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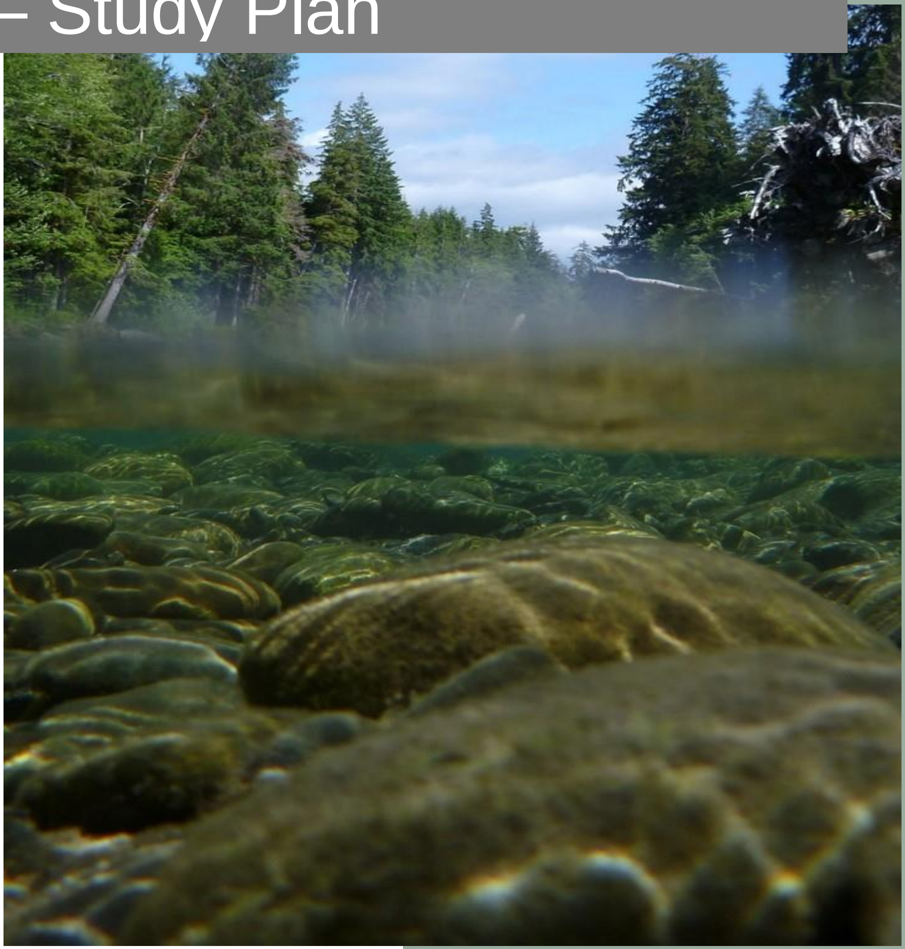
Washington State Department of Natural Resources' Riparian Validation Monitoring Program for Salmonids on the Olympic Experimental State Forest – Study Plan



Kyle D. Martens

Washington State Department of Natural Resources, Forest Resources Division

1111 Washington Street SE
Olympia, WA 98512

WASHINGTON STATE DEPARTMENT OF
NATURAL RESOURCES
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Scientific Advisory Group:

Dr. Patrick Connolly – Research Fisheries Biologist, U. S. Geological Survey

Dr. Martin Liermann – Statistician (Biology), NOAA Fisheries

Dr. Scott Horton – Wildlife Biologist, Washington Department of Natural Resources

Dr. J. Ryan Bellmore – Research Fish Biologist, Pacific Northwest Research Station, U. S. Forest Service

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Washington State Department of Natural Resources
Forest Resources Division
1111 Washington St. SE
Mail stop: 47014
Olympia, WA 98504
www.dnr.wa.gov

Acronyms and Abbreviations

AIC – Akaike’s Information Criterion

BACI – Before-After and Control-Impact

CCA – Canonical Correspondence Analysis

COH – Coho Salmon

CTT – Cutthroat Trout

DNR – Washington Department of Natural Resources

eDNA – Environmental DNA

EIS – Environmental Impact Statement

ESA – Endangered Species Act

HCP – Habitat Conservation Plan

IP – Intrinsic Potential

LWD – Large Woody Debris

NMS – Non-metric Multidimensional Scaling Ordination

NOAA - National Oceanic and Atmospheric Administration

OESF – Olympic Experimental State Forest

ONP – Olympic National Park

PIT – Passive Integrated Transponder

SaSI – Salmonid Stock Inventory

STH – Steelhead/rainbow trout

USFWS – United States Fish and Wildlife Service

USGS – United States Geological Survey

WDFW – Washington Department of Fish and Wildlife

WRIA – Water Resource Inventory Areas

Executive Summary

In 1997, the Washington State Department of Natural Resources (DNR) completed a Habitat Conservation Plan (HCP) that allows for long-term certainty in forest management (primarily for the purpose of timber harvest) for the western portion of Washington under the Endangered Species Act. One of the conditions agreed to in the HCP directs DNR to conduct riparian validation monitoring across the conglomeration of state managed lands on the western portion of the Olympic Peninsula known as the Olympic Experimental State Forest (OESF). Validation monitoring is defined in the HCP as monitoring "to evaluate cause-and-effect relationships between habitat conditions resulting from implementation of the conservation strategies and the animal populations these strategies are intended to benefit." The Riparian Conservation Strategy for the OESF in the HCP was designed to protect or improve habitat for viable salmonid populations. The strategy consists of: (1) interior-core buffers to protect soils on floodplains and unstable stream banks, incised stream valleys, and adjoining unstable slopes; (2) exterior, or wind buffers adjacent to interior buffers, as needed, to protect against blowdown; (3) a comprehensive program of road management, maintenance and improvement, including stabilizing and decommissioning particularly risky roads; and (4) protecting forested wetlands. Riparian validation monitoring should determine if the Riparian Conservation Strategy is maintaining or improving salmonid habitat and expressing stable or positive effects on salmonids as anticipated in the HCP.

DNR has been monitoring 54 basins for aquatic and riparian habitat conditions throughout the OESF since 2012 through the Status and Trends of Riparian and Aquatic Habitat program. The use of these existing monitoring basins and habitat data could reduce the cost and workload for the Riparian Validation Monitoring Program. To evaluate the potential use of these basins for validation monitoring, backpack electrofishing was attempted for all basins to determine fish presence and the species composition. After sampling was completed, a Scientific Advisory Group was formed to advise on the development of this study plan and continued operation of the Riparian Validation Monitoring Program.

The approach for the Riparian Validation Monitoring Program was based on the ability to determine salmonid conditions (e.g., abundance, biomass, species composition, age structure, % anadromy, and [or] number of spawning redds) in different habitats across the OESF, to provide information on cause-and-effect relationships, the amount of alterations required for current DNR operations, cost effectiveness, and adaptability of the program. Understanding cause-and-effect relationships can be difficult due to the inherent natural variability in salmonids and riparian habitat conditions, the potential impacts of past management practices, as well as the potential that the management practices agreed to in the HCP may result in less detectable management effects. With all of this in mind, two approaches were considered for riparian validation monitoring. The first approach (observational) would assess management effects over a large number of sites and time, but would have potential to be influenced by multiple factors (e.g., ocean and freshwater harvest, climate change, and natural disturbance). The second approach (experimental) would use treatment (management actions) and control sites in a paired-basin design to evaluate the salmonid response to specific management actions. Essentially, an observational approach may imply cause-and-effect relationships, while an experimental approach would have a greater potential to determine cause-and-effect relationships (assuming the conditions exist within the OESF to conduct this type of approach).

A literature review, preliminary sampling, and recommendations from the Scientific Advisory Group led to the conclusion to start with the observational approach, and after all basins have been initially sampled and on six-year rotations thereafter, evaluate the potential addition of experimental studies. In addition, over the first two years of the study, a methodology examination will be conducted to identify the most effective sampling method (continuous sampling, reach based, or a combination of both) for determining juvenile salmonid abundance and trends among the monitored basins. During this evaluation, monitoring will focus on 20 basins to be sampled annually within the observational framework. The remaining basins will be added through a rotating panel design on a two- or three-year rotation after the evaluation.

Evidence for cause-and-effect relationships between management actions and salmonids should be provided to some degree through both approaches. Information collected under the observational approach will be used to evaluate presumed cause-and-effect relationships and (or) hypotheses about the relationships of salmonids and/or habitat use with natural and management-related processes. In addition, process-based simulation modeling may be used to elucidate cause-and-effect mechanisms, as well as generate hypotheses that could be tested experimentally, through a paired-basin design. Experimental studies may also be added to examine specific management action effects (e.g., variable retention harvest or riparian thinning) that have the greatest potential to reveal cause-and-effect relationships. The observational approach would be more sensitive to outside factors (e.g., climate change) influencing the results, but would cover a broader area and multiple management activities, while the experimental approach would be used to control outside factors and would be more sensitive for detecting change from a single management activity. A combination of approaches would allow for detection of management effects over a range of salmonid species, life histories, habitats, and management activities (observational approach), while also focusing on specific cause-and-effect relationships (experimental approach).

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Introduction

The Olympic Experimental State Forest (OESF) covers over 270,000 acres of land managed by Washington’s Department of Natural Resources (DNR) throughout the western side of the Olympic Peninsula. It is comprised of a conglomeration of state lands (lands granted to the Washington Territory from the federal government) and state forest lands (lands deeded from Clallam and Jefferson counties for the state to manage) designated to provide revenue to specific trust beneficiaries (e.g., schools, universities, and county governments). Both categories are referred to as “state trust lands” and are held as fiduciary trusts to provide revenue to specific trust beneficiaries such as schools and counties. The OESF is an actively-managed forest with sustainable harvest level set at 575 mbf for the decade 2005-2014 (DNR 2007), with a new sustainable harvest calculation currently underway. Between 1999 through 2014, an average of 600 ha (1475 ac) or 0.55% of the total DNR land within the OESF were harvested annually (DNR 2013). The OESF is also managed under the legal mandate to sustain ecosystem values such as conservation of habitat and biological diversity, long-term productivity, and ecosystem resilience. The mission of the OESF is to determine the best methods for integrating this mandate to produce revenue for the trusts (primarily through timber harvest) while protecting ecosystem values (ecological values have been defined by DNR as “the elements [e.g., trees, wildlife, soil, water] and natural relationships between them that are biologically and functionally important to the continued health of the forest ecosystem”; DNR 1991)

The OESF was first recommended by the Commission on Old Growth Alternatives for Washington’s Forest Trust Lands in 1989 with “the intent to experiment with harvest and regeneration methods to enhance habitat characteristics and commodities production” (DNR 1997). The OESF’s status was officially confirmed in the 1992 Forest Resource Plan with a mission “to gain and apply knowledge about old-growth forests and modern commercial forest management”. Also in 1992, the United States congress passed the Olympic Experimental Forest Act (Title II of P.L. 102-436 [106 Stat. 2217]) supporting DNR to create a plan that provides “for the conservation of the northern spotted owl on the forest and reflect scientifically sound ecosystem management to aid conservation of fisheries, other sensitive species, and the ecology of the forest in general”. The multispecies Habitat Conservation Plan (HCP) was finalized in 1997, providing DNR, through an incidental take permit for current and future Endangered Species Act (ESA) listed species, with long-term certainty to conduct management actives on DNR managed lands on the western portion of Washington (including the OESF). Within the HCP, the Riparian Conservation Strategy places constraints on management activities with the intent to maintain or restore salmonid habitat on DNR-managed lands. Under the HCP, DNR committed to conduct monitoring, using adult and juvenile salmonids, within the OESF to validate the Riparian Conservation Strategy. This document outlines the plan to implement a Riparian Validation Monitoring Program for the OESF.

Purpose

The purpose of this study plan is to describe how DNR will implement validation monitoring in the OESF. The plan defines the monitoring goal and objectives, recommends a monitoring approach and study design, formulates hypotheses and monitoring questions, develops a conceptual model of the monitored system, identifies monitoring indicators and metrics, describes field methods and a potential analytical framework, and suggests an implementation schedule. The Riparian Validation Monitoring Program should be acceptable to both DNR managers and federal listing agencies (NOAA and USFWS).

HCP Commitment for Validation Monitoring

In the 1997 HCP, DNR defined the objective of validation monitoring "to evaluate cause-and-effect relationships between habitat conditions resulting from implementation of the conservation strategies and the animal populations these strategies are intended to benefit." The HCP committed DNR to conduct validation monitoring on spotted owls, marbled murrelets and salmonids only within the OESF (no other HCP planning units). DNR described the expectations for salmonid monitoring through a validation monitoring program as follows:

> Validation monitoring for salmonid habitat will be focused to detect changes in the productivity of spawning adults and salmon-habitat relationships, parameters that are not affected by marine conditions and downstream fisheries. This will involve estimating numbers of spawning adults and numbers of recruits (i.e., out migrating smolts or rearing juveniles), and surveying different stream habitat types and conditions to determine fish numbers, species composition, and densities. Validation monitoring for salmonid habitat will be conducted in an appropriate watershed unit comprised primarily of DNR-managed lands, to minimize the potential influences of management activities not under DNR's control. Validation monitoring will not be conducted for any other, non-salmonid fish species, or for wildlife species (other than spotted owls and marbled murrelets; DNR 1997).

DNR Management in the OESF

DNR manages the OESF under an experimental management approach called integrated management – under this approach, the entire land base is managed for both revenue production and ecological values instead of dividing it into large zones to be managed primarily for one objective or another. DNR's integrated management approach is designed to create and maintain a "biologically diverse working forest, with healthy streams and wetlands, a mix of tree species, and a diversity of forest structures at the stand and landscape level" (DNR 2016). This approach is based on disturbance ecology that recognizes a natural mosaic of successional stages that shift in time through disturbances. This is in contrast to a more widely implemented conservation biology approach where the forest is divided into large land-use designations (blocks managed for individual purposes, such as late-successional habitat in late-successional reserves or timber production in the matrix). For riparian areas, the integrated management approach is expressed as lack of fixed-width riparian area buffers and specific desired future conditions. Instead, riparian buffer width and the type of management activities allowed are depended on the overall health of the watershed and the desired sediment, hydrological, and temperature regimes in streams (DNR 1997).

DNR actively manages as much of the forested land base as possible to provide both revenue production and ecological values. Active forest management in the OESF includes but is not limited to activities such as: variable-retention harvest (stand-replacement harvest in which elements of the existing stand are left to incorporate into the new stand), pre-commercial thinning (removal of less desirable trees to maintain the growth and stability of retained trees), commercial thinning (thinning that generates revenue and is performed to meet a wide range of objectives), variable density thinning (commercial thinning in which a mixture of openings, patches of trees, and varying densities of trees are created to achieve specific objectives), site preparation, planting trees, vegetation management, and road building and maintenance (DNR 2016). Activities are designed to encourage the development of forest conditions for revenue production while restoring or maintaining agreed upon levels of ecological values.

The integrated management approach has both promise and uncertainties. Uncertainties include the response of forests and fish and wildlife species to management activities, and the operational and economic feasibility of the approach itself. Research and monitoring is expected to reduce these uncertainties and inform DNR on the best forest management practices through the formal process of adaptive management. Adaptive management allows for flexibility in DNR management and for changes in management activities as knowledge of forest practices and their effects on the environment evolve (Lindenmayer and Likens 2010).

Riparian Conservation Strategy

The Riparian Conservation Strategy for the OESF (DNR 1997) was based on the assumption that mass wasting (such as landslides and debris torrents) and windthrow (blowing over or breaking of trees in the wind) exert the greatest short- and long-term influences on habitat for salmonids and other riparian-dependent species. It hypothesized that riparian buffers large enough to minimize the impact of mass wasting and windthrow would simultaneously protect all other key physical and biological functions of riparian systems (DNR 1997). Thus, the strategy explicitly addressed those influences with interior-core buffers, exterior or wind buffers, protection of forested wetlands, and road management. The underlying theme of the Riparian Conservation Strategy is “to conserve habitat complexity as afforded by natural disturbance regimes”.

Riparian buffers consist of: 1) an interior-core buffer which is adjacent to the 100-year floodplain and is intended to protect and aid restoration of riparian processes and functions;

and 2) potentially an exterior wind buffer which is adjacent to the interior-core buffer and is intended to protect the integrity of the interior-core buffer from loss of riparian function that results from severe endemic windthrow. Buffer size and configuration will be determined by the condition of individual watersheds, presence of unstable slopes, and risk of severe endemic windthrow. While interior-core buffer widths will vary, the default widths are 150 feet for DNR Type 1 and Type 2 streams and 100 feet for DNR Type 3 and Type 4 streams measured outwardly from the 100-year floodplain. Interior-core buffers will be extended to incorporate any potentially unstable slopes or landforms. In a small number of cases, regeneration harvest will be allowed within the default widths of interior-core buffers as determined by a watershed assessment within a tactical model. This model allows harvest inside interior-core buffers only if it will not result in a declining yield of shade and large woody debris and prevents detectible increases of peak flows (i.e. ≥ 10% over unmanaged conditions). Thinning is also allowed in interior-core buffers up to the last row of trees adjacent to the 100-year floodplain. Regardless of any activities allowed, interior-core buffers contain a 30-foot-wide “equipment limitation zone” (measured from the outward edge of the 100-year floodplain) that restricts equipment and disturbance. Exterior buffers will only be established if recommended by the OESF windthrow probability model (or any replacement models) and a subsequent field assessment by a forester. If there is a risk of severe windthrow, foresters can either apply an exterior wind buffer or reconfigure the shape, orientation, and (or) leave tree distribution of a proposed harvest to resolve the risk. If applied, an 80-foot exterior buffer will be added to the interior-core buffer creating 230-foot buffers in Type 1 and Type 2 streams and 180-foot buffers in Type 3 and Type 4 streams (DNR 2016). Riparian buffers may be more extensive in the OESF than other areas in western Washington due to the dense stream network associated with heavy annual precipitation, steep terrain, and erosive soils.

Pre-HCP road conditions and practices were identified as potentially having significant negative impacts on salmonids within the OESF (DNR 1997). As a result, a comprehensive road management program was implemented to minimize the impact of DNR roads on the OESF. This road management program includes: (1) annual inventories of road conditions; (2) maintenance and improvement to existing roads to minimize runoff entering surface water to avoid contributing to peak flows and sedimentation; (3) decommissioning and stabilizing roads that no longer serve a management function or that cause intractable management or environmental problems; (4) sound construction of new roads; (5) minimizing new construction so that additional roads are built only where no other operationally or economically viable option exists for access; (6) minimizing active road density; (7) prioritizing roads for decommissioning, upgrading, and maintaining; and (8) identification of road-related fish blockages for retrofitting or removal.

