The **Learning Forest**

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

Issue 15 • Spring 2024

Editorial Board Message

This edition of the Learning Forest highlights the work of two groups that were formed to address challenges in our forests and coastal waters.

In the featured article, we discuss the **Washington Needlecast Working Group**. This group was formed to address Swiss needle cast, a fungal disease that affects Douglas-fir trees. Though it is not fatal, the disease causes needle loss and discoloration and slower tree growth. The working group conducts surveys to monitor the spread of the disease in Washington, and provides critical information to forest managers and small forestland owners who are managing Douglas-fir for timber, especially in coastal areas.

In the guest article, **Olympic Natural Resources Center** (ONRC) Marine Program Director Vera Trainer discusses the **Olympic Region Harmful Algal Bloom (ORHAB) partnership**. Established in 2000, this group of tribal, federal, state, and local scientists created an early warning system for harmful algal blooms. These blooms can make clams and other shellfish unsafe to eat due to concentrations of domoic acid. The early warning system provides managers more time to determine which beaches need to close when blooms are detected on the Washington coast.

Finally, a new lab is being set up at ONRC to allow for collaboration between marine science projects, such as ORHAB, and forestry activities. Not only do marine and terrestrial scientists often use similar methods, but these ecosystems are linked. For example, animals, plants and the microscopic organisms in lakes and rivers eventually make their way to the coastal ocean. Collaborations between terrestrial and marine scientists strengthen our understanding of the overall health of the Olympic peninsula's natural systems.

In this Issue

DNR staff photo

The Bogachiel River, which empties into the Quillayute River on its journey to the Pacific Ocean.

Featured Article

Fungal Awareness

The Washington Needlecast Working Group

by Cathy Chauvin, DNR

In the 1970s, forestland owners in coastal Oregon and Washington began a practice that is normal and required today: they started replanting harvested forests rather than allow them to grow back naturally.

Many of these forestland owners planted large numbers of Douglas-fir, one of the premier lumber trees in the Pacific Northwest. In doing so, they unwittingly set the state for an outbreak of Swiss needle cast, a defoliating fungal disease that is specific to Douglas-fir and often associated with the cool, wet springtime weather of coastal areas.

Up until this point, the disease had mostly been an issue for Pacific Northwest Christmas tree farms, isolated Dougas-fir plantations, and areas where Douglas-fir was being grown outside its range. But by the 1990s, the disease had become a full-blown forest health issue for coastal Douglas-fir working forests in Oregon and Washington.

Oregon State University (OSU) established its **Swiss Needle Cast Cooperative** in 1997 to help affected forest landowners. The co-op conducts research, performs field surveys, and develops a host of valuable resources including fact sheets, maps, and silvicultural guides.

However, in 2017 forester and former state senator Jim Hargrove felt that more attention needed to be paid to Swiss needle cast in Washington state. So he helped secure funding from the state legislature to establish the **Washington Needlecast Working Group**.

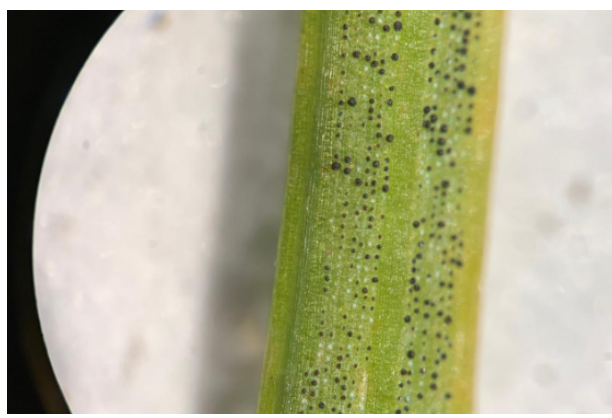
The working group includes small forestland owners, representatives of the timber industry, and staff from DNR and the U.S. Forest Service, and has an advisory board that plans annual meetings and other events. Its mission is to provide timely and accurate scientific information to Washington forestland owners, especially anyone growing Douglas-fir for timber production in hard-hit areas near the Washington coast.

A Native Disease

Although first identified on planted Douglas-fir trees in Switzerland, Swiss needle cast is caused by a fungus (*Nothophaeocryptopus gaeumanni*) that is native to North America.

