FISH AND WILDLIFE HABITAT
IN MANAGED FORESTS
RESEARCH PROGRAM

PROGRESS REPORTS

FY 2017

December 8, 2016

Forest Research Laboratory
College of Forestry
OREGON STATE UNIVERSITY
Corvallis, Oregon

Foreword

The 1993 Oregon Legislature added $0.10 per thousand board feet to the Oregon Forest Products Harvest Tax rate for research through the Forest Research Laboratory (FRL) that would provide new information about meeting the needs of fish and wildlife in managed forests of Oregon. The resulting Fish and Wildlife Habitat in Managed Forests (FWHMF) Research Program was established on November 1, 1994, and is conducted by the Oregon State University College of Forestry.

The FWHMF Research Program is integral to the mission of the College's Institute for Working Forest Landscapes (IWFL). The Dean sets the program of research, with guidance from a FWHMF Technical Advisory Committee (TAC) comprised of fish and wildlife specialists and forest managers from government, industry, and non-industrial land owners. The TAC functions as an extension of the IWFL Advisory Board. The work of the FWHMF Research Program is primarily accomplished by faculty and students in the College's Forest Engineering, Resources, and Management Department and the Forest Ecosystems and Society Department, with strategic collaboration from scientists residing in other OSU units and state/federal agencies.

Priority is given to projects that contribute to the scientific information base supporting the Oregon Forest Practices Act. Harvest tax funds that support projects are commonly leveraged with additional funds from other sources. Without the combined support from the harvest tax and from research partners, many projects would not be possible or as successful. Other IWFL research activities contribute to or complement the goals of the FWHMF Research Program; however, because they are funded from other sources, they are not included in documents describing the FWHMF Research Program.

The net funding available for new projects in FY 2017 was $219,448. The advisory committee evaluated thirteen proposals and prioritized them for recommended funding. Given available funding, I approved initiation of five new studies. Two projects continue from the prior year. Funding for six projects has ended, with the projects either completed or transitioning to other sources of support for their longer-term continuation.

I am confident this program will continue to help inform policy and management decisions that support the quality of Oregon's forest resources for the benefit of Oregonians.

Thomas Maness, Dean and Director
College of Forestry and Forest Research Laboratory
July 1, 2016

Introduction

Historically, fish, wildlife and timber have largely been managed independently. With increasing demands for more of all of these resources from a common land base, it has become essential to find ways in which their individual productivities can be optimized in aggregate. Current forest resource management, policy, and regulation attempt to do this, but they are hampered by gaps in knowledge. This enhanced program of research, service, and technology transfer was developed to fill at least a portion of these gaps. The goal is to provide the information needed by forest managers and policy makers in the establishment and evaluation of forest policy, and the active management of Oregon forests, with a specific focus on the science needed to support the Oregon Forest Practices Act.

The purpose of this document is to report on progress made on activities funded by the Fish and Wildlife Habitat in Managed Forests (FWHMF) Research Program over the past year. Continuing projects are reporting on efforts since the last progress reports were prepared in December 2016. New projects were only initiated on July 1, 2016, with the beginning of FY17. The Program may fund projects in three areas:
a) Research, b) Service, and c) Technology Transfer. This year's Program includes seven research projects. Five are new and two are continuing projects.

Titles Of New Research Projects:

1) Predicting Stream Nutrient Concentrations from Landscape Metrics to Develop Better Nutrient Criteria
2) Distribution of Rare Forest Carnivores (Fisher, Marten) in Coastal Southern Oregon
3) Assessing Pollinator Response to Natural and Anthropogenic Disturbances in Mixed-Conifer Forests
4) The Role of Catchment Storage in Controlling Stream Temperature Response to Forest Harvesting
5) From Chaos to Consistency: Moving Towards Data Stewardship and Sharing for the Watershed Research Cooperative

Titles Of Continuing Research Projects:

1) Identifying Primary and Secondary Controls on Turbidity and Sediment Yield in Oregon's Long-term Paired Watershed Studies
2) Revisiting the CFIRP: Assessing Long-term Ecological Value and Characteristics of Snags Created for Wildlife

Titles Of Research Projects For Which Funding From FWHMF Has Ended:

1) Effects of Landscape-Scale Forest Management on Pacific Marten Occupancy and Population Connectivity in Coastal Oregon
2) Assessing the Demographic Response of Early Seral Songbird Species to Intensive Forest Management
3) Top-Down Effects of Wildlife and Bottom-Up Drivers of Soils and Productivity in Intensively Managed Forest Plantations
4) Natural Variability in Water Quality and Changes after Forest Harvest in the Trask Watershed
5) Experimental Evaluation of Plethodontid Salamander Responses to Forest Harvesting
6) Modeling Geomorphic Response to Large Wood Introduction as a Strategy to Restore Fish Habitat in Managed Forest Watershed

Service: The service area includes activities that are not research, but which support current forest management and policy development activities. No active projects are underway this year.

Technology Transfer: Technology transfer is a function that is an integral part of the research process. No active projects are underway this year.

Table of Contents

OSU Forest Research Laboratory
Fish and Wildlife Habitat in Managed Forests Research Program
Spendable Budget for FY 2017
July 1, 2016 - June 30, 2017

New Projects Funded for FY 2017	FY 2017	FY 2018
Predicting Stream Nutrient Concentrations from Landscape Metrics to Develop Better Nutrient Criteria (FY 17-FY 18) -- Alba Argerich, Kevin Bladon, Jeff Hatten, Sherri Johnson	$52,317	$62,106
Distribution of Rare Forest Carnivores (Fisher, Marten) in Coastal Southern Oregon (FY 17) -- Katie Moriarty, John Bailey	$42,000	0
Assessing Pollinator Response to Natural and Anthropogenic Disturbances in Mixed-Conifer Forests (FY 17-FY 18) -- Jim Rivers, James Cane	$58,353	$41,359
The Role of Catchment Storage in Controlling Stream Temperature Response to Forest Harvesting (FY 17) -- Catalina Segura, Nickolas Cook, Kevin Bladon	$57,925	0
From Chaos to Consistency: Moving Towards Data Stewardship and Sharing for the Watershed Research Cooperative (FY17) -- Jon Souder, Jeff Hatten, Lisa Ganio, Kevin Bladon	$24,274	0
Subtotal:	**$234,869**	**$103,465**

Continuing Projects and Activities for FY 2017	FY 2017	
Identifying Primary and Secondary Controls on Turbidity and Sediment Yield in Oregon's Long-term Paired Watershed Studies (FY 16-FY 17) -- Kevin Bladon, Catalina Segura, Arne Skaugset, Sherri Johnson	$63,360	0
Revisiting the CFIRP: Assessing Long-term Ecological Value and Characteristics of Snags Created for Wildlife (FY 16-FY 17) -- Jim Rivers, Joan Hagar	$27,046	0
Subtotal:	**$90,406**	
TOTAL:	**$325,275**	**$103,465**

The net funding available for new projects in FY 2017 was $219,448. This was based on the current 10-year rolling average harvest of 3.66 billion board feet that yields an initial gross budget of $366,000, of which $290,476 was spendable after 26% overhead. Additional spendable funds included $19,378 in carryover funds from FY 2016. Two continuing projects draw $90,406 from FY 2017 funds.

The Advisory Committee evaluated 13 proposals and prioritized them for recommended funding. Their voting resulted in a tight cluster of scores favoring five new projects, at a first year cost of $234,869, which exceeded the funds available by $15,421. The Advisory Committee strongly endorsed this slate of projects and proposed advancing FY 2018 funds to initiate them immediately. After deliberation, Dean Maness accepted this recommendation and the following five projects will received full funding as proposed, with the spendable budget for FY 2018 reduced accordingly.

New Projects

Title: Predicting stream nutrient concentrations from landscape metrics to develop better nutrient criteria

Investigators:
Alba Argerich, OSU FERM; Kevin Bladon, OSU FERM; Jeff Hatten, OSU FERM; Sherri Johnson, PNW

Project duration:
July 1, 2016 – June 30, 2018

Objectives:
The overall goal of this project is to increase our understanding of the factors and processes driving natural variability (both temporal and spatial) in background nutrient concentrations to better inform nutrient criteria. Specifically, we will:

a) Synthesize stream nutrient concentration, landscape, and climate data from Trask, Hinkle and Alsea.
b) Identify primary and secondary controls of nutrient concentrations at a catchment scale by modeling the relationship between stream nutrient concentrations and landscape and climate variables.
c) Create a model to predict magnitude, duration, and frequency of stream nutrient concentrations at a catchment scale.

Summary of accomplishments toward objectives over past year:

- We have started to compile stream chemistry data, and landscape and climate metrics from the Trask.
- We have also started data analysis to identify primary and secondary controls of nutrient variability.

Problems, barriers, proposed changes to objectives:
The analysis of the complete set of storm water samples for the Trask, initially planned for Spring/Summer 2016, has been delayed until Spring 2017 due to the moving of the laboratory where we are analyzing all of our samples (the COLLAB) during Peavy remodel. This might delay the end date of the data analysis phase.

Planned work:
Fall 2016: compilation of stream chemistry data, and landscape and climate metrics from the Trask, start compiling Hinkle and Alsea datasets.

Winter/Spring 2017: identification of primary and secondary controls of nutrient variability in the Trask using statistical methods.

List of names and brief overview of graduate and/or undergraduate engagement in project:

- Casey Steadman, a PhD student, will study the fundamental processes and principles of water and nutrient movement through forested watersheds and how these may be impacted by land management activities using data from the Trask Watershed.

- Emilee Moles, an undergraduate student in the Mentored Employee Program, will begin working on this project in Fall 2016. She will assist with acid washing, organization of samples to be analyzed, and water chemistry analysis using manual methods and the Lachat auto-analyzer instrument.

List of presentations, posters, etc.:
None to report

List of publications, thesis citations:
None to report

Title: Distribution of Rare Forest Carnivores (Fisher, Marten) in Coastal Southern Oregon

Investigators:
Dr. John Bailey, Professor, FERM Department, Oregon State University
Dr. Katie Moriarty, Postdoctoral Research Wildlife Biologist, USDA Forest Service, Pacific Northwest Research Station; Courtesy Faculty, FERM Department, Oregon State University

Project Duration:

2016 – Conduct non-invasive fisher (*Pekania pennanti*) and Pacific marten (*Martes caurina humboldtensis*) surveys with scent detection dog teams in the landscapes within Curry County. Send in scats for genetic evaluation. Produce progress report.

2017 – Complete detection dog surveys in Curry and Coos counties. Send samples to genetics lab and evaluate distribution and ideally identify areas to quantify abundance and population boundaries of each species.

Objectives:

We have three objectives to achieve the overall goal regarding a better understanding of whether and how forest management affects fisher and marten occupancy in the southern Oregon Coast Range Mountains:

1. Survey areas using scat detection dogs in strategic areas, filling significant spatial gaps in survey efforts for fisher and marten (e.g., gaps remaining following earlier surveys, see Moriarty *et al*. 2016).
2. Use genetic techniques to verify species, and (ideally) the sex and number of individuals.
3. Supply distribution data to collaborators to ensure quick decision making on pressing issues.

Summary of Accomplishments:

During spring 2016 a scent detection dog team surveyed 16 sample units (about half of our goal) for a total of 179 km traveled. The team (Jennifer Hartman and "Scooby" from Conservation Canines) collected 110 scats, potentially targeting fisher, marten, lion, bobcat, and porcupine. These were sent to the Levi Lab (OSU), 66 were confirmed marten and 6 were verified as bobcat. Of the scats Jennifer identified as high or medium confidence in the field, she was accurate 96% of the time for marten identification – suggesting 2 scats were fisher but genetic results confirmed them as marten. She was accurate 67% of the time identifying bobcat – she suggested 2 samples were lion but genetic results confirmed the species identification as bobcat.

Spring 2016 surveys identified marten in two locations further east than known by any prior survey (Figure 1). The Levi lab was able to identify scats to species promptly and with over 70% amplification rate to species (mitochondrial sequencing). In March, the lab will be using Illumina sequencing, which is a high-powered Next-Generation sequence system, to assess individual and sex identification for a portion of the marten samples, as well as to explore not only at what rate scat samples can be used for such a task – but also to better understand the minimum number of individuals.

Problems, Barriers, Proposed Changes to Objectives:

We were only able to survey half of our suggested units because there was a mismatch between when funding was provided (July) and when the detection teams could be available. We were able to survey for a portion in good faith that funds would come, but funds still need to be transferred to University of Washington.

Using traditional microsatellite techniques, scat amplification to sex and individual has been lower than expected. Results are upcoming from the study on marten detectability funded by the Oregon Forestry Industries Council in 2015; from that survey 157 scats were collected, 60 were verified as marten and 17% were sequenced to sex and individual (n=10). We're going to try Illumina sequencing to individual and, if that works, then it could revolutionize our capacity to document individuals (and thus abundance). Meanwhile, the Levi lab has made contributions in meta-barcoding for prey, also using the Illumina technology.

Planned Work:
During 2017 we will finish scent detection dog surveys in the southern coast, ideally moving most of the effort to industrial land owner partners or mixed ownership areas (our prior work was on public lands). Such surveys will be conducted during spring or early summer, following rains but before fire season. All scats will be sent to the Levi lab. A new grant was awarded by NCASI in which we will have the capacity to sample a majority of the marten, fisher, bobcat, and lion scats for prey using meta-barcoding. This technique also allows the species to be identified. Funds from genetic work will ideally be used to continue using Illumina sequencing to improve our capacity to obtain individual identification and sex information from scats. By fall, all scats will have been finished at least to species and we will write a final report.

Comprehensive Summary:
Not applicable – study concludes fall 2017.

Undergraduate Engagement in Project:
We have an undergraduate student working on photo-tagging and processing with the few cameras we set out in the coast range this year. Another undergraduate, Mark Stevens, is sorting through scats to identify berries and seeds. In this round, we did not include primers to identify this class of potential prey. The Levi lab also involves over 10 undergraduate students to help in both the lab work and with carnivore photographs – providing valuable experience using specific scientific protocols and preparing samples for analyses.

List of Presentation and Publications:
These data will be combined into our larger efforts to understand fisher and marten distributions and detectability.

Publications: (this does not include this current round of surveys, but all prior also funded by FWHMF)

Moriarty, K. M., J. D. Bailey, S. E. Smythe, and J. Verschuyl. 2016. Distribution of Pacific marten in coastal Oregon. *Northwestern Naturalist* 97:71-81.

Moriarty, K. M., M.A. Linnell, J.E. Thornton, and G.W. Watts III. In prep. Seeking efficiency with carnivore survey methods: a case study with elusive martens. ** should be in review by December, compares marten surveys with cameras and differing bait treatments and scent detection dogs; funded by OFIC*

Presentations (planned and completed):

Moriarty, K.M., M.A. Linnell., B.R. Barry. 2017. Distribution to Density: updates regarding coastal marten and fisher in Oregon and Washington. Western Section-TWS Annual Conference, Reno, NV.

Moriarty. K.M., Golding, J. and many others. 2017. Assessing surveying methodologies to address information gaps for forest carnivores. Oregon Forest Carnivore Working Group. (January).

Moriarty. K.M., Golding, J. and many others. 2016. Assessing surveying methodologies to address information gaps for forest carnivores. USDA Forest Service and Association of Fish and Wildlife Agencies Monthly Webinar Series (November).

Moriarty, K. M., S.M. Matthews, T. Levi, J. Thornton, J.D. Bailey, M.A. Linnell, B.R. Barry. 2016. Update and considerations for marten and fisher monitoring. Oregon-TWS Annual Conference, Forest Carnivore Meeting, Seaside, OR.

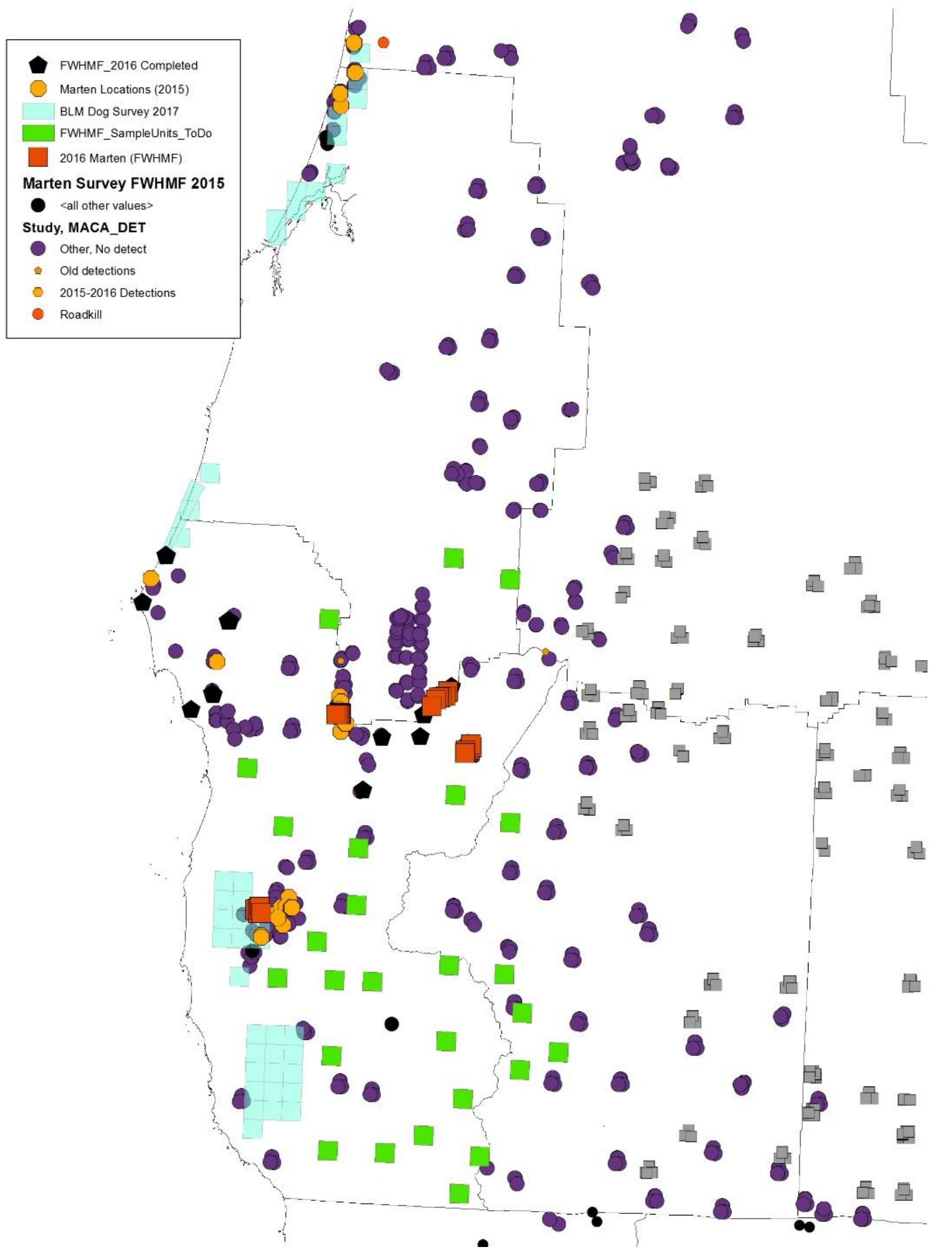
Moriarty, K. M., S.M. Matthews, T. Levi, J. Thornton, J.D. Bailey, M.A. Linnell, B.R. Barry. 2016. If we build it, will they come? Considerations for marten and fisher monitoring. Oregon-TWS Annual Conference, Seaside, OR.

Watts, G.W. III, K.M. Moriarty, and M.A. Linnell. 2016. Comparing the cost-effectiveness and reliability of scent detection dogs and remote cameras for sampling coastal martens in Oregon. Poster. Western Section-TWS Annual Conference, Pomona, CA. (largely funded by OFIC)

Literature Cited:

Moriarty, K. M., J. D. Bailey, S. E. Smythe, and J. Verschuyl. 2016. Distribution of Pacific marten in coastal Oregon. *Northwestern Naturalist* 97:71-81.

Figure 1. We did not detect fishers but did confirm a population of marten (orange circles) during our surveys in 2015 despite an effort that included 944 camera stations in the Coast Range (purple circles, largely funded by FWHMF, OFIC, and NCASI, Moriarty *et al*. 2016). Fishers were detected during the OSU surveys (grey squares, detections not shown). Our scent detection dog surveys funded by FWHMF for this report (black hexagons) also did not detect fisher, but found marten at 4 additional sample units (orange squares) – including 2 east of Powers. Teams will survey at least 20 more sample units (green squares) during summer 2017. In addition, the BLM will add to the 2017 survey effort (blue squares). Detection dog teams will target fisher, marten, bobcat, and mountain lion. Scats will be sent to the Levi lab (OSU) for species confirmation.