All these activities are expected to be monitored for compliance and effectiveness (HCP implementation and effectiveness monitoring). In addition, the assumption that these activities will result in viable salmonid populations is expected to be tested through riparian validation monitoring.

Additional Benefits from Implementing Riparian Validation Monitoring

In addition to validating the assumptions of the Riparian Conservation Strategy, several other benefits are expected to be realized by implementing the OESF Riparian Validation Monitoring Program:

- To increase knowledge of and confidence in management practices within DNR.
- To provide data on current habitat and fish conditions. Recent reports on salmonids on the Olympic Peninsula have indicated that habitat conditions on DNR lands are continuing to negatively impact salmonids. (e.g., "While the upper Hoh lies within the Olympic National Park [ONP] and the lower Hoh within the Hoh Indian Reservation, the middle Hoh is surrounded by private landowners and Washington DNR land, and is the location of numerous impacts to salmonids." [Smith 2000] and "More recent analysis of fish production in the Queets River strongly suggest that habitat conditions have continued to deteriorate in the Clearwater watershed, pointing towards certain types of actions [see Lestelle 2009]."[WRIA 21 Lead entity 2011]).
- To validate habitat and fish distribution models used in analyses such as the OESF Environmental Impact Statement (EIS) or Forest Land Plan. If current models are providing wrong or misleading information, this may increase risk to habitat and protected species, reduce timber harvest opportunities, or lower the credibility of DNR.
- To provide documentation of the potential effects of climate change on the OESF through long-term monitoring of habitat and salmonid conditions (e. g. abundance, biomass, species composition, age structure, % anadromy, and [or] number of spawning redds).
- To increase visibility within the fisheries' community that may lead to additional studies on the OESF, thus helping realize the OESF vision to be a focal point for experimentation in Washington. Providing "free" baseline data may encourage outside organizations and universities to collaborate and conduct additional research within the OESF.
- To establish stronger relationships and in turn increase the trust and creditability with outside natural resource agencies or departments (e.g., WDFW, local Native American tribes, universities, NOAA Fisheries, U. S. Forest Service, USFWS, and USGS).

Scientific Advisory Group

In the fall of 2015, a Scientific Advisory Group was formed to ensure the use of sound scientific principles within the Riparian Validation Monitoring Program and that the program meets the commitment to the HCP (DNR 1997). The four-member group consists of individuals from U.S.

Geological Survey, U. S. Forest Service, NOAA Fisheries, and DNR who are experts in fish biology, ecology, statistics, and (or) with local knowledge of the OESF. The group's efforts consists of two phases. The first phase (developmental phase) was launched in October 2015 and will last through the completion of the study plan resulting in the establishment of the Riparian Validation Monitoring Program. The second phase (guidance phase) will start after implementation and will evaluate the Riparian Validation Monitoring Program on an annual basis. A copy of the Scientific Advisory Group's charter is provided in Appendix A.

Terminology

Throughout the document, fisheries terminology is used to describe life stages (Zimmerman et al. 2012), life histories, or reproductive activities commonly found in salmonids. DNR terminology is used to describe DNR stream types (Bigley and Deisenhofer 2006; http://file.dnr.wa.gov/publications/lm_hcp_rfrs.pdf).

Salmonid – Belonging or pertaining to the family Salmonidae, including salmon, trout, char, and whitefish.

Anadromous – A life history where fish migrate up rivers as adults from the ocean to reproduce in fresh water.

Resident – A life history where fish live their entire life and reproduce in the same stream that they were born.

Fluvial – A life history where mature fish live in one stream, but migrate to another stream to reproduce. Typically, a fish will mature in a larger stream and spawn in a smaller stream.

Fry – Recently emerged juvenile salmonids. Fry have a disproportionally large head and a slight body.

Parr – The parr stage follows the fry stage and is characterized by juvenile salmonids with dark marks on their sides. Parr range in age from sub yearling to several years of age.

Smolt – Juvenile salmonids that are undergoing physiological changes required for living in the ocean. Smolt pigmentation will become more silvery as they complete their transformation.

Adult – Fish that are capable of reproduction.

Redd – A spawning nest made in stream gravel by some species of fish, including salmon or trout.

DNR Type 1 stream – Streams inventoried and classified as "Shoreline of the State" which are streams and rivers with greater than 20 cubic feet per second mean annual flow.

DNR Type 2 stream – Segments of natural waters that are not classified as Type 1 water and have a high fish, wildlife, or human use. Specifically this includes: a) streams where water diversions for domestic use exceeds 100 units, b) streams where water is diverted for use by fish hatcheries, c) stream sections that are within a campground having more than 30 units, d) streams that are used by substantial numbers of game fish for spawning, rearing or migrating, or e) streams that are used by salmonids for off-channel habitat.

DNR Type 3 stream – Segments of natural waters that are not classified as Type 1 or Type 2 water and have a moderate to slight fish, wildlife, and human use.

DNR Type 4 stream – Non-fish bearing stream and is more than 2 feet in width between the ordinary high-water mark.

DNR Type 5 stream – Non-fish bearing stream and is less than or equal to 2 feet in width between the ordinary high-water mark.

Study Area

The OESF is located in western Clallam and Jefferson counties on the Olympic Peninsula in Washington. It is bordered by the Pacific Ocean to the west, the Strait of Juan de Fuca to the north, and the Olympic Mountains to the east and south (Figure 1). The OESF covers over 270,000 acres of DNR-managed trust land with elevations ranging from sea level to 3,400 feet. The OESF experiences large quantities of rainfall in the winter with precipitation averaging between 84 to 170 inches per year (https://www.nps.gov/olym/planyourvisit/weather.htm). Major river systems that run through the OESF include: Queets, Clearwater, Hoh, Bogachiel, Calawah, Sol Duc, Quillayute, Dickey, Ozette, Sekiu, Hoko, Clallam, and Pysht rivers. According to DNR's GIS database, there are 2,785 miles of streams located on the OESF (DNR 2013). DNR Type 1 and Type 2 streams (miles) make up 5% and 2% of the stream network respectively, while DNR Type 3 streams make up 16% of the total stream network and 71% of fish bearing streams on the OESF (DNR 2013).

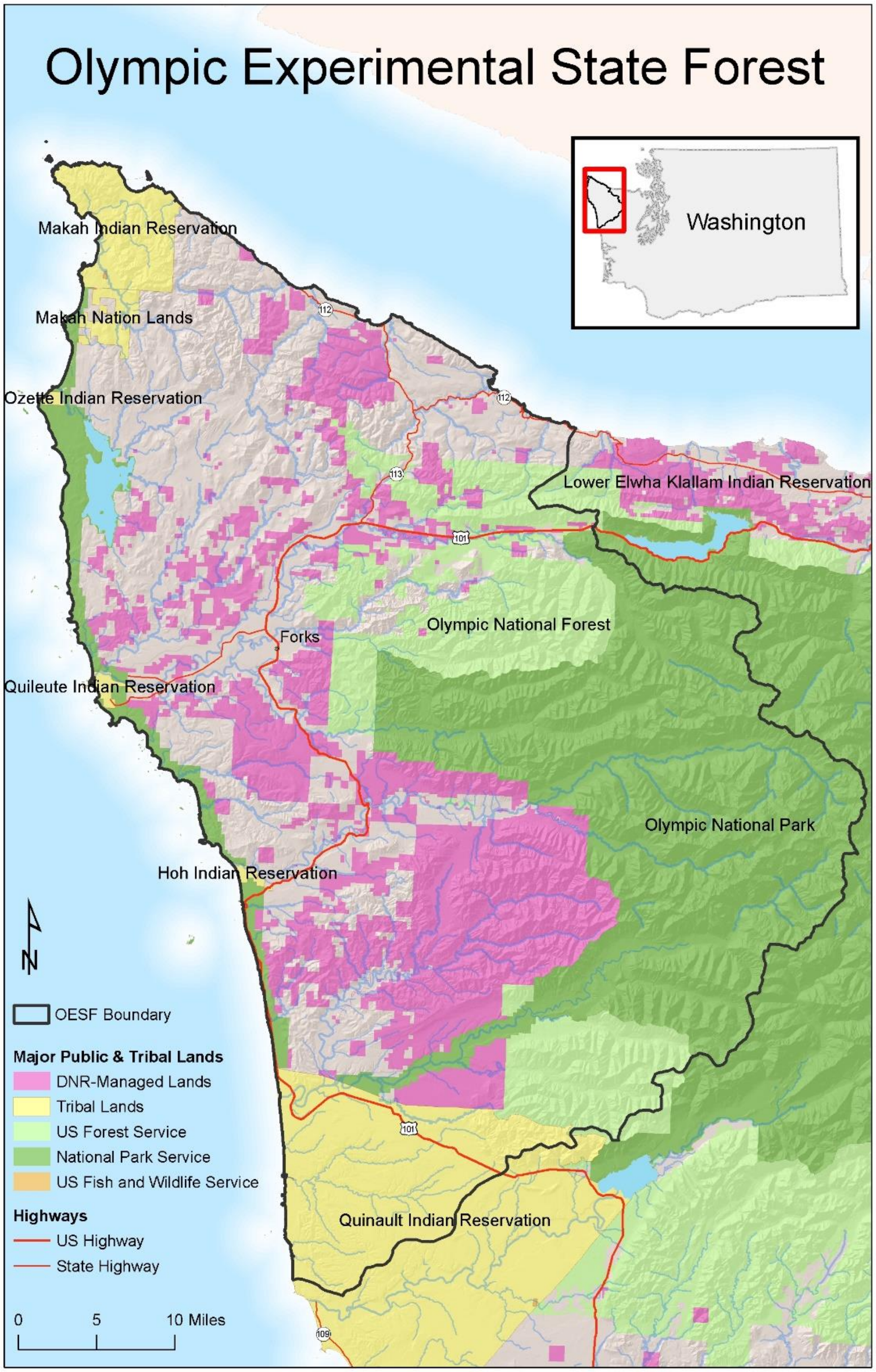


Figure 1 Map of the Olympic Experimental State Forest

Nine native species of salmonids have potential to be found in streams of the OESF: sockeye salmon (*Oncorhynchus nerka*), pink salmon (*O. gorbuscha*), chum salmon (*O. keta*), Chinook salmon (*O. tshawytscha*), coho salmon (*O. kisutch*), steelhead trout (*O. mykiss*), coastal cutthroat trout (*O. clarkii clarkii*), bull trout (*Salvelinus confluentus*), and mountain whitefish (*Prosopium williamsoni*). In addition, seventeen species of non-game fish, including dace (*Cyprinidae spp.*), lampreys *(Lampetra spp.),* minnows (*Phoxinus spp.*), suckers *(Catostomus spp.)*, and sculpins (*cottus spp.*), may also be found in the OESF (DNR 2013). Salmonid spawning and rearing summaries from the nine species potentially found on the OESF are presented in Table 1.

Table 1. Life history traits of salmonids thought to be present in the Olympic Experimental State Forest (Wydoski and Whitney 2003).

Species	**Spawning timing**	**Age at spawning**	**Time in freshwater**	**Spawning locations/Juvenile habitat preferences**
Sockeye salmon	Sep to Oct	3-5 yrs	1-2 yrs[a]	Lakes and streams near lakes
Pink salmon	Aug to Oct	2 yrs	Weeks	Mainstem rivers
Chum salmon	Oct to Dec	3-5 yrs	Weeks	Mainstem rivers
Chinook salmon	Sep to Nov	2-8 yrs	Months to 1 year[b]	Upper tribs to mainstem rivers[c]
Coho salmon	Oct to Jan	3 yrs	1 year	Headwater streams
Steelhead/ Rainbow trout[d]	Feb to Jun	Variable (1 yr or older)	1 year to life	Headwater streams
Cutthroat trout (coastal)[d]	Jan to Jun	Variable (2 yrs or older)	1 year to life	Headwater streams
Bull trout[d]	Aug to Dec	Variable[e] (3 yrs or older)	3 years[f] to life	Headwater streams
Mountain whitefish[g]	Sep to Dec	Variable (3 yrs or older)	Life	Mainstem rivers

a Resident sockeye (also known as kokanee) are known to occur in Lake Pleasant and Ozette and will live their entire life in freshwater.

b Chinook show two life histories; a “spring-type” that spend a year in freshwater and an “ocean type” that spend a few months in freshwater.

c Chinook have three races (spring, summer, and fall), the races have different preferences for spawning locations. Spring Chinook tend to prefer upper tributaries in a watershed.

d Can exhibit both anadromous and non-anadromous life histories

e Brenkman et al. 2007

f Al-Chokhachy and Budy 2008

g These species have non-anadromous life histories and may never migrate to the ocean

Status and Trends Monitoring of Riparian and Aquatic Habitat

In 2012, DNR initiated a program for monitoring the Status and Trends of Riparian and Aquatic Habitat across the OESF (referred to as Status and Trends Habitat Monitoring for the remainder of this document). This program was designed to assess whether the implementation of the HCP riparian conservation strategy improves riparian and aquatic conditions and increases "habitat complexity as afforded by natural disturbances" (DNR 2013). The program has been identified as a high priority project because it will help reduce the number of key uncertainties identified during the Environmental Analysis for the OESF Forest Land Plan (DNR 2016) and habitat data from this program has potential to be used in the Riparian Validation Monitoring Program (Minkova et al. 2012). Using data collected from this status and trends program for riparian validation monitoring, rather than conducting additional habitat surveys, would result in a cost and workload savings to DNR.

The Status and Trends Habitat Monitoring uses DNR Type 3 streams in 50 basins across the OESF and an additional 4 reference basins within the Olympic National Park (Figure 2). Stream basins were selected using stratified random design. Basins considered for sampling contained DNR Type 3 streams with 50% or more of DNR managed land (244 out of 848 basins [601 that contain DNR land] within the boundaries of the OESF; Minkova et al. 2012). Sampling 50 out of the 244 basins would result in 20% of DNR Type 3 basins (basins with over 50% of DNR managed land) sampled. Basins were balanced spatially using a north (townships 29-33) and south (townships 24-28) designation and resulting in 8 basins located in the north and 42 basins located in the south. Basins within each zone were further stratified using median basin slope (Minkova et al. 2012; Minkova and Vorwerk 2014). This characteristic was identified as being integrative for a number of biophysical attributes (elevation, distance from the ocean, etc.) and for management history.

The 54 sample reaches have a length of at least 100 m or 20 bankfull widths and are located at the outlet of the Type 3 basin, above the 100-year floodplain of the mainstem stream that it confluences. The status and trends program includes measures of in-stream wood (commonly known as large woody debris [LWD]), coarse channel substrate, channel morphology, habitat typing, stream discharge (n = 10 basins), stream temperature, stream shade, valley and channel typing, confinement, riparian forest stand conditions, and riparian microclimate (n= 10 basins; Minkova et al. 2012). Frequency of basin sampling varies by habitat attributes ranging from stream temperature sampled with automatic data loggers every hour to stream gradient sampled every five years. A compendium of monitoring protocols for measuring habitat metrics is in preparation and is expected in 2016.

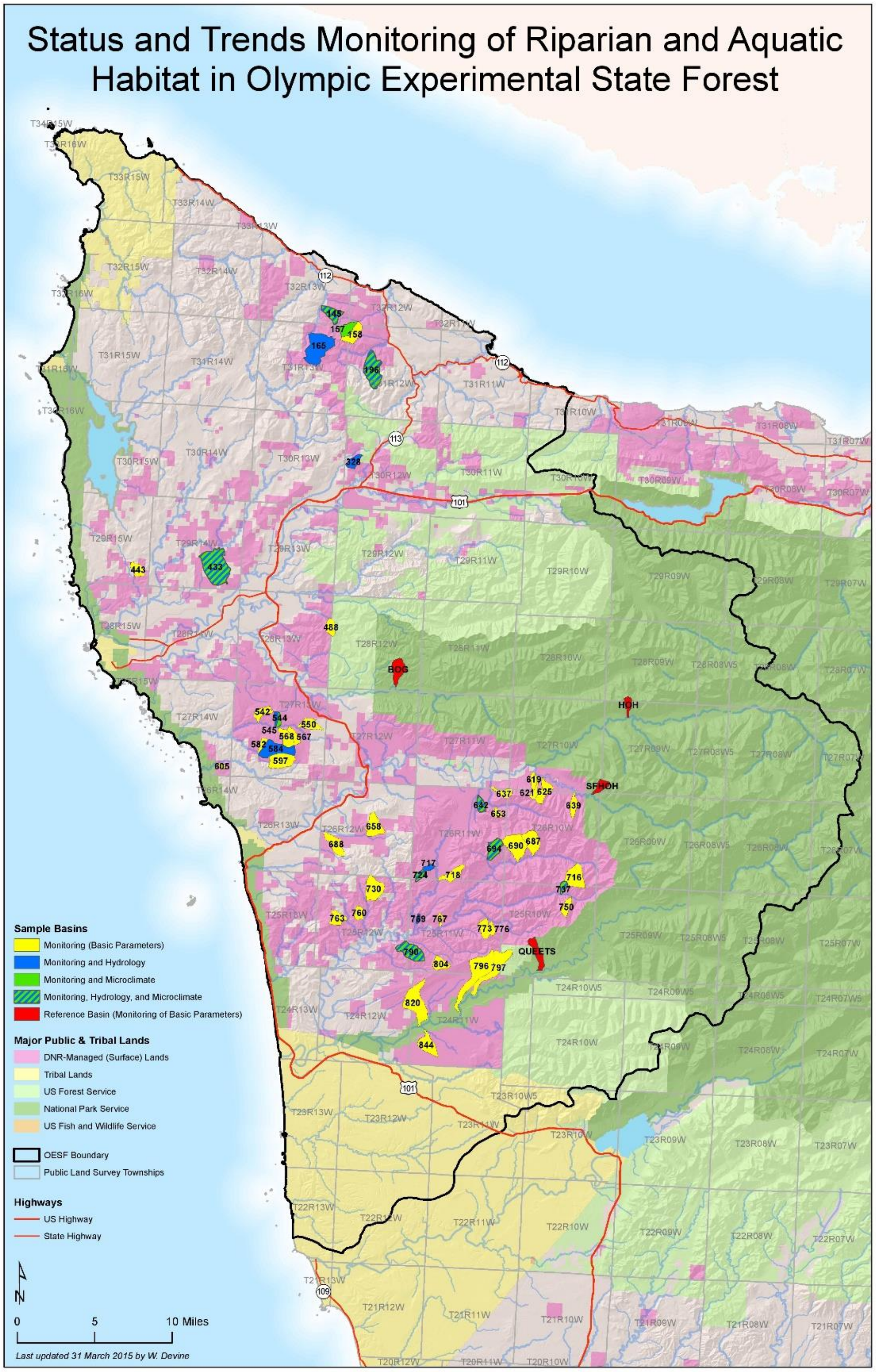


Figure 2 Map of the 50 Status and Trends of Riparian and Aquatic Habitat Monitoring Program's sites with description of type of monitoring within each basin.

