2017). Based on this modeled climate scenario, average annual water temperatures rising more than 3.5°F (1.4°C) across the permit area during the permit term would be considered unforeseen.

In response to potential changes in water temperature and flow from climate change, which will be identified during reporting, ODSL will take preventive measures for streams and rivers in the permit area as well as responsive measures if HCP-based monitoring of water temperature and flow trends, as described above in section 1.3.4, Table 2 (triggers for adaptive management). 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 OC coho salmon presence to further minimize risk of temperature rise should the HCP monitoring program establish that stream temperatures are rising.
- Reconnect streams to floodplains and protect seeps, springs, and wetlands to facilitate flow (including hyporheic) and water-related temperature benefits.
- Increase the potential of large wood production to streams through management of the buffers in Reserves to promote shading and large wood. Increased bed load will lead to cooler groundwater temperature, reducing stream temperatures.
- Introduce large wood during restoration projects (e.g., riparian thinning) to provide habitat for OC coho salmon.
- Manage RCAs to increase beaver habitat and presence where possible to create improved habitat conditions for OC coho salmon. This may include translocation of beaver consistent with other state and federal regulations and policies.

- Consider adjustments in harvest management and retention of cover within subwatersheds to manage streamflow over the long term.

1.3.6 Reporting

Annual Reporting

The ODSL will prepare and submit an annual report to the Services for the duration of the permit term to document compliance with the ITP. The annual reports will summarize the previous fiscal year's implementation activities (July 1 to June 30) and upcoming fiscal year's planned activities and expenditures on the ESRF. The report will be provided to the Services by November 15 of each year. An annual meeting with the Services will be held within 60 days of receipt of the annual report.

The goals of the annual report include demonstration to FWS and NMFS that the HCP is being implemented properly and to deliver information necessary to assess whether the level of take is within the respective agencies' ITP. 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 future changes to the management and monitoring program. Through adaptive management, and remedial actions needed to address changed circumstances, such actions or changes will be processed and carried out in accordance with the provisions described in section 7.6 of the HCP, *Modifications to the HCP* (ICF 2024).

The required content of the annual reports is as follows:

- The description covered activities implemented during the reporting year and cumulative total (i.e., from the start of the permit term as it relates to the HCP commitment).
- Acres in location of timber harvested by harvest type.
- Treatment by allocation within the CRW and MRW.
- 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, including acres disrupted for supporting management activities such as road maintenance or construction and dates of operations in modeled terrestrial species habitat. Habitat data will include modeled quality ratings (e.g., highly suitable, suitable, marginal) for stand conditions prior to and after treatment. For extensive treatments, habitat data will also include pre-and post-treatment stand density conditions.
- Acres thinned in the CRW, MRW reserves, as well as RCAs including location (by stream type and independent population) thinning regime pre- and post- thinning stand conditions (e.g., density, species composition, age, stream shade, tree diameter).
- Acres of barred owl management type, specifically, acres of NSO habitat treated, total barred owl removal results, and the results of monitoring NSO activity in all the areas for active barred owl removal has occurred.
- Aquatic restoration projects completed by OC coho salmon independent population.

- Road miles constructed or vacated in location by treatment allocation and location with respect to stand age, modeled terrestrial species habitat, and independent coho population.
- Road management actions performed including location of number of culvert upgraded or replaced.
- Supporting activities completed, including location and acres or other metrics describing the nature and extent of activity completed and the primary activities or outcomes they supported.
- Details regarding removal of trees (or restoration actions) associated with the indigenous use of cedar covered activity.
- Barriers to fish passage upgraded or removed, including location and length of newly accessible habitat.
- 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, and any other documentation of unforeseen circumstances as described in 7.8.2.
- Reporting of landslides and debris flows location, site photos, and if the slide reached a fish-bearing stream.
- Summary of the implementation of conditions on covered activities.
- For deviations/exceptions (to conditions on covered activities) that fall outside pre-approval requirements, provide documentation and justification for those that may have occurred in the reporting year and those that are proposed for the upcoming year.
- Summary of all conservation measures implemented.
- Summary of acres of Reserves and Intensive allocations by subwatershed, including
- RCA widths applied by treatment type, stream type, and independent population.
- Progress toward achieving the HCP biological goals and objectives by conservation actions (including avoidance, minimization, and mitigation).
- Compliance with the Stay-Ahead provision, including an assessment of whether the loss of habitat and habitat quality from natural disturbance caused the Permittee to fall behind the Stay-Ahead provision, as described in Section 7.4, *Stay-Ahead Provisions*.
- Monitoring actions conducted in the reporting year (monitoring results will be reported annually as well as summarized every 6 years as part of the 6-year Summary Report or 12-year Comprehensive Review).
- Summary of surveys conducted through the monitoring program in the reporting year, including a description of surveys conducted, protocols used, and survey results (e.g., presence, breeding, occupancy, location, species response,).
- 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 7.8.1, *Changed Circumstances*, that were triggered during the reporting year, if applicable. If any such circumstances were triggered, also include any responses implemented (i.e., remedial measures) and resulting monitoring.

- 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 any possible changes relevant to HCP implementation that are a result of the adaptive management decisions during the reporting year, as applicable (see Section 7.6). This description will include the information that triggered the potential change consideration (whether met or unmet), the rationale for the planned responses, and the results of any applicable monitoring actions or changes to identified triggers for adaptive management.
- Include a comprehensive list of adaptive management triggers and responses from previous annual reports.
- 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 fiscal reporting year, as well as any budget projections for the next fiscal year.

6-year Check-ins

Every 6 years of HCP implementation, ODSL will summarize the following items 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, ODSL anticipates that there will still be an ongoing accounting of activities needed for that individual year and an annual report will be prepared. Whether that report is provided as a separate document or under the same cover as the 6-year Summary Report is up to the preference of the Permittee, FWS, and NMFS. This frequency of reporting allows the completion of two full 3-year cycles of monitoring, as described in Chapter 6, *Monitoring and Adaptive Management*. One goal of the 6-year (and 12-year) Summary Report is to present information on any detectable trends. In addition to the summary of annual report components rolled up at this 6-year interval, the 6-year Summary Report will also address the following.

- A summary of compliance and effectiveness monitoring efforts and activities, including trends in aquatic and riparian habitat and water quality/quantity 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. This will include an updated evaluation of Habitat Suitability Index (HSI)-weighted acres from the preceding years.

- Amount and general location (e.g., subwatershed) of CRW and MRW Reserve allocations that are treated with restoration thinning and a 6-year projection of additional thinning that will occur.
- Amount and general location (e.g., subwatershed) by independent coho population of RCAs treated with restoration thinning and a 6-year projection of additional thinning that will occur.
- Updated wood recruitment modeling with known buffer widths included to gauge progress towards biological objectives for each independent population of Oregon Coast coho.
- Compliance with the Stay-Ahead provision as described in HCP Section 7.4, *Stay-Ahead Provisions*.

12-year Check-ins

Every 12 years of HCP implementation, ODSL will complete a comprehensive review of the monitoring program and monitoring results. This frequency of reporting allows for the completion of four full 3-year cycles of monitoring, as described in HCP Chapter 6, *Monitoring and Adaptive Management*. Information gathered for the 12-year Comprehensive Review will largely be the same as described in HCP Section 7.3.2, *Six-Year Summary Report*, except it will contain a more comprehensive analysis as described in HCP Sections 6.3, *Aquatic and Riparian Monitoring*, and 6.4, *Terrestrial Monitoring*. These reviews will include information from the annual reports in the intervening 12 years and the summary provided in the 6-year mid-point check-in. These reviews will examine whether any program-level or systemic changes need to occur to adjust the level or location of habitat loss, the type of management activities, or the type or location of conservation actions that are being implemented. Information generated during the 12-year comprehensive review process will be informed by ODSL staff along with FWS, NMFS, and ODFW.

Activities Not Covered by the ITP

The HCP (ICF 2024) identified activities not covered by the HCP or for which DSL was not requesting incidental take coverage under an ITP. These activities include recreational activities and infrastructure, pesticide use, fire suppression, easement use, and passive research. Application of forest management chemicals such as herbicides or insecticides, is not a covered activity. An incidental take exemption is not provided for the application of forest management chemicals.

Under the MSA, "federal action" means any action authorized, funded, or undertaken, or proposed to be authorized, funded, or undertaken by a federal agency (see 50 CFR 600.910). For MSA the federal action is the issuance of an ITP for the ESRF HCP, which is described above. We determined that the proposed federal action would adversely EFH for Pacific salmon in the action area.

2. ENDANGERED SPECIES ACT: BIOLOGICAL OPINION AND INCIDENTAL TAKE STATEMENT

The ESA establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat upon which they depend. As required by section 7(a)(2) of the ESA, each federal agency must ensure that its actions are not likely to jeopardize the continued existence of endangered or threatened species or to adversely modify or destroy their designated critical habitat. Per the requirements of the ESA, federal action agencies consult with NMFS, and section 7(b)(3) requires that, at the conclusion of consultation, NMFS provide an opinion stating how the agency's actions would affect listed species and their critical habitats. If incidental take is reasonably certain to occur, section 7(b)(4) requires NMFS to provide an ITS that specifies the impact of any incidental taking and includes reasonable and prudent measures (RPMs) and terms and conditions to minimize such impacts.

NMFS determined the proposed action is not likely to adversely affect Southern Resident (SR) killer whales (*Orcinus orca*), southern distinct population segment (DPS) North American green sturgeon (*Acipenser medirostris*) (hereafter referred to as 'green sturgeon'), southern DPS Pacific eulachon (*Thaleichthys pacificus*), or their designated critical habitat. Our concurrence is documented in the "Not Likely to Adversely Affect" Determinations section (Section 2.12).

2.1. Analytical Approach

This biological opinion includes both a jeopardy analysis and an adverse modification analysis. The jeopardy analysis relies upon the regulatory definition of "jeopardize the continued existence of" a listed species, which is "to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species" (50 CFR 402.02). Therefore, the jeopardy analysis considers both survival and recovery of the species.

This biological opinion also relies on the regulatory definition of "destruction or adverse modification," which "means a direct or indirect alteration that appreciably diminishes the value of critical habitat as a whole for the conservation of a listed species" (50 CFR 402.02).

The designation of critical habitat for OC coho salmon uses the term primary constituent element (PCE) or essential features. The 2016 final rule (81 FR 7414; February 11, 2016) that revised the critical habitat regulations (50 CFR 424.12) replaced this term with physical or biological features (PBFs). The shift in terminology does not change the approach used in conducting a "destruction or adverse modification" analysis, which is the same regardless of whether the original designation identified PCEs, PBFs, or essential features. In this biological opinion, we use the term PBF to mean PCE or essential feature, as appropriate for the specific critical habitat.

The ESA Section 7 implementing regulations define effects of the action using the term "consequences" (50 CFR 402.02). As explained in the preamble to the final rule revising the definition and adding this term (84 FR 44976, 44977; August 27, 2019), that revision does not change the scope of our analysis, and in this opinion, we use the terms "effects" and "consequences" interchangeably.

We use the following approach to determine whether a proposed action is likely to jeopardize listed species or destroy or adversely modify critical habitat:

- Evaluate the rangewide status of the species and critical habitat expected to be adversely affected by the proposed action.
- Evaluate the environmental baseline of the species and critical habitat.
- Evaluate the effects of the proposed action on species and their critical habitat using an exposure–response approach.
- Evaluate cumulative effects.
- In the integration and synthesis, add the effects of the action and cumulative effects to the environmental baseline, and, in light of the status of the species and critical habitat, analyze whether the proposed action is likely to: (1) directly or indirectly reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species; or (2) directly or indirectly result in an alteration that appreciably diminishes the value of critical habitat as a whole for the conservation of a listed species.
- If necessary, suggest a reasonable and prudent alternative to the proposed action.

2.2.Rangewide Status of the Species and Critical Habitat

This opinion examines the status of each species that is likely to be adversely affected by the proposed action. The status is determined by the level of extinction risk that the listed species face, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This informs the description of the species' likelihood of both survival and recovery. The species status section also helps to inform the description of the species' "reproduction, numbers, or distribution" for the jeopardy analysis. The opinion also examines the condition of designated critical habitat, evaluates the conservation value of the various watersheds and coastal and marine environments that make up the designated critical habitat, and discusses the function of the PBFs that are essential for the species' conservation.

One factor affecting the status of ESA-listed species considered in this opinion, and aquatic habitat at large, is climate change. Climate change is likely to play an increasingly important role in determining the abundance and distribution of ESA-listed species, and the conservation value of designated critical habitats, in the Pacific Northwest. These changes will not be spatially homogeneous across the Pacific Northwest. Major ecological realignments are already occurring in response to climate change (IPCC 2022). Long-term trends in warming have continued at global, national and regional scales. Global surface temperatures in the last decade (2010s) were estimated to be 1.09 °C higher than the 1850-1900 baseline period, with larger increases over land ~1.6 °C compared to oceans ~0.88 (IPCC WGI, 2021). The vast majority of this warming has been attributed to anthropogenic releases of greenhouse gases (IPCC WGI, 2021). Globally, 2014-2018 were the 5 warmest years on record both on land and in the ocean (2018 was the 4th warmest) (NOAA NCEI 2022). Events such as the 2013-2016 marine heatwave (Jacox et al. 2018) have been attributed directly to anthropogenic warming in the annual special issue of Bulletin of the American Meteorological Society on extreme events (Herring et al. 2018). Global warming and anthropogenic loss of biodiversity represent profound threats to ecosystem functionality (IPCC WGII 2022). These two factors are often examined in isolation, but likely have interacting effects on ecosystem function.

Updated projections of climate change are similar to or greater than previous projections (IPCC 2021). NMFS is increasingly confident in our projections of changes to freshwater and marine systems because every year brings stronger validation of previous predictions in both physical and biological realms. Retaining and restoring habitat complexity, access to climate refuges (both flow and temperature) and improving growth opportunity in both freshwater and marine environments are strongly advocated in the recent literature (Siegel and Crozier 2020).

Climate change is systemic, influencing freshwater, estuarine, and marine conditions. Other systems are also being influenced by changing climatic conditions. Literature reviews on the impacts of climate change on Pacific salmon (Crozier 2011, Crozier 2012, Crozier 2013, Crozier 2014, Crozier 2015, Crozier 2016, Crozier 2017, Crozier and Siegel 2018, Siegel and Crozier 2019, Siegel and Crozier 2020) have collected hundreds of papers documenting the major themes relevant for salmon. Here we describe habitat changes relevant to Pacific salmon and steelhead, prior to describing how these changes result in the varied specific mechanisms impacting these species in subsequent sections.

Forests

Climate change will impact forests of the western U.S., which dominate the landscape of many watersheds in the region. Forests are already showing evidence of increased drought severity, forest fire, and insect outbreak (Halofsky et al. 2020). Additionally, climate change will affect tree reproduction, growth, and phenology, which will lead to spatial shifts in vegetation. Halofsky et al. (2018) projected that the largest changes will occur at low- and high-elevation forests, with expansion of low-elevation dry forests and diminishing high-elevation cold forests and subalpine habitats.

Forest fires affect salmon streams by altering sediment load, channel structure, and stream temperature through the removal of canopy. Holden et al. (2018) examined environmental factors contributing to observed increases in the extent of forest fires throughout the western U.S. They found strong correlations between the number of dry-season rainy days and the annual extent of forest fires, as well as a significant decline in the number of dry-season rainy days over the study period (1984-2015). Consequently, predicted decreases in dry-season precipitation, combined with increases in air temperature, will likely contribute to the existing trend toward more extensive and severe forest fires and the continued expansion of fires into higher elevation and wetter forests (Alizedeh 2021).

Agne et al. (2018) reviewed literature on insect outbreaks and other pathogens affecting coastal Douglas-fir forests in the Pacific Northwest and examined how future climate change may influence disturbance ecology. They suggest that Douglas-fir beetle and black stain root disease could become more prevalent with climate change, while other pathogens will be more affected by management practices. Agne et al. (2018) also suggested that due to complex interacting effects of disturbance and disease, climate impacts will differ by region and forest type.

Freshwater Environments

The following is excerpted from Siegel and Crozier (2019), who present a review of recent scientific literature evaluating effects of climate change, describing the projected impacts of climate change on instream flows:

Cooper et al. (2018) examined whether the magnitude of low river flows in the western U.S., which generally occur in September or October, are driven more by summer conditions or the prior winter's precipitation. They found that while low flows were more sensitive to summer evaporative demand than to winter precipitation, interannual variability in winter precipitation was greater. Malek et al. (2018), predicted that summer evapotranspiration is likely to increase in conjunction with declines in snowpack and increased variability in winter precipitation. Their results suggest that low summer flows are likely to become lower, more variable, and less predictable.

The effect of climate change on ground water availability is likely to be uneven. Sridhar et al. (2018) coupled a surface-flow model with a ground-flow model to improve predictions of surface water availability with climate change in the Snake River Basin. Projections using RCP 4.5 and 8.5 emission scenarios suggested an increase in water table heights in downstream areas of the basin and a decrease in upstream areas.

As cited in Siegel and Crozier (2019), Isaak et al. (2018), examined recent trends in stream temperature across the Western U.S. using a large regional dataset. Stream warming trends paralleled changes in air temperature and were pervasive during the low-water warm seasons of 1996-2015 (0.18-0.35°C/decade) and 1976-2015 (0.14-0.27°C/decade). Their results show how continued warming will likely affect the cumulative temperature exposure of migrating sockeye salmon *O. nerka* and the availability of suitable habitat for brown trout *Salmo trutta* and rainbow trout *O. mykiss*. Isaak et al. (2018) concluded that most stream habitats will likely remain suitable for salmonids in the near future, with some becoming too warm. However, in cases where habitat access is currently restricted by dams and other barriers salmon and steelhead will be confined to downstream reaches typically most at risk of rising temperatures unless passage is restored (FitzGerald et al. 2020, Myers et al. 2018).

Streams with intact riparian corridors and that lie in mountainous terrain are likely to be more resilient to changes in air temperature. These areas may provide refuge from climate change for a number of species, including Pacific salmon. Krosby et al. (2018), identified potential stream refugia throughout the Pacific Northwest based on a suite of features thought to reflect the ability of streams to serve as such refuges. Analyzed features include large temperature gradients, high canopy cover, large relative stream width, low exposure to solar radiation, and low levels of human modification. They created an index of refuge potential for all streams in the region, with mountain area streams scoring highest. Flat lowland areas, which commonly contain migration corridors, were generally scored lowest, and thus were prioritized for conservation and restoration. However, forest fires can increase stream temperatures dramatically in short time-spans by removing riparian cover (Koontz et al. 2018), and streams that lose their snowpack with climate change may see the largest increases in stream temperature due to the removal of temperature buffering (Yan et al. 2021). These processes may threaten some habitats that are currently considered refugia.

Marine and Estuarine Environments

Along with warming stream temperatures and concerns about sufficient groundwater to recharge streams, a recent study projects nearly complete loss of existing tidal wetlands along the U.S. West Coast, due to sea level rise (Thorne et al. 2018). California and Oregon showed the greatest threat to tidal wetlands (100%), while 68% of Washington tidal wetlands are expected to be submerged. Coastal development and steep topography prevent horizontal migration of most wetlands, causing the net contraction of this crucial habitat.

Rising ocean temperatures, stratification, ocean acidity, hypoxia, algal toxins, and other oceanographic processes will alter the composition and abundance of a vast array of oceanic species. In particular, there will be dramatic changes in both predators and prey of Pacific salmon, salmon life history traits and relative abundance. Siegel and Crozier (2019) observe that changes in marine temperature are likely to have a number of physiological consequences on fishes themselves. For example, in a study of small planktivorous fish, Gliwicz et al. (2018) found that higher ambient temperatures increased the distance at which fish reacted to prey. Numerous fish species (including many tuna and sharks) demonstrate regional endothermy, which in many cases augments eyesight by warming the retinas. However, Gliwicz et al. (2018) suggest that ambient temperatures can have a similar effect on fish that do not demonstrate this trait. Climate change is likely to reduce the availability of biologically essential omega-3 fatty acids produced by phytoplankton in marine ecosystems. Loss of these lipids may induce cascading trophic effects, with distinct impacts on different species depending on compensatory mechanisms (Gourtay et al. 2018). Reproduction rates of many marine fish species are also likely to be altered with temperature (Veilleux et al. 2018). The ecological consequences of these effects and their interactions add complexity to predictions of climate change impacts in marine ecosystems.

Perhaps the most dramatic change in physical ocean conditions will occur through ocean acidification and deoxygenation. It is unclear how sensitive salmon and steelhead might be to the direct effects of ocean acidification because of their tolerance of a wide pH range in freshwater (although see Ou et al. 2015 and Williams et al. 2019), however, impacts of ocean acidification and hypoxia on sensitive species (e.g., plankton, crabs, rockfish, groundfish) will likely affect salmon indirectly through their interactions as predators and prey. Similarly, increasing frequency and duration of harmful algal blooms may affect salmon directly, depending on the toxin (e.g., saxitoxin vs domoic acid), but will also affect their predators (seabirds and mammals). The full effects of these ecosystem dynamics are not known but will be complex. Within the historical range of climate variability, less suitable conditions for salmonids (e.g., warmer temperatures, lower streamflows) have been associated with detectable declines in many of these listed units, highlighting how sensitive they are to climate drivers (Ford 2022, Lindley et al. 2009, Williams et al. 2016, Ward et al. 2015). In some cases, the combined and potentially additive effects of poorer climate conditions for fish and intense anthropogenic impacts caused the population declines that led to these population groups being listed under the ESA (Crozier et al. 2019).

Climate change effects on salmon and steelhead

In freshwater, year-round increases in stream temperature and changes in flow will affect physiological, behavioral, and demographic processes in salmon, and change the species with which they interact. For example, as stream temperatures increase, many native salmonids face increased competition with more warm-water tolerant invasive species. Changing freshwater temperatures are likely to affect incubation and emergence timing for eggs, and in locations where the greatest warming occurs may affect egg survival, although several factors impact intergravel temperature and oxygen (e.g., groundwater influence) as well as sensitivity of eggs to thermal stress (Crozier et al. 2020). Changes in temperature and flow regimes may alter the amount of habitat and food available for juvenile rearing, and this in turn could lead to a restriction in the distribution of juveniles, further decreasing productivity through density dependence. For migrating adults, predicted changes in freshwater flows and temperatures will likely increase exposure to stressful temperatures for many salmon and steelhead populations, and alter migration travel times and increase thermal stress accumulation for ESUs or DPSs with early-returning (i.e. spring- and summer-run) phenotypes associated with longer freshwater holding times (Crozier et al. 2020, FitzGerald et al. 2020). Rising river temperatures increase the energetic cost of migration and the risk of *en route* or pre-spawning mortality of adults with long freshwater migrations, although populations of some ESA-listed salmon and steelhead may be able to make use of cool-water refuges and run-timing plasticity to reduce thermal exposure (Keefer et al. 2018, Barnett et al. 2020).

Marine survival of salmonids is affected by a complex array of factors including prey abundance, predator interactions, the physical condition of salmon within the marine environment, and carryover effects from the freshwater experience (Holsman et al. 2012, Burke et al. 2013). It is generally accepted that salmon marine survival is size-dependent, and thus larger and faster growing fish are more likely to survive (Gosselin et al. 2021). Furthermore, early arrival timing in the marine environment is generally considered advantageous for populations migrating through the Columbia River. However, the optimal day of arrival varies across years, depending on the seasonal development of productivity in the California Current, which affects prey available to salmon and the risk of predation (Chasco et al. 2021). Siegel and Crozier (2019) point out the concern that for some salmon populations, climate change may drive mismatches between juvenile arrival timing and prey availability in the marine environment. However, phenological diversity can contribute to metapopulation-level resilience by reducing the risk of a complete mismatch. Carr-Harris et al. (2018), explored phenological diversity of marine migration timing in relation to zooplankton prey for sockeye salmon *O. nerka* from the Skeena River of Canada. They found that sockeye migrated over a period of more than 50 days, and populations from higher elevation and further inland streams arrived in the estuary later, with different populations encountering distinct prey fields. Carr-Harris et al. (2018) recommended that managers maintain and augment such life-history diversity.

Synchrony between terrestrial and marine environmental conditions (e.g., coastal upwelling, precipitation and river discharge) has increased in spatial scale causing the highest levels of synchrony in the last 250 years (Black et al. 2018). A more synchronized climate combined with simplified habitats and reduced genetic diversity may be leading to more synchrony in the productivity of populations across the range of salmon (Braun et al. 2016). For example, salmon productivity (recruits/spawner) has also become more synchronized across Chinook populations from Oregon to the Yukon (Dorner et al. 2018, Kilduff et al. 2014). In addition, Chinook salmon have become smaller and younger at maturation across their range (Ohlberger et al. 2018). Other Pacific salmon species (Stachura et al. 2014) and Atlantic salmon (Olmos et al. 2020) also have demonstrated synchrony in productivity across a broad latitudinal range.

At the individual scale, climate impacts on salmon in one life stage generally affect body size or timing in the next life stage and negative impacts can accumulate across multiple life stages (Healey 2011; Wainwright and Weitkamp 2013, Gosselin et al. 2021). Changes in winter precipitation will likely affect incubation and/or rearing stages of most populations. Changes in the intensity of cool season precipitation, snow accumulation, and runoff could influence migration cues for fall, winter and spring adult migrants, such as coho and steelhead. Egg survival rates may suffer from more intense flooding that scours or buries redds. Changes in hydrological regime, such as a shift from mostly snow to more rain, could drive changes in life history, potentially threatening diversity within an ESU (Beechie et al. 2006). Changes in summer temperature and flow will affect both juvenile and adult stages in some populations, especially those with yearling life histories and summer migration patterns (Crozier and Zabel 2006; Crozier et al. 2010, Crozier et al. 2019).

At the population level, the ability of organisms to genetically adapt to climate change depends on how much genetic variation currently exists within salmon populations, as well as how selection on multiple traits interact, and whether those traits are linked genetically. While genetic diversity may help populations respond to climate change, the remaining genetic diversity of many populations is highly reduced compared to historic levels. For example, Johnson et al. (2018), compared genetic variation in Chinook salmon from the Columbia River Basin between contemporary and ancient samples. A total of 84 samples determined to be Chinook salmon were collected from vertebrae found in ancient middens and compared to 379 contemporary samples. Results suggest a decline in genetic diversity, as demonstrated by a loss of mitochondrial haplotypes as well as reductions in haplotype and nucleotide diversity. Genetic losses in this comparison appeared larger for Chinook from the mid-Columbia than those from the Snake River Basin. In addition to other stressors, modified habitats and flow regimes may create unnatural selection pressures that reduce the diversity of functional behaviors (Sturrock et al. 2020). Managing to conserve and augment existing genetic diversity may be increasingly important with more extreme environmental change (Anderson et al. 2015), though the low levels of remaining diversity present challenges to this effort (Freshwater 2019). Salmon historically maintained relatively consistent returns across variation in annual weather through the portfolio effect (Schindler et al. 2015), in which different populations are sensitive to different climate drivers. Applying this concept to climate change, Anderson et al. (2015) emphasized the additional need for populations with different physiological tolerances. Loss of the portfolio increases volatility in fisheries, as well as ecological systems, as demonstrated for Fraser River and Sacramento River stock complexes (Freshwater et al. 2019, Munsch et al. 2022).

2.2.1 Status of Critical Habitat

This section describes the status of designated critical habitat affected by the proposed action by examining the condition and trends of the essential physical and biological features (PBFs) of that habitat throughout the designated areas. These features are essential to the conservation of the ESA-listed species because they support one or more of the species' life stages (e.g., sites with conditions that support spawning, rearing, migration and foraging).

The long-term decline in Oregon Coast coho salmon productivity reflects deteriorating conditions in freshwater habitat as well as extensive loss of access to habitats in estuaries and tidal freshwater (Stout et al. 2012, NWFSC 2015). Many of the habitat changes resulting from land-use practices over the last 150 years that contributed to the ESA-listing of Oregon Coast coho salmon continue to hinder recovery of the populations; changes in the watersheds resulting from land use practices have weakened natural watershed processes and functions, including loss of connectivity to historical floodplains and wetlands and side channels; reduced riparian area functions (stream temperature regulation, wood recruitment, sediment and nutrient retention); and altered flow and sediment regimes (NMFS 2016a). Several historical and ongoing land uses have reduced stream capacity and complexity in Oregon coastal streams and lakes through disturbance, road building, splash damming, stream cleaning, and other activities. Beaver removal, combined with loss of large wood in streams, has also led to degraded stream habitat conditions for coho salmon (Stout et al. 2012). The amount of tidal wetland habitat available to support coho salmon rearing has declined substantially relative to historical estimates. Water quality has also been identified as a factor for decline. Stout et al. (2012) determined that water temperature is the primary source of water-quality impairment in the Oregon Coast coho salmon critical habitat.

Oregon's assessment of OC coho salmon (Nicholas et al. 2005) mapped how streams with high intrinsic potential for rearing are distributed by land ownership categories. Agricultural lands and private industrial forests have by far the highest percentage of land ownership in high intrinsic potential areas and along all coho salmon stream miles. Federal lands have only about 20 percent of coho salmon stream miles and 10 percent of high intrinsic potential stream reaches. Because of this distribution, activities in lowland agricultural areas are particularly important to the conservation of OC coho salmon.

Habitat conditions in many stream reaches have improved because of restoration efforts. Restoration activities to improve coho salmon habitat have been ongoing since the 1990s, supported by NMFS, OWEB, USFWS, U.S. Forest Service, other state and federal agencies, and many landowners and stakeholders. Together, these projects are contributing to the restoration of habitat conditions in estuarine, tidal, and freshwater areas. However, despite restoration efforts, there is little evidence of an overall improving trend in freshwater habitat conditions since the mid-1990s and evidence of negative trends in some strata (Stout et al. 2012). The most recent assessment indicates that this has not changed (NWFSC 2015).

The OC coho salmon assessment concluded that at the scale of the entire domain, pools are generally abundant, although slow-water and off-channel habitat (which are important refugia for coho salmon during high winter flows) are limited in the majority of streams when compared to reference streams in minimally disturbed areas. The amount of large wood in streams is low in all four ODFW monitoring areas and land-use types, relative to reference conditions. Amounts of fine sediment are high in three of the four monitoring areas and were comparable to reference conditions only on public lands.

2.2.2 Status of the Species

NMFS first listed OC coho salmon as a threatened species under the ESA in 1998. The species was relisted in 2008 and NMFS re-affirmed the OC coho salmon listing status as threatened on June 20, 2011 (76 FR 35755). We released a recovery plan for OC coho salmon in 2016 (NMFS 2016a). In 2022, we completed a 5-year review for OC coho salmon in which we concluded this listing status remains appropriate (Ford 2022).

Abundance and Productivity. The total abundance of spawners within the ESU generally increased between 1999 and 2014, before dropping in 2015 and remaining low through 2019 (Ford 2022). The 2014 OC coho salmon return (355,600 natural and hatchery spawners) was the highest since at least the 1950s (2011 was the second highest, with 352,200; Sounhein et al. 2015), while the 2015 return (56,000 fish) was the lowest since the late 1990s. Most independent and dependent populations show synchronously high abundances in 2002–2003, 2009–2011, and 2014, and low abundances in 2007, 2012–13, and now 2015–19 (Ford 2022). Abundance of natural-origin spawners increased in the 1990–2014 time period but decreased during the most recent time period 2015–2019. Ford (2022) found all populations to have exhibited a substantial decrease in the geometric mean abundance between the previous 5-year period (2010–2014) and the recently assessed time period (2015–2019). The decrease in abundance ranged from –55 percent to –75 percent. A similar pattern was observed with 15-year trends: all were positive during the 1990–2005 period, but most were near zero or negative during the 2004–2019 period.

Estimates of productivity increased in half the populations between 2012 and 2015. However, between 2015 and 2020, estimated productivity declined in 14 populations, stayed the same in 2, and improved in 7. The number of populations for which there was moderate-to-high certainty that population production at low abundance is sufficient to withstand an extended period of adverse environmental conditions was 19 in both 2012 and 2015 but decreased to 17 populations in 2020 (Ford 2022).

Spatial Structure and Diversity**.** This species includes populations of coho salmon in Oregon coastal streams south of the Columbia River and north of Cape Blanco. The Cow Creek Hatchery Program (South Umpqua population) is included as part of the ESU because the original brood stock was founded from the local, natural-origin population and natural-origin coho salmon have been incorporated into the brood stock on a regular basis. Lawson et al. (2007) identified 56 populations in the OC coho salmon ESU, including 21 independent and 35 dependent populations in five biogeographic strata (Table 3). Independent populations are populations that historically would have had a high likelihood of persisting in isolation from neighboring populations for 100 years and are rated as functionally independent or potentially independent. Dependent populations (D) are populations that historically would not have had a high likelihood of persisting in isolation for 100 years. These populations relied upon periodic immigration from other populations to maintain their abundance (McElhany et al. 2000, Lawson et al. 2007). Most recently, spatial structure conditions have improved in terms of spawner and juvenile distribution in watersheds. Ford (2022) found that the number of populations for which there is moderate-to-high certainty that historically occupied watersheds had spawners and juveniles occupying the available habitat increased from the 2012 to 2020.

Table 3. OC coho salmon populations. Population types included functionally independent (FI), potentially independent (PI) and dependent populations (D) (McElhany et al. 2000, Lawson et al. 2007).

Stratum	Population	Type	Stratum	Population	Type
North Coast	Necanicum River	PI	Mid-Coast (cont.)	Alsea River	FI
	Ecola Creek	D		Big Creek (Alsea)	D
	Arch Cape Creek	D		Vingie Creek	D
	Short Sands Creek	D		Yachats River	D
	Nehalem River	FI		Cummins Creek	D
	Spring Creek	D		Bob Creek	D
	Watseco Creek	D		Tenmile Creek	D
	Tillamook Bay	FI		Rock Creek	D
	Netarts Bay	D		Big Creek (Siuslaw)	D
	Rover Creek	D		China Creek	D
	Sand Creek	D		Cape Creek	D
	Nestucca River	FI		Berry Creek	D
	Neskowin Creek	D		Siuslaw River	FI
Mid-Coast	Salmon River	PI	Lakes	Siltcoos Lake	PI
	Devils Lake	D		Sutton Creek	D
	Siletz River	FI		Tahkenitch Lake	PI
	Schoolhouse Creek	D		Tenmile Lakes	PI
	Fogarty Creek	D	Umpqua	Lower Umpqua River	FI
	Depoe Bay	D		Middle Umpqua River	FI
	Rocky Creek	D		North Umpqua River	FI
	Spencer Creek	D		South Umpqua River	FI
	Wade Creek	D	Mid-South Coast	Threemile Creek	D
	Coal Creek	D		Coos River	FI
	Moolack Creek	D		Coquille River	FI
	Big Creek (Yaquina)	D		Johnson Creek	D
	Yaquina River	FI		Twomile Creek	D
	Theil Creek	D		Floras Creek	PI
	Beaver Creek	PI		Sixes River	PI

A 2010 BRT (Stout et al. 2012) noted significant improvements in hatchery and harvest practices had been made, although, harvest and hatchery reductions have changed the population dynamics of the ESU. The hatchery influence on diversity continues to decrease in response to reduced hatchery production in the OC coho ESU (Ford 2022). Ford (2022) found all but two populations have either high or complete certainty that hatchery influence does not adversely affect natural populations. The sole exceptions are the North and South Umpqua populations which are influenced by the Cow Creek hatchery program.

In summary, Ford (2022) found that the current spatial structure and diversity are similar to previous assessments or improved in some cases (e.g. reduced hatchery influence).

<u>Limiting Factors.</u> Oregon Coast coho salmon are primarily affected by threats that reduce the quantity and quality of coho salmon rearing habitat. The most recent 5-year review indicates that although a number of habitat restoration and protection actions have been implemented in recent years, degraded habitat conditions throughout the range of the species remains a concern. The

greatest concerns for habitat conditions are related to the effect of forest practices on riparian areas, the continued loss of instream habitat complexity and floodplain habitats (NMFS 2022b).

Limiting factors of high concern cited in the recovery plan include:

- Reduced amount and complexity of habitat including connected floodplain habitat
- Degraded water quality
- Blocked/impaired fish passage
- Inadequate long-term habitat protection
- Changes in ocean conditions

NMFS (2016a, 2022b) also identified climate change as a threat, of medium-high concern, with effects on primary limiting factors including further habitat degradation and productivity. Similarly, a recent assessment of the vulnerability of ESA-listed salmonid "species" to climate change indicated that OC coho salmon had high overall vulnerability, high biological sensitivity and climate exposure, and only moderate adaptive capacity (Crozier et al. 2019). Because young coho salmon spend a full year in freshwater before ocean entry, the juvenile freshwater stage is considered to be highly vulnerable. They also scored high in sensitivity at the marine stage due to expected changes due to ocean acidification. These results are consistent with the climate change assessment by Wainwright and Weitkamp (2013), which indicated that Oregon Coast coho salmon will likely be negatively affected by climate change at all stages of the life cycle.

2.3. Action Area

"Action area" means all areas to be affected directly or indirectly by the federal action and not merely the immediate area involved in the action (50 CFR 402.02). Hence, the action area includes the permit area and hydrologically connected waters that may experience effects from water temperature, flow, or suspended sediment level fluctuations that are propagated downstream as a result of the covered activities. We conservatively estimate that effects resulting from the covered activities will extend up to approximately 1 mile downstream of the permit area, with the greatest extent of effects likely resulting from sediment-related impacts. Therefore, we delineate the action area to include the permit area and all hydrologically connected surface waters within a 1-mile distance downstream of the permit area as shown in Figure 1.

Additionally, because the action will impact prey species (Chinook salmon) for Southern Resident killer whales (SRKW), the action area for SRKW includes all areas of the Pacific Ocean where the marine ranges of prey species subject to this consultation overlap with SRKW. This area encompasses the whales' entire coastal range from the mouth of the Columbia River and its plume, south as far as central California (Weitkamp 2010, Shelton et al. 2019) and north as far as Southeast Alaska (NMFS 2008, Hanson et al. 2013, Carretta et al. 2022).

2.4. Environmental Baseline

The "environmental baseline" refers to the condition of the listed species or its designated critical habitat in the action area, without the consequences to the listed species or designated critical habitat caused by the proposed action. The environmental baseline includes the past and present impacts of all federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early section 7 consultations, and the impact of State or private actions which are contemporaneous with the consultation in process. The impacts to listed species or designated critical habitat from federal agency activities or existing federal agency facilities that are not within the agency's discretion to modify are part of the environmental baseline (50 CFR 402.02).

2.4.1 Physical Setting and Forest Conditions

The action area has a strong maritime influence from the Pacific Ocean. As a result, temperature fluctuations are moderate, and rainfall is high. The mean minimum January temperature in the action 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 action area, to 90 inches per year. Snowfall in the forest is normally light to moderate, both in amount and duration of the snow. The west side of the action area also experiences frequent summertime fog. During the dry summer period, the fog contributes a significant amount of moisture to vegetation through fog drip (condensation).

The topography of the action area is generally rugged and highly dissected with steep, narrow canyons, although the southeast part of the action area is less steep. 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 soils in the action 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. 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. 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 (ODSL and ODF 2011).

Watersheds and Hydro-regions in the Action Area. The streams draining the action area flow into one of three basins that can be further divided into 13 watersheds based on the Watershed Boundary Dataset layer for Oregon (Table 3).[4] About 47 percent of the action area drains southwest into Coos River Basin, 30 percent drains north to the Umpqua River Basin, and 23 percent drains west to the Tenmile Lakes Basin. The ESRF is characterized by high stream densities and, by extension, high headwater stream channel densities. Perennial stream density of the ESRF is 2.3 kilometers per square kilometer, and stream density of all first order and larger stream channels is 4.8 kilometers per square kilometer.

[4] U.S. Geological Survey 2020 National Hydrography Watershed Boundary Dataset. Available at: 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.

These three basins differ in physical characteristics and environmental setting. The Coos River Basin region is approximately 67.9 square miles and has 73.4 miles of large and medium streams that provide habitat for salmonids. The relatively large West Fork Millicoma River, a tributary to the Coos River, is particularly important for supporting OC coho salmon in the action area. The Umpqua River Basin is approximately 44.1 square miles and has 36.8 miles of large and medium stream classes. The Tenmile region is approximately 33.6 square miles and has 24 miles of large and medium stream classes. The streams in Tenmile Lakes Basin have high-quality rearing habitat for coho salmon due to an abundance of low-gradient, unconfined streams.

The action area falls within the rain hydro-region of the Coast Range (Table 4). Hydro-regions are a physical classification of landscapes based on the form of precipitation with elevation, as predominantly rain, rain-on-snow (or transient snow zone), or snow. The rain hydro-region is below approximately 2,000 feet in the Coast Range. Rain-on-snow transition areas where shallow snow accumulations can come and go have been reported by Harr (1982) and Harr and Coffin (1992) to be in the elevation range of 1,200-3,600 feet in western Oregon.

Table 4. Watersheds in the Action Area and their hydroregions.

	Watersheds		**Hydro-regions (Acres)**		
Coho IP	**HUC 12**	**Name**	**Rain Dominated**	**Rain on Snow Transition**	**Total**
Lower Umpqua	171003030403	Little Mill Creek-Umpqua River	226	0	226
	171003030502	Lower Lake Creek	1,848	0	1,848
	171003030504	Lower Camp Creek	39	0	39
	171003030505	Loon Lake-Mill Creek	6,885	1	6,886
	171003030801	Dean Creek-Umpqua River	12,962	0	12,962
	171003030802	Scholfield Creek	4,786	0	4,786
Coos	171003040202	Glenn Creek	2,925	9	2,934
	171003040203	East Fork Millicoma River	183	0	183
	171003040204	West Fork Millicoma River	28,071	15	28,086
	171003040304	Haynes Inlet	5,280	0	5,280
	171003040306	Coos Bay	180	0	180
Tenmile	171003040401	North Tenmile Lake	7,453	0	7,453
	171003040402	Tenmile Lake-Tenmile Creek	12,464	0	12,464
	Acres		**83,302**	**25**	**83,326**

Climate Change in the Action Area.

Major ecological realignments are already occurring in response to climate change (Crozier et al. 2019). As observed by Siegel and Crozier in 2019, long-term trends in warming have continued at global, national and regional scales. Globally, 2014-2018 were the five warmest years on record, both on land and in the ocean (2018 was the fourth warmest). Events such as the 2013-2016 marine heatwave (Jacox et al. 2018), have been attributed directly to anthropogenic warming in the annual special issue of Bulletin of the American Meteorological Society on extreme events (Herring et al. 2018). Global warming and anthropogenic loss of biodiversity represent profound threats to ecosystem functionality. These two factors are often examined in isolation, but likely have interacting effects on ecosystem function (Siegel and Crozier 2019). During the last century, average regional air temperatures in the Pacific Northwest increased by 1-1.4°F as an annual average, and up to 2°F in some seasons (based on average linear increase per decade; Abatzoglou et al. 2014; Kunkel et al. 2013). Warming is likely to continue during the next century as average temperatures are projected to increase another 3 to 10°F, with the largest increases predicted to occur in the summer (Mote et al. 2014).

Inventory of Known Beaver Activity within the Action Area. Limited information is known about beaver activity within the action area. However, due to the steep terrain it is likely that there is limited opportunity for beaver activity within the action area aside from the slightly gentler terrain in the lower Millicoma watershed. Beaver activity was documented as part of the ODFW Aquatic Inventories Project (AIP) surveys between 1901 and 2002. A total of 71 beaver dams were documented in the action area: 46 within the Coos and 25 within the Tenmile coho intrinsic potential (IP) area. Data from the AIP is not available for the Lower Umpqua. More current information on the distribution of beavers or beaver activity (dams) is not available.

Instream habitat characteristics. Biosystems et al. (2003) used a system described in the Oregon Watershed Assessment Manual (OWEB 1999) to delineate stream segments with similar channel gradient and geometry to evaluate fish habitat and sediment transfer characteristics for the forest. Over 50% of fish-bearing stream miles were identified as moderate gradient (2-4%), confined channel (floodplain width less than 2X the bank full width). Moderately steep (3-10% gradient), narrow valley channels make up 19% of the overall stream mileage. Confined channels, regardless of gradient, make up nearly 75% of fish-bearing stream miles. The moderate gradient, moderately confined (floodplain width greater than 2X but less than 4X bank full width) stream type is found mostly in the Marlow Creek and lower West Fork Millicoma River watersheds of the Coos River Basin. The low gradient, moderately confined stream type is relatively rare and occurs mostly in Palouse and Larson Creeks, also in the Coos River Basin. Low-gradient channels with a large flood plain occur only in Scholfield Creek (Lower Umpqua River Basin) and in lower reaches of larger streams in the Tenmile Lakes Basin. Fish-bearing streams on most of the forest have favorable gradients for salmonids (less than 4%) but are tightly confined by adjacent hillslopes. Some streamside roads have further confined the stream channels. At high flows, considerable energy is conveyed by water flowing through narrow and non-meandering channels. Thus, slower water where fish can rest during high flows is limited mostly to that provided by large wood in the channel. Unconfined streams common to the Tenmile Lakes Basin provide unique, high-quality habitat for fish not found elsewhere on the forest. These low gradient streams are more likely to provide high-quality refuge habitat during high water since the channel can meander freely and create backwater areas.

The other data source for habitat complexity is the ODFW AIP database. More information on this database can be found here: ODFW Aquatic Inventories Project (oregonstate.edu). The ODFW AIP surveys conducted within the action area occurred between 1901 and 2002 and may not reflect current conditions. However, the streams that were surveyed within the Coos River and Tenmile Lakes basins contain roughly 550 and 473 pools per kilometer. Additionally, 4 and 6 habitat units were measured every 100 meters during surveys within the Coos River and

Tenmile Lakes basins, respectively. The ODFW often uses these metrics as an index of habitat complexity.

2.4.2 Land Management in the Action Area

The ESRF is comprised of state lands with different oversight, management authority, and mandates. Most of the ESRF is lands (83,450 acres) overseen by the State Land Board. DSL manages the majority of these lands (83,326 acres); ODF manages the other 124 acres. The remainder of the Elliot State Forest (8,893 acres) is Board of Forestry Lands managed by ODF. The privately-owned parcels are located in the southern part of the action area and total 161 acres.

Forest management and timber harvest

Prior to state management, the majority of the action area was managed by the U.S. Forest Service (USFS) and the rest by private landowners. The action area transferred to state ownership in 1930 as part of an agreement to consolidate scattered Common School Fund Lands within federal forests into a contiguous block of state forest. From 1930 to 2017 (87 years), Elliott State Forest was managed by 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.

During the late 1930s and early 1940s, ODF awarded annual contracts to harvest cascara (*Frangula purshiana*) bark from the Elliott, which was used to formulate a natural laxative. Annual harvests reached 21 tons in 1943, then declined after the active ingredient was synthesized. By the mid-1940's, active forest management and timber harvesting on the Elliott gradually increased, accompanied by a rise in road construction. Since 1950, roughly 50% of the ESRF has been clearcut and replanted into a patchwork of even-aged, mostly single-species stands which now span age classes from 10 – 65+ years. In other areas, partial harvests from about 1958-1978 focused on "stand management" (Phillips 1997) and have altered growth rates, stand structure and understory communities. In the Coos watershed, slopes are more moderate than elsewhere on the ESRF, and more timber harvesting occurred here in recent decades under ODF management compared to other regions of the forest. In the Umpqua watershed, past timber harvest under ODF management was curtailed in areas directly upslope of Highway 38 (along the Umpqua River) and Loon Lake Road (along Mill Creek) owing to landslide safety concerns and to maintain visual quality along this corridor. In the Tenmile watersheds, timber harvest was limited by the early 2000s as the basins had been designated as 1600—240 year-old rotation and past harvesting did not allow for much additional near-term harvest.

Surrounding the action area, forest management has primarily included management for commercial timber harvest since the early to mid-twentieth century. Beginning in the 1930s, demand for commercial timber harvest in western Oregon increased and more land began to be managed as plantation-style forests. At present, the primary land managers adjacent to the action area include USFS to the north, Bureau of Land Management (BLM) to the north and east, the Oregon Board of Forestry (BOF) to the south and west, and private landowners to the east, south, and west. Most private lands are managed as commercial timberlands dominated by even-age

Douglas-fir (*Pseudotsuga menziesii*) plantations. Federal land, including BLM "checkerboard" lands, and state lands contain both young and late-successional forest.

Federal lands contain young forest as well as much of the late-successional forest remaining in coastal Oregon. Much of the other federal land adjacent to the action area has been managed for conservation pursuant to the Northwest Forest Plan since its adoption in 1994 (USFS and BLM 1994a, 1994b); this includes the implementation of Resource Management Plans (RMPs) for BLM lands (BLM 2016a, 2016b) and Land Management Plans (LMPs) for USFS lands. The Northwest Forest Plan and associated RMPs and LMPs designate areas of the forest for various purposes, including timber harvest, conservation, and recreation. Management and conservation under these plans include a combination of land allocations, standards and guidelines or management direction, and associated review procedures. These plans also establish allowable timber sale quantities in areas available for timber harvest. They outline conservation strategies for a wide range of terrestrial and aquatic species, including those covered under the ESRF HCP.

