Issue 4 • Fall 2018

The Learning Forest

Sharing scientific knowledge on sustainable land management in the Olympic Experimental State Forest and beyond

Editorial Board Message

We hope you enjoyed the gorgeous fall foliage on the Olympic Peninsula and across the state.

Our fall newsletter shares science findings on alternative pre-commercial thinning (PCT) treatments and salmon response to habitat restoration. These seemingly very different topics are linked by the need to provide habitat in managed landscapes.

As discussed in **our last issue**, the Washington State Department of Natural Resources (DNR) introduces gaps into commercial thinnings to increase structural complexity in working forests. In our featured article, we discuss a study that adds gaps and wider spacing to PCT prescriptions instead, when the trees are much younger. This study explores the possible ecological benefits and revenue implications of these early treatments. The article includes results from Phase I of the study, and we intend a follow-up article in a future issue on Phase II results.

The guest article looks at how stream and watershed restoration can change fish populations and their habitat. The watersheds in this study have been affected by decades of harvest, fires, landslides, floods, and other disturbances. The study involves adding wood to streams and other treatments to restore habitat complexity and reduce delivery of fine and coarse sediment. A collaborative effort by NOAA Fisheries, U.S. Environmental Protection Agency, Lower Elwha Klallam Tribe, Washington Department of Fish and Wildlife, Washington Department of Ecology, and the Weyerhaeuser Company, this study is part of a larger network of intensively monitored watersheds (IMW) across the Pacific Northwest. Results and lessons learned from regional IMWs were discussed recently at a **workshop in Oregon**. As an aside, many of the concepts from the IMWs were incorporated into DNR's **Riparian Validation Monitoring Program**, which involves evaluating the effects of forest management practices on fish.

Happy reading!

In this Issue

Teodora Minkova, DNR

Vine maple along the Clearwater River

Featured Article

Rethinking Pre-Commercial Thinning

by Cathy Chauvin *with* Richard Bigley and Warren Devine, DNR

Richard Bigley , DNR

Photo 1. A working forest with no understory

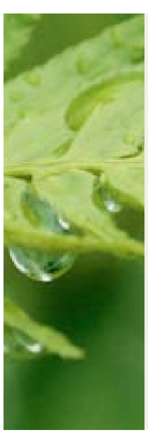
Richard Bigley , DNR

Photo 2. Understory plants in a canopy gap

In the late 1990s, there was something notably missing from the forests in the Goodman Creek watershed in the Olympic Experimental State Forest (OESF): the forest understory, that layer of shrubs, herbs, and young trees that typically thrives when enough light filters down through the overstory to the forest floor below (Photo 1). In fact, the only understory in the area was along roads and in wetlands and other areas that could not support tree survival. Also largely missing from these forests were older trees, snags, down wood, and other elements that provide habitat for wildlife.

Conditions in this watershed, which were typical of thousands of acres across the OESF, were a result of forest management techniques such as clearcutting and broadcast burning that were focused primarily on timber production. By the late 1990s, however, those techniques were beginning to change. The Washington State Department of Natural Resources (DNR) was transitioning to what forest ecologist Jerry Franklin described as "ecological forest management," which involves managing a working forest for ecological and revenue objectives at the stand and landscape level.

DNR's interpretation of this approach, later called "integrated management," involved diversifying the structure of the working forest to include understories and other elements that wildlife need (Photo 2). One technique DNR was developing at the time was variable density thinning, a treatment that involves varying tree spacing and cutting gaps into the forest canopy at the commercial stage, when trees are old enough to sell.



The Learning Forest is an electronic, biannual newsletter published jointly by the **Washington State Department of Natural Resources** (DNR) and the **Olympic Natural Resources Center** (ONRC).

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But what about the younger stands? If the goal was to diversify stand structure, why not introduce gaps and alternative tree spacing at the pre-commercial thinning (PCT) stage instead? Not only would any understory that developed be available to wildlife sooner, but trees may respond better to thinning when younger. Exposed to more sunlight, younger trees may quickly develop a healthier live crown ratio (the ratio of the length of the crown to the height of the tree). Trees with a higher live crown ratio can develop a more extensive root system to support the crown, making them more vigorous and able to respond to changing conditions.

> If the goal was to diversify stand structure, then why not introduce gaps and alternative tree spacing at the pre-commercial thinning (PCT) stage instead?