History of Riparian Validation Monitoring

Although field work has not been conducted for the purpose of riparian validation monitoring since the adoption of the HCP, several attempts have been made to determine the scope of and the approach to validation monitoring.

In 2001, Dominguez and Beauchamp drafted a monitoring plan and outlined potential issues with riparian validation monitoring such as: the scale of monitoring that will be most cost effective; the ability to detect changes beyond yearly variations in salmon abundance; and the amount of time required to detect impacts from forest management activities (Dominguez and Beauchamp 2001). They recommended exploratory monitoring and analysis as the first steps to finding existing patterns. In addition, they suggested three alternatives ranging from sampling one watershed to multiple watersheds with various options and levels of complexity and a three phase approach to implementation (assessment, pilot, and full).

In 2002, LGL LTD environmental research associates prepared a report for DNR documenting the ability to assess coho salmon production in the Clallam River for the purpose of OESF riparian validation monitoring (Brocking 2002). It concluded that the Clallam River was not suitable for validation monitoring because: coho salmon rearing areas are mostly on private lands, and measurement of smolt production may be unreliable due to early fry and smolt migration. It further suggested that Charley Creek may be a better candidate for validation monitoring if productivity could be measured before coho salmon emigration.

In 2007, DNR held a series of workshops aimed at outlining a Riparian Validation Monitoring Program using salmonids in the OESF. The workshops, which included federal listing agencies (USFWS and NOAA Fisheries), looked at the use of coho salmon and cutthroat trout as possible fish species for monitoring. The workshops also looked at the scale of stream to monitor (reach, headwater stream, or larger watershed) and a paired-basin design. While no final conclusions were reached, the process focused on the use of coho salmon.

Initial Steps for Riparian Validation Monitoring

The development of this study plan started with hiring a fish biologist in December 2014. As a first assessment step, several regional fish and habitat monitoring programs and available information on potential fish distributions (the Intrinsic Potential [IP] models used in the Revised Draft EIS for the OESF [DNR 2013] and WDFW's Salmonid Stock Inventory[SaSI]) within the OESF were reviewed. While the IP model was built to determine habitat potential and not current fish distribution (Burnett et al. 2007), by mapping only areas with high potential (>0.75) and barring downstream anadromous barriers, this model, if accurate, should be able to predict current species locations, assuming that habitat is not so severely degraded as to limit the presence of a fish species all together. Initial exploration of the IP model and Salmonid Stock

Inventory revealed a lack of detailed or conflicting information on fish presence or absence data for most DNR Type 3 streams within the OESF.

Since cost savings and an increased number of habitat metrics could be gained if validation monitoring used the existing Status and Trends Habitat Monitoring data, these sites were evaluated for use in the Riparian Validation Monitoring Program. To reliably determine the suitability of these sites, fish surveys were needed to determine fish presence and species composition within each basin.

Table 2. Summary of sampling conducted in the OESF during initial sampling in 2015. [a] Eight basins were on the Olympic National Park and could not be sampled without a permit, one basin could not be reached due to road construction, and one basin had been previously sampled and found to have no fish)

Total number of basins	Number of basins visited	Number of basins not visited[a]	Number of basins with salmonids	Number of basins sampled with no fish present	Number of basins that were visited but were too dry to safely electrofish
54	44	10	39	2	3

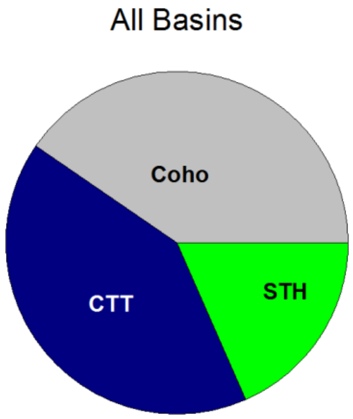


Figure 3 Proportion of salmonids collected during the 2015 field season

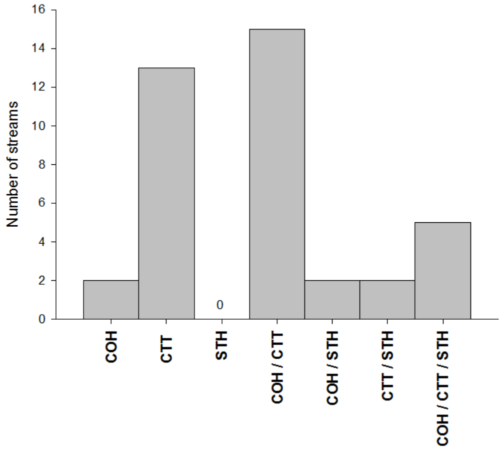


Figure 4 Salmonid composition of status and trends habitat monitoring sites in the OESF.

Sampling was conducted from late July 2015 to September 2015 using a backpack electrofisher with a goal to collect 30 fish per site. If fish were not found within the first six habitat units, sampling continued upstream until nine consecutive pool habitat units were sampled. Of the 54 sites, 44 were visited; 8 sites were on National Park Service land and could not be sampled because of the lack of a specific sampling permit; one site was previously sampled and found to have no fish; and one site was not reachable due to road construction (Table 2). Based on field judgment, five sites were not sampled due to lack of flowing water and the high likelihood of fish mortalities from electrofishing in shallow pockets of water. All five of these sites were in the Goodman block of the OESF. It is unknown if sites in the Goodman block are more likely to go dry or if this was due to the timing of visitation relative to the last rainfall event. Two of these sites were revisited in the fall after rain had renewed surface flows to the streams. One of the sites that was not sampled in the summer due to lack of water and then later sampled in the fall after surface flows were restored, and a second site with coho salmon easily collected in the summer were resampled in February to assess potential winter movement.

All basins with fish bearing streams contained at least one species of salmonid. Fish were collected in 39 of 41 (95%) basins with similar numbers of total coho salmon (n=281) and cutthroat trout (n=286; Figure 3). In addition, three streams were visited, but could not be sampled due to lack of water and were not revisited later in the year resulting in a sample of 39 basins (Table 2; 44 total basins; 2 basins with no fish, 3 basins that could not be sampled, and 39 basins that were sampled and had fish present). The most common salmonid composition was coho salmon and cutthroat trout, these species co-occurred in 15 of the sampled streams. This was followed closely by cutthroat trout only streams (n=13; Figure 4). Overall, steelhead were found in 23% (9 out of 39) of the basins, while coho salmon and cutthroat trout were found in 62% (24 of 39) and 82% (32 of 39) respectively. For those sites that were initially de-watered and resampled in the fall, one fish was found in each of the sites, revealing very low densities of fish from streams that were previously dewatered. In February, only one coho salmon (two avoided capture) was collected during winter sampling within two basins. This sampling provided no evidence for winter movement into the two sites, even though Scarlett and Cederholm (1984) documented winter colonization from juvenile coho salmon within small tributaries of the OESF.

The next step was to compare the empirical data from the 2015 fish surveys to the available GIS layers used for fish distribution. The two GIS layers available for evaluation were: distributions of high potential fish habitat data for coho salmon and steelhead (Fish index >0.75) from the IP models used in the OESF's Forest Land Plan Revised Draft EIS (DNR 2013), and distributions of coho salmon, cutthroat trout, and steelhead from WDFW's Salmon Stock Inventory. Both layers were inaccurate for determining fish presence within the habitat basins based on the limited sampling done in 2015 (Figure 5). The IP model correctly predicted coho salmon presence or absence in only 30% of the sites. The IP model predicted steelhead absence in 78% of the streams, but was unable to predict the presence of steelhead in any of the streams. Both the IP models and SaSI were unreliable for determining presence or absence of salmonids within the OESF based on the limited sampling in 2015. Species composition data along with individual basin characteristics derived through GIS data have potential to be used to develop better locations-specific models for determining fish distribution. Initial work on this model has begun with a goal of a working model by the spring of 2017.

The final step in the preliminary assessment of fish status in the OESF was to analyze the age structure (based on fish lengths) and potential life history use of the salmonids within the basins. Coho salmon length frequencies from all sites with coho salmon present had mostly age-0 coho salmon with a few holdover age-1 fish. Length frequency graphs of steelhead/rainbow trout and cutthroat trout show that the sites were used by different ages and potentially different life histories within these streams (Figures 6 and 7), though numerous sites revealed low or no age-1 or older steelhead/rainbow trout and cutthroat trout. While coho salmon typically smolt after one winter, steelhead and cutthroat trout typically spend between 1 and 7 years in freshwater (Wydoski and Whitney 2003). The low number of age-1 of older steelhead and cutthroat trout may indicate that winter habitat is poor within the basins, and fish may be leaving to find better habitat. Future analysis of the relationships between fish species, life stage, life history, and habitat data have potential to better explain the range of differences found between sites.

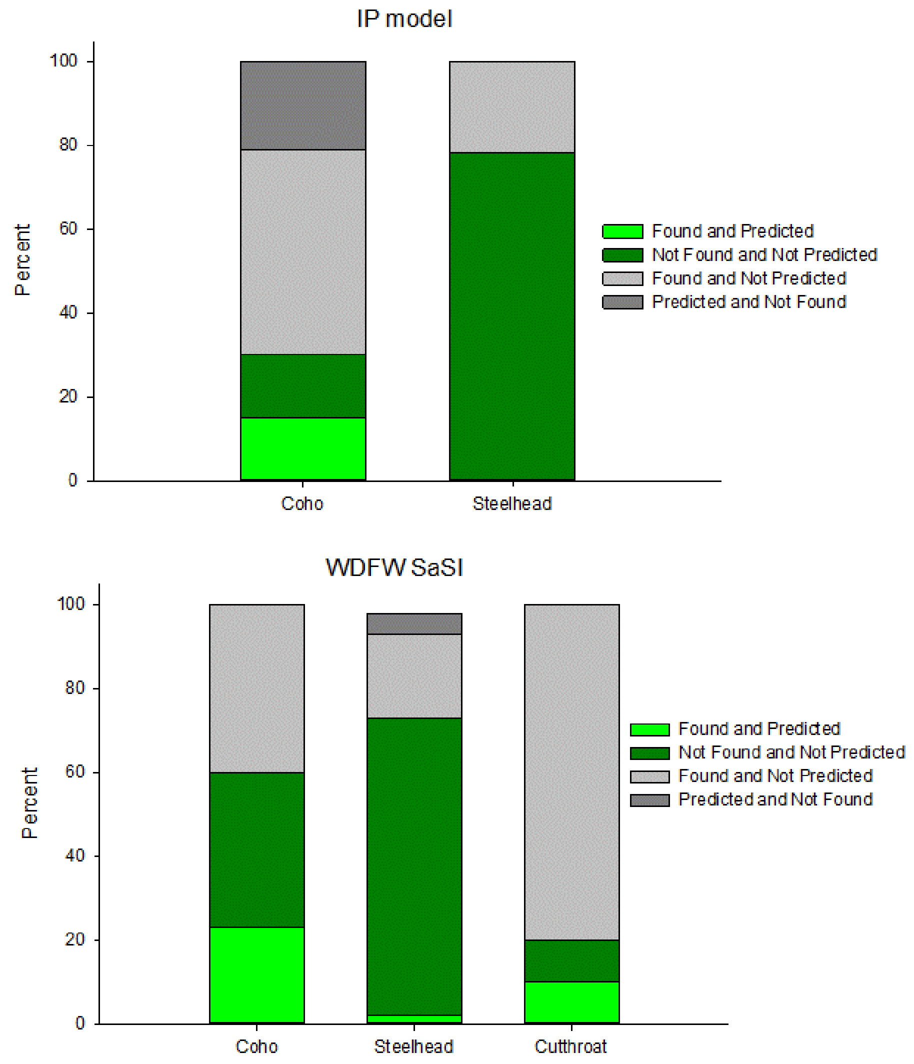


Figure 5 Comparison of sites sampled during the summer of 2015 with Intrinsic Potential model distributions (coho salmon and steelhead only) showing high potential habitat and Washington Department of Fish and Wildlife's Salmonid Stock Inventory fish distribution layers (coho salmon, steelhead, and cutthroat).

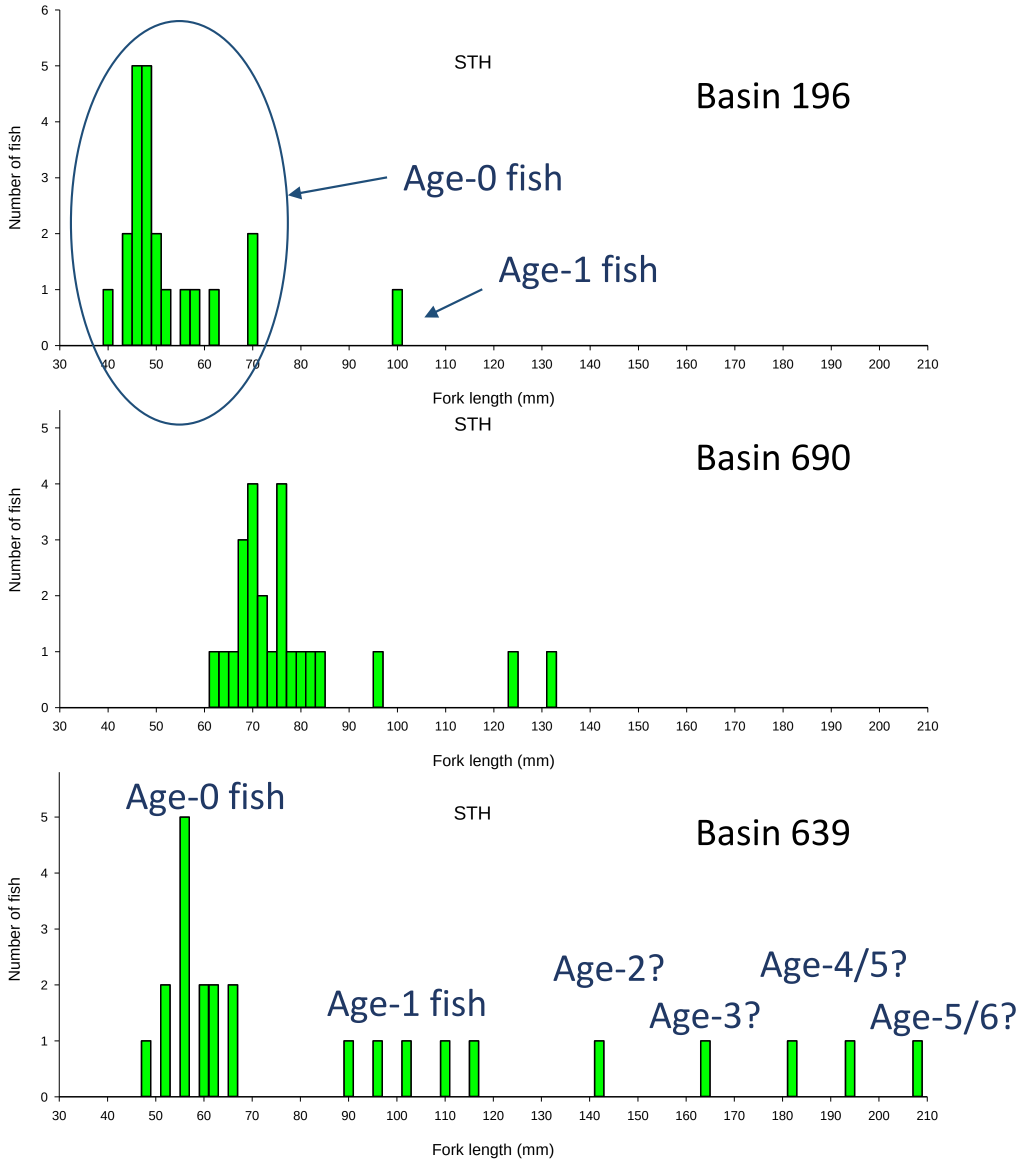


Figure 6 Three examples of length frequencies of steelhead/rainbow trout (STH) found in basins within the OESF with estimates of ages of fish collected. Graphs were picked to show the widest range of diversity among all sites where steelhead/rainbow trout were collected.

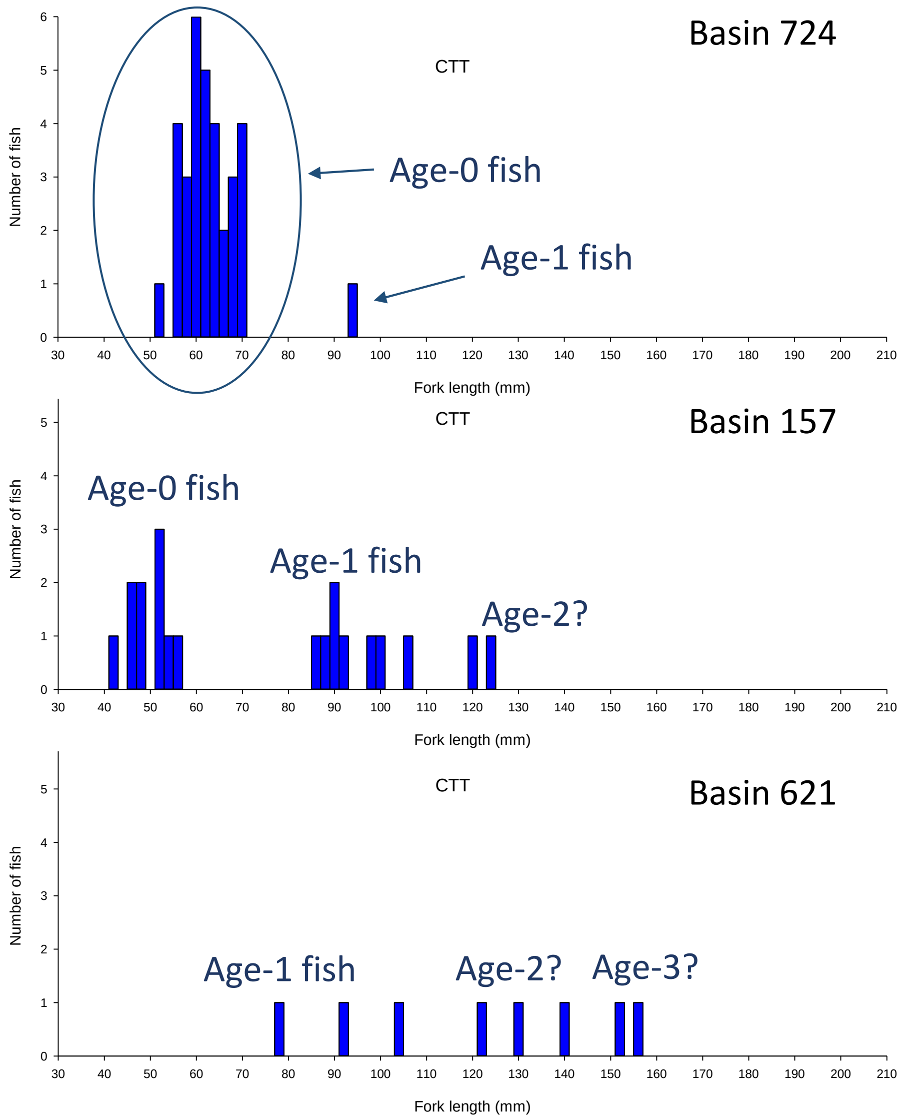


Figure 7 Three examples of length frequencies of cutthroat trout (CTT) found in basins within the OESF with estimates of ages of fish collected. Graphs were picked to show the widest range of diversity among all sites where cutthroat trout were collected.