Road management

The initial road network on the Elliott was established by the Civilian Conservation Corp (CCC) in the 1930s, and the system was gradually extended after World War II. Road building increased at a faster rate after 1955 with the transfer of forest management from DSL to ODF and ramp-up of timber sales. At least 150 miles of road were rapidly constructed in the western part of the forest after the Columbus Day windstorm of 1962 to provide access for salvage harvest. By approximately 1968 the all-weather road system on the Elliott was essentially complete, although construction of spurs, and upgrades and maintenance of existing roads continued (Biosystems et al. 2003, Phillips 1997).

The current ESRF road network consists of approximately 550 miles of roads, over 300 miles of which are located along ridgetops. About 175 miles of road are on side slopes, with the remainder along valley bottoms and varying in proximity to streams. The road system in the action area has a road density of 3.79 mi/mi^2 averaged across all subwatersheds. Within the entire action area, roughly 60 percent of the road system is on or within close proximity to ridgelines (330 feet).

The NMFS uses habitat indicators to help characterize watershed habitat conditions for salmonids in the Northwest Forest Plan Area on USFS and BLM lands. While not federally owned land, road density and how it functions to support aquatic habitat can be described in the ESRF with the habitat indicator for road density at the watershed level. Road density in a watershed is deemed properly functioning, functioning at risk, or not properly functioning if the density is less than 2 miles/square mile (mi/mi^2), 2 to 3 mi/mi^2, or greater than 3 mi/mi^2, respectively. Road density for sub-watersheds in the ESRF as described by OSU (2021) (management basins, similar to HUC12) are either functioning at risk or not properly functioning (see Table 5). When considering the population of OC coho salmon distribution in the ESRF (Figure 11), the Coos, Tenmile, and Lower Umpqua are functioning at risk for road density.

Table 5. Road densities are provided by independent population and management basin (roughly HUC12); that table is provided below.

Coho IP	Management Basin	Road Length (Miles)	Size of Basin (Square Miles)	Road Density (Miles of Road/Square Mile)
Coos	Palouse Larson	32.65	10.14	3.22
	Henrys Bend	49.48	13	3.81
	Marlow Glenn	50.05	10.18	4.92
	Millicoma Elk	94.57	17.07	5.54
	Trout Deer	83.23	17.72	4.7
	Total	**309.98**	**68.11**	**4.6**
Lower Umpqua	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
	Ash Valley	27.87	6.1	4.57
	Total	**133.13**	**43.14**	**3.1**
Tenmile	Big Creek	33.78	12.22	2.76
	Benson Roberts	34.42	11.44	3.01
	Johnson Creek	35.54	9.83	3.62
	Total	**103.74**	**33.49**	**3.1**
	Scattered Tracts[1]	3.59	0.61	5.89
	Total	**550.44**	**145.35**	**3.79**

Recreational use

Current recreational use of the ESRF is largely determined by its location, topography, and accessibility. Most recreational visitors to the ESRF come from the surrounding communities given its distance from major metropolitan areas and general lack of awareness and accessibility for visitors to Oregon's coastal tourism resources. Highest visitation times occur in the summer months, especially over long holiday weekends, and in the fall for deer and elk hunting seasons, although overall recreation use remains low across most of the forest. The steep terrain concentrates recreational use to certain low-lying areas and access via the forest road network.

Current recreational uses and allowances on the ESRF include primitive camping, fishing, hunting, hiking, motorized and off-highway vehicles, firewood cutting, and non-commercial special forest products gathering (e.g., mushrooms, berries, boughs, etc.). Hunting, fishing and trapping are allowed as regulated by ODFW. During extreme fire conditions, recreational and other public access to the forest may be limited or restricted.

Landslides and Mass Wasting

The ESRF encompasses steep, mountainous terrain with an abundance of landforms that reflect past slope instability. Steep slopes are a distinguishing feature of the ESRF. Slopes with greater than 65 percent comprise 73 percent of the area of the CRWs and 54 percent of the MRWs. Situated in two geological units consisting of weak and weathered sedimentary rock – the Tyee and Elkton formations – deep-seated failures such as earthflows and bedrock landslides are prevalent throughout much of the ESRF, although the current activity of most of these features is largely unknown. Shallow-seated features prone to significant mobility, such as shallow landslides in soil or weathered rock, are also frequent in this terrain. However, the magnitude and distribution of these failures are largely event-driven and dependent on climatic drivers like atmospheric rivers and/or rain-on-snow events, such as those in the winter of 1996-1997. The outflows of many channels exhibit fan-like topography, suggesting that debris flow events stemming from landslides or failed logjams are prevalent and likely source from smaller-order channels in the numerous tributaries upstream of major streams. Anthropogenic slope failures occur in the ESRF, primarily in the form of shallow-seated failures at roads, channel crossings, and fill slopes.

Oregon State University developed a landslide inventory of the ESRF using mapping protocols developed by the Oregon Department of Geology and Mineral Industries. Approximately 1,350 landslides were mapped and assigned inferred mechanisms, volumes, and mapping confidence levels. Many of the features mapped in the eastern portion of the ESRF are large, deep-seated landslides typically prone to intermittent movements and dormancy, likely associated with geologic controls from the Elkton Formation. The western portion of the ESRF is primarily in the Tyee Formation, and has numerous mapped debris fans as well as numerous deep-seated bedrock landslide features.

Water Quality

As required by the federal Clean Water Act (CWA) the Oregon Department of Environmental Quality (DEQ) has designated beneficial uses (e.g., fish and aquatic life, recreation, water supply) for Oregon waters and establishes water quality standards (benchmarks) to maintain these uses. The DEQ has established standards for criteria including sedimentation, biocriteria (e.g., fecal coliform), dissolved oxygen, and water temperature. In the case of temperature, the most sensitive beneficial use is Oregon’s native cold-water aquatic communities, indicated by the presence of fish such as salmon and trout. Several temperature standards have been established to protect various life stages and fish species, depending on their thermal requirements (OAR 340-041-0028).

As of 2022, four streams on the ESRF of stream order 5 or above are 303(d) listed as having an impairment: segments of Dean, Johnson and Big Creeks along the western border of the forest (dissolved oxygen) where past land use has included agriculture, and the WF Millicoma River below its confluence with Panther Creek (temperature) (Table 6). Several other stream segments, smaller than stream order 5 and aggregated at the watershed level for EPA reporting, are listed as having an impairment (mostly for temperature).

Table 6. Streams listed for 303(d) water quality parameters.

Coho Independent Populations	Stream Miles		
	Dissolved Oxygen	**Temperature**	**Total**
Coos			
Millicoma River	0	17.3	17.3
Lower Umpqua			
Lower Umpqua River	1.6	0	1.6
Mill Creek	0	0.0	0.0
Tenmile			
Tenmile Creek-Frontal Pacific Ocean	2.7	1.3	4.0
Grand Total	**4.3**	**18.7**	**23.0**

Total maximum daily loads (TMDLs) for the Lower Umpqua are in place for bacteria (fecal coliform) and temperature. TMDL for aquatic weeds and algae is in place for Tenmile Lakes. TMDLs for the Coos subbasin are in progress.

Historical Fires

Wildfire is an essential disturbance process in the Oregon Coast Range. The influence of wildfire on a forest ecosystem is generally characterized in terms of its fire regime – a broad description of fire frequency, severity, and variability over time and across the landscape. Disturbance regimes in Douglas-fir/western hemlock forests within these "moist" forests have often been characterized as driven by predominately infrequent, high-severity fires, with intermittent gap-scale disturbances generated by wind and biotic disturbance agents (Agee 1993; Franklin and Johnson 2012). These infrequent, severe fires are usually associated with largescale east wind events that occur sporadically during the dry season from late August until early October.

Fire records suggested that most historical fires were relatively small (i.e. < 2500 acres), and included a substantial portion of low- to moderate- severity fire effects. In contrast, fires in 1849 and 1868 were extensive and relatively severe, burning across much of the ESRF and on both sides of the Umpqua River. Evidence in earlier centuries is relatively limited, but earlier fires in 1776 and 1628 may have been similar to the 1849 and 1868 fires. East wind events that support large, high-severity wildfires are relatively rare in the central Oregon Coast Range, but when these extreme fire weather events do occur meteorological records indicate they are relatively severe and of long duration (Reilly et al. 2022).

The well-known 1868 fire and previously undocumented fires in 1849 and 1883 and 1894 were all likely influential to the development of mature stands that are common across the ESRF today. Results also suggest that temporal variation in fire frequency and severity facilitated multiple successional pathways and increased forest structural and compositional diversity across the ESRF prior to fire suppression.

Aquatic habitat restoration and enhancement.

The Oregon Watershed Enhancement Board maintains a database of habitat restoration activities (Oregon Watershed Restoration Inventory (OWRI)) undertaken by governmental and non-governmental entities in Oregon. The majority of activities recorded in the OWRI represent voluntary actions of private citizens and landowners who have worked in partnership with federal, state, and local groups to improve aquatic habitat and water quality conditions. Projects in OWRI may have one to many treatments that are categorized within a specific activity type. The types of activities are: riparian habitat improvement and protection, instream and estuarine habitat improvement, fish passage improvements, upland projects designed to provide benefits to aquatic habitats, and road improvements to reduce risk of road failure and reduce chronic sediment inputs. Since 1997, OWEB has been collecting information on watershed restoration projects to track on-the-ground efforts to restore aquatic habitat and water quality conditions in Oregon. In the past three decades 354 restoration projects and 427 activities have been initiated and/or completed within the Action Area (Table 7).

Table 7. Restoration activities recorded by watershed. The number of activities is greater than the number of projects, some projects include more than one restoration activity.

Watershed	Estuarine	Fish Passage	Instream	Riparian	Road	Upland	Grand Total
Coos Bay-Frontal Pacific Ocean		4	7	22	5		38
Lower Umpqua River	1	1	7	7	3	1	20
Mill Creek		2	3	21	5		31
Millicoma River		31	59	119	73	1	283
Tenmile Creek-Frontal Pacific Ocean		12	5	28	8	2	55
Grand Total	**1**	**50**	**81**	**197**	**94**	**4**	**427**

2.4.3 Critical Habitat in the Action Area

The action area includes designated critical habitat for OC coho salmon. The critical habitat PBFs that support spawning, rearing, and migration for OC coho salmon are described in section 2.2.1 of this opinion (*Status of Critical Habitat*). The PBFs include salinity, substrate, floodplain connectivity, forage, natural cover, water quality, water quantity, and fish passage free of artificial obstruction.

Key management activities that occur or have occurred in the action area that have reduced the quality and function of the covered listed species' critical habitat in the action area include forest management, road building, agriculture, urbanization, irrigation and water withdrawals, grazing, and gravel mining (NMFS 2007 and 2016a). Each of these activities has contributed to a myriad of interrelated factors for the decline in quality and function of critical habitat PBFs essential for the conservation of OC coho salmon. These activities have resulted in increases in water temperatures, sedimentation and suspended sediments in streams, altered stream substrate composition, and reduced habitat complexity from timber harvest, road building and use, and other forest management activities that have reduced forest canopy and increased the likelihood and frequency of landslides and debris flows in the action area. Among the most important changes to critical habitat are altered stream channel morphology, degradation of spawning substrates, reduced in-stream channel roughness and natural cover, loss and degradation of riparian areas, water quality degradation (e.g., water temperature, sediment, and dissolved oxygen), altered water quantity and stream flows, blocked fish passage, and loss of off-channel habitats and floodplain connectivity.

2.4.4 Species in the Action Area

The action area includes portions of the Umpqua River, Coos River, and Tenmile Lake/Creek basins. OC coho salmon use the habitat in the action area for adult migration, adult spawning, juvenile rearing, and juvenile migration. The anadromous life cycle of coho salmon begins in their home stream where they emerge from eggs as ‘alevins’ (a larval life stage dependent on food stored in a yolk sac). These very small fish require cool, slow moving freshwater streams with quiet areas such as backwater pools, beaver ponds, and side channels (Reeves et al. 1989) to survive and grow through summer and winter seasons. In particular, low gradient stream reaches on lower elevation land are important for winter survival of juvenile coho salmon (Stout et al. 2012).

Most juvenile coho salmon migrate to the ocean as yearling smolts in the spring, typically from as late as March into June. Coho salmon smolts outmigrating from freshwater reaches may feed and grow in lower mainstem and estuarine habitats for a period of days or weeks before entering the nearshore ocean environment. Research shows that substantial numbers of coho fry may also emigrate downstream from natal streams into tidally influenced lower river wetlands and estuarine habitat (Chapman 1962; Koski 2009; Bass 2010). The BRT (Stout et al. 2012) reported at least three discrete life history strategies involving coho fry and presmolt migrations into lower river habitats: 1) late fall migration into side-channel or pond habitats connected to lower mainstem reaches from mainstem summer rearing habitats, 2) lower mainstem and estuarine summer rearing followed by upstream migration for overwintering, and 3) lower mainstem and estuarine rearing followed by subyearling outmigration to ocean. The relative contribution of these alternative life history pathways to either current or historical adult coastal coho salmon populations is not known (Stout et al. 2012).

Oregon Coast coho salmon tend to make relatively short ocean migrations. Coho salmon from this ESU are present in the ocean from northern California to southern British Columbia, and even fish from a given population can be widely dispersed in the coastal ocean, but the bulk of the ocean harvest of coho salmon from this ESU are found off the Oregon coast. This ESU is strongly influenced by ocean conditions off the Oregon Coast, especially by the timing and intensity of upwelling (a condition characterized by near-shore ocean currents providing cool, nutrient-rich water that stimulates production of food that supports coho salmon and other fish species).

Adult coho salmon return to natal tributaries from September to November, and normally spawn in relatively small tributaries with low to moderate gradient stream reaches close to where they were hatched. This life history exposes young fish to variability in climatic patterns affecting rainfall and temperature, estuarine habitats, and catastrophic events like floods and fire. It also exposes them to the effects of land modifications and uses adjacent to streams, including roads, culverts, rural residential, agricultural, and other uses that may degrade habitat conditions or access. Current production of smolts in the Oregon Coast coho salmon ESU is particularly limited by the availability of complex stream habitat that provides the shelter for overwintering juveniles during periods when flows are high, water temperatures are low, and food availability is limited (ODFW 2007). Since coho salmon spend up to half of their lives in freshwater, the condition of the winter and summer juvenile rearing habitat is a key factor in their survival.

The description of climate change effects discussed in section 2.2 is applicable to the environmental baseline of the species. We summarize status information from Ford (2022) and compare it to recovery criteria for each basin and population below.

Umpqua River Basin

The Umpqua River basin represents one of five strata within the OC coho salmon ESU.[5] There are four functionally independent populations of OC coho salmon in the Umpqua River basin: (1) Lower Umpqua River; (2) Middle Umpqua River; (3) South Umpqua River; and (4) North Umpqua River populations. Each population and each stratum has a role in the ESU; for the ESU to be sustainable all five strata must be sustainable and for each stratum to be sustainable, most of the independent populations within each stratum must be sustainable (NMFS 2016a). The primary recovery strategy for the populations in the Umpqua Stratum is to protect current high-quality summer and winter rearing habitat and strategically restore habitat quality in adjacent habitat.

Lower Umpqua River Population

The Lower Umpqua River population consists of all naturally-spawned individuals from the mouth of the Umpqua River upstream to the confluence of Elk Creek near Elkton, Oregon. The five-year geometric mean of natural spawner abundance in this population increased from 2,904 in the 1990–1994 time period to 12,862 in the 2010–2014 time period (Table 8). During the most recent time period, spawner abundance decreased (2015–2019) to 7,082 (Ford 2022). A similar pattern is observed with 15-year trends in natural spawner abundances: a positive trend during the 1990–2005 period and slightly negative during the 2004–2019 period (Table 9; Ford 2022). Furthermore, the confidence interval for the recently estimated negative trend includes a non-zero number indicating that there is insufficient evidence to support a conclusion that the recent trend was in fact negative. This however should not be interpreted as evidence in support of the alternative possibilities that the trend is stable or increasing.

[5] A functionally-independent population is a population with a likelihood of persisting in isolation over a 100-year period and is not substantially altered by exchanges of individuals of other populations.

Table 8. The 5-year geometric mean of raw natural-origin spawner counts (Ford 2022). This is the raw total spawner count times the fraction natural estimate, if available. In parentheses, 5-year geometric mean of raw total spawner counts is shown. The geometric mean was computed as the product of counts raised to the power 1 over the number of counts available (2 to 5). A minimum of two values were used to compute the geometric mean. Percent change between the two most-recent 5-year periods is shown on the far right.

Population	1990-94	1995-99	2000-04	2005-09	2010-14	2015-19	% change
Tenmile Lake	841 (843)	2,176 (2,206)	2,439 (2,445)	2,851 (2,868)	5,509 (5,513)	885 (889)	–84 (–84)
Lower Umpqua	2,616 (2,632)	5,420 (5,420)	8,918 (8,931)	9,547 (9,562)	9,986 (10,008)	1,684 (1,684)	–83 (–83)
Middle Umpqua	2,904 (2,976)	4,197 (4,390)	11,348 (11,758)	10,180 (10,944)	12,862 (12,874)	7,082 (7,096)	–45 (–45)
North Umpqua	2,857 (3,039)	1,828 (1,935)	7,907 (8,265)	5,239 (5,689)	8,797 (8,804)	2,062 (2,062)	–77 (–77)
South Umpqua	900 (2,650)	939 (3,276)	2,729 (11,356)	2,946 (6,503)	4,552 (5,018)	1,976 (2,135)	–57 (–57)
Coos	1,633 (2,295)	3,125 (4,151)	6,876 (7,272)	8,670 (9,163)	18,237 (19,055)	1,977 (2,326)	–89 (–88)

Table 9. Fifteen-year trends in log natural spawner abundance computed from a linear regression applied to the smoothed natural spawner log abundance estimate. Only populations with at least four natural spawner estimates from 1980 to 2019 are shown and with at least two data points in the first 5 years and last 5 years of the 15-year period.

Population	1990-2005	2004-2019
Tenmile Lake	0.12 (0.07, 0.16)	–0.11 (–0.19, –0.04)
Lower Umpqua	0.12 (0.07, 0.17)	–0.05 (–0.12, 0.03)
Middle Umpqua	0.11 (0.06, 0.16)	–0.06 (–0.14, 0.01)
North Umpqua	0.07 (0.02, 0.13)	–0.02 (–0.12, 0.08)
South Umpqua	0.16 (0.10, 0.21)	–0.08 (–0.16, 0.00)
Coos	0.11 (0.07, 0.16)	–0.09 (–0.17, –0.01)

In addition to the analysis of trends in abundance and productivity, Ford (2022) used the knowledge-based Decision Support System (DSS) developed by Wainwright et al. (2008) to evaluate the biological sustainability of populations and the ESU. The DSS uses a diverse array of biological criteria to evaluate biological status. This list includes: watershed- and population-level spawner and juvenile occupancy and distributions, population-specific productivity, probability of persistence (from population viability models), spawner abundance, hatchery influence, and genetic and phenotypic diversity (Wainwright et al. 2008). For the purposes of this analysis we will focus on two DSS criteria: population persistence and population sustainability. Wainwright et al. (2008) defined persistence as the ability of a population to persist through a period of 100 years without artificial support. Sustainability refers to the ability of the population to maintain its genetic legacy and long-term adaptive potential for the foreseeable future. The DSS generates a score for each criteria ranging from certainly false (value of -1) through uncertain (value of zero) to certainly true (value of 1).

Ford (2022) reported the population persistence and sustainability as assessed by Stout et al. (2012), Lewis (2015), and Lewis (2020) (Table 10). The recent population persistence evaluation indicated a high probability that the Lower Umpqua River population will persist into the future. Similarly, the recent evaluation of population sustainability indicated a high probability that this population is sustainable. These results indicate that there is a high degree of certainty that this population is viable.

Table 10. Population persistence and sustainability scores for Oregon Coast coho salmon (Ford 2022).

Population	Population Persistence			Population Sustainability		
	2012	2015	2020	2012	2015	2020
Tenmile Lake	0.98	0.9	0.93	0.2	0.34	0.87
Lower Umpqua	0.74	0.81	0.85	0.65	0.84	0.87
Middle Umpqua	0.45	0.61	0.43	0.31	0.53	0.38
North Umpqua	-0.95	-0.3	0.52	-0.95	-0.57	-0.41
South Umpqua	0.8	0.75	0.26	0.33	0.45	0.14
Coos	0.75	0.89	0.8	0.8	0.87	0.82

The Oregon Coast Coho Salmon Recovery Plan (NMFS 2016a) identified primary and secondary limiting factors for independent populations within the OC coho salmon species. The primary and secondary limiting factors in the Lower Umpqua River population are stream complexity and water quality. Stream complexity refers to the ability of a stream to provide various types of habitat. The type of habitat most limiting to OC coho salmon is high quality over-winter and summer rearing habitat (NMFS 2016a).

Middle Umpqua River population.

The Middle Umpqua River population of OC coho salmon consists of all naturally-spawned individuals from the Elk Creek confluence with the Umpqua River to the confluence of the North and South Umpqua rivers near Roseburg, Oregon. The five-year geometric mean of natural spawner abundance in this population increased from 2,857 in the 1990-94 time period to 8,797 in the 2010-2014 time period (Table 7). During the most recent time period, spawner abundance decreased (2015-19) to 2,062 (Ford 2022). A similar pattern is observed with 15-year trends in natural spawner abundances: a positive trend during the 1990–2005 period and slightly negative during the 2004–19 period (Table 8; Ford 2022). Furthermore, the confidence interval for the recently estimated negative trend includes a non-zero number indicating that there is insufficient evidence to support a conclusion that the recent trend was negative. This however should not be interpreted as evidence in support of the alternative possibilities that the trend is stable or increasing.

The 2020 population persistence evaluation indicated moderate certainty that the Middle Umpqua River population will persist into the future (Table 9). Similarly, an evaluation of population sustainability indicated a moderate probability that this population is sustainable. As indicated by these analyses there is a moderate degree of certainty that this population is viable. Only adults and smolts from this population are likely to found in the action area.

The primary and secondary limiting factors in the Middle Umpqua River population are water quality and quantity, and stream complexity (NMFS 2016a).

North Umpqua River population.

The North Umpqua River population includes individuals in the North Umpqua River and its tributaries. The five-year geometric mean of natural spawner abundance in this population increased from 900 in the 1990-94 time period to 4,552 in the 2010-2014 time period (Table 7). During the most recent time period, spawner abundance decreased (2015-19) to 1,976 (Ford 2022). A similar pattern is observed with 15-year trends in natural spawner abundances: a positive trend during the 1990–2005 period and slightly negative during the 2004–19 period (Table 8; Ford 2022). Furthermore, the confidence interval for the recently estimated negative trend includes non-zero numbers indicating that there is insufficient evidence to support the estimated trend. This however should not be interpreted as evidence in support of the alternative possibility that the trend is stable or increasing.

The 2020 population persistence evaluation indicated moderate certainty that the North Umpqua River population will persist into the future (Table 9). This is a notable change from previous analyses where the persistence criteria were negative for this population. The recent evaluation of population sustainability indicated a moderate probability that this population is not sustainable, a pattern that has persisted in all three DSS analyses. As indicated by these analyses there is a moderate degree of certainty that this population is not viable. This result is largely due to the proportion of natural spawners that are of hatchery origin. Only adults and smolts from this population are likely to found in the action area.

The primary and secondary limiting factors in the North Umpqua River population are stream complexity and water quality and quantity.

South Umpqua River population

The South Umpqua River population includes individuals in the South Umpqua River and its tributaries. The five-year geometric mean of natural spawner abundance in this population increased from 1,633 in the 1990-94 time period to 18,237 in the 2010-2014 time period (Table 7). During the most recent time period, spawner abundance decreased (2015-19) to 1,977 (Ford 2022). A similar pattern is observed with 15-year trends in natural spawner abundances: a positive trend during the 1990–2005 period and slightly negative during the 2004–19 period (Table 8; Ford 2022). Furthermore, the confidence interval for the recently estimated negative trend includes zero indicating that there is insufficient evidence to support a conclusion that the recent trend was negative. This however should not be interpreted as evidence in support of the alternative possibility that the trend is stable.

The 2020 population persistence evaluation indicated a low degree of certainty that the South Umpqua River population will persist into the future (Table 9). Similarly, the recent evaluation of population sustainability indicated a very low probability that this population is sustainable. As indicated by these analyses there is a low degree of certainty that this population is viable. Only adults and smolts from this population are likely to found in the action area.

The primary and secondary limiting factors in the South Umpqua River population are water quantity and quality and stream complexity (NMFS 2016a).

Coos River population

The Coos River Basin is bordered the Umpqua River Basin to the east, the Tenmile Lakes Basin to the north, and the Coquille River Basin to the south. Two main rivers drain the Coos Basin: the Millicoma River, formed by the confluence of East and West Fork Millicoma, and the South Coos River, formed by the confluence of the Williams River and Tioga Creek. The 5-mile-long Coos River is formed by the joining of the Millicoma and South Coos Rivers. The Coos River population is an independent population within the Mid-South Coast Stratum of the OC Coho salmon ESU (NMFS 2016a). The basic recovery strategy for coho salmon populations in the Mid-South Coast Stratum aims to protect freshwater and estuarine reaches that currently contain high quality habitat, and restore reaches with potential for additional high-quality habitat.

The five-year geometric mean of natural spawner abundance in this population increased from 7,228 in the 1990-94 time period to 15,029 in the 2010-2014 time period (Table 7). During the most recent time period, spawner abundance decreased (2015-19) to 4,071 (Ford 2022). A similar pattern is observed with 15-year trends in natural spawner abundances: a positive trend during the 1990–2005 period and negative during the 2004–19 period (Table 8; Ford 2022). Furthermore, the confidence interval for the recently estimated negative trend does not include zero indicating that there is sufficient evidence to support a conclusion that the recent trend was negative.

The 2020 population persistence evaluation indicated a moderate degree of certainty that the Coos River population will persist into the future (Table 9). Similarly, the recent evaluation of population sustainability indicated a moderate degree of certainty that this population is sustainable. As indicated by these analyses there is a moderate degree of certainty that this population is viable.

The primary and secondary limiting factors in the Coos River population are stream complexity and water quality (NMFS 2016a).

Tenmile Lake population

The Tenmile Lakes basin is situated on the southwest coast of Oregon, in northern Coos and western Douglas Counties, and encompasses approximately 98 square miles of lakes, river valleys, and ocean dunes. Tenmile Creek drains all streams in the basin directly to the Pacific Ocean, seven miles to the south of the Umpqua River. The Tenmile Lake population is part of the OC Coho ESU’s lakes stratum (NMFS 2016a). NMFS recognizes that the lakes stratum has consistently been the most sustainable stratum within the ESU. The primary strategy to ensure the continued health of the populations in the Lakes Stratum is to reduce summer predation rates by non-indigenous fish species.

The five-year geometric mean of natural spawner abundance in this population increased from 2,616 in the 1990-94 time period to 9,986 in the 2010-2014 time period (Table 7). During the most recent time period, spawner abundance decreased (2015-19) to 1,684 (Ford 2022). A similar pattern is observed with 15-year trends in natural spawner abundances: a positive trend during the 1990–2005 period and negative during the 2004–19 period (Table 9; Ford 2022). Furthermore, the confidence interval for the recently estimated negative trend does not include zero indicating that there is sufficient evidence to support a conclusion that the recent trend was negative.

The 2020 population persistence evaluation indicated a high degree of certainty that the Coos River population will persist into the future (Table 10). Similarly, the recent evaluation of population sustainability indicated a high degree of certainty that this population is sustainable. As indicated by these analyses there is a high degree of certainty that this population is viable.

The primary and secondary limiting factors in the Tenmile Lakes population are non-native species, stream complexity, and water quality (NMFS 2016a).

2.5. Effects of the Action

Under the ESA, "effects of the action" are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action but that are not part of the action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (see 50 CFR 402.02).

2.5.1 Effects on the Envirement

Water Temperature

Timber management activities. Removing trees in riparian areas reduces the amount of riparian shade, which leads to increased thermal loading of adjacent streams (Moore and Wondzell 2005). A reduction in riparian shade can influence water temperatures at a sub-reach or reach scale, and, in some cases, may affect water temperature at a watershed scale. Substantial effects on riparian shade and water temperature in clear-cut systems have been observed with no-cut buffers ranging from 20–30 meters (66–99 feet) (Brosofske et al. 1997; Kiffney et al. 2003; Groom et al. 2011a), and small effects have been observed in studies that examined no-cut buffers 46 meters (151 feet) wide (Science Team Review 2008; Groom et al. 2011b). For no-cut buffer widths of 46–69 meters (151–227 feet), the effects of tree removal on riparian shade and water temperature were either not detected or were minimal (Anderson et al. 2007; Science Team Review 2008; Groom et al. 2011a; Groom et al. 2011b). The limited response observed in these studies can be attributed to the lack of trees that were capable of casting a shadow greater than 46 meters (150 feet) during most of the day in the summer (Leinenbach 2011).

Some of the best available science regarding the effects of riparian vegetation conditions on stream temperatures is found in modeling conducted by EPA to evaluate the effects of thinning prescriptions in uplands adjacent to no-harvest buffers on stream shading (EPA 2013). EPA addressed the following riparian vegetation attributes when evaluating the effects of riparian management on stream shade conditions: 1) total width of the riparian buffer management zone; 2) width of the no-harvest buffer; 3) density of the vegetation within the no-harvest buffer (expressed as canopy cover); 4) pre-harvest vegetation density within the outer “thinned” buffer; and 5) post-harvest vegetation density within the outer buffer.

For EPA’s modeling results, they referenced a before-after-control-impact (i.e., BACI) study on 33 streams exposed to riparian harvest and subsequent Bayesian modeling completed by ODF (EPA 2013). ODF’s modeling was designed to evaluate the effect of riparian harvest on stream shade and stream temperature. ODF’s modeling showed that shade loss and corresponding stream temperature increases decreased as riparian buffer widths increased, and for a clear-cut with a 120-foot, no-cut riparian buffer, there would be essentially no shade loss or stream temperature increase (Figures 8 and 9). However, EPA (2013) noted that the modeled values are the estimated mean response based on these sites and that individual site responses may range outside of the 98.5 and 2.5 percent credibility intervals based on site-specific characteristics. In other words, certain variables that affect temperature change exist on the landscape are naturally dynamic and vary in quality and function across the permit area to naturally regulate stream temperature. The potential for temperature responses to fall outside this range is accounted for in our analysis.

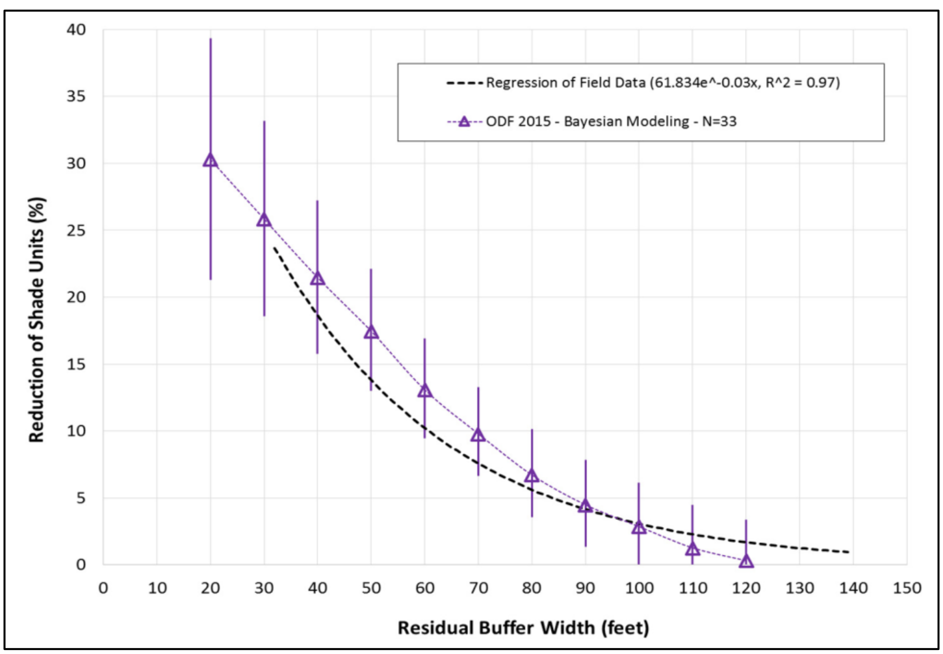

Figure 8. Modeled mean stream shade response associated with no-cut riparian buffers adjacent to clear-cut harvest.

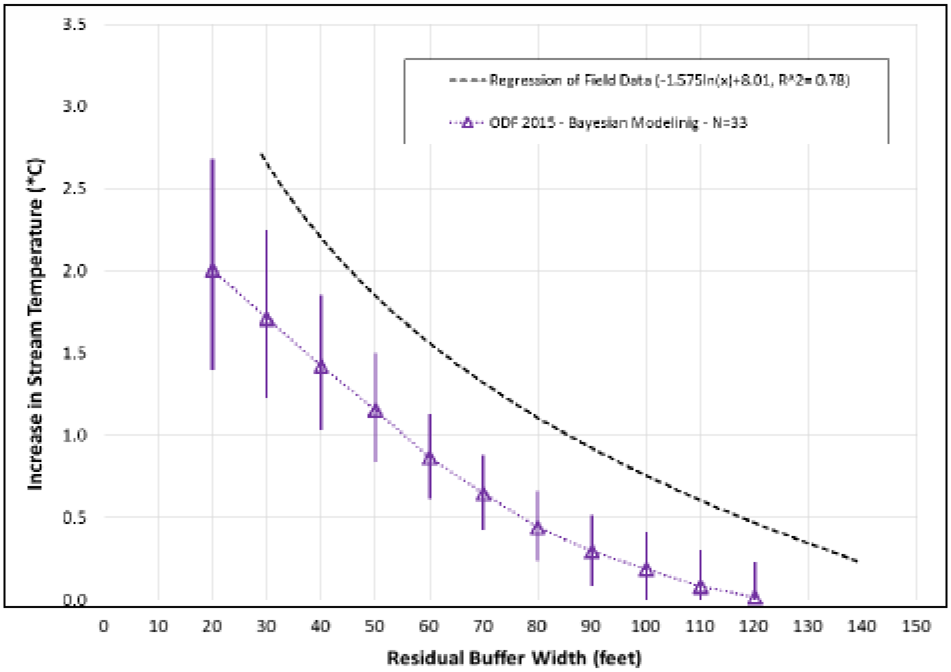

Figure 9. Modeled mean stream temperature response associated with no-cut riparian buffers with adjacent clear-cut harvest.

Using the results of ODF's modeling, EPA developed a relationship between stream-shade loss and expected stream temperature increases associated with riparian tree removal. This relationship showed that riparian tree removal would result in an increase in stream temperature when shade loss was greater than 6 percent. Based on the BACI results, EPA developed a shade loss Assimilative Capacity that used a maximum of 3 percent shade loss of streams to add a margin of safety. The 120-foot no-cut buffer width scenario results indicate that shade loss would not exceed 3 percent for essentially all scenarios. There was a slight exceedance for only one model run (e.g., sparse initial canopy cover at an east-west stream aspect condition, Table 11).

Table 11. Modeled shade loss for a 180-feet wide riparian buffer management zone with a 120-foot no-cut buffer at various thinning intensities and initial canopy cover conditions (EPA 2013).

	Percent Shade Loss			
	Stream Aspect			
Pre-harvest Condition-80% Canopy Cover	**North South**	**NW/SE**	**East West**	**Average**
60ft - Outer Thinning Zone 70CC / 120ft - Inner Zone 80CC / Stream	0.1	0.0	0.0	0.0
60ft - Outer Thinning Zone 50CC / 120ft - Inner Zone 80CC / Stream	0.2	0.1	0.0	0.1
60ft - Outer Thinning Zone 30CC / 120ft - Inner Zone 80CC / Stream	0.4	0.2	0.0	0.2
Pre-harvest Condition - 60% Canopy Cover				
60ft - Outer Thinning Zone 50CC / 120ft - Inner Zone 60CC / Stream	0.6	0.4	0.6	0.5
60ft - Outer Thinning Zone 30CC / 120ft - Inner Zone 60CC / Stream	1.5	0.9	0.6	1.0
Pre-harvest Condition - 40% Canopy Cover				
60ft - Outer Thinning Zone 30CC / 120ft - Inner Zone 40CC / Stream	2.3	1.8	3.5	2.5

While stream shade correlates with the width of no-cut buffers, the relationship is quite variable and highly dependent upon site-specific factors such as stream size, substrate type, stream discharge, topography (Caissie 2006), channel aspect, forest structure, and plant species composition. The primary factors that influence stream shade are the height and density of riparian vegetation and the surrounding terrain, the latter of which typically provides most of the stream shading (Allen et al. 2007; Allen 2008; Groom et al. 2011a). Cold-water inputs from the streambed, seepage areas on the stream bank, and tributaries can help cool the stream on hot summer days if such inputs are sufficiently large relative to the stream discharge (Wondzell 2012). The density of vegetation in riparian areas affects shade and thermal loading of a stream because solar radiation reaches steams through gaps in the canopy and among the branches and stems (Brazier and Brown 1973; DeWalle 2010). In some instances (such as narrow streams with dense, overhanging streamside vegetation, or stands on the north sides of streams with an east-west orientation), no-cut buffers as narrow as 30 feet adjacent to clear-cuts can maintain stream shade (Brazier and Brown 1973). However, wider buffers, in general, will provide increased protection of stream temperature (Anderson et al. 2007, Science Team Review 2008, Groom et al. 2011a, Groom et al. 2011b).

Shade loss resulting from reduced canopy cover associated with riparian thinning can be highly variable depending on the pre-harvest conditions (canopy cover, density etc.). During riparian thinning ODSL will retain the largest trees in a stand, which are the primary contributors of shade in riparian areas. While shade loss from riparian thinning can cause local and downstream temperature increases, the increases are often temporary because riparian forest canopies eventually close after thinning, often within 3 years, although the amount of time is dependent on the level of thinning, can be highly variable depending on site characteristics, and can take longer to close completely (more than 8 years) (Chan et al. 2006; Yeung et al. 2017). Suzuki and Hayes (2003) compared percent canopy closure of unthinned stands and stands thinned 7 to 24 years prior to conducting this study. They reported that stands thinned to result in 10 to 20 percent loss in canopy cover recovered in 7 to 24 years to 97 percent of the canopy cover of unthinned stands that had the same percent canopy cover of the thinned stands prior to thinning. Chan et al. (2006) reported an increase of canopy cover at an average of 2 percent per year after thinning and heavy thinning resulted in a decrease in canopy cover of 48 percent. Using this relationship, a decrease in canopy cover of 48 percent would take approximately 24 years to return to pre-harvest levels. Therefore, in most instances we expect that shade loss associated with restoration thinning in RCAs will return to preharvest levels within a decade, but in some instances reduced shade loss may last for up to approximately 25 years.

While shade loss and stream temperature increases associated with timber harvest are of great concern in fish-bearing streams (i.e., Type FB streams within the permit area), temperature increases in non-fish-bearing streams (i.e., Type PNFB, HLDP, and XNFB streams within the permit area), if not managed, can extend downstream into fish-bearing streams and adversely affect water quality. Numerous upstream-downstream longitudinal studies have examined temperature recovery downstream of single harvest units. Davis et al. (2016) found that temperature changes 300 meters (984 feet) downstream of harvest units on small and medium fish-bearing streams were, on average, approximately 56 percent of the change at the harvest unit (range of 1 to 82 percent of harvest unit change). However, this behavior was highly site-dependent (streams with lower gradients and/or greater surface area showed lower temperature change magnitudes at 300 meters). Arismendi and Groom (2019) also showed a tendency for downstream sites to converge toward the pre-harvest equilibrium, that the tendency generally strengthened with time, and that post-harvest temperature regimes associated with wide buffers returned to behavior that was statistically similar to their pre-harvest characteristics while sites with narrow buffers often did not. Several other studies examining the extent of stream temperature recovery towards pre-harvest conditions downstream of harvest units show incomplete downstream mitigation of single harvest unit temperature where narrow stream buffers are applied. These studies include Keith et al. (1998), who found 0.5°C of a 5.0°C temperature increase remaining after 73 meters (240 feet) and 0.5°C of a 6.0°C temperature increase remaining after 46 meters (151 feet); Macdonald et al. 1998, who found 2°C of a 3.0°C increase remaining after 500 meters (1,640 feet); Rutherford et al. (2004), who found a 0.77°C to 7.18°C increase reduced by 0.35°C to 2.51°Cover distances of 153 to 892 meters (502 to 2,926 feet); Wilkerson et al. (2006), (unbuffered streams) who found 1.8°C of a 2.8°C of increase remaining and 1.3°C of a 2.5°C increase remaining after 100 meters (328 feet); and Zwieniecki and Newton (1999), who found a mean increase of 0.4°C of 1.09°C remaining after 150 meters (492 feet) across their study sites.

Another key consideration is the potential for cumulative stream heating when multiple harvest units are present in a specific watershed or subwatershed. When multiple harvest units are present in the same watershed, measurable cumulative temperature increases are probable. Cumulative temperature increases have been observed in studies below confluences of harvested streams or along stream reaches with sequential harvested and unharvested reaches (Keith et al. 1998, Macdonald et al. 1998, Shrimpton et al. 1999, Bartholow 2000, Pollock et al. 2009, Cole and Newton 2013).

A key element of the management strategy for the ESRF is the designation of conservation and management research watersheds and associated treatment strategies (Figure 6). Section 1.3.2. of this opinion and Section 3.3 of the HCP describe the treatment types and operational standards for each allocation in the CRWs and MRWs. Allocations in the CRWs include reserves and RCAs. Allocations in the MRWs include reserves, RCAs, intensive, and extensive. The remaining allocations include flexible, flexible extensive, and volume replacement. Table 12 shows the treatment types allowed by allocation.

Table 12. Treatment types allowed in each allocation.

Allocation	Acres[2] Available for Treatment	Treatments		
		Intensive	Extensive	Restoration Thinning
Intensive	**9,912**	X		
Extensive	**10,870**		X	
RCA	**16,024**			X
Reserve	**11,986**			X
Volume Replacement	**943**		X	
Flexible[1]	**8,887**	X	X	
Flexible Extensive	**819**		X	

[1] It is unknown how many acres in Flexible allocations will be subject to intensive or extensive treatment types, therefore, NMFS assumes all acres will be subject to treatments and operational standards described for the intensive allocation.
[2] The remaining 23,866 acres are in reserves in the CRWs.

Although there are seven allocation types, treatment types and operational standards are specifically described only for reserves, extensive, intensive, and RCA allocations. Table 13 summarizes those treatment types and operational standards. For analysis purposes, NMFS assumes ODSL will conduct harvest to the minimum retention standards for each treatment type.

Table 13. Treatments and operational standards for reserve, RCA, extensive, and intensive allocations.

Allocation	Treatment type	Operational Standards				
		Stand Age	Retention standard	Number of entries	Timing/ Rotation	Harvest Cap
Reserves	Restoration Thinning	65 years old or younger (as of 2020)	20 to 80% of pre-harvest density	1 to 2	CRW – first 30 years; MRW – permit term	CRW - N/A < 20 years, 20 ≤ 30 years, 3,500 acres; MRW - None
RCAs	Restoration Thinning	65 years old or younger (as of 2020)	≥ 40 ft^2 conifer basal area per acre	600 acres 1-entry; 600 acres 2-entries	CRW – first 30 years; MRW – permit term	1,200 acres for permit term
Extensive	Extensive - Variable Retention Regeneration Harvest; [1]	65-150 years (as of 2020)	≥ 20% of pre-harvest density (including RCAs); avg. 50% pre-harvest density (range 20 to 80%) across total extensive harvest stands [2]	Up to 4 entries, including regeneration harvest	Based on 100-year avg. rotation	Regeneration harvest – 3,200 acres; thinning treatments - none
		≤ 65 years old (as of 2020)	20 to 80% of pre-harvest density (including RCAs)	Up to 4 entries, including regeneration harvest	Based on 100-year avg. rotation	No cap
Intensive	Intensive - Regeneration Harvest (clearcut)	≤ 65 years old (as of 2020)	Meet retention standards for OFPA	Up to 3 entries including regeneration harvest	60 year rotation	N/A

[1] The information in the table columns summarizes the regeneration harvest portion of the stand. The retention portion of the stand that was left as dispersed retention or unharvested aggregates is not eligible for regeneration harvest, but is eligible for up to three thinning treatments that must meet the retention and entry standards for stands aged 65 to 150 years (as of 2020).
[2] At the sub-watershed level, retention will maintain a minimum of 20% pre-harvest density, not including RCAs already present in the sub-watershed.

Treatment types, tree retention standards, number of entries per stand, and timing of harvest will vary by allocation type (i.e., reserves, intensive, extensive, and RCAs)[6] and stand age. The

[6] Volume replacement and flexible extensive allocations will be subject to extensive allocation treatment types and flexible allocations will be subject to, for this analysis, intensive treatment types.

effects on stream temperature will range from no change to increased water temperature that will adversely affect critical habitat and coho salmon individuals (> 0.3°C) in parts of the action area.

Harvest types and methods include the full suite of thinning and harvest techniques used in contemporary forestry including pre-commercial and commercial thinning, retention harvests (thinning), and regeneration harvests (clearcut) that will occur under intensive, extensive, and restoration thinning treatment types. For the amount of harvest, the ODSL will not exceed 1,000 acres per year based on a 4-year rolling average of contracted sales, which will consist of intensive, extensive and restoration treatments. Of this 1,000-acre cap, no more than 480 acres per year may be from regeneration harvests as part of intensive treatments in intensive and flexible allocations. In addition to the 1,000-acre cap, ODSL will conduct up to 300 acres per year of restoration thinning during the first 20 years of the permit term and up to 200 acres per year of restoration thinning during years 21 to 30 of the permit term. After the initial 30 years of the permit term, no harvest of acres beyond the 1,000-acre cap will be allowed by ODSL.

The ODSL also proposed to cap the amount of RCA thinning and extensive treatments. For RCA thinning, ODSL will not conduct more than 1,200 acres of thinning in RCAs over the entire 80-year permit term, of which 160 acres will occur within the first 5 years of the permit term. ODSL will only conduct thinning in RCAs as part of approved research studies. For extensive treatments, the ODSL will not treat more than 3,200 acres of stands that are older than 65 years old (as of 2020). The ODSL will not conduct intensive treatments in RCA or extensive allocations.

As described in Section 1.3.2, implementation of the covered forest management activities will include establishment of RCAs to reduce the effects of timber harvest on stream temperatures. Extensive, intensive, and restoration thinning treatments will occur adjacent to RCAs throughout the permit area and for these treatments ODSL will retain the minimum retention densities. The proposed RCAs vary by stream type and upslope allocation and are delineated as the horizontal distance from the outer edge of the channel migration zone and in reference to a site potential tree height of 200 feet. Stream types defined in this HCP include fish bearing (FB), perennial non-fish bearing (PNFB), high landslide and debris flow potential (HLDP),[7] and non-fish bearing or non-seasonal (XNFB) streams.[8] Table 14 shows ODSL's proposed RCA widths for the four stream types and allocation types NMFS will use in the effects analysis.

[7] Identified as non-fish bearing stream that comprises 25 percent of the total non-fish bearing channel wood delivery budget to fish-bearing streams per TerrainWorks (2021) Slope Stability Analysis Tool based on Benda and Dunne (1997) and Miller and Burnett (2008).
[8] XNFB streams can also be defined as non-fish bearing ephemeral, intermittent, or non-seasonal streams that are also not designated as HLDP streams.

Table 14. Widths of RCAs by stream type and adjacent allocation. Widths are measured in horizontal distance (feet) from the outer edge of the channel migration zone.

Stream Type	CRW Reserves	MRWs			Volume Replacement	Flexible	Flexible Extensive	WF Millicoma River
		MRW Extensive	MRW Intensive	MRW Reserves				
FB	200	100	100	100	200	120	200 (Big Cr.)[a] 120 (outside Big Cr.)	200 (mainstem) 120 (non-mainstem)
PNFB	200	50	50	50	200	50	200 (Big Cr.)	50
HLDP	200	50	50	50	200	50	200 (Big Cr.)	120
XNFB	0	0	0	0	0	0	0	0

[a] Big Creek subwatershed

Based on the modeling results presented above concerning the effectiveness of no-cut riparian buffers (i.e., no riparian treatments), temperature increases in adjacent FB and PNFB streams will most likely occur when RCAs widths are 120 feet or less or if thinning occurs within the RCA. Stream temperature increases in FB and PNFB streams with 120-foot RCAs will likely be infrequent depending on level of canopy cover and vegetation types of the RCA, stream aspect, and topographic conditions (steepness) of the adjacent harvest unit. Across the permit area, shade losses leading to water temperature increases will more frequently occur in FB and PFNB streams where RCAs are 100 or 50 feet. This is supported by Brosofske et al. (1997), Kiffney et al. (2003), and Groom et al. (2011a), which suggest that substantial effects on riparian shade and water temperature in clear-cut systems have been observed with no-cut buffers ranging from 20–30 meters (66–99 feet). Additionally, based upon findings reported by Groom et al. (2018), a 50-foot buffer width would result in an average water temperature increase of approximately 1.2°C with a 95 percent credibility interval of approximately 0.9 to 1.5°C (Figure 10). This study also reported that an average increase of 1.65°C could occur at buffer widths of 0 to 46 feet. These results indicate that the magnitude of stream temperature change, when applying buffering strategies, is variable depending on site conditions including, but not limited to, stream aspect, canopy cover and vegetation types in the RCA, and topographic conditions (steepness).

