The Learning Forest

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

Issue 9 • Spring 2021

Editorial Board Message

All of you working from home in the pandemic should relate to the articles in this issue of *The Learning Forest*. Recent developments in unmanned aerial vehicles (UAV, also known as drones) and light detection and ranging (lidar) technology will allow managers and researchers to spend more time studying the forests of the Olympic Peninsula from their desks.

It is not that we do not want to be in the woods as much. For researchers, it is a matter of scale. In the past, we asked research questions at the stand scale, usually a few acres or smaller. Now we ask questions at the scale of management operations (about 30 acres) to entire watersheds, such as the Hoh River drainage. The Large-Scale Integrated Management Experiment (**T3 Watershed Experiment**) is a good example of this. Although the new technology is invaluable at these scales, rest assured that staff and students will still climb the steep and soggy hills in the depths of the Olympic Mountains to verify the remotely sensed data and collect the remaining information that the technology cannot detect.

This issue's featured article discusses how UAV imagery can be transformed into 3D models of forests and streams that yield data for entire study areas, not just sample plots or transects. Collecting the images is faster and safer than collecting data on foot.

The guest article gives us a fascinating look into the new world of UAV-based lidar. This cutting-edge technology reveals a virtual reality unimaginable just a few years ago. It will be really fun to see this technology applied to environmental research and monitoring.

In this Issue

Teodora Minkova, , DNR

The Hoh River on the Western Olympic Peninsula

Today's research questions focus on ecological processes at large scales, such as entire watersheds.

Featured Article

A New Perspective

Using UAV Imagery for Forest Management in the OESF and Beyond

by Cathy Chauvin and Miles Micheletti, DNR

Prior to 2010, the best way to obtain aerial photos was to hire someone to take them from a plane or helicopter. The more adventurous could strap a camera to a kite or balloon, send it skyward, and hope for the best.

Today we have the small, unmanned aerial vehicle (UAV), better known as a drone (Figure 1). These affordable, camera-equipped craft are remarkably stable in the air, interface with a smartphone or tablet, and can be sent buzzing up to 400 feet to give photographers, foresters, and other users a new perspective on their subjects.

The ability to take high-quality aerial photos on demand is a huge advantage for land managers like the Washington State Department of Natural Resources (DNR). But the real power of UAVs is not so much the aerial photos, as what can be derived from them. Recent advances in digital cameras, UAVs, computers, and software have made it possible to create spatially accurate, 2D and 3D digital products that can be used to measure anything from distance to tree height and even timber volume. This article will explore how DNR harnesses this technology in the Olympic Experimental State Forest (OESF) and beyond.

Teodora Minkova, DNR

Figure 1. UAV and controller on launch pad

Getting to 3D

First, a note about flying UAVs.

In 2016, Dutch police trained eagles to snatch unauthorized UAVs from commercial airspace. This impressive solution demonstrates the problem of UAVs showing up in places they definitely should not be, like airports.

Here in the U.S., anyone flying a UAV for commercial purposes must be certified under the Federal Aviation Administration "Small UAS Rule," **Title 14 of the Code of Federal Regulations, Part 107**. Obtaining a remote pilot certification involves passing a written exam that demonstrates more than passing familiarity with safety rules, including air space restrictions. All DNR pilots are certified under Part 107 and follow DNR policy and Washington state law on ensuring privacy.

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).

All newsletter issues are available **online**. To receive this publication or to be added to the distribution list, go to our **sign-up page** or contact the editor at cathy.chauvin@dnr.wa.gov.

The first step in building digital products is to take photos of the site. Using a smartphone, DNR programs the UAV to fly over the site in a grid, taking photos at regular intervals. The photos overlap as much as 70 percent, so that all points on the ground are photographed more than once at slightly different angles.

The next step is to process the images using "structure from motion" software. Those who are just starting a UAV program or prefer not to complete this step themselves can send their photos to services who will process the images for a fee (Text Box 1).