Title: Assessing pollinator response to natural and anthropogenic disturbances in mixed-conifer forests

Investigators:
Dr. James W. Rivers (OSU), Dr. James H. Cane (USDA Pollinating Insect Research Unit, Utah State Univ.)

Project duration:
Funding granted to support field activities during the 2016 and 2017 field seasons

Objectives:
1. Evaluate how natural and anthropogenic disturbances structure pollinator communities in early seral forests

2. Assess whether changes in pollinator diversity and abundance are linked to changes in pollination services

3. Test whether remote sensing data (e.g., LiDAR) can be used to discern differences in pollinator communities

Summary of accomplishments over past year:
In April 2016 we established n=41 study plots within the vicinity of the Douglas Complex in southern Oregon based on satellite-derived relative differenced normalized burn ratio (RdNBR) values that quantify post-fire changes in tree basal area. Our study plots represent the full range of fire severity within the ~19,700 ha complex and includes study plots of low fire severity (n=10), moderate-low fire severity (n=6), moderate-high fire severity (n=8), and high fire severity (n=9). We also established study plots that were subjected to high fire severity and were also salvage logged (n=8).

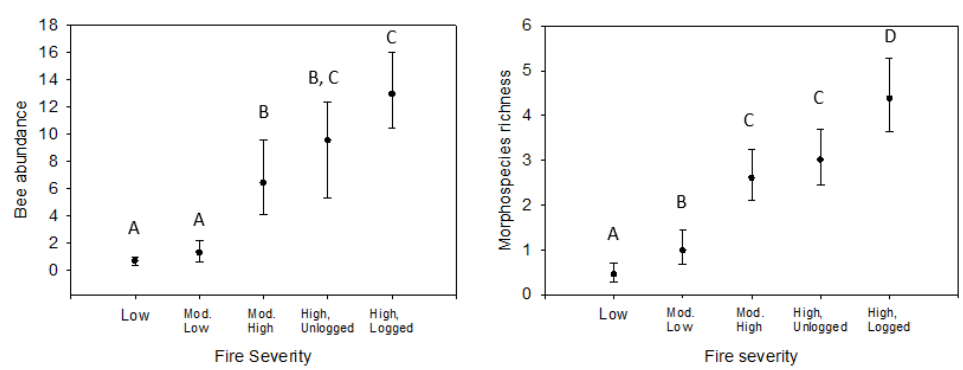


Fig. 1 | Preliminary results indicate bee diversity measures were positively linked to increases in disturbance intensity within burned forest. Mean (95% CI) bee abundance (left panel) was positively associated with fire severity, with the greatest number of bees captured on stands that experienced high fire severity and were subjected to salvage logging. Mean (95% CI) bee morphospecies richness (right panel) showed a similar pattern as abundance. Results are based on linear mixed models for fire severity and sampling date, weighted by number of plots. Estimates with the same letter within each panel are not significantly different at $P = 0.05$.

We sampled bee communities using blue vane traps (BVTs) every 3-4 weeks from May-September 2016. During our four sampling periods, we collected a total of 2,377 bees representing 20 genera and approximately 85 species. Bee abundance varied with sampling date, with the majority trapped during the third collection period (late July-early August, n=1319). Preliminary analyses show a positive relationship between fire severity and bee diversity measures (i.e., abundance and richness), and both measures were greater on stands that were subjected to salvage logging (Fig. 1). The majority of bees captured were ground-nesting species, although a sizable number of cavity- and wood-nesting species were detected across all treatment types (Table 1). We also collected data on relevant habitat variables within the plots such as floral richness and abundance, percent canopy cover, and percent exposed bare ground and we piloted a method for quantifying coarse woody debris which will be used to survey plots in March 2017.

Table 1. Distribution of captured bees by nesting substrate and for disturbance treatments in our study. Ground = bee species that nest in exposed soil, Cavity = bee species that nest in hollow logs or rock piles, Wood = species that nest in tunnels within wood, Stem = species that nest in pithy plant stems, Cleptoparasite = parasitic bee species that do not build their own nest but instead lay their eggs into the nest of other species. We restrict reporting to bee genera with known nesting preferences (17 of 20 genera; 97% of collected specimens).

		Disturbance type				
Nesting substrate	n	Low fire	Moderate-low fire		High fire	High fire + salvage logged
Ground	1853	60 (3%)	51 (3%)	417 (23%)	596 (32%)	729 (39%)
Cavity	278	25 (2%)	3 (1%)	57 (21%)	70 (25%)	123 (44%)
Wood	176	0 (0%)	7 (4%)	20 (11%)	59 (34%)	90 (51%)
Stem	7	1 (14%)	0 (0%)	2 (29%)	1 (14%)	3 (43%)
Cleptoparasite	1	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (100%)

In addition to surveying the diversity of bee communities, we also measured reproductive output of the alfalfa leafcutter bee (Megachile rotundata) by placing two nesting structures on each plot with a standardized number of pre-emergent adult bees still in cocoons. After 10 weeks, we collected the nest boxes and quantified the number and size of new cocoons produced on stands as a measure of relative reproductive output. We collected a total of 182 cocoons from nests, with plots that experienced high severity fire and were subsequently salvage logged had greater reproductive output (mean = 4.6 cocoons/nest, SD=8.7) relative to stand that experience low fire severity (mean = 0.7 cocoons/nest, SD=1.7). However, there was high variation in reproductive output among treatments, likely due to modest sample sizes.

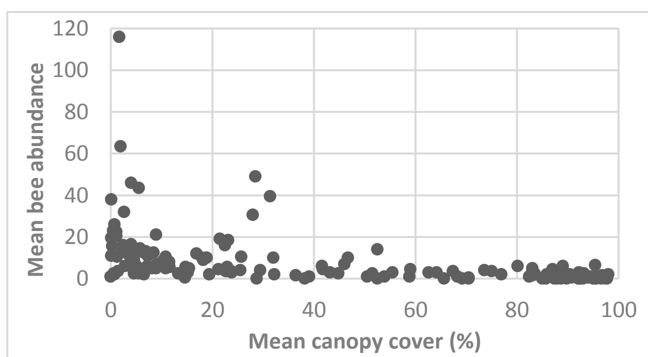


Fig. 2 | Bee abundance decreased with increased canopy cover in burned forest. Stand-level data from 2016 confirm that open areas within forested landscapes harbor more bees. However, how the surrounding landscape structure interacts with stand-level habitat data is currently unknown. We will address this knowledge gap through our study objective #3 that uses remote sensing data, including LiDAR, to determine how landscape-level factors influence local bee diversity measures, and how this may vary among bee guilds (e.g., soil- vs. wood-nesting species).

As proposed in our second objective, we will use an experimental approach to exclude pollinators from flowers to evaluate how differences in bee diversity measures translate to variation in pollination services to native plants. We piloted the use of Helenium autumnale for this experiment, but determined that it would be more effective to use wild plants already established on stands. Our pilot data indicated that salal (Gaultheria shallon) was present on stands across the continuum of disturbance intensity, and we observed several bee genera visiting this plant throughout the spring and summer, including Xylocopa, Bombus, and Anthophora. Therefore, our pollinator exclusion experiments will measure the contribution of native bees to salal fertilization success.

During summer 2016, we measured canopy cover with each stand and found that bee abundance decreases as canopy cover increases (Fig. 2); however, it is unknown how bee diversity measures are linked to canopy cover at different scales within the landscape. Therefore, as part as study objective #3 we will use bee capture data and habitat data collected over the course of this study to discern if remotely sensed LiDAR flight data can be used to predict bee diversity measures. Once data collection is finished after the 2017 field season, we will test this important, yet heretofore unaddressed component of how bees respond to landscape-scale changes in habitat within managed temperate forests.

Problems, barriers, proposed changes to objectives:
We did not encounter any significant problems or barriers that prevented us from meeting our research objectives, only making minor adjustments to the proposed methods based on new information about the study area. For example, our initial site selection found that salvage logging in the Douglas Complex only occurred on stands experience high fire severity, preventing us from looking at the influence of logging severity across the entire fire severity gradient. We also intended to use potted Helenium autumnale for the pollination experiment, but learned that these plants were difficult to raise and transfer to field plots, so we instead chose to use on-site plants for this experiment. Finally, we suspect that the limited number of alfalfa leafcutter bees that were raised on sites may have been due to phenological mismatches between flowering of local plants and the timing that bees emerged from cocoons. Therefore, in 2017 we will instead use mason bees (Osmia lignaria) for this experiment. This species emerges earlier in the season when floral resources are more abundant on our stands, which should provide a better opportunity to evaluate how bee reproductive output is influenced by disturbance intensity

In addition to addressing all of the initial research objectives we proposed, we also expanded the objectives of our study in two significant ways. First, we collected pilot data to evaluate the quality of roadside habitats for bees, as forest roads represent an additional anthropogenic disturbance type within forested landscapes. We established roadside plots that were paired with interior stand plots for low fire severity, high fire severity, and high fire severity + salvage logging treatments (n=5 sites/treatment). We used BVTs and collected habitat data at these roadsides during late summer 2016, and we plan to continue sampling across the entire field season (May-August) in 2017. We collected 1,180 bees on roadside plots representing 18 genera and approximately 48 species, indicating roadsides might provide important habitats for bees and other pollinators within managed forests.

Second, we expanded our project to quantify the physiological health of pollinators foraging across the disturbance gradient by measuring the lipid content of individual bees. We piloted this method in the 2016 field season, netting bumble bees from low fire severity (n=17 individuals), high fire severity (n=35), and high fire severity + salvage logged treatments (n=31). We are working with a collaborator (Dr. Amy Toth, Iowa State University) to undertake laboratory assays that will assess size-specific lipid contents, which are an indication of overall health. We plan to expand our netting of bees in these treatment types in late spring, early summer, and mid-summer 2017, providing additional information about how disturbance type and intensity is linked to pollinator health.

Planned work:
Our planned work remains as outlined in our project proposal. Currently, post-doctoral research associate Dr. Sara Galbraith is refining specimen identification, undertaking preliminary analyses of field and LiDAR data, and preparing for the 2017 field season. Data collection is expected to begin in April 2017 and be completed by mid-September 2017. Analysis and write-up will continue as new data become available, and we expect to submit at least two manuscripts to peer-review journals in 2018. We will also continue to give presentations to scientists and land managers in a variety of settings to highlight our findings.

In addition to our field research, we are also organizing and hosting a workshop in March 2017 titled, "Pollinators in Managed Forest Landscapes." The primary goal of the workshop is to bring together resource managers and pollination scientists to develop an agenda for pollinator research in managed forests of the Pacific Northwest. Researchers from across the country will share results from recent and ongoing projects focused on pollinators within managed forests, and resource managers will be called upon to outline potential investigations to assess how current management actions may impact native pollinators. We expect to host 50-60 participants for the one-day event, including students, researchers, and land managers, and attendees will have the option of receiving continuing education credits from Society of American Foresters and The Wildlife Society for attending.

List of names and brief overview of young professionals engaged with project:
Three young professionals worked as research assistants on this project during the 2016 field season: Ian Lively (B.S., OSU), Nicole Scavo, and Katarzyna Szczurek. All three are interested in pursuing graduate school careers and learned field-, laboratory- and museum-based methods for working with bees, as well as collecting data for an independent project investigating trap bias in BVTs. We are currently seeking 1-2 OSU undergraduate students to assist with laboratory tasks, and we plan to hire 4 full-time young professionals for field work during the 2017 season.

List of presentations and posters:
Rivers, J. W. 2016. Pollinator response to natural and anthropogenic disturbances in mixed-conifer forests. Douglas Complex Status Review Meeting for the Bureau of Land Management, Roseburg, Oregon.

Galbraith, S. M. 2016. The influence of fire severity and post-fire management on bee community composition in a mixed-conifer forest. Oregon State University Postdoctoral Association Annual Research Symposium, Corvallis, OR. Won award for best overall presentation.

List of expected publications:
Galbraith, S. M., J. H. Cane, and J. W. Rivers. Bee response to fire severity and post-wildfire management in a mixed conifer forest. For Journal of Insect Conservation.

Galbraith, S. M., C. J. Dunn, J.H. Cane, and J. W. Rivers. LiDAR-derived habitat variables for predicting bee diversity in mixed conifer forest after wildfire. For Remote Sensing of Environment.

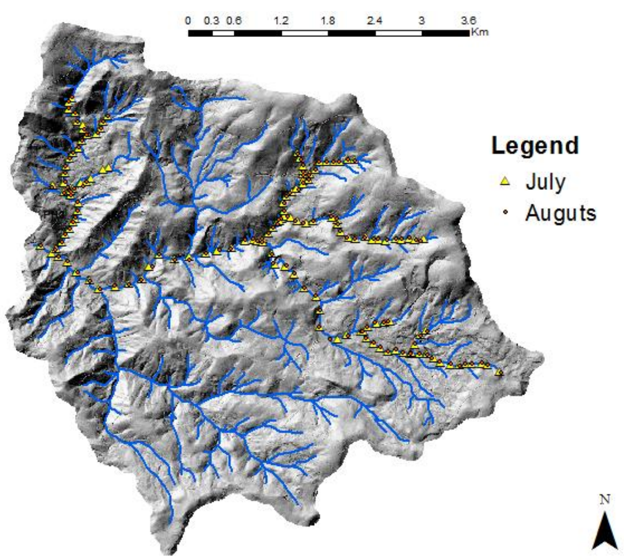
Title: **The role of catchment storage in controlling stream temperature response to forest harvesting**

Investigators:
PI: Catalina Segura (OSU FERM); Co-PI: Kevin Bladon (OSU FERM)

Project duration:
July 1, 2016 – June 30, 2017

Objective:
Stream water temperature (T_s) response to timber harvest has been widely studied for decades in the Pacific Northwest; yet there is still a lack of understanding of T_s response at spatial scales larger than the individual harvest unit. Preliminary analysis of stream temperature data pre- and post-harvesting in the Trask Watershed indicated notable differences in downstream T_s response that appear to be related to differential hydrologic behavior of the catchments (i.e., ground water contributions to summer base flow) likely related to rock permeability (i.e., geology) of the contributing areas. However, the current data set does not allow us to describe the mechanisms that produce the differential T_s responses. More importantly, the data do not yet allow for prediction or anticipation of the sensitivity of streams across the landscape. ***Our project intends to investigate the spatial variability of groundwater contributions and its relation to stream temperature under natural (reference) and harvested conditions.***

Summary of accomplishments toward objectives over past year:



- We collected ~130 water samples for lab analysis during each of 3 field campaigns (~390 total samples) in July, August, and September 2016 (Fig. 1)
- 30% percent of the samples have been analyzed for water stable isotopes

Fig 1. Water sampling locations in the Trask Watershed from July, August, and September 2016.

Problems, barriers, proposed changes to objectives:
No problems or barriers to report other than two changes in research group personnel:

1. The postdoctoral scholar Nicholas Cook accepted a position in a consulting firm in Portland and left the project on August 31, 2016.
2. The PhD student, Lydia Nickolas who was going to work in the project has decided to pursue a Master's degree instead and will not participate in this project.

Considering the mentioned changes in personnel, the budget has been adjusted to include salary for a lab technician who will aid with the isotope analysis in the laboratory; salary for temporary personnel to conduct some on the analysis (i.e., spatial GIS) and a higher FTE to cover summer salary for the PI (Segura) and Co-PI (Bladon). It is important to emphasize that none of the objectives or deliverables of the project have changed.

Planned work:

- The analysis of samples for water stable isotopes will be complete between November and December 2016.
- Data analysis will follow, incorporating the 2016 stream temperature data that has been collected in the Trask.
- Spring 2016 – Segura will participate in a workshop "Spatial Statistical Network Models" to strengthen the analysis.
- Summer 2017 – Synthesize data and prepare manuscript.

List of names and brief overview of graduate and/or undergraduate engagement in project:
A graduate student (Amelia Yeager) and 4 undergraduates (Joey Tinker, Cameron Minson, Noah Kanzig, and Ryan Cole) were involved in water sampling during the summer. Cameron Minson has also been involved in the analysis of water samples in the lab. Part of the funds to support these students came from the College of Forestry Mentored Employment Program.

List of presentations, posters, etc.:
None to report

List of publications, thesis citations:
None to report

Title: From Chaos to Consistency: Moving Towards Data Stewardship and Sharing for the Watershed Research Cooperative

Investigators:
Jon Souder, Jeff Hatten, Lisa Ganio, Kevin Bladon

Project Duration:
July 1, 2016 – June 30, 2017

Objectives:
The primary objective for this project is design a WRC data stewardship and management framework that will allow integration and synthesis across disciplines within a particular study, across studies within a discipline, and an overall synthesis across disciplines and sites. Consistent with the WRC MOAs with funders, these data sets need to be available to the Cooperators and others in a timely and transparent manner.

The second objective of the project is to respond to the increasing emphasis on the part of many funders (NSF, NIH, federal resource agencies) that require data management plans and data sharing for projects they fund. As part of this objective, we will begin structuring the WRC datasets to meet ESA publication standards.

Summary of Accomplishments:
In our proposal, we identified four approaches that we would use to fulfill the two project objectives identified above. These are:

a. ***Steering Committee***. As outlined in our proposal, the initial task for the Steering Committee was to prepare a position description (PD) and select a data manager.
   - An opportunity arose for us to work with the Research Data Services group at the OSU Valley Library. We were able to work with Steven Van Tuyl (Data & Digital Repository Librarian) and Dr. Clara Llebot Lorente (Data Management Specialist) to use FWHMF funds to purchase Dr. Llebot Lorente's time to coordinate and prepare the data management plan. This has relieved the Steering Committee (and PIs) of a considerable burden and risk associated with recruiting, housing, and supervising a data manager.
   - Members of the Steering Committee have been identified, and an initial meeting is scheduled for late November, 2016.

b. ***Framework Design***. The goal for the Data Framework Design approach is to identify a database management system that a consensus of the WRC PIs and Cooperators can support. Tasks accomplished to date to achieve this goal are:
   - Dr. Llebot Lorente has met with the WRC Trask PWS team to receive input on their data management process, which is based on the H.J. Andrews LTER and NSF protocols.
   - A consolidated database structure has been created on the CoF's server, consistent with the structure used for the WRC-Trask PWS.
   - Dr. Llebot Lorente has evaluated other data management systems (such as Open Science Framework) for their potential for joint use and long-term archiving of WRC data. This evaluation will be brought to the Steering Committee for their review.
   - Dr. Llebot Lorente has designed a procedure to perform a data inventory, based on a questionnaire that will be distributed to the researchers involved in WRC. The survey will

gather information about the existing data sets, how they are organized, the period of time that they cover, how many versions of the same data set there are, the researchers that are responsible for the data set, active users or active managers, documentation, and level of quality control performed on the data. Iterations between researchers and Dr. Llebot Lorente will be repeated as needed until the data inventory is complete. The data inventory plan also involves personal interviews to the few researchers more heavily involved in data management to get a sense of the workflows that they follow.

- The data obtained from the surveys and interviews will also be used to publish research on data management. The goal of the research is to evaluate the data management practices of this particular group of researchers, and understand their main challenges. We will assess how the behavior of this group can be extrapolated to others. We will also address the potential of data management projects as educational tools, evaluating whether being involved in a data management project like the present one affects the data practices of the researchers that have been involved outside of the project. An extra questionnaire has been developed for this purpose.

c. ***Pilot Using Alsea Revisited Data***. The goal for this activity is to demonstrate the data management approach using the Alsea Revisited dataset. To date, we have achieved:

- We have completed the initial inventory of the Alsea Revisited datasets, and are currently confirming that it's up to date.
- The Alsea Revisited PWS datasets on CoF servers have been consolidated into a single folder in the consolidated WRC data folder. This activity required significant effort since datasets were spread over eight different folders in three different groups on the CoF server. We are also working to insure that any datasets residing on individual PIs computers are duplicated in the consolidated dataset.
- Dr. Catalina Segura has completed a draft QA/QC workup of the Alsea Revisited streamflow data for Flynn, Deer, and Needle Branch Creeks. Beyond the QA/QC, this includes assessing uncertainty on the flow estimates, tagging empty cells, and saving these in an archival format.
- We are currently working with Terry Bousquet at NCASI to insure that her QA/QC results are incorporated into the Alsea Revisited dataset.

d. ***Develop Future Strategy***. The goal of this activity is to use the results from the Alsea Revisited pilot to develop a strategy, including effort and costs, to transition the WRC datasets into the data stewardship framework. We have not made sufficient headway on the other activities to report any progress on this activity.

Problems, barriers, proposed changes to objectives:

Our agreement with the OSU Valley Library has resolved one of the biggest barriers to project success: finding a well-qualified and supervised data management specialist. This arrangement increases our confidence that we will be able to create a state-of-the-art data management program for the WRC.