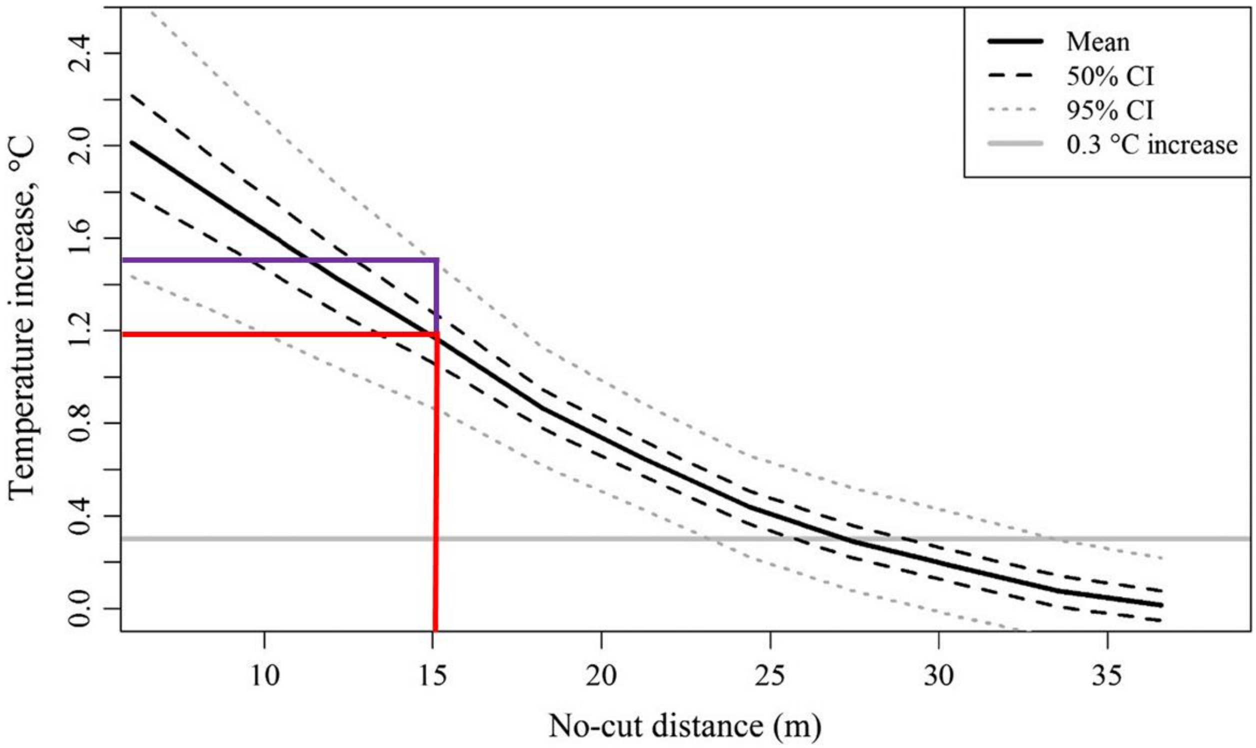

Figure 10. From Groom et al. (2018) – Mean temperature response to various riparian-buffer-width conditions. Red indicates the approximate average temperature increase at a 50-foot (15.2 meters) riparian buffer (approximately 1.2°C). Purple indicates the upper bound of the 95 percent confidence interval (approximately 1.5°C).

In their review of literature related to thinning activities in riparian buffers adjacent to clearcut harvest units, Leinenbach et al. (2013) cited studies and reviews by Mellina et al. (2002), Macdonald et al. (2003), Wilkerson et al. (2006), Science Team Review (2008), and Kreutzweiser et al. (2009). These studies stated "reductions in shade and increases in stream temperature were associated with thinning activities occurring within riparian buffers, along with the narrowing of the buffer. The response varied from no effects to large effects which appeared to be related to differences in the intensity of thinning, with stronger effects associated with higher thinning densities." In support of this, Kruetzweiser et al. (2009) reported that removal of roughly 29 percent of basal area in a riparian zone reduced canopy cover and shade and increased light penetration and stream temperature up to 4.4 ℃ (mean weekly maximum (MWMT)). Their study also reported 10 to 20 percent reductions of riparian basal area and canopy cover at two other sites resulted in stream temperatures within the range of prelogging values. Roon et al. (2021) reported that removal of 50 percent canopy closure along 200 meter stream reaches increased summer MWMT by a mean of 2.8 ℃ (1.8, 3.8 ℃ 95 percent confidence interval). This study also reported that removal of 40 percent of riparian basal area on slopes less than 20 percent along 100 to 150 meter reaches of stream resulted in no changes to stream temperatures. While the limited number of studies that have specifically evaluated thinning in riparian buffers and the many different possible combinations of thinning intensity and buffer width make it difficult to generalize (Leinenbach et al. 2013), it is widely accepted that removal of trees from riparian areas can reduce stream shade that can cause increased stream temperature.

Figure 11 shows where RCA thinning has the potential to occur in the 16,024 acres of RCAs across the permit area. As described above, removal of trees adjacent to no-cut buffers in the riparian area can cause decreases in shade and increases in thermal loading and water temperatures in streams. In RCAs, ODSL will retain a minimum of 40 square feet basal area per acre.

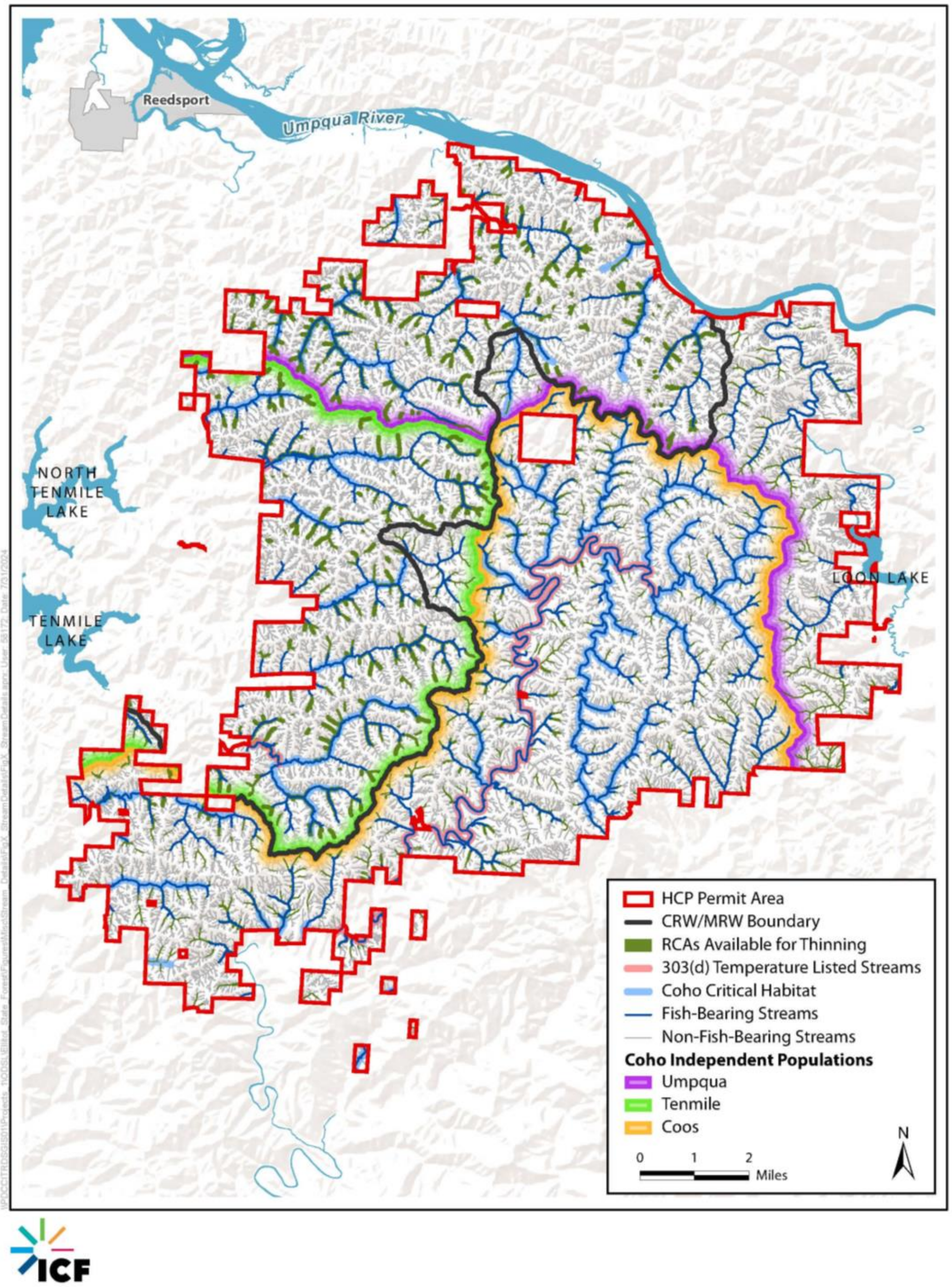

Figure 11. RCAs available for thinning across the permit area.

Groom et al. (2011b) looked at data collected at 33 field sites along small and medium fish bearing streams to determine the change in temperature associated with timber harvest. At this time, the OFPA allowed timber harvest in riparian management areas (RMAs). The width of RMAs was determined by stream type and stream size as defined under the OFPA (OAR 629-600-0100) (Table 15). Common to all Type F RMAs was a 20-foot no-harvest buffer. For medium and small type F streams the retention requirements under OFPA were approximately 99 ft^2 and 44 ft^2 basal area per acre (Groom et al. 2011b). Groom et al. (2011b) found that maximum temperatures for streams located adjacent to privately owned harvest sites (clearcut adjacent to harvested RMAs per OFPA retention requirements) increased on average of 0.7°C (range –0.9 to 2.5°C) due to decreased shade in longer treatment reaches with low gradients and that basal area and tree height were the best predictors of shade. Based on this and Leinenbach et al. (2013), it is likely that thinning in RCAs adjacent to intensive allocations (clearcut) and low retention extensive and restoration thinning treatments increase the likelihood and magnitude of temperature increases in streams adjacent to RCAs where temperature increases of zero to 4.4°C, could occur.

Table 15. Riparian management area widths (feet) by stream size and type under the OFPA in 2015.

Stream Size	Type F	SSBT	Type D	Type N
Large	100	--	70	70
Medium	70	80	50	50
Small	50	60	20	0

XNFB streams, will not have designated RCAs. Although equipment limitation zones (ELZs) will be applied to portions of XNFB streams meeting OFPA stream type definitions, which will limit disturbance within 35 feet of such streams, these ELZs are not expected to prevent substantial loss of riparian shade.

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

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

When an increase in stream temperature occurs in a non-fish-bearing stream, downstream temperature recovery would not be sufficient when the riparian areas have low canopy cover, there are not sufficient cold-water inputs or groundwater exchange downstream of the harvest unit prior to where the stream transitions from a non-fish-bearing stream to a FB stream, and/or when stream gradients are low. When these site conditions exist and overlap, there will be higher risk of stream temperature increases in FB streams that are within a mile from non-fish-bearing streams affected by shade loss associated with timber harvest. For these reasons, some temperature increases in FB streams from non-fish-bearing streams will adversely affect water quality in FB streams locally until shade is reestablished in the non-fish-bearing streams within the harvest unit..

Given the discussion above, timber harvest adjacent to RCAs and restoration thinning in RCAs will result in temperature increases ranging from 0 to 4.4 ℃. ODSL's implementation of operational standards, conservation measures and conditions, and establishing RCAs will likely result in most temperature increases on the lower end of this range. These increases will likely exceed the 0.3 ℃ for up to approximately 1 mile downstream of a harvest unit and will recover to pre-harvest levels in 5 to 10 years (Arismendi and Groom 2019, Groom et al. 2017).

Road Construction and Management. Road construction and maintenance will occur as described in Section 1.3.2 of this Opinion and Chapter 3, *Covered Activities*, of the HCP. ODSL committed to constructing no more than 40 miles of new permanent roads, up to 0.5 mile per year, and 2 miles of temporary roads per year in the permit area over the course of the permit term. Temporary roads that are not vacated after 5 years will become part of the 40-mile total of permanent roads constructed over the permit term. The extent of the existing road system within the permit area is shown in Figure 12. Existing roads will be maintained and repaired as needed to conduct timber harvest and other covered activities.

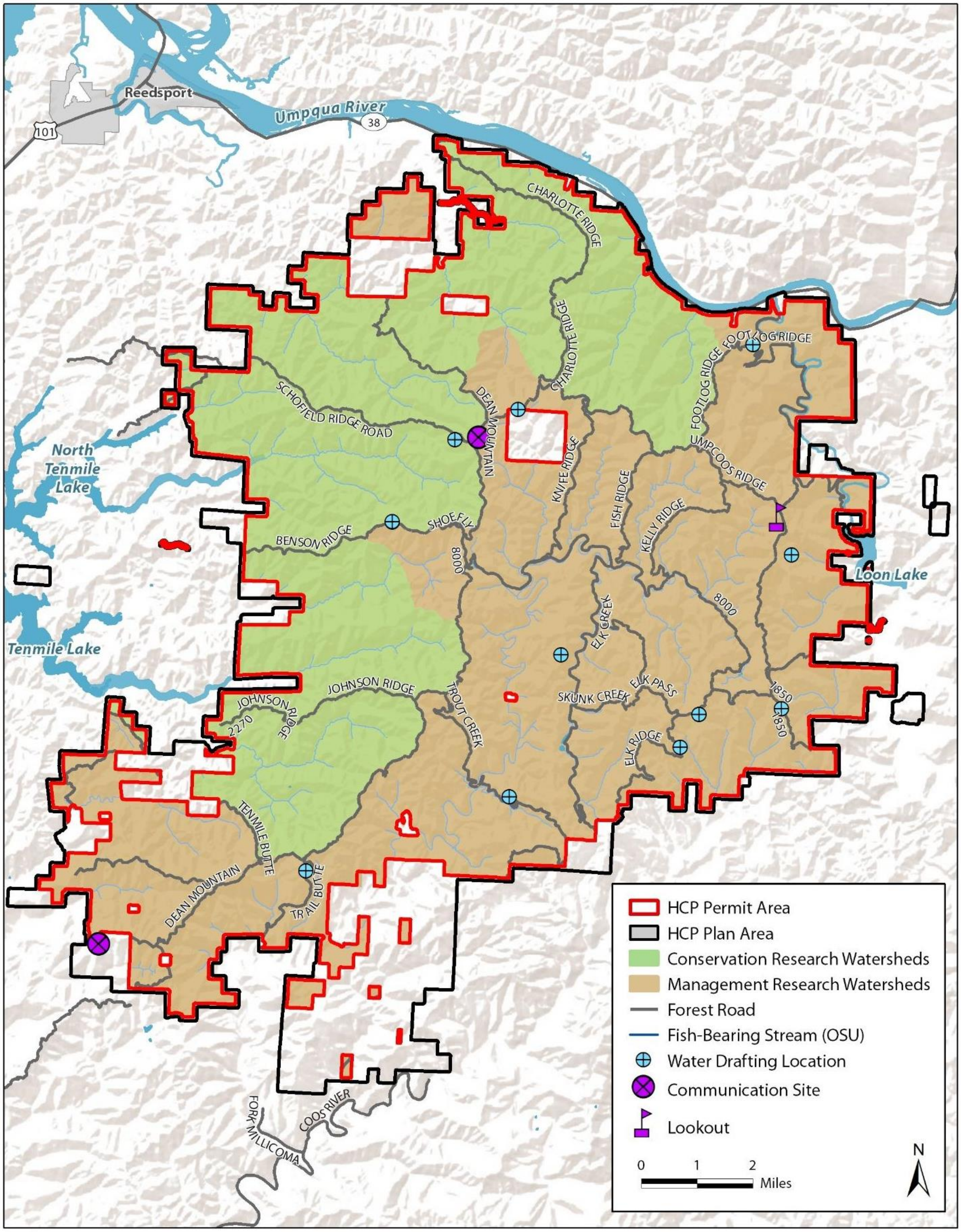

Figure 12. Existing Primary Road Network, Water Withdrawal Sites, and Communication and Lookout Sites within the Permit Area.

ODSL's adherence to measures prescribed in the OFPA related to road system management—OAR 629-625-0200 (Road Location), OAR 629-625-0300 (Road Design), and OAR 629-625-0600 (Road Maintenance)—will decrease the likelihood of stream shade loss and subsequent stream temperature increases occurring within the permit area as a result of tree removal associated with road system construction and management activities. The following key measures included in these rules are expected to reduce stream shade loss and resultant stream temperature increases:

- Operators shall avoid locating roads in critical locations unless a written plan is submitted to the State Forester for review pursuant to OAR 629-625-0200. Critical locations include:
    - Areas within 50 feet of stream channels or lakes, excluding crossings and approaches to crossings
    - Any active stream channel, exclusive of stream crossings in compliance with OAR 629-625-0320
    - Locations parallel to, and within a riparian management area for a distance exceeding a cumulative 500 feet of road length measured from the first point of entry into the riparian management area to the last point of exit from the riparian management area, exclusive of stream crossings in compliance with OAR 629-625-0320
- Operators shall minimize the number of stream crossings.

To supplement the OFPA restrictions related to road management outlined above, ODSL will implement Condition 11, which includes the following road design measures that will further reduce the potential for stream temperature increases associated with road construction:

- Temporary and permanent roads and landings will be located on stable locations (e.g., upper slope, midslope, or flats) and gentle to moderate side slopes, and will be constructed at least 35 feet from the edge of the aquatic zone, whenever possible. Road development within the RCAs will only occur when other alternatives are not operationally feasible.
- New roads will use the minimum practical design standards with respect to road width, radius, and gradient.

It is important to note that the forest management activities, such as the covered activities, have short- and long-term effects and that various stages of stand management (e.g., stand preparation; pre-commercial thinning; clearcut, regeneration, or retention harvests; etc.) and road maintenance and construction will occur in different watersheds and populations across the permit area at various times throughout the duration of the 80-year permit term. This is reflected in the varying stand harvest rotation areas in extensive (average 100 years) and intensive (60 years in intensively managed watersheds and 50 years in flexible extensive allocations that will be subject to intensive harvest) allocated watersheds. It is also reflected in the timing of restoration thinning in CRWs (only the first 30-years of the permit term), the 1,000-acre 4-year rolling average cap of all treatment types, the 1,200-acre cap over the permit term on RCA thinning, and the 3,200-acre cap on extensive treatments of stands older than 65 years (as of 2020). This means that the effects that occur from the covered activities will be spatially distributed across the action area and populations of OC coho salmon and will be temporally distributed (will occur at different times), throughout the 80-year permit term. While there may be some spatial and temporal overlap of effects, this separates effects of the covered activities on spatial and temporal scales such that it eliminates or significantly reduces the potential for, the magnitude of, and duration of additive effects (short term and long term) of more than one stand alone research or harvest project within a population of OC coho salmon.

Tree removal associated with road construction and maintenance, including repairing or replacing culverts and bridges and landing construction, is expected to be infrequent in RCAs and spatially and temporally separated across the action area over the permit term. Nonetheless, even with these measures in place, covered activities that occur within RCAs will, in some instances, cause riparian shade loss and resultant increases in stream temperature within the range of that stated above for timber harvest. Comparatively, tree removal associated with road construction and management will likely be less impactful than that from timber harvest described above. ODSL will limit activities within RCAs and near streams and covered activities will occur intermittently spaced out over the action area. Therefore, instances of increased stream temperature resulting from tree removal associated with road construction and management are expected to be smaller in magnitude and, likely on the lower end of the range of that for timber harvest, localized to the site scale, spatially and temporally separated, and infrequent.

Suspended sediment and substrate embeddedness

Fine sediment delivery to streams within the action area will occur as a result of natural processes such as landslides and debris flows, as well as from anthropogenic soil disturbance near streams associated with the covered activities, the majority of which will be caused by timber harvest and road construction, maintenance, and use. We also expect periodic localized increases in fine sediment delivery to occur where riparian-restoration and stream-enhancement actions are conducted. In general, once mobilized, fine sediments (e.g., clay, silt, or sand) tend to stay suspended for long distances within the relatively fast flowing waters of upper-watershed streams. These sediments eventually settle to the streambed in areas where flows are sufficiently slow. Substrate embeddedness refers to the extent that the gravel, cobble, and boulders that make up the streambed are surrounded by, covered, or sunken into fine sediments. The level of substrate embeddedness is partially dependent on the amount of fine sediment that is discharged to a stream. Increased substrate embeddedness makes it more difficult for salmon to dig redds, clogs interstitial spaces, reduces intergravel velocities, and reduces dissolved oxygen concentrations in redds, thereby reducing the quality and function of stream substrate to support salmon spawning and the egg and alevin life stages of salmonids.

Timber harvest. The covered activities proposed by ODSL include varying degrees of timber harvest across the permit area over the 80-year permit term, as further described in Section 1.3.2. The primary mechanisms of sediment discharge to streams associated with timber harvest are episodic overland mobilization of sediment during precipitation events and sediment discharge resulting from landslides and associated debris flows triggered by timber-harvest-related activities.

Timber felling and yarding disturbs soils, removes vegetation, and increases the potential for sediment transport to proximal stream channels resulting from overland flow during episodic precipitation events. These activities can also decrease soil productivity through vegetation removal, soil compaction, and associated erosion. When vegetation is removed through forestry activities, erosion on the forest floor can increase over natural rates until vegetation is reestablished. Removing vegetation allows precipitation (i.e., rainfall and snowmelt) to mobilize particles and move them downhill (Nunamaker et al. 2007, Picchio et al. 2020) toward streams.

For yarding, ground-based yarding has the highest risk of causing an increase in suspended sediment and substrate embeddedness, particularly where yarding corridors cross streams (Rice et al. 1972). However, ground-based yarding can be accomplished with relatively little damage to the existing shrub and herbaceous ground cover, thus limiting the exposure of bare soil and maintaining important root structure that holds soil in place. Skyline or multi-spanning yarding systems reduce soil impacts because the logs are suspended above the ground throughout much or all of the yarding process. Helicopter yarding also reduce soil impacts because logs are fully suspended above the ground.

The establishment of RCAs (Table 14) will reduce the delivery of fine sediments to streams from soil erosion and overland flow that transits harvested areas. Several studies document the ability of buffer strips to reduce erosion and sediment delivery from areas subject to timber harvest. Vegetated buffer areas ranging in width from 40 to 100 feet appear to prevent sediment from reaching streams (Burroughs and King 1989, Corbett and Lynch 1985, Gomi et al. 2005). Lakel et al. (2010) concluded that streamside management zones (buffers) between 25 and 100 feet were effective in trapping sediment before it could enter streams. Unthinned RCAs will be effective at filtering out sediment before it discharges to stream channels. Streams in the action area with the greatest susceptibility to sediment discharge from timber harvest adjacent to unthinned RCAs will be XNFB streams that will not have an established RCA, or on steeper slopes in RCAs of any width where restoration thinning occurs in the RCA. In steeper areas in the permit area, RCA thinning may contribute to sediment delivery, particularly when conducted within 30 feet of stream banks (Rashin et al. 2006). Therefore, RCAs that are subject to restoration thinning may be less effective in preventing surface erosion and sediment delivery.

RCA thinning across the entire permit area will be limited to 1,200 acres over the course of the 80-year permit term. Thinning within CRW RCAs will occur within the first 30 years of the permit term, and if stands reach 80 years old, they will become ineligible for thinning. Thinning of RCAs in MRWs would not be subject to this 30-year limitation but would adhere to the limitation on number of entries and 80-year stand age limit. When thinning does occur, it will likely result in discharge of sediment to adjacent stream channels. Although, the potential for sediment delivery will be reduced by (1) implementing a 35-foot equipment limitation zone along all OFPA-defined streams; (2) outside of the ELZ, ground-based equipment use in RCAs will be limited to slopes less than 40 percent; and (3) all cut trees within 50 feet of a steam will be left on the ground or tipped toward or place in the stream. The ELZ and ground-based equipment limitation to slopes less than 40 percent will minimize soil disturbance and compaction and the potential for and amount of sediment discharge to streams. Cut wood that is left on the ground within 50-feet of streams will contribute to the capture and retention of sediments being conveyed via overland flow from adjacent upland areas, thereby reducing the potential for and the amount of sediment discharge to nearby stream channels. Therefore, these measures will likely reduce the magnitude and duration of episodic increases of suspended sediment in adjacent stream channels until forest floor vegetation disturbed or removed by RCA thinning can be reestablished (≤10 years).

Timber felling on steep or unstable slopes can also increase the potential for slope failure, landslides, and debris flows. Timber harvest reduces root strength and the resultant root decomposition removes the vegetative structure that holds soil in place, which increases the probability of slope failure (Swanson and Swanston 1977), particularly on steep slopes (i.e., >70 percent concave, >80 percent planar or convex slopes) (Robison et al. 1999). The period of low root strength can be longer following clear-cutting than fire, extending up to 100 years (Schmidt et al. 2001). This increased probability of slope failure increases the potential for fine sediment to be delivered to stream networks. The occurrence probability of slope failure (e.g. landslides) is related to the harvest intensity, soil properties, geology, unit slope, and precipitation level. Substantial high rainfall events, such as the 1969 storm in western Oregon (Yazzie et al. 2023), can generate widespread landsliding (Hofmeister 2000) that can affect much of the channel network simultaneously.

Upland, potentially unstable slopes and their associated debris-flow tracks are potential landslide-initiation sites that are above, and often not adjacent to, a stream. Examples include channel headwalls (otherwise known as "zero-order basins" and "bedrock hollows"). These slopes may also include the over-steepened toes of large deep-seated landslides, or legacy sidecast along old roads. Steep and convergent terrain is more likely to be an initiation site for these landslides. Some slides occur in the absence of forest management activities, while some may be related to past logging practices or current forest management activities. As landslides are initiated, debris moves downslope. In cases where the slide reaches a confined stream channel, it may continue, incorporating water and becoming a more fluid mass known as a channelized debris flow. Channelized debris flows can gather volume by adding soil, stream sediment, and woody material as they traverse the stream network to lower topographic positions. These flows are events that can shape stream habitat. However, not all debris flows reach the stream network, and not all channelized debris flows travel into fish-bearing streams. When a channelized debris flow enters a fish-bearing stream, increased sedimentation can deteriorate instream habitat and water quality (Ubechu and Okeke 2017).

Shallow-rapid landslides occur within the forest rooting zone, generally less than 10 feet deep (Cohen and Schwarz 2017, Hairiah et al. 2020). Shallow landslides usually only involve the upper weathered bedrock and overlying soil, are almost always less than 5 feet deep, and have been found to average only 2.5 feet deep at the initiation site (Robison et al. 1999). The topography of the Oregon Coast, including the action area, is generally steep and highly dissected by stream channels. Much of the landscape is prone to initiating landslides and many streams have characteristics that foster transport of debris flows over long distances (Montgomery et al. 2001, Benda and Dunne 1997). Consequently, landslides and debris flows are the dominant erosional processes in much of the Oregon Coast Range (Dietrich and Dunne 1978, Swanson et al. 1982). Rainstorms in this region can also initiate landslides and debris flows in intact forests but are more likely to do so after forest disturbance (e.g., May 2002).

Studies in both the Oregon Coast Range and southeast Alaska have found that landslides are somewhat more common in young forests than in mature and old-growth forests and that the volumes of sediment moved and the run-out length of the landslides is much greater in young forests than in older forests (Johnson et al. 2000, May 2002). Consistent with this, Miller and Burnett (2007) found that average landslide density in the Oregon Coast Range was less in older forests (6.5 landslides/mile^2) than in recently harvested areas (21.8 landslides/mile^2) or in younger forests (8.0 landslides/mile^2) after accounting for topographic variability between sites, size of the area examined, and detection bias in aerial photo inventories. This is supported by Robison et al. (1999) describing landslides on timberlands affected by February and November 1996 storms as being rare in stands more than 100 years old. As compared to landslides and debris flows associated with fire, those associated with timber harvest tend to contain less wood and greater volumes of sediment relative to wood (May 2002). Thus, of particular concern is the potential increase in the frequency of failure of these watershed features and the frequency of discharge of fine sediments to stream channels, specifically fish habitat, as removal of trees can increase the frequency of landslides and deep-seated earthflows or debris flows (Roering et al. 2003, Schanz and Colee 2022).

Increased frequency of shallow-rapid landslide because of root decomposition is higher in the 3 to 15 years after tree harvest, known as the window of vulnerability (Phillips et al. 2012). The landslide recurrence interval (i.e., average time between landslides at a particular location) during the window of vulnerability at clear-cut sites in the Coast Range in Oregon was determined to be approximately three times that of the landslide recurrence interval in undisturbed forest (Benda in prep).

Another important factor in the magnitude of impact of landslides and debris flows is the amount of wood captured by the landslide and debris-flow event. Wood can make up a significant portion of a debris flow by volume as evidenced by Lancaster et al. (2003), which showed an average of 60 percent wood volume of total debris flow volume over 14 debris flow deposits, and Johnson et al (2000), which showed that 15 deposits in southeast Alaskan old-growth forests contained 10 to 35 percent of wood by volume. The wood and water content as well as stream channel geometry affect how far debris torrents travel in stream channels (ODF 2003; Robison et al. 1999; Benda et al. 2004). Booth et al. (2020) reported that the abundance of large woody debris in debris flows was the primary mechanism restricting debris-flow runout. Lancaster et al. (2003) indicated that wood in the Oregon Coast Range is an "important debris flow constituent that acts as a first order control on not only runout lengths, but also locations of deposition in the network. A corollary result is that removal of wood from small drainage basins would increase runout lengths enough to significantly increase the downstream extent of direct impact by debris flows."

Depending on the harvest type (regeneration, variable retention regeneration, or restoration thinning), timber harvest will greatly reduce the number of living trees within the treated stands that may overlap with landslide initiation sites, stream-adjacent unstable slopes, and riparian and upland areas along high-energy debris-flow-track streams. Subwatersheds where the greatest effects to landslide initiation potential are those allocated for intensive treatments (regeneration/clearcut harvest) and extensive regeneration treatments. Subwatersheds where extensive retention treatments and restoration thinning (CRWs and MRW reserves and RCAs) will occur will have reduced effect to landslide initiation potential compared to intensive and extensive regeneration treatments. Figure 3 shows the subwatershed allocations and Table 16 shows the percentage of permit area in each OC coho population that is >65% slope by treatment type. In watersheds that are subject to intensive treatment types (regeneration/clearcut harvest), forest floor vegetation will begin to re-establish and ODSL will replant trees in the harvested areas as required by the OFPA. In watersheds subject to extensive treatments (variable retention regeneration) and restoration thinning forest floor vegetation will begin to re-establish and the stands will be left to grow trees naturally. As this vegetation becomes established (approximately 15 years), it will increase the stability and integrity of the forest floor to resist erosion and increase capture of sediment.

Table 16. Areas of steep slopes in the permit area by treatment type and the percentage of treated acres of slopes >65% of total permit area acres by OC coho salmon population.

Population (acres)	CRW		MRW				Percent Treated Acres >65%
	RCA Restoration Thinning	Non-RCA Restoration Thinning	Intensive	Extensive	RCA Restoration Thinning	Non-RCA Restoration Thinning	
Tenmile (19,880)	1,045	2,852	259	935	207	13	27%
Lower Umpqua (26,688)	1,080	2,461	1,772	2,204	345	206	30%
Coos (36,735)	53	104	6,513	5,018	1,015	1,196	38%

The covered forestry management activities are designed to protect the ecological processes associated with landslides while minimizing detrimental impacts on aquatic habitats supporting OC coho salmon. During treatment planning and development, ODSL will use the TerrainWorks slope stability analysis tool (TerrainWorks 2021) to identify hillslopes with the potential to initiate shallow, rapid landslides that can deliver sediments and wood to fish-bearing streams and streams through which these sediments are likely to travel before reaching fish-bearing channels. This modeling will identify the non-fish-bearing streams with the highest probability of delivering wood to fish-bearing streams (i.e., HLDP streams). Should landslides deliver to HLDP streams, the RCAs established along these streams are intended to reduce the speed and distance the slide travels downslope and ensure large wood is available to be transported to fish-bearing streams. As part of determining how watersheds would be allocated for treatment (extensive, intensive, and restoration thinning), the Slope Stability Analysis Tool (TerrainWorks 2021) was used to allocate steep areas to less intensive treatments (e.g., extensive, reserves, restoration thinning). To protect aquatic processes, ground-based equipment use will be limited on slopes greater than 40 percent. Second, intensive treatments in Intensive and Flexible allocations will be focused on previously logged stands where construction of new roads will be minimal. Finally, to the extent possible, intensive harvest will be avoided on unstable slopes as identified by the Slope Stability Analysis tool (TerrainWorks 2021).

The proposed RCA widths will also help to minimize sediment discharge to streams from slope failures of aquatic adjacent unstable slopes, and upland potentially unstable slopes and their channelized debris flow tracks. The approach for applying RCAs on non-fish-bearing streams integrates shallow translational landslide probabilities and prioritizes protection for those slopes and stream channels most likely to initiate and sustain a debris torrent that delivers large wood directly to fish-bearing streams (HLDP streams). HLDP streams will receive a 50 to 200-foot RCA as well as a 35-foot equipment limitation zone. Additionally, any restoration thinning in RCAs on slopes greater than 40 percent will be completed using predominantly hand-thinning methods.

RCAs established in landslide-prone areas (i.e., HLDP streams) will help reduce the risk of shallow landslides by maintaining or improving root cohesion in the riparian zone, though RCAs subject to thinning are expected to demonstrate decreased root cohesion relative to unthinned RCAs. When slope failures do occur, the proposed RCA widths should be sufficient to contain the majority of debris-flow-impact widths, based on unpublished debris-flow-track data collected from two 1996 storms (Robison et al. 1999). As a result, existing standing trees and downed wood within reaches identified as likely debris flow tracks will likely be available as large wood inputs to the aquatic system and to limit the runout lengths of debris flows (Lancaster et al. 2003, Booth et al. 2020). Large wood inputs from debris flows will improve the sediment storage capacity of upstream reaches, likely resulting in reduced fine sediment transport and a potential increase in the quantity and quality of available spawning habitat in downstream reaches.

Road management. Road use, including that for timber harvest and research traffic, is a covered activity under the HCP. Forest roads are unnatural, compacted surfaces and offer opportunities for accelerated erosion and potential sediment delivery to stream channels from a variety of sources including small slumps and slides into the roadway from the cutbank; water channeling from the road or ditches, if not properly directed and controlled; and blocked culverts and road-fill washouts during floods. The amount of sediment eroded from road surfaces depends on the amount of traffic, the durability of the surface, the level of maintenance, the condition of the ditches, and the amount of precipitation. Fine sediment from surface erosion caused by vehicular traffic may be transported to streams through ditch lines or directly into streams. During the dry season, vehicular traffic can cause sediment to accumulate on the road surface and in roadside ditches that will later mobilize during the first freshets of the following fall. Road use during the wet season will mobilize sediment that could potentially be delivered to streams. While a potential pathway for sediment delivery to streams, paved roads are the smallest contributors of sedimentation to streams. Road use on native-surfaced and aggregate-surfaced roads that either cross or drain to streams have the highest likelihood of delivering sediment to adjacent waters. Roads and landings associated with timber harvest also play a significant role in discharging fine sediments to streams. Road use will primarily be for harvested timber transport and research related traffic that will introduce sediment to roadside ditches and, in some instances, into streams.

Roads and their use in forest management have a variety of environmental consequences, such as degradation of water quality, stream substrate, and pool quality (Great Lakes Environmental Center 2008), which occur primarily from road associated sediment discharge. Winter road use is of particular concern because heavy log trucks traveling over wet road are more likely to break down the road. Frequent maintenance of road ditches can increase sediment yields by removing an armor layer and stabilizing vegetation (Luce and Black 2001). Luce and Black (2001) reported a 17 percent increase in sediment yield from 12 logging trucks making round-trips each day of work during the November to January period. Lee et al. (1997) and Burnett et al. (2006) found positive correlation between road density and fine sediment in streams, but negative correlation between road density and the number of pools per mile and density of large wood in pools. Cederholm and Salo (1979) found that fine sediment levels in the Clearwater River, Washington, were directly correlated to the density of logging roads. Road density by subwatershed as defined by OSU (2021) is shown in Table 6 in section 2.4.2 of this Opinion above. The majority of subwatersheds in the permit area are not properly functioning with the remainder functioning at risk of becoming not properly functioning.

Road density alone is a coarse measure of potential for effects from sediment discharge on streams. Road location relative to stream channels can provide additional context for considering effects of roads on sediment discharge to streams. Roads in the permit area were characterized by ODSL in each OC coho salmon population and allocation based on their location relative to ridgelines and streams Table 17.

Table 17. Miles of roads in riparian areas and near ridgelines in the permit area in each population by allocation.

Population	Allocation	0-35	35-200	Mid-Slope	Multiple Zones	Upper Slope (Ridgeline)	Total
Tenmile	Extensive	0	0.2	2.6	0	9.1	11.9
	Intensive	0	0.3	1.4	0	2.5	4.2
	RCA	1.0	8.0	0.3	0.2	0	9.5
	Reserve	0	0.2	10.3	0.1	61.2	71.8

Population	Allocation	0-35	35-200	Mid-Slope	Multiple Zones	Upper Slope (Ridgetop)	Total
Coos	Extensive	0.1	4.8	22.8	0.4	40.7	68.8
	Intensive	0.1	4.9	33.1	0.2	59.2	97.5
	RCA	3.6	25.3	0.5	1.6	0	30.1
	Reserve	0	4.6	23.1	0.1	30.1	57.9

Population	Allocation	0-35	35-200	Mid-Slope	Multiple Zones	Upper Slope (Ridgetop)	Total
Lower Umpqua	Extensive	0	0.7	8.1	0.1	14	22.9
	Intensive	0.1	2.3	17.1	0.1	14.8	34.4
	RCA	3.9	8.2	0.3	0	0.2	12.6
	Reserve	0	1.5	8.3	0.1	60.6	70.5

Use of roads that are adjacent to streams occupied by OC coho salmon has a higher likelihood of adversely affecting the species and their habitat through associated water-quality impairments. Roads that are hydrologically connected to streams by road ditch lines or stream crossings can be significant and chronic sources of sediment and surface water discharge to their associated stream channels; however, sediment transport and routing is a complex process driven by variables such as water discharge, stream storage capability, and sediment characteristics. Ridgeline roads are generally good locations to minimize fill failure hazards and the hydrologic connectivity between the road system; sediment from upslope roads does not move beyond the road prism (Wemple et al. 2001). Roads characterized as mid-slope were more than 330 feet from ridgelines and more than 200 feet from streams. Wemple et al. (2001) observed that older mid-slope roads dominated the production of sediment during storm events and, thus, can pose significant risk to aquatic environments and the species inhabiting them. Total road miles within 200 feet and 35 feet were also calculated. Roads within 35 feet of a stream represent the highest likelihood of sediment delivery (Rashin et al. 2006). In the permit area, there are 128 miles of mid-slope roads, 61 miles of roads from 35 to 200 feet from streams, and 9 miles of roads within 35 feet of streams. Thus, it is likely that the use of roads will result in delivery of sediment to stream channels in the permit area.

Roads can also cause a higher likelihood and frequency of landslides if constructed on steep slopes, unsuitable soil materials, or with inadequate drainage. Higher landslide frequency can increase, beyond the natural contribution, the amount of fine sediment in stream substrates and substrate embeddedness at the reach and even the watershed scales. Most sediment generated from roads is caused by landslides and debris flows (Reid 1981). Roads in western Oregon have been shown to alter landslide and debris flow characteristics, including increasing the likelihood of their occurrence, sediment volumes, and runout lengths above those for intact forests or harvested areas (Amaranthus et al. 1985; May 2002; Miller and Burnett 2007). Sessions et al. (1987) found landslides do occur in association with both mid-slope and ridge-top roads, but observed fewer landslides with smaller volumes where road layout attempted to minimize mid-slope positions. Poorly constructed roads dating from before the OFPA was enacted have caused an increase in shallow-rapid landslides and fine-sediment input, particularly on steep slopes (ODF 2000), and the frequency of sediment-discharge events. Landslides associated with roads have been found to be larger in volume than landslides not associated with roads by a factor of four in the Oregon Coast Range (Robison et al. 1999).

Over the permit term, ODSL commits to constructing no more than 40 miles of new permanent roads, up to 0.5 mile per year, and up to 2 miles per year of temporary roads. If temporary roads are not vacated within 5 years of construction, they will become part of the 40-mile total over the permit term. The ODSL will implement conservation measures and conditions on road management to minimize the impacts from road management has on suspended sediment and substrate embeddedness that may result from sediment discharge associated with road construction, maintenance, and potential landslides and debris flows. The ODSL will implement a road design strategy consistent with the OFPA OAR-629 and other applicable statutes as described in section 1.3.2 of this Opinion and Section 3.6.1 of the HCP, conservation measure 3, and condition 11 of the conservation strategy (Chapter 5 of the HCP) in an effort to avoid, minimize, and mitigate the effects of road management on stream channels. These are summarized below.

Conservation measure 3 includes a formal assessment of the road system in the first 12 years of the permit term to identify in the permit area where the road network is and to what degree the road network hydrologically connected to the stream network. ODSL will identify current and legacy roads that contribute to sediment discharge, landslides, erosivity and habitat fragmentation to aquatic and riparian systems. From this, ODSL will identify road projects that reduce and modify the road network in the permit area to reduce the impact of roads to aquatic and riparian habitats. These road projects include road vacating and road relocating that will hydrologically disconnect roads from stream channels.

Condition 11: Road Construction and Management (Section 5.5.12 of the HCP), of the conservation strategy consists of road construction and maintenance and use measures that will be supplemental to the measures prescribed in OFPA OAR-629. The intent of these supplemental measures will be to minimize potential impacts on aquatic habitat and species through hydrologic disconnection of the road streams and reducing the potential of landslides and debris flows. These are summarized below:

- Construction
  - ODSL will locate roads on stable locations (upper slope, mid-slope, or flats), 35 feet away the edge of the aquatic zone and not in RCA, and away from sensitive resource sites (streams, seeps, wetlands, and unstable areas) whenever possible;
  - ODSL will design and build fish-bearing stream crossings to meet NMFS fish passage standards (NMFS 2022a or most recent) and Oregon fish-passage laws (ORS 509.580 to 910 and OAR 635-412);
  - ODSL will minimize the footprint of constructed roads and incorporate proper drainage of surface water outsloping, insloping, grade breaks, dips, water bars, relief culverts, and cross drains; runoff, erosion, and sediment containment measures when outsloping is not possible; incorporate drainage structures when a road exposed springs, seeps, or wet areas; and proper location of drainage structures;
  - ODSL will add rock to roads with high erosion potential and will use the hardest crushed rock available to stabilize the road surface; and
  - ODSL will dispose of excess excavation materials at stable sites located outside of the 100-year floodplain where it will contribute to sedimentation.
- Maintenance and use:
  - ODSL will close roads in or adjacent to RCAs that cannot be hydrogically disconnected or are unsuitable for winter haul during wintertime; or commercial road use will be stopped if the road surface is deteriorating or standing water is likely to reach waters of the state;
  - ODSL will conduct in-water work during the established ODFW in-water work guidelines (ODFW 2024) and properly time maintenance work outside of wintertime wet weather; and
  - ODSL will implement sediment and erosion control during maintenance activities, clean drainage features to ensure proper function, and stabilize or ensure effective drainage for disturbed or exposed soils.

Measures to minimize road footprint, provide surface drainage, stabilize road surfaces and manage seasonal road use reduce the effects that roads have on aquatic habitats and sediment discharge. Where road construction is necessary, the potential occurrence of associated mass failures can be reduced by controlling road width or length or both dimensions (Edwards et al. 2016). Megahan et al. (1979) reported that main access roads in Idaho had 3.4 mass failures per kilometer of road compared to narrower spur roads, with averaged only 0.8 mass failures per kilometer. Road-maintenance BMPs, including adding and maintaining cross drains and ditches, were 93 percent effective in minimizing sediment to streams (Luce and Black 1999). Forest vegetation buffers flow and prevents sediment from reaching streams (Copstead and Johansen 1998). The integrity of the road surface can be enhanced during high runoff periods by applying gravel to produce well-aggregated surfaces. Forest roads in erosion-prone areas can be surfaced with gravel, rock, asphalt, or other suitable materials to provide sufficient bearing strength and reduce deterioration and erosion of the road surface. Appropriate surfacing can be combined with compacting methods to further increase bearing strength and resistance to erosion. Roads that were well-graded and graveled have been found to not show signs of surface runoff during storm events (Copstead et al. 1998). Swift (1986) found that 15 centimeters (6 inches) of crushed rock reduced sediment yield by 78 percent compared to a bare road surface. Kochenderfer and Helvey (1987) found an 87 percent reduction in sediment yield from roads with 15 centimeters (5 inches) of rock compared to bare-soil roads. More recently, Coe (2006) found 15 times greater median sediment production from un-rocked forest roads than from rocked roads.

Although the conservation measures and conditions described above will avoid sediment delivery or reduce the amount of sediment delivered to streams by up to 78 to 93 percent , it will not be prevented in all cases. Based on the findings of seven studies conducted in different geological settings including western Oregon, the average distance traveled by road-associated sediment is 40 feet, with a range of 0 to 639 feet (Packer 1967, Swift 1986, Burroughs and King 1989, Ketcheson and Megahan 1996, Brake et al. 1997). ODSL identified existing roads within 200 feet of streams that could deliver sediment to adjacent streams including existing roads paralleling streams and existing roads with inside ditches that carry concentrated flows from roads that lack ditch relief culverts. Table 18 indicates the miles of existing roads in the action are that are within 200 feet of streams inhabited by OC coho salmon. Use of roads within this distance are highly likely to create a chronic source of sediment. We expect that conservation measures and conditions for road construction and management discussed above will avoid and reduce the amount of road produced sediment discharge to streams and reduce the duration, frequency, and magnitude of effects on suspended sediment and substrate embeddedness.

Table 18. Miles of roads that are within 200 feet of streams inhabited by OC coho salmon.

Independent Coho Population	**Miles of Road within 200 feet of a Stream**
Tenmile	9.8
Coos	44
Lower Umpqua Below Loon Lake	14.1
Lower Umpqua Above Loon Lake	4.4
Total	**72.2**

Road drainage and location is also an important design consideration to reduce the risk of landslides and debris flows. Roads and ditches can concentrate and increase storm runoff to destabilize downslope hillsides and fill slopes (Wemple and Jones 2003). Water drainage is a critical factor affecting road subgrade load-bearing capacity and stability, slope stability, and associated stream sedimentation. Amaranthus et al. (1985) suggested that avoiding concentration of water on unstable slopes by careful location of culverts would minimize debris-slide erosion.

Robison et al. (1999) concluded that good drainage can reduce the landslide hazard; however, drainage systems must be functional during storms to prevent road-associated landslides. While it is not clear that any specific drainage spacing criteria are appropriate for hazard reduction, results indicate that it is critical to keep all drainage waters off of the steepest slopes. Damaging landslides are unlikely for roads constructed on slopes of less than 50 percent if these roads have frequently spaced and properly sized drainage structures (Robison et al. 1999, ODF 2000). Sessions et al. (1987) found landslides do occur in association with both mid-slope and ridge-top roads, but observed fewer landslides with smaller volumes where road layout attempted to minimize mid-slope positions. In accordance with OAR 629-625-0330, for all forest roads, ODSL will provide a drainage system that reduces the development of gully erosion of the road prism or slopes below the road using grade reversals, surface sloping, ditches, culverts, waterbars, or any combination thereof; will not concentrate road drainage water into headwalls, slide areas, high landslide hazard locations, or steep erodible fillslopes; and will provide drainage when roads cross or expose springs, seeps, or wet areas. The location of new roads has yet to be determined as road placement will be dictated by where they are needed to carry out the covered activities. However, roads constructed under the proposed action will involve consultation with a geotechnical specialist and adherence to measures prescribed under Condition 11, which will reduce instances of road-building across steep slopes, stream channels, and other sensitive areas and the probability of road-associated landslides.