To begin, the software finds features that are common to more than one photograph, for instance a line, point, corner, or object on the ground. These features are called "key points." Then, the software triangulates the actual location of each key point by projecting an imaginary line from the position of the camera down through the key point in each image. The key point's location in 3D space is where these lines intersect (Figure 2). Each triangulated point is also geo-rectified, meaning it is tied to the geographic coordinate system (latitude, longitude, and altitude) using the data the UAV collects for each photo with its onboard sensors. As DNR UAV program manager Miles Micheletti says, "There is a lot going on in that tiny fuselage."

Once this step is done, the software uses the key points to make an orthomosaic, which is an image made from numerous, overlapping photos. The software aligns all the photos and then stitches together the least-distorted part of each photo into a single image. This image is then corrected for camera tilt and angle, perspective, topography, and other factors (Figure 3). The orthomosaic is spatially accurate and has a perfectly straight-down perspective all the way across, like a map. For a good example, visit Google Maps and turn on the background imagery.

The thousands of triangulated, geo-rectified key points also comprise a point cloud (Figure 4 on page 4). A point cloud is a collection of points in 3D space that describe the shape of the site or object being photographed. Point clouds are a simple type of 3D model. Imagine covering an object in tiny dots and then removing the object, leaving those dots suspended in the air.

Text Box 1. Image processing software and services

Common drone imagery processing software:

- Agisoft Metashape
- Pix4DMapper
- OpenDroneMap (free)
- WebODM (free)

Services to process drone imagery in the cloud:

- DroneDeploy
- MapsMadeEasy
- ArcGIS Drone2Map

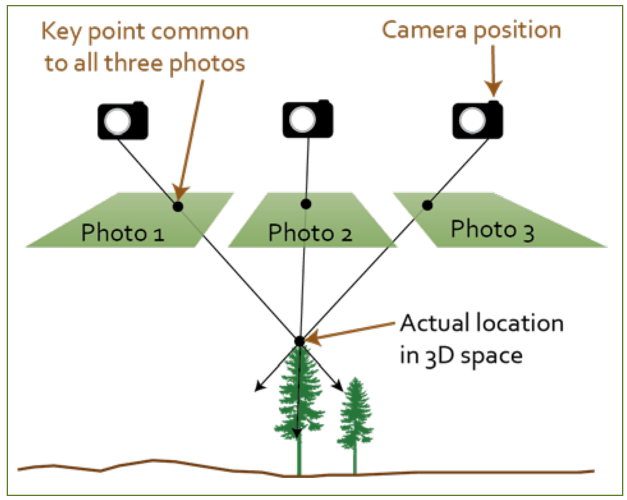


Figure 2. Triangulation

To build the point cloud, the software triangulates the true location of key points that are common to each image.

Miles Micheletti, DNR

Figure 3. Image distortion

Because of the curvature of the lens, aerial photos are most accurate in the center and become more distorted toward the edges. To create the orthomosaic, the software retains the least distorted, center portion of the image and discards the rest.

With spatial analysis tools, the point cloud can be used to estimate tree height, trees per acre, canopy cover, and other, more detailed forest metrics, particularly when the point cloud is combined with a 3D ground or "bare earth" model. A bare earth model shows the contours of the ground without vegetation, and can be made with light detecting and range (lidar) data. Lidar data is derived from precise measurements made with an airplane-mounted laser and can be downloaded from DNR's **lidar data portal**.

The UAV Advantage

Because UAVs fly much lower than planes or helicopters, the images they take are much richer in detail than traditional aerial photos. That detail means the orthomosaic and point cloud are suitable for site-specific planning and monitoring. Plus, the timing is in the pilot's hands. Need photos when the leaves are off the trees, but before the first snow? As long as it is not pouring rain, the UAV can fly.

UAV products provide more comprehensive data than is usually collected on foot. Two examples are surveys to ensure young trees are growing well, and surveys to ensure that loggers met contract requirements on the stand's first thinning. Foresters cannot count every tree on a 100-acre (40-hectare) site, so they typically grid the site and survey within representative sample plots. "Sample plots can miss things, like a patch of seedlings that aren't growing well," explains Micheletti. By contrast, the point cloud and orthomosaic give foresters a detailed understanding of the entire site.

A similar situation is monitoring the amount of large woody debris in streams within the OESF. This work is being done as part of the **Status and Trends Monitoring of Riparian and Aquatic Habitat** project, and typically involves sampling along five, equally spaced transects along a 328-foot (100-meter) stream reach.