The fungus lives in the needles of Douglas-fir trees and is usually benign. Yet in a cool, wet spring, the fungus can form a "fruiting body" (called a pseudothecia) on infected needles. The fruiting body grows out of the needle's stomata, which are openings on the underside of the needle that allows it to exchange gasses with the atmosphere (Photo 1). If the stomata are blocked, the needle's capacity for photosynthesis will be diminished. Infected needles can turn chlorotic (yellowish), and may die and be "cast" (dropped) from the branch (Photo 2). Cast needles tend to be two or more years old.

The fruiting body also releases spores in the spring that are carried by the wind to the needles of other trees,



Rachel Brooks, DNR

Photo 1. Infected needle; black dots are fruiting bodies.

Rachel Brooks, DNR

Photo 2. The sparse crown of an infected tree.

where they can germinate and begin to grow. New needles just pushing out from the bud are especially vulnerable to infection.

Needle loss gradually reduces the tree's ability to produce sugars, which affects tree growth. **A 2023 study** found that in Washington, volume growth loss began when as few as two and a half "cohorts" of needles remained on the branches (Photo 3). A cohort is a year's worth of needles, with the cohorts getting older as one moves down the branch. Infected trees begin casting the oldest cohorts first. At less than two cohorts, growth losses (in Scribner board feet) ranged from 21.6 percent (1.8 cohorts) to over 48 percent (1 cohort). The disease is rarely fatal to the tree.

There is still much to learn about the disease and its effects on growth. "The disease can be very complicated, and there are different strains of the fungus that causes it," says Dan Omdal, working group member and forest pathologist with the Washington State Department of Natural Resources (DNR) **Forest Resilience Division**. More research is needed to understand the link between needle retention and tree growth, and trees may react differently to the disease on different sites and in different conditions, he explains. In addition, needle loss can be attributed to other factors as well, such as soil nutrients, moisture availability, other foliar diseases, and pests.

Despite this uncertainty, one thing is clear: even small growth losses can be significant for those managing for timber, especially small forestland owners. "The smaller the land base, the more painful those losses can be," says Jim Hargrove.

Addressing the Issue in Washington

Swiss needle cast is a complex issue that has required cooperation across state and organizational boundaries to address. For example, the Washington Needlecast Working Group collaborates with the OSU Swiss Needle Cast Cooperative, the U.S. Forest Service, and DNR on a variety of efforts. Several working group members are DNR forest health specialists who participate in outreach, surveys, and research as part of their day-to-day jobs. DNR, the U.S. Forest service, OSU, and the Washington State Legislature have all contributed funding.

To join the Washington Needlecast Working Group contact Sandor F. Toth at **toths@uw.edu**.

One key, collaborative effort is the biennial aerial and ground surveys to track disease spread and severity. Like OSU, DNR and the U.S. Forest Service conduct these surveys in Washington in the spring before bud break. Why spring? Because needle retention is at its lowest, the fungus is producing fruiting bodies, and the discoloration of the needles is easiest to see from above.

In the aerial portion of the survey (via airplane), surveyors map areas of discolored needles associated with the disease (Photo 4). Because other factors besides Swiss needle cast can affect needle color, "we also do ground-based surveys, in which we walk the forest, set up a transect, and gather samples" to bring to the lab, explains Dan. Under a microscope, an infected needle is characterized by visible fruiting bodies (Photo 1). Results of the Washington and Oregon surveys are **published online**.

Dan Omdal, DNR

Photo 3. a) Branch with nearly 4 cohorts of needles, b) branch with a little more than two cohorts remaining, and c) branch with less than one cohort remaining.

Another vital, collaborative effort is outreach. The working group holds an annual technical meeting in the fall to share research, survey results, and other information. Working group members also speak to forestland owners as part of their jobs. For example, DNR staff in the working group not only provide one-on-one assistance but participate in the **Western Washington Forest Owner's Field Day** and the Forest Stewardship Coached Planning courses, both held by Washington State University's (WSU) **Extension Forestry Program**.

Finally, working group members give forest health lectures at Grays Harbor and Peninsula colleges to train the natural resource professionals of tomorrow, and are always looking for new, creative ways to bring Swiss needle cast awareness into the curriculum.