Sediment transport and routing is a complex process driven by variables such as water discharge, stream storage capability, and sediment characteristics. Some streams within the permit area upstream of OC coho salmon habitat will have the capacity to store sediment because of their having a stream gradient, in pools behind wood structures and boulders, and along the banks where flows are slower (Skidmore et al. 2011). Upstream reaches with high sediment-storage capacity may greatly reduce the amount of sediment from landslides and debris flows reaching OC coho salmon habitat.

After considering the road related covered activities; their relation to landslides and debris flows; the relative and best available information and science relating to roads, landslides and debris flow, and sedimentation; the proposed action or the covered activities will not significantly increase the number or frequency of landslides and debris flows or the magnitude of their associated sediment discharge to streams and subsequent increases in suspended sediments and substrate embeddedness in the in the action area over the permit term.

Controlled burning. Under the HCP, controlled burning includes prescribed burns and pile burning. Although there is considerable research available on the effects of wildfire on streams and riparian areas, there is less information available on the effects of controlled burns, and considerably less on controlled burns within riparian areas. Effects from low- to moderate-intensity prescribed fire in riparian areas include minor reductions in stream shade, minor reductions in large wood recruitment, and inputs of fine sediment and nutrients to streams. In a recent study conducted in the Sierra Nevada Mountains of California, Bêche et al. (2005) concluded that low- to moderate-intensity prescribed fire that was actively ignited in the riparian area had minimal effects on a small stream and its riparian zone during the first year after the fire. The prescribed fire did result in a tenfold increase in bare ground and a significant decrease in understory vegetation but did not increase fine sediment in pools.

ODSL will conduct prescribed-burn activities, including single or multiple burns to manage fuels and increase or maintain suitable conditions for species of cultural value to local tribal communities. Prescribed burning of slash piles on landings following harvest, broadcast burning of harvest units for site preparation prior to planting, and/or use of prescribed fire for maintenance of meadows or other habitat may also occur, where appropriate, as part of the research management program. Potential sources of fine sediment delivery to stream channels in the permit area resulting from controlled burns generally include resulting fire lines and areas of bare soil. However, controlled burning will be conducted in accordance with OAR 629-615-0300, which imposes requirements for the protection of riparian areas, and ODSL has committed to avoid conducting prescribed burns inside RCAs. Therefore, given that controlled burning will be limited to upland areas and conducted consistent with restrictions under OAR 629-615-0300, it is unlikely that controlled burning will cause a meaningful increase in suspended sediments or substrate embeddedness in streams within the action area.

Riparian restoration and stream enhancement. ODSL will conduct riparian restoration and stream enhancement as part of the HCP's conservation strategy. This will include wood placement in stream reaches where large wood and associated channel structure is currently deficient. Installing large wood in streams can enhance habitat quality for salmonids by trapping gravel and fine sediments, sorting gravels, and filtering fine sediments out of spawning gravels. Instream wood can also contribute to sediment storage in upstream reaches that reduces the downstream transport of fine sediments that can substrate embeddedness in spawning gravel.

Wood placement will occur directly in stream channels and adjacent floodplains using equipment such as helicopters, excavators, dump trucks, front-end loaders, full-suspension yarders, and similar equipment. Using heavy equipment for wood placement will compact soils, thereby reducing soil permeability and infiltration. Wood placement activities may require instream work where substrate could be compacted or displaced or fine sediment exposed that may later be transported downstream.

We expect that fine sediment will enter stream channels because of the covered riparian restoration and stream enhancement activities described above. These sediment inputs will increase suspended sediment concentrations and substrate embeddedness in streams within the action area. The measures associated with the actions that ODSL will implement as part of the conservation strategy will reduce the introduction of fine sediment to streams and related increases in suspended sediments and substrate embeddedness. Additionally, suspended sediment increases and substrate embeddedness will recover as conservation actions are implemented and as natural sediment transport of fine sediments occurs during higher flow events. Following implementation of stream enhancement conservation actions, natural sediment sorting and transport processes affected by covered activities will improve, as will substrate quality and quantity, while decreasing the frequency and magnitude of suspended sediment increases. Additionally, these effects will be spatially and temporally separated throughout the permit and action area.

Chemical contaminants and nutrients

Covered activities that could affect water quality through the introduction of chemical contaminants and nutrients include timber harvest activities, road work, road use, and stream-enhancement activities. Chemicals and nutrients may be introduced and water quality degraded because of road runoff to streams and heavy equipment use in or near streams.

Chemical contaminants including hydraulic fluids and fuels may be introduced to stream channels through equipment leaks or spills associated with the operation of heavy equipment near or in stream channels or equipment fueling related to the covered activities. The amount of contaminant discharge from leaks is expected to be small (ounces). The conservation strategy will include implementation of RCAs that establish vegetative buffers as shown in Table 14. These RCAs will minimize, but not eliminate, the likelihood and amount of contaminant discharge to stream channels associated with the covered activities. However, ODSL will conduct the covered activities in accordance OAR 629-620-0000 through 629-620-0800, which are collectively known as the chemical and other petroleum product rules. These rules include best management practices related to heavy-equipment operation including measures pertaining to the prevention, control, and reporting of leaks and spills (OAR 629-620-0100) and required setbacks for locations where the mixing, transfer, and/or staging of chemicals and other petroleum products will occur (OAR 629-620-0300). Nonetheless, there is a low likelihood that contaminants will be discharged in small amounts to streams. These instances are expected to be infrequent, localized to the discharge points and immediately downstream, short-term (days to weeks), and spatially and temporally separated throughout the action area over the permit term.

Deforestation can cause a release of carbon, nitrogen, phosphorus, and sulfur through timber harvest, burning of slash, accelerated decomposition, decreased production of wood and roots, and erosion (Vitousek 1983). Riparian forests have been found to be effective filters for nutrients from agricultural runoff, including nitrogen, phosphorus, and sulfur. Stream buffers as small as 62 feet have been shown to decrease input of nutrients from 48 to 95 percent (Lowrance et al. 1984; Jordan et al. 1993; Snyder et al. 1995). Implementation of the conservation strategy will include establishment of RCAs that will vary in size and configuration according to stream type and upslope allocation as shown in Table 14. Additionally, equipment limitation zones will be applied to a portion of XNFB streams meeting Oregon FPA stream type definitions. Stream channels with the greatest potential to experience nutrient inputs as a result of the covered activities consist of those where a 50-foot RCA will be applied (see Table 14 for applicable stream types) and those for which an RCA will not be designated (i.e., XNFB streams). The RCA widths are measured horizontally; therefore, slope distances will vary depending on the slope gradient. Nonetheless, there is potential that the application of 50-foot RCAs or ELZs will not adequately prevent nutrients from entering the streams in all situations and that there will be increases of 5 to 52 percent (Lowrance et al. 1984; Jordan et al. 1993; Snyder et al. 1995) of the available nutrients to streams from timber harvest that will last until the disturbed vegetation is reestablished (years).

Physical Barriers

The covered activities that could affect habitat access include road construction and maintenance, specifically culvert replacement installation and removal, and fish-passage barrier upgrade and removal. Where OC coho salmon occur, ODSL will design new and replacement culverts and culvert removals to meet NMFS fish passage criteria (NMFS 2022a or most recent). Meeting the NMFS fish passage criteria will ensure that culvert installations, replacements, and removals are designed to maintain hydraulic conditions, including hydrology, velocities, and slopes that pass juvenile and adult fish.

Large Wood and Wood Recruitment

The forest management activities covered under the proposed action will influence the character of tree stands throughout the permit area. Specifically in RCAs that are thinned for research. The development of these tree stands then relates to the availability of trees for recruitment to stream channels from adjacent riparian and upland areas. In this opinion, we refer to these trees as large wood for their function and role in ecological processes within a watershed, both within the stream and upslope. Large wood is a critical habitat element of Pacific Northwest streams and forests that was historically abundant throughout the region. Over the years, large wood has been removed from streams through timber salvage, splash damming, and stream cleaning. Additionally, large wood has been removed from riparian forests through commercial harvest, road building, forest clearing for agriculture and other land uses, and forest thinning to improve tree growth.

Large wood provides important habitat features for the populations of OC coho salmon that inhabit the action area. Large wood in streams provides channel roughness and interacts with streamflow to create log jams, pools, and slow-water areas; interacts with water to modify streamflow paths, activating side channels and off-channel areas; and improves floodplain connectivity, all of which are important habitat features that support juvenile salmonid resting, predator avoidance, and feeding. Large riparian trees that die and fall into and near streams, such as within floodplains and wetlands, regulate sediment and flow routing, influence stream channel complexity and stability, increase pool volume and area, and provide hydraulic 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). Large wood affects stream channel morphology in low gradient streams at both the individual pool and reach scale (Carroll and Robison 2007). Large wood can provide cover for fish in pools by covering the surface and creating shadows, velocity refugia, and three-dimensional partitions within the water column (Harmon et al. 1986). At the reach scale, large wood also creates habitat partitions by increasing pool distribution and habitat unit diversity (Carroll and Robison 2007). Large wood also plays an important role in floodplain connectivity as it decreases flow velocity (Davidson and Eaton 2013) and increases the frequency and magnitude of inundation in adjacent floodplains (Collins and Montgomery 2002). Greater large wood abundance in streams increases the number of pools (Beechie and Sibley 1997; Montgomery et al. 1999), pool area (Beechie and Sibley 1997), and residual pool depth (Collins et al. 2002) and can change the overall channel morphology of a stream from plane-bed to forced-pool-riffle channels (Buffington and Montgomery 1999, and Montgomery et al. 1996).

Instream wood may be recruited through multiple processes including tree fall, bank erosion, and debris flows or landslides; though, the majority of instream wood originates from within the riparian zone (Martin and Benda 2001, Reeves et al. 2003, Seo et al. 2010, Ruize-Villanueva et al. 2016). Near-stream wood recruitment tends to be more evenly distributed throughout a drainage network, whereas episodic landslides tend to create large concentrations of wood at tributary junctions, which contributes to habitat complexity and ecological productivity (Bigelow et al. 2007). For near-stream riparian inputs, empirical and modeling studies suggest that stream wood input rates decline exponentially with distance from the stream and vary by stand type and age (McDade et al. 1990, Van Sickle and Gregory 1990, Gregory et al. 2003) (Figure 13). For example, 95 percent of the total instream wood inputs in these studies came from distances that ranged between approximately 25 meters and 45 meters (approximately 82 to 148 feet) from the water's edge, depending on the stand conditions. Near-stream inputs are the primary source of large wood recruitment (up to 100 percent) in low-gradient streams with floodplains. Upslope, episodic delivery can account for a substantial portion (up to 80 percent) of the large wood in small to mid-sized streams (Reeves et al. 2003, Bigelow et al. 2007) in mountainous settings. Topographic features of a watershed influence the relative contribution of upslope sources of wood. Steeper, more highly dissected watersheds will likely have a greater proportion of wood coming from upslope sources than will watersheds that are less dissected or steep (Martin and Benda 2001). The majority (90 percent) of the wood recruited to a stream channel from adjacent riparian areas comes from within 30 meters (98 feet) of the channel (McDade et al. 1990, Van Sickle and Gregory 1990, Spies et al. 2013) (Figure 13). However, in any watershed, only a subset of the upslope channels will deliver wood to valley floors and fish-bearing streams via debris flows. Both types of wood delivery are necessary for functioning and productive stream ecosystems.

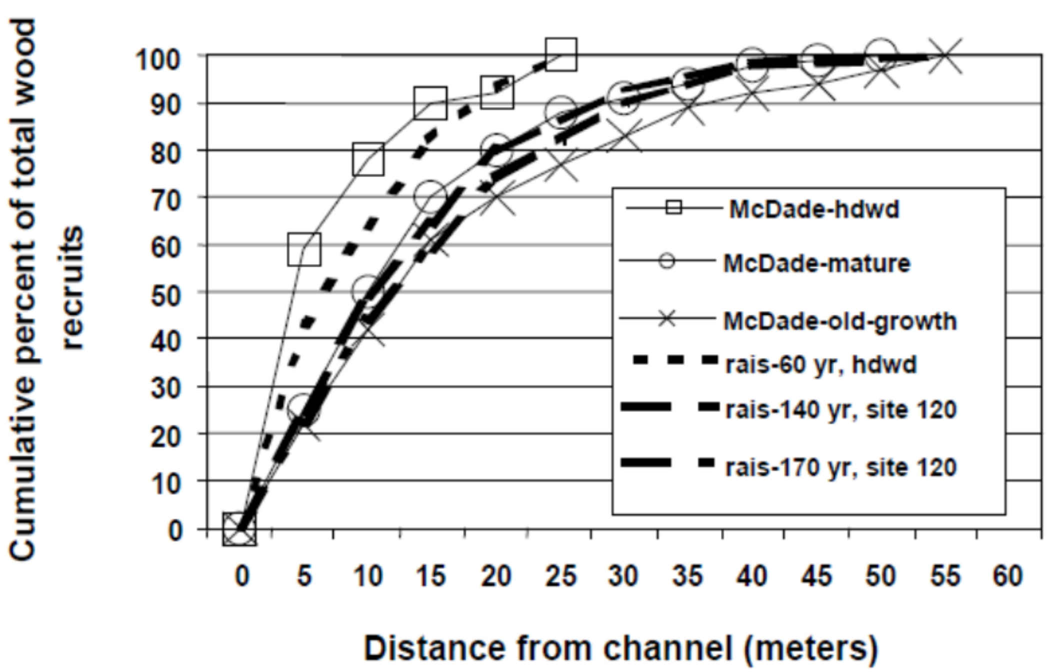

Figure 13. Comparison of predictions of total wood accumulation with distance from channel using the Organon forest growth model and RAIS instream wood recruitment

model verse the observations of McDade et al. (1990) for streams in the Cascade Mountains of Oregon and Washington (as cited in Spies et al. 2013).

Timber harvest. ODSL will implement conservation measures for timber harvest, which will affect large wood production and recruitment to streams. ODSL will also conduct stream restoration and enhancement activities that include instream-wood-placement projects. The key elements of the covered activities and conservation strategy pertaining to large wood production and recruitment are listed below:

- ODSL will integrate the establishment of RCAs into implementation of covered forest-management activities. These RCAs will be applied along all FB, PNFB, and HLDP streams, the widths of which will dictated by stream type and the upslope allocation type (Table 14). Restoration thinning treatments in RCAs in the CRW and MRW will be applied on up to 1,200 acres of dense plantations 65 years old or younger (as of 2020). Riparian stands greater than 65 years (as of 2020) will not be subject to thinning. Up to two restoration thinning entries per stand may occur on up to 50 percent of these 1,200 acres of RCAs over the course of the permit term, the remaining 50 percent would be single entry thins. Restoration thinning that occurs within RCAs will be subject to the following restrictions:
    - All trees cut within the first 50 feet of all RCAs will be left on the ground, or tipped toward or placed into the stream; no trees will be removed.
    - Outside 50 feet, 0 to 20 percent of the volume of cut logs within RCAs will be left on the ground or felled towards, or placed in the stream channel. These will consist of the largest cut trees in order to provide the greatest ecological benefit to coho salmon.
  - Additional activities that will involve tree removal within RCAs are those related to road construction and maintenance (e.g. new roads, stream crossings installation or replacement, and roadside tree removal that will be contained to the roadbed).

We evaluated the effects of the covered activities on wood recruitment for each stream type with regard to near-stream and landslide and debris flow inputs based on modeling conducted by ODSL. ODSL used the model *ElliottSFWood*, developed by Dr. Dan Miller of Earth Systems Institute to generate wood recruitment estimates for the permit area. This model estimates:

- The relative proportions of total wood recruitment attributable to treefall recruitment directly into fish-bearing streams (i.e., stream-adjacent mortality)
- Shallow transitional landslide (STL) recruitment to fish-bearing streams
- Tree fall recruitment that accumulates in non-fish-bearing channels and is subsequently transported by periodic debris flow to fish-bearing streams
- STL recruitment that is transported forthwith through non-fish-bearing channels to fish-bearing streams or that is deposited in non-fish-bearing stream channels and is subsequently transported by periodic debris flows to fish-bearing streams

The results of this model were then integrated with the large wood source-distance relationships described by McDade et al. (1990) within a geographic information system (GIS) environment to estimate potential protected wood recruitment, which is defined as the quantity of large wood that could be recruited to fish-bearing streams via adjacent riparian areas and debris flow processes. The wood recruitment model indicates that, based on McDade et al. (1990) and a 200--foot site-potential tree height:

- 60 percent of full-potential wood recruitment is protected by 50-foot RCAs
- 85 percent of full-potential wood recruitment is protected by 100-foot RCAs
- 90 percent of full-potential wood recruitment is protected by 120-foot RCAs
- 100 percent of full-potential wood recruitment is protected by 200-foot RCAs
- 50 percent of full-potential wood recruitment is protected outside of RCAs in extensive allocations.
- 100 percent of full-potential wood recruitment is protected in reserve allocations.
- 50 percent of full-potential wood recruitment is protected in XNFB streams that fall within RCAs of RCA-protected streams.

The wood recruitment model does not account for partial harvests including restoration in RCAs and upslope areas and likely overestimates the amount of wood available for recruitment.

Outside of RCAs, ODSL will manage stands within the permit area in accordance with operational standards prescribed in the HCP for their corresponding allocation type. The findings summarized above suggest that the proposed RCA widths along all fish-bearing streams, perennial non-fish-bearing (PNFB) streams, and non-fish-bearing streams that were modeled to deliver 25 percent of the total wood budget to fish-bearing streams (i.e., HLDP streams) will maintain a substantial proportion of the existing potential for riparian wood recruitment to adjacent streams, regardless of the land allocation type attributed to adjacent upland areas. This is supported by previously noted studies, including McDade et al. (1990), that demonstrate 95 percent of the total instream wood inputs comes from distances ranging between approximately 82 to 148 feet, depending on the stand conditions.

Where thinning occurs in CRWs, near-stream wood inputs will be protected along all perennial streams by a 200-foot RCA, which is expected to be sufficiently wide to protect virtually all potential near-stream wood recruitment (Welty et al. 2002). The RCA widths on HLDP streams in CRWs will also be 200 feet wide, which will support recruitment of wood to these streams that may in turn be delivered to fish-bearing reaches downstream. In MRWs, RCA widths on fish-bearing streams will typically be 100 feet but will extend up to 200 feet where expanded RCAs are adopted per Conservation Measure 2. These RCA widths are expected to maintain approximately 85 and 100 percent of the existing potential for riparian wood delivery, respectively (Welty et al. 2002). With the exception of XNFB streams, which are discussed below, non-fish-bearing streams in MRWs will be assigned a minimum RCA width of 50 feet. The modeling conducted by ODSL indicates that this corresponds to the minimum RCA width necessary to maintain approximately 70 percent of the potential for wood recruitment from near-stream sources. In MRWs, tree removal resulting from commercial thinning and/or regeneration harvest that occurs outside the 100-foot RCAs on fish-bearing streams will remove the majority of the remaining approximately 15 percent of wood available for recruitment to adjacent fish-bearing streams. Similarly, where tree removal occurs outside the 50-foot RCAs established along PNFB and HLDP streams, up to approximately 40 percent of the wood available for recruitment to adjacent streams and subsequent transport to fish-bearing waters downstream will be removed. In MRWs, the degree to which wood recruitment from outside of RCAs is reduced because of tree removal will depend on the harvest type (i.e., clear-cut, retention, or light, moderate, or heavy commercial thinning) and the management objectives for the corresponding stands.

No RCAs will be assigned to XNFB streams. These streams are expected to typically consist of smaller streams (i.e., first-order or second-order streams) where wood is not reorganized or transported, except during unusual flood events or debris flows with recurrence intervals that are greater than decadal (Kramer and Wohl 2017). Furthermore, non-fish-bearing streams are often separated from downstream reaches by artificial or natural barriers, gorges, or other natural constraints that limit both fish passage and wood transport. It is important to note that XNFB streams are not considered important sources of large wood recruitment to coho salmon habitat in the permit area. XNFB streams are seasonal or intermittent, are usually located in stream headwalls, and have limited hydraulic transport capacity and low probability of delivering wood to fish-bearing streams through landslides or debris flows, when compared to HLDP streams. Therefore, the lack of RCAs along XNFB streams is expected to have little impact on large wood recruitment to fish-bearing streams within the action area because such streams are unlikely to deliver large wood to fish-bearing streams.

Thinning conducted in riparian areas will influence wood recruitment to adjacent streams. There are few published studies on the effects of thinning on wood recruitment and thinning effects on wood recruitment in riparian zones (Spies et al. 2013). To address this for the purpose of evaluating the likely effects of thinning proposed as part of the BLM's Western Oregon Resource Management Plan (BLM 2016a, 2016b), NMFS conducted a study to assess the effect of contemporary restoration thinning programs on the BLM's management direction for production of large wood and the development of complex forest structure (Pollack 2016). While there are differences in the way that ODSL will conduct restoration thinning relative to methods described in BLM's management plan, ODSL's thinning strategy in RCAs to accelerate the development of complex forest structure is consistent with BLM's riparian reserve thinning strategy in that it aims to produce larger trees and more complex forests in RCAs . Thus, general conclusions from Pollack (2016) can be applied to ODSL's strategy for conducting restoration thinning within RCAs.

RCA thinning will occur on up to 1,200 acres of stands aged 65 years old or younger (as of 2020) across both MRWs and CRWs over the course of the 80-year permit term, with approximately 150 acres of RCAs being thinned every 5 to 7 years. Currently, the RCAs available for thinning are douglas fir timber production stands of high stand density and trees that are growth limited due to competition for water and sunlight. Where RCA thinning occurs, basal area may be reduced to a minimum of 40 square feet per acre. The HCP does not specify a minimum DBH for trees to be retained during RCA thinning. However, the HCP does indicate that restoration thinning in RCAs would focus on the retention of the largest existing trees at the site. Therefore, for the purposes of our analysis, we assume that trees retained during RCA thinning will have a minimum DBH of approximately 11 inches, which is consistent with the tree size identified for tree stocking scenarios described in the Oregon FPA with similar levels of basal area retention (OAR 629-610-0020). Under this assumption, a basal area of 40 square feet per acre equates to approximately 60 trees per acre. For coast-range Douglas-fir forests, such as those that comprise the permit area, Pollack (2016) estimated that thinning to 60 trees per acre may decrease large wood production by an average of 50 percent with a 95 percent confidence interval of 45 to 55 percent. It is difficult to infer potential effects of RCA thinning on instream wood loads within the permit area from these estimates without considering site-specific parameters (e.g., location within the stream network, stand conditions). However, results from Pollock (2016) suggest that thinning in RCAs within the permit area will result in a measurable reduction in the capacity of treated stands to produce large wood for recruitment to fish-bearing streams.

This general conclusion in reduction in large wood recruitment for ODSL's management of RCAs in the ESRF is consistent with modeling for large wood recruitment under the *ElliottSFModel*, although the model likely overestimates the percentage of available wood recruited to streams in the permit area since it does not take into account partial harvests such as restoration thinning in RCAs and upslope areas. With this in mind, the model estimated that the percentage of available wood that could be recruited to streams is 87.5, 94.7, and 98.3 percent in the Coos, Umpqua, and Tenmile population portions of the permit area, respectively and 92 percent across the permit area. While there is uncertainty associated with the modeled wood recruitment estimates, the model provides a framework for identifying streams and channels most likely to deliver wood to fish-bearing streams and helps ensure those areas are protected by RCAs in light of the provisions discussed below.

Reductions in large wood recruitment from RCA thinning will be offset, in part, by either leaving in place, tipping toward or placing into the stream all trees cut within the first 50 feet of RCAs. This action has the potential to conserve approximately 60 percent of the wood available for recruitment in RCAs treated with restoration thinning and would immediately increase the amount of dead wood available for recruitment via near-stream inputs (e.g., bank erosion). However, wood functions vary with the size of wood relative to the size and type of the channel (Spies et al. 2013). Therefore, the degree to which this action will lead to the recruitment of wood that is sufficiently large to support habitat-forming process that benefit coho salmon will depend on the size of trees at the time of thinning relative to the size of wood required to support specific instream functions (e.g. pool formation, sediment sorting, energy dissipation, nutrient and organic material retention) in adjacent streams. Outside of the first 50 feet of RCAs where thinning occurs, 0 to 20 percent of the volume of the largest cut logs within the remaining portion of the RCA will be left on the ground or felled towards, or placed in, the stream channel. Given the potential for no additional cut logs (i.e., 0 percent) to be retained outside of the first 50 feet, the benefit to large wood recruitment from this action is considered negligible.

Considering the scientific literature relative to riparian and upland restoration thinning and wood recruitment and the condition of stands to be thinned in the RCA and upland areas in the permit area, it is likely that a measurable reduction in wood recruitment will occur. However, the reduction in wood recruitment will not be meaningful to aquatic habitat because of the establishment of RCAs, conservation measures, and conditions intended to protect the natural processes that make up the contribution of large wood to streams in the permit area.

Road Management and Maintenance. Throughout the action area, we expect a minor decrease in wood recruitment potential because of vegetation removal associated with road construction. To limit the extent to which road construction decreases the availability of large wood, design measures described under Condition 11 will be implemented. These include, locating new roads at least 35 feet from the edge of the aquatic zone, whenever possible; limiting road development within RCAs to situations where alternatives are not operationally feasible; and using the minimum practical design standards with respect to road width, radius, and gradient. We expect there will be some decrease in wood recruitment potential from the removal of riparian vegetation, especially when roads are located adjacent to streams. This will result in a minor reduction of trees available for wood recruitment to the stream. The effects will continue as long as the permanent road is in place and continue for several decades for temporary roads until additional trees grow to replace those lost because of temporary road construction. The expected reduction in wood volume from road construction in the permit area will be small and, thus, will not have a meaningful effect on wood recruitment in the action area.

Riparian-Restoration and Stream-Enhancement. To offset the effects of the covered activities on OC coho salmon from resulting decreases in wood recruitment, ODSL will conduct in-channel restoration and enhancement projects (large wood placement) on fish bearing streams within or adjacent to all harvest operations when the stream is below the desired level of wood or as part of Conservation Measure 1. These projects will include wood placement on fish-bearing streams that currently lack adequate levels of large wood to create sufficient habitat complexity for juvenile coho salmon rearing and overwintering because of previous disturbance or forestry management practices. These wood placement projects will install large wood in focal streams that will enhance or re-establish natural physical and biological processes that support the development of high-quality juvenile rearing habitat for coho salmon.

Pool Frequency and Quality, Off-channel Habitat, Refugia, Width-to-Depth Ratio, Streambank Condition, and Floodplain Connectivity

Changes in these channel-associated habitat features are dependent on changes to the physical processes that shape and develop them, which include erosion, aggradation, and large wood recruitment. Large pools, off-channel habitat, refugia, streambank condition, and floodplain connectivity are habitat features related to woody material, the process of in-stream wood recruitment, and sediment delivery from riparian and upland sources. Stream channels and these habitat features can be altered by changes in the natural rate of wood recruitment, sediment discharge, or landslides and debris flows, which episodically contribute large amounts of fine and coarse sediment and wood to streams. From the analysis above for large wood recruitment, the effects of the proposed action on large wood recruitment are expected to be minor with reduced large wood recruitment expected to result from restoration thinning in RCAs, timber harvest in stands directly adjacent to RCAs, and road construction. These reductions in wood recruitment will be both temporally and spatially separated across the action area over the course of the permit term and, thus, will not have appreciable adverse effects on large pools, off-channel habitat, refugia, streambank condition, and floodplain connectivity.

Pool quality and width-to-depth ratio are habitat features related to sediment discharge to streams. Sediment discharge to streams can result in burial of existing habitat, scouring of smaller headwater stream channels, increased streambed mobility, and decreased summer pool capacity for juvenile salmonids (Everest and Meehan 1983, Benda 1990, Nawa and Frissell 1993, May and Lee 2004). Because the covered activities, including timber harvest and road construction and use, will increase sediment discharge and suspended sediment concentration levels in the action area, they will have an adverse effect on pool quality and width-to-depth ratio. Pool quality will be degraded where suspended sediment settles and fills in pools.

Increased suspended sediment can also have adverse effects on stream width-to-depth ratios. In areas where excessive sediment aggradation occurs, the channels could widen, causing a wider shallower stream channel.

As described above, sediment inputs to streams resulting from the covered activities will be reduced through ODSL's implementation of conservation actions that establish RCAs and ELZs and implement measures for road construction and maintenance that reduce discharge of sediments, hydrologically disconnect roads from streams, and avoid causing a meaningful increase in the number or frequency of landslide and debris flows in the permit area over the permit term. In addition, actions that cause an increase in suspended sediment will be spatially and temporally separated throughout the permit area and over the permit term, which will reduce the frequency, magnitude, and spatial distribution of adverse effects on pool quality and width-to-depth ratio associated with sediment discharge.

Peak and Base Flows

Forest management activities can affect the rate that water is stored or discharged from a watershed. Total water yield typically increases following timber harvest because of reduced evapotranspiration (Harr et al. 1975, Harr 1976, Duncan 1986, Keppler and Zeimer 1990, Jones 2000) and decreased water interception (Reid and Lewis 2007). Covered activities that will affect peak and base flows include timber harvest and road construction, maintenance, and use.

Timber Harvest. Timber harvest may result in winter flows with higher peak volumes and earlier peak discharge times (Jones and Grant 1996). Elevated peak flows occur when a high proportion of timber basal area has been removed by forest harvest (Grant et al. 2008). This is particularly true within rain-on-snow watersheds (Grant et al. 2008). However, less than 1 percent of any of the subwatersheds that make up the permit area fall within the rain-on-snow hydroregion. Therefore, the potential for increased peak flows specifically related to rain-on-snow watersheds is very low.

Studies suggest that flow changes are not measurable when less than 19 percent of the watershed is clear-cut (Grant et al. 2008). Where there is no snow component, water yield and flood peaks will increase if rainfall is more rapidly transferred to the stream via reduced interception or more rapid routing (Harr et al. 1975, Zeimer 1981, Jones and Grant 1996). In rain-dominated hydroregions, increased flows appear to be proportional to increased acreage harvested (i.e., more timber harvest equals more water) (Bosch and Hewlett 1982, Keppler and Zeimer 1990). A compilation of many studies of small basins with conifer vegetation indicates that annual water yield increases about 40 millimeters for every 10 percent of the basin harvested (Bosch and Hewlett 1982). Another study focused on the Pacific Coast range noted 50 millimeters increase for every 10 percent harvested (Stednick 1996). Stednick (1996) suggests that flow changes are not measurable when less than 25 percent of the watershed is clear-cut.

Grant et al. (2008) found that peak flow increases generally approach the 10 percent limit (minimum detectable change in flow) at storm events with recurrence intervals less than 6 years. The data also supports that peak flow effects on channels is confined to a relatively discrete portion of the stream network, particularly where channel gradients are less than 0.02 and streambed and banks are composed of gravel and finer material. These are primarily the domain of gravel-bed rivers and streams in forested landscapes in western Oregon and Washington. Furthermore, Grant et al. (2008) states that peak flow effects on stream channels are likely to be minor in most step-pool systems and can be confidently excluded in high-gradient slopes (i.e., greater than 10 percent). Grant et al. (2008) also found that the percentage change in peak flow generally decreases with time after harvest (Jones 2000, Jones and Grant 1996, Thomas and Megahan 1998). Peak flow effects seem to diminish over the first 10 to 20 years (as the stand grows) (NMFS 2005).

Geomorphic changes in stream channels can be affected by the magnitude of flows. Geomorphically effective flows are defined as those that affect bedload sediment transport. Flows that are large enough to alter channel morphology, bank erosion, or habitat structure have the highest likelihood of affecting fish (Grant et al. 2008). Increased frequency and severity of flood flows during winter can affect over-wintering juvenile fish and eggs incubating in the streambed. Scouring of the streambed can dislodge the eggs (Schuett-Hames et al. 2000), and elevated sediment transport caused by high flow can increase sediment deposition in redds, thereby suffocating eggs (Peterson and Quinn 1996).

The permit area contains only rain dominated subwatersheds and no rain-on-snow watersheds. Stednick (1996) suggests that flow changes are not measurable when less than 25 percent of the watershed is clear-cut or less than 10 years old. While effects on peak flows may not be measurable or observable at the fifth-field watershed level when 25 percent or less of the watershed is less than 10 years old, they are more likely to be measurable or observable at the sixth-field-watershed (i.e., HUC-12), or subwatershed, scale because the spatial magnitude of harvest would likely affect a larger proportion of a subwatershed. ODSL did not model the percentages of subwatershed within the permit area that would be less than 10-years old after harvest over the course of the permit term. However, ODSL will cap total harvest in the action area at 1,300 acres during the first 20 years of the permit term, 1,200 acres from years 21 to 30 of the permit term, and average 1,000 acres for the remainder of the 80-year permit term. Of these totals, intensive treatments cannot exceed 480 acres, annually. ODSL will also cap RCA thinning and extensive harvest at 1,200 and 3,200 acres, respectively, for the permit term. Additionally, ODSL will harvest on 60 and an average of 100-year (based on stand age) rotations in intensive and extensive allocated areas. We expect that these annual and permit term restrictions on acres of harvest will not result in any one subwatershed with greater than 25 percent of forest less than 10 years old. Therefore, it is unlikely that streams supporting OC coho salmon within the action area will be exposed to scour and increased sedimentation resulting from geomorphically effective flows due to peak flow increases associated with timber harvest conducted as part of the covered activities.

Water Drafting. Water developments in the permit area are used for firefighting, filling water trucks employed during prescribed burning, and chemical mixing. No new water developments are planned or covered as part of the HCP. The amount of aquatic habitat decrease from water withdrawals would depend on the amount of stream flow, how much water is withdrawn, and the duration of water drafting. When large amounts of water are withdrawn (e.g., greater than 10 percent of flow), slight water level drops may occur on larger rivers and streams. On smaller streams, shallower riffles and pools are likely to result from water withdrawal, leading to a temporary loss of stream margin habitat and instream cover. These adverse effects are most likely to occur in smaller streams (less than about 10 cubic feet per second of discharge) and to persist only during the periods of time that active pumping is occurring. All water maintenance and abandonment, including drafting, will be performed in accordance with restrictions place by the OFPA (OAR 629) and other applicable statutes.

Road Construction, Maintenance, and Use. Soil compaction associated with the construction of new access roads or skid trails results in less stormwater infiltration and greater overland flow (Grant et al. 2008). As a result, road networks can alter both the timing and magnitude of peak flow events (Grant et al. 2008). These changes should roughly scale with the percentage of area compacted or length of road network that is directly connected to streams or both (Wemple et al. 1996) but is highly dependent on the location of roads in the landscape (Wemple and Jones 2003). Overland flow and peak flow events can also be altered by the compaction of soil associated with timber hauling at landings, stream crossings, and on temporary and permanent roads. The effects of timber hauling on peak flows are connected with the effects of roads on peak flows.

To minimize the effects of roads on peak flows, ODSL will conduct road construction and maintenance in accordance with measures stipulated under Road Location (OAR 629-625-0200), Road Design (OAR 629-625-0300), Drainage (OAR 629-625-0330), and Road Maintenance (OAR 629-625-0600). These measures will minimize hydrological connectivity between roads and adjacent streams. Applicable measures under these rules include the following:

- Road Location (OAR 629-625-0200)
  - When locating roads, operators shall designate road locations which minimize the risk of materials entering waters of the state and minimize disturbance to channels, lakes, wetlands, and floodplains.
- Road Design (OAR 629-625-0300)
  - Operators shall design and construct roads to limit the alteration of natural slopes and drainage patterns to that which will safely accommodate the anticipated use of the road and will also protect waters of the state.
- Drainage (OAR 629-625-0330)
  - All active, inactive, and vacated forest roads and landings shall be hydrologically disconnected to the maximum extent practicable from waters of the state to minimize sediment delivery from road runoff and reduce the potential for hydrological changes that alter the magnitude and frequency of runoff. Operators shall locate drainage structures based on the priority listed below. When there is a conflict between the requirements of sections (2) through (7) of this rule, the lowest numbered section takes precedence and the operator shall not implement the later numbered and conflicting section.
  - Operator shall not install cross-drains and ditch-relief culverts in a way that causes stream diversion.
  - Operators shall not concentrate road drainage water into headwalls, slide areas, high landslide hazard locations, or steep erodible fillslopes.
  - Operators shall not divert water from stream channels into roadside ditches.
  - Operators shall install drainage structures at approaches to stream crossings to divert road runoff from entering the stream. If placement of a single drainage

    structure cannot be placed in a location where it can effectively limit sediment from entering the stream, then additional drainage structures, road surfacing, controlling haul, or other site-specific measures shall be employed so that the drainage structure immediately prior to the crossing will effectively limit sediment from entering the stream. Operators may also use best management practices to manage sediment at the outflow of the drainage structure nearest to the crossing.
    - Operators shall provide drainage when roads cross or expose springs, seeps, or wet areas.
    - Operators shall provide a drainage system that minimizes the development of gully erosion of the road prism or slopes below the road using grade reversals, surface sloping, ditches, culverts, waterbars, or any combination thereof. For new road construction, operators shall use outsloping to the maximum extent practicable when site-specific conditions allow for its safe and effective use.
- <u>Road Maintenance (OAR 629-625-0600)</u>
    - Road surfaces must be maintained as necessary to:
        - Minimize erosion of the surface and the subgrade;
        - Minimize direct delivery of surface water to waters of the state;
        - Minimize sediment entry to waters of the state;
        - Direct any groundwater that is captured by the road surface onto stable portions of the forest floor;
        - Ensure properly functioning and durable drainage features; and
        - For existing roads with inboard ditch, avoid overcleaning of ditchlines.
    - Operators shall provide effective road surface drainage, such as water barring, surface crowning, constructing sediment barriers, or outsloping prior to the rainy and runoff seasons.

To further reduce the potential for road-related effects on peak flows within the action area, ODSL will implement the measures prescribed under Condition 11 in Chapter 5, *Conservation Strategy*, of the HCP , which include the following:

- Road designs will provide for proper drainage of surface water and will not introduce runoff into streams. These measures will include, as appropriate, the use of grade breaks, outsloping, insloping, ditching, road dips, water bars, and relief culverts.
- 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).
- 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.

The implementation of the measures prescribed under Condition 11, particularly the construction and spacing of cross drains and ditches (Luce and Black 1999), will reduce the amount of road runoff that is discharged to streams within the permit area. Luce and Black (1999) found that incorporating design features such as cross drains and ditch-relief culverts into roads reduced the hydrological connection of these structures. Forest vegetation buffers flow and prevents sediment from reaching streams (Copstead et al. 1998). Adding and spacing cross drains helps ensure that only a small portion of the road is capable of routing water to streams.

Road vacating can reduce changes in peak stream flows caused by road runoff by hydrologically disconnecting roads from the stream network. Per the HCP, Conservation Measure 3, ODSL will vacate existing roads in 10-year increments to reduce the net density of roads within the permit area (relative to current density). The location, method, specific timing, and rate of road density decreases will be based on actions set forth in biennial operations plans consistent with the HCP, the forest management plan, and 10-year planning projections reviewed and adopted by forest managers in coordination with the HCP implementation and adaptive management committee. Road vacating conducted by ODSL will be performed in compliance with 629-625-0650, which entails a suite of measures intended to leave vacated roads in a condition where related impacts on proximal waters is unlikely. Of the actions proposed as part of HCP implementation, road vacating will mostly contribute to reducing the amount of road-related runoff introduced to streams throughout the action area, which will in turn reduce the effects of the proposed action and covered activities on peak flows.

2.5.2 Effects on Critical Habitat

Designated critical habitat for OC coho salmon within the action area includes PBFs that support spawning, rearing, and migration. The PBFs in the action area for OC coho salmon include salinity, substrate, floodplain connectivity, water quality, water quantity, forage, natural cover, and fish passage free of artificial obstruction. The proposed action and covered activities are not expected to affect the salinity PBF in the action area. The covered activities that will affect the remaining PBFs for OC coho salmon critical habitat include timber harvest (i.e., tree felling, yarding, salvage harvest), commercial and restoration thinning, road system management (i.e., construction, maintenance, vacating, road use, and water drafting), and riparian restoration and stream enhancement.

Substrate

The substrate PBF supports OC coho salmon spawning, egg incubation and development, and alevin growth and development. The pathway of effect for this PBF includes fine sediments that are discharged, transported, and ultimately deposited throughout stream networks because of covered activities including timber harvest, timber yarding and yarding corridors, road management and maintenance (including temporary roads, stream crossings, and vacating roads), and riparian restoration and stream enhancement. These activities will increase fine sediment discharge through overland flow where soil and vegetation are disturbed in riparian areas, where roads are adjacent to streams, or from landslides and debris flows associated timber harvest or road building. Substrate embeddedness caused by covered activities will be greatest near fine sediment discharge points associated with road runoff and stream crossings. It is also possible that fine sediment will be discharged to OC coho salmon critical habitat via debris flows, which will increase substrate embeddedness where they deposit sediments. However, the effects of landslides and debris flow on substrate embeddedness will decrease over time as natural stream processes sort and redistribute sediment downstream. Reeves et al. (1995) reported that following debris flow events, stream flows sort sediments, clean gravels, and scour around wood and deposited debris to form deep pools and improve habitat complexity. Critical habitat in extensive and intensive subwatersheds where these covered activities are concentrated temporally and spatially will experience the highest magnitude of effects on this PBF.

To minimize sediment delivery to streams and OC coho salmon critical habitat, ODSL will establish RCAs that will not be managed unless as part of an approved research study, and will implement conservation measures 1, 2, and 3 and conditions 10 and 11 of the conservation strategy. These measures and conditions establish RCAs along FB, PNFB, and HLDP stream types (RCAs and conservation measure 2); will implement a strategy to assess road condition and reduce hydrological connectivity of roads to streams throughout the permit area through road construction, maintenance, and road vacating (conservation measure 3 and condition 11); will implement a strategy to protect natural process associated with landslides and debris flows so as to not increase their frequency of occurrence or the magnitude of impact they can have on OC coho salmon habitat through deposition of sediments and large wood (RCAs, conservation measures 1, 2, and 3 and conditions 10 and 11); and implement key restoration and stream enhancement projects on fish-bearing streams to improve sediment transport and sorting processes.

The establishment of RCAs (Table 14) along streams will minimize the delivery of fine sediments to streams from overland flow that transits harvested areas as vegetated buffer areas ranging in width from 40 to 100 feet appear to prevent sediment from reaching streams (Burroughs and King 1985, Corbett and Lynch 1985, Burroughs and King 1989, Gomi et al. 2005). Lakel et al. (2010) concluded that streamside management zones (buffers) between 25 and 100 feet were effective in trapping sediment before it could enter streams. The proposed RCA widths will also help to minimize sediment discharge to streams from slope failures of aquatic adjacent unstable slopes, and upland potentially unstable slopes and their channelized debris flow tracks by maintaining vegetation and root strength. RCAs will protect near-stream wood inputs that can reduce the speed and distance traveled by landslide and debris flow minimizing the impact of fine sediment to stream substrate. Road maintenance within the permit area will be conducted in accordance with restrictions placed by the OFPA (OAR 629) and conservation measure 3 and Condition 11 will help to minimize road-related sediment delivery and any resultant increases in substrate embeddedness. On balance, these measures will minimize fine sediment discharges to fish-bearing streams that may result from overland flow, surface erosion, road use and management, and landslides and debris flows associated with the covered activities.

Implementation of in-channel restoration projects on fish-bearing streams within or adjacent to all harvest operations and riparian vegetation management practices as described under Conservation Measure 1 will promote sediment sorting and transport processes affected by the covered activities, thereby contributing to improved substrate quality and quantity by decreasing the frequency and magnitude of suspended sediment inputs and the duration of adverse effects on substrate embeddedness. Substrate embeddedness is expected to decrease throughout the permit term as conservation actions are implemented.

Fine sediments generated by the covered activities will reach streams designated as critical habitat for OC coho salmon and impact the substrate PBF in a manner that reduces quantity and quality of spawning habitat in affected areas. However, these impacts will be spatially and temporally separated throughout the action area over the course of the permit term. Furthermore, localized reductions in spawning habitat quality will not appreciably reduce the number of juveniles rearing in the summer or winter since inadequate spawning habitat is not a primary limiting factor for OC coho salmon. Therefore, proposed action will not reduce quality and function of the substrate PBF or its ability to conserve OC coho salmon within the action area.

Floodplain Connectivity

Stream and river floodplains provide important winter-rearing habitat for juvenile OC coho salmon that inhabit the action area. They also play an important role in maintaining water quality sufficient to support all coho salmon life stages throughout the year by providing areas for sediment deposition and storage, filtering nutrients and contaminants, and cooling stream temperatures through the storage and release of cool water during summer months. Floodplains also provide important habitat for coho salmon prey organisms, the availability of which influences juvenile coho growth rates. The covered activities that will affect floodplain connectivity within the action area include timber harvest and road management.

Changes in floodplain connectivity are dependent upon changes to the physical processes that influence floodplain connectivity, which include sediment transport and instream wood recruitment. Instream wood and coarse bed materials (cobbles and boulders) help to filter and trap sediment and aggrade stream channels, improving access and connectivity to stream channel floodplains. From the analyses in section 2.5.1, *Effects on the Environment*, for large wood and wood recruitment, covered activities will likely reduce the amount of available wood for recruitment to adjacent stream channels. This will likely occur from restoration thinning in all RCAs, extensive and intensive timber harvest in stands directly adjacent to 50, 100, or 120 foot RCAs, and road construction. Construction of new roads will also affect floodplain connectivity from placing fill into the floodplain and installing or maintaining stream crossings.

ODSL will implement conservation measures for roads prescribed by the Oregon FPA and Condition 11 of the HCP, which include the following:

- ODSL will design bridges and culvert stream crossings to meet NMFS fish passage criteria (NMFS 2022a or most recent) and ODFW fish passage laws (Oregon Revised Statute 509.580 through 910 and OAR 635, Division 412), which requires culverts and bridges to be 1.5 times bankfull width and maintain stream simulation.
- ODSL will locate all new roads away from streams, wetlands, unstable areas, and sensitive resource sites, including sensitive wildlife habitats. Road development in the RCAs will only occur when other alternatives are not operationally feasible or economically viable.
- When locating roads, operators shall designate road locations that minimize the risk of materials entering waters of the state and minimize disturbance to channels, lakes, wetlands, and floodplains.

- 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

ODSL will also implement HCP Conservation Measure 1, *Targeted Restoration and Stream Enhancement*, which will include conducting wood placement activities and fall and leave of trees within 50 feet of stream channels during RCA thinning. Large wood placement and fall and leave during RCA thinning is expected to augment the change in the duration and frequency of floodplain connectivity associated with the covered activities.. This may in turn increase access to and the quantity and quality of important floodplain rearing habitats for juvenile coho that provide opportunities for increased growth and development. The magnitude and extent of benefits to OC coho resulting from implementation of restoration and stream enhancement projects conducted as part of the proposed action will be commensurate with the number and scope of projects completed over the course of the permit term.

Loss of stream complexity, including connected floodplain habitat, is a primary limiting factor for OC coho salmon. Quality and function of floodplain connectivity are expected to improve throughout the permit term as conservation measures and conditions are implemented. These conservation actions will be planned and implemented at a level commensurate with the scope and scale of the covered activities. Additionally, effects from the covered activities with respect to floodplain connectivity will be spatially and temporally separated across the action area over the course of the permit term. For these reasons and given the discussion above, we do not expect that reduction in wood recruitment or effects associated with road fill or stream crossings will result in a meaningful change in the function of wood to reconnect or improve connection to and the complexity of floodplain habitat in the action area. Thus, the proposed action and covered activities will not appreciably reduce the quality and function of the floodplain connectivity PBF such that it would preclude or significantly delay development of this critical habitat feature and its ability to conserve OC coho salmon within the action area.

Water Quality

Cold, clean water is essential for OC coho salmon egg and alevin development, juvenile rearing, and adult and juvenile migration. Based on the discussion in section 2.5.1, *Effects on the Environment*, water quality will be affected throughout the action area over the course of the permit term by increased thermal loading, sediment discharge, and chemical contaminants and nutrients associated with timber harvest, road management, and stream restoration and enhancement.

As described in the discussion of effects on the substrate PBF and in section 2.5.1, sediment discharges associated with surface runoff in harvested areas, roads near streams, and road crossings will contribute to increased suspended sediment concentrations in streams throughout the action area. Increased suspended sediment concentrations may also be caused by fine sediments introduced to streams via landslides and debris flows triggered by the covered activities. Increased suspended sediments in streams can reduce the quality of aquatic habitat that supports OC coho salmon spawning and rearing in the action area where suspended sediment settles and fills interstitial spaces between streambed substrates.

