

"growing together"

# WFGRS 2020

Western Forestry Graduate Research Symposium  
[gradsymp.forestry.oregonstate.edu](http://gradsymp.forestry.oregonstate.edu)

April 30 - May 6

on Zoom

[forestry.oregonstate.edu/](http://forestry.oregonstate.edu/)

stay-home-lecture-series



Oregon State University  
College of Forestry



WESTERN  
FORESTRY  
GRADUATE  
RESEARCH  
SYMPOSIUM

# WELCOME TO THE 2020 WESTERN FORESTRY GRADUATE RESEARCH SYMPOSIUM

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The annual Western Forestry Graduate Research Symposium (WFGRS), hosted by Oregon State University's College of Forestry, showcases current graduate student research. The symposium fosters educational opportunities, community building, and academic excellence by providing a space for students to present their work to the university community. This event offers graduate students a forum to receive feedback on their proposed and current research, promoting student engagement, enthusiasm, and interdisciplinary collaboration.

This year's symposium was made part of the College of Forestry's Stay at Home Lecture Series under unusual circumstances. The Covid-19 outbreak quickly changed the way we conduct and communicate research. It emerged when we were to debut the College of Forestry's anticipated new home, Peavy Hall: a space to anchor roots while cultivating ourselves and each other in a sustaining environment. Remarkably, the WFGRS 2020 theme, Growing Together, holds different meaning than originally intended as we find ourselves apart. WFGRS 2020 now offers supportive science communication connecting colleagues during a historical moment of detachment.

We are honored to share presentations by graduate students who chose to continue WFGRS participation. Presentation topics this year include forest networks and interactions, tree growth and mortality, harvesting and safety, human-forest connections, and remote sensing applications. Participants communicate an array of research spanning all three departments in the College of Forestry: Forest Ecosystems and Society (FES), Forest Engineering, Resources and Management (FERM), and Wood Science and Engineering (WSE). We proudly feature student presenters from additional OSU departments like Botany and Plant Pathology and Applied Economics. WFGRS prioritizes support and inclusivity for all natural resource students.

While WFGRS is a graduate student-organized event, it would not be possible without generous support from the College of Forestry and the Graduate School. The organizing committee would like to thank Anthony Davis (Interim Dean of the College of Forestry), Katy Kavanaugh (Associate Dean for Research), the college's marketing and communications team, and the FERM, FES and WSE department administrators and program leads. Additionally, this year's symposium would not be possible without the help of Michael Collins, Jessica Fitzmorris, and Irene Schoppy. Their cooperation was invaluable in smoothly transitioning WFGRS online to the Stay at Home Lecture Series. We would also like to thank the many students, staff, faculty and research associates who volunteered their time to make this event possible.

**We welcome you to the symposium and invite you to share in the success of the students' research efforts, as well as this year's theme: Growing Together.**



Oregon State University  
College of Forestry



Oregon State University **OSU** Graduate School

# Western Forestry Graduate Research Symposium

## SCHEDULE OF TALKS

April 30<sup>th</sup> – May 6<sup>th</sup>, 2020 | Oregon State University

Zoom access: <https://www.forestry.oregonstate.edu/stay-home-lecture-series>

<b>Thursday, April 30<sup>th</sup></b>		
	<b>Speaker</b>	<b>Presentation Title</b>
3:00	Anthony Davis, Interim Dean	Opening Remarks
3:15	Chantal Tumpach	Supply Chain Approach to Understanding the Cost and Benefits of Sustainable Forest Certification
3:23	Anna Rose Peterson	Ties to the Land – Creating a Legacy with Succession Planning
3:31	Erin Baumgart	Can Oregon White Oak ( <i>Quercus garryana</i> ) Seedling Survival be Increased by Manipulating the Root:Shoot Ratio?
3:39	Lilah Gonen	Describing a Pacific Northwest Center of Origin of <i>Phytophthora pluvialis</i> , the Cause of Red Needle Cast in New Zealand
3:47	Matthew Barker	Automatic Methods for Quantifying Coarse Woody Debris from Unmanned Aircraft Systems Imagery
3:55	Katie Nicolato	Aerial Lidar Quantifies Snag Retention Treatments in Postfire Woodpecker Habitat
4:03	Graham Frank	The Birds and the Bees... and Plants: Cross-taxon Congruence in Early Successional Forests of the Klamath-Siskiyou
<b>Friday, May 1<sup>st</sup></b>		
3:00	Moderator	Welcome
3:03	Lucie Law	Riparian Restoration: Planted Tree and Shrub Survival and Growth
3:11	Katie Wampler	Investigating the Effects of Wildfire on Downstream Source Water Quality Using the Soil & Water Assessment Tool (SWAT) Model
3:19	Austin Wissler	Comparing Headwater Stream Thermal Sensitivity Across Two Contrasting Lithologies in Northern California, USA
3:27	Karla Jarecke	Water Stress Signals in Douglas-fir: Disentangling the Effect of Atmospheric Demand and Soil Moisture Deficit
3:35	Mandira Pokharel	Timber Faller Safety on Integrated Mechanized Operations in Steep Terrain
3:43	Sudeera Wickramarathna	Automated Detection of Individual Juniper Tree Centroids and Forest Cover Changes Using Google Earth Engine
3:51	Skye M. Greenler	Too Hot, too Cold, or Just Right: Can Managing Wildfire for Resource Benefits Restore Historical Fire Conditions?
4:06	Jenessa Stemke	Spatio-Temporal Variation of Burn Severity in the Chetco Bar Fire

<b>Tuesday, May 5<sup>th</sup></b>		
3:00	Moderator	Welcome
3:03	Madelene Elfstrom	Drought Resistance and Resiliency in Uneven-aged Management in Western Oregon
3:11	Keiki Howe	Tree Mortality in the McDonald-Dunn Research Forest: Which Characteristics are Associated With the Differential Mortality of Douglas-fir?
3:19	Sylvan Pritchett	Wildfire and Defensible Space: The Role of Arborists in Wildfire Risk Mitigation in Communities of the Pacific Northwest
3:27	Rebecca Weber	Assessing Vegetation Recovery and Reburn Severity in the Klamath Siskiyou Ecoregion
3:35	Emilee Mowlds	Effects of Contemporary Forest Harvest as Disturbance Events on Stream Food Webs
3:43	Bryan Erik Begay	Assessment of Forest Management Activities Using Photogrammetric Point Clouds
3:58	Duckha Jeon	Real-time Decision Making on Helicopter Dispatch During Multiple Forest Fires
4:13	Jun Zhai	The economic consequence of a log export tax in Oregon
<b>Wednesday, May 6<sup>th</sup></b>		
3:00	Moderator	Welcome
3:03	Sujit Bhandari	Use of Low-Grade Cross Laminated Timber in Low-Rise Buildings
3:11	Martin Uranga	Evaluation of Alternative Algorithms for Generating Douglas-fir Tree Lists at Young Plantation Ages
3:19	Amanda Brackett	Managing the Microclimate
3:27	Austin Finster	Soil, Productivity, and Operator Comparisons of Tethered Felling Systems Versus Hand Falling on the Olympic Experimental State Forest
3:35	Patricio Alzugaray	Comparing Performance of Douglas-fir and Western Hemlock Seedlings Produced in Ellepot® and Styrobloc Containers
3:50	Sonia R. Bruck	Influence of Health and Market Access on Agroforestry Adoption Choices: Evidence from Rural Tanzania
4:05	David Rossi	Economic Significance of Oregon Timber Exports: A Partial Equilibrium Analysis