As we began consolidating the various paired watershed study datasets, concerns were raised about data ownership and intellectual property rights. Review of the WRC agreements revealed that the MOA with the funders specifically vested in the WRC ownership rights and publication clearance. However, there were no equivalent agreements with the researchers conducting the studies. The WRC Trask PWS PIs has a publications policy that they created in 2011, but this was never approved by the WRC Advisory Committee; there are apparently no publications policies for either the Hinkle or Alsea Revisited PWSs, although some of the PIs have worked on a draft. At the WRC's 2016 Business Meeting, a Publications Policy Committee was formed to create a unified process for all three PWS and for future data syntheses among the studies.

Planned Work:
In our proposal, we presented a timeline for the project. We anticipate largely following this schedule, with the primary focus on getting the Alsea Revisited data into the archival database structure and developing the data management strategy. During mid-December through mid-March, we expect that Dr. Llebot Lorente will be on maternity leave, but have frontloaded her work to accommodate that absence. However, we may adjust the Steering Committee meeting dates depending upon her availability and project progress.

The planned strategy to complete the data and workflows inventory during the next month is**:**

- Get IRB approval for the surveys and interviews
- Send the survey and start interviews.
- Summarize information gotten from the interviews and redistribute to researchers to detect any missing data. Iterate with the researchers as many times as necessary until the data is complete, via questionnaires or personal visits.
- Summarize information from surveys (data inventory) and interviews (workflows) in a report.

List of names and brief overview of graduate and/or undergraduate engagement in project:
None

List of presentations, posters, etc.:
Data management was one of the four focus areas at the WRC's 2016 Annual Business Meeting on October 4, 2016. Dr. Llebot Lorente presented the structure and outline of the anticipated data management plan to the attendees.

List of publications, thesis citations:
N/A

Continuing Projects

Title: Identifying primary and secondary controls on turbidity and sediment yield in Oregon's paired watershed studies

Investigators:
Kevin Bladon, Catalina Segura, Arne Skaugset, and Sherri Johnson

Project duration:
24 months (Dec. 1, 2015-Nov. 30, 2017)

Objectives:
The Watersheds Research Cooperative (WRC), consists of three paired watershed studies (Trask [TWS], Hinkle Creek [HCWS], and Alsea [AWS]). Turbidity and suspended sediment data have been collected at all of these watershed studies; however, there has been no attempt to integrate the results across studies to provide broader insights that may not be possible otherwise. The overall objectives of the proposed research are to:

I. Synthesize the turbidity and suspended sediment data from the watershed studies in Oregon.
II. Model the relationship between turbidity and sediment yield and morphometric, soils, geologic, and climatic variables at the catchment scale to identify primary and secondary controls.
III. Provide a process-based framework to classify watersheds in terms of resilience and vulnerability to sedimentation, to be used to assess contemporary forest practices.
IV. Develop testable hypotheses for identifying 'hot spots' for turbidity and sediment production within forested watersheds.

Summary of accomplishments toward objectives over past year:

I. Considerable efforts were required to conduct an assessment of data usability from the three WRC study sites. Despite previous QA/QC efforts, the data sets for discharge, turbidity, sediment, and spatial information were incomplete or unusable for the objectives of the planned study. After this assessment, it was determined that the TWS data was the only site that could be analyzed immediately (see "Problems, barriers, proposed changes to objectives" for more details). As a result, we used the TWS to develop an initial framework for analysis and testable hypotheses that could be validated at other locations.
II. The analysis investigated trends in suspended sediment yields in reference and harvested catchments of the TWS. Trends were related catchment morphometry, soils, geology, and climate to identify primary and secondary controls.
III. It was determined that catchment geology, morphometry, and soils were correlated, and collectively provided a model to predict the observed differences in sediment yields and vulnerability to contemporary forest practices among sites. Within the framework of contemporary forest practices, the suspended sediment yield response to land management was determined to be secondary or dependent on catchment characteristics (i.e., primary control).

IV. A testable hypothesis for 'hot spots' in increased yields was proposed, by which catchment characteristics (geology and morphometric variables) can be used to predict resilience and vulnerability to sedimentation.

V. This preliminary analysis and framework were summarized in a manuscript that was submitted to the Journal of Hydrology for publication. It is currently under peer review.

Problems, barriers, proposed changes to objectives:

I. Initial assessment of data quality, indicated quality issues with the turbidity data at all sites due to lack of calibration of the instruments that were deployed in the field. Lack of calibration lead to poor and unreliable relationships between with other variables, including discharge, suspended sediment concentration, and lab turbidity. As such, the turbidity data is likely not usable for any robust analyses.

II. The AWS discharge and climate data have been undergoing a rigorous quality assessment. As such, this data is still not usable to undertake rigorous analyses.

III. Suspended sediment data at the TWS was collected by different methods at different spatial scales, which created substantial challenges for comparisons.

IV. Data quality/accessibly issues have resulted in a decision by Bywater-Reyes (postdoctoral scholar) and mentors (Bladon and Segura) to investigate the usage of other existing data sets in the Pacific Northwest to achieve the overall objectives of the originally proposed work. It is important to reiterate that the overall objectives of the originally proposed work have not changed—only the approach to achieve those objectives has been amended.

Planned work:

I. Compile suspended sediment data from additional sources (USGS, USFS, NP, DEQ) for sites within the western Pacific Northwest region (underway).

II. Analyze trends in suspended sediment yields at sites through time and space in relation to their morphometric, soils, geologic, and climatic setting and land use history.

III. Test and compare results obtained through TWS analysis to develop a process-based framework to classify watersheds in terms of resilience and vulnerability to sedimentation, which may be used to assess contemporary forest practices.

IV. Test and compare results obtained through TWS analysis for identifying 'hot spots' for turbidity and sediment production within forested watersheds.

List of names and brief overview of graduate and/or undergraduate engagement in project [e.g., thesis, research experience for UG, etc.]:

I. Dr. Nicholas Cook (Postdoctoral Scholar), Casey Steadman (PhD candidate), Ryan Cole (undergraduate; honors thesis student), Joey Tinker (undergraduate student).

- Cook, Steadman, Cole, and Tinker aided the project in quality assurance/quality control of data sets from the TWS, HCWS, and AWS. They have also assisted in standardization of data set presentation across studies to prepare the data for analyses. Additionally, Dr. Cook was integral in preparation of the spatial (GIS) layers across studies, which he used in his OFIC funded research project that is closely aligned to this FWHMF project. We believe this graduate and undergraduate engagement will aid in achieving the project objectives while also providing excellent educational opportunities.

List of presentations, posters, etc.:

Bywater-Reyes, S., Segura, C., and Bladon, K.D. 2016. Influence of Geology and Basin Characteristics on Suspended Sediment Yield in Harvested Western Oregon Headwater Streams. American Geophysical Union Fall Meeting. Dec. 12-16, 2016. San Francisco, CA.

List of publications, thesis citations:

Bywater-Reyes, S., Segura, C., and Bladon, K.D. Geology and geomorphology control suspended sediment yield and modulate increases following timber harvest in Oregon headwater streams. *In review*: Journal of Hydrology.

Title: Revisiting the CFIRP - Assessing long-term ecological value and characteristics of snags created for wildlife

Investigators:
Dr. James W. Rivers (CoF, OSU), Dr. Joan C. Hagar (USGS)

Project duration:
Our group initiated a two-year (2015-2016) study to assess snag characteristics, as well as foraging and breeding use of snags that were created as part of the College of Forestry Integrated Research Project (CFIRP).

Objectives:
1. Quantify contemporary foraging and nesting use of 25-year old snags by birds.
2. Assess whether silvicultural treatments undertaken at the time of snag creation have caused differences in contemporary snag persistence and characteristics.
3. Measure contemporary avian community response to created snags.

Summary of accomplishments over past year:
During the 2015 breeding season we surveyed a large sample of created snags (n=136) to quantify nesting and foraging use by birds. In 2016, we resurveyed the snags that were monitored in 2015 and increased our sample by 50% for a total of 204 created snags. In both years, we found 36 active bird nests belonging to 4 forest species in our focal snags (Table 1), with the majority of nests belonging to the Chestnut-backed Chickadee (see Tables 1 and 2 for scientific names), an obligate cavity-nesting species. Other species included the Red-breasted Nuthatch, Red-breasted Sapsucker, and Northern Flicker. Through the course of regular field work we also located an additional 17 nests in non-focal created snags of the Chestnut-backed Chickadee (n=12 nests), Northern Flicker (n=2 nest), Red-breasted Sapsucker (n=1 nest), Red-breasted Nuthatch (n=1 nest) and Northern Pygmy Owl (*Glaucidium gnoma*, n=1 nest); we note these additional nest data were not included in summary estimates because non-focal snags were not included within our original sampling frame. The great majority of nests we monitored (97.2%) appeared successful and produced offspring based on behavioral observations made in the vicinity of nest sites, with the exception of a single Chestnut-backed chickadee nest in 2016.

We found that approximately 10% of focal snags harbored active nests during the 2015 and 2016 breeding seasons (Table 1). Nests we located were found in all three silvicultural treatments, with more nests in the group selection (n=15) than either the clearcut (n=13) or the two-story treatments (n=8). Chickadee nests were found in all three treatments whereas the flicker and nuthatch nest were both in group selection stands; the single sapsucker nest was found in a clearcut treatment stand. Relative to our current-day data, nest searching efforts conducted on created snags during the 2001 breeding season located active nests in 20.2% of the created snags monitored by Walter and Maguire (2005, Journal of Wildlife Management 69:1578-1591). The relative composition of active nests used by Chestnut-backed Chickadee, a species classified as a weak cavity excavator, shifted from 33% in 2001 to 89% in 2015-2016. Moreover, we detected a notable decline in strong excavators that nested in created snags during 2001 (i.e., Red-breasted Sapsucker, Northern Flicker, and Hairy Woodpecker), yet these species were detected regularly within the vicinity of created snags during the course of our field work. Taken together, this suggests that the suitability of created snags as a nesting resource at the current time has decreased markedly over the last 15 years.

Table 1. Number of active nests located in 836 created snags surveyed during the 2001 breeding season (Walter and Maguire, 2005) contrasted with those located during the 2015-2016 breeding season.

	2001		2015-2016	
Species	**# nests**	**% total nests***	**# nests**	**% total nests***
Chestnut-backed Chickadee (*Poecile rufescens*)	56	33%	32	89%
House Wren (*Troglodytes aedon*)	31	18%	0	0%
European Starling (*Sturnus vulgaris*)	28	16%	0	0%
Red-breasted Sapsucker (*Sphyrapicus ruber*)	21	12%	1	3%
Red-breasted Nuthatch (*Sitta canadensis*)	15	9%	2	6%
Violet-green Swallow (*Tachycineta thalassina*)	10	6%	0	0%
Northern Flicker (*Colaptes auratus*)	7	4%	1	3%
Hairy Woodpecker (*Leuconotopicus villosus*)	1	1%	0	0%
All species combined	**169**	---	**36**	---

In addition to nesting activity, we also quantified use of created snags by birds within the context of foraging activities during the breeding season. We amassed >750 hours of observations on focal snags over both seasons, documenting foraging events by 13 bird species on 61 separate occasions (Table 2). The greatest number of foraging observations was made in the group selection treatment, followed by the clearcut, and the two-story treatments (Table 2). The Pileated Woodpecker was the most commonly observed species foraging on created snags (n=21 observations), followed by the Chestnut-backed Chickadee (n=15 observations) and the Brown Creeper (n=8 observations); 10 additional species were observed foraging on created snags 3 times or less.

Table 2. Distribution of bird foraging observations collected during focal watches on created snags from May-July 2015-2016 relative to initial silvicultural treatment.

	# of foraging observations		
Species	**Clearcut**	**Group selection**	**Two-story**
Pileated Woodpecker (*Hylatomus pileatus*)	12	6	3
Brown Creeper (*Certhia americana*)	0	7	1
Chestnut-backed Chickadee	7	6	2
Red-breasted Nuthatch	0	2	0
Pacific Wren (*Troglodytes pacificus*)	0	2	0
Northern Flicker	0	1	0
Red-breasted Sapsucker	0	1	1
Gray Jay (*Perisoreus canadensis*)	0	1	2
Barred Owl (*Strix varia*)	0	0	1
Swainson's Thrush (*Catharus ustulatus*)	1	0	0
Black-throated Gray Warbler (*Setophaga nigrescens*)	1	0	0
Dark-eyed Junco (*Junco hyemalis)*	0	1	0
Hairy woodpecker (*Leuconotopicus villosus)*	0	3	0
All species combined	**21**	**30**	**10**

From mid-January to mid-April 2016, we collected data on persistence (i.e., proportion of snags standing) for all snags created as part of the CFIRP program (n=731 snags). On a random subset of created snags that were still standing (n= 238), we also collected data on cavity cover, bark cover, and bark integrity; these measures provide information about historic use of snags, habitat components of snags that are available for birds, and level of snag decomposition. We found that 91% of all created snags were still standing after 25 years. Additionally, we found that 35% of all created snags had broken somewhere along the bole. Snag persistence did differ among at least one of the silvicultural treatments (X^2 = 7.12, P = 0.03) and the odds of a created snag being broken also differed among at least one of the silvicultural treatments (X^2 = 6.46, P = 0.04). Group selection stands had that highest proportion of snags still standing and also the lowest proportion of snags broken 25 years after creation (Table 3).

Table 3. Persistence and proportion of snags broken among treatments in CFIRP stands in 2016.

Silvicultural Treatment	# snags	Proportion standing	Proportion broken
Clearcut	171	87%	46%
Group Selection	386	93%	33%
Two-story	174	89%	49%

Cavity cover across all treatments averaged 11%, with bark cover averaging 82%; both measures differed by treatment (both P < 0.01). Slightly over half of created snags (54%) had bark that was loosely attached or peeling away from the bole of the snag. The proportion of snags that had bark loosely attached also differed by treatment (X^2 = 38.3, P < 0.01). Group proportions for snag characteristics are displayed in Table 4.

Table 4. Snag characteristic measurements for focal snags (n = 238) among treatments in CFIRP stands in 2016.

Silvicultural Treatment	# snags	Mean % cavity cover	Mean % bark cover	Proportion of snags with bark loosely attached
Clearcut	96	12%	75%	
Group Selection	73	9%	94%	22%
Two-story	69	13%	80%	66%

Avian point count and call-playback surveys were conducted from May-June in 2016 only (2016) to increase detection rates and to estimate occupancy for 4 woodpecker species present on our study sites: Red-breasted Sapsucker, Northern Flicker, Hairy Woodpecker, and Pileated Woodpecker). Each point was visited 4-5× over the survey season. During call-playback surveys, we detected woodpecker species using all three treatment types, and naïve occupancy varied among focal woodpecker species from 27-58%. That these primary cavity-nesting species were detected on stands with created snags but where not observed using them (with the Pileated Woodpecker being the lone exception for its foraging use of created snags) suggests created snags are not suitable habitat features for woodpeckers 25 y after creation.

Problems, barriers, proposed changes to objectives:
We did not experience any significant problems or barriers to field work during 2015 or 2016. One minor issue that did arise is that the video cameras that were used to peer into nest cavities to quantify nest survival and record nesting data (e.g., clutch size) were too large and could not be used as planned. However, we were still able to quantify nest success using a more traditional manner by recording behaviors around the nest site that are indicative of successful nests (e.g., parents entering the cavity with food, begging calls of fledglings near the nest).

Planned work:
Our planned work remains as outlined in the initial project proposal. At the current time, graduate student Amy Barry is collating historical data from multiple sources, undertaking statistical analysis, and writing up results. We anticipate analysis and write-up will continue through spring 2017, at which time manuscripts should be finalized for submission to peer-review journals.

List of names and brief overview of graduate and/or undergraduate engagement in project:
Amy Barry in the Department Forest Ecosystems and Society, Oregon State University is involved with the project as a graduate student and is collecting data toward her M.S. thesis by investigating use of created snags by wildlife, with a focus on understanding contemporary use of snags as foraging and nesting substrates by birds. During 20152-2016 she hired and worked closely with four young professionals to collect data on the project, three of which were recent graduates of Oregon State University.

In addition, our group has provided outreach activities to high school students as part of the College of Forestry STEM Academy program during 2015-2016, as well as the 2016 "Explore Your Forests" program. In all programs, students were taught about the importance of snags and cavity-nesting species in forested ecosystems and were introduced to research methodologies used to study forest birds. We also worked with videographers creating an outreach video for the College Forests and the College of Forestry, and informally presented research to Sarah Beldin with USGS (FRESC) for general use at USGS. Finally, we have also provided an interview to Hannah O'Leary for an article for the Oregon Stater magazine focused on the history of the College Forest.

Finally, we are organizing a symposium on cavity-nesting bird ecology at the joint 2017 meeting of the American Ornithological Society and Canadian Society of Ornithologists. This symposium will bring together researchers from across North America to share results from studies focused on cavity-nesting bird species, and we are targeting students and other young professionals (e.g., postdoctoral researchers) for inclusion in the symposium.

List of presentations, posters:

Barry, A. M., J. C. Hagar, and J. W. Rivers. 2016. Created snag dynamics and impacts on cavity-nesting bird communities over 25 years in western Oregon. Invited oral presentation at the West Coast Regional Meeting of The National Council for Air and Stream Improvement, Inc., Vancouver, WA.

Comstock. A. M. 2015. An investigation of long-term use of created snag by cavity-nesting birds in timber stands in the Pacific Northwest. Poster presentation at the annual Western Forestry Graduate Research Symposium (WFGRS), Oregon State University, Corvallis, Oregon. ***Won award for best overall poster.***

Comstock, A. M., J. C. Hagar, and J. W. Rivers. 2015. Re-evaluation of the effectiveness of created snags as bird habitat after 25 years. Oral presentation at the Willamette Valley Bird Symposium, Oregon State University, Corvallis, Oregon.

Comstock, A. M. 2014. An investigation of long-term avian use of created snags in managed forests. Oral presentation to the AVES seminar group, Oregon State University, Corvallis, Oregon.

List of publications, thesis citations:

Barry, A. M. An assessment of the long-term ecological value and characteristics of snags intentionally created to provide habitat for wildlife. M.S. thesis, Department of Forest Ecosystems and Society, Oregon State University. Anticipated March 2017.

Barry, A. M., J. C. Hagar, and J. W. Rivers. Created snags provide long-term ecological value for birds breeding in managed Douglas-fir forests. For *Ecological Applications*. Anticipated May 2017.

Projects For Which Funding From FWHMF Has Ended

Original Title: Effects of Landscape-scale Forest Management on Pacific Marten Occupancy and Population Connectivity in Coastal Oregon

Investigators:
Dr. John Bailey, Associate Professor, FERM Department, Oregon State University (OSU)
Dr. Katie Moriarty, Postdoctoral Research Wildlife Biologist, USDA Forest Service, Pacific Northwest Research Station

Project Duration:
2014 –Completed non-invasive Pacific marten (*Martes caurina humboldtensis*) surveys in the landscapes within northern Coos, western Douglas, and western Lane Counties. Conduct initial analysis for Year-1 survey region and produce progress report.
2015 – Completed surveys in the southern Coos, northern Curry, Lincoln, Polk, Tillamook, and Yamhill Counties. Conduct final analysis, submit manuscript.
2016 – Provide edits for the peer-reviewed publication (Moriarty *et al*. 2016) and complete this final report.

Objectives:
1. Conduct systematic surveys for martens across a gradient in management intensities on private, federal, and state lands in the vicinity of two marten populations in coastal Oregon.
2. Deploy hair snares at all marten detection locations to non-invasively collect genetic material for individual identification and abundance estimation.
3. Collaborate with all marten survey efforts to assess distribution, and, as sampling allows, minimum population size and indices of abundance.

Summary of Accomplishments:

Carnivore surveys were conducted during 2015 at over 845 camera stations across the study area, providing >250,000 photographs. Our surveys included over 100 sample units (with 4 camera stations) for assessing distribution and over 200 sample units (with 2 camera stations) to evaluate detectability (jointly funded by the Oregon Forestry Industries Council, OFIC, Figure 1). In total, there were **908** camera or track plate surveys at 348 sample units. We have successfully accomplished one of the *largest* organized carnivore surveys conducted in the Pacific Northwest in a relatively short period (Figure 1D). Our 2015 work built on 87 sample units surveyed during summer 2014 (Figure 1B), and we significantly expanded the geographic extent and focus.

We created and executed three carnivore sampling protocols. Slauson and Moriarty (2014) mirrored prior efforts with Humboldt marten in northern California. Sample units were comprised of two devices (track plate or camera), one at a 2-km systematic grid point and the second at a riparian area or the oldest stand within 500m. Stations were operational for 21 days and checked every 3-4 days.