Reduced water quality in the form of increased water temperature is correlated with thermal loading to streams, which is moderated by riparian shading. Under the proposed action, riparian buffers are used to maintain stream temperatures by preserving vegetation providing riparian shade. Although stream shade correlates with the width of no-cut buffers, the relationship is quite variable, depending on site-specific factors such as stream size, substrate type, stream discharge, topography (Caissie 2006), channel aspect, and forest structure and species composition. Another factor affecting changes in water temperature is management and silvicultural prescriptions in riparian buffers. As described in section 2.5.1 of this Opinion above, changes in water temperature associated with timber harvest associated with the covered activities will increase the likelihood and magnitude of temperature increases in streams from zero to 4.4 °C. Increases in water temperature and the associated effects on OC coho salmon critical habitat associated with reduced shade from covered activities will be most significant and meaningful during summer months when air temperatures are at their highest and streamflows are at their lowest, which is a critical rearing time for juvenile coho. Preferred temperatures for rearing juvenile coho salmon range from 11.4 °C to 14.6°C (Beschta et al. 1987, Bell 1990, Reiser and Bjornn 1979, Coutant 1977, and Brett 1952, as cited in Richter and Kolmes 2005), with cessation of growth reported as occurring above 20.3 °C (Reiser and Bjornn 1979, Brett 1952, as cited in Richter and Kolmes 2005). As described in the discussion of effects of the covered activities on water temperature in section 2.5.1, implementation of the proposed RCAs and the 1,200-acre RCA thinning cap, increases in stream temperature resulting from the covered activities will be infrequent, localized to within 1 mile of the stand, and spatially and temporally separated throughout the action area over the permit term.

Chemical contaminant and nutrient levels in some streams throughout the action area will be slightly increased because of timber harvest and equipment operation near streams. Deforestation can cause a release of carbon, nitrogen, phosphorus, and sulfur through timber harvest, burning of slash, accelerated decomposition, decreased production of wood and roots, and erosion (Vitousek 1983). Riparian forests have been found to be effective filters for nutrients from agriculture runoff, including nitrogen, phosphorus, and sulfur. Stream buffers as small as 62 feet have shown a decrease of nutrients from 48 to 95 percent (Lowrance et al 1984; Jordan et al. 1993; Snyder et al. 1995). Stream channels with the greatest potential for introduction of nutrients include PNFP and HLDP streams with steep adjacent hillslopes where 50-foot RCAs are applied and XNFB streams, which are not afforded RCAs. Chemical contaminants including small amounts (ounces) of hydraulic fluids and fuels may be introduced to stream channels via equipment leaks or spills from operation of heavy equipment near or in stream channels or equipment fueling associated with the covered activities. ODSL will establish RCAs, that we expect will reduce the concentrations of nutrient and contaminant discharges associated with the covered activities to stream channels with 100, 120, and 200-foot RCAs (Vitousek 1983) and some streams with 50-foot RCAs such that adverse effects on the water quality PBF will be infrequent. Nonetheless, there is potential that the application of 50-foot RCAs or ELZs will not adequately prevent nutrients or contaminants from entering streams in all situations and that there will be minor increases of 5 to 52 percent in of the available nutrients to streams from timber harvest that will last until the disturbed vegetation is reestablished (decades).

Additionally, ODSL will conduct the covered activities in accordance OAR 629-620-0000 through 629-620-0800, which include best management practices related to heavy-equipment operation including measures pertaining to the prevention, control, and reporting of leaks and spills and required setbacks for locations where the mixing, transfer, and/or staging of chemicals and other petroleum products will occur. These measures will reduce the magnitude (concentrations) and frequency of the discharge of nutrients and contaminants that adversely affect the water quality PBF.

Water quality is a limiting factor for OC coho salmon. Covered activities will result in increases in water temperature, increases in suspended sediments, and minor increases of chemical contaminants and nutrients, which will adversely affect and reduce the quality and function of the water quality PBF. ODSL will establish RCAs and implement conservation measures and conditions on covered activities that we expect will reduce the magnitude and frequency of increases in water temperature, suspended sediment, nutrients, and contaminants that adversely affect the water quality PBF. These increases will be infrequent, localized to within 1 mile of the site, and spatially and temporally separated through the action area throughout the permit term. Therefore, the proposed action will not appreciably reduce the quality and function of the water quality PBF such that it would preclude or significantly delay development of this critical habitat feature and its ability to conserve OC coho salmon within the action area.

Water Quantity

Changes in streamflow caused by the covered activities can affect the quantity of aquatic habitat used by OC coho salmon across the action area. As described in the discussion of peak and base flows in section 2.5.1 of this opinion, covered activities including timber harvest, commercial and restoration thinning, road construction and management, and water drafting may affect water quantity in the action area over the permit term.

Cleared areas resulting from timber harvest and roads are responsible for increases in water quantity in the context of peak flows as they increase the drainage efficiency of basins in which they occur by integrating with the existing stream-channel network (Thomas and Megahan 1998). Timber harvest may result in winter flows with higher peak volumes and earlier peak discharge times (Jones and Grant 1996). In rain-dominated hydroregions, increased flows appear to be proportional to increased acreage harvested (i.e., more timber harvest equals more water) (Bosch and Hewlett 1982, Keppler and Zeimer 1990). A compilation of many studies of small basins with conifer vegetation indicates that annual water yield increases about 40 millimeters for every 10 percent of the basin harvested (Bosch and Hewlett 1982). Another study focused on the Pacific Coast range noted 50 millimeters increase for every 10 percent harvested (Stednick 1996). Stednick (1996) suggests that flow changes are not measurable when less than 25 percent of the watershed is clear-cut. Compaction of soils from construction of new access roads or skid trails results in less stormwater infiltration and greater overland flow (Grant et al. 2008). When this increased flow is intercepted by road networks that cross subsurface flow paths and change flow routing, both the peak magnitude and timing of peak flows can change in a watershed (Grant et al. 2008).

As discussed in the peak flows discussion in section 2.5.1 of this Opinion above, ODSL will implement harvest caps that restrict the areas of harvest annually and over the permit term and will conduct extensive treatments on an average of 100 years and intensive treatments on 60-year rotations. We expect that these annual and permit term restrictions on acres of harvest will not result in any one subwatershed with greater than 25 percent of forest less than 10 years old. Therefore, it is unlikely that streams supporting OC coho salmon within the action area will be exposed to scour and increased sedimentation resulting from geomorphically effective flows due to peak flow increases associated with timber harvest conducted as part of the covered activities.

The process of reforestation in harvested stands and water drafting can affect water quantity to the extent that steam flow is decreased, especially under base flows conditions. Once forests are 10 or more years old and regrowing rapidly, they transpire more than three times the amount of water as mature forests (Moore et al. 2004). This increased transpiration can exacerbate summer low flow conditions, thereby reducing available rearing habitat for juvenile OC coho salmon. Water withdrawal during forest management activities can also temporarily (hours to a day) decrease the availability of instream habitat by decreasing pool sizes, areas of stream margin habitat, and instream cover. When large amounts of water are withdrawn during forest management activities (e.g., greater than 10 percent of flow), slight water elevation drops may occur on larger rivers and streams. On smaller streams, shallower riffles and pools are likely to result from water withdrawal, leading to the temporary (hours to a day) loss of stream margin habitat and instream cover.

The greatest risk to water quantity in the action area is where timber harvest, young stand management, road construction and maintenance, and water drafting will overlap with subwatersheds or streams that are more susceptible to changes in water quantity. It is likely that covered activities listed above will affect water quantity in these areas during summer rearing periods, but the effects will be infrequent and of low magnitude because: 1) they will be spatially and temporarily separated, *i.e*., covered activities and their effects will be distributed throughout the action area over the duration of the permit term and 2) ODSL will implement harvest caps, stand rotations, and establish RCAs. Additionally, ODSL will implement applicable conservations actions at a level commensurate with the scope and scale of the covered activities. These conservation actions measures and conditions are expected to reduce the effects of the covered activities on the water quantity PBF.

Additionally, per Conservation Measure 1, ODSL will implement stream enhancement projects that may increase the floodplain storage of water, which may ameliorate decreases in the quality and function of the water quantity PBF resulting from covered activities. For these reasons, the proposed action, on balance, will not reduce the quality and function of the water quantity PBF such that it would preclude or significantly delay development of this critical habitat feature and its ability to conserve OC coho salmon in the action area.

Forage

Reductions in the production and abundance of prey organisms because of the covered activities may reduce the quality of rearing habitat for OC coho salmon within the action area. Increases in sediment discharge, substrate embeddedness, and water temperature in streams throughout the action area resulting from the covered activities will cause varying degrees of decreases in the production and abundance of coho prey organisms. As described in the discussion of suspended sediments in section 2.5.1 of this opinion, covered activities including timber harvest, road construction and maintenance, and riparian-restoration and stream-enhancement activities will affect the frequency and magnitude of sediment discharge to streams that can affect the forage PBF in the action area over the permit term.

Sediment discharge associated with surface runoff from harvested areas, roads near streams, and road crossings will contribute to increased suspended sediment concentrations in streams throughout the action area. Increases in suspended sediment concentrations may also be caused by fine sediment inputs associated with landslides and debris flows. Suspended sediment fills in interstitial spaces in the streambed that provide habitat for macroinvertebrates, thereby reducing habitat for and potentially killing coho prey organisms. ODSL will implement conservation measures to minimize increases in suspended sediments and related effects on forage including establishing RCAs to trap sediment before it enters streams and conducting road management in compliance with a suite of requirements prescribed under the Oregon FPA as well as Condition 11. These conservation measures are intended to hydrologically disconnect roads from the stream network and minimize sediment discharge associated with road use.

The proposed action will result in localized, minor reductions in coho prey organism abundance and productivity. These reductions will be spatially and temporally separated as covered activities will be distributed throughout the action area over the duration of the permit term. In some cases where tree removal in riparian areas occurs, a resultant increase in the amount of solar energy reaching the stream combined with a concurrent increase in understory vegetation may cause a minor, localized increase in invertebrate abundance that may, on balance, maintain forage availability for OC coho salmon at the site level. Additionally, ODSL will implement applicable conservation measures and conditions specific to the covered activities during implementation, and the conservation actions described above will be implemented at a level commensurate with the scope and scale of the covered activities. This will support rapid recolonization (weeks to months) of coho salmon prey organisms where reductions in their abundance and productivity occur because of the covered activities. Thus, the overall effect of the proposed action and covered activities on forage will be small and short-term and will not reduce the quality and function of the forage PBF in the action area such that it would preclude or significantly delay development of this critical habitat feature and its ability to support and conserve OC coho salmon within the action area.

Natural Cover

Juvenile OC coho salmon inhabiting the action area require rearing habitats that provide shelter and resting areas during high fall/winter flows and flooding events and natural cover for predator avoidance. Natural cover consists of stream habitat features including deep and frequent pools with associated log jams, beaver ponds, side channels, alcoves, accessible floodplains, and undercut banks. This PBF supports juvenile coho salmon growth, development, and survival during rearing and migration and is related to pool frequency and quality, off-channel habitat, refugia, and stream bank condition habitat indicators. Typically, the frequency, distribution, and quality of these habitat features in streams are associated with the amount of large wood in the stream channel, the amount of large wood recruited to the stream from riparian areas, the presence and management of beavers, and the amount of sediment in and discharged to streams. Large wood recruitment is largely dependent on the condition of riparian areas—primarily the presence of large-diameter trees in the riparian areas and on slopes that have a high likelihood of failing and delivering wood to a stream channel. Sediment discharge to streams is dependent on the vegetative conditions of associated riparian areas, how close to streams covered activities occur, the frequency of covered activities that will occur in RCAs, the occurrence of landslides and debris flows, and the measures implemented to minimize sediment discharge to streams. The covered activities that will affect large wood recruitment and sediment discharge to streams in the action area include timber harvest, road construction and maintenance, and riparian-restoration and stream-enhancement activities.

From the analysis above, the effects of the covered activities on large wood recruitment are not expected to be meaningful. Timber harvest and road management (i.e., construction and maintenance) will also increase the frequency and rate of sediment delivery to streams that may cause pools and off-channel habitat features that provide natural cover for OC coho salmon to fill in. ODSL will conduct timber harvest and road management activities in accordance with restrictions placed by the Oregon FPA (OAR 629) and Condition 11, which are intended to minimize the effects of the covered activities on wood recruitment, sediment discharge, and the habitat features of the natural cover PBF.

Beaver ponds are unique and important stream features that provide high-quality natural cover and rearing habitat for juvenile OC coho salmon. A lack of the type of habitat provided by beaver ponds has been repeatedly identified as limiting the production of OC coho salmon (Nickelson et al. 1992; ODFW 2005; ODFW 2007; Stout et al. 2012). Under Conservation Measure 1, ODSL may conduct beaver restoration projects, such as installation of beaver dam analogs and beaver habitat enhancement. The goal of such projects would be to promote the occurrence of beaver ponds containing abundant natural cover within the action area to increase the availability of valuable summer and winter habitat for juvenile coho salmon. However, the HCP does not include a commitment to conducting beaver restoration projects. Therefore, we cannot estimate the benefits to OC coho that may accrue from beaver restoration projects implemented by ODSL, specifically.

The proposed action will have localized effects on the habitat features that provide natural cover for OC coho salmon. Localized reductions in natural cover will occur where sediment discharges and reductions in wood recruitment resulting from the covered activities decrease the quality and frequency of stream habitat features that provide cover. Larger areas of natural cover may be affected by the occurrence of landslide associated debris flows, but these areas will recover as natural stream processes work to reestablish habitat features and habitat complexity (Reeves et al. 1995). Additionally, effects on the natural cover PBF will be spatially and temporally separated across the action area over the permit term. Additionally, ODSL will implement applicable conservation measures and conditions specific to the covered activities during implementation, and the conservation actions described above will be implemented at a level commensurate with the scope and scale of the covered activities. Additionally, under Conservation Measure 1 ODSL will implement stream-enhancement projects to address decreases in the quality and function of the natural cover PBF that result from covered activities over the permit term. Thus, the proposed action will not reduce the quality and function of the natural cover PBF in the action area such that it would preclude or significantly delay development of this critical habitat feature and its ability to support and conserve OC coho salmon in the action area.

Fish Passage Free of Artificial Obstruction

Artificial obstructions to fish passage include culverts, bridges, dams, and water diversions. Covered activities that could affect this PBF include road construction and maintenance, specifically stream crossing replacement, installation, and removal. Stream crossings that are replaced, installed, or removed under the proposed action will be compliant with Condition 11, which requires that new or replacement stream crossings are designed to meet current NMFS fish passage criteria (NMFS 2022a or latest version) and ODFW fish-passage laws (Oregon Revised Statute 509.580 through 910 and OAR 635, Division 412). Meeting these requirements will ensure that stream crossings are designed to maintain hydraulic conditions, including hydrology, velocities, and slopes, that pass juvenile and adult coho salmon. Improving fish passage at road stream crossings by replacing existing fish passage barriers with culverts and bridges consistent with NMFS and ODFW fish-passage criteria will improve this PBF over the permit term. Therefore, the proposed action will not reduce the quality and function of this PBF in the action area such that it would preclude or significantly delay development of this critical habitat feature and its ability to support and conserve OC coho salmon in the action area.

2.5.3 Effects on Species

As discussed in section 2.4.4, *Species in the Action Area,* the action area encompasses portions of basins inhabited by three independent populations of OC coho salmon—Coos, Tenmile Lake, and Lower Umpqua River. Each of these populations use streams within the action area for spawning, migration, and rearing. To provide context for the following effects analyses, we begin by clarifying the degree to which the action area, in which take and/or adverse effects would occur, overlaps with the full extent of habitats occupied by these populations plus streams that flow out of the permit area for 1 mile downstream of the permit area boundary. Based upon habitat-use data compiled by StreamNet, the permit area contains approximately 2 to 8 percent of the total available rearing and migration habitat and approximately 4 to 51 percent of the total available spawning and rearing habitat available to each of these populations (Table 19).

Table 19. Percent of Available Habitat within the Permit Area by Independent Population and Habitat-Use Type.

Independent Population	Percent of All Rearing and Migration Habitat within the Action Area	Percent of All Spawning and Rearing Habitat within the Action Area
Coos	4%	22%
Lower Umpqua	8%	4%
Tenmile	2%	51%

Effects Related to Water Temperature

OC coho salmon are likely to be exposed to localized water temperature increases due to riparian shade loss resulting from timber harvest and tree removal in upland areas and RCAs and road construction and maintenance that occur as part of the covered activities. Increases in water temperature and the associated effects on OC coho salmon critical habitat associated with reduced shade from covered activities will be most significant and meaningful during summer months when air temperatures are at their highest and streamflows are at their lowest, which is a critical rearing time for juvenile coho salmon. The areas that are at greatest risk of experiencing riparian shade loss and resultant increases in adjacent stream temperatures include those where RCA thinning will occur (retain minimum of 40 ft^2 basal area per acre), stream aspect is east-west, lower canopy cover in the RCA, and small burned areas, rock outcroppings, or diseased areas exist within the RCAs. Additionally, downstream temperature recovery will not be sufficient when the riparian conditions are as described in the previous sentence, there are not sufficient cold-water inputs or groundwater exchange downstream of the harvest unit prior to where the stream transitions from non-fish-bearing to fish-bearing, and/or when stream gradients are low. When these site conditions exist and overlap, there will be higher risk of stream temperature increases.

Water temperature influences water chemistry as well as every phase of coho salmon life history. Research indicates that most salmonid species are at risk when water temperatures exceed 73 to 77°F (22.8 to 25°C) (Spence et al. 1996). Preferred temperatures for rearing juvenile coho salmon range from 11.4 ℃ to 14.6℃ (Beschta et al. 1987, Bell 1990, Reiser and Bjornn 1979, Coutant 1977, and Brett 1952, as cited in Richter and Kolmes 2005), with cessation of growth reported as occurring above 20.3 ℃ (Reiser and Bjornn 1979, Brett 1952, as cited in Richter and Kolmes 2005). For coho salmon, Hicks (2000) recommends an upper water temperature limit of 68 to 70°F (20 to 21°C) to avoid direct lethality. In addition to the lethal effects of high water temperatures, salmonids rearing at water temperatures near the upper lethal limit have decreased growth rates because nearly all consumed food is used for metabolic maintenance (Bjornn and Reiser 1991). Water temperatures exceeding the upper lethal limits may be tolerated for brief periods or fish may seek thermal refugia. Sutton and Soto (2012) reported that juvenile coho salmon in the Klamath River mainstem began using thermal refugia when the water temperature approached approximately 66°F (19°C). Coldwater refugia, such as springs and groundwater seeps, allow salmonids to persist in areas where water temperatures in mainstream channels exceed their upper lethal limit. The loss of riparian vegetation, removal of large woody debris, and reduced groundwater discharge resulting from changes in upland vegetation, water withdrawals, and other human activities can decrease the availability of thermal refugia upon which salmon rely (Poole et al. 2001).

Adverse physiological and behavioral effects on coho salmon may accrue not only from persistent high water temperatures in summer but from intermittent exposure to high water temperatures, increased diurnal variation in water temperature, and altered cumulative exposure history (McCullough 1999). As discussed for the water quality PBF in section 2.5.2 above, we expect temperature increases from the covered activities to range from 0 to 4.4 ℃. Adverse effects on coho salmon from increases in water temperature are likely to include 1) increased adult mortality and reduced gamete survival during pre-spawn holding; 2) reduced growth of

alevins or juveniles; 3) reduced competitive success relative to non-salmonid fish species; 4) outmigration from unsuitable areas and truncation of spatial distribution; 5) increased disease virulence and reduced disease resistance; 6) delay, prevention, or reversal of smoltification; and 7) harmful interactions with other habitat stressors such as pH and certain toxic chemicals, the toxicity of which is affected by temperature (Reeves et. al. 1987; Berman 1990; Marine 1992, Marine and Cech 2004; McCullough 1999; Dunham et al. 2001; Materna 2001; McCullough et al. 2001; Sauter et al. 2001). Individuals of all life stages of OC coho salmon that occur within the action area have potential to be exposed to varying degrees of these adverse temperature-related effects. However, summer rearing juveniles have the highest probability of being adversely affected by temperature increases associated with the covered activities.
ODSL will designate RCAs along all FB, PNFB, and HLDP streams to restrict tree removal within riparian areas that could decrease riparian shading, except where thinning in RCAs will occur. For FB streams, we anticipate that rearing juvenile OC coho salmon will be exposed to temperature increases associated with the covered activities and stream temperatures within or above the ranges identified above. We expect that application of the proposed RCAs will, overall, reduce the magnitude and minimize the occurrence of temperature increases that adversely affect OC coho salmon such that they will be infrequent across the action area and short term (5 to 10 years). We expect that instances of riparian shade loss along FB streams sufficient to cause stream temperature increases will be spatially and temporally separated throughout the permit area over the permit term as they will be limited to a specific subset of conditions—FB streams where RCAs less than 120 feet wide are applied; streams with an east-west aspect; streams where the corresponding RCA has low levels of existing canopy cover; streams where the corresponding RCA is characterized by a prevalence of small burned areas, rock outcroppings, or diseased areas; or where riparian thinning occurs in the RCA. Based on previous discussion above concerning the effectiveness of no-cut riparian buffers, temperature increases in adjacent FB and PNFB streams will most likely occur when RCAs are 120 feet or less or if thinning occurs within the RCA.

Based upon habitat-use data compiled by StreamNet, the majority (approximately 86%) of waters with potential to support OC coho salmon from the Lower Umpqua and Tenmile populations are protected by RCA widths of 120 feet or wider (Table 20). Although a lesser percentage of streams with potential to supporting individuals from the Coos population of OC coho salmon are protected by RCAs that are at least 120 feet wide (Table 20), all such streams are protected by minimum RCA widths of 100 feet, which are expected to experience an increase in water temperature (0 to 0.5 ℃), although increases of 0.3 ℃ or above are expected to be infrequent because of the RCAs and conservation measures and conditions ODSL will implement along with the covered activities. Additionally, streams within the portion of the permit area inhabited by the Coos population that are most vulnerable to heating due to decreased riparian shading (i.e., sections of the West Fork Millicoma River that are listed as impaired under Section 303(d) of the Clean Water Act for temperature) are protected by a 200-foot-wide RCA, which will **eliminate any potential** for adjacent stream temperature increases (Figure 8 [EPA 2013], Figure 10 [Groom et al. 2018]). Where RCAs of any width are subject to restoration thinning we expect temperatures will increase anywhere from 0 to 4.4 ℃ (Kreutzweiser et al. 2009).

Table 20. Stream miles assigned to RCA widths by stream type.

		RCA Width (feet)										
OC coho Population	Stream Classification	0	% Total	50	% Total	100	% Total	120	% Total	200	% Total	Grand Total
Coos	FB (total)		0%		0%	58	46%	45	36%	21	17%	124
	FB (coho salmon habitat)		0%		0%	24	44%	13	23%	18	33%	55
	FB (outside coho salmon habitat)		0%		0%	33	49%	32	47%	3	5%	69
	XNFB	674	100%		0%		0%		0%		0%	674
	PNFB		0%	74	95%		0%		0%	4	5%	78
	HLDP		0%	9	45%		0%	9	49%	1	7%	19
Lower Umpqua	FB (total)		0%		0%	13	23%	7	13%	36	64%	56
	FB (coho salmon habitat)		0%		0%	4	21%	5	27%	10	52%	19
	FB (outside coho salmon habitat)		0%		0%	9	24%	2	6%	26	71%	37
	XNFB	529	100%		0%		0%		0%		0%	529
	PNFB		0%	29	48%		0%		0%	32	52%	61
	HLDP		0%	9	27%		0%		0%	25	73%	34
Tenmile	FB (total)		0%		0%	3	6%	0	0%	52	94%	56
	FB (coho salmon habitat)		0%		0%	0	1%	0	0%	17	99%	17
	FB (outside coho salmon habitat)		0%		0%	3	8%	0	0%	35	92%	38
	XNFB	392	100%		0%		0%		0%		0%	392
	PNFB		0%	4	11%		0%		0%	36	89%	40
	HLDP		0%	1	3%		0%		0%	23	97%	24

Some non-fish-bearing streams (i.e., PNFB and HLDP streams where 120-foot or wider RCAs are applied [see Table 14]), will be afforded a similar level of protection with respect to riparian shading. However, where 50-foot RCAs are applied along PNFB and HLDP streams in MRWs and flexible allocations, RCA widths will not be sufficient to prevent stream heating or provide temperature recovery, which may, in turn, result in the introduction of warm water to fish-bearing reaches downstream. Similarly, some XNFB streams, which will not be protected by RCAs, are expected to experience increased thermal loading and resulting temperature increases due to decreased riparian shading. However, timber harvest of any type will not exceed 1,000 acres per year based on a 4-year rolling average of contracted sales.[9] This equates to approximately 3, 4, and 5 percent of the portions of the permit area within the ranges of the Coos, Lower Umpqua, and Tenmile populations, respectively. Hence, harvest-related increases in stream temperature associated with riparian shade loss, would affect a small portion of the range of any population of OC coho salmon in any given year because the 1,000 acres of harvest would be distributed across all three populations and the majority of harvest would entail implementation of RCAs that would maintain riparian shading sufficient to avoid, in most cases, and reduce the frequency and magnitude of stream temperature increases. Additionally, adverse effects on OC coho salmon that occur as a result of water temperature increases related to the covered activities are expected to primarily occur during summer months. Therefore, temperature related effects on OC coho will be largely limited to rearing juveniles.

As described in Section 2.5.1 of this opinion, ODSL's adherence to measures prescribed in the OFPA related to road system management and Condition 11 will minimize tree removal in riparian areas associated with road construction, vacating, and maintenance activities. Nonetheless, in some instances road-related work in RCAs will cause site-level riparian shade loss and subsequent stream temperature increases. However, these changes will be localized to 1 mile downstream of the harvest unit, short term (5 to 10 years) and spatially and temporally separated across the permit area over the course of the permit term.

When OC coho salmon are exposed to water temperature increases at a magnitude and duration that exceeds thresholds for adverse effects (approximately 59 to 63 °F) (Hicks 2000, Sullivan et al. 2000), they will experience the physiological and behavioral adverse effects described above, resulting in sublethal injury (reduced growth, survival, and/or fitness). An individual's injury response will vary and range from sublethal injury to death, depending on magnitude of increase, duration of exposure, species, and life stage of the individual. However, because water temperature increases will be localized, short term, and spatially and temporally separated over the permit area, individuals experiencing sublethal injury and death will be infrequent.

Effects related to wood recruitment

Large wood is a critical habitat element of Pacific Northwest streams and forests that was historically abundant throughout the region. The following covered activities would reduce wood recruitment potential–restoration thinning in RCAs, timber harvest in stands directly adjacent to RCAs, and road construction.

Large living and dead wood provide important habitat for OC coho salmon within the action area. Large wood in streams provides channel roughness and interacts with streamflow to create log jams, pools, and slow water areas; interacts with water to modify stream flow paths

[9] Exceptions to this for restoration thinning in the first 30-years of the permit term are described in section 1.3 of this opinion and Chapter 3 of the HCP. Restoration thinning in addition to the 1,000 average will not exceed 300 acres for the first 20 years or 200 acres during years 21 to 30 of the permit term.

activating side channels and off-channel habitat; and improves floodplain connectivity, all of which are important habitat features that support juvenile coho salmon resting, predator avoidance, and feeding. Large riparian trees that die and fall into and near streams regulate sediment and flow routing, influence stream channel complexity and stability, increase pool volume and area, and provide hydraulic 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). Large wood affects stream channel morphology in low gradient streams at both the individual pool and reach scale (Carroll and Robison 2007). Large wood can provide cover for fish in pools by covering the water's surface and creating shadows, velocity refugia, and three-dimensional partitions within the water column (Harmon et al. 1986). Greater large wood abundance in streams increases the number of pools (Beechie and Sibley 1997, Montgomery et al. 1999), pool area (Beechie and Sibley 1997), and residual pool depth (Collins et al. 2002) and can change the overall channel morphology of a stream from plane-bed to forced-pool riffle channels (Buffington and Montgomery 1999, and Montgomery et al. 1996). At the reach scale, large wood also creates habitat partitions by increasing pool distribution and habitat unit diversity (Carroll and Robison 2007). Large wood also plays an important role in floodplain connectivity as it decreases flow velocity (Davidson and Eaton 2013) and increases the frequency and magnitude of inundation in adjacent floodplains (Collins and Montgomery 2002).

Wood is delivered to streams through multiple processes including tree mortality and fall, bank erosion, and debris flows or landslides (Martin and Benda 2001, Reeves et al. 2003, Seo et al. 2010, Ruize-Villanueva et al. 2016). ODSL will establish RCAs to reduce the effects of covered activities on riparian wood production and recruitment as well as the delivery of wood to fish-bearing streams via landslides and debris flows. As noted in section 2.5.1 of this Opinion 60, 90, 95, and 100 percent of wood available for recruitment to streams comes from within 50, 100, 120, and 200 feet of stream channels, respectively (McDade et al. 1990). Table 21 below shows the stream types and miles of stream bordering the various RCA widths for where streams are occupied by OC coho salmon, and FB, PNFB, and HLDP streams, which contribute to delivery of wood to streams. In the Tenmile population, 131 miles out of 136 miles (96 percent) of stream will receive RCAs of at least 100 feet (200 feet, 128 miles; 100 feet, 3 miles). In the Lower Umpqua population, 133 out of 157 miles (85 percent) will receive RCAs of at least 100 feet (200 feet, 105 miles; 120 feet, 14 miles; and 100 feet, 14 miles). In the Coos population, 184 out of 267 miles (69 percent) will receive RCAs of at least 100 feet (200 feet, 44 miles; 120 feet, 66 miles; and 100 feet, 84 miles). It is important to note that in the Tenmile, Lower Umpqua, and Coos populations the miles of fish bearing streams that will have 200-foot RCAs extends 37, 31, and 67 additional miles beyond the miles of coho habitat for each population.

Table 21. Miles of coho, FB, PNFB, and HLDP streams with 200, 120, 100, and 50-foot RCAs in each population of OC coho salmon in the permit area.

Population	Stream Type	RCA Widths (feet)			
		200’	120’	100’	50’
Tenmile	Coho	17	0	0	0
	FB	52	0	3	0
	PNFB	36	0	0	4
	HLDP	23	0	0	1
Total Miles		128	0	3	5
Lower Umpqua	Coho	12	6	5	0
	FB	36	8	9	0
	PNFB	32	0	0	16
	HLDP	25	0	0	8
Total Miles		105	14	14	24
Coos	Coho	18	12	26	0
	FB	21	45	58	0
	PNFB	4	0	0	74
	HLDP	1	9	0	9
Total Miles		44	66	84	83

No RCAs will be assigned to XNFB streams. XNFB streams are not considered important sources of large wood recruitment to coho salmon habitat in the permit area. These streams are expected to typically consist of smaller streams (i.e., first-order or second-order streams) where wood is not reorganized or transported, except during unusual flood events or debris flows with recurrence intervals that are greater than decadal (Kramer and Wohl 2017). These streams are seasonal or non-seasonal, non-fish bearing, are usually located in stream headwalls, and have limited hydraulic transport capacity and low probability of delivering wood to fish-bearing streams through landslides or debris flows, when compared to HLDP streams. Therefore, the covered activities will have little impact on potential wood recruitment from XNFB streams because they are unlikely to deliver wood to streams with fish-bearing or OC coho salmon habitat.

As further discussed in Section 2.5.1 of this opinion, results from Pollock (2016) suggest that thinning in RCAs will likely result in a measurable reduction in the capacity of treated stands to produce large wood for recruitment to fish-bearing streams. This reduction will be lessened by either leaving in place, tipping toward or placing into the stream all trees cut within the first 50 feet and greater than 0 to 20 percent of the volume of the largest cut logs within the remaining portion of thinned RCAs. For the three populations of OC coho salmon that may experience reductions in wood recruitment resulting from riparian thinning, the proportion of RCAs that would be available for restoration thinning within the portions of the permit area that overlap their respective distributions ranges from approximately 34 to 40 percent (Table 22). However, restoration thinning in all RCAs will be limited to 1,200 acres over the course of the permit term, with roughly 160 acres of RCAs being thinned every 5 to 7 years. Assuming a maximum RCA thinning rate of approximately 160 acres per 5-year period, wood recruitment in no more than approximately 3 percent of the RCA acreage in each of the three OC coho populations that inhabit the permit area would be impacted by restoration thinning over any 5-year period. This is a conservative estimate as it is unlikely that restoration thinning would fall within the range of a single population in any 5-year period but, nonetheless, serves to demonstrate the limited spatial extent of expected impacts on OC coho populations from reduced wood recruitment that may be caused by restoration thinning.

Table 22. Total Acres of RCAs and Acres of RCAs Eligible for Restoration Thinning by Independent Population of OC coho salmon.

Allocation	RCAs	Coos	Lower Umpqua		Tenmile	Total
			Below Loon Lake	Above Loon Lake		
CRW RCAs	Total	470	4,288	-	4,939	9,697
	Available for Restoration Thinning*	102	1,412	-	1,490	3,004
	Proportion Available for Thinning	22%	33%		30%	31%
MRW RCAs	Total	4,681	888	319	430	6,319
	Available for Restoration Thinning*	1,941	467	172	325	2,906
	Proportion Available for Thinning	41%	53%	54%	75%	46%
Permit Area	Total	5,151	5,177	319	5,376	16,024
	Total Available for Restoration Thinning	2,043	1,886	172	1,817	5,919
	Proportion Available for Thinning	40%	36%	54%	34%	37%

Landslides and debris flows are expected to be the primary sources of wood delivery to small to mid-sized non-fish-bearing streams in steeper, more highly dissected watersheds within the permit area (Reeves et al. 2003, Bigelow et al. 2007). Other potential sources of wood delivery to these stream types are riparian tree mortality, windthrow or windsnap, and bank erosion; however, their contribution to wood recruitment in these stream types is expected to be minor relative to upslope sources. Under the proposed action, RCAs ranging in width from 50 to 200 feet will be applied along the non-fish-bearing streams that ODSL has identified as having the highest modeled potential to deliver wood to fish-bearing streams (i.e., HLDP streams). Additionally, no restoration thinning will be conducted within RCAs associated with HLDP streams. These measures are expected to retain the majority of potential sources of upslope wood delivery to non-fish-bearing streams situated higher in drainage networks across the permit area that may ultimately be delivered to fish-bearing steams lower in the drainage network.

We expect a minor decrease in wood recruitment potential to occur where trees are removed in association with road construction. ODSL has committed to constructing no more than 40 miles of new permanent roads over the permit term, constructing no more than 1 mile of permanent and 2 miles of temporary roads per year, and limiting road construction within RCAs to instances where no operationally feasible alternatives exist. Therefore, we expect that any loss of wood recruitment potential from road construction within any particular fifth-field HUC watershed will be small and, thus would not meaningfully reduce the amount of wood available for recruitment to streams in the action area.

Reduced wood recruitment and resultant decreases in instream wood loads can decrease the availability of complex stream habitats for coho salmon. Individual coho salmon that are subject to decreased availability of complex habitat because of reduced wood recruitment and instream wood volume are likely to experience reduced foraging opportunities; decreased access to flow refugia and resting areas, and a reduction in cover available for predator avoidance. Such individuals are, consequently, at a higher risk of predation and reduced growth, survival, and fitness. The covered activities will result in a minor reduction of trees available for recruitment to fish-bearing streams within the action area and, consequently, will have minor adverse effects on the quality and quantity of complex habitats. Because of this, some juvenile coho salmon will experience injury or death from predation or reduced growth, survival, and/or fitness. However, magnitude and frequency of adverse effects on individual juvenile coho salmon resulting from decreased amount of available rearing habitat associated with reduced wood recruitment will be low because ODSL will establish RCAs to maintain available wood for delivery to stream channels, harvest activities will be spatially and temporally separated throughout the action area over the permit term, and ODSL will implement conservation measures to place wood in stream channels and fall and leave wood in RCAs that could potentially be recruited to stream channels.

Effects related to peak and base flows

Similar to wood recruitment, changes in peak and base flows resulting from the covered activities can cause geomorphic changes in stream channels that can change the quality and quantity of complex habitats required by coho salmon during spawning, rearing, and migration. Geomorphically effective flows are defined as those that affect bedload sediment transport. Flows that are large enough to alter channel morphology, bank erosion, or habitat structure have the highest likelihood of affecting fish (Grant et al. 2008). An increase in the frequency and severity of flood flows during winter can affect over-wintering juvenile fish and eggs that are incubating in the streambed. Eggs of fall- and winter-spawning fish, such as OC coho salmon, may suffer higher levels of mortality when exposed to increased flood flows (Jager et al. 1997). Scouring of the streambed can dislodge the eggs (Schuett-Hames et al. 2000), and elevated sediment transport caused by high flows can increase sediment deposition in redds, thereby suffocating eggs (Peterson and Quinn 1996).

As discussed in section 2.5.1, Stednik et al. (1996) suggests that flow changes are not measurable when less than 25 percent of the watershed is less than 10 years old for rain dominated watersheds. ODSL did not estimate the percentages of watersheds within the permit area that would be less than 10-years old due to timber harvest over the course of the permit term. As discussed in the peak flows discussion in section 2.5.1 of this Opinion above, ODSL will implement harvest caps that restrict the areas of harvest annually and over the permit term and will conduct extensive treatments on an average of 100 years and intensive treatments on 60-year rotations. We expect that these annual and permit term restrictions on acres of harvest will not result in any one subwatershed with greater than 25 percent of forest less than 10 years old at any one time. Therefore, it is unlikely that streams supporting OC coho salmon within the action area will be exposed to scour and increased sedimentation resulting from geomorphically effective flows due to peak flow increases associated with timber harvest conducted as part of the covered activities.

Base flows will be affected through increased transpiration after harvest and replanting and water drafting. The greatest impact on base flows from the covered activities and magnitude of resultant effects on coho salmon will occur during summer low-flow periods. In instances where water drafting occurs in small streams (i.e., streams with less than about 10 cubic feet per second of discharge), juvenile coho salmon may be subject to increased predation risk where dewatering either causes fish to be crowded into remaining habitat or stranded in pockets of water that are isolated from the main channel. A small number of juvenile coho salmon are likely to be injured or die where such events occur. The number is small because effects will be spatially and temporarily separated; covered activities and their effects will be distributed throughout the action area over the duration of the permit term, ODSL’s implementation of harvest caps and stand rotations, and establishment of RCAs adjacent to stream channels.

Soil compaction associated with access road and skid trail construction results in less infiltration and greater overland flow (Grant et al. 2008). When this increased flow is intercepted by road networks that cross subsurface flowpaths and change flow routing, both the peak magnitude and timing of peak flows can change in a watershed (Grant et al. 2008). This effect should roughly scale with percentage of area compacted or length of road network that is directly connected to streams or both (Wemple et al. 1996) but is highly dependent on the location of roads on the landscape (Wemple and Jones 2003). Water routing is predominantly affected by road and ditch networks (Harr et al. 1975, Jones and Grant 1996). The complex process of water routing can also be modified by soil compaction associated with timber hauling. The effects of timber hauling on peak flows are connected with the effects of roads on peak flows. To address the potential effects of roads associated with the proposed action on peak flows within the action area, ODSL will conduct road construction, maintenance, and use in accordance with measures stipulated under the OFPA and Condition 11, as further described in section 2.5.1 of this opinion. Additionally, ODSL will vacate existing forest roads in 10-year increments to reduce the net density of roads within the permit area, thereby further decreasing the amount of road-related runoff introduced to streams throughout the action area. These measures will, on balance, reduce hydrological connections between roads and adjacent stream networks such that road-related effects on peak flows will be minimal and temporally and spatially separated across the permit area over the course of the permit term.

Effects related to suspended sediments

Oregon Coast coho salmon will be exposed to increases in suspended sediment that result from covered activities including timber harvest and road construction, maintenance, and use. These increases will occur where sediment is delivered to streams through pathways including overland flow, road runoff, and landslide and debris flows. Elevated suspended sediment concentrations associated with the covered activities will cause physical and behavioral responses in OC coho salmon that are exposed to such conditions. OC coho salmon spawn and rear in streams throughout the action area. Therefore, individuals of all life stages have the potential to be exposed to suspended sediments generated by the covered activities. We anticipate that coho salmon individuals will be adversely affected by increases in suspended sediment and sedimentation caused by the covered activities. OC coho salmon within the action area are expected to be exposed to increases in suspended sediment that are proportional to the frequency, extent, and duration of the covered activities conducted in the watersheds they occupy.

The relative level of increased suspended sediment in any particular area is expected to be proportional to the extent and magnitude of the covered activities that are conducted in that area, the area's geological erosion risk, and the precipitation levels experienced by that area. Across the permit area, the environmental and covered-activity-related variables that influence erosion and sedimentation rates are diverse, and we are not aware of any accurate means to quantify potential sediment loading resulting specifically from the covered activities at a defined geographic scale. To assess the relative amount of sediment that may be generated in association with road use, we analyzed the miles of roads per independent population of OC coho salmon. The road miles correspond to the amount of sediment that may be generated by the road use, which includes log-haul. Additional sediment delivery to streams and subsequent sedimentation will result from soil disturbance associated with timber harvest and sediment generating activities within riparian zones including establishing yarding corridors, constructing or maintaining roads (including temporary roads and stream crossings), vacating roads, and conducting riparian-restoration and stream-enhancement activities.

Increased sediment delivery to streams throughout the action area from covered activities, as further described in section 2.5.1 of this opinion, will likely directly and indirectly affect OC coho salmon through physical impairments, behavioral responses, availability of preferred forage, and changes in habitat quality. Sediment that enters streams can contribute to total suspended sediment concentrations, as well as the bedload. Increased suspended sediment concentrations resulting from the covered activities are likely to have detrimental physical effects on OC coho salmon (Bilotta and Brazier 2008, Scheurer et al. 2009, Kemp et al. 2011). The effect of mineral particles on free swimming salmon and steelhead decreases with particle size and increases with particle concentration and exposure duration (Newcombe and Jensen 1996). Fine suspended sediments generated as part of the proposed action may affect OC coho salmon and cause direct physical damage (Newcombe and Jensen 1996, Newcombe 2003). Studies show that salmon and steelhead regularly experience physiological stress when exposed to suspended sediment particles, a response often paralleled by decreased leucocrit values (Servizi and Martens 1987). Likewise, gill abrasion and particle uptake in the gills and spleen have been reported (Servizi and Martens 1987, Goldes et al. 1988). Behavioral responses include avoidance of sediment plumes and alarm reactions (Bisson and Bilby 1982, Berg and Northcote 1985). Reduced growth and mass of salmon and steelhead exposed to suspended sediment beyond 4 days has been attributed to increased energy demands (Shrimpton et al. 2007) but also reduced feeding in turbid waters (Shaw and Richardson 2001). We expect that OC coho salmon that are exposed to elevated fine suspended sediment concentrations resulting from the proposed action will experience varying degrees of the adverse effects described above.

Research investigating relationships between suspended sediment concentrations and exposure duration provide general predictors for coho salmon response. Of key importance in considering the detrimental effects of suspended sediment on juvenile coho salmon are the frequency and duration of the exposure, as well as the concentration. Suspended sediment may be estimated by turbidity measurements in Nephelometric Turbidity Units (NTUs), which is a measure of light scattered by particles suspended in liquid. Sublethal effects of short-term exposure (i.e., hours to weeks) of juvenile coho salmon to suspended sediment occur at approximately 20 NTUs in laboratory settings (Robertson et al. 2006). Increases in suspended sediment concentrations as low as 30 NTU can result in reduced prey capture success or gill flaring for juvenile coho salmon exposed to turbidity pulses for periods as short as four hours (Berg and Northcote 1985). Other negative behavioral responses can include changes in territorial behavior, alarm reactions with downstream displacement and increased predation and competition, avoidance behavior, decreased feeding, and reduced growth (Noggle 1978, Berg 1983, Lloyd 1987, Newcombe and Jensen 1996, Bash et al. 2001, Robertson et al. 2006). High levels of suspended sediment can be lethal to salmonids; lower levels can cause chronic sublethal effects including loss or reduction of foraging capability, reduced growth, reduced resistance to disease, reduced respiratory ability, increased stress, and interference with cues necessary for homing and migration (Bash et al. 2001). Sublethal effects (such as olfactory effects) are those that are not directly or immediately lethal but are detrimental and have some probability of leading to eventual death via behavioral or physiological disruption.

No specific information is available to describe the intensity and duration of the turbidity plumes that are likely to be caused by the covered activities. However, we anticipate that the covered activities will result in elevated turbidity levels that exceed 20 NTUs and will likely elicit behavioral changes in coho salmon. Most exposed individuals would likely first respond to increased suspended sediment by attempting to avoid the turbidity plume. For juvenile coho salmon, this avoidance behavior may cause abandonment of preferred shelter and forage resources. Displaced juveniles may experience decreased growth and fitness and reduced likelihood of survival because of increased energetic costs associated with foraging in suboptimal habitat and increased intra-species competition. Displaced individuals may also experience increased exposure to predators. Juveniles that remain within the area of increased turbidity may experience reduced feeding efficiency because of reduced visibility. Depending on the intensity and duration of the elevated turbidity, exposure could cause decreased growth and fitness and reduced likelihood of survival in some individuals. Prolonged exposure to relatively low levels of suspended sediments can cause physiological stress in coho salmon that may reduce growth rates and increase susceptibility to disease.

We anticipate that elevated turbidity in the action area resulting from the covered activities will exceed 20 NTUs. Exposure to high levels of suspended sediment can cause gill irritation or abrasion that can reduce respiratory efficiency or lead to infection. Compromised gill function would reduce fitness and may increase mortality. As the turbidity levels approach 60 NTUs, feeding may cease (Berg and Northcote 1985). At very high levels, suspended sediments can clog gills, which may cause direct mortality.

We expect that OC coho salmon individuals within the action area will be adversely affected by increased suspended sediment concentrations resulting from the covered activities and will respond to various suspended sediment concentrations and exposure durations as described above. Thus, some OC coho salmon individuals will experience injury or death in response to increased suspended sediment concentrations resulting from the covered activities. ODSL will implement conservation measures and conditions for timber harvest and road construction, maintenance, and use to reduce the frequency and magnitude of increases in suspended sediment associated with the covered activities as described in section 2.5.1 of this opinion. Additionally, based on the expected frequency and extent of covered activity implementation, increases in suspended sediment will be spatially and temporally separated throughout the action area. This, combined with the conservation actions indicated above, will reduce the magnitude and frequency of increases in suspended sediments concentrations that result from the covered activities, which will, in turn, minimize the frequency and magnitude of associated adverse effects on OC coho salmon within the action area. Furthermore, an undefined number of anthropogenic barriers to fish passage will be upgraded to increase coho salmon habitat connectivity within the action area. Where fish passage projects are successfully implemented, they are likely to support improved sediment transport and storage capacity. This may further reduce the frequency, duration, and magnitude of suspended sediment increases resulting from covered activities and associated adverse effects on OC coho salmon.

Effects Related to Substrate Changes

Stream substrate characteristics are altered by coarse and fine sediment deposition. Fine sediments are discharged to streams during precipitation events and transported downstream within the water column until they settle to the streambed where flows are sufficiently low. Fine sediment discharges to streams within the action area will occur as a consequence of timber harvest; road construction, maintenance, and use; activities that occur within RCAs; and episodically from landslides and debris flows associated with roads and timber harvest. When these fine sediments are deposited on the streambed, they are likely to fill interstitial spaces, which may result in reduced hyporheic water flow, decreased invertebrate habitat, degraded coho salmon spawning substrate, and, in extreme situations, altered channel morphology. Potential adverse effects on coho salmon from sedimentation/substrate embeddedness include increased mortality of eggs, embryos, and emerging fry; reduced feeding and growth of rearing and out-migrating juveniles; temporarily decreased macroinvertebrate prey abundances; and increased juvenile predation.

In redds, eggs undergo incubation and hatching with the emergence of fry. Survival to emergence is related to flow conditions and substrate quality. High levels of sediment settling onto substrates in spawning habitats clogs interstitial spaces, reduces intergravel velocities, and reduces dissolved oxygen concentrations in redds, which are all detrimental to egg survival, hatching, and fry emergence. Embedded substrate also makes it more difficult for fish to dig redds (Cederholm et al. 1997). Spawning females can remove deposited fine sediment when creating redds and burying eggs (Lisle and Lewis 1992), but we expect that, in some situations, the extent of sedimentation will be more than a spawning female can sufficiently reverse. Eggs deposited in subpar or degraded incubation conditions have reduced growth and survival, increased mortality of embryos and emerging fry, and lead to adverse effects on the timing and size of emerging fry (Chapman 1988, Lisle and Lewis 1992). Salmon that survive incubation in degraded conditions and emerge later and smaller than other fry, appear to be weaker, less dominant, and less capable of maintaining their position in the environment (Mason and Chapman 1965).

Increased fine sediment levels in streams from timber harvest; road construction, maintenance, and use; and activities within RCAs will occur and will likely adversely affect the egg and fry life stages of OC coho salmon by reducing their growth and survival. However, based on the expected frequency and extent of covered activity implementation, increases in suspended sediment will be spatially and temporally separated throughout the action area over the permit term. Additionally, ODSL will implement conservation measures and conditions, as described in sections 2.5.1 and 2.5.3 of this opinion, at a level commensurate with the scope and scale of the covered activities, which will minimize increases in fine sediments caused by the covered activities and resultant adverse effects on OC coho salmon. Nonetheless, some OC coho salmon individuals will experience injury or death because of adverse effects associated with increased fine sediment deposition on stream substrates resulting from the covered activities.