## ABSTRACTS

April 30<sup>th</sup> – May 6<sup>th</sup>, 2020 | Oregon State University

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### 1. Comparing performance of Douglas-fir and western hemlock seedlings produced in Ellepot® and Styrobloc containers

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In the PNW, styrofoam containers (Styroblocs) are the main greenhouse growing system for containerized conifer seedlings. Different shapes and sizes have been developed to meet the needs of varying reforestation projects. The horticultural industry has recently developed the Ellepot® container system, a plantable container for growing seedlings, which minimizes planting shock and is claimed to facilitate early root development. Ellepots may offer both biological and operational advantages to nursery growers and foresters, when compared to traditional plastic or styrobloc containers as these require seedlings to be removed from containers before transporting to outplanting sites. To test the effectiveness of the Ellepot container system relative to an equivalent size Styrobloc, on the quality of Douglas-fir (DF) and western hemlock (WH) seedlings, five different seed sources for DF and one WH seed source were grown at OSU's College of Forestry Research greenhouse at Oak Creek between March and November 2019. Resulting seedling morphology, root and stem hydraulic conductivity and vulnerability to cavitation curves were compared for 6 months old DF seedlings from the five seed sources grown in Ellepots and Styroblocs. Also, DF seedlings from the 5 seed sources and the two containers were planted in experimental trails on 5 sites across Oregon last fall: Lincoln City, Philomath, Brownsville, Sutherlin and Bandon. WH was planted only on the two coastal sites and Philomath. A winter planting treatment planted between January and February 2020 with the matching seed source for each site was also included. Morphological and physiological measurements of the seedling production phase at the greenhouse and initial root development from sampled fall planted seedlings will be presented.

### 2. Automatic Methods for Quantifying Coarse Woody Debris from Unmanned Aircraft Systems Imagery

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Stage 0 restoration projects seek to restore natural processes in riparian environments. Large downed wood is central to this approach and provides habitat for fish and wildlife in alluvial stream ecosystems. Specifically, coarse woody debris (CWD – woody material at least 0.5 m in length and 8 cm diameter at largest end) distribution and retention are of primary concern in these restoration efforts. Unmanned aircraft systems (UAS) provide a cost-effective and efficient alternative to field-based methods for measuring CWD. We seek to develop remote sensing methods to monitor and quantify CWD in stage 0 restoration projects, produce wood distribution maps, and analyze CWD retention through time. Manually delineating CWD from centimetric-resolution UAS imagery is time-consuming, therefore, we have created methods to semi-automatically classify CWD that integrate geographic object-based image analysis and random forest classification. Methods produced in this study will likely be applicable to other stage 0 monitoring efforts throughout the western Cascades of Oregon.

### 3. Can Oregon white oak (*Quercus garryana*) seedling survival be increased by manipulating the root:shoot ratio?

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Garry oak or Oregon white oak (*Quercus garryana* Dougl. Ex Hook.) is an ecologically and culturally important tree in the Pacific Northwest. Garry oak has been adversely affected by land-cover change, increased fragmentation of its environments, and fire suppression that has increased encroachment of conifer species in previous oak savannah habitat (Devine 2007, Thysell 2001, Marsico 2009). Natural regeneration is difficult due to a lack of seed source and the species physiological characteristics. Because of this, artificial regeneration has become an essential task in helping to sustain current and past populations. However, seedlings are difficult to get established. Post-outplanting water stress is one of the most important factors in seedling mortality (Chirino 2011). The root:shoot ratio (R:S) is often used as a simple characteristic to evaluate a seedling's ability to cope with water stress (Sheridan 2019). This ratio indicates the balance needed for a seedling to uptake soil moisture while also managing the process of transpiration of the leaves. There are several ways to manipulate the morphology of a seedling in order to support a desirable root:shoot ratio. The goal of my research is to improve Garry oak regeneration in Washington State. The objective of this study is to evaluate the effect(s) of varying container sizes in combination with pruning treatments on Oregon white oak seedlings. A secondary objective is to understand how timing and effort in nursery culture translates to field establishment. This experimental approach study consists of two separate but related greenhouse and field experiments. The first greenhouse experiment will quantify the effect of root pruning and container size on the R:S. The second field experiment will determine the effect of the R:S ratio on growth, water stress and field survival. I hypothesize that root pruning increases seedling survival because oak mortality results primarily from drought and root pruning creates a R:S ratio that reduces seedling water stress. I will test for statistically significant differences between the treatment and control groups using ANOVA.

<sup>1</sup>Chirino, E., A. Vilagrosa, and V. Vallejo. 2011. Using hydrogel and clay to improve the water status of seedlings for dryland restoration. *Plant and Soil* 344: 99-110. <sup>2</sup>Devine, W. D., C.A. Harrington, and L.P. Leonard. 2007. Post-Planting Treatments Increase Growth of Oregon White Oak (*Quercus garryana* Dougl. Ex Hook.) Seedlings. *Restoration Ecology* 15, 2: 212-222. <sup>3</sup>Marsico, T., J. Hellmann, and J. Romero-Severson. 2009. Patterns of seed dispersal and pollen flow in *Quercus garryana* (Gagaceae) following post-glacial climatic changes. *Journal of Biogeography* 36: 929-941. <sup>4</sup>Sheridan, R.A.. 2019. Influence of Limited Water Access on Douglas-fir Seedling Root Systems, Physiology and Growth. Dissertation. University of Oregon, Corvallis, Oregon, USA. <sup>5</sup>Thysell, David R., and A. B. Carey. 2001. *Quercus garryana* Communities in the Puget Trough, Washington. *Northwest Science* 75, 3: 219-235.