Monitoring Goal and Objectives

The goal of riparian validation monitoring in the OESF is to determine whether salmonids are expressing the intended positive or neutral response from the conservation strategies implemented under the HCP. If trends in salmonid conditions (e. g. abundance, biomass, species composition, age structure, % anadromy, and [or] number of spawning redds) are detected, monitoring will seek to evaluate cause-and-effect relationships between DNR management activities, riparian habitat, and salmonids. Once the underlying mechanisms are established, DNR management practices could be altered to avoid or minimize negative, or accentuate positive effects.

The following monitoring objectives have been identified for the riparian validation monitoring program:

1) Determine the best methods for defining salmonid conditions (e. g. abundance, biomass, species composition, age structure, % anadromy, and [or] number of spawning redds) within the OESF.

2) Document the status, trends, and variability (site and year) among salmonids within the OESF.

3) Identify potential negative effects on salmonids from current DNR management practices and develop experimental studies to further evaluate cause and effect relationships.

4) Evaluate potential negative cause and effect relationships between current DNR management practices, riparian habitat, and salmonids, and if found, recommend changes to DNR management practices to mitigate any negative effects.

Guiding Principles for Riparian Validation Monitoring

1. Riparian validation monitoring sites should represent the habitat and salmonids that occur across the OESF.

2. Riparian validation monitoring should be directed at the effects that have occurred or are occurring since the implementation of the HCP (1997).

3. Riparian validation monitoring should have the least amount of impact on current DNR operations and should take advantage of planned activities.

4. Riparian validation monitoring should take advantage of the knowledge gained from existing monitoring projects in and outside the OESF.

5. Monitoring should occur over the life of the HCP. Riparian validation monitoring is a continuing and long-term process. While there is potential to verify large negative or positive effects within a few years, verifying small negative or positive effects and the mechanism of an effect will require long-term monitoring (greater than 10 years).

6. Riparian validation monitoring should be cost effective.

7. The study design should be adaptive and allow for flexibility as current knowledge of sampling techniques and management impacts on riparian systems evolve (Lindenmayer and Likens 2010).

8. Sites located in the Olympic National Park should be used to help determine patterns of fish and habitat response to factors other than DNR land management (e.g., climate change, drought, floods) and to establish a range of conditions that may provide greater contrast between managed and unmanaged basins.

Design Options for Riparian Validation Monitoring

Riparian validation monitoring will be difficult because responses to the HCP strategy occur in the context of overall, variable, natural and non-forestry human influences and are likely to be relatively subtle when compared with background variability. In addition, with the potential diversity of habitat, fish species, and fish life histories throughout the OESF, there is a high likelihood that if management activities are having an effect on salmonids, the degree of the effect would be expressed across a gradient based on this diversity. Factors such as ocean and freshwater harvest, climate change, Pacific Decadal Oscillation, stream nutrient reductions related to range-wide salmonid declines, and the lag effects from past management practices may also have a greater effect on current salmonid conditions (e. g. abundance, biomass, species composition, age structure, % anadromy, and [or] number of spawning redds) within the OESF than current management practices. These factors may mask any of the potentially positive or neutral effects expected from current management practices, especially at larger scales. As a result, potential effects from current management practices will be more discernable from smaller site-specific studies (reach or Type 3 basin level), though information gained from these studies will need to be representative of the entire OESF. With this in mind, two approaches for examining stream environments were evaluated for riparian validation monitoring.

The first approach (observational) would document salmonid responses over a large number of sites that are influenced by multiple factors such as individual basin characteristics or climate change. The second approach (experimental) would use a much smaller number of treatments and control sites in a paired-basin design to evaluate responses to specific treatments. These approaches were evaluated based on their ability to determine salmonid response in different habitats across the OESF, to evaluate cause-and-effect relationships, the amount of impact on current DNR operations, and adaptability of the approach. Understanding the mechanisms of cause-and-effect relationships has a greater chance of success through an experimental design that uses both control and treatment sites (Eberhardt and Thomas 1991), though there is currently no widely accepted methodology for determining these relationships (Adams 2005). Successful monitoring approaches should have "clear goals and objectives, a conceptual model linking the stressors to consequences, consistent and reliable measurement protocols, a study design that has the potential to detect differences, and clear linkage between monitoring results and management decisions." (Kershner et al. 2004).

Observational Approach

Observational monitoring is a common method for studying multiple sites over a large area. Using this approach, one would typically collect fewer fish and habitat metrics in order to sample more watersheds. This type of approach would cover a range of current and past management activities as well as natural disturbances. Typically, data from this type of monitoring are analyzed using correlations between watershed characteristics (e.g., fish, habitat, and management activities; Figure 8). Interpretation of the mechanisms of effects using correlations is considered weak, since correlations may not reflect the underlying cause or may even be wrong (Rosenfeld et al. 2000). Though Shipley (2000) argued that inferring causes without randomized experiments is possible. In addition, Hewitt et al. (2007) noted that gradients in the strength of effect and consistency among studies have often been used to conclude causality. This type of approach would not definitively isolate the effects of individual actions and has potential for unknown factors, such as climate change or Pacific Decadal Oscillation, to confound the results. This approach could provide evidence that supports initial hypotheses about cause-and-effect relationships and/or allows for the development of more informed hypotheses on the effects of management practices on salmonids. In addition, a NOAA report by Crawford and Rumsey (2011) on the "Guidance for Monitoring Recovery of Pacific Northwest Salmon & Steelhead listed under the Federal Endangered Species Act" states that status and trends monitoring (a type of observational approach) can meet multiple monitoring objectives and is necessary to determine the biological condition of species and the status of specific listing factors and threats. Essentially, this approach may detect a management effect, would provide information on the status and trends of salmonids across the OESF, would help to identify hypotheses for further evaluation, and would add support to existing hypotheses, but would only imply the cause of an effect rather than determine the underlying cause.

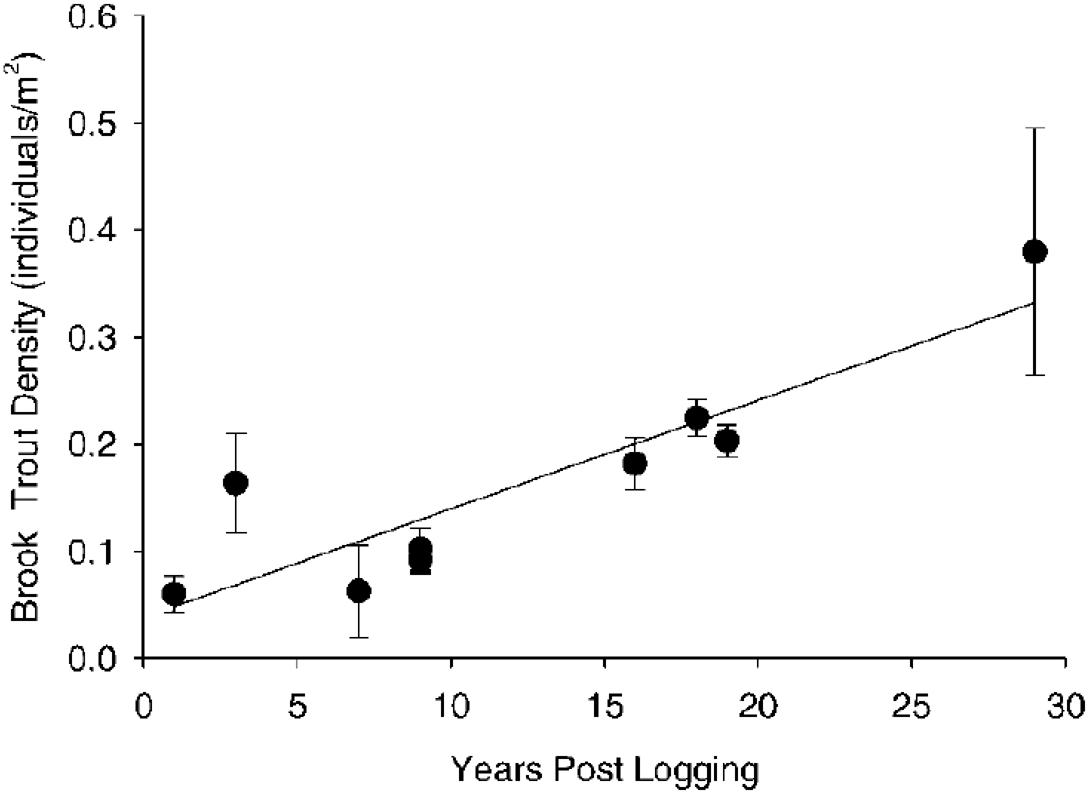


Figure 8 Example of a correlation using fish densities and years post logging. Example taken from VanDusen et al. (2005).

The following guidance for establishing a status and trends project is adopted from Reeves et al. (2004):

- The more sample units, the better for estimating status.
- Revisiting sample units across years is best for trend detection.
- About 50 sample units gives a reasonable description of a regional resource of interest when focus is on estimating frequency distributions.
- Inference precision roughly doubles with each fourfold increase in sample size, other considerations being equal.
- Spreading samples evenly across the region of interest better represents the region than does simple random sampling or clustered sampling.
- Stratification does not necessarily improve the ability to estimate status and detect trends and can sometimes be harmful. Benefits of stratification for aquatic and riparian purposes need to be carefully considered by the analysis team. Possible stratifications include stream size, channel type, land allocation, application of key standards and guides, or percentage of federal land.

Experimental Approach

An experimental approach using paired basins is a common method for determining changes in fish metrics resulting from watershed manipulations (either positive or negative). This type of approach would examine the effects of an individual forest management action or actions (e.g., variable retention harvest or riparian forest thinning) within the OESF. When using an experimental approach, a Before-After and Control-Impact (BACI) design is often used to test for a response at the treatment site or sites. An experimental approach is typically limited to a smaller number of basins, since they often cover a larger proportion of a watershed (e.g., a large river with multiple tributaries compared to a specific reach or stream) and (or) use more expensive and permanent equipment (e.g., smolt traps, instream passive integrated transponder [PIT] tag interrogators, and weirs) that allows for the collection of more intensive fish metrics (e.g., fish survival and movement). An independent science panel that evaluated a paired-basin design in southwest Washington (the type of an experimental approach most likely to be conducted for validation monitoring) recommended that a paired-basin design meet three conditions for it to be considered successful: (1) Indicators must be measured with sufficient precision and duration to detect changes, (2) Treatments must have sufficient contrast to affect a detectable change in salmonids, and (3) Environmental variability must be measured to account for its effects (Zimmerman et al. 2012). Relative to the observational approach, the experimental approach would likely provide more statistical power for evaluating cause-and-effect relationships, but challenges in applying sufficiently contrasting treatments in a working forest managed in accord with strict environmental regulations and the ability to find appropriate control basins to account for environmental variability may limit its applicability in the OESF.

The BACI design examines a site both before and after a treatment and uses control sites to isolate the effect of the treatment (Figure 9). Crawford and Rumsey (2011) of NOAA have recommended a BACI design for use in reach-scale effectiveness monitoring. The BACI design provides the greatest statistical power to detect significant changes in treated areas compared to untreated areas (Crawford and Rumsey 2011). When a study is designed around predefined treatment or control sites rather than randomly selected sites, the design is considered a quasi-experimental approach. A true experimental approach would be preferable, but is not reasonable in natural settings or under management conditions (Block et al. 2001). For a BACI design to be effective, treatments must have sufficient habitat contrast in order to detect a change in fish abundance (Crawford and Rumsey 2011). Thus a BACI design is not likely to detect an effect from a specific management action at the watershed scale (DNR Type 1 or Type 2 level) because it is unlikely that sufficient area could be treated, however this approach is more applicable at the reach or Type 3 basin level where contrasts would be relatively greater (Roni and Quinn 2001). Correlations among control and treatment sites before the treatment is applied are necessary to apply the BACI design (Clausen and Spooner 1993; Korman and Higgins 1997; Steel et al. 2013). If controls are not properly used, they can actually reduce the power of the design because unanticipated, natural variability within control sites and between control and treatment sites (i.e., lack of correlation) can be confounding (Roni et al. 2005). Overall, a BACI design improves the ability to detect effects since a portion of the inter-annual variation is accounted for by the correlation between treatment and control sites (Zimmerman et al. 2012).

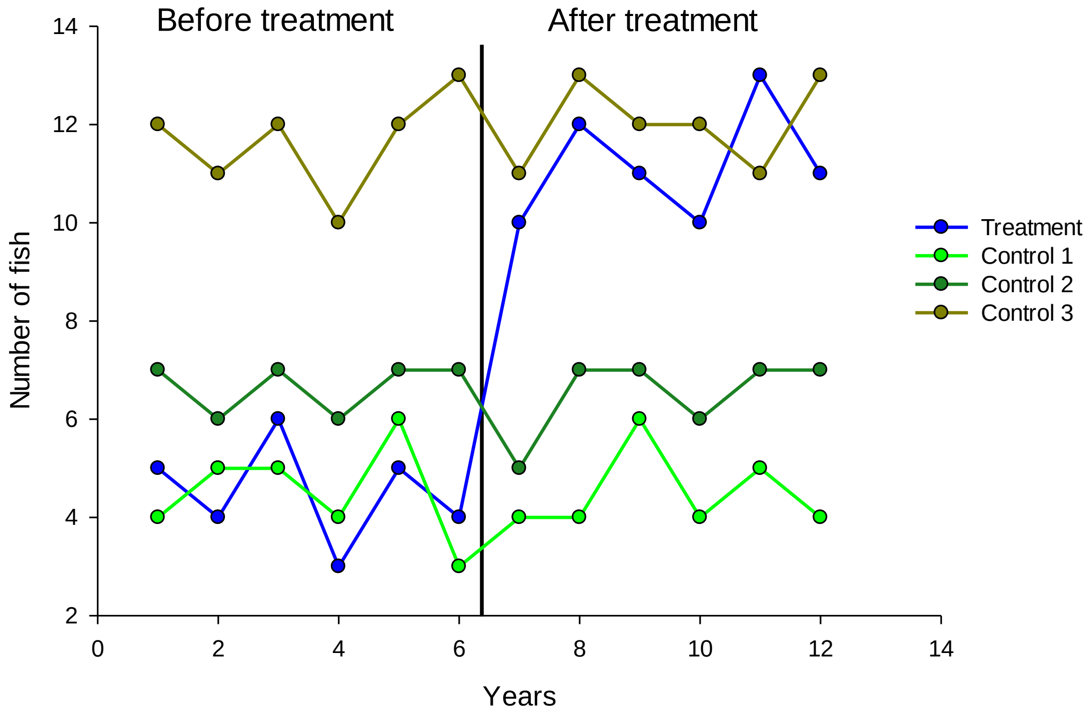


Figure 9 Example of a BACI design with one treatment (blue) and three control sites.

A larger (DNR Type 1 or Type 2 stream basin) more traditional paired-basin approach (e.g., Washington's Intensively Monitored Watershed program; http://wdfw.wa.gov/conservation/research/projects/watershed_monitoring/) was considered, but was found to be unsuitable for the OESF. This larger paired-basin approach typically includes adult and smolt monitoring to detect an overall response in a watershed. Due to the potential for effects from numerous actions (past and present) within a larger basin and multiple landowners with different objectives and practices, this type of monitoring would not determine specific cause-and-effect fish-habitat-management relationships without supplementary monitoring. Additionally, a larger paired-basin approach would necessitate that DNR could not conduct management activities in the control watershed. Due to the size of these basins, this approach would limit the amount of land harvested and funding to the trusts. Since the OESF contains several major river systems (Queets, Clearwater, Hoh, Bogachiel, Calawah, Sol Duc, Quillayute, Dickey, Ozette, Sekiu, Hoko, Clallam, and Pysht rivers), a larger paired-basin design would only represent a small portion of the OESF. Finally, the OESF is not spatially contiguous, with only one large basin (Clearwater) mostly contained on DNR-managed land. Potential options for control basins exist in the ONP, but since the management histories between DNR and ONP were so dissimilar (DNR lands may still be showing effects from past management practices), it is unlikely that these basins would act as appropriate controls. Furthermore, most of the ONP land is a greater distance from the ocean and at higher elevations than DNR land, which makes it difficult to find ecologically similar watersheds of such large scales.

In summary, a large-scale paired-basin design using an experimental approach is unlikely to provide strong evidence of effects from DNR management on salmonids, would be costly to implement, would reduce funding to the trusts, would not be representative of the entire OESF, and would lack a control watershed. Therefore, a paired-basin design, if attempted, should be limited to smaller DNR Type 3 basins, though this type of study would limit the inference to only Type 3 basins. Before attempting a paired-basin study at the Type 3 basin level, potential basins should be evaluated for their suitability for comparisons between basins.

Importance of a Long-term Approach

Improving our understanding of cause-and-effect relationships, regardless of the chosen monitoring approach, will take a considerable amount of time. The exact amount of time required to understand these relationships will depend on the natural variability in habitat and salmonids, and the size and consistency of the effects (Liermann and Roni 2008). Unfortunately, salmonid variability is known to be high, even when environmental conditions are relatively stable (Bayley 2002). Natural variability within stream habitat will also be a factor since watersheds naturally cycle through conditions of high and low quality (Miller et al. 2015). Furthermore, the modification to management practices directed by the HCP on the OESF may result in less detectable management effects. The chance to detect smaller effects improves with increasing the period of monitoring. Long-term monitoring may be the only way to detect if management activities are changing habitat conditions and fish metrics (Kershner et al. 2004). The Carnation Creek study in British Columbia, one of the longest running studies (>20 years) on fish and timber harvest, found that long-term studies were needed to clarify the complex interactions among land-use practices, fishing, climate change, shifts in marine conditions, and salmonids (Hogan et al. 1998).