Effects Related to Forage

Sedimentation and substrate embeddedness resulting from the covered activities will contribute to temporary decreases in the abundance of important forage resources for juvenile coho salmon by filling interstitial spaces necessary for colonization by aquatic invertebrates. Sedimentation and substrate embeddedness will occur as a consequence of increased sediment discharge associated with timber harvest, road management, activities that occur within RCAs, and episodically from landslides and debris flows associated with roads and timber harvest. Additionally, disturbance and removal of riparian vegetation will cause localized reductions in the abundance of terrestrial macroinvertebrates, which may constitute a substantial proportion of juvenile coho salmon diet in some stream reaches. In some cases, an increase in the amount of solar energy reaching a stream caused by riparian tree removal may locally increase primary production and, in turn, locally increase the abundance of coho salmon prey organisms.

Reductions in forage availability for juvenile coho salmon will likely result from the covered activities. Reduced forage availability decreases feeding opportunities, reduces feeding success, and ultimately reduces the growth, survival, and fitness of affected individuals. It is likely that OC coho salmon individuals will be exposed to reduced forage availability in the action area and will experience subsequent reductions in growth, survival, and fitness because of the covered activities. Most reductions in forage availability will be short-term, only affecting OC coho salmon individuals for weeks to months, and will be spatially and temporally separated throughout the permit area over the permit term. ODSL will implement conservation actions intended to minimize the effects on forage, as described in sections 2.5.1 and 2.5.3 of this opinion, at a level commensurate with the scope and scale of the covered activities. Nonetheless, some OC coho salmon individuals will experience reduced growth and survival because of reduced forage.

Non-Habitat Effects

Water drafting. The ODF will generally use a 2- to 3-inch pipe attached to a pump to pull water from streams when needed for specified activities. When pumping water from a stream, juvenile individuals of the covered species can become entrained in the pipe because they cannot swim away from the hydraulic pull of water (intake velocity) into the pipe. To avoid entrainment, ODF will use an end-of-pipe screen that is consistent with NMFS' juvenile fish pump screening criteria (NMFS 2022a or most recent). The end-of-pipe screen reduces the intake velocity by spreading it over a large surface area that is greater than the surface area of the end of the pipe. Thus, it is unlikely that water drafting will result in entrainment of any covered species individuals.

Work area isolation and fish salvage. Over the course of the permit term, up to 50 culverts or bridges are expected to be repaired, replaced, or constructed across the permit area. ODSL commits to installing/upgrading no more than three bridges or culverts in any single year over the course of the permit term. Where in-water work is required as part of these bridge and culvert installation/upgrades, ODSL will conduct work-area isolation and fish salvage. Work area isolation will involve using sandbags or other materials to isolate the work area from the actively flowing stream, which will trap fish in the isolation area. ODSL will use fish salvage methods including but not limited to electrofishing, seine netting, and dipnets, which will result in capture, handling, and relocation of OC coho salmon.

Only juvenile OC coho salmon are likely to be captured during work area isolation. This is because any adult coho salmon that may be present when the isolation area is being staged are likely to leave of their own volition or can otherwise be easily excluded without capture or other direct contact before the isolation is complete.

An estimate of the effect that capture and release operations for projects authorized or completed under this opinion would have on the abundance of adult salmon in the OC coho salmon ESU was obtained as follows: A = n(pct), where:

A = Number of adult equivalents "killed" each year
n = Number of projects likely to occur each year
p = 31, *i.e.*, number of juveniles to be captured per project, based on Oregon Department of Transportation's (ODOT's) data for site isolation[10]
c = 0.05, *i.e.*, rate of juvenile injury or death caused by electrofishing during capture and release, primarily steelhead and coho salmon. Consistent with observations by Cannon (2008 and 2012) and data reported in McMichael *et al*. (1998).
t = 0.02, *i.e.*, an estimated average smolt to adult survival ratio, see Smoker *et al*. (2004) and Scheuerell and Williams (2005). This is very conservative because many juveniles are likely to be captured as fry or parr, life history stages that have a survival rate to adulthood that is exponentially smaller than for smolts.

Based on ODOT fish salvage data, we determined a multiplication factor of 1.5 to estimate the maximum number juveniles that would be captured during work isolation and fish salvage.[11] We

[10] In 2007, ODOT completed 36 work area isolation operations involving capture and release using nets and electrofishing; 12 of those operations resulted in capture of 0 Chinook salmon, 345 coho salmon, and 22 steelhead; with an average mortality of 5% Cannon (2008). Cannon (2012) reported a mortality rate of 4.4% for 455 listed salmon and steelhead captures during 30 fish capture and release operations in 2012. No sturgeon or eulachon have been captured because of ODOT fish capture and operations.
[11] Since p = 31 fish per salvage is an average, we calculated the multiplication factor by using the total fish salvaged in Cannon (2008 and 2012) ([455/367] + 0.25 ≈ 1.5) to estimate the maximum number of salmon that could be

estimate that up to 47 juvenile coho salmon individuals per culvert/bridge installation/upgrade project and up to 141 for three projects per year would be captured and handled and that 8 juvenile coho salmon would be injured or killed because of work necessary to isolate in-water work areas for culvert/bridge installation/upgrade projects. Over the 80-year permit term, this estimate is 11,280 juvenile coho salmon captured and handled and 564 injured or killed because of isolation and fish salvage for culvert/bridge installation/upgrade projects. The likelihood that three culvert/bridge installation/upgrade projects requiring isolation and fish salvage would occur within the range of a single population varies by population but has the potential to occur. Thus, in any given year during the permit term, 141 individuals could be captured and handled and 8 individuals could be killed in a single population. Using the formula above, the number of individual OC coho salmon injured or killed by work area isolation and fish salvage is likely to be small, resulting in less than three adult-equivalents captured and less than one adult equivalent killed per year.

Research and Monitoring. ODSL will monitor OC coho salmon within the permit area to evaluate effects of the various treatments on OC coho salmon populations using various demographic measurements. For example, juvenile OC coho salmon density will be monitored in streams subject to RCA thinning (treatment) and in untreated streams (controls). These streams would likely be monitored prior to and following treatment for a predetermined amount of time based on the research design.

Each year, approximately 10 sites will be sampled within treated and untreated (control) streams. No more than 2,000 linear meters will be sampled per year, which will likely be equally split among treatment and control reaches. Based on conservative density estimates reported by Nickelson and Lawson (1998), sampling 2,000 linear meters per year is expected to result in approximately 5,000 juvenile coho being encountered annually. Sampling for coho salmon will be conducted via electrofishing by qualified and trained biologists, and NMFS (2000) electrofishing guidelines will be adhered to during all sampling activities. Sampling will occur during ODFW-designated in-water work windows (ODFW 2024), which will minimize potential interactions with more vulnerable life-history stages of OC coho salmon. If sampling needs to occur outside of established in-water work windows, appropriate approvals from ODFW and NMFS will be required. All sampled juveniles will be anesthetized, weighed, and measured before being released back into the sampled stream.

Assuming a 50 percent capture-efficiency rate during electrofishing sampling (Peterson et al. 2004), approximately 2,500 fish would be captured, handled, and released each year, and another 2,500 unhandled fish would be, at a minimum, exposed to the electrofishing field. Either category may cause injury, stress, fatigue, and even cardiac or respiratory failure (Snyder 2003). Over the course of the 80-year permit term, approximately 400,000 juvenile coho salmon would experience varying degrees of the aforementioned sampling-related effects. It is conceivable that over the 80-year permit term sampling may occur at times and locations where encounters with returning adults are possible. If this does occur, migrating or spawning adults could be exposed to electrofishing-related effects. Therefore, the likelihood of adults being exposed to

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salvaged for a fish passage project. This likely is more consistent with the maximum of the range of fish salvage data reported in Cannon (2008 and 2012).

electrofishing effects is low, and no more than 20 (10 captured and handled, 10 harassed) adult OC coho salmon are expected to be encountered per year.

Assuming an injury rate consistent with observations by Cannon (2008 and 2012) and data reported in McMichael et al. (1998), up to 250 juveniles may experience injury or death each year from electrofishing sampling, including capture and handling. The remaining 4,750 juveniles encountered annually during electrofishing sampling are expected to, at a minimum, experience harassment from exposure to the electrofishing field. Based upon these annual estimates, we anticipate that up to 20,000 juvenile which equates to 1,280 adult OC coho salmon would be injured or killed because of electrofishing sampling over the course of the 80-year permit term.

2.6. Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving federal activities, that are reasonably certain to occur within the action area of the federal action subject to consultation [50 CFR 402.02]. Future federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Some continuing non-federal activities are reasonably certain to contribute to climate effects within the action area. However, it is difficult if not impossible to distinguish between the action area's environmental conditions caused by global climate change that are properly part of the environmental baseline *vs.* cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are similar or the same as those that are described in the environmental baseline (Section 2.4).

The cumulative effects of future state, tribal, local, or private activities that are reasonably certain to occur in the action area during the permit term are summarized below.

2.6.1 Timberland Management

At present, the primary land managers adjacent to the action area include Oregon Board of Forestry (BOF) to the south and west, and private landowners to the east, south, and west. While outside the action area, activities on these lands can affect habitat in the action area due to activities conducted where effects (e.g., water temperature, sediment, etc.) that originate outside the action area flow downstream into the action area.

Most private lands adjacent to the action area are maintained as commercial timberlands dominated by plantations composed of relatively young, uniformly aged Douglas-fir forests. Private and non-federal lands must be managed in accordance with the OFPA and associated Forest Practice OARs. As outlined in OAR Chapter 629, the Forest Practice Administrative Rules address requirements for numerous forest-management activities, including clear-cut harvest, road design and construction, leave trees, chemical use, and habitat protection for certain fish and wildlife species. Effects from activities under OFPA are similar to those described in this opinion and may extend into the action area and affect OC coho salmon or their designated critical habitat.

Pesticides, including herbicides, are commonly applied to private forestlands in Oregon and it is likely that their use will occur on state and private forestlands surrounding and within the permit area. Forest landowners primarily use herbicides to prepare sites for tree planting and to control competing weeds that hinder survival and growth of young, commercially important tree species. Herbicides are also used to control invasive weeds such as Himalayan blackberry (*Rubus armeniacus*). Herbicides are applied by aerial (e.g., helicopter, fixed-wing or drone) and ground-based equipment or by hand. Forest landowners are responsible for approximately 4 percent of all pesticides (including herbicides), by weight, used every year in Oregon.

Application of herbicides must follow federal and state laws and regulations, including label restrictions. Additionally, pesticide users on private forestlands must also follow Oregon FPA rules on pesticide application, including some restrictions on the application of herbicides near streams. These restrictions reduce, but likely do not prevent, herbicides from entering streams. Once these chemicals enter streams, they can have a host of negative effects on water quality, invertebrate ecology, and fish physiology.

Timberland management activities on adjacent state and private forestlands including timber harvest, yarding, loading, hauling, site preparation, planting, and vegetation management are expected to continue during the permit period. These activities are likely to reduce riparian shading, decrease large wood recruitment, and increase fine sediment inputs to streams contiguous with those within the permit area, which will contribute, to varying degrees, to adverse effects on OC coho salmon and their habitats. However, application of the conservation actions outlined above for state, and private forestlands, respectively, are expected to reduce forestry-related effects on aquatic habitats, including those occupied by OC coho salmon.

2.6.2 Roads

Numerous private, county, and state roads occur on lands within the action area. Effects from road management and construction are similar to those described in this opinion and may extend into the action area and affect OC coho salmon or their designated critical habitat. The amount of road maintenance and new road construction that may cause effects in the action area cannot be determined; however, maintenance and new construction are expected to continue similar to current levels. Standard aquatic resource protection measures are expected to continue and maintain trends for higher road construction, reconstruction, and maintenance standards compared to historical standards. Therefore, continued incremental improvement of environmental conditions on private and state lands related to roads throughout the action area is expected during the permit period.

Potential impacts from roads on lands adjacent to the action area are subject to OFPA restrictions. Hence, road conditions on private forestlands are expected to continue incrementally improving from implementation of OFPA-required road and drainage improvements.

2.6.3 Agricultural Activities

Agricultural activities are expected to occur on a limited subset of private lands in Coos and Douglas counties, including parcels zoned for exclusive farm use (EFU). In Douglas County, the

EFU parcels closest to the action area are zoned specifically for grazing and related activities. In Coos County, EFU parcels receive a general EFU zoning designation, which does not assign a specific type of farm use. The State of Oregon has maintained a strong policy to protect agricultural land across the state (ORS 215.243). Oregon's Statewide Planning Program has carried out this policy over the years and has effectively slowed the loss of farmland in Oregon, especially those lands formally designated as EFU. It is anticipated that the State of Oregon would continue to carry out this policy; however, the conversion of rural land (i.e., land not designated EFU) to other land uses could continue to occur in the future. Regardless, agricultural activities within the action area are expected to continue throughout the permit term. Although potential impacts on water quality from agricultural activities would be regulated under applicable laws, they are, nonetheless, expected to affect proximate OC coho salmon populations and their habitats through continued loss of riparian vegetation, decreased bank stability, loss of overstory shade, increased sediment inputs, and elevated bacteria levels.

2.6.4 Residential Development and Infrastructure

Past and present urban development in Coos and Douglas counties comprises residential, commercial, industrial, and recreational uses. The largest cities (by population) in these counties are Roseburg, Coos Bay, and North Bend. The population of Coos County increased by 3 percent between 2010 and 2020, from 63,043 to 64,929. The population of Douglas County increased by 3.3 percent between 2010 and 2020, from 107,667 to 111,201.[12] By 2070, the estimated population of Coos County is expected to reach 66,949 (Chen et al. 2022a), representing a 3.1 percent increase from 2020. By 2070, the estimated population of Douglas County is expected to reach 119,193 (Chen et al. 2022b), representing a 7.2 percent increase from 2020.

Approximately 40 percent of the population in these counties lives outside of designated urban growth boundaries. Projections show that the share of the population living outside of urban growth boundaries will decrease over time to approximately a third of the county populations by 2072. At present, there are small parcels zoned for residential use in the unincorporated community of Ash in Douglas County along the northeastern side of the permit area.

Potential impacts on OC coho salmon and their habitats from residential development and associated utility and road infrastructure include riparian habitat loss, changes to stream channel morphology, altered watershed hydrology (increased storm runoff), increased sediment loading, pollutants, and water temperature. Potential impacts on OC coho salmon and their habitats, including water quality, will be regulated by state and local requirements. The anticipated impacts on OC coho salmon and their habitats from residential development are expected to be sustained and locally intense but are not expected to increase substantially over current levels because of the existing regulatory framework and associated conservation, minimization, and mitigation measures.

[12] U.S. Census Bureau, Oregon County population profiles. Available at: https://data.census.gov/profile?g=040XX00US41

2.6.5 Recreation

The action area is open to the public and used for dispersed recreation activities such as camping, hiking, fishing, off-highway-vehicle (OHV) use, forest-product harvest and collection, and hunting. The action area also borders other public and private recreation sites like the Loon Lake Recreation Area, BLM campgrounds, and private campgrounds along the eastern border. Potential impacts on OC coho salmon and their habitats from these activities include localized effects on turbidity, water quality, streambanks, riparian vegetation, and redds wherever human use is concentrated and these resources occur.

All fishing within action area is regulated by ODFW rules, which include seasonal closures and retention restrictions intended to protect wild coho salmon. Potential impact levels on OC coho salmon within the action area from fishing are unknown, but given limited legal public access and various closures and restrictions per the ODFW regulations, are likely very low and expected to remain at current levels.

Effects on OC coho salmon from these activities are similar as those described above in section 2.5 of this opinion. Effects include behavioral modification and sub-lethal or lethal injury from adverse effects on water quality and quantity and reduced quality and quantity of rearing and spawning habitat. We expect that the cumulative effects of these activities will result in reduced growth, survival, fitness, or even death of some OC coho salmon individuals in the action area. We expect that cumulative effects on OC coho salmon designated critical habitat will reduce quality and function of PBFs discussed in section 2.5.2 of this Opinion that support rearing, migration, and spawning of OC coho salmon in the action area. Best management practices to reduce the effects of these activities on stream habitats and intentional restoration or enhancement of OC coho salmon habitat will lessen the adverse effects on OC coho salmon and their designated critical habitat in the action area.

2.7. Integration and Synthesis

The Integration and Synthesis section is the final step in assessing the risk that the proposed action poses to species and critical habitat. In this section, we add the effects of the action (Section 2.5) to the environmental baseline (Section 2.4) and the cumulative effects (Section 2.6), taking into account the status of the species and critical habitat (Section 2.2), to formulate the agency's biological opinion as to whether the proposed action is likely to: 1) reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or 2) appreciably diminish the value of designated or proposed critical habitat as a whole for the conservation of the species.

The environmental baseline for OC coho salmon has improved since the original ESA listing of this species in 1997 as indicated by the increase in the abundance, productivity, distribution, and diversity shown in the latest viability assessment (Ford 2022). The current primary limiting factors/threats affecting the recovery of the ESU are all related to the juvenile life stage in freshwater and estuarine areas for OC coho salmon. Key past and present management activities in the action area include forest management, road building, agriculture, urbanization, irrigation and water withdrawals, grazing, and gravel mining (NMFS 2007). Throughout the management history of the ESRF, the magnitude and intensity of effects on OC coho salmon and their critical habitat have slowed due to improvements in forest management practices and implementation of numerous stream restoration and enhancement projects in the action area over time. Nonetheless, adverse effects of the key management activities on coho salmon habitat have reduced the quality and function of OC coho salmon critical habitat and PBFs in the action area. As a result, the response of OC coho salmon individuals in the action area has been observed as adverse behavioral modification or sublethal or lethal injury leading to reduced individual growth, survival, and fitness.

The status of OC coho salmon ESU showed a decline in viability overall from the previous status assessment (from 2015 to 2020; Ford 2022). The latest ESU scores indicate a high certainty of persistence and a low to moderate certainty of sustainability. The three populations directly affected by the proposed action (Lower Umpqua (0.87), Tenmile (0.87), Coos (0.82)) have the highest populations sustainability scores for the entire ESU (Ford 2022). Directly related to the proposed action, NMFS (2022b) emphasized several priority actions that would provide the greatest opportunity to advance the recovery of this ESU including:

- Complete ESA consultation and section 10 permit for the Elliot State Forest HCP consistent with OC coho salmon recovery.
- Implement recovery actions (NMFS 2016a) that improve the viability of the Umpqua Stratum. This stratum is currently at the lowest viability within the ESU. The Lower Umpqua population is within the action area.
- Fund, implement, and promote habitat restoration actions that increase stream complexity for juvenile coho salmon rearing by applying the principles of process-based habitat restoration (e.g., beaver dams, large wood pools, floodplains, etc.).

Overall, the proposed action and covered activities will cause increases in water temperatures, suspended sediment concentrations, substrate embeddedness, and peak flows to varying extent over the permit term. Minor decreases in large wood recruitment, forage, and low flows will reduce the functional levels of habitat features within streams across the action area. Both individually and collectively, these habitat impacts would cause altered behaviors, reduced fitness, and mortality in OC coho salmon individuals and reduced quality and function of substrate, water quality and quantity, natural cover, and floodplain connectivity PBFs of critical habitat. These effects are expected to last over the permit term, and legacy effects could also occur for up to 20-years after the end of the permit term. However, the frequency and magnitude of effects will slowly diminish over the permit term because the HCP’s conservation measures and conditions are more protective of natural processes and riparian function than past forest management activities.

Of the three populations within the ESU directly affected by the proposed action (Tenmile, Lower Umpqua, and Coos), effects vary in scope depending upon the specific population. Coho populations from the Middle, North, and South Umpqua populations are indirectly affected while present in the mainstem Umpqua River where tributaries from the action area enter the mainstem and the effects of the covered activities are not expected to result in adverse effects on these upriver populations.

For the Tenmile Lakes population, approximately 20 percent (19 miles)of this population's habitat is within the action area. Expressed in acres, 86 percent of the area of the Tenmile population in the permit area is in the CRWs and 14 percent is in MRWs. Of the total acres of forestlands in the Tenmile portion of the watershed, 3 percent will be treated intensively (MRW), 7 percent will be treated extensively (MRW), and 29 percent will be available for restoration thinning (CRW, MRW, and RCA), while the remaining 62 percent will remain untreated. Additionally, the distribution of OC coho salmon ends well downstream from most intensive allocation areas. The treated portion of the Tenmile Lakes watershed where OC coho salmon are present will be primarily restoration and RCA thinning. A small portion (14 percent) of the Tenmile population will be subject to regeneration and variable retention regeneration harvest, which will occur on an average of 100 years (rotation based on stand age; extensive) and 60 years (intensive). Conservation measures and conditions including establishing RCAs, harvest caps, and terrestrial habitat protections proposed by ODSL and the spatial and temporal separation of activities will reduce the magnitude and frequency of occurrence of adverse effects on coho salmon such that the number of coho salmon from the Tenmile population injured or killed by the proposed action will be very small at any one time given the temporal separation of the relevant covered activities. Therefore, the effects of the proposed action at the population level would not be meaningful and would not reduce the persistence or sustainability of the Tenmile population of OC coho salmon.

For the Lower Umpqua population, the action area comprises three percent of this population's overall range. Fish-bearing streams above Loon Lake do not support coho salmon, given that Loon Lake precludes access above it. Of the area in the Lower Umpqua population below Loon Lake, 34 percent is in the MRW and 66 percent is in the CRW. Of the 35 stream miles below Loon Lake, 23 miles support coho salmon. In this part of the action area, 1,897 acres (8.3%) will be available for intensive treatments (MRW), 2,349 acres (10%) will be available for extensive treatments (MRW), 5,214 acres (23%) will be available for restoration thinning (CRW and MRW RCAs and uplands), and 13,320 acres (58%) will not be treated (MRW and CRW). Of this area of forest lands, 18.3 percent will be subject to intensive and extensive treatments or regeneration or variable retention regeneration harvests and the rest (81.7 percent) will be subject to restoration and RCA thinning (23 percent) or no treatment (58 percent). RCA thinning in the CRWs will occur only in the first 30 years of the permit term. Eleven miles of the 23 miles of coho streams will be subject to intensive or extensive treatments on stand rotations of 60 and an average of 100 years (based on stand age). These and the remaining miles of fish bearing streams (53 miles) will have RCAs of 100 to 200 feet wide. Conservation measures and conditions including establishing RCAs, harvest caps, and terrestrial habitat protections proposed by ODSL, the small proportion the action area is of the range of Lower Umpqua OC coho salmon, and the spatial and temporal separation of activities will reduce the magnitude and frequency of occurrence of adverse effects described in section 2.5 of this Opinion on coho salmon such that the number of coho salmon from the Lower Umpqua population injured or killed by the proposed action will be very small at any one time. Therefore, the effects of the proposed action at the population level would not be meaningful and would not reduce the persistence or sustainability of the Lower Umpqua population of OC coho salmon.

For the Coos River population, the action area comprises 11 percent of the OC coho salmon Coos River population's range. In the action area, 96 percent (118 miles) of the fish-bearing stream miles within the Coos population are in the MRW and the remaining 4 percent (5 miles) are in the CRW. Within the Coos River population, 11,715 acres (32 percent) will be treated intensively (MRW), 8,713 acres (24 percent) will be treated extensively (MRW), 4,065 acres (11 percent) will be available for restoration thinning (including RCAs) (MRW and CRW), and 12, 242 acres (33 percent) will not be treated (MRW and CRW). Two miles of the 56 miles of coho salmon streams are in CRW and the remaining 54 are in MRWs that will be subject to intensive and extensive harvest on stand rotations of 60 and an average of 100 years (based on stand age). All coho and fish-bearing streams (180 miles) will have RCAs of 100 to 200 feet wide. Conservation measures and conditions including establishing RCAs, harvest caps, and terrestrial habitat protection measures proposed by ODSL, the small proportion of the range of Coos River OC coho salmon that is within the action area, and the spatial and temporal separation of activities will reduce the magnitude and frequency of occurrence of adverse effects on coho salmon such that the number of coho salmon from this population injured or killed by the proposed action will be small at any one time given the temporal separation of the relevant covered activities. Therefore, the effects of the proposed action at the population level would not be meaningful and would not reduce the persistence or sustainability of the Coos population of OC coho salmon.

For non-habitat effects related to capture and handling during fish salvage and research related monitoring, up to 20 adult coho salmon may be captured, handled, or experience adverse behavior modification. Additionally, up to 5,141 individual OC coho salmon juveniles may be captured, handled, or experience adverse behavior modification during these activities with up to 258 mortalities per year across the Tenmile, Coos, and Lower Umpqua populations. Using parr to pre-smolt, pre-smolt to smolt, and a 10 percent smolt to adult survival rate (Nickelson et al. 1998) and the 20 adults exposed to capture, handling, and behavior modification, this equates to the number of adult coho salmon that are 0.5 percent of the Tenmile, 0.31 percent of the Coos, and 0.34 percent of the Lower Umpqua populations' previous 5-year average spawner abundance if all mortality were to occur in just one of the populations. Therefore, the non-habitat effects on the Tenmile, Coos, and Lower Umpqua populations of OC coho salmon will not be meaningful or detectable to reduce the persistence or sustainability of these populations.

The proposed action and covered activities will reduce the quality and function of the substrate, water quality and quantity, forage, natural cover, and floodplain connectivity PBFs of OC coho salmon critical habitat in the action area. The adverse effects of the covered activities will vary in frequency, magnitude, and duration throughout the action area, depending on the scope and extent of the covered activities implemented within each watershed. Conservation measures and conditions, harvest caps will minimize the frequency, magnitude, and duration of adverse effects on the critical habitat PBFs such that these effects will not be meaningful or measurable at the fifth field watershed (critical habitat unit) scale in the Tenmile, Coos, and Lower Umpqua populations. Through permit term, the quality and function of some PBFs including substrate, natural cover, forage, floodplain connectivity, and water quality will be improved as conservation measures and conditions are implemented to protect and improve natural processes and riparian condition and function. Therefore, the effects of the proposed action will not be meaningful or detectable to reduce the quality and function of the critical habitat at the fifth field watershed scale in the Tenmile, Coos, or Lower Umpqua populations of OC coho salmon to serve the intended conservation role for OC coho salmon.

Forest management is the primary non-federal activity affecting coho salmon and their habitat in the action area. Other anthropogenic effects (e.g. agricultural, urbanization) are relatively minor in scale due to the forest characteristics of the landscape. Climate change and the specific effects on air and water temperatures within the action area will affect coho salmon and their habitats. Temperature changes associated with climate change and cumulative effects affect the terrestrial habitats (e.g. growth and survival of timber) and aquatic habitats (e.g. summer water temperatures, summer streamflows). These effects are likely to continue and increasingly affect the abundance and distribution of the OC coho salmon and designated critical habitats. Crozier et al. (2019) completed a vulnerability assessment for Pacific salmonid ESUs and concluded that OC coho salmon had high vulnerability and moderate adaptive capacity to impacts of climate change.

The proposed action and the covered activities will affect OC coho salmon and their habitats. However, proposed action would result in greater conservation of OC coho salmon habitat compared to previous management. Based on the best available information, the effects of the proposed action, when considered in combination with the baseline, cumulative effects, and the impacts of climate change, would not be meaningful to reduce the quality or functionality of the PBFs of critical habitat at the fifth field watershed scale in the Tenmile, Coos, and Umpqua populations. Therefore, the critical habitat across the range of the OC coho salmon ESU would maintain its current level of functionality, and retain its current ability for PBFs to become more functionally established, to serve the intended conservation role for OC coho salmon.

2.8.Conclusion

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, the effects of other activities caused by the proposed action, and the cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of OC coho salmon or destroy or adversely modify their designated critical habitat.

2.9.Incidental Take Statement

Section 9 of the ESA and federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. "Harm" is further defined by regulation to include significant habitat modification or degradation that actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering (50 CFR 222.102). "Harass" is further defined by guidance as to "create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering." "Incidental take" is defined by regulation as takings that result from, but are not the purpose of, carrying out an otherwise lawful activity conducted by the federal agency or applicant (50 CFR 402.02). Section 7(b)(4) and section 7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA if that action is performed in compliance with the terms and conditions of an ITS.

The ESA and its regulations require that HCPs specify the impact that will likely result from the taking (ESA Section 10(a)(2)(A)(i), 50 CFR 222.307(b)(5)(i)). While take happens to individuals, the impact of taking occurs at the population and species level.

2.9.1 Amount or Extent of Take

In the biological opinion, NMFS determined that incidental take is reasonably certain to occur as follows:

- Take in the form of harm to OC coho salmon egg and juvenile life stages from exposure to the following habitat-related impacts resulting from the covered activities:
  - Increased stream temperature
  - Increased suspended sediment and substrate embeddedness
  - Reductions in wood recruitment and associated reductions in the quality and quantity of complex rearing habitat
  - Short-term, localized reductions in forage abundance
- Take in the form of capture, harassment and harm to OC coho salmon juvenile and adult life stages resulting from the following covered activities:
  - Capturing, handling, and release of OC coho salmon individuals during work area isolation and fish salvage
  - Research and monitoring

We can predict, with some confidence, and reliably measure the number of fish that will be captured during work area isolation and fish salvage and research and monitoring. We have, therefore, quantified incidental take from these actions. However, with respect to other covered activities, accurately quantifying the number of fish that will be taken by these actions is not possible. Fish population sizes fluctuate annually and seasonally by watershed depending on many complex environmental variables. Fish distribution within a watershed also varies widely in response to a myriad of environmental variables. Additionally, take caused by habitat-related pathways cannot be accurately predicted as a number of fish because the relationship between habitat conditions and the distribution and abundance of individuals within the action area is influenced by habitat quality, competition, predation, and the interaction of processes that influence genetic, population, and environmental characteristics. These biotic and environmental processes interact in ways that may be random or directional and may operate across far broader temporal and spatial scales than those affected by the actions described for the covered activities. Thus, the distribution and abundance of fish within the action area cannot be attributed entirely to habitat conditions, nor can we precisely predict the number of fish that are reasonably certain to be injured or killed if their habitat is modified or degraded by activities that will be completed under the proposed action. In such cases, we use a take surrogate or take indicator that rationally reflects the incidental take caused by the covered activities. Each of these surrogates is proportionally related to the numbers of fish expected to be taken, is quantifiable and measurable, and may be effectively monitored, and thus will serve as a meaningful reinitiation trigger. For the best available indicators to describe the extent of incidental take caused by the proposed action, we have identified two quantified take limits and two take surrogate indicators for the extent of take caused by the proposed action.

1. Take from Work Area Isolation and Fish Salvage

Work related to road stream crossings, as described in section 1.3.2, will typically necessitate work-area isolation and the capture and release of OC coho salmon. The capture and handling of OC coho salmon will constitute take in the form of capture, harm or harassment. OC coho salmon juveniles will be captured during work area isolation and fish salvage. Some OC coho salmon adults may also be present during in-water work periods and are reasonably certain to be captured or subject to harassment in instances work-area isolation occurs in areas that support migration and/or spawning.

We expect that work area isolation for in-water construction areas will result in the capture of approximately 141 juvenile OC coho annually. Of the 141 individuals captured, we anticipate that no more than 8 will be killed per year. Therefore, the best available indicator for the extent of take from work area isolation and fish salvage is the number of juveniles captured per year. Hence, if more than 141 juvenile OC coho are captured and handled per year during work area isolation for in-water construction areas, then incidental take will be exceeded.

2. Take from Research and Monitoring

Monitoring of OC coho salmon within the action area to evaluate the effects of various covered activities will involve electrofishing sampling, as described in section 2.5.3. This will result in the exposure of approximately 5,000 fish per year to an electrofishing field, of which 2,500 will be captured, handled, and released. We anticipate that a small proportion of the fish exposed to electrofishing sampling including capture and handling each year, approximately 250 juveniles, may experience injury or death. Therefore, the best available indicator for the extent of take from electrofishing sampling is the number of juveniles captured per year. Hence, if more than 2,500 juvenile OC coho are captured per year during electrofishing sampling, then incidental take will be exceeded.

3. Take from Timber Harvest and Associated Activities

The covered activities related to timber harvest—road use; clear-cuts, retention cuts, and thinning; cable, ground-based, or helicopter yarding; salvage harvest; and supporting management activities—will take place adjacent to and within RCAs and stream habitats occupied by OC coho salmon.

The effects analysis that provides the basis for this incidental take statement is predicated on the assumption that ODSL will not exceed the following limits on timber-harvest and restoration thinning:

- Timber sales from all treatments will not exceed 1,000 acres per year based on a 4-year rolling average of contracted sales. Of these 1,000 acres, no more than 480 acres per year will be from regeneration (clearcuts or retention cuts) harvest.
- In addition to the 1,000 acres per year, restoration thinning in plantation stands in CRW and MRW reserves and RCAs on up to 300 acres per year for the first 20 years of the

permit term and 200 acres per year during years 21 to 30 of the permit term to enhance covered species habitat needs.

- Restoration thinning will be conducted on up to 1,200 acres of RCAs over the permit term across the permit area in accordance with the operational standards outlined under the *Riparian Conservation Areas* heading in section 1.3.2 of this document.
- RCA thinning stands that receive two entries stands will not exceed 600 acres over the permit term.

Incidental take of OC coho salmon in the form of harm from habitat impacts resulting from timber harvest and associated activities as contemplated in this biological opinion will be proportional to the number of acres that are subject to such activities. For the reasons outlined above, it is not practicable to quantify the number of fish harmed by new road construction. Therefore, the most appropriate thresholds for the extent of incidental take that is expected to occur as a result of timber harvest and associated activities are the harvest caps indicated above. Exceedance of any of these acreage limits would trigger reinitiation of consultation. This indicator functions as a valid reinitiation trigger because it includes clear measurable metrics that are measured through the HCP's monitoring and reporting requirements during the 80-year permit term.

4. Take from Road Construction and Maintenance

Take associated with road construction and maintenance will occur from roads that are hydrologically connected to streams, and that alter peak and base flows and increase sedimentation and sediment discharge to stream channels. For the reasons outlined above, it is not practical to quantify the number of fish harmed by new road construction. The best indicator for the extent of take from road construction is the miles of road that ODSL will construct annually and over the course of the permit term. The surrogate of miles of new road constructed rationally reflects the amount of incidental take because it correlates with the number of large trees removed that provide shade and future wood recruitment into streams and the amount of sediment generated from the amount of road construction and associated future timber haul. The effects analysis that provides the basis for this incidental take statement is predicated on the assumption that ODSL will not exceed the following limits on road construction:

- 40 miles of new road construction over the 80-year permit term
- 1.0 mile of new permanent road construction per year
- 2.0 miles of temporary road construction per year

Therefore, the most appropriate thresholds for the extent of incidental take that is expected to occur as a result of road construction are those indicated above. If either of these mileage limits are exceeded, reinitiation would be triggered. This functions as valid reinitiation trigger because it includes clear measurable metrics that are measured through the HCP's monitoring and reporting requirements during the 80-year permit term.

2.9.2 Effect of the Take

In the biological opinion, NMFS determined that the amount or extent of anticipated take, coupled with other effects of the proposed action, is not likely to result in jeopardy to OC coho salmon or destruction or adverse modification of their critical habitat.

2.9.3 Reasonable and Prudent Measures

"Reasonable and prudent measures" refer to those actions the Director considers necessary or appropriate to minimize the impact of the incidental take on the species (50 CFR 402.02).

The proposed Elliott State Research Forest HCP and its associated documents identify anticipated impacts to OC coho salmon likely to result from the proposed taking and the measures that are necessary and appropriate to minimize those impacts. All conservation measures described in the proposed HCP, together with the terms and conditions of any section 10(a)(1)(B) permit or permits issued with respect to the proposed HCP, are incorporated herein by reference as reasonable and prudent measures and terms and conditions within this incidental take statement as stated in 50 CFR 402.14(i). Such terms and conditions are non-discretionary.

The amount or extent of incidental take anticipated under the proposed Elliott State Research Forest HCP, consistent with that which is described above, associated reporting requirements; and provisions for disposition of dead or injured animals are as described in the HCP and its accompanying section 10(a)(1)(B) permit(s).

1. Minimize the extent of incidental take from exposure of covered species to the covered activities according to the conservation strategy in the HCP
2. Conduct compliance and effectiveness monitoring and reporting in accordance with the HCP to ensure the amount and extent of take is not exceeded

2.9.4 Terms and Conditions

In order to be exempt from the prohibitions of section 9 of the ESA, the Federal action agency must comply (or must ensure that any applicant complies) with the terms and conditions. ODSL or any applicant has a continuing duty to monitor the impacts of incidental take and must report the progress of the action and its impact on the species as specified in this ITS (50 CFR 402.14). If the entity to whom a term and condition is directed does not comply with the following terms and conditions, protective coverage for the proposed action would likely lapse.

The HCP permit contains all measures necessary to avoid, minimize, and mitigate incidental take of OC coho salmon to the maximum extent practicable and requires that the HCP be fully implemented. Monitoring will be conducted as stated in Chapter 6 of the HCP. Therefore, no additional reasonable and prudent measures and terms and conditions are necessary for OC coho salmon.

1. To implement reasonable and prudent measure #1, "Minimize the extent of incidental take from exposure of covered species to the covered activities according to the conservation strategy in the HCP", ODSL shall adhere to the following:

a. All conservation measures and conditions described in the final HCP in Chapter 5, Sections 5.3, *Avoidance and Minimization Measures Integrated into the Covered Activities*; 5.4, *Conservation Measures*; and 5.5, *Conditions on Covered Activities* together with the associated ESA Section10(a)(1)(B) ITP are hereby incorporated by reference as terms and conditions within this ITS. Such terms and conditions are nondiscretionary and must be undertaken for the exemptions under Section 10(a)(1)(B) and Section 7(o)(2) of the ESA to apply. If ODSL fails to adhere to these terms and conditions, the protective coverage of the Section 10(a)(1)(B) permit and Section 7(o)(2) may lapse. The amount or extent of incidental take anticipated with implementation of the proposed HCP is described in Section 2.9.1 of this biological opinion and incorporated as a term and condition in NMFS' accompanying Section 10(a)(1)(B) permit. The associated reporting requirements and provisions for disposition of dead or injured animals are as described in the HCP and its accompanying section 10(a)(1)(B) ITP.

2. To implement reasonable and prudent measure #2, "Conduct compliance and effectiveness monitoring and reporting as according to the HCP to ensure the amount and extent of take is not exceeded" and ensure the HCP is meeting the biological goals and objectives, ODSL shall adhere to the following:
   a. Annual reporting shall include:
      i. Monitoring components identified by ODSL in Section 7.3.1, *Annual Reporting*
      ii. Monitoring components identified by ODSL in Section 6.2.1, *Compliance Monitoring*;
      iii. Monitoring components identified by ODSL in Chapter 6.3, *Aquatic and Riparian Monitoring*,
      iv. Data assessment relative to the habitat-based surrogates identified in Section 2.9.1 of this opinion including:
         1) The number of OC coho salmon captured and killed during work area isolation and fish salvage. This should include the population they were salvaged from and documentation of de-watering and fish capture, handling, and relocation activities;
         2) The number of OC coho salmon captured and handled or killed during research monitoring activities. This should include the population they were captured and handled or killed in;
         3) The acres of timber harvest conducted by ODSL across the permit area by treatment types, i.e., intensive, extensive, restoration thinning, and RCA thinning;
         4) The miles of new permanent roads constructed in the permit area; and
         5) The miles of temporary roads constructed in the permit area.
   b. The 6-year summary reporting shall include monitoring components identified by ODSL in Section 7.3.2, *6-year Summary Report*; and
   c. The 12-year summary reporting shall include monitoring information identified by ODSL in Section 7.3.3, 12-*year Comprehensive Reviews*.

2.10. Conservation Recommendations

Section 7(a)(1) of the ESA directs federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and endangered species. Specifically, "conservation recommendations" are suggestions regarding discretionary measures to minimize or avoid adverse effects of a proposed action on listed species or critical habitat or regarding the development of information (50 CFR 402.02). NMFS has not identified any additional conservation recommendations beyond those contained in the HCP.

2.11. Reinitiation of Consultation

This concludes formal consultation for NMFS' proposed issuance of an ESA section 10(a)(1)(B) incidental take permit for the Elliott State Research Forest HCP.

Under 50 CFR 402.16(a): "Reinitiation of consultation is required and shall be requested by the federal agency, where discretionary federal involvement or control over the action has been retained or is authorized by law and: (1) If the amount or extent of taking specified in the incidental take statement is exceeded; (2) If new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not previously considered; (3) If the identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in the biological opinion or written concurrence; or (4) If a new species is listed or critical habitat designated that may be affected by the identified action."

2.12. "Not Likely to Adversely Affect" Determinations

When evaluating whether the proposed action is not likely to adversely affect listed species or critical habitat, NMFS considers whether the effects are expected to be completely beneficial, insignificant, or discountable. Completely beneficial effects are contemporaneous positive effects without any adverse effects to the species or critical habitat. Insignificant effects relate to the size of the impact and should never reach the scale where take occurs. Effects are considered discountable if they are extremely unlikely to occur. When effects are beneficial, insignificant and/or discountable, these species are not likely to be adversely affected by the proposed action and we present our justification for that determination separately from the biological opinion since no take, jeopardy, or adverse modification of critical habitat would reasonably be expected to occur.

The proposed action and the action area for this consultation are described in section 1.3 and section 2.3 of this document, respectively. The effects analysis in this section relies heavily on the descriptions of the proposed action and environmental baseline discussed in sections 1.3 and 2.4, respectively, and on the effects analyses presented in section 2.5.

2.12.1 Southern Resident Killer Whales and Designated Critical Habitat

The Southern Resident killer whale (SRKW) was listed as endangered on November 18, 2005 (70 FR 69903). Critical habitat was designated on November 29, 2006 (71 FR 69054) and expanded on August 2, 2021 (86 FR 41668). The 5-year reviews of SRKW status completed in 2016 and 2021 concluded that the species should remain listed as endangered and include recent information on the population, threats, and new research results and publications (NMFS 2016b, NMFS 2021a). Detailed information about the biology, habitat, and conservation status and trends of SRKW can be found in the listing regulations and critical habitat designations published in the Federal Register, as well as in the recovery plans and other sources at: https://www.fisheries.noaa.gov/species-directory/threatened-endangered, and are incorporated here by reference.

SRKW spend considerable time in the Georgia Basin from late spring to early autumn, with concentrated activity in the inland waters of Washington State around the San Juan Islands, and typically move south into Puget Sound in early autumn (NMFS 2008). Pods make frequent trips to the outer coast during this season. In the winter and early spring, SRKW move into the coastal waters along the outer coast from the Queen Charlotte Islands south to central California, including coastal Oregon and off the Columbia River (NMFS 2008). The major environmental threats to SRKW include prey availability, pollution/contamination, vessel effects, oil spills, and acoustic effects (NMFS 2008). PBFs of critical habitat for SRKW are water quality to support growth and development; prey species of sufficient quantity, quality, and availability to support individual growth, reproduction, and development, as well as overall population growth; and passage conditions to allow for migration, resting, and foraging. Of those environmental threats and PBFs, only prey species will be affected by the proposed action.

Adult Chinook salmon have been identified as the preferred prey of SRKW (Hilborn et al. 2012, PFMC 2020, Hanson et al. 2021). Thus, a decrease in the abundance of adult Chinook salmon could reduce prey availability for SRKW or negatively affect the prey PBF. Oregon coast Chinook salmon use the action area for spawning, migration, and rearing. Therefore, all life stages of Chinook salmon have the potential to be exposed to varying degrees of effects of the covered activities. Thus, the proposed action could indirectly affect SRKW through the trophic web by decreasing the availability of their preferred prey species. Given the scope, scale, and timing of the covered activities, we anticipate that the proposed action would result in the mortality of a small number of juvenile and adult Chinook salmon within the action area as a consequence of exposure to habitat degradation caused by the covered activities. However, when converted to adult equivalence, this small reduction in juvenile abundance is not expected to have a measurable effect on adult abundance for any of Chinook salmon populations that may use the action area. Therefore, we conclude that the proposed action will result in an insignificant reduction in adult Chinook salmon prey resources for SRKW. Similarly, we do not anticipate that the proposed action will have a discernible effect on the forage PBF of SRKW critical habitat.

Based on this analysis, NMFS finds that the effects of the proposed action on SRKW are expected to be insignificant and thus are not likely to adversely affect SRKW or their critical habitat.

2.12.2 Southern DPS Green Sturgeon and Designated Critical Habitat

Southern DPS green sturgeon were listed as threatened on April 7, 2006 (71 FR 17757), their critical habitat was designated on October 9, 2009 (74 FR 52300), and protective regulations for southern DPS green sturgeon were issued on June 2, 2010. The 5-year reviews of southern DPS green sturgeon status completed in 2015 and 2021 (NMFS 2015, NMFS 2021b) concluded that the species should remain listed as threatened and include recent information on the population, threats, and new research results and publications. Detailed information about the biology, habitat, and conservation status and trends of southern DPS green sturgeon can be found in the listing regulations and critical habitat designations published in the Federal Register, as well as in the recovery plans and other sources at: https://www.fisheries.noaa.gov/species-directory/threatened-endangered, and are incorporated here by reference.

Southern DPS green sturgeon include all naturally spawned populations of green sturgeon that originate south of the Eel River in Humboldt County, California. Telemetry data and genetic analyses suggest that southern DPS green sturgeon generally occur from Graves Harbor, Alaska to Monterey Bay, California (Moser and Lindley 2007; Lindley et al. 2008, 2011) and, within this range, most frequently occur in coastal waters of Washington, Oregon, and Vancouver Island and near San Francisco and Monterey bays (Huff et al. 2012). Southern DPS green sturgeon are known to make significant use of estuaries and move among different estuaries in summer months (Moser and Lindley 2007, Lindley et al. 2011). A principal factor for the decline of southern DPS green sturgeon is loss of spawning habitat. At this time, spawning is largely limited to the upper Sacramento River mainstem; however, some low levels of spawning, relative to the Sacramento River, have also been documented in the Feather and Yuba rivers. The species is currently at risk of extinction primarily because of the elimination of freshwater spawning habitat, degradation of freshwater and estuarine habitat quality, water diversions, fishing, and other causes (USDC 2009).

The Columbia, Nehalem, Yaquina, Coos, and Umpqua rivers are designated critical habitat for southern DPS green sturgeon. Critical habitat in bays and estuaries includes tidally influenced areas as defined by the elevation of mean higher high water. The PBFs of critical habitat that support green sturgeon within the action area include food resources, migratory corridor, sediment quality, water flow, water depth, and water quality. Table 23 lists the PBFs of critical habitat designated for southern DPS green sturgeon and corresponding species life history events. The conservation role of the critical habitat in the action area for southern DPS green sturgeon estuarine areas is likely limited by the water quality, sediment quality, and food resources PBFs.

Table 23. Physical or biological features of critical habitat designated for green sturgeon and corresponding species life history events.

Physical or Biological Features		Species Life History Event
Site Type	**Site Attribute**	
Freshwater riverine system	Food resources Migratory corridor Sediment quality Substrate type or size Water depth Water flow Water quality	Adult spawning Embryo incubation, growth and development Larval emergence, growth and development Juvenile metamorphosis, growth and development
Estuarine areas	Food resources Migratory corridor Sediment quality Water flow Water depth Water quality	Juvenile growth, development, seaward migration Subadult growth, development, seasonal holding, and movement between estuarine and marine areas Adult growth, development, seasonal holding, movements between estuarine and marine areas, upstream spawning movement, and seaward post-spawning movement
Coastal marine areas	Food resources Migratory corridor Water quality	Subadult growth and development, movement between estuarine and marine areas, and migration between marine areas Adult sexual maturation, growth and development, movements between estuarine and marine areas, migration between marine areas, and spawning migration

The PBFs of designated critical habitat for southern DPS green sturgeon that are likely to be affected by the covered activities are water quality, flow, and food resources. The covered activities affecting PBFs will occur in tributary streams within 1 mile upstream of estuarine waters that may be occupied by southern DPS green sturgeon. Effects of the covered activities—including increased sedimentation, water temperature, contaminants, and peak flows, and reduced base flows and abundance of prey organisms—will decrease in magnitude and severity with increased downstream distance and will likely be unmeasurable when they reach the estuary and mix with flow in the Umpqua River. Therefore, while effects of the covered activities are likely to extend to portions of the action area occupied by southern DPS green sturgeon (i.e., the inland extent of Umpqua River Estuary), such effects are extremely unlikely to be measurable or meaningful or change the quality and function of water quality, water quantity, and food resources PBFs of affected southern DPS green sturgeon critical habitat.