Adding gaps at the PCT stage was a novel idea for DNR, though not completely unique to the Pacific Northwest. At the time, the U.S. Forest Service was completing a similar study in young Douglas fir plantations that were established after the 1980 eruption of Mount St. Helens devastated over 240 square miles of forest. Like DNR, the U.S. Forest Service was interested in meeting multiple objectives in their stands.

DNR silviculturalist Richard Bigley applied for and was awarded a grant from the U.S. Geological Survey to test gaps, wider spacing, and retention of a wider range of tree species than DNR's typical PCT prescription in young forest plantations in the OESF. Called "Influence of Repeated Thinnings on Young Stand Development Pathways," the study's primary questions were as follows: How can alternative PCT approaches provide structural complexity (and thus wildlife habitat) to a working forest? How will gaps influence the understory? And how will these treatments affect revenue years later when the stand is harvested?

Study Design

The study began in 1998 and included two phases, a PCT (Phase 1) and a commercial thinning (Phase 2). As results for Phase 2 are pending, only Phase 1 of the study will be discussed here.

Bigley and his team selected five blocks of forest with similar ecological conditions. Each block had been clearcut, broadcast burned, and replanted 10 to 15 years earlier with Douglas fir, sometimes as many as three times to reach the desired density due to deer browsing and other losses. Some of these blocks had more than 1,200 trees per acre prior to treatment, the result of both planting and ingrowth from adjacent forests. All five blocks were located in low-elevation, coastal areas with highly productive soils and gentle slopes: four in the lowlands between the Bogachiel and Hoh rivers, and one close to the city of Forks.

Each block was divided into 5 treatment areas of 7 to 10 acres each. Treatment Area 1 was the reference and was not thinned. Following pre-treatment measurements in 1997, the other four treatment areas in each block were thinned in 1998 as follows:

- **Treatment Area 2 (Traditional PCT):** Thinning to 300 trees per acre with preference given to retaining Douglas fir (this was a typical PCT prescription for DNR in 1998).
- **Treatment Area 3 (PCT with gaps):** Thinning to 300 trees per acre with less preference for Douglas fir; gaps 30 and 60 feet wide (less than one tenth of an acre) uniformly spaced in the stand.
- **Treatment Area 4 (Wide PCT):** Thinning to 200 trees per acre with preference given to retaining Douglas fir.
- **Treatment Area 5 (Wide PCT with gaps):** Thinning to 200 trees per acre with less preference for Douglas fir, gaps 30 and 60 feet wide uniformly spaced in the stand.

For Phase 1, Bigley and his team completed 1, 5, 10, and 15 year post-treatment measurements. Individual tree metrics included diameter at breast height, live crown ratio, tree height, and crown class and radius. Stand-level metrics included basal area, trees per acre, relative density, and the distribution of trees in different diameter classes.

Response to PCT

DNR currently is analyzing results and preparing a detailed report on Phase I. From what has been observed so far, the most surprising result from this study has been the lack of surprises.

Data confirmed that thinning has a noticeable influence on live crown ratio (Figure 1). By 2014, live crown ratios had increased after thinning in all the thinned treatment areas, and then gradually decreased as the trees grew. The decrease in live crown ratio was less pronounced in those stands with gaps, wider spacing, or both, meaning the benefits of thinning lasted longer in these stands.

Tree diameter results also were in line with expectations. Figure 2 shows the change in average diameter of the 100 largest trees per acre (D100). Results showed that tree spacing has far more influence over average tree diameter than gaps, which made sense given that wider spacing would increase light levels across the entire stand. Both of the wide PCT treatments showed an average increase in tree diameter of 1.2 inches by 2014, as compared to both traditional PCT and PCT with gaps (16.6 inches versus 15.4 inches).

Looking at trees in different diameter classes (Figure 3), by 2014 the unthinned stand (reference) had the largest number of trees in the smaller diameter classes, while all four thinned treatment areas had more trees in the largest diameter classes. Stands without gaps had less variation in tree diameter than those that did, with the greatest range of diameters in the wide PCT with gaps.