### 4. Assessment of forest management activities using photogrammetric point clouds

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Maintaining the social license for forestry in locations with active management is necessary for public acceptance of the forest operations. The appearance of timber harvests in highly visible locations reduces forest aesthetics and antagonizes the public, which in many instances acts as a stakeholder. The objective of this study is to maximize forest aesthetics in highly visible locations by integrating point clouds derived from UAS platforms. A Mavic 2 Pro drone captured high resolution imagery over two stands in the McDonald-Dunn Research Forest, Oregon. Point clouds generated by Structure from Motion photogrammetry algorithms were used as the canvas for modelling simulated harvests. Point clouds were overlaid on digital elevation models and cropped to simulate the visual impacts of 30 different harvest scenarios. Total visible area, local cloud metrics, volume of timber harvested, and stand metrics were calculated for each scenario. A principle component analysis and canonical discriminant analysis was performed on the variables in each scenario to determine which variables explained potential visibility impacts. We found significant difference between the clear-cut scenario and some scenarios that ensures invisibility of the forest operations from major roads. However, we found limited differences between the scenarios leaving limited trees and the one that obstruct entirely the view of an observer. The visualization techniques used in this analysis offers a workflow to assess the potential impacts from forest operations in highly visible locations, without sacrificing significantly the revenue stream. Approaching the issue of visualization in forestry that integrates UAS systems and 3-D point clouds offers foresters a method to operate in visibly sensitive areas and maintain their social license to practice forestry.

## 5. Use of Low-Grade Cross Laminated Timber in Low-Rise Buildings

Sujit Bhandari<sup>1\*</sup>, Sina Jahedi<sup>1</sup>, Zhixin Luo<sup>2</sup>, Mariapaola Riggio<sup>1</sup>, Lech Muszynski<sup>1</sup>

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Restoration programs aimed at reducing fire risks in the Western US produce a large volume of small-diameter Ponderosa pine (PP) lumber with a high proportion of wane, knots, and juvenile wood. The high cost of the operation may be offset if a substantial volume of the material is used in Cross-Laminated Timber (CLT). CLT is often promoted for use in mid- and high-rise buildings; IBC 2021 will allow for the prescriptive design of up to 18-story CLT structures. These, however, are unlikely applications of low-grade CLT fabricated with PP lumber. Our hypothesis is that PP CLT can be used in affordable low-rise housing. Ongoing research at Oregon State University is focused on utilizing these low-value PP lumbers in CLT. The aim of this part of the research is to demonstrate the utilization of PP CLT panels obtained from restoration forests in low-rise, modular construction. Modular walls and floor elements are studied parametrically and in various use cases to match the design values of Ponderosa pine CLT. The results from analytical models will be presented in the form of graphs, illustrations and drawings. These results will be used to design, build and test a demonstration unit.

## 6. Managing the Microclimate

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There is a critical scale mismatch between global and regional climate datasets and predictions and the actual climate experienced by biota in forests. To overcome this disconnect I will use and expand a microclimate prediction model created using long term below-canopy air temperature data and vegetation structure data from the H.J. Andrews from Wolf et al. (2020). I have an overarching question of: How does stand structure modify below-canopy air temperature when compared to regional open-air temperatures? The goal of this research is to provide managers with the tools necessary to prevent or minimize the effect of harsh or unfavorable predicted future climate regimes on temperature-sensitive ecological processes, such as regeneration. My hypothesis is that below-canopy temperature responds differently to increases in free-air temperature depending on stand structure. To test this, I will first identify which vegetation and stand structure conditions are not covered by the existing model. I will then collect temperature data and use LiDAR data to assess and validate model performance in these conditions. Once the model performance is validated for a wider variety of stand structures I will explore below-canopy air temperature across stand structures, seasons, and climate change scenarios and the ecological relevance of those relationships. I expect that the model will perform well in the expanded stand types. I also predict a moderating effect of canopy closure on open-air temperature increases in all stands, but the degree of moderation will vary with canopy closure and stand structure. For increases in open-air temperature, I anticipate that closed canopy stands will experience the lowest increase in below-canopy temperature with increasing open-air temperature.

## 7. Influence of Health and Market Access on Agroforestry Adoption Choices: Evidence from Rural Tanzania

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Subsistence farmers in sub-Saharan Africa are subject to climatic and environmental risk, and a higher chance of facing food insecurity. Agroforestry systems are known to manage these risks. To understand household decisions when subject to risk, we explore how each of the following influences agroforestry adoption: household health and access to health clinics, credit and banking access, long-term illness and injury, and agricultural extension agent interactions and discussing agroforestry systems at community groups. A survey of farming practices and household

characteristics was collected from a random sample of 435 households in Tabora, Tanzania. Using multinomial and nested logit models, we explore adoption of multiple agroforestry systems, as well as partial adoption of agroforestry packages. Agroforestry adoption choices are numerous in this region and include: planted woodlots, *Gliricidia sepium* (Gliricidia or common name Forest Lilac), intercropping of cassava (*Manihot esculenta*) and pigeonpea (*Cajanus cajan*), and the combination of all of these systems, as well as non-adoption (monocropping). Households with access to credit for farming have a relative odds 7.1 times greater of choosing full adoption of intercropping systems and 4.3 times greater of choosing partial adoption rather than non-adoption. Households with bank access have a relative odds of choosing Gliricidia 5.4 times greater than non-adoption. Interestingly, households who have access to a health clinic have a relative odds of choosing to adopt the partial intercropping package 3.5 times greater than non-adoption. Additionally, we find that those households who have less education and more extension interactions have a higher relative odds of choosing to plant Gliricidia and woodlot systems. This may be because extension agents target households who need more help, or those with less formal education seek more extension agent assistance. Finally, we explore a nested logit model where we combine both cropping and treed systems. We find similar results, where both crop and tree choices are driven by credit and bank access, as well as extension interactions. However, unlike the multinomial model, we do not find that decisions are significantly influenced by health factors.

## **8. Drought Resistance and Resiliency in Uneven-Aged Management in Western Oregon**

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Recent climate projections predict more frequent and severe drought conditions in Western Oregon which is a threat to forest health, productivity and structure. Land managers are increasingly concerned with how to create forest drought resistance and resilience. Resistance is a tree or stand's ability to maintain its growth rates during a drought. Resilience is defined as a tree or stand's ability to return to pre-drought growth rates after the end of a drought. While thinning has been found in several studies to increase drought resistance and resilience, we currently lack studies that look at this benefit in comparison with other forest values such as timber production and wildlife habitat development. Uneven-aged management is a method of managing forests simultaneously for timber and late successional structure suitable for wildlife habitat. Three different thinning and planting treatments plus one control unit were implemented in 2000 on the H.J. Andrew's Experimental Forest's Uneven-aged Management Project (UAMP) to study the process of turning a Douglas-fir plantation into a forest that produces both these values. I am using this experimental site for a dendrochronological study to investigate drought resistance and resilience during and following the 2001 and 2015-2016 droughts. My hypothesis is that due to a reduction in competition for water, the thinning treatments will increase drought resistance and resilience as compared to the control, while heavy thinning may reduce timber yields. I predict that the treatment with the heaviest thin will show superior drought tolerance to the other treatments. After calculating drought resistance and resilience, I will analyze tradeoffs between drought response variables and volumetric growth. By using established tradeoff tools, we can find which treatment is best for drought resistance and resilience and better understand what the tradeoffs between promoting drought adaptation and volume growth are.