Adult and sub-adult southern DPS green sturgeon may be present in estuarine habitats affected by the covered activities from May to October. While in the action area, they would be actively foraging in the deeper portions of tidally influenced waters as they feed primarily on benthic and epibenthic organisms. Thus, there is low probability that individual southern green sturgeon would occur in areas where they could be exposed to effects of the proposed action. In the unlikely event an individual is exposed to increases in suspended sediment, water temperature, or contaminants from the covered activities it is unlikely the levels of effect would be measurable or the individual would remain in the affected area for a duration long enough to trigger a behavioral or physiological adverse response. Additionally, it is unlikely that any increases in peak flows or reduction in base flows resulting from the covered activities would be measurable in downstream waters occupied by southern DPS green sturgeon because flows in such areas are primarily influenced by tidal fluctuation. For these reasons, the effects of the covered activities are insignificant and not likely to adversely affect southern DPS green sturgeon or their designated critical habitat.

2.12.3 Southern DPS Pacific Eulachon and Critical Habitat

The southern DPS of Pacific eulachon comprises fish that spawn in rivers south of the Nass River in British Columbia to, and including, the Mad River in California (Gustafson et al. 2010) and was listed as a threatened species under the ESA on March 18, 2010 (75 FR 13012). The 2016 5-year review concluded that the DPS's threatened designation remained appropriate. Critical habitat was designated for eulachon on October 20, 2011 (76 FR 65324). Detailed information about the biology, habitat, and conservation status and trends of the southern DPS of Pacific eulachon can be found in the listing regulations and critical habitat designations published in the Federal Register, as well as in the recovery plans and other sources at: https://www.fisheries.noaa.gov/species-directory/threatened-endangered, and are incorporated here by reference.

Although they spend 95 to 98 percent of their lives at sea (Hay and McCarter 2000), little is known concerning the saltwater existence of eulachon. They are reported to be present in the "food rich" and "echo scattering layer" of coastal waters (Barraclough 1964, as cited in Gustafson et al, 2010) and "in near-benthic habitats in open marine waters" of the continental shelf between 20 and 150 meters in depth (Hay and McCarter 2000). Eulachon leave saltwater to spawn in their natal streams in late winter through early summer and typically spawn at night in the lower reaches of larger rivers fed by snowmelt. After hatching, larvae are carried downstream and widely dispersed by estuarine and marine currents.

The southern DPS of Pacific eulachon includes four major subpopulations: Columbia, Klamath, Frazier, and British Columbia. However, these subpopulations do not include all spawning aggregations within the DPS. For instance, spawning runs of eulachon have been noted in Redwood Creek and the Mad River in California, the Umpqua River and Tenmile Creek in Oregon, and the Naselle and Quinault rivers in Washington (NMFS 2017). Therefore, fish from the southern DPS of Pacific eulachon may occur within the action area in the Lower Umpqua River and Tenmile Creek and their estuaries during certain times of the year.

Critical habitat for the southern DPS of Pacific eulachon includes portions of 16 rivers and streams in California, Oregon, and Washington (USDC 2011). All of these areas are designated as migration and spawning habitat for this species. In Oregon, 24.2 miles of the lower Umpqua River, 12.4 miles of the lower Sandy River, and 0.2 mile of Tenmile Creek have been designated as critical habitat for the southern DPS of Pacific eulachon. Critical habitat within the action area that may be adversely affected by the proposed action include the lower Umpqua River and Tenmile Creek. Table 24 delineates the designated PBFs for eulachon.

Table 24. Physical or biological features of critical habitats designated for eulachon and corresponding species life history events.

Physical or Biological Features Site Type	Physical or Biological Features Site Attribute	Species Life History Event
Freshwater spawning and incubation	Flow Water quality Water temperature Substrate	Adult spawning Incubation
Freshwater migration	Flow Water quality Water temperature Food	Adult and larval mobility Larval feeding

The PBFs of designated critical habitat for the southern DPS of Pacific eulachon that are likely to be affected by the covered activities are flow, water quality, water temperature, substrate, and food resources.

The covered activities will occur in tributary streams upstream of estuarine and tidally influenced waters within 1 mile of and that may be occupied by eulachon in the Umpqua River. In Tenmile Creek, it is unlikely effects from the covered activities would reach the reach occupied by eulachon because the Tenmile Lakes will buffer all the effects that would occur in their tributary streams. Additionally, covered activities will occur well beyond 1 mile from the occupied reach of Tenmile Creek. Therefore, effects of the proposed action and covered activities on eulachon are extremely unlikely and are discountable. Effects of the covered activities—including increased sedimentation, water temperature, contaminants, and peak flows, and reduced base flows and abundance of prey organisms—will decrease in magnitude and severity with increased downstream distance and will likely be unmeasurable when they reach the estuary and mix with flow in the Umpqua River. This will result in a low probability of eulachon individuals being exposed to effects of the covered activities. However, in the event they do become exposed to the effects mentioned above, it is unlikely they will be exposed for a duration long enough to elicit an adverse behavioral response. Therefore, while effects of the covered activities are likely to extend to portions of the action area that may be occupied by eulachon (i.e., the lower Umpqua River), effects are extremely unlikely to be of sufficient magnitude to trigger a physical or behavioral response in individual eulachon or change the quality and function of PBFs of eulachon critical habitat within the action area. For these reasons, the effects of the covered activities would be insignificant for individual eulachon and their habitat and, thus, not likely to adversely affect the southern DPS of Pacific eulachon or their designated critical habitat.

3. MAGNUSON–STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT ESSENTIAL FISH HABITAT RESPONSE

Section 305(b) of the MSA directs federal agencies to consult with NMFS on all actions or proposed actions that may adversely affect EFH. Under the MSA, this consultation is intended to promote the conservation of EFH as necessary to support sustainable fisheries and the managed species’ contribution to a healthy ecosystem. For the purposes of the MSA, EFH means “those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity”, and includes the associated physical, chemical, and biological properties that are used by fish (50 CFR 600.10). Adverse effect means any impact that reduces the quality or quantity of EFH and may include direct or indirect physical, chemical, or biological alteration of the waters or substrate and loss of (or injury to) benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality or quantity of EFH. Adverse effects may result from actions occurring within EFH or outside of it and may include direct, indirect, site-specific or habitat-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810). Section 305(b) of the MSA also requires NMFS to recommend measures that can be taken by the action agency to conserve EFH. Such recommendations may include measures to avoid, minimize, mitigate, or otherwise offset the adverse effects of the action on EFH (50 CFR 600.905(b))].

3.1. EFH Affected by the Proposed Action

The proposed action for this consultation is described in the Introduction, section 1.3, and the action area is described in section 2.3 of this opinion. The action area includes areas designated as EFH for various life stages of Pacific Coast salmon in the Umpqua and Coos HUC-8 subbasins.

In addition, the action area overlaps a portion of the uppermost (i.e., inland) extent of the Umpqua River Estuary, which is designated as a habitat area of particular concern (HAPC) for various federally managed salmon species within the Pacific Coast Salmon FMP. HAPCs are described in the regulations as subsets of EFH that are rare, particularly susceptible to human-induced degradation, especially ecologically important, or located in an environmentally stressed area. Designated HAPCs are not afforded any additional regulatory protection under the MSA; however, federal projects with potential adverse impacts on HAPC will be more carefully scrutinized during the consultation process.

3.2. Adverse Effects on EFH

The ESA portion of this document (sections 1 and 2) describes the adverse effects of the proposed action on ESA-listed species and critical habitats and is relevant to the effects on EFH for Pacific Coast salmon. Based on the effects analysis presented in section 2.5 of this document, the covered activities will cause adverse effects on EFH through direct and indirect alteration of water quality, water quantity, natural cover, forage, and substrate. The effects of the covered activities on these habitat features include:

- The covered activities including timber harvest, restoration thinning, and road construction and maintenance will cause increased suspended sediment concentrations, stream temperatures, and contaminant levels. Effects on water quality from increased suspended sediments, stream temperature, and contaminants caused by the covered activities are documented in sections 2.5.1 and 2.5.2 of this document. Increased suspended sediments, temperature, and contaminants will adversely affect water quality in the action area, but the effects on water quality will be spatially and temporally separated throughout the action area over the permit term. These adverse effects will be minimized, but not avoided, by the proposed conservation actions described in sections 1.3.2 and 1.3.3 of this document.

- Effects on water quantity, specifically peak and base flows, will result from the covered activities and are detailed in sections 2.5.1 and 2.5.2 of this document. The greatest risk to water quantity within the action area will occur where effects from timber harvest, restoration thinning, road and trail construction and maintenance, and water drafting activities overlap with streams that are more susceptible to changes in water quantity, such as those where summer salmon rearing habitat is limited by low summer flows. It is likely that the covered activities will affect water quantity in these areas, but such effects will be spatially and temporally separated throughout the action area over the permit term. ODSL will implement conservations actions at a level commensurate with the scope and scale of covered-activity implementation. Hence, adverse effects from the covered activities will be minimized, but not avoided, by the conservation actions described in sections 1.3.2 and 1.3.3 of this document.
- The proposed action will result in small, localized reductions in prey organism abundance and productivity for juvenile Chinook and coho salmon. These reductions will be spatially and temporally separated throughout the action area over the permit term. In some cases, increased solar radiation to the streams and concurrent increases in understory vegetation may cause a small increase in insect populations at the site-scale that and may balance forage abundance for juvenile Chinook and coho salmon. ODSL will implement conservations measures and conditions, harvest caps, and establish RCAs, which will reduce the frequency and magnitude of adverse effects on forage and support quick recolonization (weeks to months) of prey organisms where reductions in their abundance and productivity occur because of the covered activities. Thus, the overall effect on forage will be small.
- The proposed action will result in localized effects on the habitat features that provide natural cover for all life history stages of Chinook and coho salmon. Reductions in natural cover will be localized to where sediment discharges from roads and denuded areas and slight reductions in wood recruitment affect the quality and frequency of stream habitat features that provide cover. Larger areas of natural cover may be affected by landslide-associated debris flows, but these areas will recover as natural stream processes work to reestablish habitat features and habitat complexity (Reeves et al. 1995). Additionally, effects on natural cover will be spatially and temporally separated throughout the action area over the permit term. ODSL will implement conservation measures and conditions, harvest caps, and establish RCAs that will reduce the frequency and magnitude of adverse effects on natural cover such that the overall effect on natural cover will be small.
- Substrate will be affected by fine sediments that are discharged to streams within the permit area and subsequently deposited on and among stream substrates, thereby contributing to substrate embeddedness. Fine sediment discharge to streams occurs from natural processes such as landslides and debris flows and anthropogenic soil disturbance near streams, timber harvest, and road use and management. Additionally, some sediment-generating activities will be allowed in RCAs including establishing yarding corridors, constructing or maintaining roads (including stream crossings), vacating roads, and conducting stream-enhancement activities. Substrate embeddedness will increase with fine sediment deposition as the sediments are discharged and transported through the

stream system because of covered activities authorized by issuance of an ITP including timber harvest, road management, and stream enhancement activities. Therefore, fine sediment discharges associated with the covered activities will increase substrate embeddedness in streams in the action area.

3.3.EFH Conservation Recommendations

NMFS determined that the following conservation recommendations are necessary to avoid, minimize, mitigate, or otherwise offset the impact of the proposed action on EFH.

1. ODSL shall follow Term and Condition #1 above in the ESA portion of this document to minimize and mitigate the adverse effects on Pacific coast salmon EFH and Pacific Coast salmon HAPCs from the activities covered under the HCP.
2. ODSL shall follow Term and Condition #2, except Term and Condition #2(a)(iv)(1 and 2), above in the ESA portion of this document to ensure that they are effectively minimizing and mitigating the adverse effects of the covered activities on Pacific coast salmon EFH and Pacific Coast salmon HAPCs.
3. ODSL shall minimize and mitigate adverse effects on Pacific coast EFH and Pacific Coast salmon HAPCs by limiting recreational use of the permit area near sensitive fish-bearing streams via educational signage, relocating or blocking informal trails, and reverting dispersed campsites to a natural state where they occur within RCAs.

Fully implementing these EFH conservation recommendations would protect Pacific Coast salmon by avoiding or minimizing and/or mitigating the adverse effects described in section 3.2 above.

3.4.Statutory Response Requirement

As required by section 305(b)(4)(B) of the MSA, ODSL must provide a detailed response in writing to NMFS within 30 days after receiving an EFH conservation recommendation. Such a response must be provided at least 10 days prior to final approval of the action if the response is inconsistent with any of NMFS’ EFH conservation recommendations unless NMFS and ODSL have agreed to use alternative time frames for ODSL’s response. The response must include a description of the measures proposed by ODSL for avoiding, minimizing, mitigating, or otherwise offsetting the impact of the activity on EFH. In the case of a response that is inconsistent with the conservation recommendations, ODSL must explain its reasons for not following the recommendations, including the scientific justification for any disagreements with NMFS over the anticipated effects of the action and the measures needed to avoid, minimize, mitigate, or offset such effects (50 CFR 600.920(k)(1)).

3.5.Supplemental Consultation

ODSL must reinitiate EFH consultation with NMFS if the proposed action is substantially revised in a way that may adversely affect EFH, or if new information becomes available that affects the basis for NMFS’ EFH conservation recommendations (50 CFR 600.920(l)).

4. DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW

The Data Quality Act (DQA) specifies three components contributing to the quality of a document. They are utility, integrity, and objectivity. This section of the opinion addresses these DQA components, documents compliance with the DQA, and certifies that this opinion has undergone pre-dissemination review.

4.1. Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. The intended users of this opinion are NMFS and ODSL. Other interested users could include USFWS. Individual copies of this opinion were provided to the [*name of action agency(ies)*]. The document will be available at the NOAA Library Institutional Repository [https://repository.library.noaa.gov/welcome]. The format and naming adhere to conventional standards for style.

4.2. Integrity

This consultation was completed on a computer system managed by NMFS in accordance with relevant information technology security policies and standards set out in Appendix III, 'Security of Automated Information Resources,' Office of Management and Budget Circular A-130; the Computer Security Act; and the Government Information Security Reform Act.

4.3. Objectivity

Information Product Category: Natural Resource Plan

Standards: This consultation and supporting documents are clear, concise, complete, and unbiased; and were developed using commonly accepted scientific research methods. They adhere to published standards including the NMFS ESA Consultation Handbook, ESA regulations, 50 CFR 402.01 et seq., and the MSA implementing regulations regarding EFH, 50 CFR part 600.

Best Available Information: This consultation and supporting documents use the best available information, as referenced in the References section. The analyses in this opinion and EFH consultation contain more background on information sources and quality.

Referencing: All supporting materials, information, data and analyses are properly referenced, consistent with standard scientific referencing style.

Review Process: This consultation was drafted by NMFS staff with training in ESA and MSA implementation and reviewed in accordance with West Coast Region ESA quality control and assurance processes.

5. REFERENCES

Abatzoglou, J. T., Rupp, D. E., & Mote, P. W. (2014). Seasonal Climate Variability and Change in the Pacific Northwest of the United States. Journal of Climate, 27(5), 2125-2142. doi:10.1175/JCLI-D-13-00218.1

Agee, J. K. (1993). Fire Ecology of Pacific Northwest Forests. Washington D.C.: Island Press.

Agne, M. C., Beedlow, P. A., Shaw, D. C., Woodruff, D. R., Lee, E. H., Cline, S. P., & Comeleo, R. L. (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. doi:10.1016/j.foreco.2017.11.004

Alizedeh, M. R., Abatzoglou, J. T., Luce, C. H., Adamowski, J. F., Farid, A., & Sadegh, M. (2021). Warming enabled upslope advance in western US forest fires. Proceedings of the National Academy of Sciences, 118(22), e2009717118. doi:10.1073/pnas.2009717118

Allen, D.M. 2008. Development and application of a processed-based, basin scale stream temperature model. (dissertation). Berkeley, California. University of California, Berkeley. 183 p.

Allen, D.M., W. Dietrich, P. Baker, F. Ligon, and B. Orr. 2007. Development of a mechanistically based, basin-scale stream temperature model: Applications to cumulative effects modeling. Gen. Tech. Rep. PSW-GTR-194. U.S. Department of Agriculture, Forest Service.

Amaranthus, M., Rice, R., Barr, N., & Ziemer, R. (1985). Logging and Forest Roads Related to Increased Debris Slides in Southwestern Oregon. Journal of Forestry 83:229-233. https://doi.org/10.1093/jof/83.4.229

Anderson, P. D., Larson, D. J., & Chan, S. S. (2007). Riparian Buffer and Density Management Influences on Microclimate of Young Headwater Forests of Western Oregon. Forest Science 53(2):254-269. https://doi.org/10.1093/forestscience/53.2.254

Anderson, S.C., J.W. Moore, M.M. McClure, N.K. Dulvvy, and A.B. Cooper. 2015. Portfolio conservation of metapopulations under climate change. Ecological Applications 25(2):559-572.

Arismendi, I. & Groom, J. D. (2019). A novel approach for examining downstream thermal responses of streams to contemporary forestry. Science of the Total Environment 651(Pt 1):736-748. https://doi.org/10.1016/j.scitotenv.2018.09.208

Barnett, H. K., Quinn, T. P., Bhuthimethee, M., & Winton, J. R. (2020). Increased prespawning mortality threatens an integrated natural- and hatchery-origin sockeye salmon population in the Lake Washington Basin. Fisheries Research, 227, 105527. doi:10.1016/j.fishres.2020.105527

Barraclough, W.E. 1964. Contribution to the marine life history of the eulachon *Thaleichthys pacificus*. Journal of Fisheries Research Board of Canada 21(5):

Bartholow, J. M. (2000). Estimating Cumulative Effects of Clearcutting on Stream Temperatures. Rivers (Fort Collins, Colo.) 7(4):284-297.

Bash, J., Berman, C. H., & Bolton, S. (2001). Effects of Turbidity and Suspended Solids on Salmonids (Research Project T1803, Task 42). Washington State Department of Transportation, Seattle, Washington.

Bass, A. (2010). Juvenile coho salmon movement and migration through tide gates. Master's thesis. Oregon State University, Corvallis, Oregon.

Bêche, L. A., Stephens, S. L., & Resh, V. H. (2005). Effects of prescribed fire on a Sierra Nevada (California, USA) stream and its riparian zone. Forest Ecology and Management, 218(1-3), 37-59. doi:10.1016/j.foreco.2005.06.010

Beechie, T., Buhle, E., Ruckelshaus, M., Fullerton, A., & Holsinger, L. (2006). Hydrologic regime and the conservation of salmon life history diversity. Biological Conservation, 130(4), 560-572. doi:10.1016/j.biocon.2006.01.019

Beechie, T. J. & Sibley, T. H. (1997). Relationships between Channel Characteristics, Woody Debris, and Fish Habitat in Northwestern Washington Streams. Transactions of the American Fisheries Society 126(2):217-229. https://doi.org/10.1577/1548-8659(1997)126<0217:Rbccwd>2.3.Co;2

Bell, M.C. 1990. Fisheries handbook of engineering requirements and biological criteria. Third edition. U.S. Army Corps of Engineers, North Pacific Division. Fish Passage Development and Evaluation Program. Portland, Oregon.

Benda, L. (1990). The influence of debris flows on channels and valley floors in the Oregon Coast Range, U.S.A. Earth Surface Processes and Landforms 15(5):457-466. https://doi.org/https://doi.org/10.1002/esp.3290150508

Benda, L. In Prep. Rates of Shallow Landslides, effects of Forest Management and implications for the supply of sediment and wood to fish streams.

Benda, L., Andras, K., Miller, D., & Bigelow, P. (2004). Confluence effects in rivers: Interactions of basin scale, network geometry, and disturbance regimes. Water Resources Research 40(5). https://doi.org/10.1029/2003wr002583

Benda, L. & Dunne, T. (1997). Stochastic forcing of sediment routing and storage in channel networks. Water Resources Research 33(12):2865-2880. https://doi.org/10.1029/97wr02387

Berg, L. (1983). Effects of short-term exposure to suspended sediment on the behavior of juvenile coho salmon (Oncorhynchus kisutch). University of British Columbia.

Berg, L. & Northcote, T. G. (1985). Changes in Territorial, Gill-flaring, and Feeding Behavior in Juvenile Coho Salmon (Oncorhynchus kisutch) following Short-term Pulses of Suspended Sediment. Canadian Journal of Fisheries and Aquatic Sciences 42(8):1410-1417. https://doi.org/10.1139/f85-176

Berman, C. H. (1990). The effect of elevated holding temperatures on adult spring Chinook salmon reproductive success. University of Washington.

Beschta, R. L., & al, e. (1987). Stream Temperature and Aquatic Habitat: Fisheries and Forestry Interactions. In Streamside Management: Forestry and Fishery Interactions (pp. 191-232).

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(2):220-238. https://doi.org/10.1093/forestscience/53.2.220

Bilby, R. E. & Bisson, P. A. (1998). Function and Distribution of Large Woody Debris. in.

Bilotta, G. S. & Brazier, R. E. (2008). Understanding the influence of suspended solids on water quality and aquatic biota. Water Research 42(12):2849-61. https://doi.org/10.1016/j.watres.2008.03.018

Biosystems, Consulting, W., Coos Watershed Association Alsea Geospatial, I., & Bahus., K. (2003). Elliott State Forest Watershed Analysis. Oregon Department of Forestry.

Bisson, P. A. & Bilby, R. E. (1982). Avoidance of Suspended Sediment by Juvenile Coho Salmon. North American Journal of Fisheries Management 2(4):371-374. https://doi.org/10.1577/1548-8659(1982)2<371:AOSSBJ>2.0.CO;2

Bisson, P. A., Bilby, R. E., Bryant, M. D., Dolloff, C. A., Grette, G. B., House, R. A., Murphy, M. L., Koski, K. V., & Sedell, J. R. (1987). Large Woody Debris in Forested Streams in the Pacific Northwest: Past, Present, and Future. E. O. Salo & T. W. Cundy, editors. Streamside management: forestry and fishery interactions. University of Washington, Institute of Forest Resources, Seattle, Washington.

Bjornn, T. C. & Reiser, D. W. (1991). Habitat Requirements of Salmonids in Streams. Pages 83-139 in American Fisheries Society Special Publication, volume 19.

Black, B. A., Van Der Sleen, P., Di Lorenzo, E., Griffin, D., Sydeman, W. J., Dunham, J. B., . . . Bograd, S. J. (2018). Rising synchrony controls western North American ecosystems. Global Change Biology, 24(6), 2305-2314. doi:10.1111/gcb.14128

Bladon, K.D., C. Segura, N.A. Cook, S. Bywater-Reyes, and M. Reiter. A multicatchment analysis of headwater and downstream temperature effects from contemporary forest harvesting. Hydrological Processes 32:293-304.

BLM (Bureau of Land Management). (2016a). Proposed Resource Management Plan/Final Environmental Impact Statement for the Resource Management Plans for Western Oregon. in.

BLM (Bureau of Land Management). (2016b). Southwestern Oregon Record of Decision and Resource Management Plan. in.

Booth, A. M., Sifford, C., Vascik, B., Siebert, C., & Buma, B. (2020). Large wood inhibits debris flow runout in forested southeast Alaska. Earth Surface Processes and Landforms 45(7):1555-1568. https://doi.org/10.1002/esp.4830

Bosch, J. M. & Hewlett, J. D. (1982). A Review of Catchment Experiments to Determine The Effect of Vegetation Changes on Water Yield and Evapotranspiration. Journal of Hydrology (Amsterdam) 55:3-23. https://doi.org/10.1016/0022-1694(82)90117-2

Brake, D., Molnau, M., & King, J. G. (1997). Sediment transport distances and culvert spacings on logging roads within the Oregon Coast Mountain Range. in American Society of Agricultural Engineers, Annual International Meeting, Minneapolis, Minnesota.

Braun, D. C., Moore, J. W., Candy, J., & Bailey, R. E. (2016). Population diversity in salmon: linkages among response, genetic and life history diversity. Ecography, 39(3), 317-328. doi:10.1111/ecog.01102

Brazier, J. R. & Brown, G. W. (1973). Buffer strips for stream temperature control. Forest Research Laboratory School of Forestry Oregon State University, Corvallis, Oregon.

Brett, J.R. 1952. Temperature tolerance in young Pacific salmon, genus *Oncorhynchuss*. Journal of Fisheries Research Board of Canada, 9(6):265-323.

Brosofske, K. D., Chen, J., Naiman, R. J., & Franklin, J. F. (1997). Harvesting Effects on Microclimatic Gradients from Small Streams to Uplands in Western Washington. Ecological Applications 7(4):1188-1200. https://doi.org/10.1890/1051-0761(1997)007[1188:Heomgf]2.0.Co;2

Buffington, J. M. & Montgomery, D. R. (1999). Effects of hydraulic roughness on surface textures of gravel-bed rivers. Water Resources Research 35(11):3507-3521. https://doi.org/https://doi.org/10.1029/1999WR900138

Buisson, L., W. Thuiller, S. Lek, P. Lim, and G. Grenouillet. 2008. Climate change hastens the turnover of stream fish assemblages. Global Change Biology, 14:2232-2248.

Burke, B.J., W.T. Peterson, B.R. Beckman, C. Morgan, E.A. Daly, M. Litz. 2013. Multivariate Models of Adult Pacific Salmon Returns. PLoS ONE 8(1): e54134. https://doi.org/10.1371/journal.pone.0054134

Burnett, K. M. (2006). Comparing Riparian and Catchment Influences on Stream Habitat in a Forested, Montane Landscape. American Fisheries Society Symposium, 48-175-197.

Burroughs, E. R. & Jr. King, J. G. (1985). Surface Erosion Control on Roads in Granitic Soils. in ASCE Convention, Denver, Colorado.

Burroughs, E. R. J. G. K. (1989). Reduction of Soil Erosion on Forest Roads (INT-GTR-264). Retrieved from Intermountain Research Station, Ogden, Utah.

Caissie, D. (2006). The Thermal regime of Rivers: A Review. Freshwater Biology 51(8):1389-1406. https://doi.org/10.1111/j.1365-2427.2006.01597.x

Cannon, K. (2008). Email from Ken Cannon, Oregon Department of Transportation transmitting ODOT 2007 Fish Salvage Report. in M. Liverman, editor. NMFS.

Cannon, K. (2012). Email from Ken Cannon, Oregon Department of Transportation transmitting ODOT 2012 Fish Salvage Report. in M. Liverman, editor. NMFS, NMFS.

Carretta, J. V., E. M. Oleson, K. A. Forney, M. M. Muto, D. W. Weller, A. R. Lang, J. Baker, B. Hanson, A. J. Orr, J. Barlow, J. E. Moore, and R. L. Brownell Jr. 2022. Draft U.S. Pacific Marine Mammal Stock Assessments: 2022. NOAA Fisheries. Revised 9/13/2022. Available at: https://www.fisheries.noaa.gov/s3/2023-01/Draft%202022%20Pacific%20SARs_final.pdf.

Carr-Harris, C. N., Moore, J. W., Gottesfeld, A. S., Gordon, J. A., Shepert, W. M., Henry, J. D. J., . . . Beacham, T. D. (2018). Phenological Diversity of Salmon Smolt Migration Timing within a Large Watershed. Transactions of the American Fisheries Society, 147(5), 775-790. doi:10.1002/tafs.10068

Carroll, S. & Robison, G. E. (2007). The Effects of Large Wood on Stream Channel Morphology on Three Low-Gradient Stream Reaches in the Coastal Redwood Region.

Cederholm, C. J. & Salo, E. O. (1979). The effects of logging road landslide siltation on the salmon and trout spawning gravels of Stequaleho Creek and the Clearwater River basin, Jefferson Co., Washington, 1972-1978 (FRI-UW-7915). Fisheries Research Institute, College of Fisheries, University of Washington, Seattle, Washington.

Cederholm, C. J., Bilby, R. E., Bisson, P. A., Bumstead, T. W., Fransen, B. R., Scarlett, W. J., & Ward, J. W. (1997). Response of Juvenile Coho Salmon and Steelhead to Placement of Large Woody Debris in a Coastal Washington Stream. North American Journal of Fisheries Management, 17(4), 947-963. doi:10.1577/1548-8675(1997)017<0947:Rojcsa>2.3.Co;2

Chan, S. S., Larson, D. J., Maas-Hebner, K. G., Emmingham, W. H., Johnston, S. R., & Mikowski, D. A. (2006). Overstory and understory development in thinned and underplanted Oregon Coast Range Douglas-fir stands. Canadian Journal of Forest Research, 36(10), 2696-2711. doi:10.1139/x06-151

Chapman, D. (1962). Aggressive Behavior in Juvenile Coho Salmon as a Cause of Emigration. Journal of the Fisheries Research Board of Canada 19:1047-1080. https://doi.org/10.1139/f62-069

Chapman, D. W. (1988). Critical Review of Variables Used to Define Effects of Fines in Redds of Large Salmonids. Transactions of the American Fisheries Society 117(1):1-21. https://doi.org/10.1577/1548-8659(1988)117<0001:Crovut>2.3.Co;2

Chasco, B., Burke, B., Crozier, L., & Zabel, R. (2021). Differential impacts of freshwater and marine covariates on wild and hatchery Chinook salmon marine survival. PLoS One, 16(2), e0246659. doi:10.1371/journal.pone.0246659

Chen, C., Sharygin, E., Whyte, M., Loftus, D., Rynerson, C., & Alkitkat, H. (2022a). Coordinated Population Forecast for Coos County, its Urban Growth Boundaries (UGB), and Area Outside UGBs 2022-2072. Population Research Center, Portland State University.

Chen, C., Sharygin, E., Whyte, M., Loftus, D., Rynerson, C., & Alkitkat, H. (2022b). Coordinated Population Forecast for Douglas County, its Urban Growth Boundaries (UGB), and Area Outside UGBs 2022-2072. Population Research Center, Portland State University.

Coe, D. B. R. (2006). Sediment production and delivery from forest roads in the Sierra Nevada, California. Colorado State University Fort Collins, CO, USA.

Cohen, D. & Schwarz, M. (2017). Tree-root control of shallow landslides. Earth Surface Dynamics 5:451-477. https://doi.org/10.5194/esurf-5-451-2017

Cole, E. & Newton, M. (2013). Influence of streamside buffers on stream temperature response following clear-cut harvesting in western Oregon. Canadian Journal of Forest Research 43:993-1005.

Collins, B. D. & Montgomery, D. R. (2002). Forest Development, Wood Jams, and Restoration of Floodplain Rivers in the Puget Lowland, Washington. Restoration Ecology 10(2):237-247. https://doi.org/10.1046/j.1526-100X.2002.01023.x

Collins, B. D., Montgomery, D. R., & Haas, A. D. (2002). Historical changes in the distribution and functions of large wood in Puget Lowland rivers. Canadian Journal of Fisheries and Aquatic Sciences, 59(1), 66-76. doi:10.1139/f01-199

Cooper, M. G., Schaperow, J. R., Cooley, S. W., Alam, S., Smith, L. C., & Lettenmaier, D. P. (2018). Climate Elasticity of Low Flows in the Maritime Western U.S. Mountains. Water Resources Research, 54(8), 5602-5619. doi:10.1029/2018wr022816

Copstead, R. L., & Johansen, D. K. (1998). Water/Road Interaction Series: Examples from Three Flood Assessment Sites in Western Oregon. USDA Forest Service, *Water/Road Interaction Technology Series*, San Dimas Technology and Development Center, San Dimas, California.

Copstead, R. L., Johansen, D. K., & Moll, J. (1998). Water/Road Interaction: Introduction to Surface Cross Drains (Report 9877 1806-SDTDC). San Dimas, California:

Corbett, E. S. & Lynch, J. A. (1985). Management of Streamside Zones on Municipal Watersheds. in R. R. Johnson, C. D. Ziebell, D. R. Patton, P. F. Folliott, & R. H. Hamre, editors. First North American Riparian Conference. USDA Forest Service, Tuscon, Arizona.

Coutant, C. C. (1977). Compilation of Temperature Preference Data. Journal of the Fisheries Research Board of Canada, 34(5), 739-745. doi:10.1139/f77-115

Crozier, L. (2011). Impacts of Climate Change on Columbia River Salmon: A review of the scientific literature published in 2010. Pages D1-D50 in Endangered Species Act Section 7(a)(2) supplemental biological opinion: consultation on remand for operation of the Federal Columbia River Power System. National Marine Fisher Service, West Coast Region.

Crozier, L. (2012). Impacts of Climate Change on Columbia River Salmon: A review of the scientific literature published in 2011. Pages D1-D50 in Endangered Species Act Section 7(a)(2) supplemental biological opinion: consultation on remand for operation of the Federal Columbia River Power System. National Marine Fisher Service, West Coast Region.

Crozier, L. (2013). Impacts of Climate Change on Columbia River Salmon: A review of the scientific literature published in 2012. Pages D1-D50 in Endangered Species Act Section 7(a)(2) supplemental biological opinion: consultation on remand for operation of the Federal Columbia River Power System. National Marine Fisher Service, West Coast Region.

Crozier, L. (2014). Impacts of Climate Change on Columbia River Salmon: A review of the scientific literature published in 2013. Pages D1-D50 in Endangered Species Act Section 7(a)(2) supplemental biological opinion: consultation on remand for operation of the Federal Columbia River Power System. National Marine Fisher Service, West Coast Region.

Crozier, L. 2015. Impacts of Climate Change on Columbia River Salmon: A review of the scientific literature published in 2014. Pages D1-D50 in Endangered Species Act Section 7(a)(2) supplemental biological opinion: consultation on remand for operation of the Federal Columbia River Power System. U.S. National Marine Fisheries Service, Northwest Region.

Crozier, L. (2016). Impacts of Climate Change on Columbia River Salmon: A review of the scientific literature published in 2015. Pages D1-D50 in Endangered Species Act Section 7(a)(2) supplemental biological opinion: consultation on remand for operation of the Federal Columbia River Power System. National Marine Fisheries Service, West Coast Region.

Crozier, L. 2017. Impacts of Climate Change on Columbia River Salmon: A review of the scientific literature published in 2016. Pages D1-D50 in Endangered Species Act Section 7(a)(2) supplemental biological opinion: consultation on remand for operation of the Federal Columbia River Power System. U.S. National Marine Fisheries Service, West Coast Region.

Crozier, L. G., Hendry, A. P., Lawson, P. W., Quinn, T. P., Mantua, N. J., Battin, J., Shaw, R. G., & Huey, R. B. (2008). Potential responses to climate change in organisms with complex life histories: evolution and plasticity in Pacific salmon. Evolutionary Applications 1(2):252-270. https://doi.org/https://doi.org/10.1111/j.1752-4571.2008.00033.x

Crozier, L., & Siegal, J. (2018). Impacts of Climate Change on Columbia River Salmon: A review of the scientific literature published in 2017. Pages D1-D50 in Endangered Species Act Section 7(a)(2) supplemental biological opinion: consultation on remand for operation of the Federal Columbia River Power System. U.S. National Marine Fisheries West Coast Region.

Crozier, L.G., J.E. Seigel, L.E. Wiesebron, E.M. Trujillo, B.J. Burke, B.P. Sanford, and D.L. Webster. 2020. Snake River sockeye and Chinook salmon in a changing climate: implications for upstream migration survival during recent extreme and future climates. PLoS ONE 15(9): e0238886. https://doi.org/10.1371/journal.pone.0238886.

Crozier, L. G., & Zabel, R. W. (2006). Climate impacts at multiple scales: evidence for differential population responses in juvenile Chinook salmon. Journal of Animal Ecology, 75(5), 1100-1109. doi:10.1111/j.1365-2656.2006.01130.x

Crozier, L. G., McClure, M. M., Beechie, T. J., Bograd, S. J., Boughton, D. A., Carr, M. H., Cooney, T. D., Dunham, J. B., Greene, C. M., Haltuch, M. A., Hazen, E. L., Holzer, D. M., Huff, D. D., Johnson, R. C., Jordan, C. E., Kaplan, I. C., Lindley, S. T., Mantua, N. J., Moyle, P. B., Myers, J. M., Nelson, M. W., Spence, B. C., Weitkamp, L. A., Williams, T. H., & Willis-Norton, E. (2019). Climate vulnerability assessment for Pacific salmon and steelhead in the California Current large marine ecosystem. PLoS One 14(7):e0217711. https://doi.org/10.1371/journal.pone.0217711

Crozier, L. G., Scheuerell, M. D., & Zabel, R. W. (2011). Using Time Series Analysis to Characterize Evolutionary and Plastic Responses to Environmental Change: A Case Study of a Shift toward Earlier Migration Date in Sockeye Salmon. The American Naturalist 178(6):755-773. https://doi.org/10.1086/662669

Crozier, L., R.W. Zabel, S. Achord, and E.E. Hockersmith. 2010. Interacting effects of density and temperature on body size in multiple populations of Chinook salmon. Journal of Animal Ecology. 79:342-349.

Davidson, S. L. & Eaton, B. C. (2013). Modeling channel morphodynamic response to variations in large wood: Implications for stream rehabilitation in degraded watersheds. Geomorphology 202:59-73. https://doi.org/https://doi.org/10.1016/j.geomorph.2012.10.005

Davis, L. J., Reiter, M., & Groom, J. D. (2016). Modelling temperature change downstream of forest harvest using Newton's law of cooling. Hydrological Processes 30(6):959-971. https://doi.org/10.1002/hyp.10641

DeWalle, D. R. (2010). Modeling Stream Shade: Riparian Buffer Height and Density as Important as Buffer Width1. Journal of the American Water Resources Association 46(2):323-333. https://doi.org/10.1111/j.1752-1688.2010.00423.x

Dietrich, W. & Dunne, T. (1978). Sediment Budget for a Small Catchment in Mountainous Terrain. Z. Geomorphol. Suppl. 29. https://doi.org/10.1130/0091-7613(2001)029

Dorner, B., Catalano, M. J., & Peterman, R. M. (2018). Spatial and temporal patterns of covariation in productivity of Chinook salmon populations of the northeastern Pacific Ocean. Canadian Journal of Fisheries and Aquatic Sciences, 75(7), 1082-1095. doi:10.1139/cjfas-2017-0197.

Duncan, S. H. (1986). Peak discharge during thirty years of sustained yield timber management in two fifth order watersheds in Washington State. Northwest Science 60:258-264.

Dunham, J., Lockwood, J., & Mebane, C. (2001). Issue Paper 2: Salmonid distributions and temperature. Prepared by US EPA.

Durance, I., and S. Omerod. 2009. Trends in water quality and discharge confound long-term warming effects on river macroinvertebrates. Freshwater Ecology, 54:388-405.

Edwards, P. J., Wood, F., & Quinlivan, R. L. (2016). Effectiveness of Best Management Practices that Have Application to Forest Roads: A LITERATURE SYNTHESIS. United States Department of Agriculture.

EPA (Environmental Protection Agency). (2013). Potential Modeling Approach to Evaluate the Effects of Thinning Activities on Stream Shade. EPA Comment to BLM 11/19/2013., Portland, OR.

Everest, F. H. & Meehan, W. R. (1983). Forest Management and Anadromous Fish Habitat Productivity. in 46th North Amer. In Wildlife and Natural Resources Conf.

Fitzgerald, A. M., S.N. John, T.M. Apgar, N.J. Mantua, and B.T. Martin. (2020). Quantifying thermal exposure for migratory riverine species: Phenology of Chinook salmon populations predicts thermal stress. Global Change Biology, 27:536-549. doi:https://doi.org/10.1111/gcb.15450

Ford, M. J. (2022). Biological Viability Assessment Update for Pacific Salmon and Steelhead Listed under the Endangered Species Act: Pacific Northwest. U.S. National Oceanic and Atmospheric Administration (NOAA), Rockville.

Franklin, J. & Johnson, K. (2012). A Restoration Framework for Federal Forests in the Pacific Northwest. Journal of Forestry 110:429-439. https://doi.org/10.5849/jof.10-006

Franklin, J. F., Johnson, N. K., & Johnson, D. L. (2018). Ecological forest management, Waveland Press.

Freshwater, C., S.C. Anderson, K.R. Holt, A. Huang, and C.A. Holt. 2019. Weakened portfolio effects constrain management effectiveness for population aggregates. Ecological Application 29(7):e01966. doi:10-1002/eap.1966

Glick, P., Clough, J., & Nunley, B. (2007). Sea-Level Rise and Coastal Habitats in the Pacific Northwest: An Analysis for Puget Sound, Southwestern Washington, and Northwestern Oregon. National Wildlife Federation, Seattle, Washington.

Gliwicz, Z. M., Babkiewicz, E., Kumar, R., Kunjiappan, S., & Leniowski, K. (2018). Warming increases the number of apparent prey in reaction field volume of zooplanktivorous fish. Limnology and Oceanography, 63(S1), S30-S43. doi:10.1002/lno.10720

Goldes, S. A., Ferguson, H. W., Moccia, R. D., & Daoust, P. Y. (1988). Histological Effects of the Inert Suspended Clay Kaolin on the Gills of Juvenile Rainbow-Trout, Salmo-Gairdneri Richardson. Journal of Fish Diseases 11(1):23-33. https://doi.org/10.1111/j.1365-2761.1988.tb00520.x

Gomi, T., Moore, R. D., & Hassan, M. A. (2005). Suspended Sediment Dynamics in Small Forest Streams of the Pacific Northwest. Journal of the American Water Resources Association 41(4):877-898. https://doi.org/10.1111/j.1752-1688.2005.tb03775.x

Gosselin, J. L., Buhle, E. R., Van Holmes, C., Beer, W. N., Iltis, S., & Anderson, J. J. (2021). Role of carryover effects in conservation of wild Pacific salmon migrating regulated rivers. Ecosphere, 12(7). doi:10.1002/ecs2.3618

Gourtay, C., Chabot, D., Audet, C., Le Delliou, H., Quazuguel, P., Claireaux, G., & Zambonino-Infante, J.-L. (2018). Will global warming affect the functional need for essential fatty acids in juvenile sea bass (Dicentrarchus labrax)? A first overview of the consequences of lower availability of nutritional fatty acids on growth performance. Marine Biology, 165(9). doi:10.1007/s00227-018-3402-3

Grant, G. E., Lewis, S. L., Swanson, F. J., Cissel, J. H., & McDonnell, J. J. (2008). Effects of forest practices on peak flows and consequent channel response: a state-of-science report for western Oregon and Washington. Portland, OR.

Great Lakes Environmental Center. (2008). National Level Assessment of Water Quality Impairments Related to Forest Roads and Their Prevention by Best Management Practices Final Report.

Gregory, S. V., Boyer, K. L., & Gurnell, A. M. (2003). The Ecology and Management of Wood in World Rivers: Riparian Management for Wood in Rivers.

Gregory, S. V., Lamberti, G. A., Erman, D. C., Koski, K. V., Murphy, M. L., & Sedell, J. R. (1987). Influence of forest practices on aquatic production. Pages 233-255 in E. O. Salo & T. W. Cundy, editors. Streamside Management: Forestry and Fishery Interactions, volume 57. College of Forest Resources, University of Washington, Seattle, WA.

Gregory, S. V., Boyer, K. L., & Gurnell, A. M. (2003). The Ecology and Management of Wood in World Rivers: Riparian Management for Wood in Rivers. American Fisheries Society Symposium 37, Bethesda, Maryland

Groom, J. D., Dent, L., & Madsen, L. J. (2011a). Stream temperature change detection for state and private forests in the Oregon Coast Range. Water Resources Research 47(1). https://doi.org/10.1029/2009wr009061

Groom, J. D., Dent, L., Madsen, L. J., & Fleuret, J. (2011b). Response of western Oregon (USA) stream temperatures to contemporary forest management. Forest Ecology and Management 262(8):1618-1629. https://doi.org/10.1016/j.foreco.2011.07.012

Groom, J. D., Johnson, S. L., Seeds, J. D., & Ice, G. G. (2017). Evaluating Links between Forest Harvest and Stream Temperature Threshold Exceedances: The Value of Spatial and Temporal Data. Journal of the American Water Resources Association, 53(4), 761-773. doi:10.1111/1752-1688.12529

Groom, J. D., Madsen, L. J., Jones, J. E., & Giovanini, J. N. (2018). Informing changes to riparian forestry rules with a Bayesian hierarchical model. Forest Ecology and Management 419-420:17-30. https://doi.org/https://doi.org/10.1016/j.foreco.2018.03.014

Gustafson, R. G., Ford, M. J., Teel, D. J., & Drake, J. S. (2010). Status Review of Eulachon (Thaleichthys pacificus) in Washington, Oregon, and California.

Hairiah, K., Widianto, W., Suprayogo, D., & Van Noordwijk, M. (2020). Tree Roots Anchoring and Binding Soil: Reducing Landslide Risk in Indonesian Agroforestry. Land 9(8):256.

Halofsky, J. E., Peterson, D. L., & Harvey, B. J. (2020). Changing wildfire, changing forests: the effects of climate change on fire regimes and vegetation in the Pacific Northwest, USA. Fire Ecology, 16(1). doi:10.1186/s42408-019-0062-8

Halofsky, J. S., Conklin, D. R., Donato, D. C., Halofsky, J. E., & Kim, J. B. (2018). Climate change, wildfire, and vegetation shifts in a high-inertia forest landscape: Western Washington, U.S.A. PLoS One, 13(12), e0209490. doi:10.1371/journal.pone.0209490

Hanson, M. B., C. K. Emmons, E. J. Ward, J. A. Nystuen, and M. O. Lammers. 2013. Assessing the coastal occurrence of endangered killer whales using autonomous passive acoustic recorders. The Journal of the Acoustical Society of America 134(5):3486–3495.

Hanson, M. B., Emmons, C. K., Ford, M. J., Everett, M., Parsons, K., Park, L. K., Hempelmann, J., Van Doornik, D. M., Schorr, G. S., Jacobsen, J. K., Sears, M. F., Sears, M. S., Sneva, J. G., Baird, R. W., & Barre, L. (2021). Endangered Predators and Endangered Prey: Seasonal Diet of Southern Resident Killer Whales. PLoS One 16(3):e0247031. https://doi.org/10.1371/journal.pone.0247031

Harmon, M. E., Franklin, J. F., Swanson, F. J., Sollins, P., Gregory, S. V., Lattin, J. D., Anderson, N. H., Cline, S. P., Aumen, N. G., Sedell, J. R., Lienkaemper, G. W., Cromack, K., & Cummins, K. W. (1986). Ecology of Coarse Woody Debris in Temperate Ecosystems. Pages 133-302 in A. MacFadyen & E. D. Ford, editors. Advances in Ecological Research, volume 15. Academic Press.

Harr, R. D. (1976). Hydrology of small forest streams in western Oregon. USDA, Denver, CO.

Harr, R. D. (1982). Fog Drip in the Bull Run Municipal Watershed, Oregon. JAWRA Journal of the American Water Resources Association 18(5):785-789. https://doi.org/https://doi.org/10.1111/j.1752-1688.1982.tb00073.x

Harr, R. D. & Coffin, B. A. (1992). Influence of Timber Harvest on Rain-On-Snow Runoff: A Mechanism for Cumulative Watershed Effects. Inierdisciplromy Approaches in Hydrology and Hydrogeology:455-469.

Harr, R. D., Harper, W. C., Krygier, J. T., & Hsieh, F. S. (1975). Changes in storm hydrographs after road building and clear-cutting in the Oregon Coast Range. Water Resources Research 11(3):436-444. https://doi.org/10.1029/WR011i003p00436

Hay, D. & McCarter, P. (2000). Status of the eulachon Thaleicthys pacificus in Canada.

Healey, M. (2011). The cumulative impacts of climate change on Fraser River sockeye salmon (Oncorhynchus nerka) and implications for management. Canadian Journal of Fisheries and Aquatic Sciences, 68(4), 718-737. doi:10.1139/f2011-010

Herring, S. C., Christidis, N., Hoell, A., Kossin, J. P., Schreck, C. J., & Stott, P. A. (2018). Explaining Extreme Events of 2016 from a Climate Perspective. Bulletin of the American Meteorological Society 99(1):S1-S157. https://doi.org/10.1175/bams-explainingextremeevents2016.1

Hicks, B. J., Beschta, R. L., & Harr, R. D. (1991). Long-Term Changes in Streamflow Following Logging in Western Oregon and Associated Fisheries Implications. Water Resources Bulletin 27(2):217-226. https://doi.org/10.1111/j.1752-1688.1991.tb03126.x

Hicks, M. (2000). Evaluating Standards for Protecting Aquatic Life In Washington’s Surface Water Quality Standards.

Hilborn, R., S.P., C., Gulland, F. M. D., Hankin, D. G., Hobbs, N. T., Schindler, D. E., & Trites, A. W. (2012). The Effects ofSalmon Fisheries on Southern ResidentKiller Whales: Final Report of the Independent Science Panel. National Marine Fisheries Service and Fisheries and Oceans Canada, Seattle, WA and Vancouver, BC.

Hofmeister, R.J. 2000. Slope failures in Oregon: GIS inventory for three 1996/97 storm events. Oregon Department of Geology and Mineral Industries Special Paper 34.