A revised protocol by Moriarty *et al.* (2015) was created for the OFIC detectability study, a partnered endeavor with Oregon State University and the statistical team at Weyerhaeuser. Two cameras per sample unit, one baited with 2 randomized treatments (bait type, height) and one unbaited or lured along a trail were surveyed for 21 days and checked weekly. The publication is in a final draft phase and is under review by our Weyerhaeuser collaborator (J. Thornton). We expect that it will be submitted for publication this calendar year. Although it was anticipated earlier, we included data from scent detection dog teams and cost evaluation such that managers could assess survey methods more broadly.

Winter survey efforts informed a new protocol, executed during summer 2015. During summer 2015, we modified the Sierra Nevada Carnivore Monitoring Protocol that has been focused on fishers for >10 years (Truex et al. 2013, Zielinski et al. 2013). Sample units consisted of 4 remote cameras, 3 placed in formation similar to Truex et al. (2013) and one trail-based set. Stations were lured, baited with both chicken and catfood, and checked weekly. Sample units were >6km apart and in a random stratified design by access and forest age class. Our goal with the final protocol was to examine the distribution of martens in coastal Oregon.

We detected fisher (*Pekania pennanti*) at 9 sample units and marten at 36 sample units. We detected over 28 species in the Oregon Coast Ranges in 2015. We report the total number of photos (No. Photos), sample units with detections (n = 277 surveyed), and percent for each species or group. Data are ordered by class (carnivores, small mammals, other) and by percent of sample units with detections (Overall Percent), also published in Moriarty *et al*. 2016.

Species	FWHMF (%)	OFIC (%)	No. Photos	Sample Units	Overall Percent
Black Bear (*Ursus americana*)	81	23	23,995	106	47
Spotted Skunk (*Spilogale gracilis*)	54	41	16,777	106	47
Bobcat (*Lynx rufus*)	32	26	814	64	28
Grey Fox (*Urocyon cinereoargenteus*)	23	29	12,266	60	26
Opposum (*Didelphis virginiana*)	22	25	18,151	54	24
Pacific Marten (*Martes caurina*)	3	25	4316	36	16
Raccoon (*Procyon lotor*)	11	14	2195	29	13
Short-tailed Weasel (*Mustela erminea*)	7	8	304	17	7
Striped Skunk (*Mephitis mephitis*)	14	2	118	16	7
Domestic Dog (*Canis familaris*)	0	11	269	15	7
Mountain Lion (*Puma concolor*)	11	3	197	14	6
Fisher (*Pekania pennanti*)	10	0	803	9	4
Coyote (*Canis latrans*)	4	4	83	9	4
Long-tailed Weasel (*Mustela frenata*)	4	1	31	5	2
House Cat (*Felis cattus*)	0	2	25	3	1
Ringtail (*Bassariscus astutus*)	0	2	117	2	1
Mice and Voles (*Peromyscus, Myodes, Microtus*)	67	61	13,689	144	63
Douglas Squirrel (*Tamiasciurus douglassii*)	51	53	2128	118	52
Chipmunk (*Tamias* spp.)	65	29	6082	99	44
No. Flying Squirrel (*Glacomys sabrinus*)	47	23	1058	75	33
Woodrat (*Neotoma* spp.)	26	11	3381	39	17
Cottontail (*Sylvilagus* spp.)	23	8	1217	33	15
California Ground Squirrel (*Otospermophilus beecheyi*)	6	0	272	6	3
Gray Squirrel (*Scirus griseus*)	0	5	27	6	3
Golden-manteled Ground Squirrel (*Callospermophilus lateralis*)	2	0	9	2	1
Birds	82	63	20,814	161	71
Deer (*Odocoileus* spp., *Cervus* spp.)	70	29	4880	104	46

The combination of the OFIC effort paired with the FWHMF marten distribution surveys were submitted to the Northwest Naturalist in December 2015 and published this fall (Moriarty *et al.* 2016). Title: Distribution of Pacific marten in coastal Oregon. Authors: Katie M. Moriarty, John D. Bailey, Sharon E. Smythe, and Jake Verschuyl.

Acknowledgement section: "**Survey efforts were largely funded by the Oregon State University Fish and Wildlife Habitat in Managed Forests Research Program** and the National Council for Air and Stream Improvement. The Oregon Forestry Industry Council funded surveys within 5-km of prior locations. USDA Forest Service, Pacific Northwest Research Station funded data management and provided external support. Additional surveys were conducted by Hancock Forest Management, Plum Creek, USDA Forest Service (USFS) Siuslaw National Forest, Oregon Department of Forestry, and the Confederated Tribes of Siletz Indians of Oregon. Considerable aid with field logistics, vehicles, housing, and equipment was provided by the US Fish and Wildlife Service, Salem District Bureau of Land Management (BLM), USFS Rogue River-Siskiyou and Siuslaw National Forests, Weyerhaeuser, Hancock Forest Management, and USFS Region 6 Regional Office. We obtained private land access or surveys were completed by trained staff within the ownership for all randomly selected survey points – thanks to Plum Creek, Weyerhaeuser, Hancock Forest Management, Starker Forests, and Roseburg Timber for access or data. Thanks to Keith Slauson, Pacific Southwest Research Station, who assisted during the 1st year with study design and explaining California protocols. Extreme thanks to all field crew leaders (S Smythe, M Linnell, B Peterson, GW Watts, J Bakke, C Shafer, K Kooi, and M Penk) and team members (D Baumsteiger, M.Cokeley, J Ellison, P Iacano, A Kornak, T McFadden, E Morrison, A Palmer, N Palazzotto, S Roon, S Riutzel, C Scott, R Smith, T Stinson, and M Williams)."

The field team above consisted of Oregon State employees, students, and the employees from Hancock Timber and Plum Creek that helped with the surveys.

Problems, Barriers, Proposed Changes to Objectives:

We changed our 2014 protocol and our plan from the original proposal given the lack of initial detections. Instead of continuing to survey martens along a gradient of forest types, we prioritized to simply evaluating the distribution of martens in coastal Oregon. This shift to a large-scale distribution survey required additional crew members, time, and funding. We consulted with our collaborators about the change in focus and revised protocols, and we obtained funds from the NCASI to supplement our efforts.

We therefore have neither the positive marten occurrence data nor additional funding/time to conduct home range analyses on vegetation composition and forest management configuration as originally proposed. We detected martens at two locations near the South Coast population and one location in the Central Coast survey during the 2014 and 2015 work from this grant. A model based from two positive occurrences (detection sites) and over 500 negative occurrences would, of course, not be representative of the conditions in which martens persist. We detected martens during surveys funded by the OFIC, but that study design was not randomized across the gradient of forest types. The OFIC detectability surveys were solely conducted within known marten populations and may not be representative of all home range and landscape conditions (but see Planned Work).

Planned Work:

N/A. A publication has been completed from this grant. However, in terms of future direction for related research, there are four efforts that are in progress:

1. We have collected fine-scale vegetation data and aim to compare between marten locations and northern spotted owl habitat expectations. Vegetation data were collected at a combination of locations in which martens have been detected (e.g., scat dog, telemetry). This work was funded by NCASI. Dennis Rock (NCASI) and his team completed the surveys by September 2016, 395 vegetation plots were planned. The data are being entered currently. We hope to prioritize these analyses in the very near future (J. Verschuyl and K. Moriarty, personal communication).

2. Charlotte Eriksson, a visiting scholar, has completed her masters on small mammal diversity and abundance in the Central Coast dunes (Eriksson 2016). She is currently using novel metabarcoding methods to evaluate marten diet and will be comparing diet versus available and potentially adding other camera data. She is being mentored by Dr. Taal Levi and Moriarty.

3. Mark Linnell and Moriarty finished GPS telemetry surveys during fall 2015 in the Central Coast dunes. Eleven martens were radio collared. Movement data, density, and minimum population size are being estimated.

4. Scat detection dog surveys have been funded by FWHMF in southern Oregon (see other report). In addition, Coos Bay BLM will be conducting detection dog surveys. With the combination of surveys, we hope to collect scats in the coast, Klamath-Siskiyou mountain range, and southern Cascades – focusing on fisher, marten, bobcat, and lion. NCASI funded meta-barcoding to evaluate diet and move forward to describing potential limiting factors for fisher and marten in Oregon. Field work will occur during 2017. Genetic analyses should be finished within 8 months following scat collections.

Comprehensive Summary:
These data will be used to inform the USFWS for listing petitions and decisions, although it is uncertain what the current state is within the agency. The USFWS was sued by the Center of Biological Diversity and partners during December 2015. It is unknown how agencies are using data, but we have provided timely peer-reviewed information as to the current status of martens in coastal Oregon.

These distribution data (Moriarty et al. 2016) have been the foundation for fisher and marten surveys is coastal Oregon (see Planned work). As of summer 2016, we surveyed 348 sample units using a total of 72 track plate and 908 remote camera stations for greater than 14 days each within a 25,330 km^2 area, yielding 355,018 photographs. Martens were detected (photographs, tracks, or genetically verified hair samples) at 72 sample units. We detected 28 individual martens in coastal Oregon using a combination of genetic confirmation and captured individuals. Marten observations were clustered in the Central and South Coast regions, suggesting existing populations have persisted since published observations prior to 1998. We did not locate new populations despite an extensive effort to survey new areas, but did learn a unique population exists in the coastal dunes of Central Oregon.

Undergraduate Engagement in Project:
We provided research experience and internships for four OSU undergraduates and one former undergraduate during 2014. In 2015, we worked with four recent OSU graduates (2 MS and 2 BS students) and two BS students from other institutions (Humboldt State and Paul Smith College). In addition, we are collaborating with a visiting scholar from Sweden (focusing her masters on small mammal abundance and diversity). Research experience consisted of training by multiple agencies

(Weyerhaeuser, Hancock Timber, BLM, and USFS) regarding field safety, participating in the field survey, and data management activities.

Undergraduate student participants from OSU included: Erin Morrison (female, senior status), Thomas Stinson (E-campus student, Fisheries emphasis, male junior status), Jordan Ellison (female, senior status), Corwin Scott (male, junior status), and Allen Palmer (male, senior status).

List of Presentation and Publications:

Presentations with these data:

Moriarty, K.M., M.A. Linnell., B.R. Barry. 2017. Distribution to Density: updates regarding coastal marten and fisher in Oregon and Washington. Western Section-TWS Annual Conference, Reno, NV.

Moriarty. K.M., Golding, J. and many others. 2017. Assessing surveying methodologies to address information gaps for forest carnivores. Oregon Forest Carnivore Working Group. (January).

Moriarty. K.M., Golding, J. and many others. 2016. Assessing surveying methodologies to address information gaps for forest carnivores. USDA Forest Service and Association of Fish and Wildlife Agencies Monthly Webinar Series (November).

Moriarty, K. M., S.M. Matthews, T. Levi, J. Thornton, J.D. Bailey, M.A. Linnell, B.R. Barry. 2016. Update and considerations for marten and fisher monitoring. Oregon-TWS Annual Conference, Forest Carnivore Meeting, Seaside, OR.

Moriarty, K. M., S.M. Matthews, T. Levi, J. Thornton, J.D. Bailey, M.A. Linnell, B.R. Barry. 2016. If we build it, will they come? Considerations for marten and fisher monitoring. Oregon-TWS Annual Conference, Seaside, OR.

Watts, G.W. III, K.M. Moriarty, and M.A. Linnell. 2016. Comparing the cost-effectiveness and reliability of scent detection dogs and remote cameras for sampling coastal martens in Oregon. Poster. Western Section-TWS Annual Conference, Pomona, CA. (largely funded by OFIC)

Moriarty, K.M., J.D. Bailey. 2015. Humboldt marten update. NCASI barbeque and campout ~40 representatives from all land ownerships and all regional projects (e.g., ODFW, BLM Region and districts, USFS R6 and districts, USFWS Roseburg, Hancock Timber, Plum Creek, Weyerhaeuser). 2 day meeting with 45 minute presentation.

Moriarty, K.M., G.W. Watts. 2015. Humboldt marten ecology and knowledge. Dunes field trip with 9 representatives from local land ownerships dunes restoration (e.g., USFWS, Siuslaw National Forest, Central Coast Ranger District (Ranger, district biologist and staff), R6 Ecologist). Full day meeting with continuous marten discussions.

Moriarty, K.M., K.M. Slauson, J.D. Bailey. 2014. Humboldt marten update – collaborative efforts and future strategies. U.S. Forest Service Region 6 Wildlife Program Managers Meeting. Green Springs, Oregon.

Moriarty, K.M., K.M. Slauson, J.D. Bailey. 2014. Humboldt marten update – collaborative efforts, future strategies, and resource needs. National Council for Air and Stream Improvement (NCASI) West Coast Regional Planning Meeting. Vancouver, Washington.

Publications or official reports:

Eriksson, C. 2016. Martens in a novel habitat - the importance of prey and habitat structure. M. S. thesis, Lund University. Lund, Skåne, Sweden.

Moriarty, K. M., J. D. Bailey, S. E. Smythe, and J. Verschuyl. 2016. Distribution of Pacific marten in coastal Oregon. Northwestern Naturalist 97:71-81.

Literature cited:

Eriksson, C. 2016. Martens in a novel habitat - the importance of prey and habitat structure. M. S. thesis, Lund University. Lund, Skåne, Sweden.

Moriarty, K. M., J. D. Bailey, S. E. Smythe, and J. Verschuyl. 2016. Distribution of Pacific marten in coastal Oregon. Northwestern Naturalist 97:71-81.

Moriarty, K. M., M. A. Linnell, J. Thornton, and J. D. Bailey. 2015. Humboldt marten detectability protocol Oregon State University, Unpublished protocol: 6.

Slauson, K. M. and K. M. Moriarty. 2014. Determining the distribution and size of Humboldt marten populations in coastal Oregon: survey design and field survey protocol. Humboldt Marten Working Group, Unpublished Protocol:

Truex, R. L., J. M. Tucker, J. S. Bolis, J. J. Vale, and S. J. Hegg. 2013. Forest carnivore monitoring protocol: phase II. Sierra Nevada Forest Plan Amendment Strategy Report.:

Zielinski, W. J., J. A. Baldwin, R. L. Truex, J. M. Tucker, and P. A. Flebbe. 2013. Estimating trend in occupancy for the southern Sierra fisher *Martes pennanti* population. Journal of Fish and Wildlife Management 4:3-19.

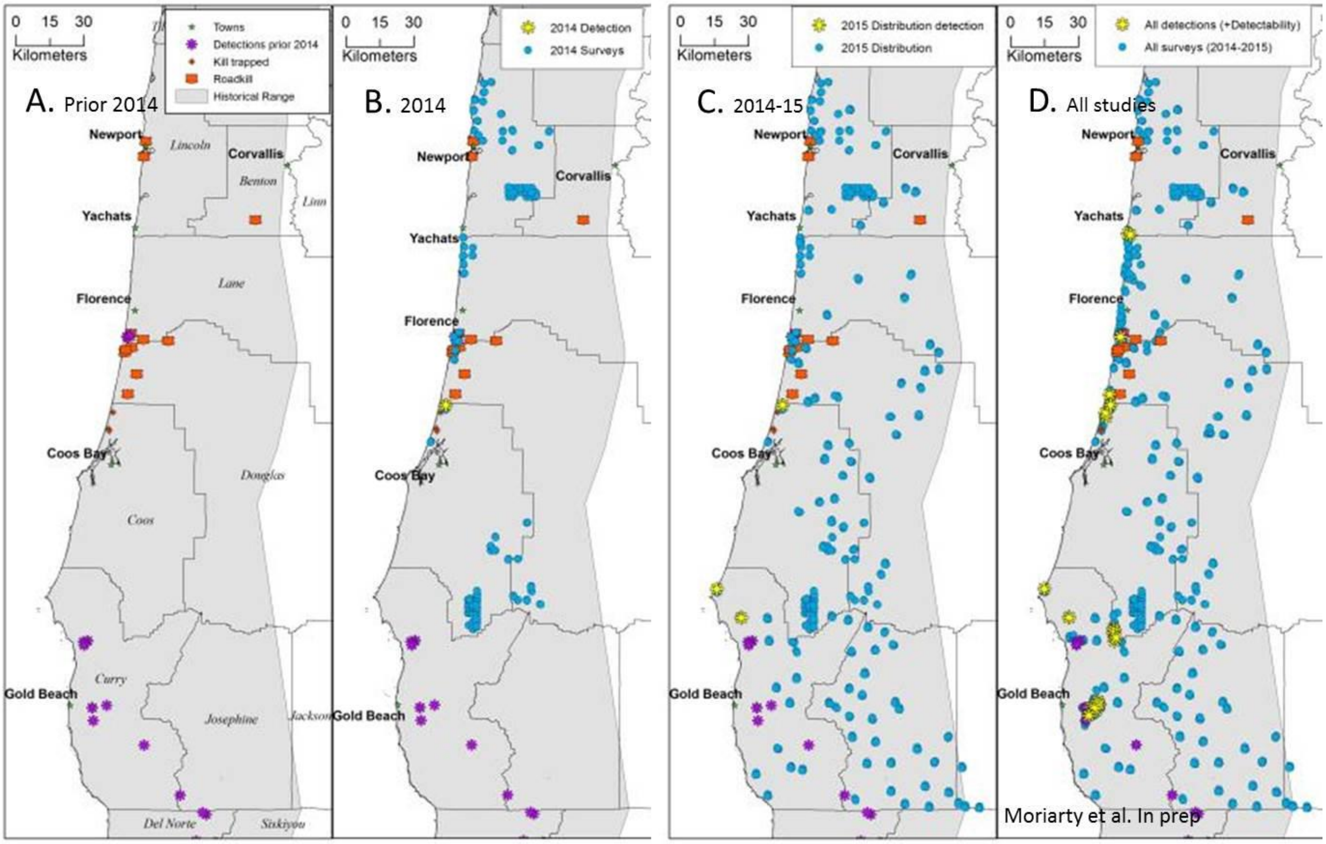


Figure 1. Humboldt marten (*Martes caurina humboldtensis*) distribution map. **A)** Verified locations before included 14 road kill (red highway symbols), 3 legal kill trap records (red bullseye) and 9 locations from surveys (purple stars). **B)** Teams surveyed 87 sample units (blue) in 2014 for 21 days using the Slauson and Moriarty (2014) protocol with two stations per sample unit, one on a systematic point and one near a riparian area or the oldest stand within 500m. A single marten was detected (yellow star) during fall surveys sponsored by the Siuslaw National Forest and Hancock. **C)** Teams surveyed over 100 sample units for 15 days using the Moriarty et al. (2015) protocol sympatric with Sierra Nevada Carnivore Monitoring, each sample unit consisted of 4 remote cameras, 3 in a triangle and 500m apart and one along a trail >75m from a station. Two martens were detected (yellow stars). **D)** All surveys completed in 2014-2015 (blue, some still in progress and to be added) and all detections (yellow stars). This includes the OFIC sponsored detectability study with greater than 200 sample units and 400 camera stations surveyed for 21 days as well as scat detection dog (Conservation Canines) verified locations. With all efforts combined, martens have been detected at 72 locations with new locations verified weekly with current efforts in the Central Coast population.

Title: Assessing the demographic response of an early seral songbird to intensive forest management

Investigators:
Dr. Matthew G. Betts (CoF, OSU), Dr. James W. Rivers (CoF, OSU)

Project duration:
Our group initiated a two-year (2013-2014) landscape-scale manipulative experiment to assess how IFM impacts songbirds that require early seral forests. Funding from FWHMF funding was obtained to expand this work by supporting field operations scheduled for the 2015 field season (May-August).

Study objectives:
1. Determine whether the intensity of herbicide application is linked to songbird nesting success.
2. Quantify juvenile survival during the critical period immediately after young fledge from the nest.
3. Assess survival of adults that depend on early seral habitats to raise their young.

Summary of accomplishments over past year:
Good progress continued to made on the avian demography study over the last year. As discussed in past progress reports, we did not conduct field work in 2015 but instead undertook detailed data analysis on data collected during the 2013 and 2014 field seasons (>760 sparrow nests located, 70 fledglings radio-tagged). That work has uncovered several important results regarding how herbicides impact songbird demography. Against our initial predictions, we detected no difference in the daily survival rate of nests located across our gradient of experimental herbicide application ($X2 = 3.56$, $P = 0.313$) although daily survival rate was notably lower in the second year of study for all treatments 2014 ($X2 = 12.83$, $P < 0.001$), with no treatment × year interaction ($X2 = 0.38$, $P = 0.944$; Fig. 1A). When examining the number of fledglings produced ha-1 we detected a treatment × year effect on area-specific reproductive output ($F3,8 = 14.69$, $P = 0.001$), but no effect of treatment ($F3,9 = 0.49$, $P = 0.695$) or year ($F1,3= 0.14$, $P = 0.732$; Fig. 1B). For the two least intensive treatments (control, light) area-specific productivity decreased from 2013 to 2014, whereas the opposite pattern was found for the two most intensive treatments (moderate, intensive; Fig. 1B). This result reflects the “green-up” hypothesis, which posits that any negative effects of herbicide on songbird reproduction in the early stages of succession becomes dampened in later years once vegetation emerges in stands on which herbicides are applied more intensively.