In 2018 and 2019, DNR experimented with using a UAV on two sample reaches that are part of this project. The photos were taken by zigzagging the UAV up the stream and beneath the forest canopy, and the photos were processed into point clouds and orthomosaics. While analyzing the imagery, fish biologist Kyle Martens also made simple drawings from the data (Figure 5 on page 5).

Figure 4. Point clouds made from UAV imagery

With the color data collected by the drone, point clouds can be processed to look photo-realistic.

These products allow DNR to compare the two streams at a glance and understand how wood is moving through the stream. And because the UAV sees the entire stream, not just the transects, "there is less chance of missing the wood that is there," explains Kyle.

A final advantage of UAV imagery is time saved and safety. On young stand surveys, "A hundred acres could take two days to grid and survey," says Matt Perry of DNR's Olympic Region. "A drone can fly it in 25 minutes." Even with data processing time, DNR still comes out ahead. As for safety, foresters are less likely to be injured flying a UAV than walking a rugged site on foot.

An Effective Tool

A few things should be kept in mind when considering UAVs for land management. UAVs are not likely to replace the need for first-hand experience in the field; validation of imagery results and on-the-ground interpretation is an important component of any

UAV program. Creating digital products from UAV imagery can take a lot of expertise as well as the right software, although the data can be sent to a service for processing (Text Box 1). Finally, UAVs are not suitable for all uses. Dense forests and hardwoods are particularly difficult to render.

The list of uses that *are* suitable is long and constantly evolving. DNR's aquatics scientists are using UAVs to estimate the size and density of eelgrass beds in the intertidal zone. DNR's engineering group is using UAVs to model rock stockpiles so they can estimate how much rock they contain. UAVs have also been used to model landslides while the pilot stands safely on stable ground.

In short, UAVs are a safe, economical, and effective tool that can make routine tasks safer and more efficient and provide a whole new perspective on the lands we manage. ☙

Figure 5. Vector drawing and a close-up of the point cloud made from UAV imagery of a stream reach in the OESF

Note the change in wood and channel shape from one year to the next.

About Miles Micheletti and DNR's UAV Program

Miles Micheletti is the UAV Data Manager in DNR's Forest Resources Division. In this role, he helps train and coordinate DNR's UAV pilots, and writes software to process the data they collect. Micheletti studied landscape ecology and GIS at The Evergreen State College in Olympia, WA.

DNR's State Uplands UAV Program has trained more than 30 DNR pilots, who work in every region and most operational divisions in DNR. The UAV program supports several collaborative work groups and provides UAV-related, forestry-specific training and support to the public and other government agencies through conference presentations, guest lectures, tutorials, pre-packaged sample data, and more. For more information, contact Micheletti at **Miles.Micheletti@dnr.wa.gov**.

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. Information on past and current projects in the OESF can be found at this **link**.

Guest Article

UAV Lidar

An Effective and Affordable Tool for Forest Management

by Sean Jeronimo, Resilient Forestry and Caleigh Shoot, Weyerhaeuser

Light detection and ranging (lidar) is a popular remote sensing technology that uses laser scanning to create detailed 3D models of objects (Figure 1). To collect lidar data across a large area, an airplane fitted with a lidar unit flies back and forth as the device sends numerous laser pulses downward in a narrow swath. Each pulse reflects off the ground or an object above the ground (called a "return"). By measuring the time it takes for the laser pulse to return to a sensor on the device and combining that data with the position of the sensor, it is possible to calculate (spatially resolve) the 3D coordinates of each point from which the laser pulse reflected.

The combination of all spatially resolved returns constitutes a point cloud, which is the most fundamental lidar data product (Figure 2 on page 7). Other common products derived from point clouds are 3D ground models (also known as "bare earth") and canopy models.