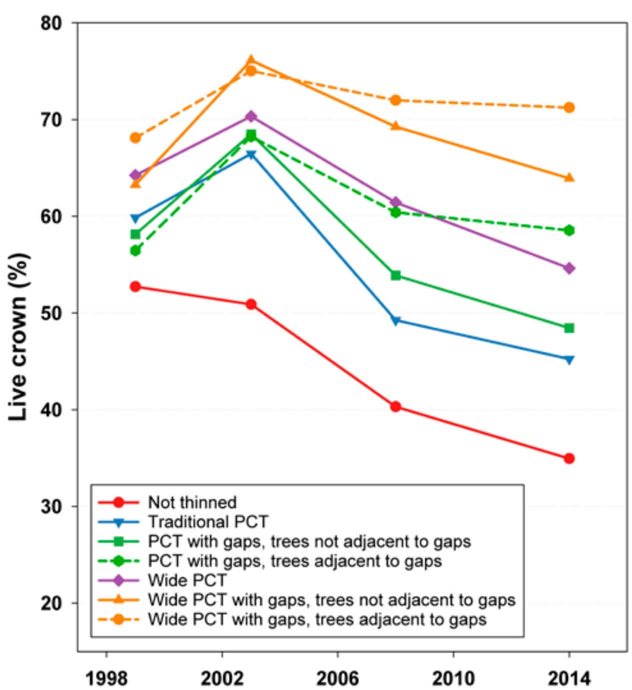


Figure 1. Changes in average live crown ratio after treatment

Of all the thinned treatment areas, the wide PCT with gaps had the most trees in the smallest diameter class (4 inches), reflecting a large amount of ingrowth between the thinned trees and within the gaps.

Although gaps had little influence over average tree diameter (D100), they did affect basal area (an indication of the total amount of wood in the stand). The 2014 basal area of the traditional PCT treatment area

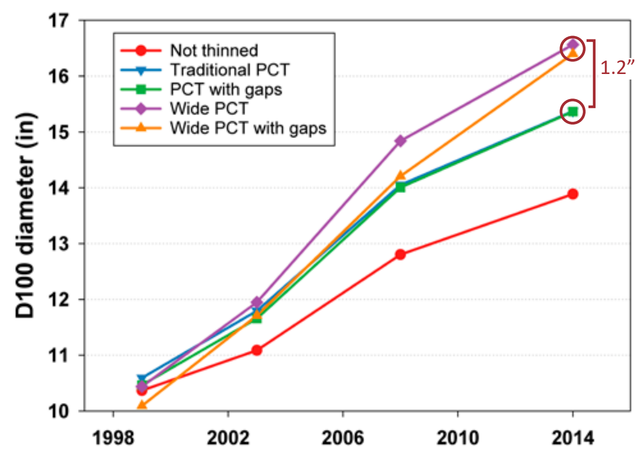


Figure 2. Average diameter of the 100 largest trees per acre (D100) after treatment

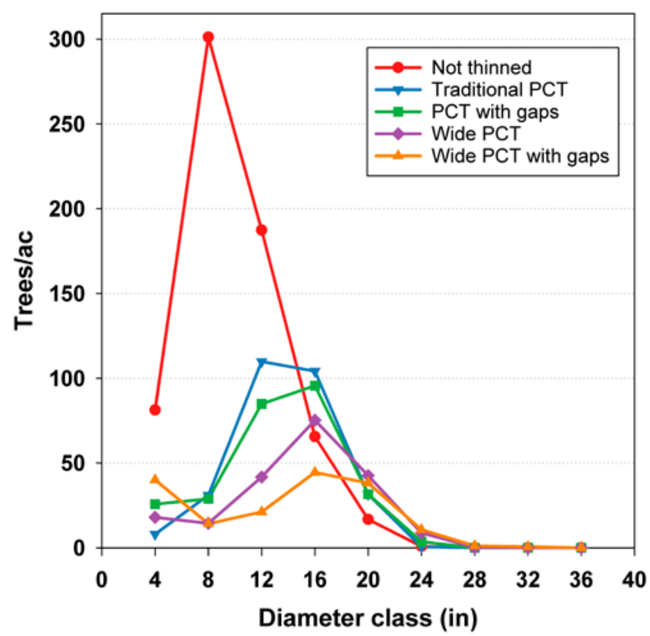


Figure 3. Diameter distribution of trees in 2014 (16 years after treatment)