Options for Infected Stands

In consultations with forestland owners, working group members often share a sage piece of advice. "Go look at your trees," advises Jim. "What color are the needles, and how many cohorts of needles remain on the branch? Are just a few trees affected, or the entire stand?" Landowners should also observe the overall sparseness of the crown, and for extra certainty, use a hand lens to check the undersides of the needles for fruiting bodies. If in doubt, they can contact a trained natural resource professional through DNR's new **Find Your Forester web page**.

Swiss needle cast affects both tree height and diameter, so close observation can help forestland owners judge how tree growth is being affected, an important consideration when deciding what to do next.

Unfortunately, there is no "cure" for Swiss needle cast. Fungicides must be reapplied annually and are expensive and impractical for working forests. Once the trees are infected, thinning or other stand management actions can do little, especially if the trees have already lost a significant number of needles.

So the next step for an infected stand may be harvest, but when? Should the forest be harvested when the trees are merchantable, or does it make financial and ecological sense to wait a few years? The working group is currently developing a web-based economic "calculator" that may help with this decision.

Rachel Brooks, DNR

Figure 4. Photograph from the 2022 aerial survey.

Another key consideration is whether to replant with Douglas-fir after the harvest. When making this decision, "Do not ignore" Swiss needle cast, cautions Jim, or hope that the next rotation will be better. Know that even small pockets of Douglas-fir can become infected. In susceptible areas, it may be best to plant well-adapted western hemlock, Sitka spruce, wester redcedar, or red alder instead, or to plant a mixed-species stand to hedge one's bets. In all cases, always plant seedlings that are well adapted to the land's planting zone and elevation to give them a fighting chance. The working group has recently posted maps of the outbreak in Washington **on its website** to help landowners know if they are in a high-risk area. If in doubt, contact a professional through DNR's **Find Your Forester** web page.

Swiss needle cast is cause for concern, not alarm. The working group's message is to be aware of the disease and to weigh the risks when it is time to replant. And above all, go visit the woods. Summer is almost here, and it is as good an excuse as any to get some fresh air. ☙

Additional Resources

- **OSU Swiss needle cast silvicultural guide**
- **Swiss needle cast fact sheet**
- **Growth of young Douglas-fir plantations across a gradient in Swiss needle cast severity (focus on Oregon)**

Featured Article

The Olympic Region Harmful Algal Bloom Partnership: a Community-Based Approach to Protect Coastal Shellfish Harvest

by Vera Trainer, Olympic Natural Resources Center

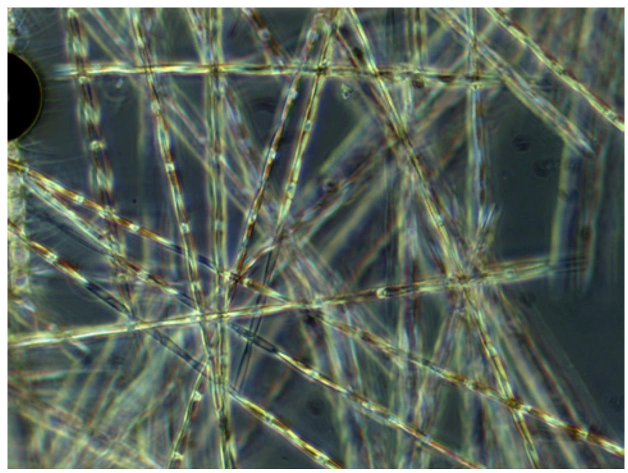
Vera Trainer, UW

Photo 1. Razor clamming on the Washington coast.

The salty smell of ocean breezes, the lap of the waves on the shore, and the company of people in boots holding shovels or clam guns are all part of the scene during coastal razor clam digs (Photo 1). Razor clams (*Siliqua patula*) are common in Washington and northern Oregon and are also harvested in Alaska.