Detecting an effect can be improved by decreasing measurement error and (or) increasing the number of years (Crawford and Rumsey 2011). Kershner et al. (2004) stated that the largest problem with most monitoring programs is the length of monitoring. Additionally, Bayley (2002) found that 27% percent of watershed studies were not monitored for long enough periods of time. Morgan and Smith (1997) suggested that monitoring should last for 10 to 50 years or more, while Roni et al. (2015) found that most salmonid BACI studies suggested that more than 10 years were needed to detect changes in fish abundance of 25% or greater. Larsen (2004) demonstrated that a network of 30 to 50 sites regularly monitored can detect changes of 1-2% per year in key habitat characteristics within 10-20 years or sooner. Caution should be taken with short-duration studies, since the lack of detecting an effect may be from a study design that is not strong enough to detect an effect, rather than the lack of an effect from the management practice (Lindenmayer 1999). Studies with an insufficient duration (or presumably not enough sites) risk misinterpreting results and the ability to predict responses to disturbances (Michener 1997).

Recommended Approach for Riparian Validation Monitoring

Given the limited knowledge of 1) natural variability in fish and habitat metrics across space and time; 2) the optimal fish sampling methods; 3) potential effects of current and past management activities on salmonids throughout the OESF; and 4) the factors external to forest management and their effects, using a combined approach to riparian validation monitoring is recommended.

Initial field work will focus on the observational approach and will evaluate current conditions and potential hypotheses. This initial work is designed to be adaptive, so that information collected on current riparian habitat conditions, salmonids, and collection methods can be used to modify and strengthen the monitoring program (Lindenmayer and Likens 2010). Additionally, information from sources such as ocean survival indices (NOAA Fisheries), adult abundance estimates (WDFW), and smolt abundance estimates in the Clearwater River (Quinault Indian Nation) can be used to build relationships between activities conducted within the OESF to conditions outside of the OESF. The use of mechanistic models will also be explored to predict potential relationships and the magnitude of habitat and (or) fish responses to management actions, as well as to provide additional mechanistic understanding of cause-and-effect relationships. Finally, an information criterion multi-model approach (e.g., Akaike's Information Criterion; AIC) will be used to examine existing hypotheses, to formulate more specific hypotheses, and (or) to identify which (if any) hypotheses should be further evaluated through a more formal experimental approach (Burnham and Anderson 2003).

Once all basins have been initially sampled and on a six-year rotation (either after two rotations in a three-year panel design or three rotations in a two-year panel design; Figure 10) thereafter, information gained from these monitoring efforts will be used to evaluate the feasibility and likely success of a paired-basin experimental approach. This evaluation will identify which, if any, management activities are most likely to express an effect large enough to assess cause-and-effect relationships and which habitat and fish response metrics (fish per m, m^2 or m^3 and biomass per m, m^2, or m^3) are most appropriate (sensitive, yet precise). Experimental studies will be conducted if analyses on salmonid conditions (e. g. abundance, biomass, species composition, age structure, % anadromy, and [or] number of spawning redds) show a significant negative response (P-value to be determined; see levels of significance section below) from management practices, AIC modeling ranks management metrics within the top models ($\Delta AIC<2$) and model testing supports the findings, mechanistic modeling suggests a negative effect from management practices and observational data provides additional support to the model conclusions, and (or) opportunities for experimental studies on DNR management practices exist within the framework of the observational approach. Using the observational data to test the correlation (fish abundance, fish biomass, and habitat conditions) between potential treatment (management action) and control basins would increase the likelihood of successfully implementing a BACI design and understanding cause-and-effect relationships.

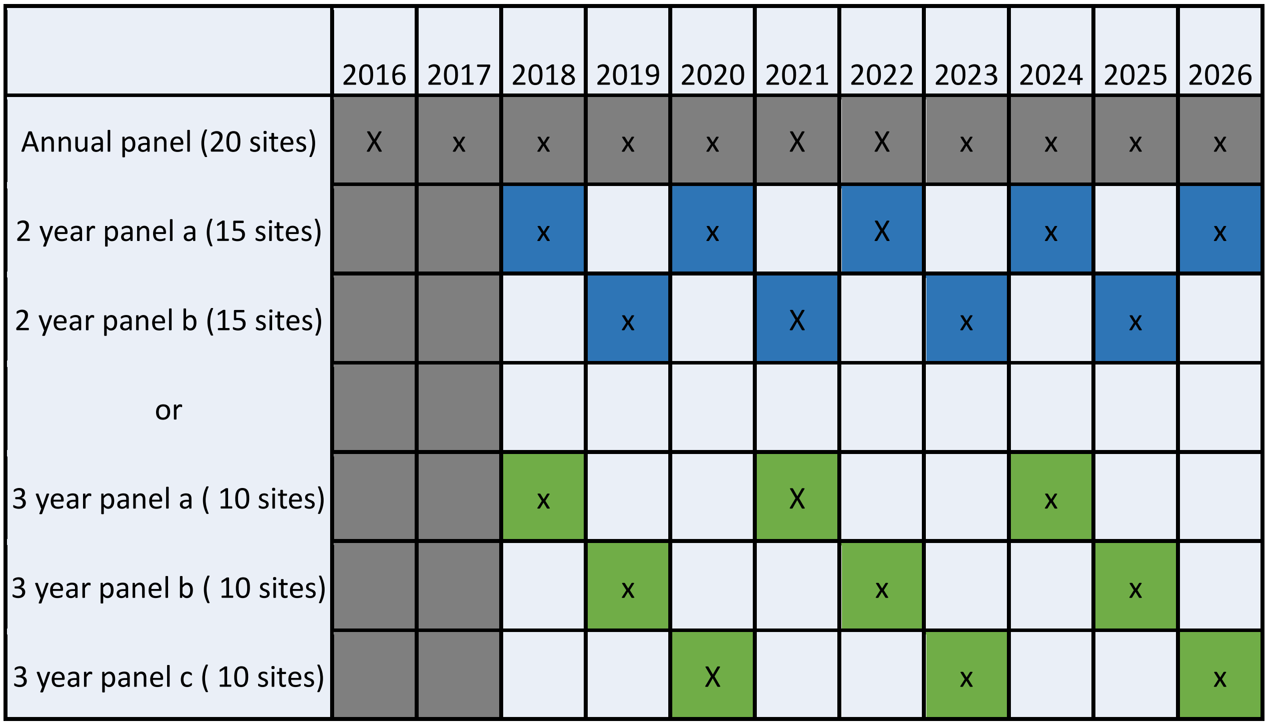
After an experiment or experiments have been added to the monitoring program (if deemed feasible), the combination of observational and experimental approaches should provide for the greatest potential to evaluate cause-and-effect relationships across the OESF. Hewitt et al. (2007) argued that a study that combines a large correlative study (such as an observational approach) with small experimental studies is the best way to answer questions on habitat conditions over multiple basins. Crawford and Rumsey (2011) also recommended utilizing “the same protocols for conducting reach scale project effectiveness monitoring (in which they suggested using a BACI design) as those used in broad scale status and trends monitoring (a type of observational approach) so that the results can be compared”. Using a combination of both approaches could allow for the detection of effects over a range of salmonid species, life histories, habitats, and management activities (observational approach), while also using an experimental approach to attempt to understand specific cause-and-effect relationships.

Design for the Recommended Approach of Riparian Validation Monitoring

The Riparian Validation Monitoring Program will be adaptive, meaning that changes may occur to the sample design, analysis, or fish collection techniques as learning occurs from new and innovative ideas or if problems arise from initial monitoring. Changes will be carefully considered to avoid compromising the statistical integrity of the study. Based on the 2015 electrofishing efforts and comparisons to the IP models and WDFW’s Salmonid Stock Inventory (Figure 5), there is not a reliable predictor of salmonid species occurrence in Type 3 basins of the OESF. Without a reliable predictor of species locations, there is no estimate of species assemblage for all of the basins within the OESF. As a result, it is unknown how the 50 sample basins, currently used for habitat monitoring, represent the fish populations across the OESF. A model that predicts species locations based on basin characteristics will need to be developed and validated. Once a model is established, the current sample of 50 basins will need to be reevaluated and potentially adjusted to better represent the entire OESF. Development of a locations-specific species model is currently under way, with a goal of a working model by the spring of 2017.

The first two years of validation monitoring will focus on refining juvenile abundance methods (reach vs continuous sampling; as described below), while collecting data from 20 sites (annual panel). Selecting 20 sites for the annual panel was determined by balancing the desire to sample as many sites as possible on a yearly basis to determine yearly variation for all of the fish metrics, while also sampling the total population of sites (54) as often as possible given one crew per summer to complete the field work. Full implementation will entail the sampling of 20 basins annually and 30-34 basins on a rotating basis, meaning that basins within the rotating panel will be surveyed every two (15-17 basins per year) or three (10-12 basins per year) years (Figure 10), resulting in 30-37 basins sampled annually. Anlauf et al. (2011) found that a rotating panel design would increase the number of sample sites and therefore increase the ability to assess status over an area with little or no loss in trend detection power compared to sampling fewer sites on a yearly basis. Selection between the two rotating panel options will be determined by the number of sites that can be sampled per summer (August to mid-October). The rotating panel may start as early as 2017, pending the results of the first year of the juvenile salmonid monitoring evaluation (reach vs continuous sampling), though it is more likely to start in 2018. The 20 annual basins will be selected from within the original habitat stratification to best represent the range of conditions (gradient, basin area, and fish composition) within the 50 OESF basins used for habitat monitoring.

Initial presence-absence surveys using backpack electrofishing in the habitat basins revealed that no fish were found within three basins (619, 653, and 694) and two basins (637 and 769) were unsuitable for the reach-level juvenile abundance methods (e.g., surveys could not be sampled in a continuous fashion due to extremely large amounts of instream and [or] above stream vegetation or LWD preventing the sampling crew from continuously sampling the reach). These five basins were removed from the habitat sample resulting in 45 basins in the OESF and all 4 ONP sites. Basins with no fish were removed only if a fish barrier was identified and not the result of annual shifts in fish distributions. Basins that were determined to be unsuitable for sampling, may result in fewer smaller basins within the overall sample, since these sites were typically from smaller streams with lots of vegetation or woody debris within or above the stream. Removing these sites may inflate the average overall fish density of our sites, if fish densities within these sites are lower compared to other streams within the sample. The potential exists that additional basins will be removed (sites will only be removed and replaced if the sampling methods cannot produce a reasonable abundance estimate) after initial abundance-level electrofishing efforts are conducted. If more or key basins (basins representative of identified strata) are removed from the original sample, additional basins may be added. New basins may also be added to the study if they have potential to be used in experimental studies, especially if they can be combined with new or existing DNR management studies within the OESF. The overall sample will remain near 50 basins, as it is a good balance of the number of sites, and the ability of a single crew to sample enough sites per field season. If initial sampling determines that it would be more effective to sample more sites than sampling more often or if the locations-specific species modeling determines that the current sample is inadequately sampling a specific strata, replacement basins may be incorporated into the study design by increasing the number of rotating panels or replacing existing basins.



	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Annual panel (20 sites)	X	x	x	x	x	X	X	x	x	x	x
2 year panel a (15 sites)			x		x		X		x		x
2 year panel b (15 sites)				x		X		x		x	
or											
3 year panel a (10 sites)			x			X			x		
3 year panel b (10 sites)				x			x			x	
3 year panel c (10 sites)					X			x			x

Figure 10 Sampling schedule for the first 10 years of validation monitoring based on a two or three year panel.

Monitored Species

Validation monitoring will not focus on one fish species but will encompass all salmonid species found within DNR Type 3 basins. Limiting the juvenile analysis to one species, as suggested in previous attempts to determine the scope of validation monitoring (mentioned in Minkova et al. 2012), would cover a limited amount of the OESF and would only provide insight on one species. Based on sampling done in 2015, if sampling occurred in only coho salmon streams in Type 3 (71% of fish-bearing streams) basins, the coho salmon distribution (coho were found in 62% of the habitat basins that were distributed to represent all OESF Type 3 basins) would cover <45% of fish-bearing streams in the OESF. In addition, coho salmon are known to prefer streams with lower gradients, so effects from management actions in high gradient basins would be diminished from coho-specific monitoring. Initial sampling in 2015 revealed the presence of coastal cutthroat trout, rainbow trout/juvenile steelhead, coho salmon, and sculpin within the Type 3 basins. Juvenile Chinook may have been present in some of the basins during the spring, but if present, migrated before initial sampling in the summer. Cutthroat trout, steelhead, and coho salmon all have potential to spend a year or more in DNR Type 3 streams (Wydoski and Whitney 2003), and as a result would be more susceptible to changes in stream habitat responding to management activities.

Sampling Unit

Reach-level abundance surveys have often been used for conducting multi-basin assessments (ISEMP/CHaMP 2015; Dauwalter et al. 2010; D'Ambrosio et al. 2009; Kennard et al. 2006), though recent work has called this approach into question suggesting an approach that covers the entire fish-bearing distribution of a stream may be more appropriate (Gresswell et al. 2006; McMillan et al. 2013). Gresswell et al. (2006) found that cutthroat trout were not evenly distributed and continuous sampling was needed to describe abundance within a basin, while McMillan et al. (2013) found that the location of habitat was more important than the amount of habitat for juvenile salmonids. The reach-level approach is appealing since current habitat monitoring is taking place at the reach level (near the mouth) and would not require additional habitat surveys, although GIS based basin-scale metrics (e.g., % of basin harvested, miles of road per basin, and median basin gradient) could be calculated. In addition, reach-level assessments can be designed to be completed in one day, while whole basin assessments will depend on the length of the fish-bearing distribution. A comparison study will be conducted to evaluate how continuous surveys conducted over the fish-bearing distribution of a basin compare to reach-level surveys (all habitat units combined) over the first one to two years of the program. Once evaluations are complete, a final determination will be made on a method, length of the reach, and (or) a combination of methods for monitoring juvenile salmonids densities and (or) biomass within the basins.

While most of the riparian validation monitoring effort will focus on DNR Type 3 basins, snorkel surveys will be conducted on DNR Type 1 and 2 streams. Results from this effort will provide information on salmonid species composition and distribution, assess juvenile salmonid use of the watershed, assess the potential connection of DNR Type 1 and 2 streams with Type 3 streams, and provide an index of adult salmonid abundance. Initial sampling will be exploratory with a goal of developing a robust design for future surveys. This effort will initially focus on one watershed within the OESF, although this may be expanded in the future to improve coverage of the monitoring design.

Levels of Significance

The ability of this monitoring program to detect an effect through traditional hypothesis testing will greatly depend on the amount and type of error the DNR and the services are willing to accept in determining an effect. The probability of rejecting a null hypothesis (in this case, that there is no management effect on salmonid populations) when it is true is considered a Type 1 error (also known as alpha or P-value), while failing to reject when the null hypothesis when false is a type 2 error (also known as 1.0-power or beta). A type 1 error could prove costly to salmonids on the OESF leading to further declines in salmonid populations, while a type 2 error (finding that a management practice is having an effect on salmonids when an effect is not present) could result in unnecessarily increasing management restrictions on forest harvest resulting in reduced income to the trusts. Type 1 errors of 0.05 or 0.10 are typically but arbitrarily used as the standard for determining significance for most ecological studies (Field et al 2004; Guy and Brown 2007), though these standards can be hard to achieve within highly variable stream settings (Dauwalter et al. 2009). Korman and Higgins (1997) suggested using 0.20 for both type 1 and type 2 errors. Setting the errors equal would allow for the same likelihood of incorrectly rejecting an effect (type 1 error) as incorrectly accepting an effect (type 2 error). Peterman (1990) argued that type 1 and 2 errors should be equal unless there is a larger cost associated with either error. Bryant et al. (2004) found that no fish or habitat metric was significant using a type 1 error of 0.05 in study conducted in Alaska, but several were when using 0.10 and consistent differences were detected between harvested and unharvested reaches. Prior to initiating studies on the effects of individual management activates, the principle investigator, DNR mangers, and the federal listing agencies should agree (based on suggestions by the principle investigator or Scientific Advisory Group) on the thresholds for type 1 and 2 errors.

Power Analysis Review

A literature review of power analyses was conducted to determine under what conditions the sampling framework (number of sites and years) was likely to detect changes in salmonids as a result of management practices. Harrell (2015) suggested that a good rule of thumb is to use less than 10 samples per metric in a multiple regression analysis (a type of analysis often used in observational studies). Based on this suggestion, after sampling the complete round of 50 sites, no more than 5 metrics should be used per analyses. An example of the potential fish-habitat-management metrics (a more thorough list of potential metrics can be found later in this report) that could be used for analysis may include fish density, % of basin harvested, LWD, stream substrate, and (or) basin gradient. Using a model that included known juvenile abundance and biomass variability, Dauwalter et al. (2009) found that they could detect a 5% annual decline within a population in 10 years using 30 sites per year. In addition, they found that a 5% annual decline could be detected with a type 1 and 2 error of 0.20 in 8 years with a network of 30 sites. They recommended that biologists use the least-variable metrics of trout abundance when trying to determine changes in populations. Liermann and Roni (2008) conducted a power analysis assessing the best design for determining coho salmon smolt response to stream restoration. They found that more sites were preferable to more years in a design, though changes in the variance of the estimates led to changes in the optimal design of a study. Korman and Higgins (1997) found that experimental designs could be greatly improved by increasing the precision of the estimate. Additionally, they found that Before-After designs performed better than BACI designs when the covariation between the treatment and control sites were low. In a power analysis based on a three-year pilot project using multiple-pass removal electrofishing (similar to the reach-based electrofishing efforts suggested for juvenile monitoring in this report) to assess the effectiveness of a land management plan for protecting fish and riparian habitat, Bryant et al. (2008) found that they would be able to detect a 5% annual effect with a power of over 80% (Type 2 error < 0.20) and a Type 1 error of 0.10 by monitoring 60 sites (30 treatment and 30 control) for coho salmon fry or 40 sites (20 treatment and 20 control) for parr in 10 years. These studies demonstrate that with variable salmonid metrics, small to medium-sized effects (5-20%) can be detected when monitoring enough sites (>30 sites), for a long enough duration (>10 years), and with precise estimates of salmonids. This is what DNR will try to achieve in its monitoring program. Ultimately, the ability of this program to improve our understanding of the Riparian Conservation Strategy influences on salmonids and riparian habitat, i.e., “cause-and-effect relationships” will depend on the as-yet unknown magnitude of any effects, and patient, proficient monitoring.