In addition to nest survival, we also evaluated post-fledging survival of juvenile sparrows (n=70) from nests located in stands subjected to no-spray control and moderate herbicide treatments. Using Cox-proportional hazards modeling we found no evidence for a difference between post-fledging survival between the two treatments (ß = 0.48 [95% CI: -0.18, 1.14], hazard ratio = 1.62 [95% CI: 0.84, 3.13], $X2 = 2.04$, $P = 0.154$) or year of study (ß = -0.47 [95% CI: -1.15, 0.21], hazard ratio = 0.62 [95% CI: 0.31, 1.24], $X2 = 1.84$, $P = 0.175$). However, we did detect a positive effect of the date of tag deployment on survival (ß = 0.19 [95% CI: 0.10, 0.27], hazard ratio = 1.20 [95% CI: 1.12, 1.32], $X2 = 20.49$, $P < 0.001$). Our results indicate that fledglings raised in unsprayed stands survived approximately half as long as those in stands subjected to current-day herbicide application practices. One hypothesis for this pattern is that the greater vegetative cover on unsprayed stands may have provided more hiding cover for predators of fledglings (e.g., snakes, small mammals) that are themselves preyed upon by higher-order predators (e.g., raptors).

Problems, barriers, proposed changes to objectives:

Observations made during summer 2014 indicated that the expected post-herbicide vegetation response had not advanced at the rate initially expected for all treatments. Because of this, we shifted our investigation of this response so that field work was to be conducted during the 2016 breeding season (May-August). However, observations made during both the 2015 and 2016 summers indicated that the density of White-crowned Sparrows was markedly reduced on stands subjected to no-spray control and light herbicide application treatments, making it impossible to obtain adequate nesting data for testing effects across the full suite of experimental treatments. This was due to rapid vegetation succession on control and light herbicide treatment stands during our study that reduced the amount of bare ground required by sparrows for foraging. Assessment of bird point data collected during 2015-2016 indicated that those declines continued, preventing us from collecting additional demographic data for this study and instead focusing on changes to the community level via point-count data via a related investigation.

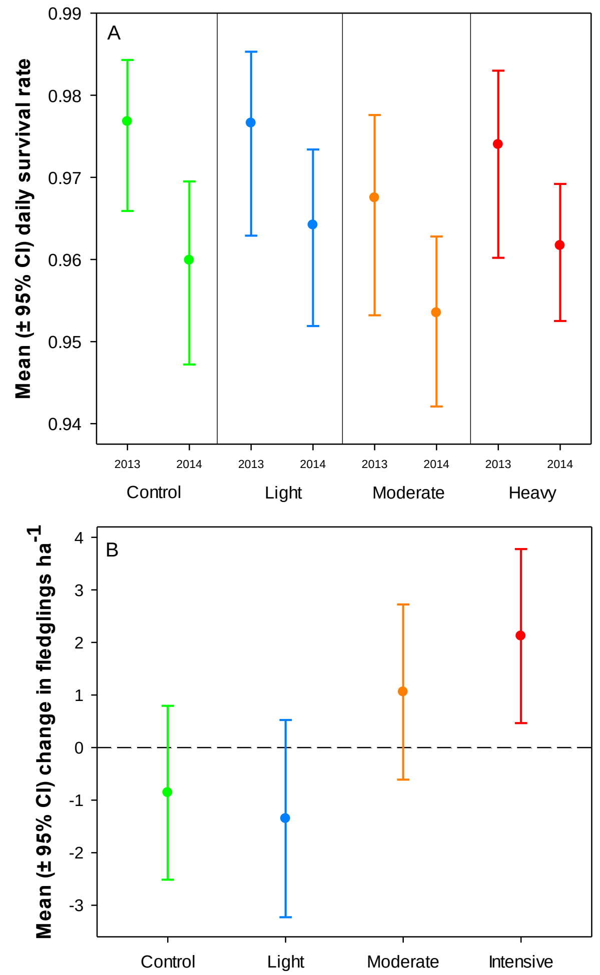


Fig. 1 | Results of a manipulative experiment testing the impacts of herbicide treatments on songbird demographic rates . Nest daily survival rate did not differ between experimental treatments, but was significantly lower in 2014. **(B).** There was a reduction in the number of fledglings produced ha^{-1} between years for nests on no-spray control and light herbicide treatment stands, whereas an increase was found for moderate and intensive herbicide treatment stands, indicating recovery from initially low levels due to management intensity. Point estimates in **(B)** are differences between years (2014 – 2013); dashed line = no difference between years.

Planned work:

Given the large and extensive dataset we have collected and the clear change in response to herbicide treatments we have already detected (Fig. 1B), we decided that adequate data had been obtained for rigorously testing our hypotheses about the impact of herbicides on demographic rates. Therefore, over the past year we have finalized data analysis and manuscript writing for the focal work in this project, and a manuscript form this effort is currently under peer review. However, we have expanded our initial project goals to evaluate how herbicide application intensity influences sex ratio of sparrow offspring through a collaboration with Dr. Brent Horton at Millersville University, Millersville, PA. Dr. Horton and his student, Jennifer Houtz. Molecular sexing for >1000 sparrow nestlings was undertaken during summer 2016 and we are in the process of writing up those results into a manuscript, with submission to Conservation Physiology targeted for early 2017.

Comprehensive summary of project results and impacts over life of project:
Results from our study have already provide new and valuable information about the demographic response of songbirds to intensive forest management practices. Against initial predictions, we have shown that key demographic rates (i.e., nest success, post-fledging survival) of a declining early-successional forest bird was not influenced by the degree of herbicide application on intensively managed stands. Moreover, we found an unexpected interaction between herbicide treatment and time since harvest, indicating that early-successional forest habitats are much more dynamic that previous work has indicated. Our research has also demonstrated that a key characteristic that relates to population structure, namely offspring sex ratio, is not influenced by the degree of herbicide application intensity. Finally, additional work being leveraged from this project is current assessing how the physiological health of adults and offspring are influenced by herbicide application intensity; thus, we expect to produce at least 3 peer-reviewed publications from this project. In addition to sharing this information via peer-reviewed scientific journals, we regularly provide presentations and outreach events for biologists, managers, and other members of the forest industry community so that our results have the broadest impacts as possible. As such, we expect that the impact of our work will extend well into the future and be used by resource managers whose goals are to balance timber production with the conservation of biological diversity.

List of names and brief overview of young professionals engaged with project:
Kristin Jones (Department Forest Ecosystems and Society, Oregon State University) was involved with the project as a graduate student and successfully defended her M.S. thesis in December 2016, which investigated the interactive effects of intensive forest management and temperature on offspring production in the House Wren. She has submitted one of her thesis chapters for publication to a peer-refereed journal (Forest Ecology and Management), and we expect a second manuscript to submitted to a second journal in the near future (Canadian Journal of Forest Research).

Jonah Powell (Department of Fisheries and Wildlife Science, Oregon State University) was involved with the project as an undergraduate student and collected towards an independent study assessing how food provisioning of the House Wren was influenced by the intensity of forest management practices.

Jennifer Houtz (Department of Biology, Millersville University) became involved with the project as an undergraduate honors student during summer 2016. She undertook laboratory work to evaluate how forest herbicide application intensity was linked to offspring sex ratio for nests used in the course of this study. She has already given two presentations on this research to date, including an international ornithological conference, and we anticipate submitting the results from this work to a peer-refereed journal in early 2017.

During summer 2014, 10 enrolled and recent graduates from colleges and universities across the United States were hired to undertaken field data collection for project objectives. Additionally, 17 undergraduate students from Oregon State University obtained research experience on the project by collecting House Wren adult provisioning data from videos during eh 2014-2015 academic year.

List of presentations, posters:
Rivers, J. W. 2016. Evaluating the effects of intensive forest management on songbird productivity. Invited oral presentation and panel discussion at the annual meeting of the Oregon Forest and Industries Council, Sun River, OR.

Rivers, J. W. 2016. Testing the impact of experimental herbicide treatments on breeding productivity of early-successional forest songbirds. Invited oral presentation at the annual meeting of the Pacific Northwest Reforestation Council, Vancouver, WA.

Houtz, J. L., J. W. Rivers, B. M. Horton, and M. G. Betts. 2016. Evaluating the influence of forest herbicides on offspring sex ratio in an early-successional forest songbird. Poster presentation at the 6th North American Ornithological Conference, Washington, D.C.

Houtz, J. L., J. W. Rivers, J. W., B. M. Horton, and M. G. Betts. 2016. Poster presentation at the annual Pennsylvania State System of Higher Education Undergraduate Research Conference in Science, Technology, Engineering, and Mathematics, Millersville, PA.

Jones, K. N., J. W. Rivers, and M. G. Betts. 2015. Effects of intensive forest management on reproductive success in a cavity-nesting songbird. Oral presentation for the Bird Nerds Student Club, Corvallis, Oregon.

Jones, K. N., J. W. Rivers, and M. G. Betts. 2015. Effects of intensive forest management on reproductive success in a cavity-nesting songbird. Oral presentation at the first annual Willamette Valley Bird Symposium, Corvallis, Oregon.

Rivers, J. W., M. G. Betts, A. J. Kroll, C. J. Schwarz, and J. Verschuyl. 2015. Songbird demographic response to herbicide application in early-seral forest. Oral presentation at the 133rd meeting of the American Ornithologists' Union, Norman, OK.

Rivers, J. W., J. Verschuyl, A. J. Kroll, and M. G. Betts. 2015. The influence of intensive forest management practices on breeding success of the White-crowned Sparrow, an early-seral songbird. Oral presentation at the Oregon Chapter of The Wildlife Society, Eugene, OR.

Rivers, J. W., J. Verschuyl, A. J. Kroll, and M. G. Betts. 2015. Influence of intensive forest management on the breeding success of an early-seral songbird. Oral presentation at the Washington Chapter of The Wildlife Society, Grand Mound, WA.

Rivers, J. W., J. Verschuyl, A. J. Kroll, and M. G. Betts. 2015. Quantifying tradeoffs between biodiversity and timber production in western Oregon. Oral presentation at the Washington Chapter of The Wildlife Society, Grand Mound, WA.

Betts, M. G. 2014. Introduction to the Intensive Management Study. Invited oral presentation at the Wildlife in Managed Forests: Songbirds and Early Seral Habitats Symposium, Oregon Forest Resources Institute, Albany, Oregon.

Betts, M. G. 2014. Are changes in bird abundance likely to influence insect abundance and herbivory on trees? Invited oral presentation at the Wildlife in Managed Forests: Songbirds and Early Seral Habitats Symposium, Oregon Forest Resources Institute, Albany, Oregon.

Jones, K. N., J. W. Rivers, and M. G. Betts. 2014. Effects of intensive forest management on reproductive success in a cavity-nesting songbird. Poster presentation at the 132nd meeting of the American Ornithologists' Union, Estes Park, Colorado.

Rivers, J. W. 2014. Songbird demography in early seral habitats. Invited oral presentation at the Wildlife in Managed Forests: Songbirds and Early Seral Habitats Symposium, Oregon Forest Resources Institute, Albany, Oregon.

Rivers, J. W., J Verschuyl, A. J. Kroll, and M. G. Betts. 2014. Quantifying the demographic consequences of intensive management practices on breeding birds in early seral plantation forests. Invited oral presentation at the 2014 Annual Meeting of the Oregon Chapter of The Wildlife Society, Bend, OR.

Rivers, J. W., and M. G. Betts. 2014. Intensive forest management practices reduce nest survival and offspring production: evidence from a landscape-scale experiment. Oral presentation at the 132nd meeting of the American Ornithologists' Union, Estes Park, Colorado.

Verschuyl, J., A. J. Kroll, J. W. Rivers, K. Jones, and M. G. Betts. 2014. A manipulative study of the effects of forest herbicide use on nest success of early seral birds. Oral presentation at the 2014 Annual Meeting of the Washington Chapter of The Wildlife Society, Pasco, WA.

List of publications, thesis citations

Rivers, J. W., M. G. Betts, A. J. Kroll, C. J. Schwarz, and J. Verschuyl. In review. Dynamic response in breeding productivity to experimental herbicide treatments by an early-successional forest songbird.

Jones, K. N., J. W. Rivers, and M. G. Betts. In review. Intensive forest management practices exert weak and variable effects on microclimate in early-seral forest.

Rivers, J. W., J. L. Houtz, B. M. Horton, and M. G. Betts. High-throughput molecular sexing finds no link between forest herbicides and offspring sex ratio in a migratory songbird. Anticipated for submission to Conservation Physiology.

Jones, K. N., M. G. Betts, and J. W. Rivers. Intensive forest management and local microclimate exert negligible effects on reproductive success in a cavity-nesting songbird. Anticipated for submission to Canadian Journal of Forest Research.

Jones, K. N. 2015. Effects of intensive forest management on air temperature and reproductive success in a cavity-nesting songbird. M.S. thesis, Department of Forest Ecosystems and Society, Oregon State University. December 2015.

Title: Top-down effects of wildlife and bottom-up drivers of soils and productivity in intensively managed forest plantations

Investigators:
PI (point of contact): Jeff Hatten (Forest Engineering, Resources & Management)
Co-PIs: Matt Betts and Thomas Stokely (Forest Ecosystems and Society)

Project duration:
July 1, 2015 – June 30, 2017

Objectives:

1. Determine the quantity and quality of O-horizon available to arthropod detritovore communities and detrital arthropod prey to songbirds.

2. Characterize the interacting effects of IFM and bird abundance on detrital arthropod communities and relative decomposition rates.

3. Characterize the impact of IFM on cervid use and the subsequent effects on relative decomposition rates.

4. Characterize role of top-down and bottom-up processes on soil fertility and conifer growth.

Summary of accomplishments toward objectives over past 12 months:

Personnel:

- Graduate student (Dave Frey (FERM)) has been hired and funded for his first year of graduate school from a FERM department AOC fellowship. His second year of funding will be paid from this project.

Data Collection:

- All foliar samples were collected from 4 Douglas-fir trees in every treatment and exclosure December, 2015. These samples have been dried, ground, and analyzed for C&N. These samples are currently in the queue at the CEOAS Stable Isotope Lab for stable isotope analysis in order to examine treatment effects on water relations ($\delta^{13}C$) and nitrogen cycling ($\delta^{15}N$).
- All forest floor and mineral soil samples have been collected from each block, treatment, and exclosure. We expanded the soil sampling effort to include two mineral soil horizons (0-15cm and 15-30cm).
- All mineral soil samples have been dried, sieved, and ground and analyzed for C&N. These samples are in the queue at the CEOAS Stable Isotope Lab for stable isotope analysis in order to examine treatment effects on relative rates of cycling of carbon and nitrogen.
- Currently, due to variable quantities of decomposing wood in O-horizon samples among sites and blocks, O-horizons are in the waning stages of being sorted to remove decomposition class four and five materials. We are nearly complete with this process and most samples have been analyzed for C&N and sent to CEOAS Stable Isotope Lab.
- All soil samples' bulk density, moisture content, and pH have been determined.

- To better examine the effects of the treatments on decomposition we have established at litter-bag decomposition study. Five litter bags filled with a homogenous set of Douglas-fir needles picked from trees (to better represent the litter entering a site after harvest) has been installed in each treatment and exclosure. We have collected the first set of samples at 3 months and plan to collect the remainder (4) at 6, 12, and 24 months. This first set of litter bags (90 days) has been analyzed for C&N.

Problems, barriers, proposed changes to objectives:

- Burlese funnel analysis was unproductive, most likely due to disturbance of the O-horizon collection area when removing biomass. The process was aborted after completing a full block without successfully collecting arthropods. We will use arthropod data collected from sweep nets and pit traps to examine the impact of the treatments on the decomposer community. Dave Frey will begin the work of analyzing that data over the coming months.

Planned work:

- Determine total carbon and nitrogen contents for Oi, Oe/Oa, and separated decomposed wood
- Stable isotope analyses on all O-horizon components
- Loss-on-ignition on all O-horizon components

- Stable isotope analysis on foliar samples
- Collect remaining sets of litterbags
- Calculate mass loss for remaining litterbags
- Determine total carbon and nitrogen contents for remaining litterbags
- Sort O-horizons (sorting into decayed wood from previous stand and forest floor material from regrowing stand)
- Our goals:
    - Have all data (except litterbags) collected by January, 2017
    - Have all data analysis, reduction, and presentation (figures and tables) complete by March, 2017
    - Dave Frey's thesis defense in late Spring.

List of names and brief overview of graduate and/or undergraduate engagement in project:
Dave Frey has taken the lead on all soil sample collection, processing, and laboratory analysis. Dave will be taking the lead on all data analysis and manuscript/thesis preparation. He will also work with Thomas Stokely and other members of the research team to integrate these results into the efforts of the entire project.

Thomas Stokely is working with Dave to collect soil and vegetation samples and the assist the integration of soils and vegetation data into the overarching goals of the project.

Mandy Allen-Kahl (NR), Hayden England, and Ethan Donoghue are undergrads working on the project to assist in sample preparation and analysis.

List of presentations, posters, etc.:

- Frey, D., J. Hatten, T. Stokely, M. Betts. 2016. Top-down Effects of Wildlife and Bottom-up Drivers of Soils and Productivity in Intensively Managed Forest Plantations. 2016 Western Forestry Graduate Research Symposium, Corvallis, OR. April 22, 2016. (poster)

- Frey, D., J. Hatten, T. Stokely, M. Betts. 2016. Effects of the interplay between wildlife, plant communities, decomposition and soils on productivity in intensively managed forest plantations. 2016 Ecological Society of America Annual Meeting, Fort Lauderdale, FL. August 7-12, 2016. (poster)

- Frey, D., J. Hatten, T. Stokely, M. Betts. 2016. Effects of the interplay between wildlife, plant communities, decomposition and soils on productivity in intensively managed forest plantations. 2016 Soil Science Society of America Annual Meeting, Phoenix, AZ, November 7-9, 2016. (poster)

List of publications, thesis citations:
None to report

Title: Natural Variability in Water Quality and Changes after Forest Harvest in the Trask Watershed

Investigators:
PI: Jeff Hatten, OSU FERM; Co-PIs: Alba Argerich, OSU FERM, Sherri Johnson, PNW.
Kevin Bladon, OSU FERM has joined the team as Casey Steadman co-advisor

Project duration:
July 1, 2014 – June 30, 2016

Objectives:
To improve the current understanding of patterns and causes of variability in water quality across forest watershed landscapes we will characterize natural and post-disturbance variability in stream nutrients at the Trask River watershed. Specifically, we will:

- Characterize variability in background nutrient concentrations across time, by analyzing water chemistry samples collected over the pre-harvest period, and across space, by comparing water chemistry data across sub-catchments.
- Analyze responses in nutrient concentrations to forest harvest by comparing pre- and post-harvest nutrient concentrations.
- Compare pre- and post-harvest data to nutrient criteria under consideration for this ecoregion.

Summary of accomplishments toward objectives over past year:

- We have integrated hydrology data with water chemistry data to explore patterns of nutrient transport (Fig. 1).
- Storm water samples collected over the duration of the Trask study (2010-2016) have been started to be analyzed to expand the database of water chemistry.

Problems, barriers, proposed changes to objectives:
The analysis of the complete set of storm water samples has been delayed until next spring due to the moving of the laboratory where we are analyzing all of our samples (the COLLAB) during Peavy remodel.

Comprehensive summary of project results and impacts over life of project:
Preliminary data analysis reveal that nutrients surpass proposed criteria throughout the year with at least 57% of analyzed samples surpassing Total Nitrogen (TN) proposed criteria of 0.12 mg L^{-1} and at least 88% surpassing Total Phosphorus (TP) proposed criteria of 0.010 mg L^{-1} (Fig. 1) Maximum concentrations were generally observed in winter months for TDN while the opposite was true for TDP, indicating distinct drivers of temporal variability for each nutrient. Spatial variability (Fig. 2) is observed among the four catchments as Upper Main Creek had the lowest median concentrations of TDN (0.100 mg L^{-1}) and TDP (0.009 mg L^{-1}) while Pothole Creek had the highest median concentrations of TDN (0.170 mg L^{-1}) and TDP (0.043 mg L^{-1}). Additionally, Pothole Creek surpassed proposed criteria most frequently with at least 76% and 95% of samples exceeding TN and TP proposed criteria, respectively. The highest

concentrations of both TDN and TDP have generally been observed in Pothole Creek, which is underlain by highly erodible volcaniclastic geology and characterized by the presence of swampy areas. In Pothole Creek, higher concentrations and greater variability of nitrate were observed during the rising limb of the annual hydrograph compared to the falling limb while orthophosphate showed little variability or change in magnitude when comparing rising and falling limb concentrations (Fig. 3) indicating different drivers for nitrogen and phosphorus. The trends observed in Pothole Creek were representative throughout all sub-catchments. For a more expanded results see the attached posters.