Lidar data products have many applications in forestry. Lidar can be used to map roads and streams and identify evidence of unstable slopes. With some processing, lidar can be used to identify individual trees within a forest stand and extract detailed information about each, such as tree height, crown diameter, and other forest inventory metrics. In commercial applications, lidar-derived maps of individual tree locations can be used to monitor stand density and pinpoint the application of treatments such as inter-planting, thinning, or fertilization. In ecosystem management, maps of tree locations can be used to plan thinnings to restore heterogeneous spatial patterns, and flights before and

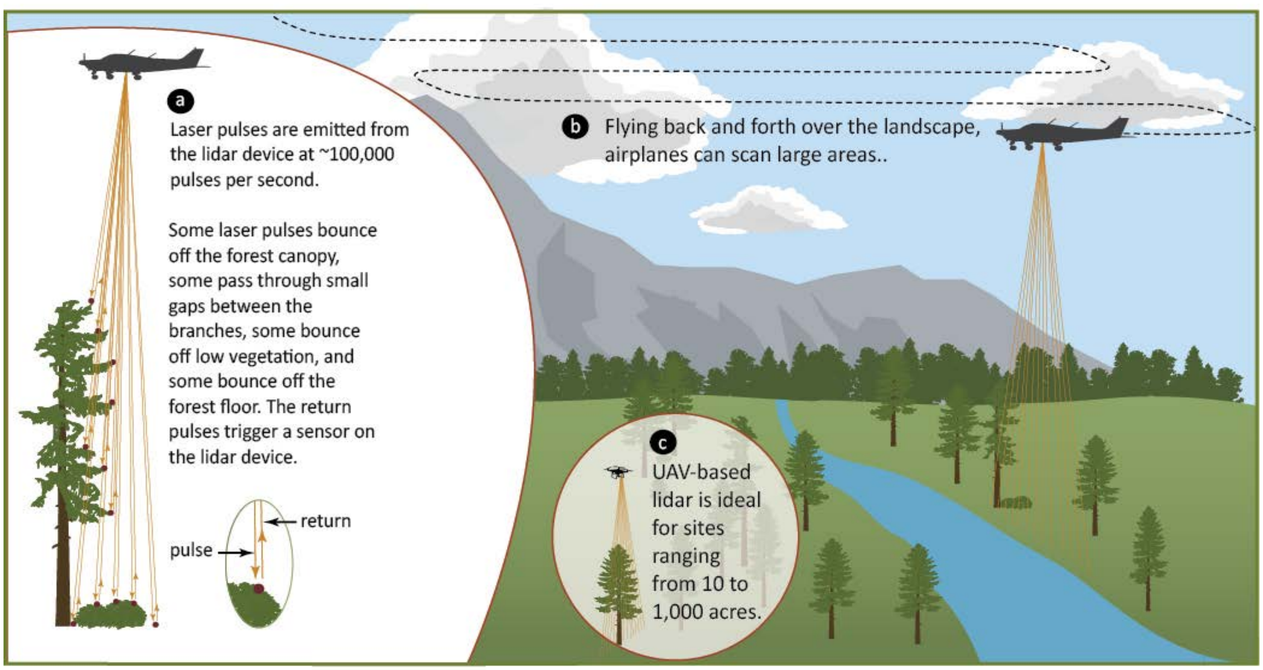


Figure 1. Lidar on airplane and unmanned aerial vehicle (UAV)

A lidar device, sometimes called a laser scanner, makes 3D models of objects by taking many distance measurements using pulses of laser light. Almost anything can be scanned, including trees, shrubs, buildings, roads, and the earth's surface. The lasers are powerful and can penetrate through small gaps in the forest canopy to reach the ground (a), making them effective even when the ground surface is visually obscured by vegetation. Lidar sensors are most commonly mounted on airplanes, especially for forestry and land management, because the airplanes can cover large areas at once (b). However, lidar sensors can be mounted on many other platforms, including stationary tripods, automobiles, and, recently, UAVs (drones) (c).

after thinning can be used to monitor treatment efficacy. The broad utility of lidar data has made it an indispensable part of forest management in the region.