Holden, Z. A., Swanson, A., Luce, C. H., Jolly, W. M., Maneta, M., Oyler, J. W., . . . Affleck, D. (2018). Decreasing fire season precipitation increased recent western US forest wildfire activity. Proceedings of the National Academy of Sciences, 115(36), E8349-E8357. doi:10.1073/pnas.1802316115

Holsman, K. K., Scheuerell, M. D., Buhle, E., & Emmett, R. (2012). Interacting Effects of Translocation, Artificial Propagation, and Environmental Conditions on the Marine Survival of Chinook Salmon from the Columbia River, Washington, U.S.A. Conservation Biology, 26(5), 912-922. doi:10.1111/j.1523-1739.2012.01895.x

Huff, D. D., Lindley, S. T., Wells, B. K., & Chai, F. (2012). Green Sturgeon Distribution in the Pacific Ocean Estimated from Modeled Oceanographic Features and Migration Behavior. PLoS One 7(9):e45852. https://doi.org/10.1371/journal.pone.0045852

ICF. 2024. Elliott State Research Forest Habitat Conservation Plan. Final. December. (ICF 103681.0.001.) Seattle, Washington. Prepared for Oregon Department of State Lands, Salem, Oregon.

IPCC (Intergovernmental Panel on Climate Change). 2021. Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.). Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 2391 pp. doi:10.1017/9781009157896.

IPCC (Intergovernmental Panel on Climate Change). 2022. Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 3-33, doi:10.1017/9781009325844.001.

Isaak, D. J., Wenger, S. J., Peterson, E. E., Ver Hoef, J. M., Nagel, D. E., Luce, C. H., . . . Parkes-Payne, S. (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 Predicty Broad Climate Warming of Rivers and Streams. Water Resources Research(53), 9181-9205. doi:https://doi.org/10.1002/2017WR020969

Isaak, D. J., Luce, C. H., Horan, D. L., Chandler, G. L., Wollrab, S. P., & Nagel, D. E. (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(3), 566-587. doi:10.1002/tafs.10059

Jacox, M. G., Alexander, M. A., Mantua, N. J., Scott, J. D., Hervieux, G., Webb, R. S., & Werner, F. E. (2018). Forcing of multi-year extreme ocean temperatures that impacted California Current living marine resources in 2016. Bulletin of the American Meteorological Society 99(1).

Jager, H. I., Cardwell, H. E., Sale, M. J., Bevelhimer, M. S., Coutant, C. C., & VanWinkle, W. (1997). Modelling the linkages between flow management and salmon recruitment in rivers. Ecological Modelling 103(2-3):171-191. https://doi.org/10.1016/S0304-3800(97)00084-7

Johnson, A. C., Swanston, D. N., & McGee, K. E. (2000). Landslide Initiation, Runout, and Deposition Within Clearcuts and Old-Growth Forests Of Alaska. JAWRA Journal of the American Water Resources Association, 36(1), 17-30. doi:10.1111/j.1752-1688.2000.tb04245.x

Johnson, B.M., G.M. Kemp, and G.H. Thorgaard. 2018. Increased mitochondrial DNA diversity in ancient Columbia River basin Chinook salmon Oncorhynchus tshawytscha. PLoS One, 13(1), p.e0190059.

Jones, J. A. (2000). Hydrologic processes and peak discharge response to forest removal, regrowth, and roads in 10 small experimental basins, western Cascades, Oregon. Water Resources Research 36(9):2621-2642. https://doi.org/10.1029/2000WR900105

Jones, J. A. & Grant, G. E. (1996). Peak Flow Responses to Clear-Cutting and Roads in Small and Large Basins, Western Cascades, Oregon. Water Resources Research 32(4):959-974. https://doi.org/https://doi.org/10.1029/95WR03493

Jordan, T., Correll, D., & Weller, D. (1993). Nutrient Interception by a Riparian Forest Receiving Inputs From Adjacent Cropland. Journal of Environmental Quality - J ENVIRON QUAL 22. https://doi.org/10.2134/jeq1993.00472425002200030010x

Keefer M.L., T.S. Clabough, M.A. Jepson, E.L. Johnson, C.A. Peery, C.C. Caudill. 2018. Thermal exposure of adult Chinook salmon and steelhead: Diverse behavioral strategies in a large and warming river system. PLoS ONE 13(9): e0204274. https://doi.org/10.1371/journal.pone.0204274

Keith, R. M., Bjornn, T. C., Meehan, W. R., Hetrick, N. J., & Brusven, M. A. (1998). Response of Juvenile Salmonids to Riparian and Instream Cover Modifications in Small Streams Flowing through Second-Growth Forests of Southeast Alaska. Transactions of the American Fisheries Society 127(6):889-907. https://doi.org/10.1577/1548-8659(1998)127<0889:Rojstr>2.0.Co;2

Kemp, P. S., Sear, D., Collins, A., Naden, P., & Jones, I. (2011). The Impacts of fine sediment on riverine fish. Hydrological Processes 25(11):1800-1821. https://doi.org/10.1002/hyp.7940

Keppeler, E. T., & Ziemer, R. R. (1990). Logging effects on streamflow: Water yield and summer low flows at Caspar Creek in northwestern California. Water Resources Research, 26(7), 1669-1679. doi:10.1029/wr026i007p01669

Ketcheson, G. L. & Megahan, W. F. (1996). Sediment Production and Downslope Sediment Transport from Forest Roads in Granitic Watersheds.

Kiffney, P. M., Richardson, J. S., & Bull, J. P. (2003). Responses of periphyton and insects to experimental manipulation of riparian buffer width along forest streams. Journal of Applied Ecology 40(6):1060-1076. https://doi.org/10.1111/j.1365-2664.2003.00855.x

Kilduff, D. P., Botsford, L. W., & Teo, S. L. H. (2014). Spatial and Temporal Covariability in Early Ocean Survival of Chinook Salmon (Oncorhynchus Tshawytscha) Along the West Coast of North America. ICES Journal of Marine Science, 71(7), 1671-1682. doi:10.1093/icesjms/fsu031

Kochenderfer, J. N. & Helvey, J. D. (1987). Using gravel to reduce soil losses from minimum-standard forest roads. Journal of Soil and Water Conservation 42:46-50.

Koontz, E. D., Steel, E. A., & Olden, J. D. (2018). Stream thermal responses to wildfire in the Pacific Northwest. Freshwater Science, 37(4), 731-746. doi:10.1086/700403

Koski, K. V. (2009). The Fate of Coho Salmon Nomads: The Story of an Estuarine-Rearing Strategy Promoting Resilience. Ecology and Society 14(1).

Kramer, N. & Wohl, E. (2017). Rules of the road: A qualitative and quantitative synthesis of large wood transport through drainage networks. Geomorphology 279:74-97. https://doi.org/10.1016/j.geomorph.2016.08.026

Kreutzweiser, D. P., Capell, S. S., & Holmes, S. B. (2009). Stream temperature responses to partial-harvest logging in riparian buffers of boreal mixedwood forest watersheds. Canadian Journal of Forest Research, 39(3), 497-506. doi:10.1139/x08-191

Krosby, M., Theobald, D. M., Norheim, R., & McRae, B. H. (2018). Identifying riparian climate corridors to inform climate adaptation planning. PLoS One, 13(11), e0205156. doi:10.1371/journal.pone.0205156

Kunkel, K. E., Stevens, L. E., Stevens, S. E., Sun, L., Janssen, E., Wuebbles, D., Redmond, K. T., & Dobson, J. G. (2013). Regional Climate Trends and Scenarios for the U.S. National Climate Assessment: Part 6. Pages 83 in N. E. S. National Oceanic and Atmospheric Administration, Data, and Information Service, editor, Washington, D.C.

Lakel, W. A., Aust, W. M., Bolding, M. C., Dolloff, C. A., Keyser, P., & Feldt, R. (2010). Sediment Trapping by Streamside Management Zones of Various Widths after Forest Harvest and Site Preparation. Forest Science 56(6):541-551. https://doi.org/10.1093/forestscience/56.6.541

Lancaster, S. T., Hayes, S. K., & Grant, G. E. (2003). Effects of wood on debris flow runout in small mountain watersheds. Water Resources Research 39(6). https://doi.org/https://doi.org/10.1029/2001WR001227

Lawson, P. W., Bjorkstedt, E. P., Chilcote, M. W., Huntington, C. W., Mills, J. S., Moore, K. M. S., Nickelson, T. E., Reeves, G. H., Stout, H. A., Wainwright, T. C., & Weitkamp, L. A. (2007). Identification of HistoricaI Populations of Coho Salmon (Oncorhynchus kisutch) in the Oregon Coast Evolutionarily Significant Unit.

Lee, D. C., J. R. Sedell, B. E. Rieman, R. F. Thurow, and J. E. Williams. 1997. Broadscale assessment of aquatic species and habitats. U.S. Forest Service, General Technical Report PNW-GTR-405 (volume 3), Portland, Oregon.

Leinenbach, P., 2011. Technical analysis associated with SRT Temperature Subgroup to assess the potential shadow length associated with riparian vegetation.

Leinenbach, P., McFadden, G., & Torgersen, C. E. (2013). Effects of Riparian Management Strategies on Stream Temperature. USEPA, Seattle WA, U.S. Geological Survey, Seattle WA, BLM, Portland OR.

Lesmeister, D. B., Davis, R. J., Singleton, P. H., & Wiens, D. (2018). Northern Spotted Owl Habitat and Populations: Status and Threats. Synthesis Of Science to Inform Land Management Within the Northwest Forest Plan Area, volume 2. USDA Forest Service, Pacific Northwest Research Station.

Lewis, M. 2015. NOAA Fisheries DSS for Oregon Coast Coho ESU. 2015 Five Year Status Review Update. Report by Mark Lewis, Oregon Department of Fish and Wildlife, Corvallis Research Lab, September 2015.

Lewis, M. 2020. NOAA Fisheries DSS for Oregon Coast Coho ESU: 2020 Five Year Status Review Update. Oregon Department of Fish and Wildlife, Salem, Oregon.

Lindley, S. T., Erickson, D. L., Moser, M. L., Williams, G., Langness, O. P., McCovey, B. W., Belchik, M., Vogel, D., Pinnix, W., Kelly, J. T., Heublein, J. C., & Klimley, A. P. (2011). Electronic Tagging of Green Sturgeon Reveals Population Structure and Movement among Estuaries. Transactions of the American Fisheries Society 140(1):108-122. https://doi.org/10.1080/00028487.2011.557017

Lindley, S. T., Grimes, C. B., Mohr, M. S., Peterson, W., Stein, J., Anderson, J. T., L.W. Botsford, D.L. Bottom, C.A. Busack, T.K. Collier, J. Ferguson, J.C. Garza, A.M. Grover, D.G. Hankin, R.G. Kope P.W. Lawson, A. Low, R.B. MacFarlane, K. Moore, M. Palmer-Zwahlen, F.B. Schwing, J. Smith, C. Tracy, R. Webb, B.K. Wells, and T.H. Williams. 2009. What caused the Sacramento River fall Chinook stock collapse? NOAA-TM-NMFS-SWFSC-447. National Marine Fisheries Service, Southwest Fisheries Science Center, Santa Cruz, California.

Lindley, S. T., Moser, M. L., Erickson, D. L., Belchik, M., Welch, D. W., Rechisky, E. L., Kelly, J. T., Heublein, J., & Klimley, A. P. (2008). Marine Migration of North American Green Sturgeon. Transactions of the American Fisheries Society 137(1):182-194. https://doi.org/10.1577/t07-055.1

Lisle, T. E. & Lewis, J. (1992). Effects of Sediment Transport on Survival of Salmonid Embryos in a Natural Stream - a Simulation Approach. Canadian Journal of Fisheries and Aquatic Sciences 49(11):2337-2344. https://doi.org/10.1139/f92-257

Lloyd, D. S. (1987). Turbidity as a Water Quality Standard for Salmonid Habitats in Alaska. North American Journal of Fisheries Management, 7(1), 34-45. doi:10.1577/1548-8659(1987)7<34:Taawqs>2.0.Co;2

Lowrance, R., Todd, R., Fail, J., Hendrickson, O., Leonard, R., & Asmussen, L. (1984). Riparian Forests as Nutrient Filters in Agricultural Watersheds. BioScience 34(6):374-377. https://doi.org/10.2307/1309729

Luce, C. H. & Black, T. A. (1999). Sediment production from forest roads in western Oregon. Water Resources Research 35(8):2561-2570. https://doi.org/10.1029/1999wr900135

Luce, C. H. & Black, T. A. (2001). Effects of Traffic and Ditch Maintenance on Forest Road Sediment Production. in Seventh Federal Interagency Sedimentation Conference.

Macdonald, J. S., Scrivener, J. C., Patterson, D. A., & Dixon-Warren, A. (1998). Temperatures in aquatic habitats: the impacts of forest harvesting and the biological consequences to sockeye salmon incubation habitats in the interior of B.C. in M.K. Brewing and D.M.A. Monita (eds.) Forest-Fish Conference: Land Management Practices Affecting Aquatic Ecosystems. Natural Resources Canada, Canadian Forest Service Information Report NOR-X-356: 313-324.

Macdonald, J.S., E.A. MacIsaac, and H.E. Herunter. 2003. The Effect of Variable-Retention Riparian Buffer Zones on Water Temperatures in Small Headwater Streams in Sub-Boreal Forest Ecosystems of British Columbia. Canadian Journal of Forest Research 33(8):1371–1382.

Malek, K., Adam, J. C., Stöckle, C. O., & Peters, R. T. (2018). Climate change reduces water availability for agriculture by decreasing non-evaporative irrigation losses. Journal of Hydrology, 561, 444-460. doi:10.1016/j.jhydrol.2017.11.046

Marine, K. R. (1992). A Backgroung Investigation and Review of the Effects of Elevated Water Temperature on Reproductive Performance of Adult Chinook Salmon (Oncorhyncus tshawytscha) with Suggestions for Approaches to the Assessment of Temperature Induced Reproductive Impairment of Chinook Salmon Stocks in the American River, California. University of California.

Marine, K. R. & Cech Jr, J. J. (2004). Effects of High Water Temperature on Growth, Smoltification, and Predator Avoidance in Juvenile Sacramento RiverChinook Salmon. North American Journal of Fisheries Management 24(1):198-210. https://doi.org/https://doi.org/10.1577/M02-142

Martin, D. J. & Benda, L. (2001). Patterns of Instream Wood Recruitment and Transport at the Watershed Scale. Transactions of the American Fisheries Society 130(5):940-958. https://doi.org/10.1577/1548-8659(2001)130<0940:Poiwra>2.0.Co;2

Mason, J. C. & Chapman, D. W. (1965). Significance of Early Emergence, Environmental Rearing Capacity, and Behavioral Ecology of Juvenile Coho Salmon in Stream Channels. Journal of the Fisheries Research Board of Canada 22(1):173-190. https://doi.org/10.1139/f65-015

Materna, E. (2001). Issue Paper 4: temperature interaction. US Environmental Protection Agency Temperature Water Quality Criteria Guidance Development Project Report EPA-910-D-01-004, Seattle, Washington.

May, C. & Lee, D. (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 - NORTH AM J FISH MANAGE 24:761-774. https://doi.org/10.1577/M03-073.1

May, C. L. (2002). Debris Flows Through Different Forest Age Classes in the Central Oregon Coast Range. JAWRA Journal of the American Water Resources Association 38(4):1097-1113. https://doi.org/https://doi.org/10.1111/j.1752-1688.2002.tb05549.x

MacCracken, J.G., M.P. Hayes, J.A. Tyson, and J.L. Stebbings. 2018. Stream-Associated Amphibian Response to Manipulation of Forest Canopy Shading. Cooperative Monitoring Evaluation and Research Report CMER #16-1600, Washington State Forest Practices Adaptive Management Program, Washington Department of Natural Resources, Olympia, WA.

McCullough, D. A. (1999). A review and synthesis of effects of alterations to the water temperature regime on freshwater life stages of salmonids, with special reference to Chinook salmon, US Environmental Protection Agency, Region 10.

McCullough, D. A., Spalding, S., Sturdevant, D., & Hicks, M. (2001). Issue Paper 5: Summary of Technical Literature Examining the Physiological Effects of Temperature on Salmonids. EPA, EPA-910-D-01-005.

McDade, M. H., Swanson, F. J., McKee, W. A., Franklin, J. F., & Sickle, J. V. (1990). Source distances for coarse woody debris entering small streams in western Oregon and Washington. Canadian Journal of Forest Research 20(3):326-330. https://doi.org/10.1139/x90-047

McElhany, P., Ruckelshaus, M. H., Ford, M. J., Wainwright, T. C., & Bjorkstedt, E. P. (2000). Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units.

McMichael, G. A., Fritts, A. L., & Pearsons, T. N. (1998). Electrofishing Injury to Stream Salmonids; Injury Assessment at the Sample, Reach, and Stream Scales. North American Journal of Fisheries Management 18(4):894-904. https://doi.org/10.1577/1548-8675(1998)018<0894:EITSSI>2.0.CO;2

Megahan, W. F., Day, N. F., & Bliss, T. M. (1979). Landslide occurrence in the western and central northern Rocky Mountain physiographic province in Idaho.

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, D. J. & Burnett, K. M. (2007). Effects of forest cover, topography, and sampling extent on the measured density of shallow, translational landslides. Water Resources Research 43(3). https://doi.org/10.1029/2005wr004807

Miller, D. & Carlson D. 2024. Modeling the Sources of Large Wood Recruited to Fish-bearing Streams by Debris-Flow Processes in the Oregon Coast Range. Appendix E to the Elliott State Research Forest Habitat Conservation Plan.

Montgomery, D., Greenberg, H., Laprade, W., & Nashem, W. (2001). Sliding in Seattle: Test of a model of shallow landsliding potential in an urban environment. Water Science and Application, 2:59-73.

Montgomery, D., Beamer, E., Pess, G., & Quinn, T. (1999). Channel Type and Salmonid Spawning Distribution and Abundance. Canadian Journal of Fisheries and Aquatic Sciences - CAN J FISHERIES AQUAT SCI 56:377-387. https://doi.org/10.1139/cjfas-56-3-377

Montgomery, D. R., Abbe, T. B., Buffington, J. M., Peterson, N. P., Schmidt, K. M., & Stock, J. D. (1996). Distribution of bedrock and alluvial channels in forested mountain drainage basins. Nature 381(6583):587-589. https://doi.org/10.1038/381587a0

Moore, G., Bond, B., Jones, J., Phillips, N., & Meinzer, F. (2004). Structural and compositional controls on transpiration in 40-and 450-year-old riparian forests in western Oregon, USA. Tree physiology 24:481-91. https://doi.org/10.1093/treephys/24.5.481

Moore, R. D. & Wondzell, S. M. (2005). Physical Hydrology and the Effects of Forest Harvesting in the Pacific Northwest: A Review. Journal of the American Water Resources Association 41(4):763-784. https://doi.org/10.1111/j.1752-1688.2005.tb04463.x

Moser, M. L. & Lindley, S. T. (2007). Use of Washington Estuaries by Subadult and Adult Green Sturgeon. Environmental Biology of Fishes 79(3-4):243-253. https://doi.org/10.1007/s10641-006-9028-1

Mote, P., Snover, A. K., Capalbo, S., Eigenbrode, S. D., Glick, P., Littell, J., Raymondi, R., & Reeder, S. (2014). Ch. 21: Northwest. J. M. Melillo, T. T. C. Richmond, & G. W. Yohe, editors. Climate Change Impacts in the United States: The Third National Climate Assessment. U.S. Global Change Research Program, 487-513.

Munsch, S. H., Greene, C. M., Mantua, N. J., & Satterthwaite, W. H. (2022). One hundred-seventy years of stressors erode salmon fishery climate resilience in California's warming landscape. Global Change Biology, 28(7), 2183-2201. doi:10.1111/gcb.16029

Myers, J.M., J. Jorgensen, M. Sorel, M. Bond, T. Nodine, and R. Zabel. 2018. Upper Willamette River Life Cycle Modeling and the Potential Effects of Climate Change. Draft Report to the U.S. Army Corps of Engineers. Northwest Fisheries Science Center. 1 September 2018.

Nawa, R. & Frissell, C. (1994). Measuring Scour and Fill of Gravel Streambeds with Scour Chains and Sliding-Bead Monitors. North American Journal of Fisheries Management 13:634-639. https://doi.org/10.1577/1548-8675(1993)013<0634:MSAFOG>2.3.CO;2

Neuheimer, A.B., and C.T. Taggart. 2007. The Growing Degree-Day and Fish Size-at-Age: The Overlooked Metric. Canadian Journal of Fisheries and Aquatic Sciences 64:375–385.

Newcombe, C. P. (2003). Impact Assessment Model for Clear Water Fishes Exposed To Excessively Cloudy Water 1. Journal of the American Water Resources Association / 39(3):529-544. https://doi.org/10.1111/j.1752-1688.2003.tb03674.x

Newcombe, C. P. & Jensen, J. O. (1996). Channel Suspended Sediment and Fisheries: A Synthesis for Quantitative Assessment of Risk and Impact. North American Journal of Fisheries Management 16:693-727. https://doi.org/10.1577/1548-8675(1996)016<0693:CSSAFA>2.3.CO;2

Nicholas, J., McIntosh, B., Bowles, E., Board, O. W. E., & Wildlife, O. D. o. F. a. (2005). Coho assessment, Part 1: Synthesis final report. Salem, OR.

Nickelson, T. E. & Lawson, P. (1998). Population viability of coho salmon Oncorhynchus kisutch in Oregon coastal basins: application of a habitat-based life cycle model. Canadian Journal of Fisheries and Aquatic Sciences 55(55):2383-2392. https://doi.org/10.1139/f98-123

Nickelson, T. E., Rodgers, J. D., Johnson, S. L., & 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(4):783-789. https://doi.org/10.1139/F92-088

NMFS (National Marine Fisheries Service). (2000). Guidelines for electrofishing waters containing salmonids listed under the Endangered Species Act. June 2000. in.

NMFS (National Marine Fisheries Service). (2005). Memorandum from Tracy K. Collier to Rob Markle; Timber Harvest and Streamflow. N. M. F. S. NOAA, editor.

NMFS (National Marine Fisheries Service). 2007. Designation of Critical Habitat for Oregon Coast Coho Final 4(b)(2) Report. National Marine Fisheries Service, Northwest Region, Portland, Oregon. December 2007.

NMFS (National Marine Fisheries Service). 2008. Recovery Plan for Southern Resident Killer Whales (*Orcinus orca*). National Marine Fisheries Service, Northwest Regional Office. January 17, 2008. 251 pages.

NMFS (National Marine Fisheries Service). (2015). Southern Distinct Population Segment of the North American Green Sturgeon (Acipenser medirostris) 5-Year Review : Summary and Evaluation. National Marine Fisheries Service, West Coast Region, Long Beach, California.

NMFS (National Marine Fisheries Service). (2016a). Recovery Plan for Oregon Coast Coho Salmon Evolutionarily Significant Unit. National Marine Fisheries Service, West Coast Region, Portland, Oregon.

NMFS (National Marine Fisheries Service). (2016b). Southern Resident Killer Whales (Orcinus orca) 5-Year Review: Summary and Evaluation. National Marine Fisheries Service, West Coast Region, Seattle, Washington.

NMFS (National Marine Fisheries Service). (2017). Recovery Plan for the Southern Distinct Population Segment of Eulachon (Thaleichthys pacificus). National Marine Fisheries Service, West Coast Region, Protected Resources Division, Portland, Oregon.

NMFS (National Marine Fisheries Service). (2021a). Southern Resident Killer Whales (Orcinus Orca) 5-Year Review: Summary and Evaluation [2021]. National Marine Fisheries Service, West Coast Region, Seattle, Washington.

NMFS (National Marine Fisheries Service). (2021b). 2021 Southern Distinct Population Segment of the North American Green Sturgeon (Acipenser medirostris) 5-Year Review: Summary and Evaluation. National Marine Fisheries Service, California Central Valley Office, West Coast Region, Sacramento, California.

NMFS (National Marine Fisheries Service). (2022a). Guidelines for Salmonid Passage at Stream Crossings in Oregon, Washington, and Idaho. National Marine Fisheries Service, West Coast Region, Portland, Oregon.

NMFS (National Marine Fisheries Service). (2022b). 2022 5-Year Review: Summary & Evaluation of Oregon Coast Coho Salmon. National Marine Fisheries Service, West Coast Region, Portland, Oregon.

NOAA National Centers for Environmental Information (NCEI), State of the Climate: Global Climate Report for Annual 2021, published online January 2022, retrieved on February 28, 2022 from https://www.ncdc.noaa.gov/sotc/global/202113.

Noggle, C. C. (1978). Behavioral, Physiological and Lethal Effects of Suspended Sediment on Juvenile Salmonids.

Nunamaker, C., Leblanc, J. P., Nakamura, G. M., & Valachovic, Y. S. (2007). Forest Stewardship Series 17: Forest Roads. in.

NWFSC (Northwest Fisheries Science Center). (2015). Status Review Update for Pacific Salmon and Steelhead Listed under the Endangered Species Act: Pacific Northwest. Northwest Fisheries Science Center, National Marine Fisheries Service, Seattle, Washington.

ODF (Oregon Department of Forestry). (2000). Forest Roads Manual, Oregon Department of Forestry, State Forests Program, Salem, Oregon

ODF (Oregon Department of Forestry). (2003). Determination of Rapidly Moving Landslide Impact Rating. Forest Practices Technical Note Number 6, Version 1.0.

ODFW (Oregon Department of Fish and Wildlife). (2005). Oregon Coastal Coho assessment part 4: The Importance of Beaver (Castor Canadensis) to Coho Habitat and Trend in Beaver Abundance in the Oregon Coast Coho ESU.

ODFW (Oregon Department of Fish and Wildlife). (2007). Oregon Coast Coho Conservation Plan for the State of Oregon. Oregon Department of Fish and Wildlife, Salem, Oregon.

ODFW (Oregon Department of Fish and Wildlife). (2024). Oregon Guidelines for Timing of In-Water Work to Protect Fish and Wildlife Resources. Oregon Department of Fish and Wildlife, Salem, Oregon.

ODSL (Oregon Department of State Lands) and ODF (Oregon Department of Forestry) 2011. Elliott State Forest Management Plan. Salem, Oregon.

Ohlberger, J., Ward, E. J., Schindler, D. E., & Lewis, B. (2018). Demographic changes in Chinook salmon across the Northeast Pacific Ocean. Fish and Fisheries, 19(3), 533-546. doi:10.1111/faf.12272

Olmos, M., Payne, M. R., Nevoux, M., Prévost, E., Chaput, G., Du Pontavice, H., . . . Rivot, E. (2020). Spatial synchrony in the response of a long range migratory species (<i>Salmo salar</i>) to climate change in the North Atlantic Ocean. Global Change Biology, 26(3), 1319-1337. doi:10.1111/gcb.14913

OSU (Oregon State University). 2014. Aquatic invasions! A menace to the West. Species Guide: Knotweed. Oregon State University, Corvallis, Oregon.

OSU (Oregon State University). 2020. Modeled Stream Network for the Elliott State Forest. GIS dataset.

OSU (Oregon State University). (2021). Elliott State Research Forest Proposal Oregon State University, Corvallis, Oregon. *in* Appendix C of the Elliott State Forest Habitat Conservation Plan.

Ou, M., Hamilton, T. J., Eom, J., Lyall, E. M., Gallup, J., Jiang, A., Lee, J., Close, D.A., Yun, S., and Brauner, C. J. (2015). Responses of pink salmon to CO2-induced aquatic acidification. Nature Climate Change, 5(10), 950-955. doi:10.1038/nclimate2694

OWEB (Oregon Watershed Enhancement Board) (1999). Oregon Watershed Assessment Manual. Oregon Watershed Enhancement Board, Salem, Oregon.

Packer, P. E. (1967). Criteria for Designing and Locating Logging Roads to Control Sediment. Forest Science 13(1):2-18. https://doi.org/10.1093/forestscience/13.1.2

Peterson, J. T., Thurow, R. F., & Guzevich, J. W. (2004). An Evaluation of Multipass Electrofishing for Estimating the Abundance of Stream-Dwelling Salmonids. Transactions of the American Fisheries Society 133(2):462-475. https://doi.org/10.1577/03-044

Peterson, N. P. & Quinn, T. P. (1996). Spatial and temporal variation in dissolved oxygen in natural egg pockets of chum slamon, in Kennedy Creek, Washington. Journal of Fish Biology 48:131-143. https://doi.org/10.1111/j.1095-8649.1996.tb01424.x

PFMC. (2020). Pacific Fishery Management Council Salmon Fishery Management Plan Impacts to Southern Resident Killer Whales.

Phillips, C., Marden, M., & Basher, L. (2012). Plantation forest harvesting and landscape response - What we know and what we need to know. New Zealand Journal of Forestry 56:4-12.

Phillips, J. (1997). Caulked boots and cheese sandwiches : a forester's history of Oregon's first State Forest, "The Elliott" (1912-1996).

Picchio, R., Mederski, P., & Tavankar, F. (2020). How and How Much, Do Harvesting Activities Affect Forest Soil, Regeneration and Stands? Current Forestry Reports:1-14. https://doi.org/10.1007/s40725-020-00113-8

Pollock, M. M. (2016). Effects of thinning on large wood production and recruitment from Riparian Reserves in the context of proposed Western Oregon Plan Revisions for BLM lands.

Pollock, M. M., Beechie, T. J., Liermann, M. C., & Bigley, R. E. (2009). Stream Temperature Relationships to Forest Harvest in Western Washington. Journal of the American Water Resources Association 45(1):141-156. https://doi.org/10.1111/j.1752-1688.2008.00266.x

Poole, G. C., Risley, J., & Hicks, M. (2001). Issue paper 3 spatial and temporal patterns of stream temperature (revised). Environmental Protection Agency. EPA-910-D-01-003:1-33.

Pörtner, H., and A. Farrell. 2008. Physiology and Climate Change. Science 322:690–692.

Ralph, S. C., Poole, G. C., Conquest, L. L., & Naiman, R. J. (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. https://doi.org/10.1139/f94-006

Rashin, E., Clishe, C., Loch, A., & Bell, J. (2006). Effectiveness of timber harvest practices for controlling sediment related water quality impacts. JAWRA Journal of the American Water Resources Association 42:1307-1327. https://doi.org/10.1111/j.1752-1688.2006.tb05303.x

Reeves, G. H., Benda, L. E., Burnett, K. M., Bisson, P. A., & Sedell, J. R. (1995). A Disturbance-Based Ecosystem Approach to Maintaining and Restoring Freshwater Habitats of Evolutionarily Significant Units of Anadromous Salmonids in the Pacific Northwest. Pages 334-349 in American Fisheries Society Symposium.

Reeves, G. H., Burnett, K. M., & McGarry, E. V. (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. https://doi.org/10.1139/x03-095

Reeves, G. H., Everest, F. H., & Hall, J. D. (1987). Interactions between the redside shiner (Richardsonius balteatus) and the steelhead trout (Salmo gairdneri) in western Oregon: the influence of water temperature. Canadian Journal of Fisheries and Aquatic Sciences 44(9):1603-1613. https://doi.org/10.1139/f87-194

Reeves, G. H., Everest, F. H., & Nickelson, T. E. (1989). Identification of physical habitats limiting the production of coho salmon in western Oregon and Washington. in. U.S. Dept. of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, Oregon.

Reid, L. & Lewis, J. (2007). Rates and implications of rainfall interception in a Coastal Redwood Forest. Gen. Tech. Rep. PSW-GTR-194. USDA Forest Service Pacific Southwest Research Station, Redwood Sciences Laboratory, Arcata, California.

Reid, L. M. (1981). Sediment Production from Gravel-surfaced Forest Roads, Clearwater Basin, Washington. Final Report FRI-UW-8108. Fisheries Research Institute, University of Washington, Seattle, Washington.

Reilly, M. J., Zuspan, A., Halofsky, J. S., Raymond, C., McEvoy, A., Dye, A. W., Donato, D. C., Kim, J. B., Potter, B. E., Walker, N., Davis, R. J., Dunn, C. J., Bell, D. M., Gregory, M. J., Johnston, J. D., Harvey, B. J., Halofsky, J. E., & Kerns, B. K. (2022). Cascadia Burning: The historic, but not historically unprecedented, 2020 wildfires in the Pacific Northwest, USA. Ecosphere 13(6):e4070. https://doi.org/https://doi.org/10.1002/ecs2.4070

Reiser, D.W. and T.C. Bjornn. Influence of forest and rangeland management on anadromous fish habitat in Western North America: Habitat requirements of anadromous salmonids. General Technical Report PNW-96. U.S. Department of Agriculture Forest Service, Portland Oregon.

Rice, R. M., Rothacher, J. S., & Megahan, W. F. (1972). Erosional consequences of timber harvesting: An appraisal. in Proceedings National Symposium on Watersheds in Transition. American Water Resources Association, Ft. Collins, Colorado.

Richter, A., and S.A. Kolmes. 2005. Maximum temperature limits for Chinook, coho, and chum salmon, and steelhead trout in the Pacific Northwest. Reviews in Fisheries Science 13(1):23–49.

Robertson, M. J., Scruton, D. A., Gregory, R. S., & Clarke, K. D. (2006). Effect of Suspended Sediment on Freshwater Fish and Fish Habitat.

Robison, G., Mills, K., Paul, J., Dent, L., & Skaugset, A. (1999). Storm Impacts and Landslides of 1996: Final Report, 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.

Roon, D.A., J.B. Dunham, and J.D. Groom. 2021b. Shade, light, and stream temperature responses to riparian thinning in second-growth redwood forests of northern California. PloS ONE 16(2):e0246822. Available: https://doi.org/10.1371/journal.

Ruiz-Villanueva, V., Piégay, H., Gurnell, A. M., Marston, R. A., & Stoffel, M. (2016). Recent advances quantifying the large wood dynamics in river basins: New methods and remaining challenges. Reviews of Geophysics 54(3):611-652. https://doi.org/https://doi.org/10.1002/2015RG000514

Rutherford, J., Marsh, N., Davies, P., & Bunn, S. (2004). Effects of Patchy Shade on Stream Water Temperature: How Quickly Do Small Streams Heat and Cool? Marine and Freshwater Research 55. https://doi.org/10.1071/MF04120

Sauter, S. T., McMillan, J., & Dunham, J. (2001). Issue Paper 1: Salmonid behavior and water temperature. Environmental Protection Agency, EPA-910-D-01-001, Seattle, Washington.

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.

Scheuerell, M. D. & Williams, J. G. (2005). Forecasting climate-induced changes in the survival of Snake River spring/summer Chinook salmon (Oncorhynchus tshawytscha). Fisheries Oceanography 14(6):448-457. https://doi.org/10.1111/j.1365-2419.2005.00346.x

Scheurer, K., Alewell, C., Banninger, D., & Burkhardt-Holm, P. (2009). Climate and land-use changes affecting river sediment and brown trout in alpine countries--a review. Environmental Science and Polllution Research 16(2):232-242. https://doi.org/10.1007/s11356-008-0075-3

Schindler, D. E., J. B. Armstrong, and T. E. Reed. 2015. The portfolio concept in ecology and evolution. Frontiers in Ecology and the Environment 13:257-263.

Schmidt, K. M., Roering, J. J., Stock, J. D., Dietrich, W. E., Montgomery, D. R., & Schaub, T. (2001). The variability of root cohesion as an influence on shallow landslide susceptibility in the Oregon Coast Range. Canadian Geotechnical Journal 38(5):995-1024. https://doi.org/10.1139/t01-031

Schuett-Hames, D., Peterson, N. P., Conrad, R., & Quinn, T. P. (2000). Patterns of gravel scour and fill after spawning by chum salmon in a western Washington stream. North American Journal of Fisheries Management 20:610-617. https://doi.org/10.1577/1548-8675(2000)020<0610:POGSAF>2.3.CO;2

Science Team Review. 2008. Western Oregon Plan Revision (WOPR). Draft Environmental Impact Statement. Science Team Review.

Seo, J. I., Nakamura, F., & Chun, K. (2010). Dynamics of large wood at the watershed scale: A perspective on current research limits and future directions. Landscape and Ecological Engineering 6:271-287. https://doi.org/10.1007/s11355-010-0106-3

Servizi, J. A. & Martens, D. W. (1987). Some effects of suspended Fraser River sediments on sockeye salmon (Oncorhynchus nerka). Can. Spec. Publ. Fish. Aquat. Sci. 96:254-264.

Sessions, J., Balcom, J. C., & Boston, K. (1987). Road Location and Construction Practices: Effects on Landslide Frequency and Size in the Oregon Coast Range. Western Journal of Applied Forestry 2(4):119-124. https://doi.org/10.1093/wjaf/2.4.119

Shaw, E. A. & Richardson, J. S. (2001). Direct and indirect effects of sediment pulse duration on stream invertebrate assemblages and rainbow trout (Oncorhynchus mykiss) growth and survival. Canadian Journal of Fisheries and Aquatic Sciences 58(11):2213-2221. https://doi.org/10.1139/f01-160

Shelton, A. O., W. H. Satterthwaite, E. J. Ward, B. E. Feist, and B. Burke. 2019. Using hierarchical models to estimate stock-specific and seasonal variation in ocean distribution, survivorship, and aggregate abundance of fall run Chinook salmon. Canadian Journal of Fisheries and Aquatic Sciences 76(1):95-108.

Shrimpton, J. M., Bourgeois, J. F., Quigley, J. T., & Blouw, D. M. (1999). Removal of the Riparian Zone During Forest Harvesting Increases Stream Temperature: Are the Effects Cumulative Downstream? in Conference Biology & Management of Species and Habitats at Risk, University College of the Cariboo.

Shrimpton, J. M., Zydlewski, J. D., & Heath, J. W. (2007). Effect of daily oscillation in temperature and increased suspended sediment on growth and smolting in juvenile chinook salmon, Oncorhynchus tshawytscha. Aquaculture 273(2-3):269-276. https://doi.org/10.1016/j.aquaculture.2007.10.009

Siegel, J. E. & Crozier, L. G. (2019). Impacts of climate change on salmon of the Pacific Northwest. A review of the scientific literature published in 2018. Fish Ecology Division, Northwest Fisheries Science Center, National Marine Fisheries Service, Seattle, Washington.

Siegel, J., & Crozier, L. (2020). Impacts of Climate Change on Columbia River Salmon: A review of the scientific literature published in 2019. Fish Ecology Division, Northwest Fisheries Science Center, National Marine Fisheries Service, Seattle, Washington.

Skidmore, P. B., Thorne, C. R., Cluer, B. L., Pess, G. R., Castro, J. M., Beechie, T. J., & Shea, C. C. (2011). Science base and tools for evaluating stream engineering, management, and restoration proposals.

Smoker, W. W., Wang, I. A., Gharrett, A. J., & Hard, J. J. (2004). Embryo survival and smolt to adult survival in second-generation outbred coho salmon. Journal of Fish Biology 65(s1):254-262. https://doi.org/https://doi.org/10.1111/j.0022-1112.2004.00550.x

Snyder, D. (2003). Electrofishing and Its Harmful Effects on Fish.

Snyder, N., Mostaghimi, S., Berry, D., Reneau, R., Jr, & Smith, E. (1995). Evaluation of a riparian wetland as a naturally occurring decontamination zone. in, Kansas City, Missouri.

Sounhein, B., E. Brown, M. Lewis and M. Weeber. 2015. Status of Oregon stocks of coho salmon, 2014. Monitoring Program Report Number OPSW-ODFW-2015-3, Oregon Department of Fish and Wildlife, Salem, Oregon.

Spence, B. C., Lomnicky, G. A., Hughes, R. M., & Novitzki, R. P. (1996). Ecosystem Approach to Salmonid Conservation. ManTech Environmental Research Services Corp., TR-4501-96-6057.

Spies, T. A., Pollock, M. M., Reeves, G. H., & Beechie, T. J. (2013). Effects of Riparian Thinning on Wood Recruitment: A Scientific Synthesis.

Sridhar, V., Billah, M. M., & Hildreth, J. W. (2018). Coupled Surface and Groundwater Hydrological Modeling in a Changing Climate. Groundwater, 56(4), 618-635. doi:10.1111/gwat.12610

Stachura, M. M., Mantua, N. J., & Scheuerell, M. D. (2014). Oceanographic influences on patterns in North Pacific salmon abundance. Canadian Journal of Fisheries and Aquatic Sciences, 71(2), 226-235. doi:10.1139/cjfas-2013-0367

Stednick, J. D. (1996). Monitoring the effects of timber harvest on annual water yield. Journal of Hydrology 176(1-4):79-95. https://doi.org/10.1016/0022-1694(95)02780-7

Stout, H. A., Lawson, P. W., Bottom, D. L., Cooney, T. D., Ford, M. J., Jordan, C. E., Kope, R. G., Kruzic, L. M., Pess, G. R., Reeves, G. H., Scheuerell, M. D., Wainwright, T. C., Waples, R. S., Ward, E., Weitkamp, L. A., Williams, J. G., & Williams., T. H. (2012). Scientific Conclusions of the Status Review for Oregon Coast Coho Salmon (Oncorhynchus kisutch). NMFS-NWFSC-118. Northwest Fisheries Science Center, National Marine Fisheries Service, Seattle, Washington.

Sturrock, A. M., Carlson, S. M., Wikert, J. D., Heyne, T., Nusslé, S., Merz, J. E., . . . Johnson, R. C. (2020). Unnatural selection of salmon life histories in a modified riverscape. Global Change Biology, 26(3), 1235-1247. doi:10.1111/gcb.14896

Sullivan, K., Martin, D. J., Cardwell, R. D., Toll, J. E., & Duke, S. (2000). An Analysis of the Effects of Temperature on Salmonids of the Pacific Northwest With Implications for Selecting Temperature Criteria.

Sutton, R. & Soto, T. (2012). Juvenile coho salmon behavioural characteristics in Klamath river summer thermal refugia. River Research and Applications 28(3):338-346. https://doi.org/https://doi.org/10.1002/rra.1459

Suzuki, N., and J.P Hayes. Effects of thinning on small mammals in Oregon coastal forests. Journal of Wildlife Management 67(2):352.

Swanson, F., Fredriksen, R., & McCorison, F. (1982). Material Transfer in a Western Oregon Forested Watershed. Analysis of coniferous forest ecosystems in the western United States.

Swanson, F. J. & Swanston, D. N. (1977). Complex mass-movement terrains in the western Cascade Range, Oregon. in D. R. Coates, editor. Landslides, volume III. Geological Society of America.

Swift, L. W. J. (1986). Filter strip widths for forest roads in the southern Appalachians. Southern Journal of Applied Forestry 10(1):27-34.

Thomas, R. B. & Megahan, W. F. (1998). Peak flow responses to clear-cutting and roads in small and large basins, western Cascades, Oregon: A second opinion. Water Resources Research 34(12):3393-3403. https://doi.org/10.1029/98wr02500

Thorne, K., Macdonald, G., Guntenspergen, G., Ambrose, R., Buffington, K., Dugger, B., . . . Takekawa, J. (2018). U.S. Pacific coastal wetland resilience and vulnerability to sea-level rise. Science Advances, 4(2), eaao3270. doi:10.1126/sciadv.aao3270

Ubechu, B. O. & Okeke, O. C. (2017). Landslide: Causes, Effects and Control. International Journal ofCurrent Multidisciplinary Research Studies 3(3):647-663.

USDC. (2011). Endangered and Threatened Species; Designation of Critical Habitat for Southern Distinct Population Segment of Eulachon.

USDC. (2009). Endangered and Threatened Wildlife and Plants: Final Rulemaking To Designate Critical Habitat for the Threatened Southerm Distinct Population Segment of North American Green Sturgeon.

USFWS (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, Oregon.

USFWS (U.S. Fish and Wildlife Service). 2025. Final Environmental Impact Statement for the Elliott State Research Forest Habitat Conservation Plan. January. Portland, Oregon. Prepared by ICF, Seattle, Washington.

USFWS and NMFS. 2016. Habitat Conservation Planning and Incidental Take Permit Processing Handbook. U.S. Department of Interior Fish and Wildlife Service and U.S. Department of Commerce NOAA National Marine Fisheries Service.

Van Sickle, J. & Gregory, S. V. (1990). Modeling inputs of large woody debris to streams from falling trees. Canadian Journal of Forest Research 20(10):1593-1601. https://doi.org/10.1139/x90-211

Veilleux, H. D., Donelson, J. M., & Munday, P. L. (2018). Reproductive gene expression in a coral reef fish exposed to increasing temperature across generations. Conservation Physiology, 6(1), cox077. doi:10.1093/conphys/cox077

Vitousek, P. (1983). The effects of deforestation on air, soil, and water. B. Bolin & R. B. Cook, editors. The Biogeochemical Cycles and Their Interactions.

Wainwright, T. C., Chilcote, M. W., Lawson, P. W., Nickelson, T. E., Huntington, C. W., Mills, J. S., Moore, K. M. S., Reeves, G. H., Stout, H. A., & Weitkamp, L. A. (2008). Biological recovery criteria for the Oregon Coast coho salmon evolutionarily significant unit. U.S. Dept. Commer.

Wainwright, T. C. & Weitkamp, L. A. (2013). Effects of Climate Change on Oregon Coast Coho Salmon: Habitat and Life-Cycle Interactions. Northwest Science 87(3):219-242. https://doi.org/10.3955/046.087.0305

Ward, E. J., Anderson, J. H., Beechie, T. J., Pess, G. R., & Ford, M. J. (2015). Increasing hydrologic variability threatens depleted anadromous fish populations. Global Change Biology, 21(7), 2500-2509. doi:10.1111/gcb.12847

Weitkamp L. 2010. Marine Distributions of Chinook Salmon from the West Coast of North America Determined by Coded Wire Tag Recoveries, Transactions of the American Fisheries Society, 139:1, 147-170, https://doi.org/10.1577/T08-225.1

Welty, J. J., Beechie, T. J., Sullivan, K., Hyink, D. M., Bilby, R. E., Andrus, C., & Pess, G. R. (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(2-3):299-318. https://doi.org/10.1016/s0378-1127(01)00524-2

Wemple, B. C. & Jones, J. A. (2003). Runoff production on forest roads in a steep, mountain catchment. Water Resources Research 39(8). https://doi.org/10.1029/2002wr001744

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. Journal of the British Geomorphological Research Group 26(2):191-204.

Wemple, B. C., Jones, J. A., & Grant, G. E. (1996). Channel network extension by logging roads in two basins, western Cascades, Oregon. Water Resources Bulletin 32(6):1195-1207. https://doi.org/10.1111/j.1752-1688.1996.tb03490.x

Wilkerson, E., Hagan, J. M., Siegel, D., & Whitman, A. A. (2006). The Effectiveness of Different Buffer Widths for Protecting Headwater Stream Temperature in Maine. Forest Science 52(3):221-231. https://doi.org/10.1093/forestscience/52.3.221

Williams, D. G., & Scott, R. L. (2009). Chapter 2: Vegetation-hydrology interactions: Dynamics of riparian plant water use. In J. C. S. a. B. J. Tellman (Ed.), Ecology and Conservation of the San Pedro River (pp. 37-36): Tucson: University of Arizona Press.

Williams, T.H., B.C. Spence, D.A. Boughton, R.C. Johnson, L.G. Crozier, N.J. Mantua, M.R. O'Farrell, and S.T. Lindley. 2016. Viability assessment for Pacific salmon and steelhead listed under the Endangered Species Act: Southwest. NOAA Fisheries Southwest Fisheries Science Center, Santa Cruz, CA: U.S. Dep Commerce NOAA Tech Memo NMFS SWFSC 564.

Williams, C. R., A. H. Dittman, P. McElhany, D. S. Busch, M. T. Maher, T. K. Bammler, J. W. MacDonald, and E. P. Gallagher. 2019. Elevated CO2 impairs olfactory-mediated neural and behavioral responses and gene expression in ocean-phase coho salmon (Oncorhynchus kisutch). 25:963-977.Wondzell, S. M. (2012). Hyporheic Zones in Mountain Streams: Physical Processes and Ecosystem Functions. in Stream Notes. Stream Systems Technology Center.

Wondzell, S. M. (2012). Hyporheic Zones in Mountain Streams: Physical Processes and Ecosystem Functions. Stream Notes, January-April 2012. U.S. Forest Service, Rocky Mountain Research Station, Fort Collins, Colorado. Retrieved from https://www.fs.usda.gov/biology/nsaec/assets/sn_04_12.pdf

Yan, H., N. Sun, A. Fullerton, and M. Baerwalde. 2021. Greater vulnerability of snowmelt-fed river thermal regimes to a warming climate. Environmental Research Letters 16(5). https://doi.org/10.1088/1748-9326/abf393

Yazzie, K.C., C.E. Torgersen, D.E. Schindler, and G.H. Reeves. 2024. Spatial and Temporal Variation of Large Wood in a Coastal River. Ecosystems 27:19–32. Available: https://doi.org/10.1007/s10021-023-00870-0.

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.

Zeimer, R. R. (1981). Storm Flow Response to Road Building and Partial Cutting in Small Streams of Northern California. Water Resources Research 17(4):907-917. https://doi.org/10.1029/WR017i004p00907

Zwieniecki, M. A. & Newton, M. (1999). Influence of Streamside Cover and Stream Features on Temperature Trends in Forested Streams of Western Oregon. Western Journal of Applied Forestry 14:106-113.