## **9. Soil, Productivity, and Operator Comparisons of Tethered Felling Systems Versus Hand Felling on the Olympic Experimental State Forest**

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Timber harvest begins with the felling of trees. Although machines have been developed for this work, sometimes the machines are cost prohibitive or do not suit the terrain to be harvested. Motor-manual hand falling with the use of chainsaws is still widely used in steep slope logging due to steep slope constraints to machinery. Tethered felling machines extend the slope operability of traditional ground based felling equipment. The felling machines in this study are often referred to as feller-bunchers, which are tethered by winch and cable systems secured to a stationary base machine. These pieces of specialized harvesting equipment have evolved over the past five decades to be increasingly safe, productive, and ergonomic machines they are today. Advancements in chassis, drivetrain, operator



cabins, booms, and cutting heads have evolved, yet machine operators and manufacturers desire further advancements. Remaining, is how to overcome slope operability limitations with mechanized felling systems. There is interest in introducing mechanized felling systems to steeper terrain due to their operational efficiency in completing the continuous task of cutting and strategically placing trees. Traditional motor-manual felling methods result in felled trees dispersed across the harvest unit. Tethered felling machines can cut trees in areas advantageous to following yarding operations. This decreases the time needed to attach rigging cables onto logs due to being more accessible than if hand felled. Tethered logging systems have not been evaluated across differing landscapes. This research will provide information needed to develop system tests and operational guidelines for tethered systems. Impacts on soil, productivity, operational cost, and workers will be quantified and evaluated to promote sustainable forest management practices.

## 10. The Birds and the Bees... and Plants: Cross-taxon Congruence in Early Successional Forests of the Klamath-Siskiyou

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Early successional forests resulting from stand-replacing disturbances can contain high levels of biodiversity, habitat specialists, and conservation-listed species, and are increasingly prioritized in management plans in the Pacific Northwest. However, biodiversity responses may differ among disturbance agents (e.g., fire vs. forest harvesting) and along a gradient of time since disturbance. Although natural and anthropogenic disturbances can create biologically diverse early successional habitat, direct comparisons are lacking for Pacific Northwest forests. Furthermore, species responses may vary among taxonomic groups due to contrasting habitat requirements; understanding this variation is critical to inform coarse filter approaches to conservation planning. We analyzed the degree of similarity in species richness and community composition of bee, bird, and vascular plant communities from the first year of data from a landscape-scale study examining patterns of biodiversity in early successional forests of the Klamath-Siskiyou. Correlations in species richness between pairs of taxa were variable and generally weak, underscoring the importance of a multi-taxon approach to understanding patterns of species richness in early successional forests. However, correlations of community similarity were consistently positive among taxa, indicating that sites with similar plant communities also tended to have similar bird and bee communities. These correlations were stronger in early successional forests following high severity fire than those developing after clearcut harvesting. Following either disturbance agent, stands of similar ages tended to have more similar community composition than those of disparate ages. These initial results suggest a need to better understand specific characteristics underpinning spatial and temporal variability in early successional forests, both within and across taxonomic groups.

## 11. Source-sink population dynamics and a Pacific Northwest center of origin of *Phytophthora pluvialis*, the cause of red needle cast in New Zealand

Lilah Gonen<sup>1\*</sup>, Javier F. Tabima<sup>1</sup>, Mireia Gomez-Gallego<sup>2</sup>, Simren Brar, Rebecca McDougal, Nari Williams, Niklaus J. Grünwald, Jared M. LeBoldus<sup>3</sup>

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**Background/Question/Methods** Identifying centers of origin of microbes that cause plant disease provides insights into latent genetic diversity, co-evolved hosts, and pathogen reservoirs. Here we investigate the population dynamics of *Phytophthora pluvialis*, an oomycete first isolated from soil, streams, and tree foliage in mixed Douglas-fir (*Pseudotsuga menziesii*) - tanoak (*Notholithocarpus densiflorus*) forests in the US Pacific Northwest (PNW) in 2011. It was then identified as the causal agent of red needle cast (RNC) of radiata pine (*Pinus radiata*) in New Zealand (NZ) in 2014. Given its low degree of pathogenicity in PNW trees, we hypothesize that the center of origin of *P. pluvialis* is in the PNW. We used genotyping-by-sequencing (GBS) to obtain 1,543 single nucleotide

polymorphisms (SNPs) across 158 *P. pluvialis* isolates collected in the PNW and NZ. Our objective was to test the hypothesis that the center of origin of *P. pluvialis* and the source of the introduction that led to the RNC epidemic in NZ was in the PNW of the USA. **Results/Conclusions** We identified the PNW Coast Range as the center of origin of *P. pluvialis*. After grouping our samples into five genetic clusters, we found the Coastal cluster spanned the widest geographic range of all identified clusters and was the central cluster in a minimum spanning network. Rooted phylogenies showed Coastal samples located at the root of every PNW clade. These clades all emerged earlier than the NZ clades. Coastal had the highest degree of heterozygosity ( $H_s = 0.254$ ) and median pairwise genetic distance (0.093) of any cluster. These results support the hypothesis that the Coastal cluster is the center of origin of *P. pluvialis*. Additionally, comparison of three different migration scenarios produced a unidirectional PNW to NZ model as the best fit for our data. This, combined with relatively low genetic distance, low population heterozygosity, and lack of geographic structure of the NZ genetic clusters, suggests a single colonization event followed by clonal expansion of *P. pluvialis* from the PNW to NZ. Future studies should increase sampling depth across the PNW to better understand *P. pluvialis*' population dynamics within its proposed center of origin, which may overlap with the native range of radiata pine in northern California.

## 12. Too hot, too cold, or just right: Can managing wildfire for resource benefits restore historical fire conditions?

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There is increasing consensus that managing wildfires for resource benefits will help reduce long-term risk and restore ecosystem function in dry forests of the American West. Many contemporary fires burn with mixed severity effects and may not achieve desired restoration outcomes where severity is too high or too low. Severity thresholds describing when and where fire effects achieve desired outcomes have not been clearly identified. We quantified fire severity windows most likely to restore stands to historical basal area, density, and composition. First, we developed probabilistic tree mortality models for 24 species based on fire severity (RdNBR) and tree characteristics from burned FIA plots. We then applied these models to current, unburned stands in four National Forests in eastern Oregon across the observed distribution of RdNBR values to predict post-fire stand conditions and compared these results to historical reconstructions. Generally, basal area and tree density targets could be achieved with low or moderate severity fires in both dry mixed-conifer and ponderosa pine stands. Much higher fire severities were required to achieve compositional targets, demonstrating that historical conditions created by chronic fire cannot be easily restored by single fires and restoration targets based on density and composition may require inherent tradeoffs.