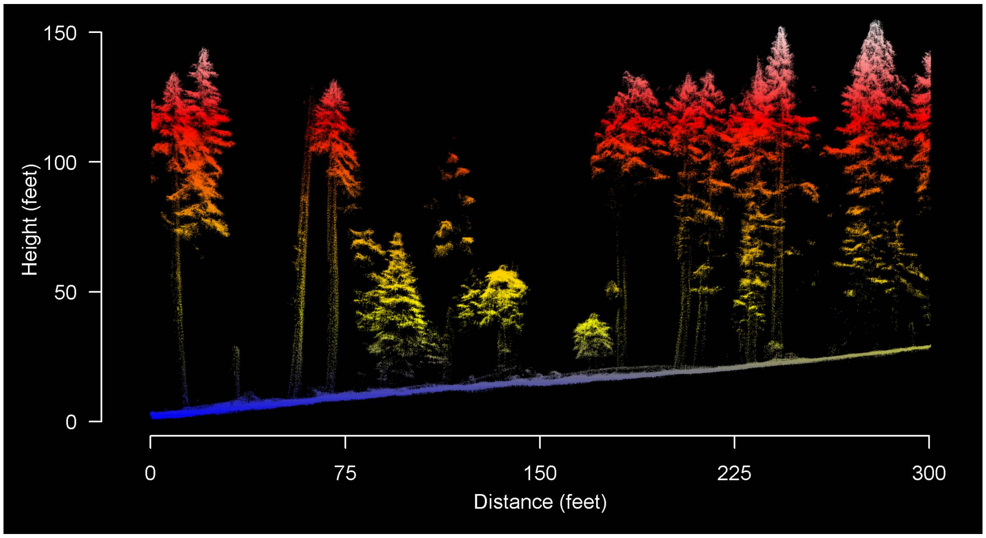


Figure 2. Point cloud made from a UAV lidar transect of a recently thinned ponderosa pine and Douglas-fir forest near White Salmon, WA

The transect width is 30 feet. Large and small trees (including trunks), snags, and complex crowns are all visually evident.

An exciting, recent development in lidar technology is the ability to collect lidar using unmanned aerial vehicles (UAVs, also known as drones). UAVs have been used by hobbyists and commercial industry for years; however, lidar units have been too heavy, power-hungry, and complex to be flown on UAVs until recently.

UAV lidar has tremendous promise to complement airplane-based data. While publicly available airplane-based lidar is collected by the Washington State Department of Natural Resources across most of the state at 5 to 10 year intervals, UAV lidar is economical to collect much more frequently and for small areas. It also boasts a higher level of detail and accuracy than airplane-based lidar data, coupled with streamlined logistics for flight planning and data processing that make it available on short notice.

The fact that small, targeted flights — including repeat flights for monitoring —are finally logistically and financially feasible is perhaps the most exciting part of UAV lidar's emergence as a commercially viable technology. A UAV-based lidar mission can be contracted for as little as $1,000, making it economical to fly as few as 10 to 15 acres or as many as 1,000 with a UAV. By comparison, it costs upward of $25,000 to contract an airplane-based lidar mission, which is not economical for any area smaller than about 50,000 acres.

In addition, UAV lidar is a very agile data source: Missions can be planned and deployed within hours, and data processing can be completed the following day. This agility makes UAV lidar a truly responsive tool for time-sensitive situations such as emergency response to landslides, floods, or wildfires, and a flexible data source for strategic implementation of everyday management activities.

Because of its low flying height, UAV lidar has much higher resolution and accuracy than airplane-based lidar (Figure 3 on page 8). UAV lidar often yields data with density exceeding 200 to 300 laser pulses per square meter, while the highest quality airplane-based lidar typically averages 8 to 10 laser pulses per square meter. And, each laser pulse is spatially resolved more accurately with UAV than airplane-based lidar (about 3 cm. versus 30 cm. error, respectively).

These improvements in resolution and accuracy allow for the detection of small details on surfaces and terrain, make UAV lidar ideal for mapping subtle topographic features like older landslides and barely remnant roads. And while airplane-based lidar does a remarkable job capturing forest structure over large areas, UAV lidar excels in making extremely detailed measurements over smaller areas, including much more complete maps of individual tree structure. Even in dense forest, UAV lidar captures detailed branch structures and unique branch patterns, crown shapes, most trees' trunks, and understory structures like low vegetation and surface fuels.