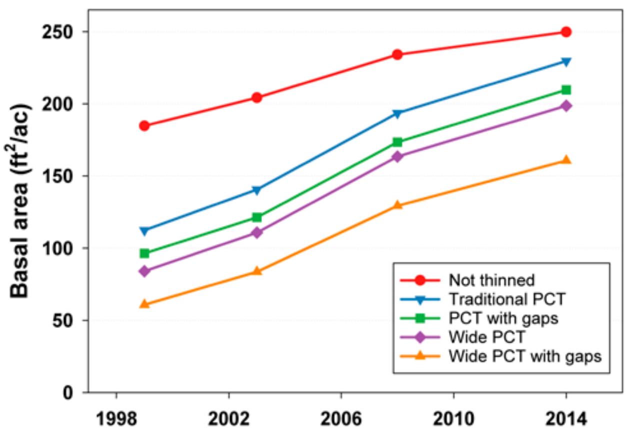


Figure 4. Basal area after treatment

was approximately 230 square feet per acre (Figure 4). In 2014, basal area of the PCT with gaps was 20 square feet per acre less than the traditional PCT, a reduction of approximately 9 percent. Basal area of the wide PCT with gaps was 69 square feet per acre, or 30 percent less than the traditional PCT. For comparison, the wide PCT without gaps was 31 square feet per acre or 13 percent less than the traditional PCT, indicating that most of the reduction in basal area came from gaps, not from wider tree spacing.

Finding the Right Balance

For meeting wildlife habitat and other non-timber goals, these preliminary results are promising. The greater range in tree diameters and species in a wider thinning with gaps, for example, means that these treatments could jump-start the development of more complex stands that better support wildlife. Also, the healthier live crown ratios of the thinned stands could make these stands more resilient to windthrow.

What is not yet known is how these treatments will affect revenue in the future when the stand replacement harvest occurs. For example, some treatments may result in larger trees but lower overall volume of wood. DNR will be completing volume measurements and future growth projections for these stands to help answer this question.

If this study shows that alternative PCT treatments decrease revenue, are they worth doing? For their benefits to habitat and resilience, possibly yes. But how much decrease is acceptable in the context of other objectives? Could those decreases be offset in how DNR markets and sells the timber in the stand, or by lengthening the harvest rotation so the trees are larger at harvest?

In other words, what is the correct balance between meeting revenue and other, non-timber objectives in a working forest? The results of this study should help DNR and other land managers answer that critical question.

DNR is currently completing the data analysis for both Phase I and the first measurements of Phase II and will issue a detailed report next year. Look for it on DNR's **OESF website**.

About the Principal Investigators

Richard Bigley, Ph.D., has been a forest ecologist and silviculturist in DNR's Forest Resources Division for 30 years. Richard has been associated with commercial stand thinning since the early efforts on the Olympic Peninsula after receiving a carbon copy speedmemo followed by a fax copy of a draft forest practices application. In the spring of 1989, DNR's Olympic region was exploring the value of thinning plantations to, in part, improve stand complexity for wildlife habitat. The PCT work reported here is an outgrowth of interactions with DNR foresters who were early adopters of what has become ecological forest management. Richard can be reached at Richard.Bigley@dnr.wa.gov.

Warren Devine is a data specialist in DNR's Forest Resources Division. Warren manages and analyzes research and monitoring data collected on the OESF and elsewhere, and is doing data analysis and reporting for this study. Warren can be reached at Warren.Devine@dnr.wa.gov.

Guest Article

Large Scale and Long Term

The Strait of Juan de Fuca Intensively Monitored Watersheds

by Karrie Hanson and Todd Bennett, NOAA Northwest Fisheries Science Center

Habitat restoration activities aimed at helping salmon recovery are logistically challenging and expensive and their outcomes often are uncertain. It is critical to monitor how habitat and fish respond to these activities to improve conservation outcomes and accomplish restoration efficiently.

The Intensively Monitored Watershed (IMW) Program is a long-term examination (years to decades) of how stream and watershed restoration can lead to changes in fish population and habitat responses. Within the program, there are currently 16 IMW studies throughout the Pacific Northwest.