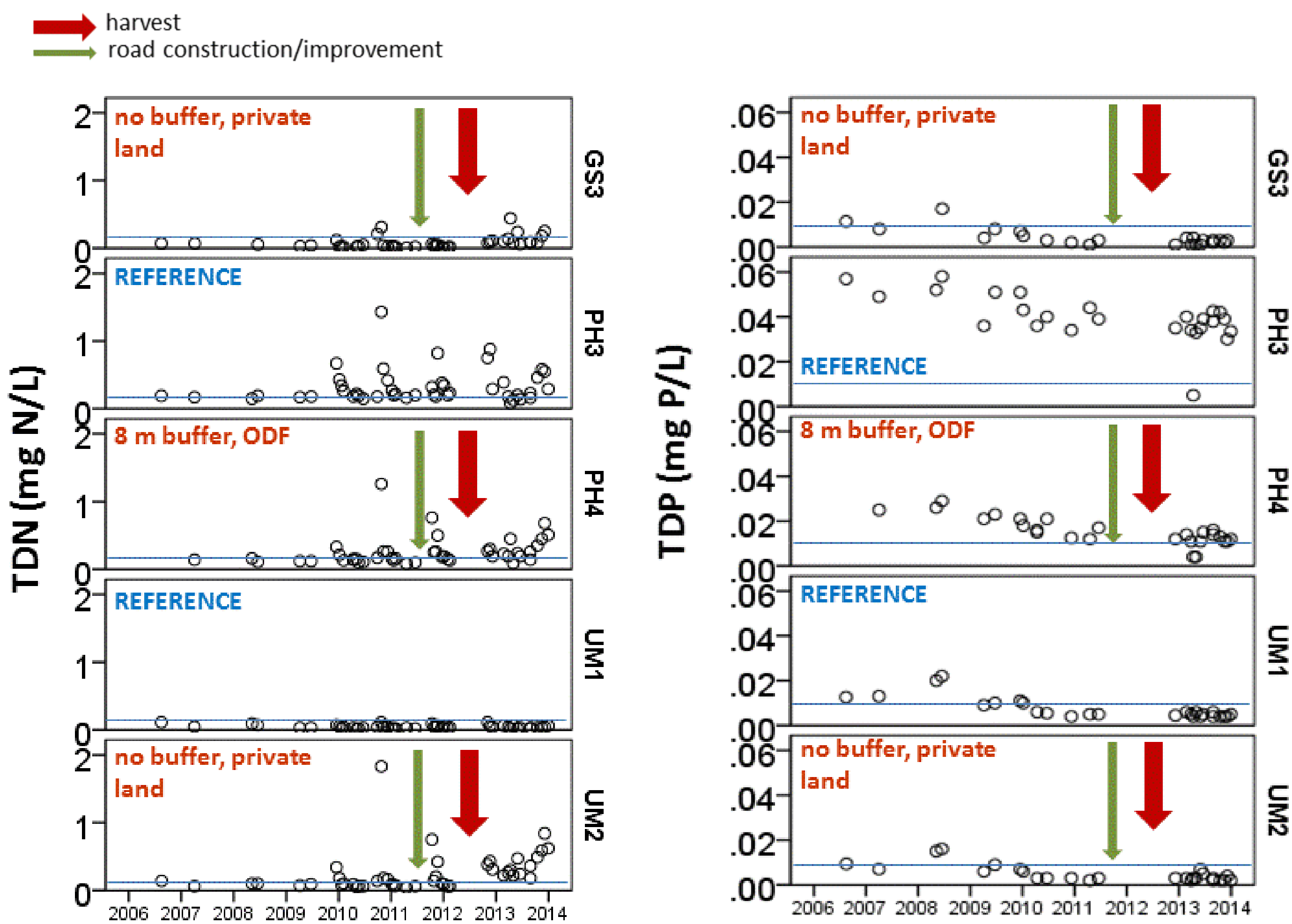


Figure 1. Variability in total dissolved nitrogen (TDN) and total dissolved phosphorus (TDP) in five Trask watersheds. Green arrows indicate road construction/improvement, red arrows indicate forest harvest period, and blue horizontal lines indicate proposed nutrient reference criteria for the ecoregion.

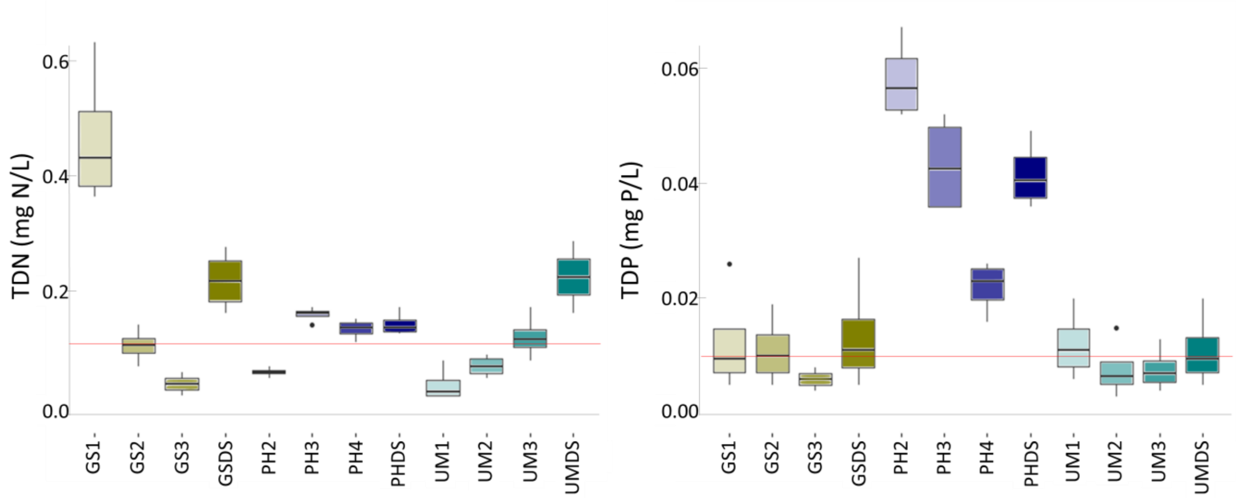


Figure 2. Total dissolved nitrogen (TDN, mg N/L) and Total dissolved phosphorus (TDP, mg P/L) concentrations for each catchment during spring (April-May) before harvest and road improvement (2007-2010). EPA proposed criteria are indicated by solid red line.

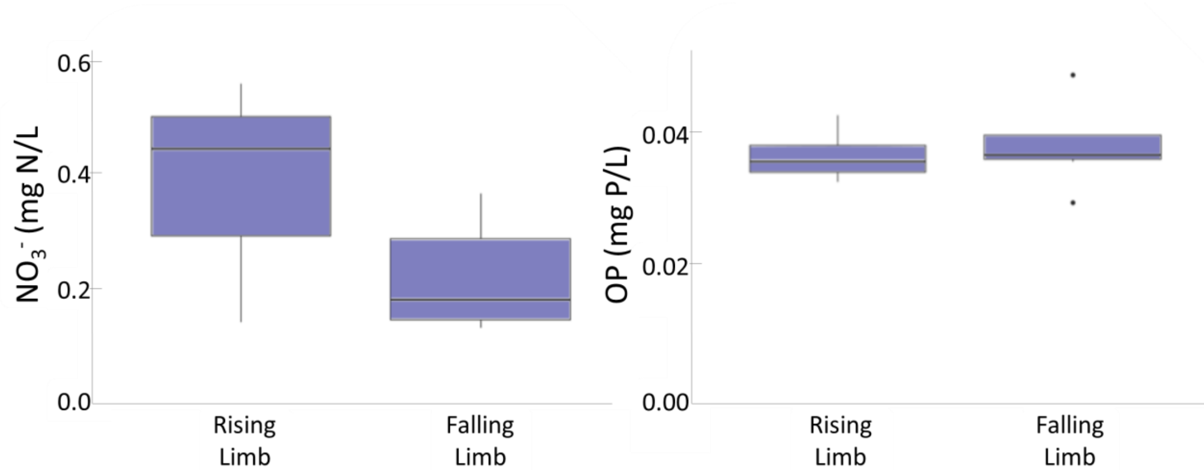


Figure 3. Orthophosphorus (OP, mg P/L) and nitrate (NO_3^-, mg N/L) concentrations during the rising limb (RL) and falling limb (FL) of the annual hydrograph during 2010 in Pothole watershed (RL n=4), FL n=7).

List of names and brief overview of graduate and/or undergraduate engagement in project:

- Casey Steadman, a PhD candidate, has joined the team on summer 2015. She has been processing and analyzing samples collected during water year 2015 and will continue analyzing the samples collected for water year 2016. During her PhD she will study the fundamental processes and principles of water and nutrient movement through forested watersheds and how these may be impacted by land management activities using data from the Trask Watershed.
- Noah Kanzig, an undergraduate student in the Mentored Employee Program, assisted with acid washing and inventory and organization of stored samples.
- Margaret McCormick, undergraduate student worker, assisted with acid washing and digestion procedures of samples for water chemistry analysis.

List of presentations, posters, etc.:

Steadman, C. L., K. D. Bladon, A. Argerich, and S. L. Johnson. Spatial and temporal variability of nitrogen and phosphorus in headwater catchments of the Northern Coast Range of Oregon. The Pacific Northwest Water Research Symposium, Corvallis, OR. April 2016

Steadman, C. L., A. Argerich, K. D. Bladon, and S. L. Johnson. Spatial and seasonal patterns in nutrient concentrations in mountainous headwater streams in Oregon. The Western Forestry Graduate Research Symposium, Corvallis, OR. April 2016

Steadman, C. L., K. D. Bladon, A. Argerich, and S. L. Johnson. Early trajectory of chemical water quality response to disturbance by forest harvesting in the Northern Coast Range of Oregon. The Society for Freshwater Science Conference, Sacramento, CA. May 2016

Steadman, C. L., K. D. Bladon, A. Argerich, and S. L. Johnson. Spatial and temporal heterogeneity of nitrogen in forested headwater catchments of the northern Coast Range of Oregon. The American Geophysical Union Fall Meeting, San Francisco, CA, December 2016

List of publications, thesis citations:

Steadman, C. L. Spatiotemporal Variability of Nitrogen and Phosphorus in Forested Watersheds: a Concurrent Modeling Approach, PhD dissertation, Dept. of Forest Engineering, Resources and Management, College of Forestry, Oregon State University, Corvallis, Oregon

Steadman, C. L., Argerich, A., Bladon, K., and Johnson, S. Natural variability of nutrients and response to contemporary forest practices in Oregon Coast Range watersheds. Journal TBD.

EARLY TRAJECTORY OF CHEMICAL WATER QUALITY RESPONSE TO DISTURBANCE BY FOREST HARVESTING IN THE NORTHERN COAST RANGE OF OREGON

Casey L. Steadman[1], Kevin D. Bladon[1], Alba Argerich[1], and Sherri L. Johnson[2]

[1] Department of Forest Engineering, Resources, and Management, Oregon State University, Corvallis, OR, 97331

[2] Pacific Northwest Research Station, United States Forest Service, Corvallis, OR, 97331

(1) Objective

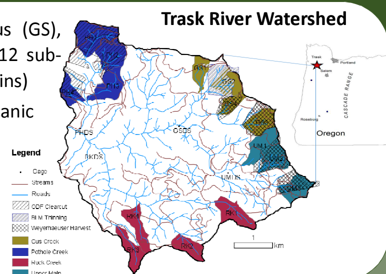
Improve understanding of processes governing retention & export of dissolved nitrogen (N) & phosphorus (P) under natural conditions & in response to forest harvest.

- Examine 10 yrs of water chemistry samples reflecting pre- & post-harvest conditions from paired, nested catchments in a forest watershed.
- Identify trends & drivers in spatiotemporal variability of N & P pre- & post-harvest.

(3) Study Site

- **Catchments**: Pothole (PH), Gus (GS), UpperMain (UM), Rock (RK); (12 sub-catchments nested within 4 basins)
- **Geology**: mixed, basaltic volcanic to sedimentary sandstone
- **Climate**: mean annual precipitation from 180-500 cm; mild temperatures yr-round

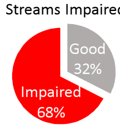
Trask River Watershed



(2) Rationale

- N & P are key macronutrients of many freshwater ecosystems.
- Many rivers and streams are impaired (Fig 1 A) ; excess nutrient concentrations are the 3rd leading cause of impairment (Fig 1 B).

A.) Percentage of Oregon Rivers & Streams Impaired



B.) Top Three Causes of Impairment

Cause of Impairment	Miles Threatened or Impaired
Temperature, Water	17253
Sedimentation/Siltation	11996
Nutrients	11272

Figure 1. Oregon Water Quality Assessment Report 2006 EPA & ODEQ. 46,035.7 miles of rivers & streams assessed. A.) Summary of water quality assessments for rivers & streams in Oregon reflecting monitoring of 141 different causes of impairment. B.) Top 3 causes of impairment of Oregon rivers and streams. (https://ofmpub.epa.gov/waters10/attains_state.control?p_state=OR)

- Forest harvest impacts hydrologic & biogeochemical processes & can alter nutrient retention & export.
- Characterization of spatiotemporal variability of N & P in forested, headwater catchments under natural vs disturbed conditions may be used to improve best practices in land management.

(4) Methods

Sample collection

Upstream

Downstream

Chemical Analysis

- 6 Headwater (HW) sites; spring & summer grab samples; 2006-2016
- 4 Downstream (DS) sites; storm ISCO's samples triggered by turbidity; 2010-2016

- Nitrate(+nitrite)-nitrogen (NO3 -N)
- Total dissolved nitrogen (TDN)
- Total dissolved phosphorus (TDP)

(5) Preliminary Results

Headwater

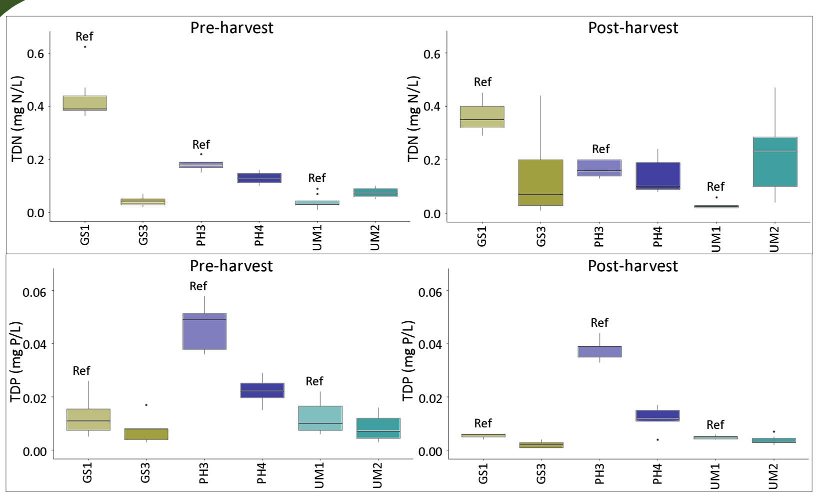
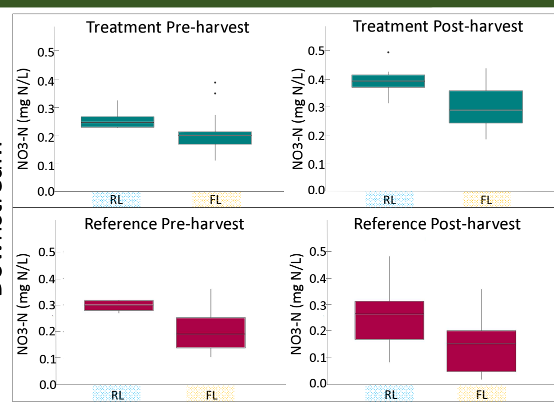


Figure 2. HW grab sample TDN and TDP concentrations (mg/L) for 6 sub-catchments during months of April, May, & June from pre-harvest years 2007-2010 & post-post-harvest year 2013 (pre-harvest n = 7-10; post-harvest n = 3-4 except GS1 = 2).

- TDN: More spatial variability in GS; ↑ temporal variability in treated sub-catchments post-harvest
- TDP: More spatial variability & highest TDP in PH

Downstream



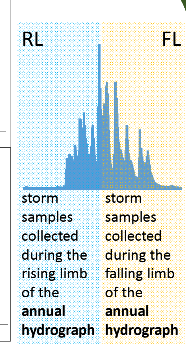


Figure 3. Storm DS sample NO3-N concentrations (mg/L) in treatment basin (UMDS) & reference basin (RKDS) during **rising limb (RL) & falling limb (FL) of the annual hydrograph** for pre-harvest year 2010 (UMDS RL n=7, FL n=26; RKDS RL n=4, FL=8) & post-harvest years 2014-2015 (UMDS RL n=10, FL n=23; RKDS RL=15, FL=23).

- ↑ median NO3-N in RL vs FL pre- & post-harvest in treatment and reference basins
- ↑ median NO3-N post-harvest vs pre-harvest in treatment basin; ≈ median NO3-N pre- & post-harvest in reference basin
- More variability in FL post-harvest in treatment basin

(6) Discussion and Next Steps

- ↓ median NO3-N in FL (Fig 3) → dissolved NO_3^- depleted early in yr pre- & post-harvest
- ↑ median NO3-N post-harvest in treatment basin vs ~no increase in reference basin (Fig 3) → effects of forest harvest
- Future analyses of basin characteristics & harvest effects → explain spatial variability (Fig 2) & response to harvest. For example, PH is distinct in that it:
  - is underlain by highly erodible volcaniclastic geology, which may be a potential source of P;
  - contains several wetland features which may create opportunity for biologic activity & settling of particulates.
- Exploration of primary & secondary controls (i.e., geology, soil type, slope, aspect, basin area, vegetation type & cover, air temperature, precipitation, streamflow) & methods & effects of harvest (i.e., presence of riparian buffers, changes in litter availability, streamflow, nutrient storage capacity, nutrient cycling) may explain spatial & temporal variability & serve to inform land management practices.

Contact
Casey L. Steadman
214-738-3188
casey.steadman@oregonstate.edu

Title: Experimental Evaluation of Plethodontid Salamander Responses to Forest Harvesting

Investigators:
Dr. Barbara Lachenbruch (CoF, OSU), Dr. Tiffany Garcia (Dept. of Fisheries and Wildlife, OSU), Dr. Andrew J. Kroll (Weyerhaeuser NR), and Dr. Blake Murden (Port Blakely Tree Farms LP)

Project Duration:
2 years, beginning June, 2014

Objectives:

A. **Correlate Oregon slender salamander (OSS; *Batrachoseps wrightii*) and Ensatina salamander (ENS; *Ensatina eschscholtzii*) occupancy and abundance with CWD density and distribution at both the site and landscape scale.**

Summary of accomplishments towards First objective:
Site Selection- Over the course of the project, we continually added sites to the study (>10 acres in size, <2500 ft. in elevation within western Cascade Range, OR, and had not been harvested in >50 years) from ownership databases in two geographic blocks: the Clackamas Block and the Snow Peak Block. We started with 66 units and finished with 88 due to site contributions from Oregon Department of Forestry and the Bureau of Land Management (BLM). We had two types of study plots in the experiment: control units, which were to remain unharvested throughout the study, and clearcut harvested (treatment) experimental units, which were to undergo harvest at some point during the study. Treatment units received from 1-4 years of pre-treatment sampling. Thirty-nine and 49 units occurred on the Clackamas and Snow Peak Blocks, respectively. Port Blakely owns 13 units on the Clackamas Block, Weyerhaeuser owns 17 units, and BLM owns 9 units; on the Snow Peak Block, Oregon Department of Forestry (ODF) owns 6 units, BLM owns 7 units, and Weyerhaeuser owns 36 units.