Certainly, UAV data collection is not without its challenges. The Federal Aviation Administration requires a certificate to fly UAVs commercially, and also imposes regulations that can present challenges to operation in remote timberlands. UAVs are required to stay within 400 feet of the ground and within visual line-of-sight of the flight team at all times, which can be difficult to maintain in the tree-covered and mountainous terrain of the Pacific Northwest. Waivers to circumvent these rules are possible but challenging to obtain. The imperative to fly safely and legally makes it all the more necessary to operate with a skilled UAV pilot and an experienced flight team.

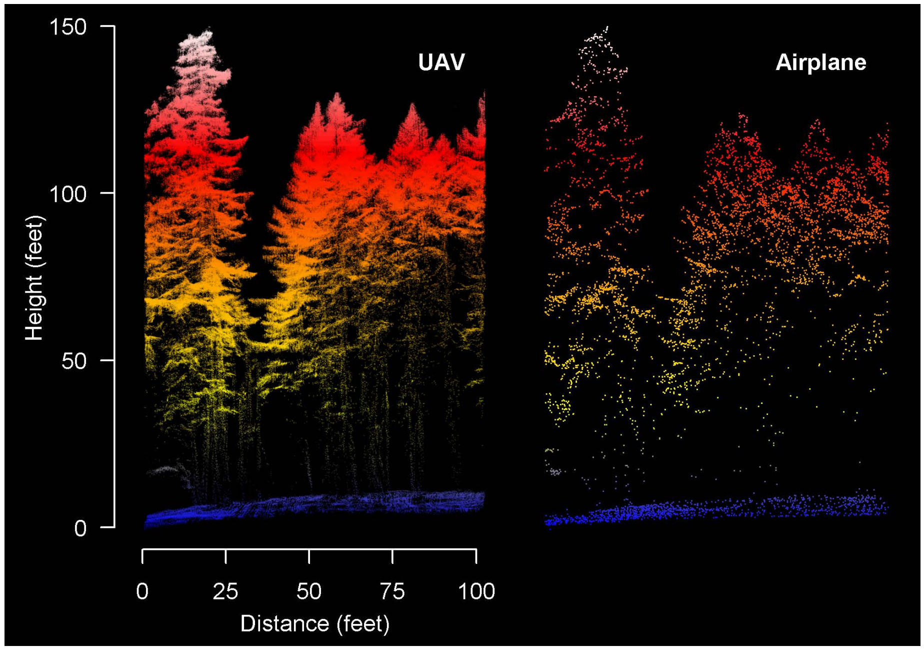
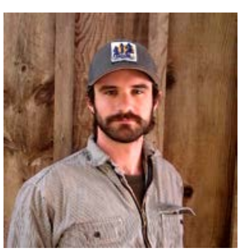


Figure 3. Comparison between UAV lidar and airplane-based lidar in an unthinned portion of the same stand depicted in Figure 2.

While airplane-based lidar does a remarkable job capturing forest structure over large areas, UAV lidar excels in making extremely detailed measurements over smaller areas. Even in dense forest, UAV lidar captures detailed branch structures, crown forms, and most trees' trunks.

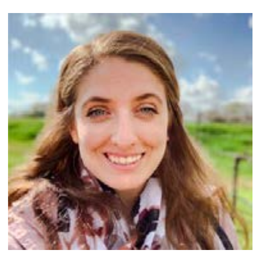
UAV lidar is poised to fill a key role as a complement to airplane-based lidar. It will be exciting to see how the science and land management community takes advantage of this incredible tool.

About the Authors



Sean Jeronimo is the co-owner of Resilient Forestry, a consulting group focused on managing forests as whole ecosystems according to the best available science and technology. Sean completed his Ph.D. at the University of Washington investigating practical, operational approaches for incorporating lidar into forest restoration. In partnership with West Fork Environmental, Resilient Forestry is beginning to offer UAV-based lidar data collection, processing, and analysis as a service to forestland owners and managers in the Pacific Northwest.

Contact: **sean@resilientforestry.com**



Caileigh Shoot works as a Remote Sensing Research Specialist at Weyerhaeuser, helping to integrate innovative remote sensing technology into internal research studies. Prior to working at Weyerhaeuser, Caileigh worked at West Fork Environmental and, alongside Sean Jeronimo, collected the UAV lidar data seen in this article. Caileigh received her M.S. from the University of Washington's Remote Sensing and Geospatial Analysis Laboratory. She is passionate about using remote sensing to solve natural resource management issues and welcomes inquiries via email.