The Strait of Juan de Fuca IMW study, located on the northern Olympic Peninsula in Washington State, was initiated in 2005 to test the watershed-scale response of steelhead trout (*Oncorhynchus mykiss*) and coho salmon (*O. kisutch*) to watershed restoration. A collaborative effort involving federal (NOAA Fisheries, U. S. Environmental Protection Agency), state (Washington Departments of Ecology and Fish and Wildlife), tribal (the Lower Elwha Klallam Tribe), and private (Weyerhaeuser Company) entities, this project involves three watersheds that drain into the Strait of Juan de Fuca: East Twin River, West Twin River, and Deep Creek (Figure 1). All three watersheds have similar characteristics, although Deep Creek is slightly larger than the Twin Rivers. The watersheds drain areas between 12 and 17 square miles (32 to 45 square kilometers) and each river contains less than 6 miles (10 kilometers) of main stem stream that is accessible to anadromous fish (fish that are born in freshwater, migrate to the

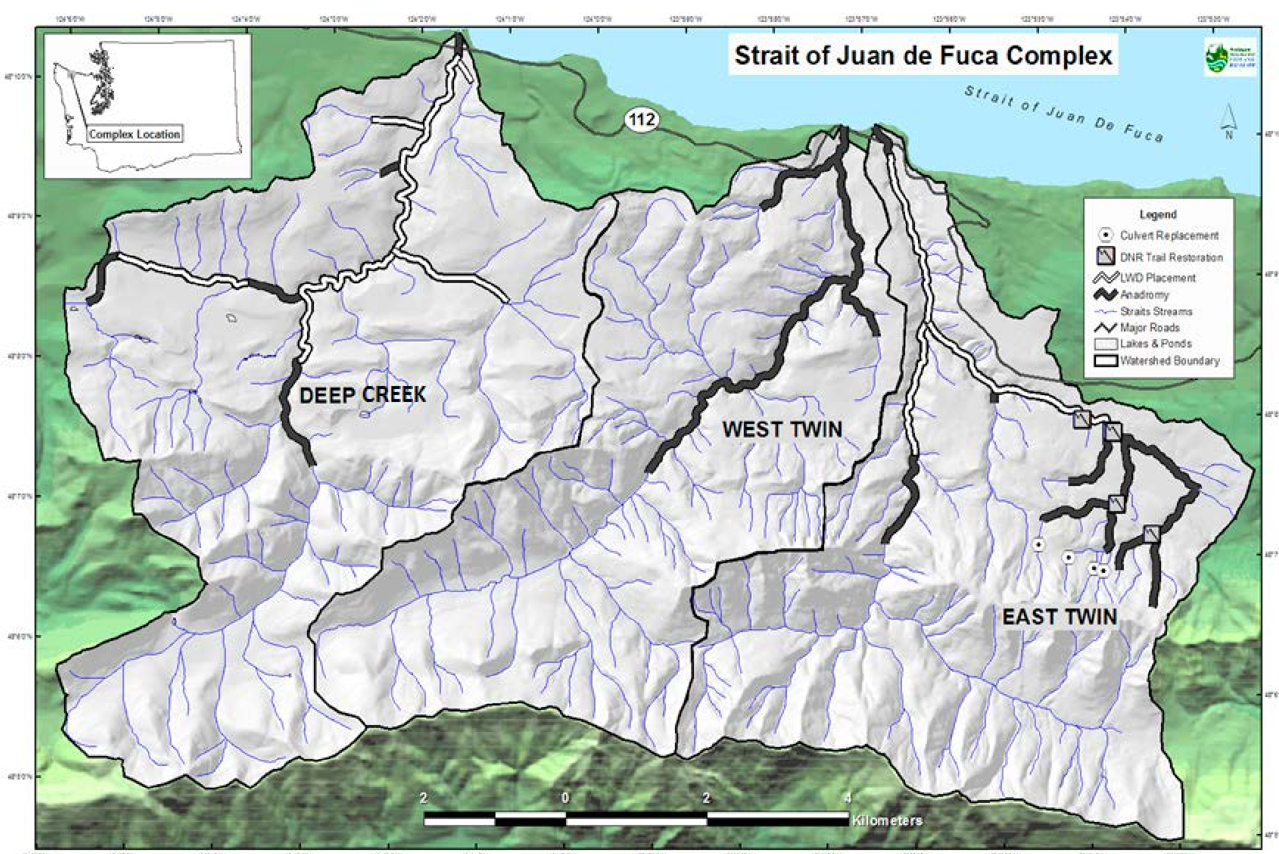


Figure 1. Map of the three watersheds selected for this study

ocean as juveniles, then return to freshwater as adults to spawn).