These delicious clams are part of the unique history of the Washington coast, and many families have their favorite way of preparing them: dipped in egg and lightly fried in a seasoned bread mixture, or included in a delicious chowder, to name a couple. Razor clam weekends are family affairs, with parents rousing their children from bed at 5 or 6 in the morning to take part. Beaches are speckled with adults, children, and dogs, with a thousand people per mile literally "getting their hands wet" chasing these wily clams. Old timers will easily get their limit of 15 to 20 clams, while novices struggle. Everyone is having a great time and giving one another tips on where the best clams are.

This all changed in 1993 with the first coast-wide closure of the razor clam harvest. The closure was due to a bloom of the harmful phytoplankton *Pseudo-nitzschia* (Photo 2). A microscopic plant that lives near the surface of the ocean, this phytoplankton produces a poison called domoic acid that can become concentrated in clams and other kinds of shellfish, like Dungeness crab, as well as sardines, anchovies, and other plankton-feeding fish. Birds and mammals who eat these organisms can become sick or die.



Anthony Odell, UW

Photo 2. *Pseudo-nitzschia* forms long chains of individual cells. This image is what you would see through a microscope, 200x magnified. The length of each cell is about the width of a human hair.

The first domoic acid poisoning event in the United States was reported in Monterey Bay in 1991, when sea lions had seizures on California beaches. In fact, Alfred Hitchcock's 1963 horror film "The Birds" may have been inspired by a domoic acid poisoning event that gave rise to sick birds that flew into walls and windows after feeding on toxic sardines and anchovies.

This phytoplankton can also be harmful to humans. A domoic acid event in Prince Edward Island, Canada, resulted in the death of 3 people and the illness of 100 others who ate toxic mussels.

In 1999, the University of Washington's (UW) Olympic Natural Resources Center (ONRC) in Forks led a survey of Washington coastal residents to ask what their most pressing needs were. One urgent need was a solution to harmful algal blooms (HABs) such as domoic-acid producing *Pseudo-nitzschia*. As a result, in 2000 a team of tribal, federal, state, and local scientists gathering to form a collaborative project called the **Olympic Region Harmful Algal Bloom** (ORHAB) partnership. Managed by the ONRC, the group was formed to establish an effective early warning system for HABs. After an initial five years of federal funding, a $2 to $3 dollar tax on State shellfish licenses was passed by the Washington State Legislature in 2005 to fund ORHAB and additional testing by the Washington State Department of Health. In 2015, this tax was increased to a $3 to $4 dollar surcharge on shellfish licenses to allow for the increased costs of testing.

When residents pay $14.10 for an annual resident razor clam license, they are supporting the science and testing needed to keep clam harvests going. Before ORHAB, coastal-wide closures like the one in 1993 turned frustrated harvesters away for months. Now, ORHAB allows safe beaches to stay open during HABs. Since the establishment of ORHAB in 2000, only one coast-wide closure occurred in March 2020, due to COVID instead of HABs.

What do ORHAB partners do? They collect weekly water samples using nets and buckets at strategic locations along the Washington coast (Photo 3). Then they use microscopes to determine whether *Pseudo-nitzschia* and other harmful phytoplankton are present in coastal waters. If they are, they test seawater and shellfish for toxins at one of the coastal labs on the Olympic peninsula, including labs managed by the Makah, Quileute, and Hoh Tribes, the Quinault Indian Nation, ONRC, and the Washington Department of Fish and Wildlife.

ORHAB partners are also increasing the warning time for HABs. ORHAB is leading a project to deploy a surface autonomous vehicle called the Lightfish to offshore HAB hotspots to identify risks and bring water samples back to shore for toxin testing (Photo 4). The

Anthony Odell, UW

Photo 3. Anthony Odell (ONRC) collects seawater through a phytoplankton net to analyze for HABs.

Anthony Odell, UW

Photo 4. The Lightfish is a surface autonomous vehicle that will sample seawater at HAB "hotspots" off the coasts of Washington and Oregon to help provide an early warning of HABs making their way to coastal beaches, where they can poison shellfish and prevent harvest of clams and crabs.

Funding for ORHAB is provided by a surcharge to shellfish licenses (**RCW77.32.555**). Research and operational programs, such as the Lightfish project and the Pacific Northwest HAB Bulletin, are funded by NOAA's National Centers for Coastal Ocean Science, the Ocean Technology Transfer program, and the Integrated Ocean Observing System, specifically the Northwest Association for Networked Ocean Observing System.