## 13. Tree Mortality in the McDonald-Dunn Research Forest: Which characteristics are associated with the differential mortality of Douglas-fir and grand fir

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Drought is a global phenomenon that has led to the widespread increase in tree mortality in recent years. These conditions are likely due to climate change (i.e. rising temperatures and greenhouse gas emissions). However, insects and disease can also serve as secondary agents for tree mortality. Global air temperatures are expected to continue rising every year, limiting moisture availability for trees. In the Pacific Northwest, tree mortality rates have almost doubled in the last 17 years (Hines 2009). Tree mortality is a topic that is underrepresented and needs to be further investigated. The main objectives of the study are to 1) compare tree mortality rates post-drought in Douglas-fir (*Pseudotsuga menziesii*) and grand fir (*Abies grandis*) and 2) identify key characteristics associated with tree mortality in the McDonald-Dunn Forest and the Interior Willamette Valley forest type. An exploratory approach will be taken in efforts to observe and identify the main culprit for tree mortality in the McDonald-Dunn Forest. The main question being addressed in this study is what characteristics (insects, disease, or drought) are associated with the different mortality rates in Douglas-fir and grand fir. I hypothesize that when drought occurs mortality is greater in grand fir than Douglas-fir. Data will be collected and analyzed in the field, a dendrochronological lab, and in statistical

programming (R studio). In the field, variable radius plots (1/50th acre) will be measured for 5-8 trees per plot in low slopes, middle slopes, and high slopes. Soil moisture will be measured in each plot using a soil auger and soil type will be determined based on texturing. While measuring the plots, an increment borer will also be used to collect dendrochronological samples from 2-3 trees in each site. The scope of inference in this study is that the sites chosen in the McDonald-Dunn Forest are limited to Douglas-fir and grand fir in transitional zones rather than measuring sites dominated by Douglas-fir and grand fir in the Oregon Coast Range.

#### **14. Water Stress Signals in Douglas-Fir: Disentangling the Effect of Atmospheric Demand and Soil Moisture Deficit**

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Management plans designed to create climate resilient forests need to correctly account for the drivers of drought stress in trees. My research will investigate how interannual variability in atmospheric water demand and soil moisture deficit influence late-summer water stress in Douglas-fir trees in the western Oregon Cascades. This research will contribute to developing forest management strategies to reduce water stress in forests of the Pacific Northwest. My preliminary findings suggest that increased atmospheric water demand suppresses latewood growth in Douglas-fir as measured by the latewood ring width index. Further, atmospheric water demand, precipitation, and soil moisture all appear to have strong controls on tree growth. However, growth-climate relationships do not fully represent the physiological response of trees to drought. Thus, to assess the relative influence of these factors on tree water stress, I will use stable carbon isotopes from tree rings, which can be used to infer the degree of stomatal closure during the growing season. I will relate carbon isotope signatures ( $\delta^{13}\text{C}$ ) to moving windows of atmospheric water demand and soil water supply over the last 30 years. I hypothesize that atmospheric water demand in the summer dry season will have a stronger relationship with  $\delta^{13}\text{C}$  compared to precipitation or soil moisture. Put another way, summers with high atmospheric water demand will lead to high  $\delta^{13}\text{C}$  in latewood regardless of the soil water conditions. Conversely, summers characterized by low atmospheric water demand will lead to low  $\delta^{13}\text{C}$  in latewood. Disentangling the role of atmospheric demand and soil moisture deficit on tree growth and tree physiology are critical to understand the underlying causes of and potential solutions to tree water stress.

#### **15. Real-time decision making on helicopter dispatch during multiple forest fires**

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In South Korea, over 500 forest fires occurred every year. More than 60 percent of forest fires were multiple fires burning simultaneously in more than two different locations across the country. These multiple fires make it difficult to make effective helicopter dispatch decisions for initial attack as they compete for limited resources. This study aims to develop a mathematical optimization framework that combines fire spread simulation, fire suppression efficacy modeling and mixed-integer linear optimization techniques for real-time decision support for fire suppression resource allocation when multiple fires occur. The decision framework integrates 1) real-time weather and fire data, 2) real-time fire spread modeling, 3) suppression resource efficacy, 4) currently available resources, 5) site-specific priorities and 6) resource dispatch rules and constraints. Data generated from each of these individual components have been tested and modified for compatibility, and then used to provide inputs for the spatially-explicit optimization model. A mixed-integer linear programming technique (MILP) is used as the optimization engine. We applied the optimization model to selected past fires in South Korea to demonstrate its utility and compare the model solutions with the manual decisions actually implemented. Although the comparisons were limited due to lack of detailed information on the extent of fire spread, our scenario analysis showed that the optimization model was able to reduce fire damage with fewer helicopters. In addition, our sensitivity analysis confirms that fast response for initial attack is the key to minimize fire damage. The optimization framework developed and demonstrated in this study can be incorporated into a decision support system that can improve resource allocation decision-making for effective suppression of multiple forest fires.

## 16. Riparian Restoration: Planted Tree and Shrub Growth

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Riparian areas are prioritized for restoration activities because of the important ecological functions riparian areas provide. Riparian restoration is a billion-dollar endeavor, yet little long-term monitoring data are collected to understand the growth and survival of the planted trees and shrubs after initial project establishment. This project provides the unique opportunity to analyze the growth and survival of over 5,200 individually tagged plants and to learn what main factors are associated with survival and growth as these stands mature. This study will analyze data from 12 riparian area restoration projects that were established beginning in 2002 by the Coos Watershed Association. This study relies on data collected from 2002 until contemporary measurements end in summer 2020. Data collected included: diameter at breast height (DBH in inches), tree height (ft.), live crown base height (ft.), and levels of competition. My research question is: What affects planted tree and shrub growth and survival in riparian areas? I hypothesize that 1) plant survival is increased if the planted tree or shrub develops a high live crown ratio because a more developed crown will shade competing species and limit near brush and grass competition, 2) proximity to neighboring tree and the neighboring tree species affects growth and survival patterns of different species due to competition for light resources. The statistical analysis of the dataset with over 25,000 monitoring records will be used to answer my research question and test my hypotheses. I will use the R package to perform analysis. This research will fill knowledge gaps of long-term survival and growth of specific species commonly planted in riparian restoration projects in Oregon's Coast Range. The overall goal of this study is to improve riparian restoration techniques.

## 17. Effects of Contemporary Forest Harvest as Disturbance Events on Stream Food Webs

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Between 2006 and 2016, a 10-year paired watershed study was conducted in the Trask watershed near Tillamook, Oregon to observe the effects of contemporary forest harvest practices on headwater streams. Recently, it was observed that community factors such as species omnivory, along with geophysical factors including basin size and gradient are strongly associated with variation in food web structure and connectance. Based on these findings, our work will focus on the temporal variation in food web structure and potential impacts of disturbance. Specifically, we will be looking at the temporal effects of contemporary forest harvest treatments (including full riparian buffer remaining, thinned riparian buffer and clear cut) on the structure of aquatic food webs. We will use Cheddar and Web builder tools in R. Data collection include 10 years of information (6 years before and 4 after forest harvest). These food webs will produce quantitative metrics including connectance, linkage density and characteristic path length, and can provide insight to aquatic community resiliency, recovery rates and the ability to withstand varying levels of harvest disturbance intensity. Through these analyses, we hope to inform decisions in forest management practices in relation to treatment intensity and how stream community composition may influence biotic structure and processes following a disturbance. This research is a collaborative effort between the USDA Forest Service, and the Oregon State University.