The watersheds in this study have suffered from a number of disturbances. For example, historic fire information indicates that large fires occurred in 1308, 1508, and between 1895 and 1939. Other disturbances include intermittent large floods through 2006 and timber harvest from the 1890s to the 1950s. Road construction, timber harvest, and landslides have increased coarse and fine sediment delivery to the fish-bearing streams. Large precipitation events, particularly in Deep Creek and East Twin River watersheds, caused landslides and dam break floods that altered and simplified channels and mobilized wood and sent it downstream. (Dam break floods occur when natural woody debris and sediment temporarily block the stream channel; water builds up to a critical point then bursts through the blockage.)

In 2002, the Lower Elwha Klallam Tribe and U.S. Forest Service produced watershed assessments to help guide restoration activities in the three watersheds. Analyses identified low levels of large instream wood; recurring landslides due to poorly constructed logging roads; a lack of mature vegetation for fish cover, shade, and terrestrial food inputs; and a loss of off-channel habitat (side channels, alcoves, and backwater pools that can provide refuge from predators and high flows during the winter months). The restoration plan contained the following goals:

- Reduce rates of human-caused landslides to background levels,
- Recover riparian forests to provide adequate supplies of large instream wood over the long term,
- Incorporate immediate additions of large instream wood to offset losses from land use impacts and provide low-velocity pool habitat, retain spawning gravels, and increase channel complexity, and
- Increase the amount of fish habitat in small tributaries that drain into the rivers.

Our ultimate question was this: will increasing the amount of instream wood (engineered logjams as well as single key pieces), along with other actions such as removing barriers, reconnecting floodplains, and decommissioning roads, improve fish habitat conditions within the watersheds and increase salmonid populations?

Our ultimate question was this: will increasing the amount of instream wood, along with other actions such as removing barriers, reconnecting floodplains, and decommissioning roads, improve fish habitat conditions within the watersheds and increase salmonid populations?

Deep Creek and East Twin River were designated as treatment watersheds, meaning they would receive restoration actions. The West Twin River was designated as the control watershed, which would be left alone. Treatments took place between 1997 and 2014 at a cost of more than $3 million, and included road abandonment, riparian planting, and instream installation of log structures via helicopters (Photo 1). Treatments are now complete, with the exception of Deep Creek, where 12 more logjams will be installed by helicopter in 2019.

Mike McHenry, Lower Elwha Klallam Tribe

Photo 1. A helicopter prepares to place another log in Deep Creek during a logjam installation in 2012

To answer our ultimate question, we have been collecting data annually since 2005 for a suite of habitat and fish metrics in each watershed. Habitat metrics include large instream wood counts, percentage of pools, percentage of gravel-sized substrate, and bankfull width. Habitat data is being collected using a modified version of the EPA's Environmental Monitoring and Assessment Program (EMAP) at 20 sites across the three watersheds.

Each summer since 2004, we also have collected and tagged fish with passive inductive transponder (PIT) tags at 36 different sites among all three watersheds (Photos 2 and 3). To date, we have tagged over 77,000 juvenile coho salmon and steelhead trout. Using instream channel-spanning antennas located near the mouth of each river, we have remotely monitored fish movement in, out, and between watersheds. We use this information, along with data from smolt traps and spawner surveys, to calculate juvenile salmonid growth, migration timing, juvenile overwinter survival, smolt-to-adult survival, and spawner abundance.

One major finding has been the diversity in life history strategies for coho salmon and steelhead trout. For example, coho salmon migrate as fry, parr during their first winter, or 1-year old smolts in the spring. Steelhead can also migrate out as fry, as parr the first winter, or as 1-, 2-, or 3-year old smolts in the spring. Similarly, coho can spend 6 to 24 months in the ocean, and steelhead can spend 6 months to several years in the ocean before the fish return to freshwater. These varying life history strategies, determined from migration timing and movement direction of PIT tagged fish, exhibit differences in juvenile survivorship and subsequent contributions to the returning adult population.

We also observed an increase in apparent survival of coho salmon and steelhead trout adults in Deep Creek over the last several years, relative to survival in West Twin River (control). In addition, juvenile coho salmon survival in Deep Creek from 2009 to 2014 increased from less than 0.5 to over 1.25 times the survival in the West Twin River.