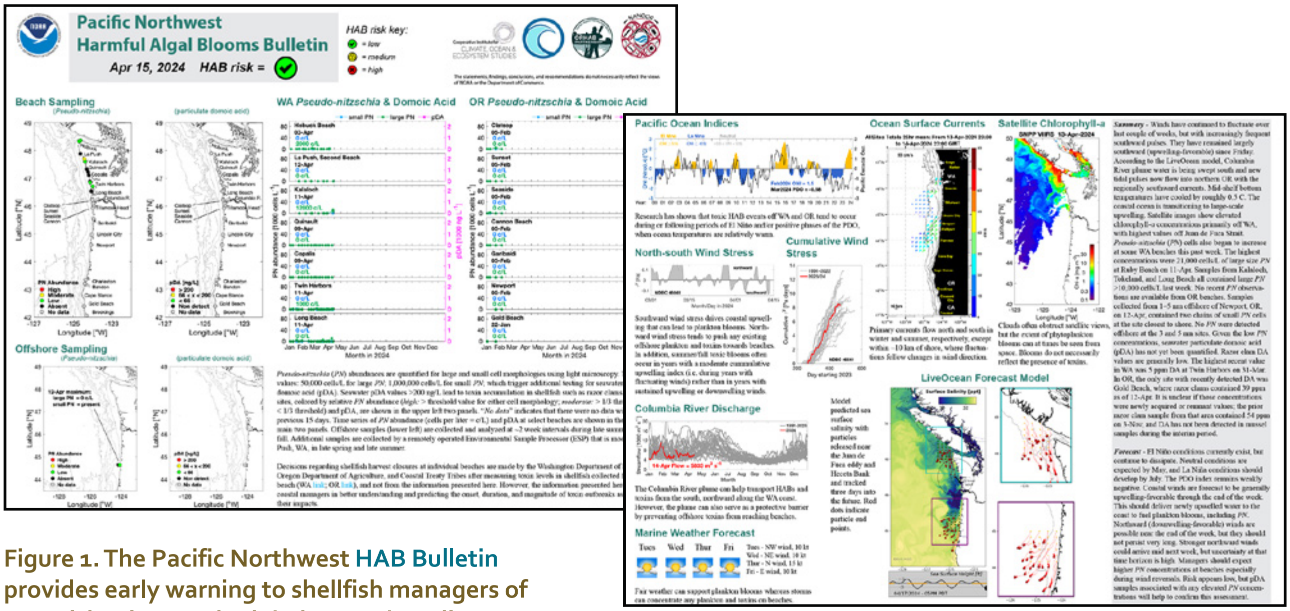


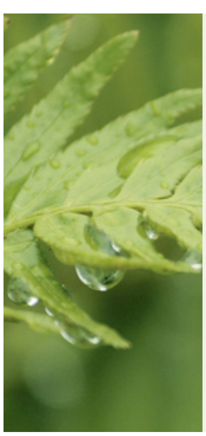
Figure 1. The Pacific Northwest HAB Bulletin provides early warning to shellfish managers of HAB risk prior to scheduled razor clam digs.

information collected by ORHAB from beaches and offshore areas is shared in a **Pacific Northwest HAB Bulletin** that is provided to coastal managers before they scheduled razor clam digs, giving them more time to determine which beaches will need to close (Figure 1).

So, the next time you and your family prepare to dig for razor clams, remember that your license fee is helping to fund ORHAB and the science behind the scenes to solve the mystery of HABs.

About the Author

Vera Trainer is the Marine Program Director of the ONRC and the principal investigator of the ORHAB partnership. Vera completed her master's and Ph.D. at the University of Miami and joined the UW School of Forestry and Environmental Sciences after a 30- year career with NOAA. She enjoys national and international collaborations, particularly with young scientists, to enhance our cultural, scientific and personal understanding of one another. She can be reached at **verat@uw.edu**.