Scientific Background

Many studies have documented the effects of forest management activities (timber harvest and road management) on riparian and aquatic habitat conditions and fish. The impacts from changes in habitat can have conflicting effects on salmonids based on the species, life stage, or life history. Management impacts are known to persist from a few years to over 35 years (Murphy and Hall 1981; Connolly and Hall 1999). Connolly and Hall (1999) found increased salmonid abundance from 2 to 20 years post-harvest, but found reduced salmonid biomass after 20 years post-harvest and attributed this change to increased shade and decreased large woody debris. Under model simulations, Ziemer et al. (1991) suggested that effects from timber harvest may last up to 100 years. While much of the existing literature reports on the negative effects from clearcut harvest without riparian buffers (Mellina and Hinch 2008; Hicks et al. 1991a; Bisson and Sedell 1984; Richardson and Béraud 2014), negative impacts have also been found from less invasive forms of logging such as selective harvest (Flaspohler et al. 2002; VanDusen et al. 2005). Riparian buffers of various widths are commonly implemented to reduce negative impacts from timber harvest (Davies and Nelson 1994; Johnson et al. 1986; Broadmeadow and Nisbet 2004), however, even large buffers may not be enough to prevent all negative effects (e.g., reductions in habitat such as increased stream temperature, loss of instream wood, and increased stream sediment that may negatively affect fish abundance, biomass or species composition; Richardson and Béraud 2014). Contradictory results from several studies on the effect of management activities, highlight the need for additional research to help explain differences in these studies across multiple landscapes (Richardson and Béraud 2014).

Modern forest practices regulations and the HCP’s Riparian Conservation Strategy are designed to conserve and restore streamside forests. However, the dynamic effects of historic and contemporary practices are potentially ongoing and may continue for many decades into the future. The following section reviews the range of stream and salmonid responses to management activities documented in peer-reviewed studies. Although, many of these management activities are no longer practiced on DNR managed land, this section is designed to identify a range of potential mechanisms for salmonid responses to current management activities (activities conducted since the establishment of the HCP).

In-stream Wood

In-stream wood (more commonly known as and referred to in the rest of this document as large woody debris [LWD]) is one of the most studied habitat features known to affect salmonids. Large woody debris can increase stream complexity, control and stabilize stream morphology, increase the number and depth of pools, and decrease riffle habitat (Hicks et al 1991a; Bisson and Sedell 1984). Historic management activities, such as clearcut logging without buffer zones and stream cleaning, resulted in reductions to LWD that were detrimental to salmonids (Lestelle and Cederholm 1984; Hicks et al. 1991a; Connolly and Hall 1999). These historic management activities may still be affecting steam environments. Morgan and Smith (1997) found similar numbers of LWD in second and old-growth streams, but reduced volumes of LWD in second-growth streams. Changes in stream environments linked to LWD have produced differing results based on landscape characteristics. Beechie and Sibley (1997) found the effects of LWD (e.g., stream complexity, stability, pool forming ability) were larger in moderate-sloped streams than in low-sloped streams, while Mellina and Hinch (2009) theorized that higher gradient streams may not be as affected by LWD, since boulders often associated with these streams may perform similar functions to LWD.

Although the overall abundance of salmonids is positively associated with the abundance of LWD (Connolly and Hall 1999), particularly during the winter (Hicks et al. 1991a), LWD can affect salmonid species and life stages in different ways. Some changes can also negatively affect one life stage while positively affecting another (Mellina and Hinch 2009). Increased riffle habitat has been found to favor steelhead and cutthroat trout fry, while decreasing the proportion of juvenile coho salmon, and older steelhead and cutthroat trout (Bisson and Sedell 1984). Roni and Quinn (2001) found increases to LWD led to higher densities of coho salmon in the summer and to higher densities of coho salmon, steelhead, and cutthroat trout in the winter. While higher densities of fish are generally considered a positive response, higher densities have also led to smaller fish (Roni and Quinn 2001). Decreased growth due to density dependence may lead to changes in migration timing (age of migration, season, or age of smolting), or reductions in fitness to migrating fish. Nickelson et al. (1992) suggested that winter habitat is a limiting factor for juvenile coho salmon. Increases to LWD have been found to increase coho salmon winter carrying capacity and smolt production (Giannico and Hinch 2003). In addition, Mellina and Hinch (2009) speculated that coho salmon may be affected the most by LWD due to their preference for pool habitat. The effects of LWD will vary by species and life stage depending on an individual species' habitat preferences.

Stream Sediment

Stream sedimentation resulting from management practices is known to negatively impact salmonids. Increased sedimentation above natural disturbance levels can occur from both road management and timber harvest practices (Hicks et al. 1991a). Sediment is gradually washed into streams through rain and snow-melt events or in pulses associated with windthrow and landslides. While timber harvest and road building are obvious potential sources of sediment, unpaved roads have also been found to be a significant source of stream sediment (Reid and Dunne 1984). Cederholm et al. (1981) found that when over 2.5% of a basins area is cover in roads, the basin had higher levels of fine sediments in spawning gravels compared to road less basins. In addition, they found that higher gradient streams were less likely to collect large amounts of fine sediment. The response from salmonids will depend on sediment size. Coarse sediments can reduce water flow, increase riffle habitat, and decrease pool habitat. The addition of coarse sediment can increase the average gravel and cobble sizes in a stream bed, and as a result increase suitable spawning areas. Fine sediment can reduce water flow through gravels and lead to reduced dissolved oxygen concentrations in spawning substrate and increase suspended sediments in streams (Hicks et al. 1991a). In addition, sediment accumulations can lead to changes in the macroinvertebrate community (Brusven and Prather 1974; VanDuesen et al. 2005). Morgan and Smith (1997) found that sediment impacts can last from 1 to 10 years in high gradient streams and 10 to 50 years in low-gradient streams.

Stream sediment can have both immediate and long-term consequences on fish. Scarlett and Cederholm (1996) found that cutthroat trout numbers were decimated immediately following a debris flow in a stream on the OESF. In smaller headwater streams, commonly found across the OESF, large additions of coarse sediment can cause water to go subsurface (Hicks et al. 1991a), eliminating surface flows, potentially creating a barrier to anadromous salmonids. This may result in the loss of anadromous populations or the elimination of fish altogether. Reductions in pool habitat and increases in riffle habitat as a result of coarse sediment additions can potentially change species abundance, age structure, and composition. Scarlett and Cederholm (1996) speculated that stream depth limited the amount of larger (older) juvenile fish available in small tributaries of the OESF. Not all of the impacts from increased coarse sediment are necessarily negative, coarse sediment additions may also increase the amount of spawning habitat for adult salmonids. Higher concentrations of suspended sediments can change fish behavior and feeding habitats (Hicks et al. 1991a). Changes to macroinvertebrates, as a response to increased fine sediment, have also been found to reduce fish abundance (VanDuesen et al. 2005). Finally, studies have documented the harmful effects of fine sediments on spawning gravels leading to decreases in fry survival (Hicks et al. 1991a). Cederholm et al. (1981) postulated that erosion from timber harvest and forest roads led to increases in fine sediments that caused a significant reduction in coho salmon fry emergence in the OESF.

Canopy Cover

The removal or modifications to the canopy cover both near the stream and throughout the watershed can have a wide range of effects on a stream. Removal of the stream canopy cover allows for increased solar radiation to reach the stream, which can influence both water temperature and rates of photosynthesis by instream primary producers such as algae (Brown and Krygier 1970). Moore et al. (2005) found that forest canopies reduced the diurnal air temperature range compared to large open areas. Daily stream temperature ranges in one study almost doubled the summer after timber harvest, with greater ranges in low-retention and patch sites than in high-retention or control sites (MacDonald et al. 2003). While individual tributaries can have positive effects from slight increases in stream temperature, the basin-wide effect may be negative, since small streams help moderate downstream temperatures in mainstem rivers (Hick et al. 1991a). Changes in canopy create changes to riparian microclimate, riparian vegetation, instream vegetation, stream structure, and leaf litter inputs (Richardson and Danehy 2007). Riparian microclimate changes as a result of increases in solar radiation, wind speed, exposure to air advected from clearings (that are likely to cause increases in summertime air), soil, stream temperatures, and decreases in relative humidity (Moore et al. 2005). Streams in open canopies are typically dominated by filamentous green algae, while heavily shaded streams are dominated by epileptic diatoms (Hicks et al. 1991a). Increases in algae productivity can lead to changes in macroinvertebrate productivity and composition (Hicks et al. 1991a). Recovery from timber harvest depends on the type of harvest, but the effects from disturbances in canopy cover have been found to last between 10 years to over 60 years (Moore et al. 2005; Murphey and Hall 1981; Morgan and Smith 1997; Connolly and Hall 1999).

As with many changes to the environment, salmonid response to changes in the stream canopy will have a range of effects on life stages and species (Hicks et al. 1991a). Young et al. (1999) found a pattern of increased salmonid production immediately after canopy removal followed by a period of decreased productivity below pre-harvest levels, as the canopy closes and in-situ primary production is reduced. Changes can range from a few years to potential decades after management activities have been completed. Small increases to temperature can accelerate the development of coho salmon embryos leading to early emergence. Earlier emergence may be beneficial by increasing the growing season (Hicks et al. 1991a), but may be negative if emergence occurs when environmental conditions are not favorable (Mellina and Hinch 2008). While a longer growing season and increased growth associated with warmer temperatures may lead to larger fish, with larger fish assumed to have higher survival (Henderson and Cass 1991), the effect of larger fish on life-time survival is complex. Larger fish may have increased survival by being better prepared for the ocean (Henderson and Cass 1991), or could decrease survival if better growth invokes an earlier migration in the fall rather than the following spring or by a full year earlier (Holtby 1988). Although slight temperature increases may be beneficial (MacDonald et al. 2003), larger increases can be harmful by affecting parr rearing, preventing upstream migration of adults, increasing susceptibility to disease, reducing metabolic efficiency, and shifting the competitive advantage from salmonid species to non-salmonid species that prefer warmer water (Hicks et al. 1991a).

Stream Flow

Stream flow is another important feature found to affect salmonids as a result of forest management. Low surface flows resulting in isolated pockets of water or lack of flow altogether is limited to small streams and may be affected by the characteristics of a channel (Richardson and Danehy 2007). Though the response to low surface flow could be significant. As with many stream indicators, stream flow can have differing effects by season in response to management activities. Timber harvest reduces transpiration and interception that can increase summer low flows and early peak fall flows (Hicks et al. 1991a). Clearcut logging was found to increase flow for 8 years after harvest, and reduced flow in July and August for 19 years; however, no changes in stream flow were detected in response to patch-cut logging (Hicks 1991b). Increases in peak flows and mean daily freshet discharge have been found as a result of timber harvest (MacDonald et al. 2003; Grant et al. 2008). These increases in flows have been attributed to vegetation loss in addition to increased road density and construction. Higher peak flows, as a result of reductions in vegetative cover, increase the energy of the sediment that is delivered and transported due to disturbance caused by management activities. The higher flows also cause bank erosion that disperses additional sediment (Lewis et al. 2001).

Reductions in stream flow can prevent adult salmonids from reaching spawning grounds and force juvenile salmonids to move from their natal streams or perish as streams lose surface flows (Figure 2). Juvenile salmonids trapped in small isolated pools are vulnerable to predation (e.g., by birds, snakes and raccoons; Sommer et al. 2005) or to dissolved oxygen falling below survivable levels (Henning et al. 2006). Juvenile fish forced to move downstream due to lack of water or increased peak flows may also be susceptible to increased predation (Bolduc 2006; Kahler et al. 2001).

Stream Nutrients

Stream nutrients can remain at increased levels for more than 20 years following a timber harvest (Knoepp and Swank 1997). Concentrations of nitrogen, potassium, and conductivity can increase after timber harvest (Gravelle et al. 2009; Richardson and Béraud 2014), while forest roads can be a source of both nitrogen and phosphorus (Forsyth et al. 2006). Additionally, changes in both the composition and age of riparian vegetation have led to alterations in nitrogen and phosphorus concentrations as a result of forest practices (Boggs and Weaver 1994). These nutrient increases from management activities are caused by the leaching of organic debris through subsurface flows and organic particulates that are washed into the stream (Campbell and Doeg 1989), and can result in increased primary production (Hicks et al. 1991a) and potentially increased macroinvertebrate production.

Nutrient increases can improve the condition (e. g. abundance, biomass, species composition, age structure, % anadromy, and [or] number of spawning redds) of juvenile salmonids. The largest impact associated with stream nutrients on salmonids and surrounding ecosystems may be associated with wide-spread salmonid population declines. Marine derived nutrients from anadromous salmonids have been found to dispense large contributions of nutrients and organic matter to streams, riparian vegetation, and wildlife (Naiman et al. 2002). These nutrients are incorporated into the ecosystem through consumption of salmon carcasses and eggs, or through chemical or biological uptake by autotrophic (i.e., algae) and heterotrophic (i.e., microbes) biofilms (Naiman et al. 2002). Gresh et al. (2000) found that nutrients in streams with anadromous fish were reduced by 93% or 94% from historical levels and speculated that these reduced nutrients may be limiting salmon abundance. Mazumder and Edmundson (2002) found that stocking a system with nitrogen and phosphorus increased the size of age-1 and age-2 sockeye smolts. Increases in smolt sizes may lead to improved survival during migration and ocean residency (Henderson and Cass 1991), creating a larger number of adult returns. Increased nutrients as a result of timber harvest may partially explain some of the short-term positive responses in fish from timber harvest (Bisson and Sedell 1984; Connolly and Hall 1999). In addition, reductions in salmonids and in turn stream nutrients, partially due to stream sedimentation and other negative effects of past management activities (Cederholm and Reid 1987), may be limiting salmonid response to improved management practices.

Conceptual Model of Hypothesized Relationships between Forest Management, Riparian Habitat, and Salmonids

A conceptual model was built to establish the hypothesized relationships of forest management effects on riparian habitat and salmonids (Figure 11). This type of model can form the foundation of a monitoring program by helping to develop hypotheses and identifying potential mechanisms of ecological interactions and monitoring indicators and metrics. Kershner et al. (2004) stated that successful monitoring approaches should use a conceptual model linking the stressors (management practices or natural disturbances) to consequences (riparian habitat and fish response). The hypothesized relationships in this model were formed based on the scientific background previously documented in this report. As with the entire monitoring program, the model is designed to be adaptive and will constantly evolve and improve as new information is incorporated from initial monitoring or scientific literature (Lindenmayer and Likens 2010). This model will be used to determine the metrics best suited for testing each hypothesis, to help formulate newer more specific hypotheses after initial monitoring, and to assist with the design and development of future studies.

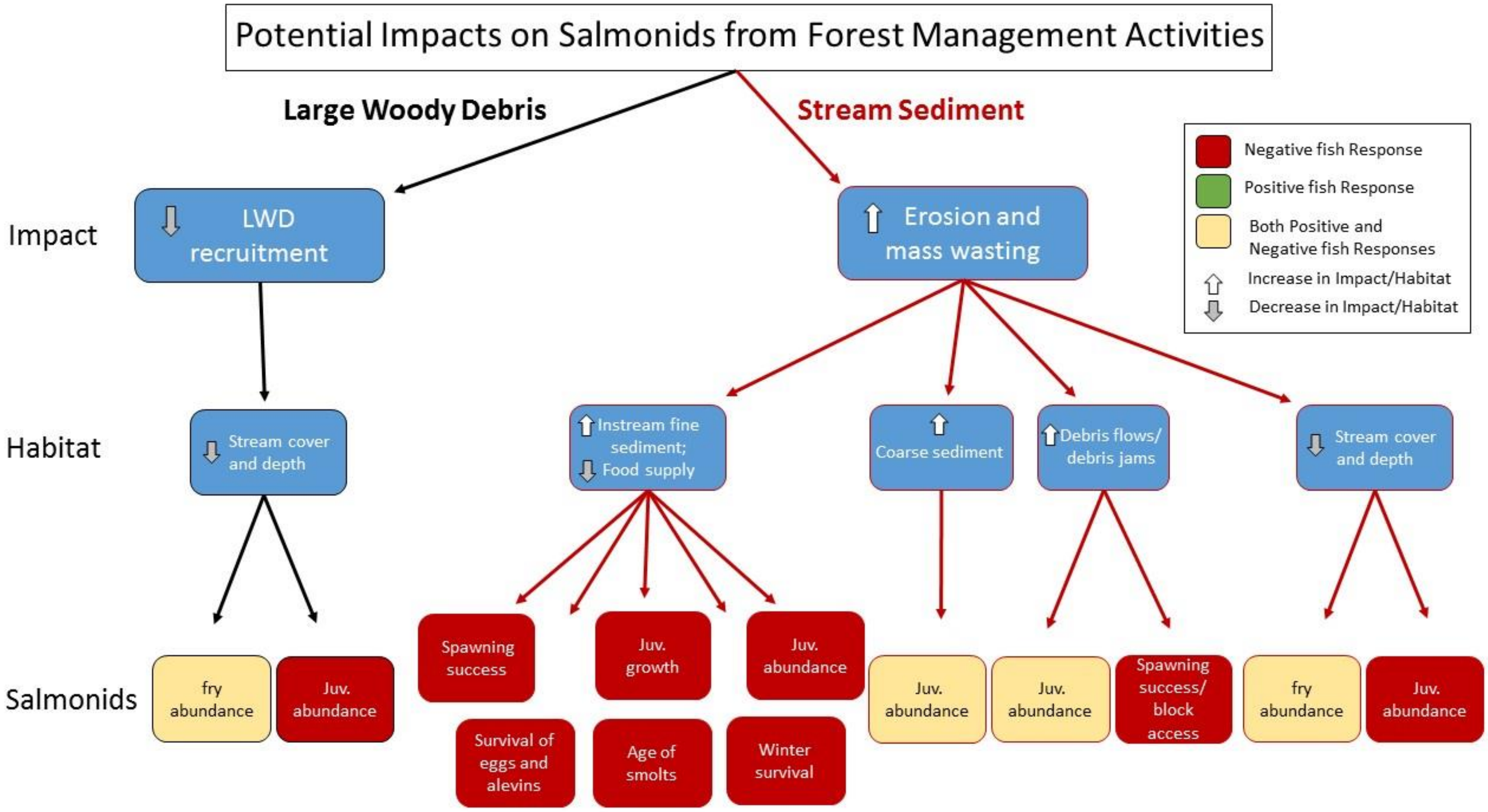


Figure 11 Conceptual model of potential impacts on salmonids from forest management activities to help identify monitoring questions, hypotheses, and indicators.