Our habitat monitoring data has shown an increase in the percentage of gravel-sized substrate (which is important for spawning) in the West Fork of Deep Creek after the 2009 restoration, as well as in the East Twin River after 2011 restoration actions.

Over the course of the study, changes in habitat metrics such as percent pool, percent gravel, very large wood, and bankfull width-to-depth ratio were very similar across watersheds, regardless of the amount of restoration activity. We also have observed that the older and more stable engineered logjams in lower Deep Creek increased channel complexity in the form of a multi-threaded channel with a clear main stem and side channels that are most evident during low summer flows.

Watersheds can take decades to respond to some restoration actions such as road decommissioning and riparian planting. In these watersheds, the inter-

Karrie Hanson, NOAA Fisheries

Photo 2. Colleagues from NOAA and the Lower Elwha Klallam Tribe collect fish near a constructed logjam in Deep Creek

Karrie Hanson, NOAA Fisheries

Photo 3. Todd Bennett with NOAA prepares to inject a juvenile Coho salmon with a 12-mm PIT tag

annual variability in adult returns and parr and smolt abundance is very high relative to the number of years monitored, which makes it difficult to attribute changes in population directly to restoration actions. In addition, the amount of localized restoration activities are small relative to the basin-scale degradation. Because EMAP monitoring focuses on the entire watershed (large scale) and not on site-specific areas associated with restoration actions (reach scale), it is difficult to determine a statistically significant change in overall physical habitat.

In the future, we hope to continue yearly PIT tagging and monitoring and install new antenna arrays with greater detection ranges. Team members and other researchers also have discussed examining how much wood is accumulating downstream of engineered logjams to determine how far wood is traveling and whether the wood is from the placed structures or naturally sourced.

The Strait of Juan de Fuca IMW project is funded in part by Washington Salmon Recovery Funding Board. NOAA's data from this project is available **here**.

About the Authors

Karrie Hanson is a biologist in the Watershed Program of the Fish Ecology Division of NOAA's Northwest Fisheries Science Center. Karrie's research interests include investigating the effects of disturbances on fish populations and habitat, and evaluating the extent to which various habitat restoration methods aid recovery efforts. For questions about this study, she can be reached at karrie.hanson@noaa.gov.

Todd Bennett is a fisheries biologist for the Watershed Program. His current projects include the Intensively Monitored Watershed Program and assisting team members with a colonization study in the Elwha River.

You are Invited to Participate

The Washington Department of Natural Resources (DNR) and the Olympic Natural Resources Center (ONRC) invite researchers and stakeholders to participate in research, monitoring, and other learning activities in the Olympic Experimental State Forest (OESF). Contact Teodora Minkova at teodora.minkova@dnr.wa.gov or Franklin Hanson at fsh2@uw.edu. Information on past and current projects in the OESF can be found at this **link**.

Project Updates

Ethnoforestry

The Olympic Natural Resources Center's (ONRC) ethnoforestry project is underway and expanding its reach by building new partnerships both on the Olympic Peninsula and at the University of Washington campus. (Ethnoforestry is using traditional ecological knowledge by local people and applying it to the forest management process.) ONRC and the Center for Inclusive Entrepreneurship have received a U.S. Department of Agriculture Rural Business Development grant that has made it possible to offer free, sustainable wildcrafting (foraging for native plants) and small business training to local community members, with events in Forks, Taholah, and La Push. In the first two months of this project, 25 people have participated in these workshops and are making strides to begin or enhance their wildcrafting businesses. In the future, individualized support will be offered to each participant to ensure success. On the University of Washington campus, ONRC has begun planting four ethnoforestry garden beds with cultural keystone species of many tribes throughout the region. Some garden beds will be harvested and others will be educational. In partnership with the University of Washington Intellectual House, ONRC will collaborate with tribal members and students to design spaces in which the university community can learn and engage in ethnoforestry. Widespread support for this project has fostered new partnerships across the region. For questions, contact Courtney Bobsin at cbobsin@uw.edu.