Contact: **c.g.shoot@gmail.com**

Recent Publications

Evaluating Coexistence of Fish Species with Coastal Cutthroat Trout in Low Order Streams of Western Oregon and Washington, USA

Fishes, Volume 6, Issue 1

Martens, K.D. and J. Dunham

This paper examines why certain species of fish are found across the landscape and whether these species impact each other when they occur together. The authors used data from the Olympic Experimental State Forest (OESF) and the Oregon Coast to examine the co-occurrence and interactions of coastal cutthroat and Coho salmon.

This work helps the Washington State Department of Natural Resources (DNR) understand cause and effect relationships between forest management, aquatic habitat, and salmon population and is part of its ongoing effort to validate the effectiveness of the riparian conservation strategy in the *State Trust Lands Habitat Conservation Plan*. The results of this study show that habitat features are a stronger predictor of fish abundance than interaction between fish species, which means that DNR can be confident in analyses that focus on a single fish species. Had stronger species interaction been found, DNR would need to account for these interactions in future validation monitoring efforts for the riparian conservation strategy, making these efforts far more complex. The paper was selected to be highlighted on the front cover of the journal.

Ecohydrological Characteristics of a Newly Identified Coastal Raised Bog on the Western Olympic Peninsula, Washington

Ecohydrology, Early View (Online Version)

Rocchio, F.J., E. Gage, T. Ramm-Granberg, A.K. Borkenhagen, and D.J. Cooper

Joe Rocchio, DNR

Crowberry Bog

In western North America, raised, ombrotrophic (rain-fed) bogs are known to occur as far south as Vancouver in coastal British Columbia. A recent discovery of a raised peatland on the western Olympic Peninsula (Crowberry Bog) prompted an investigation to determine whether this site is ombrotrophic.

Results demonstrated that Crowberry Bog has many characteristics of an ombrotrophic peatland, including raised topography and the clear formation of three ecological zones (lagg or outer margin, sloping rand, and central plateau). Hydrology and water chemistry measures clearly show that the peatland is supported solely by precipitation. The bog's vegetation is dominated by species that are characteristics of ombrotrophic peatlands, especially peat moss species (*Sphagnum spp.*) that are highly indicative of ombrotrophic conditions. These multiple lines of evidence strongly indicate that Crowberry Bog is an ombrotrophic peatland, the first ecosystem of its type identified in the conterminous western USA and the most southerly ecosystem of this type in western North America.

As such, Crowberry Bog merits special protection, restoration, management, and long-term monitoring. DNR recently protected the site as Washington state's newest Natural Area Preserve and DNR's Natural Areas Program will utilize these results to guide future monitoring activities. Additionally, its location at the southern extent of documented raised bogs makes this site an important location for understanding climate change effects on peatlands in western North America.

Project Updates

Large-scale Integrated Management Experiment (T3 Watershed Experiment)

Over the fall and winter, project leads made great progress in planning the **T3 Watershed Experiment** on DNR-managed lands in the Olympic Experimental State Forest (OESF). This study assesses the impacts of current and alternative forest management strategies on ecosystem wellbeing, including humans as part of the ecosystem. All silvicultural treatments will be implemented as part of DNR's Olympic Region timber sale program.


Teodora Minkova, DNR

Installation of a block net along a stream in one of the experimental basins in the T3 Watershed Experiment

Researchers from DNR, University of Washington (UW), USDA Forest Service Pacific Northwest Research Station, Washington State University, and National Marine Fisheries Service (NOAA Fisheries) finalized the **study plan for the riparian areas of the experimental watersheds**. Peer review was coordinated by the director of the research station. The study compares three experimental riparian treatments with current riparian management and the unharvested, control watersheds: forest thinning with gaps and delivery of in-stream wood, wide thinning of conifers and under-planting with red alder, and site-specific, variable-width buffers. Pre-treatment monitoring of streams, fish, macro-invertebrates, and algae started in 2020.