## 18. Aerial Lidar Quantifies Snag Retention Treatments in Postfire Woodpecker Habitat

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Wildfire-induced tree mortality creates snag-dominated landscapes beneficial to humans and wildlife. Postfire salvage logging can generate economic opportunities for local, often small rural communities in affected areas.

Certain woodpecker species also rely on recently burned forests for nest excavation and foraging in weakened snags. Woodpeckers indicate postfire forest health and include three Oregon species of conservation concern: the black-backed woodpecker (BBWO), Lewis's woodpecker (LEWO), and white-headed woodpecker (WHWO). We use aerial lidar to quantify forest structure before and after salvage treatments in postfire BBWO, LEWO, and WHWO habitat. The 2015 Canyon Creek fire produced 110,261 acres of burned forest in eastern Oregon's Blue Mountains and a consequent salvage harvest on the Malheur National Forest. We analyze aerial lidar datasets captured before (June 2016) and after (July 2017) snag harvest occurred in July 2016. The target areas encompass 2 sets of 3 snag retention treatments and 4 controls simulating variable BBWO, LEWO, and WHWO habitat across ~7,500 burned acres. We use the lidar package in R to process point clouds intersecting hundreds of BBWO, LEWO, and WHWO nests surveyed in the target areas before and after snag retention occurred. For each lidar dataset, we derive snag metrics quantifying stand variables known to influence woodpecker nest site selection, such as trees per acre, height and diameter class. Our methods automate clipping and normalizing lidar point clouds, deriving cloud metrics and canopy height models, and individually segmenting snags. We validate lidar-derived snag variables with field plot data and manually digitized rasters. Pre- and post-salvage treatment metrics are statistically analyzed to detect forest structure changes affecting woodpecker habitat. Future research will use lidar-derived snag metrics to describe BBWO, LEWO, and WHWO habitat preferences and model habitat suitability.

## **19. Ties to the Land – Creating a Legacy with Succession Planning**

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Over the last 20 years, small private farm, ranch, and forest lands in the US have experienced a transition in ownership and this trend is expected to continue. Many private landowners are ages 60+ and as they age and/or retire, the successful transition of their lands to the next generation of owners and managers becomes critical to retaining these ownerships on the landscape. Additionally, shifting population demographics in the US puts pressure on working lands and open space to be converted to higher and better uses, namely housing developments. In 2005, Oregon State University Forestry and Natural Resources Extension partnered with local forest landowners and professionals to address this issue. The Ties to the Land (TTTL) program was developed and has provided succession planning workshops and resources for the past fifteen years to small private forestland owners. However, revisions to the TTTL program became necessary as landowner needs and demographics evolved, and more succession planning options became available. Thus far, the main focus has been to revise the workbook and its revision has two overarching goals: 1) make the material more appealing to a wider audience of private landowners such as farmers and ranchers, and 2) recognize the diversity of landowner situations that exist and address their needs. To meet these goals for the workbook, information was collected from landowner and facilitator workshop evaluations and extension agent observations, as well as from a review of other national succession planning programs. Additionally, case studies from a variety of real landowners were included in the workbook to illustrate different working landscapes, financial situations, and succession planning tools utilized during the planning process. Currently, the TTTL workbook is in the publishing and review stage with Extension and Experiment Station Communications (EESC) with anticipated publication in early summer of 2020.

## **20. Timber Faller Safety on Integrated Mechanized Operations in Steep Terrain**

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The logging industry has experienced a decreasing trend of the total number of workplace accidents with mechanization, especially as new technology is able to provide access to mechanical harvesting in the steeper terrain. However, there are areas within harvest units such as extremely steep slopes, rocky outcrops or broken terrain that cannot be accessed by machines and are required to be felled manually. Research about the potential impact on timber faller's safety under this new scenario is limited and has been identified as a need. The broad goal of the proposed study is to assess whether timber fallers are consistently working in more difficult terrain when working in mixed mechanized operations. The three specific objectives are to a) assess the difference in terrain features

between hand-felled and mechanized harvesting, b) determine the proportion of hand-felled areas within harvesting units and find the reasons for needing handfelling in those areas and c) determine how many harvesting units have the hand fallers work before the mechanized falling starts. For the study, we have hypothesized that "timber fallers when working in mixed mechanized operations are consistently working in more difficult terrain". The terrain data will be collected from systematically located circular plots in three mixed-mechanized harvesting units around the Northern Oregon Coast Range, located about 20 miles east of the Pacific coast. These data will be analyzed using a mixed effect modeling approach due to the lack of independence for plots within the same harvest units. For the qualitative data, logging contractors will be interviewed with a set of open-ended questions, and the responses from the interview will be analyzed using "Thematic Content Analysis". The proposed research will provide initial documentation of potential safety issues for timber fallers mixed with mechanized equipment on industrial forest lands of the Northern Oregon Coast range.

## **21. Wildfire and Defensible Space: The Role of Arborists in Wildfire Risk Mitigation in Communities of the Pacific Northwest**

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Every year in North America homes in the Wildland-Urban interface (WUI) are destroyed by wildfires. The creation of defensible space around homes in the WUI, though the management of vegetation can help mitigate some of the risk posed by fire. While many homeowners recognize the need for defensible space around their homes, oftentimes work to manage vegetation goes undone. Homeowners cite a variety of reasons for this including a lack of capacity, expertise and equipment necessary to perform defensible space development (DSD) work. Green industry professionals such as arborists have the potential to help homeowners in the development of defensible space around homes in the communities they serve. This research uses an exploratory quantitative approach to determine to what extent commercial arborists in the PNW (Alaska, BC, Washington, Idaho, Oregon) are currently working to develop defensible space in their community, how they see a need or value for wildfire risk mitigation in their community, and if training or education related to DSD work would be of value to their business. The results of an online survey distributed to arborists through the PNW-ISA listserv indicate that there is a small contingency of arborists working in the PNW who regularly work to mitigate wildfire risk in their community and are interested in continuing education and training related to DSD work. There is a nearly equal population of arborists who are not currently working to create defensible space around homes, but are none-the-less interested in learning more about wildfire risk mitigation and wildfire science. Professional organizations such as the PNW-ISA have an opportunity to fill an educational need for arborists working in the PNW by providing training and education related to on wildfire risk mitigation which will support the growing need for defensible space development and help to protect homes from wildfire.