Ecological Functions of Headwater Wetlands in the Olympic Experimental State Forest (OESF)

Wetlands are critically important for biological diversity and ecological functions such as water quality improvement and stream flow regulation. In coastal regions, many small, cryptic (not well studied) wetlands occur along headwater streams. Researchers from Washington State Department of Ecology, U.S. Forest Service Pacific Northwest Research Station (PNWRS), and Washington State Department of Natural Resources (DNR) are collaborating on a study to better understand the ecology and function of these unique yet common headwater wetlands to inform how to protect and manage them. Research questions include the following:

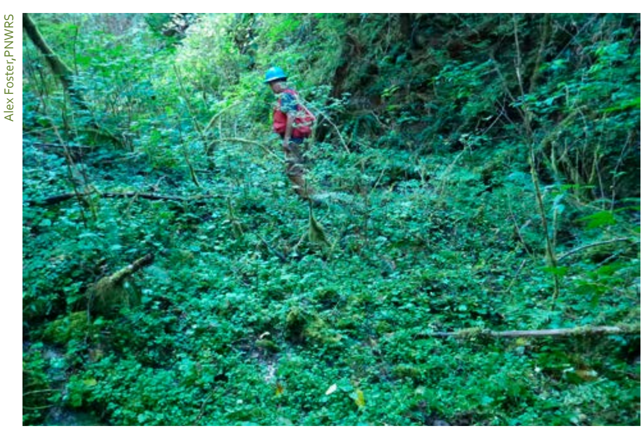
- Is it possible to predict where headwater wetlands may occur? For example, is there any correlation between wetland occurrence and forest age or other factors?
- Which headwater wetlands are more common, off-channel wetlands or those that are hydrologically connected to stream channels?
- Are amphibian counts related to wetland size, water temperature, relative humidity, or a combination of all three?

Candidate watersheds were screened in September 2017 for factors such as site accessibility and wetland presence. Researchers also created a hydrologic model to estimate where surface water was still present even after several dry months in late summer. In July 2018, researchers installed temperature and relative humidity monitoring stations at 17 sub-basins within the selected watershed. The first field surveys of the wetlands occurred in September 2018. In 2019, researchers will survey for amphibians and gather other information, such as vegetation characteristics, about these wetlands. So far, findings suggest a relationship between wetland presence and aspect, which may eventually allow accurate prediction of where these small wetlands may occur.

The study is being implemented south of Forks, WA in an OESF watershed near Goodman Creek. The study complements DNR's **long-term riparian monitoring efforts**. For more information, contact researchers Jack Janisch at the Washington State Department of Ecology (jaja461@ecy.wa.gov), Alex Foster at PNWRS (alexfoster@fs.fed.us), or Teodora Minkova at DNR (Teodora.Minkova@dnr.wa.gov).

Jack Janisch, Washington State Department of Ecology

PNWRS researcher Alex Foster poses to show the scale of a patch of *Lysichiton americanum*, commonly called skunk cabbage; this wetland occurs in an old growth forest



Alex Foster, PNWRS

Washington State Department of Ecology researcher Jack Janisch searches a headwater wetland along the channel margins for *Chrysoplenium glechomaefolium*, commonly called golden carpet, an obligate wetland plant

Upcoming Event

Olympic Natural Resources Center (ONRC) Evening Talk

Talk will be held in the Hemlock conference room, ONRC, 1455 S. Forks Avenue in Forks, WA. For questions, contact Franklin Hanson, ONRC Education and Outreach Coordinator, at fsh2@uw.edu.

On **December 7**, Garrett Dalan, Washington Coast Community Relations Manager for The Nature Conservancy, will present a program entitled "Investing in Communities for Conservation that Lasts, a Conversation on How The Nature Conservancy Works Along the Washington Coast." In this program, Garrett will discuss projects being completed by The Nature Conservancy and how these projects bridge work in economics, conservation, and community. Garrett will discuss partnerships, economic development, community forests, and forestlands managed by The Nature Conservancy. The program will consist of a presentation followed by an informal conversation. Bring your curiosity, questions, challenges, and new ideas.

A long-time resident of western Washington, Garret grew up in Sequim and now lives in Montesano with his family. Garrett has a degree in fisheries science and worked in private aquaculture and local environmental health before joining The Nature Conservancy.

Featured Photo

Teodora Minkova, DNR

Environmental Education in the OESF, August 2018

University of Washington students enrolled in a field studies class learn about forest management from DNR's Olympic Region District Manager Bill Wells on the Reade Hill Recreational Trail near Forks, WA. This trail shows the variety of forest management techniques DNR uses on state trust lands and has been frequented by student groups, visiting scientists, tourists, members of the local community, and others.