- 2014 season: We sampled 55/66 harvest units in the 2014 season, while 12 units were actively harvested. Harvested units were sampled again one year after harvest.
- 2015 season: We sampled 61/74 harvest units in the 2015 season. We did not sample 13 units because they were being harvested.
- 2016 season: We sampled 76/88 harvest units in 2015. We did not sample 12 units because they were being harvested

Sampling methods- We assigned a random starting point in each harvest unit for field crews to begin OSS/ENES sampling. This point served as the center for a single 9*9 m plot. Once the first plot was identified, a random azimuth was selected and six additional plots were established with a distance of 40 m between them. We searched plots in three sequential 10 minute intervals. Observers switched back and forth on every interval. As soon as both OSS and ENES were detected, sampling ceased. If OSS and ENES were not detected, all three intervals were completed. Observers followed a "light touch" sampling protocol in which cover objects were returned to their original position and in which disturbance to habitat features such as decayed logs was minimized. We sampled all seven plots in each harvest unit. During sampling, crews counted coarse woody debris based on length (1-5, 6-15, >15 m), width (large end; 25-50, >50 cm), and decay (none, Stage 1, and Stage 2) classes. Decay classes were based on those in Maser and Trappe (1984). In addition, crews recorded air temperature, soil moisture (at each of four points within each plot), and date.
Statistical methods- We were interested in three quantities: ψ (probability that a harvest unit is occupied by OSS/ENES), θ (probability that a sampling plot is occupied by OSS/ENES), and λ (abundance

in the sampling plot). We expected that forest harvesting will affect ψ, as harvest treatments are applied uniformly across units. However, our expectation was that θ and λ for OSS would be associated with distributions of coarse woody debris *within* the harvest units, regardless of whether the unit was assigned to the treatment or control group. Given the range of habitat associations for ENES, we did not expect to see a relationship between θ and λ and coarse woody debris. Our sampling design (three search intervals of each of seven plots within each of the 88 harvest units) allowed us to estimate these quantities. Details on the statistical models used to estimate these quantities (under different sampling designs) are provided in Royle and Nichols (2003), Nichols et al. (2008), Mordecai et al. (2011), and Pavlacky et al. (2012).

Results- In our final sampling season, twenty-two of the 76 sampled stands were harvested units and 54 were control units.

Oregon Slender Salamanders- We found OSS on sampling plots in 39/76 (51%) of the units. We found OSS on sampling plots in 6/22 (27%) of the harvested units and 33/54 (61%) of control units. On the Clackamas block, 3/11 (33%) harvested units and 13/23 (57%) control units had OSS detections. On the Snow Peak block, 3/11 (33%) harvested units and 20/31 (65%) control units had OSS detections.
Ensatina Salamanders- We found ENES on sampling plots in 36/76 (47%) of the units. We found ENES on sampling plots in 1/22 (5%) of the harvested units and 35/54 (65%) of control units. On the Clackamas block, 0/11 (0%) harvested units and 9/23 (39%) control units had ENES detections. On the Snow Peak block, 1/11 (9%) harvested units and 26/31 (84%) control units had ENES detections.

Summary information for sampling covariates indicated that plots in the Snow Peak block contained ~40% more downed wood than plots on Clackamas (Table 1). Stands in both blocks had the same average sampling date (~May 14).

Using the model described in Kroll et al. (2015), we estimated treatment-specific occupancy and abundance for both OSS and ENES in 2015 and 2016. We note that 2015 and 2016 are the post-treatment years for both responses. We did not find evidence for treatment differences in occupancy for either species in 2015 and 2016 (Figure 1). We estimated a substantial amount of uncertainty (wide credibility intervals) in treatment estimates for both OSS and ENES in 2015 and 2016 (as of 2016, a total of 22 treatment units have been sampled). Similarly, abundance was lower in 2015 and 2016 on treatment plots for both OSS and ENES in 2015 and 2016 (Figure 2). We note that OSS abundance was lower on Control units in 2015 and 2016 compared to 2013 and 2014, indicating inter-annual variability not attributable to the treatments. Given the data types (Poisson count data vs. binomial detection data), abundance estimates were more precise than occupancy estimates for 2015 and 2016. As a result, our confidence in the abundance responses is higher.

Occupancy and abundance probabilities increased with downed wood counts for both OSS and ENES across the course of this study (2013-2016; Figures 3 and 4). The effect was less pronounced for ENES, a species that has higher dispersal rates relative to OSS, and thus shows less reliance on downed wood structures.

Problems, barriers, proposed changes to First objective-

The analysis of the field data and the simulations in Kroll et al. (2015) indicates that our sample size of 88 harvest units was sufficient to answer our research questions. However, the annual variation in temperature and moisture is likely to have resulted in the observed decrease in occupancy over time. Our expectation is that the estimate of the treatment effect for both occupancy and abundance will become more precise with each additional year of sampling as the sample size of treatment units will increase with time.

B. Quantify relationship between Oregon slender salamander (OSS; *Batrachoseps wrightii*) and ensatina salamander (ENS; *Ensatina eschscholtzii*) occupancy and abundance with heartwood quantity.

Summary of accomplishments towards Second objective-

Justification- We hypothesize that heartwood content will be positively associated with both OSS and ENS occupancy and abundance, particularly as time since harvest increases. The Oregon slender salamander has a strong reliance on decayed coarse woody debris. A large portion of the geographic distribution of the Oregon slender salamander (OSS) occurs in forests managed intensively for wood production. In contrast, Ensatina salamanders (ENES) are associated with a broad range of habitat types. Reduced harvest rotation lengths can lead to lower input of total CWD and CWD heartwood at both the harvest unit and landscape scale (Bunnell and Houde 2010, Maguire and Batista 1996). Heartwood is more durable but has lower initial moisture content than sapwood, thus the overall effect of reduced heartwood on OSS or ENS habitat quality is unclear.

Sampling Status- We have sampling data on all units that include CWD length (1-5, 6-15, >15 m), width (large end; 25-50, >50 cm), sapwood width (none, <3 cm, > 3 cm), and heartwood decay class (none, Stage 1, Stage 2) (Maser and Trappe 1984).

Problems, barriers, proposed changes to Second objective:

We were unable to detect differences in CWD decay status, condition, length and width across treatments. We did find a block effect in the amount of CWD with a greater amount found in the Snow Peak Block. We hypothesize that differences in these CWD characteristics between control and treatment units would not emerge within the timeframe of this project. Further, we did not control for historical harvest practices. All units in the study have been subject to previous harvest protocols implemented by multiple ownerships and constrained by evolving industrial regulations. This variation in the amount and quality of downed wood makes current assessment of CWD response to study manipulations implausible. However, we have generated a series of hypotheses regarding microhabitat use within and around CWD that merits further study.

Comprehensive Summary:

This collaborative project successfully described the relationship between terrestrial salamander occupancy and habitat conditions associated with harvested timberlands in the western Oregon Cascades. We established sampling protocols and a BACI experimental design to quantify the detection and occupancy probabilities Oregon slender salamanders and Ensatina salamanders at the sampling plot and harvest unit spatial scales. Oregon slender salamanders are currently a candidate for listing under the Endangered Species Act and are only found on the western slopes of the Oregon Cascades. Ensatina, however, are widespread throughout the Pacific Northwest region. We predicted that both species would have a negative association with harvested plots but that the presence of CWD would dampen that treatment effect. We therefore designed a study to track salamander occupancy in units across the western Oregon Cascade Range that were gradually harvested over time.

We found a strong relationship between OSS and downed wood. Within both control and harvested units, plot occupancy and abundance increased with the number of downed wood structures. This relationship was found with ENES as well, but was less pronounced. This was predicted as OSS have narrow home ranges and are thought to have limited dispersal distances, while ENES are less reliant on CWD due to higher dispersal potential.

Detection rates for both OSS and ENES were high relative to other terrestrial salamander studies. However, we found no evidence for a treatment effect on occupancy rates for either OSS or ENES. We did find that abundances for both OSS and ENES were reduced post-harvest and relative to control units. It is important to note that a substantial amount of uncertainty exists in these estimates as both only two years of post-harvest data currently exist. Inter-annual variability also prevents us from making strong conclusions and suggests a strong climate effect.

This project would be strengthened with additional field seasons to control for between-year variation in climate conditions and to generate more harvested units. Currently, only 22 of our 88 units have been harvested, with agreements with all parties to continue participation in the study for the next 5 years. We have demonstrated that these salamanders are present in these landscapes; but further time is needed to increase confidence in our estimates of occupancy.

Graduate and/or undergraduate Engagement:

Carly Rathburn, an undergraduate student in OSU's Department of Fisheries and Wildlife, participated in the 2014 and 2015 sampling seasons and received 4 internship credits for her involvement (2014). As part of the OSU FW Dept. internship requirements, Carly submitted a report outlining her experiences and accomplishments pertaining to this experience (available upon request). She gained significant experience in multiple skill set areas, including sampling techniques, animal identification, safety skills, and experimental design.

Luke Lemieux, an undergraduate in OSU's Department of Fisheries and Wildlife, participated in the 2015 sampling season and received 4 internship credits for his involvement. Internship reporting requirements changed in 2015 and instead of a report on his experience, Luke participated in a survey on skill acquisition. He gained significant skills in data collection, sampling techniques, animal identification, and orienteering.

Jackson Curtis Meyer, an undergraduate in OSU's Department of Fisheries and Wildlife, participated in the 2015 sampling season. Jackson gained significant skills in data collection, sampling techniques, animal identification, and safety.

Eric Jacobs, an undergraduate in OSU's Department of Fisheries and Wildlife, participated in the 2015 sampling season. Eric gained significant skills in data collection, sampling techniques, animal identification, and safety.

Shelby Bauer, an undergraduate in OSU's Department of Fisheries and Wildlife, participated in the 2016 sampling season. Shelby gained significant skills in data collection, sampling techniques, animal identification, and safety.

Adam Field, an undergraduate at University of California at Santa Cruz, participated in the 2016 sampling season. Adam gained significant skills in sampling techniques, animal identification, and orienteering.

List of presentations, posters, etc.:

Kroll, A.J., T.S. Garcia, J. Jones, B. Murden, J. Johnson, S. Peterman, M. Rochelle. 2016. *Persistence and abundance of Plethodontid salamanders in production ecosystems*. The Wildlife Society Annual Conference, Raleigh, North Carolina. Symposium: Response of amphibians and reptiles to anthropogenic disturbance.

Kroll, A.J., T. Garcia, B. Murden, J. Jones, J. Johnson, S. Peterman, and M. Rochelle. 2015. Oregon slender salamander responses to intensive forest management. Joint Annual Meeting of the Oregon Chapters of The Wildlife Society and Society of American Foresters (29 April-1 May), Eugene, OR.

Garcia, T.S., A.J. Kroll, M. Rochelle, K. Dugger, J. Johnson, B. Murden and B. Lachenbruch. 2014. Oregon Forest Industries Council Board Meeting, June 17, 2014. Oregon State University, Corvallis, OR.

Garcia, T.S and T. Chestnut. 2014. Sampling techniques for terrestrial salamanders: The good, the bad, and the ugly. Society for Northwestern Vertebrate Biology Annual Meeting, Pasco, Washington.

Kroll, A.J., T. Garcia, J. Jones, B. Murden, J. Johnson, S. Peterman, and M. Rochelle. 2014. Multi-scale responses of Oregon slender and Ensatina salamanders to forest management. 21th Annual Conference, The Wildlife Society, Pittsburgh, PA.

Kroll, A.J. T.S. Garcia, J. Jones, B. Murden, J. Johnson, S. Peterman and M. Rochelle. 2014. Multi-scale responses of Oregon Slender salamander and Ensatina to forest management. North America Congress for Conservation Biology. Missoula, Montana.

Peterman, S., J. Johnson, M. Rochelle, T. Garcia, B. Murden, J. Jones, and A.J. Kroll. 2014. Experimental evaluation of Oregon Slender Salamander and Ensatina responses to forest management. 48th Annual meeting of the Oregon Chapter of The Wildlife Society, Bend, OR.

Kroll, A.J. 2014. Responses of terrestrial amphibians in production ecosystems. Joint Annual Meeting of the Society of Northwest Vertebrate Biologists and the Washington Chapter of The Wildlife Society , Pasco, WA.

List of publications, thesis citations:

Kroll, A.J., T.S. Garcia, J. Jones, K. Dugger, B. Murden, J. Johnson, S. Peterman, M. Brintz and M. Rochelle. 2015. Evaluating multi-level models to assess occupancy state responses of Plethodontid salamanders. PLoS ONE 10(12): e0145899. doi: 10.1371/journal.pone.0145899

Table 1: Summary information for sampling covariates, Clackamas and Snow Peak blocks, Oregon Cascades, 2016.

	Clackamas (n=34)				***Snow Peak (n=42)***			
	Control		**Treatment**		**Control**		**Treatment**	
Covariate	**Average**	**SD**	**Average**	**SD**	**Average**	**SD**	**Average**	**SD**
Date	May 27	19 days	May 17	21 days	May 18	17 days	May 29	20 days
Downed wood (# of pieces)	2	1.7	1.7	1.5	3.4	2.7	3.4	2.2
Air temperature (°C)	15.7	5.2	20.9	6.5	12.5	4.9	17.3	5.2
Soil temperature (°C)	10.6	1.9	12.6	2.8	10.5	2	14.5	2.4
Elevation (m)	606	208	634	216	632	215	548	154

Figure 1: Treatment × Year occupancy estimates (90% credibility intervals) for Oregon slender and Ensatina salamanders, Oregon Cascades, 2013-16**.**

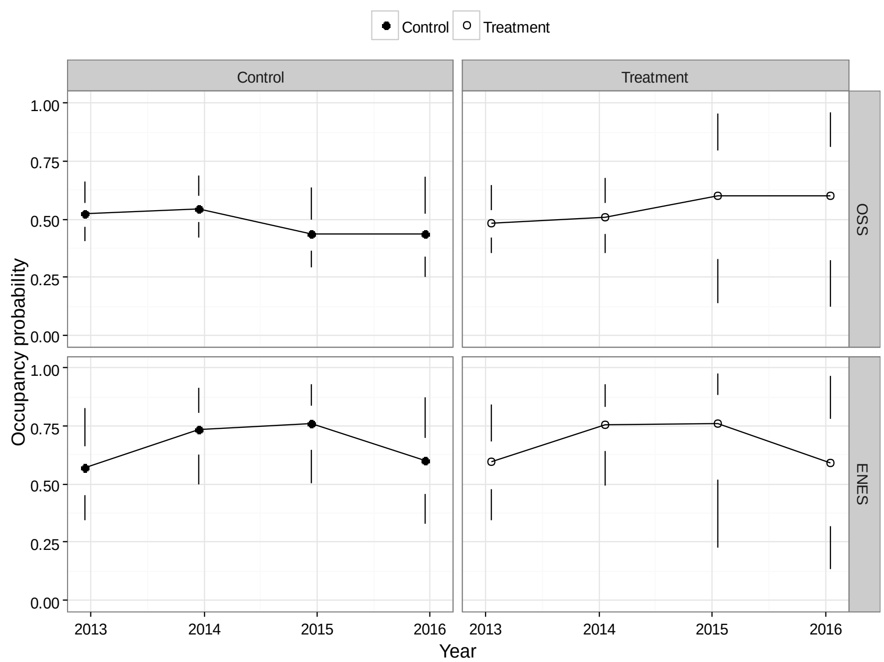


Figure 2: Treatment × Year abundance estimates (90% credibility intervals) for Oregon slender and Ensatina salamanders, Oregon Cascades, 2013-16.

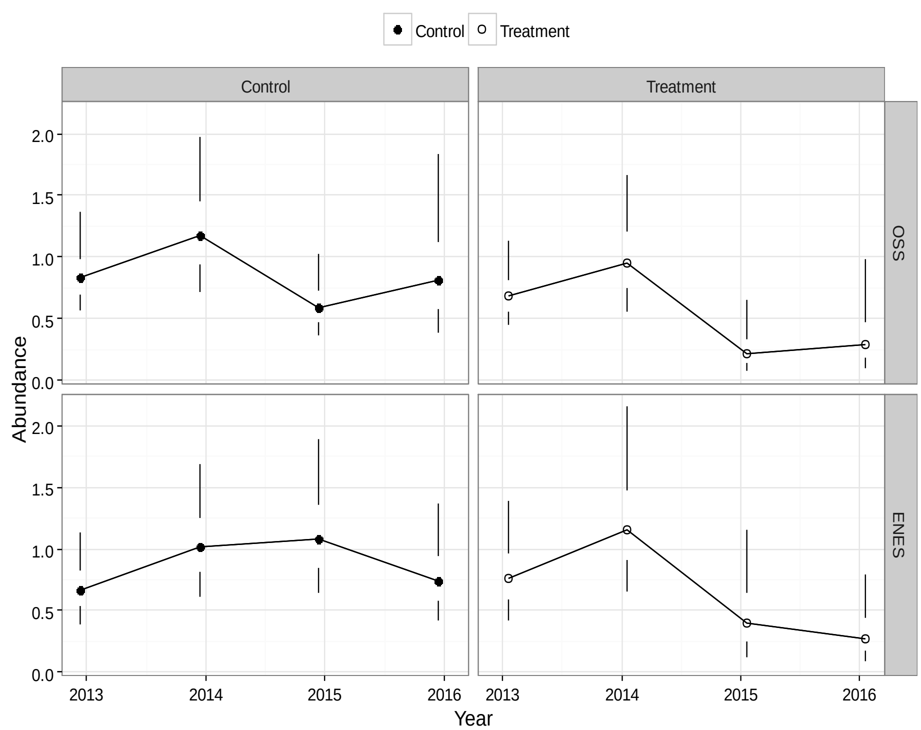


Figure 3: Plot occupancy estimates across counts of downed wood for Oregon slender and Ensatina salamanders, Oregon Cascades, 2013-16.

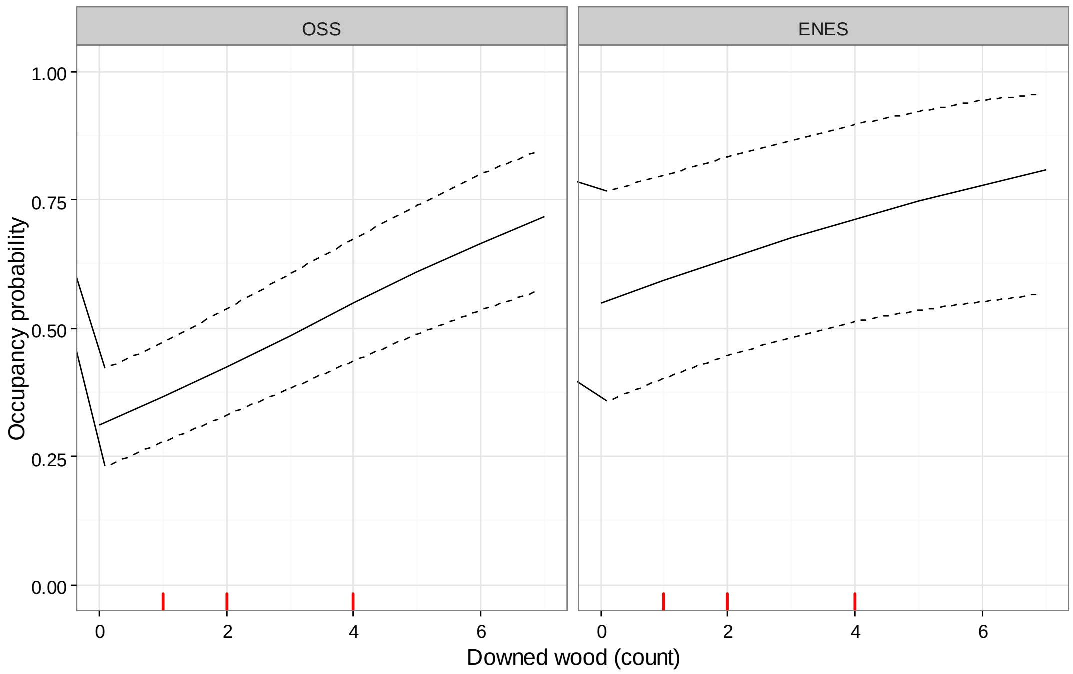
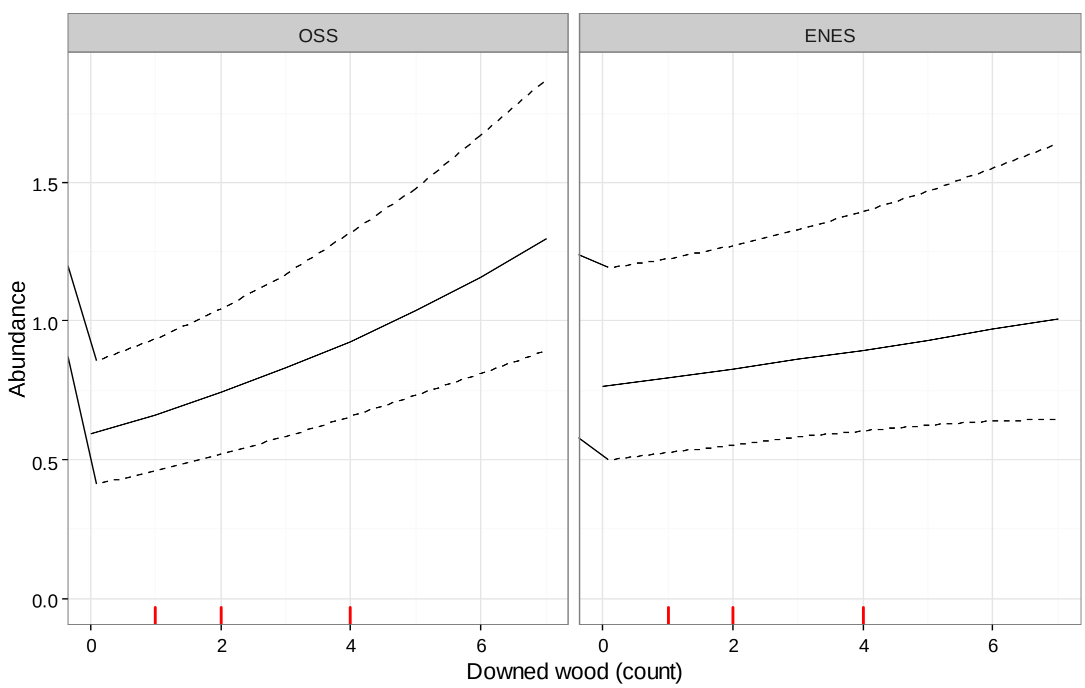


Figure 4: Plot abundance estimates across counts of downed wood for Oregon slender (OSS) and Ensatina (ENES) salamanders, Oregon Cascades, 2013-16.