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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T3 Watershed Experiment Project Updates

The Type 3 (T3) Watershed Experiment is a roughly 20,000-acre experiment that is being implemented across 16 watersheds in the Olympic Experimental State Forest (OESF). Its purpose is to test novel management strategies that benefit both communities and forests. These strategies are implemented through logging, silvicultural prescriptions, or both. The project is also testing a unique form of engagement called learning-based collaboration, in which people with diverse backgrounds, expertise and (sometimes conflicting) interests collaborate and learn together about specific topics. For background, visit **DNR's website** or the **project web page**.

Timber Harvests

All 13 timber sales implementing the T3 Watershed Experiment have been sold. Of these, three timber sales have been logged, seven are being logged now, and three are nearly ready for logging, with the necessary roads built (Photo 1). Most of the timber sales are progressing faster than expected, and all logging is expected to be completed by November 2025.

The T3 research team is working with DNR foresters to collect detailed data for timber sale compliance (the process by which foresters ensure the timber sale is implemented in compliance with the timber sale contract). DNR has also distributed surveys to purchasers and loggers with questions about harvest productivity, safety, and other aspects of the novel timber harvest practices being tested in the T3 Watershed Experiment.

Silviculture

After logging is complete, the T3 researchers will begin implementing the novel silvicultural prescriptions that are part of the experiment. Because logging is progressing faster than anticipated, Olympic region silviculturists are working with the T3 researchers to adjust the timeline for site preparation and planting. With the accelerated schedule, researchers may be able to implement the prescriptions more quickly than anticipated, possibly in the same year across all replicates. Most site preparation activities will take place in the summer of 2025 and most of the planting will take place in the winter of 2026. Researchers are preparing detailed silviculture implementation plans to guide marking in the field, site preparation, and planting.

Monitoring

Having completed four years of pre-harvest monitoring, T3 researchers are now starting post-harvest monitoring in riparian and upland areas, using indicators such as fish, leaf litter, bioacoustics, and water temperature. Researchers have added water oxygen to the list of aquatic monitoring indicators (Photo 2). Oxygen is

Emily Gardner, DNR

Photo 1. Log jams created in a thinned riparian buffer during logging as part of the "Active Habitat Restoration" watershed management strategy.

Kyle Martens, DNR

Photo 2. DNR field technician Tristan Ward installing an oxygen meter in a monitored stream reach.

a useful, integrative measure of stream metabolism and therefor aquatic productivity, and is sensitive to changes resulting from riparian forest manipulations. Twelve data loggers were deployed in the monitored stream reaches in fall 2023.

Another monitoring addition in 2024 is an amphibian study to assess responses of woodland salamanders, the most common upland amphibian species group, to the "complex early seral" and "variable retention harvest" prescriptions (Photo 3). The project is led by the U.S. Forest Service Pacific Northwest Research Station.

In February 2024, DNR conducted the first in a series of post-harvest drone flights. The flights were conducted for the "complex early seral" and "active riparian habitat restoration" silvicultural prescriptions. The goal of the flights is to track windthrow over time. Refer to the "Featured Photo" section of this newsletter for more information.

Stream Food Web Modeling

In 2023, T3 researchers modeled the food web in T3 streams using an **aquatic trophic productivity model**. The model estimates the capacity of stream ecosystems to sustain fish and is explicitly tied to transfers of organic matter between different components of a simplified stream-riparian food web. Specifically, the model tracks the biomass of leaf litter, aquatic invertebrates, juvenile fish, and periphyton (organisms attached to submerged surfaces, such as algae). Model parameters for the T3 study include stream shading, water temperature, nutrients (nitrogen and phosphorus), riparian vegetation composition, substrate size, and stream discharge. Researchers hypothesized how these parameters will change in a typical T3 stream reach in response to riparian treatments, such as thinning. Results are presented as a percent change in the average annual biomass of fish, macro invertebrates, and periphyton over a 50-year period after treatments.

Forest Growth and Yield Simulations

In February 2024, researchers completed 80-year growth and yield simulations for the standard and novel T3 silvicultural prescriptions using the Forest Vegetation Simulator (FVS). The model framework was enhanced to account for the spatial arrangement of trees by adjusting growth based on solar radiation.

Teodora Minkova, DNR

Photo 3. Amphibian monitoring plot in a recently harvested T3 timber sale.

The model provides projected tree volume, which will enable researchers to calculate the net present value of forest stands at the end of the harvest rotation. This work also helped researchers understand the uncertainties and the limitations of the available growth and yield models.