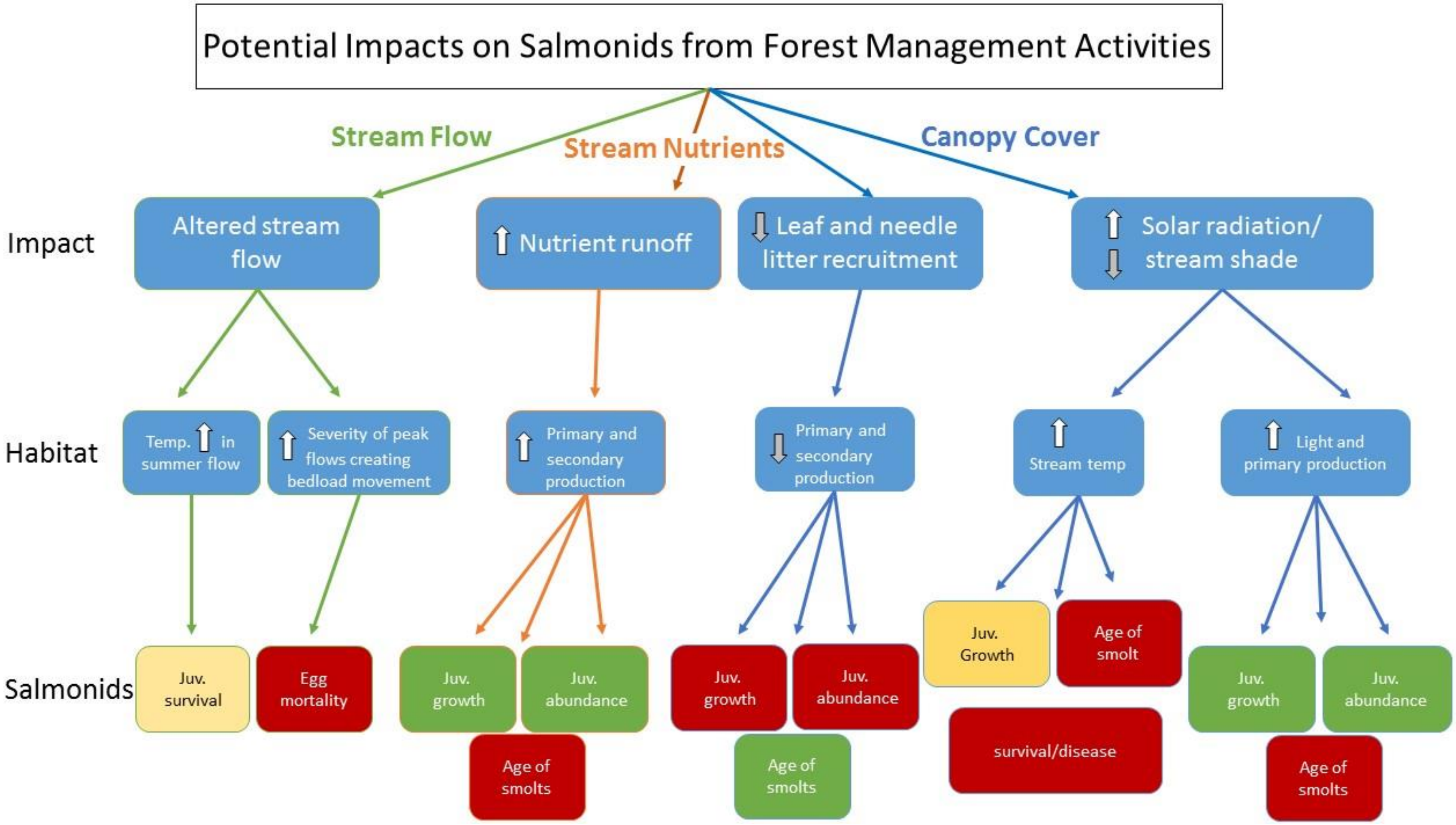


Figure 11. Continued.

Main Hypothesis

The conceptual basis, or underlying working hypothesis, for forest management in the OESF is that “It is possible to produce quality commercial timber and provide and protect ecological values in a managed forest by maintaining an arrangement of forest structure and stand diversity” (DNR 1997, p. IV.83). The working hypothesis, specific to salmonids, is that leaving riparian buffers large enough to minimize the impact of mass wasting and windthrow, implementing a road maintenance plan that reduces the negative impacts of sediment accumulations in streams and reduces fish barriers, as well as protecting forested wetlands would simultaneously protect all other key physical and biological functions of riparian systems and will result in an increasing amount of habitat capable of supporting viable salmonid populations. If the working hypothesis proves true, implementation of the Riparian Conservation Strategy as described in the HCP should lead to improved habitat in DNR-managed streams that contributes to stable or increasing populations of salmonids. The following list of discrete questions and hypotheses intends to focus validation monitoring on the management-related factors best supported as important to salmonid populations.

Monitoring Questions and Hypotheses

1. Are current management practices (post HCP) in the OESF affecting stream habitat and salmonids?

    H1 Current riparian buffers (interior-core and exterior) are maintaining and (or) improving (canopy cover, LWD, stream sediment, stream temperature, and stream flow) stream habitat and salmonid conditions (e. g. abundance, biomass, species composition, age structure, % anadromy, and [or] number of spawning redds).

    H2 Current road building and maintenance procedures are limiting the amount of fine sediment entering streams, leading to increases in suitable spawning gravels and salmonid conditions (e. g. abundance, biomass, species composition, age structure, % anadromy, and [or] number of spawning redds).

    H3 Increases in habitat complexity of stream and riparian forests will lead to increases in salmonid conditions (e. g. abundance, biomass, species composition, age structure, % anadromy, and [or] number of spawning redds).

2. Are past management practices (pre HCP) in the OESF continuing to affect salmonids?

H4 Current LWD volumes are decreased as a result of past management practices (pre-HCP) which has led to reductions in the frequency and volume of pools in previously harvested watersheds. If streams are recovering, the frequency and (or) volume of pools will increase and as result salmonid conditions (e. g. abundance, biomass, species composition, age structure, % anadromy, and [or] number of spawning redds).

H5 Stream sedimentation as a result of past management practices (pre-HCP) have reduced the volume of pools and increased fine sediment in spawning gravels in previously harvest basins. If streams are recovering, pool conditions and spawning gravels will improve and increase salmonid conditions (e. g. abundance, biomass, species composition, age structure, % anadromy, and [or] number of spawning redds)

H6 Changes in canopy cover as a result of past management practices (pre-HCP) have altered riparian vegetation and increased stream temperature in previously harvested basins. If streams are recovering, stream temperatures will decrease and riparian vegetation will change leading to increases in salmonid conditions (e. g. abundance, biomass, species composition, age structure, % anadromy, and [or] number of spawning redds).

3. What are the major within-basin natural drivers of salmonid abundance, and can these drivers explain differences in aquatic and riparian habitat and salmonids within the OESF?

H7 There are a range of ecological conditions across the OESF that determines species compositions and abundance (e.g., steelhead are only found in larger basins within the OESF; LWD is more important for salmonids in medium to low gradient streams than high gradient streams).

H8 DNR Type 1 and Type 2 streams contain different salmonid species assemblages and life histories but maintain important links to Type 3 streams. (e.g., larger resident cutthroat and rainbow trout that may spawn in Type 3 streams are found near the confluences of these streams; Type 1 and Type 2 streams support age-1 or older juvenile cutthroat and steelhead originating from Type 3 streams)

4. Are global and regional-scale forces such as climate change, Pacific Decadal Oscillation and ocean harvest affecting salmonids on the OESF?

    H9 Stream temperatures are increasing across the OESF due to increased air temperatures as a result of climate change.

Monitoring Indicators and Metrics for Riparian Validation Monitoring

A list of potential habitat and fish indicators and the resulting metrics that may be used for riparian validation monitoring are presented below. These metrics will be derived from the Status and Trends Habitat Monitoring, salmonid monitoring data, DNR management records, GIS analysis, or provided by other agencies (Quinault Indian Nation or WDFW).

Fish

Determined through DNR fish sampling (as described below) or from outside agencies data.

Metrics:

Coho redds per 100 m; Number of fish per 100 m; Fish per area (m^2);

Fish per volume (m^3); Average fish length by age class (mm);

Average condition factor; Biomass per 100 m; Biomass per area (m^2);

Biomass per volume (m^3); Fish species composition per site;

Salmonid species composition per site;

Total coho smolt abundance (Clearwater only; Quinault Indian Nation);

and Basin adult abundance (WDFW)

Habitat

Reach Scale

In-stream Wood – Wood metrics are calculated from length and diameter measurements and identification of all individual pieces or log jams (defined as having 10 or more qualifying pieces) that are $\geq$ 10 cm diameter and >2 m length within the bankfull channel of the sample reach.

Metrics:

Pieces per 100 m; Stable/key pieces per 100 m;

Medium pieces per 100 m; Large pieces per 100 m; Jams per 100 m;

Hardwood per 100m; Conifer per 100 m; and Volume per 100 m

Canopy Cover – % shade is calculated by averaging of six hemispherical photos taken in the middle of the stream from cross sections evenly spaced throughout the sample reach.

Metric:

% shade

Substrate – Substrate is measured into size bins using a gravelometer at the six habitat cross sections, sampling 21 pieces per section for a total of 126 (6 sites x 21 samples) samples per site.

Metrics:

% fines; % gravels; % cobbles; % boulders; D16 (mm); D50 (mm);

D84 (mm); D16 to D84 ratio; LRBS (which equals log[D_{50}] – log[D_{cbf}])

LRBS = the log transformed relative bed stability; and

D_{cbf} = the "erodible substrate diameter" estimated from stream hydraulic parameters

Channel complexity – Bankfull measurements (length, width, and depth) are collected at the six cross sections and averaged over the sample reach. Habitat units are identified using the field guide developed by Minkova and Vorwek (2015) and measured for length, average width, maximum depth, and the pool tail crest depth throughout the habitat reach.

Metrics:

Bankfull width-to-depth ratio; Pools per 100 m; Pool volume per 100 m;

Avg bankfull width; Reach gradient; and Habitat units per 100 m

Stream Temperature – Stream and air temperatures are monitored every 60 minutes using data loggers in each sample reach throughout the entire year.

Metrics:

Max temp; Min temp; Mean Temp; Median temp;

7 day max temp (by season); and Avg diel range (by season)

Stream flow – Stream discharge is calculated from continuously monitoring gaging stations located within 10 of the habitat basins.

Metrics:

Q10; Mean flow; Median flow; and Low flow

Riparian area vegetation – Riparian vegetation is identified and measured at two fixed plots (.44 ac) located on opposite banks of the sample reach.

Metrics:

Avg DBH; % conifer; % hardwood; Trees per ha; and Basal area per ha

Stream nutrients (if funding allows)

Metrics:

Total N; Total P; NH_3; NO_3; and Soluble reactive phosphorus (SRP)

Watershed Scale

Basin characteristics – Determined through GIS analysis.

Metrics:

Basin gradient; Elevation; Size of basin;

% area with hillslope 3 to 6%; % area with hillslope 20 to 44%;

Stream miles to ocean; and stream confinement

Forest Condition - Determined through GIS analysis

Metrics:

% forest cover and hydrologic maturity

DNR Management

Timber Harvest - Determined through GIS analysis, aerial photos, and DNR operational records.

Metrics:

% of basin harvested; Type of activity; Time of activity;

% basin harvested 1997 to 2015 (1990’s, 80’s, 70’s, 60’s);

Number of activities within each basin; and Proximity to streams

Road Maintenance - Determined through GIS analysis, aerial photos, and DNR records.

Metrics:

Miles of road per basin; % of basin consisting of roads;

Miles of road built within last 5 yrs;

Miles of unpaved road per basin;

Proximity to streams; Number of stream crossings/barriers;

and Type of stream crossing/barrier

Natural Disturbance

Determined through GIS analysis, aerial photos, and DNR records.

Metrics:

Type of disturbance (e.g., windthrow, debris torrents, and slides);

% of basin disturbed; and Time of disturbance

Methods for Monitoring Adult and Juvenile Salmonids

Adult Monitoring

Redd Surveys

Adult monitoring will consist mainly of existing WDFW redd surveys, and new DNR coho salmon redd surveys (initiated through the Riparian Validation Monitoring Program) within the 54 basins, with some additional information from DNR Type 1 and 2 stream snorkel surveys. Since the OESF largely consists of undammed rivers, adult count data would typically rely on fish collection weirs, video, or hydro-acoustic cameras. While possible, these methods can be costly to install and operate, and would be focused on individual watersheds (missing large portions of the OESF). Redd counts are a commonly used method to estimate adult salmonid abundance

(Dauphin et al. 2010; Gallagher and Gallagher 2005; Gallagher et al. 2007). Studies in California suggested that adult coho salmon estimates derived from redd surveys had higher precision than live counts and were more consistent across streams (Gallagher and Gallagher 2005; Gallagher et al. 2010). DNR redd surveys will not be used together to derive a single OESF-wide adult abundance estimates, but will serve as an index of adult returns and reproductive effort within each individual basin and can add information to help interpret variability in juvenile salmonids. This type of monitoring can provide information on local disturbances such as management practices (Peacock and Holt 2012).

WDFW adult spawner estimates from redd surveys are conducted annually for coho salmon, steelhead and Chinook in many of the streams within the boundaries of the OESF (https://data.wa.gov/Natural-Resources-Environment/WDFW-Salmonid-Stock-Inventory-Population-Escapemen/fgyz-n3uk). In 2014, WDFW estimated adult coho salmon abundance in eight watersheds (Clallam, Hoko, Sol Duc, Dickey, Bogachiel, Calawah, Hoh, and Clearwater), steelhead abundance in nine watersheds (Clallam, Hoko, Sol Duc, Dickey, Quillayute/Bogachiel, Calawah, Hoh, Clearwater, and Queets), and Chinook abundance in eight watersheds (Hoko, Sol Duc, Dickey, Quillayute/Bogachiel, Calawah, Hoh, Clearwater, and Queets). These estimates may provide a metric of overall watershed and ocean conditions regardless of land ownership.

DNR redd surveys will cover the entire fish-bearing distribution of streams for each DNR Type 3 basin with known coho salmon occurrence (coho were found in 62% of the basins during initial sampling in 2015). Surveys will begin in November and will end in late December or January and will follow the methods of Gallagher et al. (2007). No initial attempts will be made to quantify steelhead and cutthroat trout redds among the basins, because they are spring-spawning fish and stream conditions in mountainous areas during this time of year can make redd surveys difficult (Budy et al. 2012). Gallagher and Gallagher (2005) found that redd detection efficiency was significantly affected by water visibility and stream flow. If deemed necessary, spring salmonid redd surveys will be evaluated in the future for potential inclusion in the validation monitoring program.

Snorkeling Surveys

Snorkeling surveys will be conducted to understand the role of DNR Type 1 and 2 streams within the OESF. These surveys will be used to help understand the distribution and use of larger resident, anadromous, and juvenile salmonids in larger systems, as well as provide information on the possible connection of these fish with smaller Type 3 streams. This initial effort will focus on the Clearwater River in 2016 and will be conducted over a week between August and September. Sampling reaches will be selected based on snorkeler access to stream reaches, location within watershed, and (or) the presence of DNR habitat basins. Methods will closely follow the protocols of Thurow (1994) with a two to three person crew snorkeling in a downstream direction. Snorkelers will identify and enumerate all larger fish (>200 mm) and will note the presence and relative density of smaller fish (≤ 199 mm). This effort may be expanded or altered within the Clearwater or into additional watersheds in the future based on the knowledge gained from this initial effort, questions that arise from initial sampling, statistical rigor, and workload.

Juvenile Monitoring

Reach-level Abundance Estimates

Juvenile abundance estimates (reach level) will be designed to be completed by a three-person crew in one day for each basin to ensure that the maximum number of basins can be surveyed over a summer. All electrofising will be conducted under the limits and conditions agreed to through WDFW and USFW fish collection reports. Multiple-pass removal will be used instead of mark-recapture due to unknown abundance sizes and capture rates. Otis et al. (1978) stated that mark-recapture studies with capture rates between 0.4 or 0.5 an abundance would need to be at least 50 before an abundance estimate is useful and further stated that abundance should never be below 25 or capture probabilities below 0.1. Since salmonid abundance vary in small streams, mark-recapture techniques could result in wasted efforts if abundances do not meet the minimum combination of numbers or capture rates. Multiple-pass removal has been used to successfully estimate smaller abundances of fish (Rodgers et al. 1992; Connolly 1996). While some research has indicated that multiple-pass removal underestimates abundance size (Rosenberger and Dunham 2005; Peterson et al. 2004), others have found that this underestimating is not significant (Meyer and High 2011; Saunders et al. 2011). Saunders et al. (2011) reported that the underestimation typically resulted in less than one fish per reach, and recommended using a model that uses heterogeneity to correct for this bias. Using multiple-pass removal in combination with the catch charts developed by Connolly (1996) allows a sampling crew to insure a minimum precision level while in the field. This method can also increase the number of passes, which may further minimize the underestimation as suggested by Rosenberger and Dunham (2005). Insuring a higher precision in abundance estimates can help with the detection of smaller effects from management practices.

Multiple-pass removal will use a variable-pass technique (3-6 passes) to assure high precision while limiting the number of electrofishing passes to the minimum amount needed to achieve the required precision. Backpack electrofishing will closely follow the methods outlined in Martens and Connolly (2014). In addition, an abundance model that uses heterogeneity will be used to evaluate three-pass electrofishing, as recommended in Saunders et al. (2011), relative to the variable-pass method from Martens and Connolly (2014). Multiple-pass removal surveys will be conducted over existing habitat reaches (reach length is either a minimum of 100 m long or the equivalent of 20 bankfull widths, and starts above the 100-year flood plain of the mainstem stream that it flows into). If a continuous pass within the reach is not possible due to in-stream or over-stream debris, field crews may split the unit into multiple sections to avoid problematic areas. All sampling will be conducted in August through mid-October, though additional winter sampling should be explored as funding allows. Sampling will start in August to allow spring-spawned fish to grow to a size large enough to be captured and handled without endangering fish health. In some larger basins, the use of two electrofishers may be needed to effectively cover the entire sampling area. While most habitat data will be taken from ongoing habitat surveys (Minkova et al. 2012), a stream habitat unit survey, which identifies pools, riffles, runs, and cascades, will be conducted during each fish survey. The survey will identify habitat units based on the field guide of Minkova and Vorwerk (2015) and measure each unit for length (m), wetted width (m), average depth (cm), and maximum depth (cm). Data from this survey will be combined with the fish data to determine abundance and biomass per length (m), per area (m^2), and per volume (m^3).