Scientists from UW, the research station, and Oregon State University have been working with DNR scientists, practitioners, and managers to identify silviculture alternatives to current practices for the upland areas of the experimental watersheds. These alternatives, which will be included in the study plan, include clumped conifer plantings to extend forage and non-conifer vegetation, natural regeneration and increased structure retention, mixed stands of red alder and western red cedar, and accelerated variable-density thinning. The proposed prescriptions will be discussed with stakeholders in May (refer to "Upcoming Events") and the study plan will be finalized later in the year.

Scientists from DNR and Omfishient Consulting finalized a **study plan** for passive acoustic monitoring of indicator bird species. The study plan was peer-reviewed by Oregon State University and U.S. Geological Survey. This study will assess the response of songbirds to the complex early-seral habitat treatment. Pre-harvest monitoring of species occupancy (presence absence) began in 2020. The project is partially funded by a grant from the **Earthwatch Institute** and is organized as a **citizen science project**.

Olympic Region managers and foresters continued planning for 13 timber sales across the 12 treatment watersheds. Approximately 13 percent of each watershed will be harvested and later regenerated with a combination of traditional and alternative silvicultural prescriptions. The first timber sale is expected to be auctioned in fiscal year 2022.

With help from an EnviroIssues outreach consultant, project leads began a structured outreach effort. They sent an introductory email to local communities, tribes, regional stakeholders, and potential research partners in March 2021 and held two Zoom meetings as part of the annual OESF Science Conference in April. Interested stakeholders can attend virtual meetings in May (refer to "Upcoming Events") and virtual or in-person field tours later in the year. Engagement opportunities include commenting on treatment designs, assisting with monitoring, participating in data collection, or helping with scientific analysis. If you are interested in participating, contact the project team at **T3team@uw.edu** to be added to our mailing list. Additional information, including the upland study plan when ready, can be found on the recently created **project webpage**.

Contact Teodora Minkova at **teodora.minkova@dnr.wa.gov** or Bernard Bormann at **bormann@uw.edu** with questions about the T3 Watershed Experiment.

Ethnoforestry Field Study

Located near La Push on DNR-managed land, this study tests two ethnoforestry prescriptions: agroforestry, in which densely planted understory species are installed in rows every half meter and Douglas-fir seedlings are planted at 180 trees per acre (TPA); and early seral management, in which understory plants are installed at wider spacings every two meters in rows, Douglas-fir seedlings are planted at 180 TPA, and red alder is planted at 50 TPA. The control replicates the prescription DNR is implementing in the rest of the unit: planting 360 Douglas-fir TPA. Additionally, three wildlife treatments will be superimposed: 8-foot wildlife fencing, application of the wildlife repellent Plantskydd, and a no-action control (open to all browse).

In summer 2020, ONRC summer interns assisted with installing the boundaries for each experimental unit and preparing the site by breaking up existing slash and unearthing bare mineral soil to expedite planting. In December, crews constructed 8-foot wildlife fencing on one-third of the units to evaluate growth without browsing. In early 2021, 25 UW student volunteers planted nearly 5,000 understory plants and seedlings on site in each of the experimental units. In summer 2021, the new crop of ONRC summer interns will take the first post-treatment measurements including plant survival, browse, and natural regeneration. These data will be used to compare the treatments and address research questions focused on wildlife, plant success, and economics. Contact Bernard Bormann at **bormann@uw.edu** with questions.

Upcoming Events

Virtual Stakeholder Meetings for the T3 Watershed Experiment

In these Zoom sessions, principal investigators will share an overview of the study and describe planned or proposed treatments for upland and riparian areas. Participants will be able to share comments on the study plans and help refine monitoring approaches. Visit the **project website** for more information on the study.

Session 1: Riparian Treatments
May 18, 11:00 am to 1:00 pm **(register here)**

Session 2: Upland Treatments—Complex Early Seral Habitat and Accelerated Variable Density Thinning
May 19, 10:00 am to 12:00 pm (**register here**)

Session 3: Upland Treatments—Cedar-Alder Polyculture and Ethnoforestry/Variable Density Planting
May 20, 10:00 am to 12:00 pm (**register here**)

Featured Photo

Courtney Bobsin, University of Washington

University of Washington student volunteers plant several thousand understory plants and seedlings on state trust lands as part of the ethnoforestry field study, which is part of the T3 Watershed Experiment