Learning Groups

Active engagement of stakeholders and tribes has been a main feature of the T3 Watershed Experiment. Learning-based collaboration started with gathering expertise and insights during the T3 study design and continued with the formation of seven T3 learning groups focused specifically on carbon, cedar, invasive species, aquatic responses, tribal interests, historical disturbances, and economics. Visit **this link** for more information on learning groups.

Recent learning group accomplishments include the following:

- Developing a model to use remote sensing to assess cedar distribution, including multispectral analysis to estimate cedar health.

- An exploration of the efficacy of remote sensing to map the spread of invasive Scotch broom on disturbed landscapes, which will help inform future mitigation strategies.

Although intensive and time-consuming, learning-based collaboration is proving to be an effective means of building trust and capitalizing on community expertise and resources, and could serve as a model to extend this concept more broadly as an engagement tool statewide.

Recent Publications

McGaughey, R. J., A. Kruper, C. R. Bobsin, B. T. Bormann. 2023. Tree Species Classification Based on Upper Crown Morphology Captured by Uncrewed Aircraft System Lidar Data. Remote Sensing 16(4):603

Aerial light detection and ranging (LiDAR) has been used extensively to assist with forest inventory. However, determining tree species has historically been very difficult. This paper explores the use of drone-based LiDAR to distinguish between western hemlock and Douglas-fir trees, two of the most common conifer species in this region. Ground data collected in the OESF in 2021 and 2022 was paired with drone-LiDAR point clouds to build a classification model that predicts tree species with high accuracy. Distinguishing between tree species at large scales has the potential to assist with silviculture planning and economic analyses.

Minkova, T.V., Devine, W.D., Martens, K.D. 2024. T3 Watershed Experiment in the Olympic Experimental State Forest: 2016-2023 Implementation Report. Washington State Department of Natural Resources, Forest Resources Division, Olympia, WA

This implementation report summarizes 2016 through 2023 activities, the rationale behind major decisions, and the lessons learned so far for the Type 3 (T3) Watershed Experiment. This recap is needed due to the long duration of the study (at least 10 years) and the large number of participants from different organizations. The report also serves as a communication tool and helps account for the funds and staff time used in the project during the reporting period. The intended audience is Washington Department of Natural Resources (DNR) managers; DNR practitioners implementing the study, such as foresters and silviculturists; study researchers (current and prospective); stakeholders; and other land managers and researchers considering similar projects.

Whitney, E. J., J. R. Bellmore, J. R. Benjamin. 2024. Modeling Stream Food Web Response to Riparian Prescriptions in the Olympic Experimental State Forest: Summary Report

In this study, the authors describe the formulation and outcomes of a simulation model that mechanistically links the dynamics of the food web and the resultant performance of different web members (periphyton, macro invertebrates, and fish) to the physical and hydraulic conditions of the stream and the structure and composition of the adjacent riparian zone. The model was applied to the five prescriptions within the riparian component of the T3 Watershed Experiment to assess the potential impacts of current and alternative forest management strategies on stream food webs. The objective was to simulate how changes in environmental conditions associated with the prescriptions influence algal, aquatic insect, and fish productivity at a generalized stream site within the T3 study area over both the short term (5-10 years) and long term (50 years). The simulations provide a tool for comparing prescription responses under the same environmental conditions.

Education and Outreach

On April 24th and 25th, 2024, the Washington Department of Natural Resources (DNR) and the University of Washington (UW) Olympic Natural Resources Center (ONRC) hosted a field tour of several treatment sites that are part of the T3 Watershed Experiment.