## **22. Economic significance of Oregon timber exports: a partial equilibrium analysis**

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This analysis estimates the economic impacts of public policy that seeks to restrict activity in the overseas export market for Oregon-grown softwood timber. The motivation for such a policy is commonly framed in terms of bolstering domestic wood manufacturing sectors and employment. However, there has been no empirical measurement of short-run changes in net surplus and employment from export policies in Oregon. To inform policy discussions surrounding the economic significance of Oregon's timber export market, the primary focus of this report is in estimating the economic effects from a hypothetical ban on exports of Oregon timber. To provide these estimates, we use time series data on Oregon timber harvests, exports, log prices, lumber prices, harvest tax rates, currency exchange rates, and measures of housing market activity from 2003-2018 to first construct and estimate a system of supply and demand equations. Estimation of these equations provide measures of log price elasticities in both the domestic market and the export market. We find that, on average, a 1% increase in log price will decrease domestic manufacturing demand by 0.56% while domestic supply will increase by 0.49%. We also estimate that a

1% increase in log price will increase export supply by 1.6%, on average. We subsequently utilize these elasticities to parameterize a partial equilibrium model of Oregon's timber market. Our results suggest that between 2007–2017, the annual average net effect of an export ban would have been a loss in net surplus of \$14.1 million per year. The total value of the export premium would have also been lost which, on average, totaled to \$80.7 million per year. Using previously reported measures of employment impacts per unit volume of Oregon timber output, we estimate that an export ban would have resulted in an annual average loss of 340 jobs per year relative to the observed annual jobs numbers. These jobs would have been lost in the forestry support sector, land management sector, and the transportation sector. Additionally, we estimate that, on average, there would have been 101 fewer jobs per year in the export sector as a result of an export ban. However, these job losses would have been shared by both Oregon and Washington given the large share of log exports from the region that are shipped from Longview, WA.

### **23. Spatio-Temporal Variability of Burn Severity in the Chetco Bar Wildfire**

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Climate change and changing land use practices in wildlands are contributing to increased fire frequency, size, and severity. From the early 1900s to early 2000s, fire management strategies in the Pacific Northwest focused on extinguishing fires as rapidly as possible. This enabled leaf litter accumulation and growth of dense vegetation stands, both which provide ample fuel for intense fires. This report focuses on the spatio-temporal variation of burn severity in the 2017 Chetco Bar Wildfire in Southwestern Coastal Oregon. The objective of this study is to determine if there are microclimates less susceptible to wildfires due to terrain influences, and if so, define their associated properties. Slope aspect affects solar radiation, which influences soil moisture, vegetation moisture, vegetation type, vegetation density, and temperature. These factors combined may affect fire hazard potential. I hypothesize a) burn severity is most intense where pre-fire vegetation was thick, as well as in regions where vegetation moisture content was lower preceding the fire; and b) bases of north-facing slopes have less wildfire damage due to higher soil moisture content. I tested these hypotheses using the NDVI index pre- and post-fire in June 2017 vs. June 2018, and the vegetation moisture index pre-fire compared with the NBR post-fire. I overlaid these outputs on a terrain model to observe how terrain may influence vegetation type, soil moisture, and fire intensity. Results from the study indicate that extreme weather patterns override spatial variation in site conditions and result in higher burn severity, but that under more moderate weather conditions, spatial variation has a noticeable effect on burn severity. Wildfires are becoming more frequent and severe, and “protected” (in relative terms) microclimates would be useful in siting housing or other structures in fire country. Data on fire behavior helps improve fire management, mitigation, and evacuation planning.

### **24. Supply Chain Approach to Understanding the Cost and Benefits of Sustainable Forest Certification**

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Forest certification programs like the Forest Stewardship Council (FSC) and the Programme for the Endorsement of Forest Certification (PEFC) were developed as solutions to deforestation, illegal logging, and other destructive forest practices occurring in the tropical forests of the global south. Forest certification was initially promoted as a market-based solution to encourage sustainable forest management. However, a review of forest certification literature indicates that it has not created expected market incentives. Forest landowners and manufacturers report receiving little to no price premiums for producing certified products and consumers are generally unaware of the existence of forest certification and unwilling to pay more for it. The two major forest certification schemes, FSC and PEFC, recently reported that 87% of certified forestland is in the temperate forests of Europe and North America. Uptake is very low in tropical forests and parts of the world where forest certification was designed to help. These factors indicate that forest certification is not working as intended. No work to date has attempted to understand this dilemma by asking the central question of how certification acts on the forest products supply chain. As a result, it is still unclear who pays for and who benefits from forest certification. Using economic and public policy frameworks

to analyze the forest products supply chain under forest certification, I hypothesize that consumers are not directly driving the demand for certified forest products, and that the outsized buying power of big retailers causes an unequal distribution of forest certification cost-sharing. Consequently, forest landowners and forest products manufacturers pay the price for forestland and chain-of-custody certification while receiving little of the benefit. Understanding this perspective of forest certification will contribute to better policy design for the promotion of sustainable forest management and a sustainable forest products sector.

## 25. Evaluation of Alternative Algorithms for Generating Douglas-fir Tree Lists at Young Plantation Ages

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**Background and Relevance** Many forest properties of Douglas-fir in the PNW contain bare land or very young plantations (0-2-yr-old) resulting from recent clear-cut harvesting. Projection of future inventories, scheduling of future harvests, estimation of sustainable annual cut, and valuation of timberland must include these recently harvested units in growth model projections. Recently planted stands are quite homogeneous and because typical growth models are purely deterministic, they may predict unrealistic homogeneous stand structures at older reference ages (i.e. 20 years old). **Objectives** The objectives of the proposed research are: 1) Quantify the distribution of seedling heights in 0-, 1-, and 2-yr-old plantations using various approaches for simulating size distributions. 2) Analyze the capabilities of CIPS growth models to generate realistic stand structures starting from the seedling distributions generated in 1. 2) Generate a comprehensive methodology of how to incorporate tree size or/and growth variability on initial tree size distributions that helps current growth models to better represent future stand structure conditions. **Methods** For objective one, moment recovery technique will be used to estimate the most appropriate initial tree size distributions. Those smoothed distributions, the empirical distributions and some scenarios when different degrees of stochastic tree size variation are imposed to the smoothed one are also going to be assessed at future reference ages. Finally, a routine to incorporate serial correlated stochastic noise in the successive growth cycles will be assessed. **Scope of Inference and Research Products** The scope of inference will be the young Douglas-fir plantations of the Pacific Northwest Region. The final product of this research will be two manuscripts, one documenting the young plantation tree size distributions and another documenting the relative performance of different approaches to achieve the measured level of the tree size distribution at 20-25 years old. Finally, an algorithm compatible with current CIPS models will be developed for members use.