Both multiple-pass removal and mark-recapture methods assume a closed population. To meet this assumption, block nets will be placed at the beginning and end of a sampling reach. Maintaining these nets throughout the duration of the survey can be problematic due to high flows, gradient, and [or] suspended debris loads. If maintaining block nets is found to be impractical for a large number of sites, an open population technique such as Royle's (2004) N-mixture model will be explored. This technique uses multiple sites and repeat visits to estimate abundance.

Continuous Fish-bearing Distribution Abundance Estimates

Before initiation of the rotating panel, continuous sampling of the fish-bearing distribution will be evaluated and compared to the reach-based estimates described above (2016 and 2017; Figure 12). The continuous surveys will overlap with the reach surveys to allow for method comparisons and to potentially calibrate the use of the continuous sampling as a surrogate for reach level surveys. Continuous sampling will be conducted with a backpack electrofisher, sampling every pool (slow-moving, channel-spanning unit with uniform flow that would hold water if flow were turned off) and cascade (a high gradient [>7.5%] confined channel that often includes small partial channel-spanning pools; Montgomery and Buffington 1997) or every other pool and cascade along the length of the fish-bearing distribution of the stream, following the methods of Gresswell et al. (2006). A habitat unit survey will accompany the continuous electrofishing survey. This survey will identify habitat units based on the field guide of Minkova and Vorwerk (2015) and measure each unit for length (m), wetted width (m), average depth (cm), and maximum depth (cm). Fish numbers from pool and cascade habitat units will be compared to the fish numbers collected in reach surveys to assess how well the abundance can

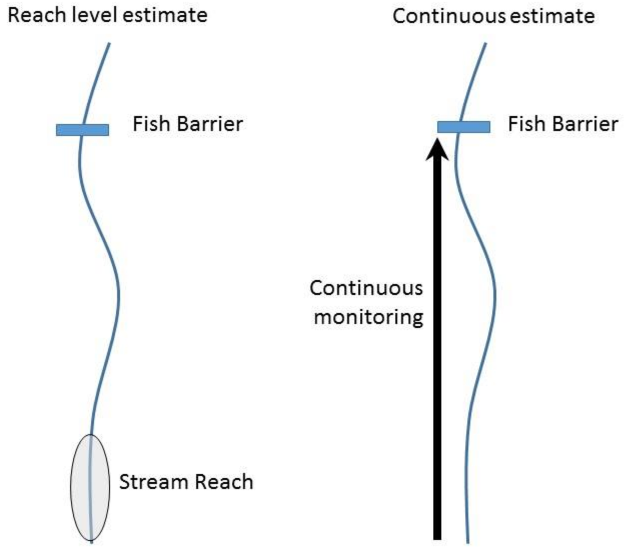


Figure 12 Example of Reach level and Continuous monitoring

be determined by sampling only pool and cascade habitat units within a stream. This sampling will be attempted in all 20 annual sampling basins, but will likely be reduced based on the amount of time required to sample each basin. This approach will be used to determine how accurately continuous sampling can determine fish density compared to multiple-pass removal (habitat reach sampling only), and to compare differences between fish density estimates from the reach sampling (multiple-pass removal) to estimates from the fish bearing distribution (continuous sampling). In addition, an evaluation will be made on using multiple-pass removal estimates to calibrate the continuous sampling method. Final determination of the sampling method will be dependent on the results of this examination, crew requirements, and the amount of time required for sampling.

Recommended Additions to the Juvenile Monitoring Program

Seasonal salmonid use of small streams has been well documented (Bjornn 1971; Bramblett et al. 2002; Brown and Hartman 1988; Scarlett and Cedarholm 1984) to the point that DNR modeled summer and winter coho salmon habitat separately in the Revised Draft Environmental Impact Statement (RDEIS) for the OESF (DNR 2013). In addition, preliminary fish sampling (Figures 6 and 7) revealed potential differences in fish use by age groups within basins of the OESF. Figure 14 hypothesizes four potential life histories expressed by coho salmon (2), and cutthroat trout and steelhead (2) within Type 3 streams of the OESF. Since the majority of juvenile anadromous cutthroat trout and steelhead smolt after spending two or more winters (sometimes as many as 7 years) in fresh water (Wydoski and Whitney 2003; Peven et al. 1994), the lack of age-1 or older cutthroat trout and steelhead observed over the 2015 field season is either an indication of low survival or fish movement. It is currently unknown the extent to which coho salmon within the OESF basins are expressing either hypothesized life history 1 or 2 (Figure 13). Winter sampling could provide useful information as to the seasonal use and (or) survival of these fish. In addition, the use of PIT tags (PIT tags are passive identification tags [tags without a battery life] that can be used to identify an individual fish if it is recaptured, scanned, or moves over an instream antenna) and potentially recaptures at existing smolt traps [Clearwater River] or detections at potential instream PIT tag interrogators could provide information on the degree of anadromy of both cutthroat trout and steelhead as well as the timing of movement for coho salmon, cutthroat trout, and steelhead. The use of PIT tags could also provide information on survival and growth of fish that remain within the sites. The consequences (survival) of early fish movement (moving in the fall compared to the spring; Figure 14 - life history 2) are unknown and may be related to habitat quality and quantity within Type 3 basins. As habitat improves, the number of age-1 or older fish within the basins may increase and could result in an increased number of smolts. Anticipated funding for this program currently does not allow for winter sampling or PIT tag equipment, this should be reassessed in the future.

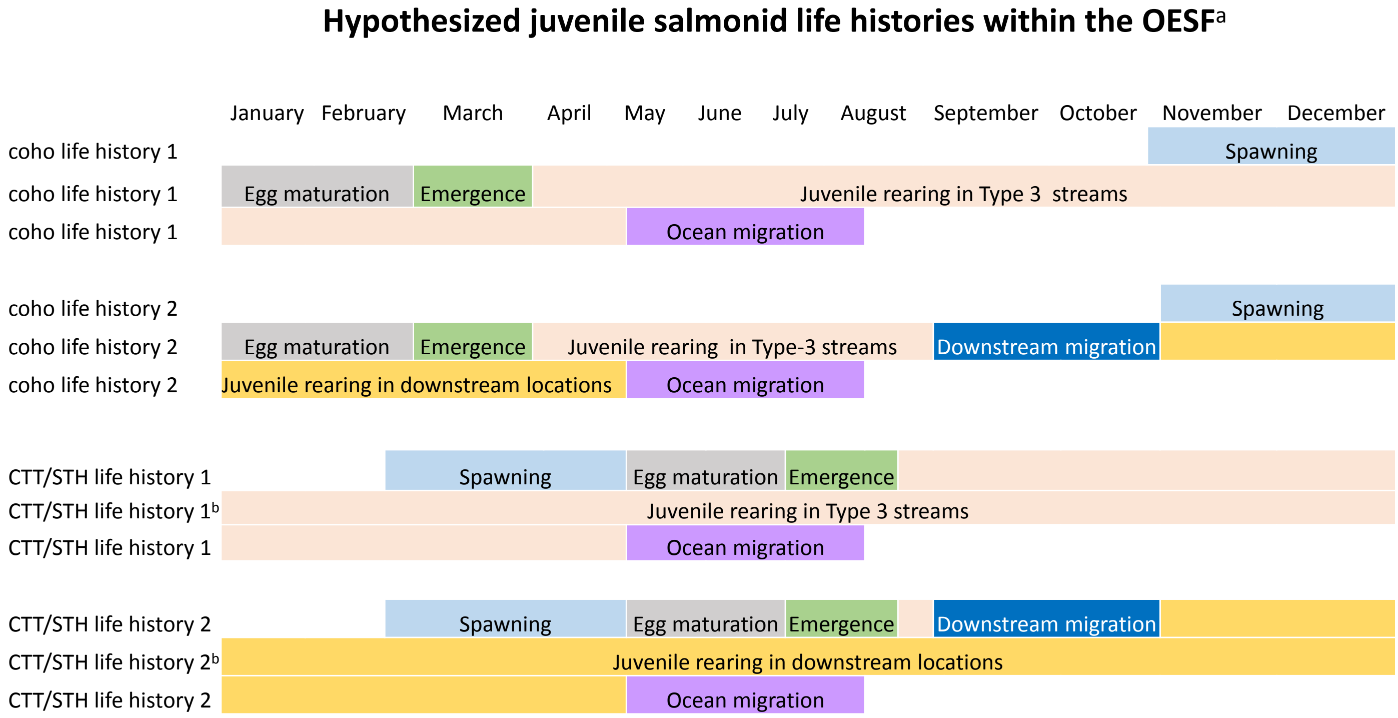


Figure 13 Hypothesized juvenile salmonid life histories for fish using Type 3 streams within the OESF based on initial sampling in the summer of 2015. a life histories events are generalized and exact timing will very. b Anadromous juvenile cutthroat trout (CTT) and steelhead (STH) rearing can last from less than one year to over 7 years, this diagram is meant to highlight difference in juvenile rearing areas, and not the number of years fish will spend in freshwater.

Analytical Framework

Data analysis will largely follow examples from relevant literature and recommendations from the Scientific Advisory Group. Once methods are finalized and the first rotation of all 49 basins are complete, initial analysis will focus on current conditions and a retrospective analysis of management history in the OESF. An information criterion multi-model approach, such as AIC, is planned for the observational data to validate initial hypotheses and help establish new hypotheses that may be used for an experimental design (Burnham and Anderson 2003). Mechanistic life-history models will be explored to help explain the links between management activities, stream habitat, and fish metrics as well as the magnitude of any effects (e.g., Bellmore et al. 2014). Multivariate approaches will be used to evaluate relationships between management, habitat, and fish, in particular, the use of multiple regression (Holtby 1988; Connolly and Hall 1999), analysis of variance (ANOVA ; Holtby 1988; Connolly and Hall 1999), canonical correspondence analysis (CCA; Smith and Kraft 2005; Tonn et al. 2003; Anderson and Willis 2003; ter Braak and Verdonschot 1995) and non-metric multidimensional scaling ordination (NMS; Galacatos et al. 2004; Mehner et al. 2005; Hitt and Angermeier 2011; Stranko et al. 2012) look promising for determining the strength of these interactions.

Reporting and Expected Products

- Annual/progress report (yearly)

- 6-year status reports (starting in 2020, 2021, or 2022; this report will take the place of the annual/progress report)

- Peer-reviewed journal articles as journal-quality information is available

Implementation Schedule

- Initial sampling of 49 existing habitat basins in the OESF - August 2015

- Formation of the Scientific Advisory Group - October 2015

- Completed Study Plan - Summer 2016

- First year of riparian validation monitoring - August – December 2016

- Finish methodology examination for juvenile salmonids and select best method – spring 2017 or 2018

- Start rotating panel (based on the completion of the juvenile salmonid methodology examination) – summer 2017 or 2018

- Complete first sample of all 49 basins (based on the rotating panel starting in 2018) - 2019 (2 panel design), or 2020 (3 panel design; Figure 10).

Resources Needed for Riparian Validation Monitoring

Resources expected under the DNR's 2015-2017 biennium and the resources needed to add additional winter sampling and PIT tagging are detailed below. The anticipating funding level will allow for summer juvenile sampling as well as adult spawning surveys in the fall/early winter. The preferred option would allow for additional winter sampling to help establish the importance of winter habitat on juvenile salmonids, while the use of PIT tags would provide information on fish movement, growth, and potentially survival. External funding and collaboration with federal, state, and tribal agencies as well as universities will be explored to help further enhance salmonid monitoring (e.g., PIT tags and PIT tag readers; instream PIT tag antennas; eDNA monitoring) throughout the OESF.

Anticipated funding level (no winter sampling or PIT tagging)

1 - Natural Resource Technician 2 (Lead position; summer sampling and redd surveys; 6 months)

2 - Natural Resource Technician 2 (summer sampling only; 3 months)

1 - Vehicle (6 months)

3 - Sets of waders and boots

Miscellaneous sampling gear (e.g., electrofishing parts, block nets, fish anesthesia)

Field Laptop

Preferred Option (including winter sampling and PIT tagging)

1 - Natural Resource Technician 2 (Lead position; 6 months)

2 - Natural Resource Technician 2 (6 months)

1 - Vehicle (6 months)

2000 - PIT tags

2 - PIT tag readers

3 - Sets of Waders and boots

Miscellaneous sampling gear (e.g., electrofishing parts, block nets, fish anesthesia)

Field Laptop

Potential Collaboration

Collaboration with external organizations has potential for many benefits to DNR and others. Collaborating with external researchers may lead to cost savings and (or) increased knowledge of the processes affecting riparian environments and may lead to improved study designs, methods, or analyses. Moreover, data collected by DNR may be valuable to external researchers working on a range of similar or other topics (e.g., climate change) as well as to regulatory agencies and salmon restoration groups. It is expected that knowledge gained from this riparian monitoring study can be used to inform researchers working in the OESF and around the region and regional land managers such as local Native American tribes, Forest Service, National Park Service, and private landowners.

Collaboration with outside entities is welcomed. If interested, please contact the author of this plan (Kyle Martens; 360 902-1272 or kyle.martens@dnr.wa.gov) or the OESF Research and Monitoring Manager (Dr. Teodora Minkova; 360 902-1175 or teodora.minkova@dnr.wa.gov).

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Appendix A.

Charter

Riparian Validation Monitoring Independent Science Group
for the Olympic Experimental State Forest

Introduction

The Riparian Validation Monitoring Independent Science Group (science group) is created to ensure that Washington Department of Natural Resources (DNR) uses sound scientific principles and information in the development of its Riparian Validation Monitoring Program (RVMP) to meet DNR's commitment to the Habitat Conservation Plan (HCP; DNR 1997). The goal of the RVMP is to assess the response of salmonids to managed landscapes and to validate the HCP Riparian Conservation Strategy. The commitment to the HCP states that "validation monitoring will employ surveys to detect changes in the productivity of spawning adults and salmon habitat relationships", and will include "estimating numbers of spawning adults and numbers of recruits (i.e., out migrating smolts or rearing juveniles), and surveying different stream habitat types and conditions to determine fish numbers, species composition, and densities" (HCP 1997).

The science group efforts will consist of two phases. The first phase (Developmental phase) will start in October 2015 and last through the completion of the study plan resulting in the formation of the RVMP. The second phase (Guidance phase) will start after the implementation phase and will evaluate the RVMP on a yearly basis.

Principle Tasks

The science group will operate as an advisory body providing input and peer review of scientific documents and materials developed.

The intent of this review is to ensure that Washington DNR's RVMP is consistent with the goals of the HCP; the methods used adhere to accepted scientific methods and principles; and that the documents incorporate best available science for identified species, habitats, and activities.

Developmental phase: If schedules will allow, a kick-off meeting will be held in November or December at the OESF. It is expected that the science group will advise the program on research questions, hypotheses, field methods, and the analytical approach. The science group will be updated and asked to review sections of the study plan monthly (October 2015 through March/April 2016). When needed, online meetings will be used to share information and discuss options for the study design.

Guidance phase: After the development phase of the RVMP, the science group will recommend opportunities for revisions, growth, and experimentation within the monitoring framework on an annual basis. In addition, the group will continually search for potential collaborators from universities and federal, state, and local governmental organizations to encourage additional research onto the forest.

Expected Outcomes

Development phase

- The foundation of the RVMP that meets DNR’s commitment to the HCP (1997) as described in a final study plan.

Guidance phase

- Recommendations on changes that can help improve the experimental designs that evaluate the effects of DNR management activities on salmonid populations.
- Recommendations that can encourage outside research onto the forest.

Supporting Resources

Data Managing Specialist (Warren Devine)
OESF Research and Monitoring Manager (Teodora Minkova)

Composition of Group

Discipline	Person and affiliation
Fish Biologist	Mr. Kyle Martens, Wash. State Depart. of Nat. Resources
Research Fishery Biologist	Dr. Patrick J. Connolly, USGS, Cook WA.
Research Fish Biologist	Dr. J. Ryan Bellmore, US Forest Service, PNW Research Station, Juneau AK.
Olympic Region Wildlife Biologist	Dr. Scott Horton, Wash. State Depart. Of Nat. Resources
Statistician (Biology)	Dr. Martin Liermann, NOAA Fisheries

Compensation

Travel expenses will be paid for any face to face meetings. Some compensation may be paid for peer-review of final study plan (outside DNR scientists only).

Structure

Lead - Work to be coordinated and facilitated by lead scientist (Kyle Martens), with assistance from other DNR staff.

Group membership – Scientists recognized for disciplines that can contribute to the creation and analysis of the RVMP. Not to exceed six members. Since membership is voluntary, DNR recognizes that members may not be able to complete reviews on schedule or may not be able to review all portions of the study plan, DNR does ask that members commit to a minimum of reviewing the final study plan.

Decision making – If the science group cannot come to a consensus, the lead scientist will be responsible for making any final decisions.

Timeline for the development of the study plan

(This timeline is meant as a guideline and adjustments will be made as necessary.)

October – The science group will be asked to review and add input to the study plan outline and the conceptual model on potential forest harvest impacts to instream habitat and fish. The lead scientist will start work on the first section of study plan (Introduction, Study Area, Scientific Background and Justification, and Initial Steps).

November – Potential kickoff meeting at OESF. The science group will be asked to review the first section of study plan. The lead scientist will modify the outline and conceptual model based on the reviewer's comments, setup an online meeting (if needed), and start work on the second section of the study plan (Goals and Objectives, Main Hypotheses, Monitoring Questions, Adult Monitoring, Juvenile Monitoring).

December – The science group will be asked to review the second section of the study plan. The lead scientist will modify the first section of study plan, organize an online meeting (if needed), and will start work on the third section of the study plan (Sampling Options, Design, and Potential Analysis).

January – The science group will be asked to review the third section of study plan. The lead scientist will modify the second section of study plan, organize an online meeting (if needed), and start work on the forth section of the study plan (Possible Future Additions, Reporting and Expected Products, and Executive Summary).

February – The science group will be asked to review the forth section of study plan. The lead scientist will modify the third and fourth sections of the study plan and organize an online meeting (if needed).

March/April – The science group will peer review the final draft of the study plan. The lead scientist will modify final draft of the study plan based on the scientific group reviews and submit the final draft to DNR.