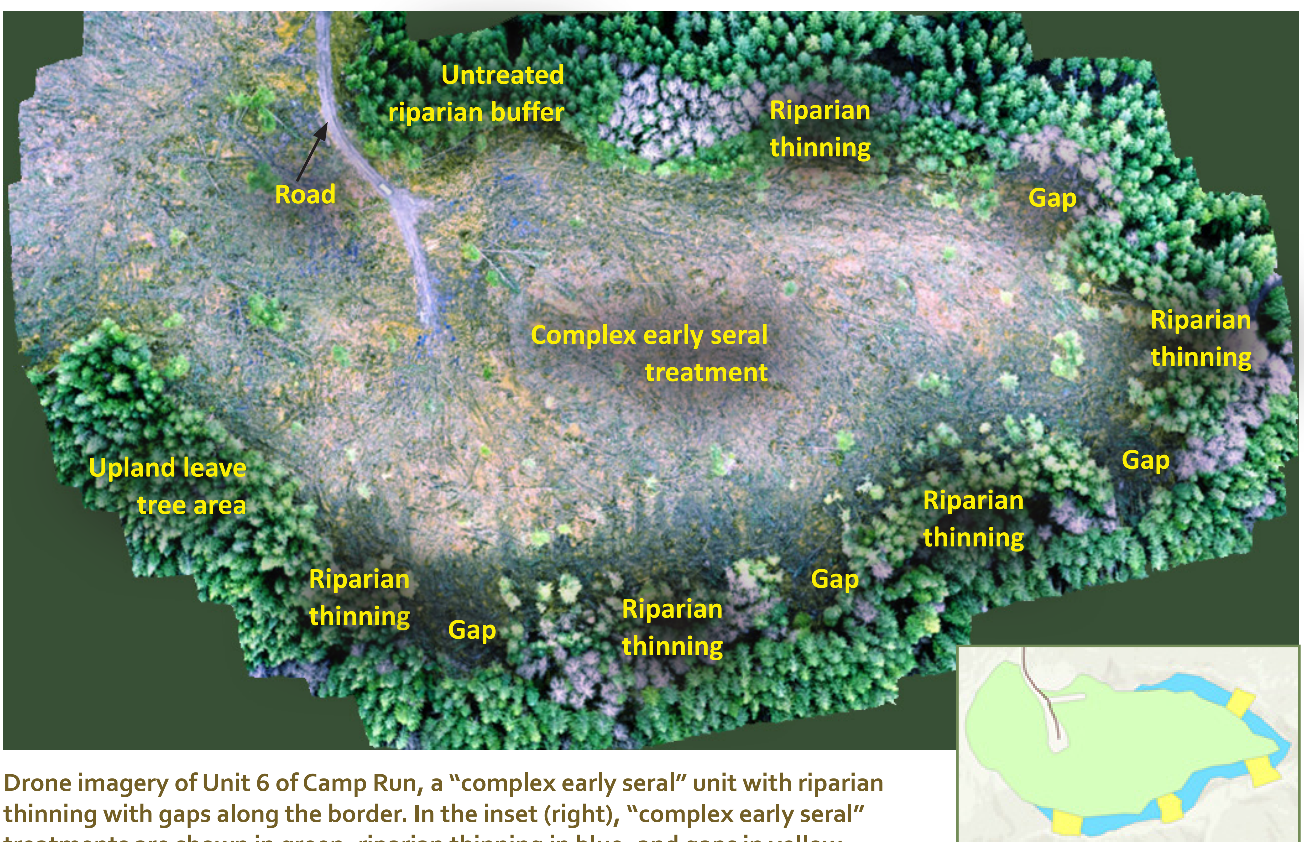
To kick off the tour, UW Masters Student Ally Kruper presented her work on a model that will assess cedar distribution on the western Olympic Peninsula using remote sensing data. The next day, nearly 30 participants gathered on a typical rainy day on the western Olympic Peninsula to visit three upland sites and one riparian site. The three, recently harvested upland sites were observed and compared against standard variable retention harvest sites. Throughout the tour, participants considered economic and social impacts of the various prescriptions, and how remote sensing might be used for monitoring.

Tracy Petroske, DNR

Field tour participants learning about a novel silviculture prescription from T3 Project Implementation Coordinator Emily Gardner.

At the end of the day, some participants enjoyed a presentation at the ONRC on traditional basket weaving by Quileute weaver Cathy Salazar. Her presentation is available on the **ONRC website**.

Featured Photo



Miles Michelletti, DNR

Drone imagery of Unit 6 of Camp Run, a "complex early seral" unit with riparian thinning with gaps along the border. In the inset (right), "complex early seral" treatments are shown in green, riparian thinning in blue, and gaps in yellow.