## 26. Investigating the Effects of Wildfire on Downstream Source Water Quality Using the Soil & Water Assessment Tool (SWAT) Model

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Almost 75 percent of the water supply in the Northwest region of the United States originates in forested land. These forested regions are vulnerable to the increasing incidence of large wildfires due to increases in regional temperatures and greater accumulation of fuels. When wildfires occur, water source quality in burned catchments can be affected, including increased sediment, organic carbon, nitrogen, and phosphorous. Increases in all of these water quality constituents can negatively affect aquatic ecosystem health and create many costly challenges to the drinking water treatment process. While past research has shown the likelihood of source water impacts from wildfire, we are still working to understand the magnitude and longevity of effects. To improve our understanding of the likely range of effects, we will model two important forested source watersheds in the Cascade Range of Oregon, which have experienced recent wildfires. We will develop several scenarios to investigate the effects of wildfire size and severity, along with watershed characteristics and climate change on key water quality parameters (sediment, OC, N, P). Previously collected hydrologic and water quality data will be used to calibrate and validate the model. This work will improve understanding of the vulnerability of source water catchments to wildfire-drinking water impacts, which can help inform forest and drinking water management decision making.



## 27. Assessing vegetation recovery and reburn severity in the Klamath Siskiyou Ecoregion

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The proposed research will use remotely-sensed data to investigate the relationship between vegetation recovery and reburn severity on National Forest lands across the Klamath Siskiyou Ecoregion spanning a time frame from 1984-2018. The first objective of this research is to use multivariate analysis both to discern important predictor variables for reburn severity on unmanaged sites from a matrix that includes daily fire weather, initial vegetation type, distance to the nearest unburned patch, interval between fire events, topography, and the trajectory of vegetation growth, and to determine those variables' corresponding predictive power for reburn severity. Based on past research, it is expected that the trajectory of vegetation growth (a measure of vegetation recovery) will be a significant predictor of reburn severity, though extreme fire weather will mask that relationship. The second objective is to assess whether there is a significant difference in reburn severity on sites that were salvage logged after the Silver Fire (1987) and subsequently burned in the Biscuit (2002) and Klondike (2018) Fires versus reburn severity on unmanaged sites that also experienced the triple reburn. Previous studies indicate that sites that experienced high severity fire during the Silver Fire and were then salvage logged, later reburned with high severity during the Biscuit Fire due to a vigorous shrub growth response. It will be interesting to note whether this pattern of vegetation recovery continued to affect fire severity during the Klondike Fire. Altogether, the results of this research will expand upon previous work concerning the drivers of reburn severity by including novel combinations of remotely sensed data for all reburned areas within the Klamath Siskiyou Ecoregion. Furthermore, the inclusion of reburn severity data from an additional fire will offer a long-term perspective on the impacts of salvage logging on vegetation recovery and reburn severity.

## 28. Automated detection of individual Juniper tree centroids and forest cover changes using Google Earth Engine

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Tree detection is the first step to appraise many forest attributes, especially when focus is tracking the growth of tree canopy and estimating forest biomass. The availability of high-resolution images through the National Agriculture Imagery Program (NAIP) allows the usage of the Google Earth Engine (GEE) as a potential platform to delineate tree canopy in a cost and time-effective manner. The objective of this study is to develop an automated method to detect the crown centroid of individual western Juniper (*Juniperus occidentalis*) and to assess the change of forest cover from the 1-meter resolution NAIP images. Images were collected over a period of more than one decade, from 2005 to 2016, over an area east of Ashwood, Oregon. Ratio vegetation index (RVI), normalized difference vegetation index (NDVI), and normalized difference water index (NDWI) were calculated as remote sensing indices from NAIP images. We segmented individual tree crown using the random forest algorithm, applied to the NAIP images enhanced with the three remote sensing indices. We computed the centroid for each segmented crown. Estimated locations of centroids were compared to centroids that were manually determined in GEE. The results suggest that the calculated latitude, longitude, and centroid were less than the NAIP image resolution, namely 0.64 m ( $\pm 0.06$ m), 0.69 m ( $\pm 0.05$  m), and 0.96 m ( $\pm 0.04$  m), respectively. Measurements of completeness (76%), correctness (94%), and mean accuracy detection (83 %) show promising performance in this study, considering that only four bands were used for crown segmentation. The calculated area for western Juniper indicates a decrease from 2006 to 2012, followed by a gradual increase from 2012 to 2016. The proposed approach has the potential not only to accurately estimate individual tree location and forest cover change using a simple and easy to implement method but also to supply reliable results to land managers.

## 29. Comparing headwater stream thermal sensitivity across two contrasting lithologies in Northern California, USA.

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Stream temperature is a critical water quality parameter; however, few studies have assessed longitudinal stream temperature trends at high spatiotemporal resolution in forested headwaters. This is of particular interest as headwater streams occupy substantial watershed area and contribute to downstream water quality. Understanding thermal regimes in headwater streams is of importance to regulators seeking to minimize aquatic disturbance from forest harvesting. We analyzed stream and air temperature data collected during summer 2018 along eight headwater stream reaches located in two areas characterized by distinct lithology, climate, and riparian vegetation. Five streams were located in the Coast Range (Caspar) and three were in the Cascade Range (LaTour) of Northern California. We instrumented each stream with 12 in-stream and 4 co-located air temperature sensors. We compared stream thermal sensitivity to air temperature—the slope of the linear regression line between mean daily stream and air temperature—to quantify atmospheric control on stream temperature. Our results indicated that summer stream temperatures were warmer, but less variable, in Caspar versus streams in LaTour. Streams in Caspar were more sensitive, on average, to changing air temperature, despite having greater riparian canopy cover. The volcanic lithology in LaTour supported discrete discharges of cooler groundwater, which likely dampened thermal sensitivity. At groundwater discharge locations in LaTour, median stream temperatures decreased by 1.4 °C, 3.7 °C, and 6.8 °C relative to the adjacent upstream sensor. The thin, friable soils in Caspar likely contributed baseflow from shallow subsurface sources, which were more influenced by changing air temperatures. Alternatively, the fractured bedrock and coarse soils in LaTour created discrete locations where groundwater strongly cooled temperatures. Overall, these results reveal greater fine-scale thermal heterogeneity in streams underlain by basalt than sandstone. Future research should consider the effects of riparian forest harvesting on fine-scale temperature dynamics and aquatic habitat viability in headwater streams.

## 30. The economic consequence of a log export tax in Oregon

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Log export has been an important component of Oregon's forest industry and more than ten percent of total log production were exported overseas at its peak time. The export of unprocessed log expands the log markets for forest landowners and thus potentially creates more profits. However, mills owners have to possibly face lower profit margin due to the increased competition from overseas market. Quantifying the benefits and losses of different players in the market is of critical importance for policy decisionmakers. The current log export policy is log export ban from all public forestlands and no substitution from private forestlands. The alternative policy instruments include log export ban, log export tax, log export subsidy and free trade. The objective of my research is to study the economic consequences of proposed log export tax using the results we estimated. To be specific, I will quantify the welfare gains and losses of forest landowners and mill owners under the scenario of a log export tax. Preliminary results will be presented and compared with the results of log export ban.