Literature Cited

Kroll, A.J., T. Garcia, B. Murden, J. Jones, J. Johnson, S. Peterman, and M. Rochelle. 2015. Oregon slender salamander responses to intensive forest management. Joint Annual Meeting of the Oregon Chapters of The Wildlife Society and Society of American Foresters (29 April-1 May), Eugene, OR.

Maser, C., and J. M. Trappe, editors. 1984. The Seen and Unseen World of the Fallen Tree. Gen. Tech Rep. PNW-164, U.S. Department of Agriculture, Pacific Northwest Forest and Range Experimental Station, Portland, OR, USA.

Mordecai, R. S., B. J. Mattsson, C. J. Tzilkowski, and R. J. Cooper. 2011. Addressing challenges when studying mobile or episodic species: hierarchical Bayes estimation of occupancy and use. Journal of Applied Ecology 48:56-66.

Nichols, J. D., L. L. Bailey, A. F. O'Connell, Jr., N. W. Talancy, E. H. C. Grant, A. T. Gilbert, E. M. Annand, T. P. Husband, and J. E. Hines. 2008. Multi-scale occupancy estimation and modelling using multiple detection methods. Journal of Applied Ecology 45:1321-1329.

Pavlacky, D. C., Jr., J. A. Blakesley, G. C. White, D. J. Hanni, and P. M. Lukacs. 2012. Hierarchical multi-scale occupancy estimation for monitoring wildlife populations. Journal of Wildlife Management 76:154-162.

Royle, J. A., and J. D. Nichols. 2003. Estimating abundance from repeated presence-absence data or point counts. Ecology 84:777-790.

Title: Modeling geomorphic response to large wood introduction as a strategy to restore fish habitat in managed forest watershed

Investigators:
PI: Catalina Segura, OSU FERM; Co-PIs: Christopher Lorion (ODFW), and Stacy A. Polkowske (ODFW)

Project duration:
July 1, 2014 – June 30, 2016

Objectives:

1) characterize the fluvial regime of three reaches before and after LW
2) classify channel types in the alluvial stream network of the Mill Creek Watershed
3) develop a watershed scale model of channel geomorphic response to LW additions,

Background:
Even though large wood (LW) additions are often part of fish habitat restoration efforts, the relative success of these efforts is rarely evaluated or reported in terms of ecological significance. Under natural conditions and adequate sediment supply the interaction of stream channels with their floodplain allows river systems to recruit wood and develop complex morphologies [1]. This high level of complexity is often associated with the best habitat for anadromous fish [2, 3]. Historic forest operations that allowed clear-cutting to the edge of river systems and in-stream clearing of stored LW strongly disturbed this interaction leading to riparian areas dominated by deciduous species such as red alder and simplified channel complexity. Prospects for natural recruitment of LW by this alder dominated forest are low because of their small size and rapid decay. The Mill Creek Watershed is a tributary of the Siletz River that drains both commercial and Tribal land (Fig. 1). This system is ideal to study the effectiveness of restoration efforts that includes LW not only because it is part of a large scale (over 7.5 miles of stream) restoration effort lead by the Oregon Department of Fish and Wildlife (ODFW) and funded by Oregon Watershed Enhancement Board (OWEB) but also because is one of the ODFW Life Cycle Monitoring sites with fish population data since 1997. Partners in the project with the Mid Coast Council and ODFW include Weyerhaeuser, Department of Environmental Quality, Oregon State University (Segura is in charge of the geomorphologic component), and the Confederated Tribes of the Siletz Indians[1].

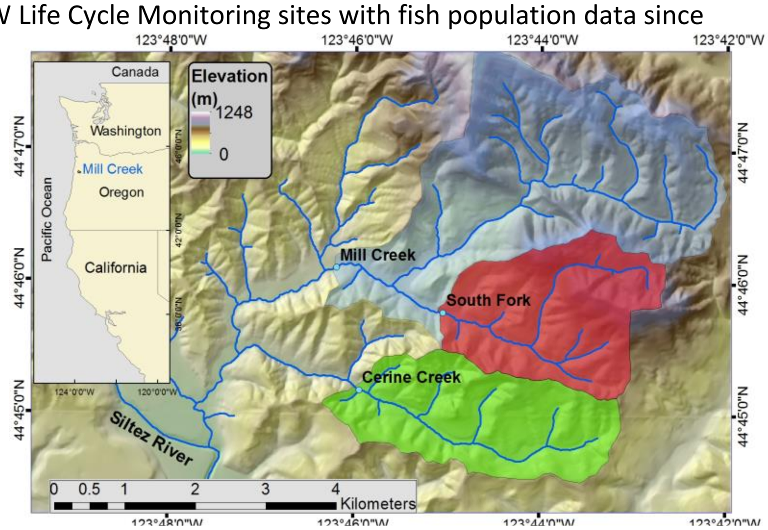


Figure 1: Location of Mill Creek watershed, OR. Study sites reaches Mill Creek, Cerine Creek, and South Fork are indicated.

Summary of accomplishments toward objectives:

Characterization of the fluvial regime in three reaches before and after LW: Using a two-dimensional flow model (Nays2DH), we were able to quantify the spatial and temporal changes in fish habitat triggered by the addition of LW in three sites (Fig. 1). This effort required a significant field campaign including topographic surveying, rating curve development, grain size characterization, etc. Here we focus on the hydraulic modeling results given that the field component of the project was presented in previous progress reports.

[1] http://www.midcoastwatersheds.org/in-progress/

<u>Model</u>: Nays2DH, a fully unsteady 2D flow model, was used in this investigation. This model solves finite differenced, depth integrated version of the Navier-Stokes equation assuming that the horizontal momentum transfer is larger than the vertical. Nays2DH inputs include: channel topography, discharge, channel bed roughness, downstream flow stage, and a characterization of the water surface initial condition at the upstream end of the model. Roughness in the model is expressed as a drag coefficient, which is typically adjusted during calibration. The model produces time variable distributions of velocity, shear stress, and wetted channel extend. We used the results of model runs considering bankfull flow (Q_{bf})conditions and bankfull flow events to develop metrics of geomorphic change relevant to fish habitat. These included vertical velocity, considering thresholds associated to the ability of fish to maintaining swimming position, and substrate stability, under the premise that juvenile fish bury during high flow as a survival strategy.

<u>Velocity:</u> At Q_{bf}, the addition of LW increased the area of habitat with acceptable velocity for juvenile Coho Salmon in all study sites. We considered 3 velocity ranges: below a critical velocity (v_{crit}=0.5 m/s) for winter-time ~8-10cm long Coho Salmon in the advanced fry to early smolt phase [4], above v_{crit} but below the burst swim speed (v_{burst} =1 m/s) of juvenile Coho Salmon [5] , and those greater than v_{burst}. Critical swimming speed is the maximum velocity at which a fish can maintain position in the flow stream for extended periods of time under a given set of environmental conditions.

LW jams backed up flow, increasing the width of channel as additional low velocity flow occupied areas near the channel margins (Fig. 2 presents an example). As a result, average velocities in the wetted channel decreased by 23-36% across all three sites. Increased floodplain connectivity upstream of LW jams created most of the additional area of acceptable habitat (dark blue in Fig. 2). This change was also evident in the shape of the frequency distributions of velocity, which became wider. Thus, further indicating that the heterogeneity of the flow field. The change in the velocity distribution show that after the addition of LW the area of long-term acceptable habitat ($v < v_{crit}$) increased by 17-26% (Fig. 2). ($v \leq v_{crit}$ where v_{crit} = 0.5 m/s [4])

We also consider temporal variability in habitat availably by modelling flow conditions over the duration of a bankfull discharge (Q_{bf}) event in all sites. Acceptable habitat area increased after LW addition for the entire storm duration in all three sites (Fig. 3, presents an example). The area of long-term acceptable habitat ($v < v_{crit}$) increased in average 23-29% over the hydrograph after the addition of LW. Wetted area increased 24-35% at Q_{bf} and additional floodplain connection occurred over 20-80 m of the banks for 33-57% of the hydrograph duration (Fig. 4, presents an example). This additional low velocity area should provide acceptable habitat locations for juvenile Coho Salmon.

<u>Substrate stability</u>: In order for bed material to provide acceptable shelter for juvenile salmon, we assume it must remain stable during high flow events. We calculated the critical shear stress for the motion of the median grain size of the bed as a metric to quantify the likelihood of substrate stability. We then quantify the area of the bed likely to remain stable during a storm event. At $Q_{bf,}$ the addition of LW caused reach-average shear stress values to decrease by 23-36%. This resulted in a 31-39% increase in the stable bed area, a 6-32% decrease in the area likely to be in partial transport, and a 7-25% decrease in the area likely in full transport. Areas of high shear stress, generally in the channel thalweg were disrupted as LW deflected flow laterally creating slower, deeper pools. Additionally, connected floodplain areas provided low shears stress habitat that was not previously available. The areas of low shear stress upstream of LW additions correspond to possible areas of sediment deposition. Further, areas of high shear stress in the immediate and downstream vicinity of LW additions indicate where scour is likely to occur over time. The changes to the distributions of shear stress, as in the case of velocity, showed that the area of acceptable habitat increased.

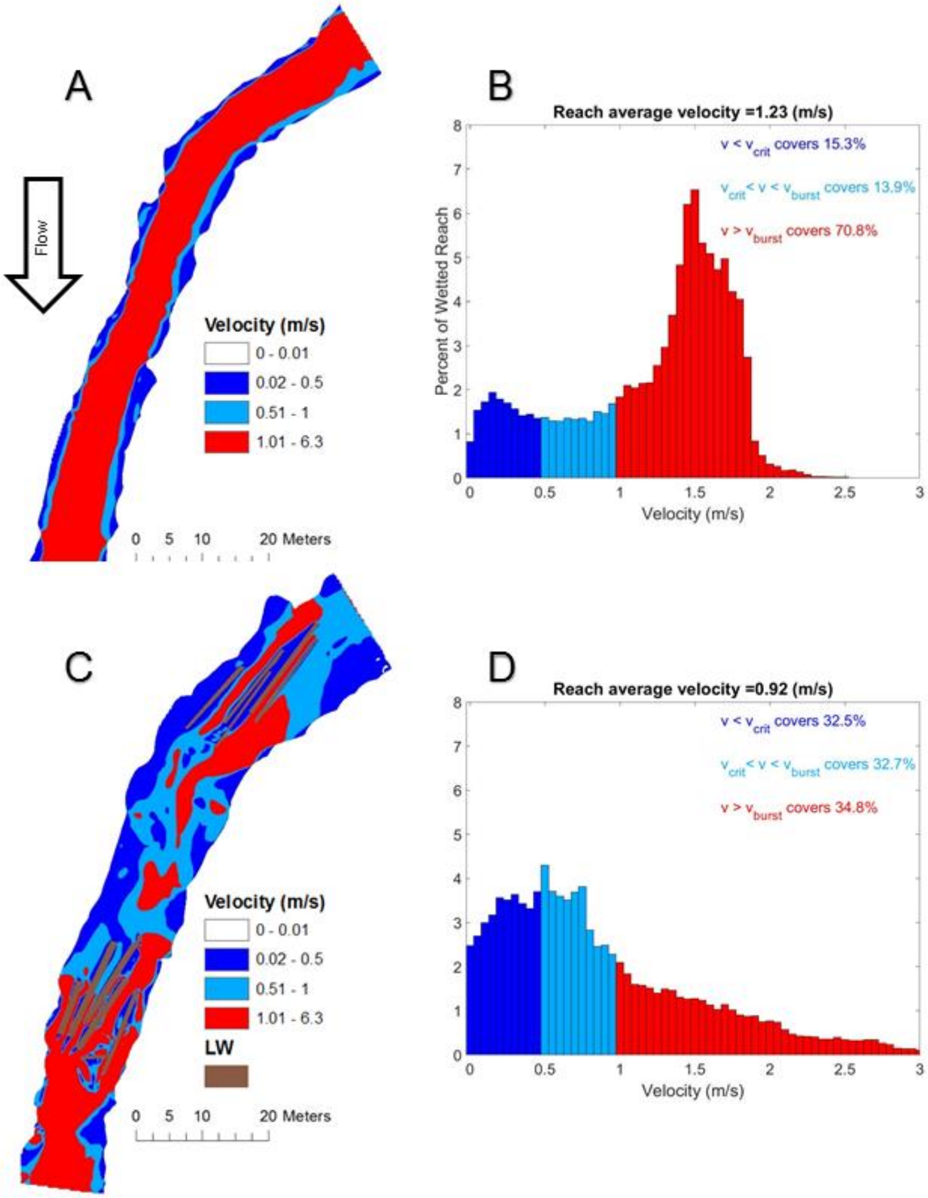


Figure 2: Spatial and frequency distributions of velocity at bankfull discharge before (A and B) and after (C and D) the addition of large wood (LW) in Mill Creek. Colors correspond to thresholds of velocity relevant to the ability of juvenile Coho Salmon to maintain position in the stream (dark $v < v_{crit}$ where $v_{crit} = 0.5$ m/s, light blue $v_{crit} < v < v_{burst}$ where $v_{burst} = 1$ m/s, and red $v > v_{burst}$).

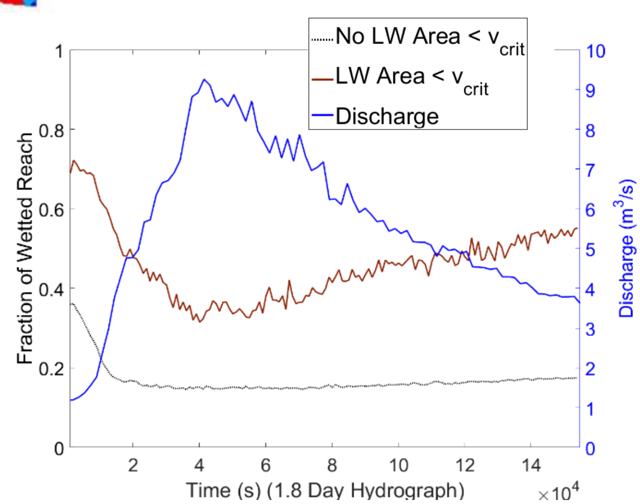


Figure 3. Fraction of wetted reach for Mill Creek, that has acceptable flow velocity ($v < v_{crit}$) over the entire 1.5 day bankfull storm hydrograph before and after LW addition.

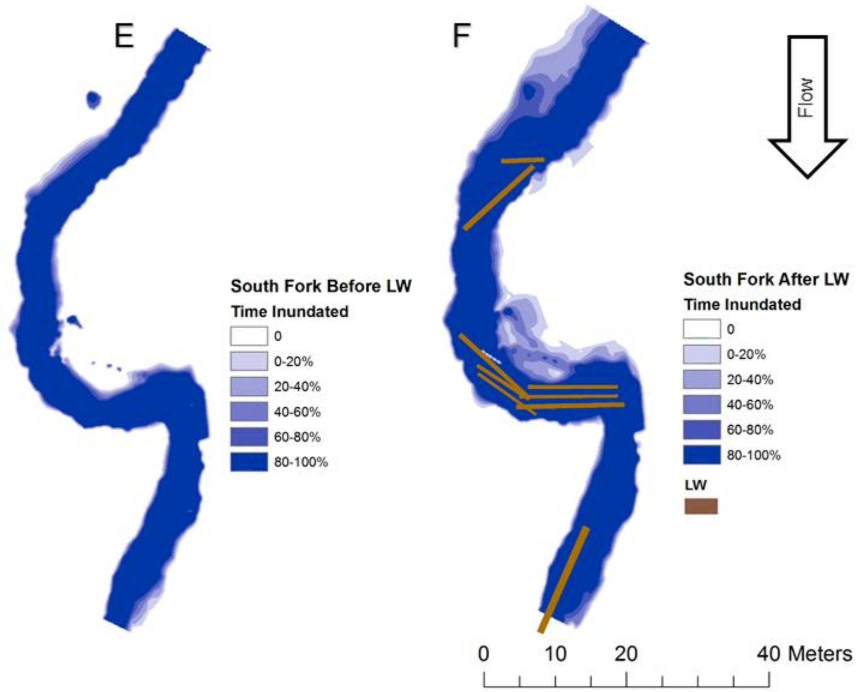


Figure 4: Timing of spatial increases in floodplain connectivity in South Fork before and after the addition large wood (LW). Colored areas show the percent of time during the storm hydrograph that an area was inundated.

<u>Classify channel types in the alluvial stream network of the Mill Creek Watershed:</u> We used the Netmap tool (http://www.terrainworks.com/) to classify all the stream network in Mill Creek considering reaches with stream order above 2 (Fig. 5). The results indicated that out of the 54 km of streams (order >2) 19% correspond to plane bed reaches; 14% are step pool; 7% are pool riffle; 2% are dune-ripple; and 58 % of the network is unclassified. In order to test the accuracy of Netmap we collected ground truth data along 5.5 km of Cerine Creek. The level of agreement was strong for plane bed reaches, which are the key interest in this study. However, Netmap was unable to classify about 2 km (or 36% of the comparison length) of channels that according to the field observations corresponded to either plane bed or forced pool riffle morphologies. In addition, Netmap incorrectly classified ~0.25 km of forced pool riffle reaches as plane bed. This inaccurate classification is not surprising considering that forced pool riffle morphology is generally triggered by the interaction of the flow with in-stream LW in reaches with slopes that could otherwise be associated with plane bed morphology [6]. The idea behind the channel calcification was to investigate how similar are the 3 sites we

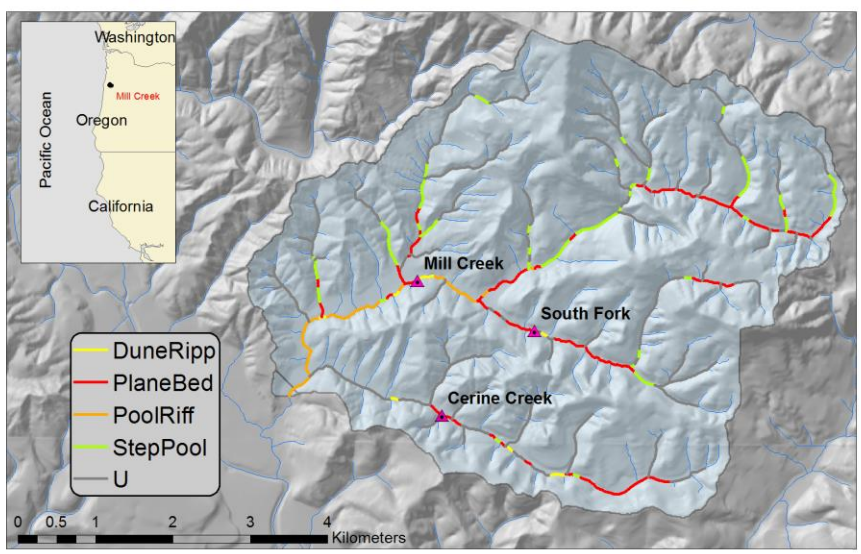


Fig. 5: Channel classification [1] of stream orders above 2 in the Mill Creek watershed. Three study reaches are also indicated.

intensely studied to the rest of the watershed. According to our results it is likely that our results are transferable to all other plain-bed reaches which occupied, according to NetMap 20% of the catchment.

Develop a watershed scale model of channel geomorphic response to LW addition: Our modelling results are one of the first attempts to include wood in a hydraulic model at the reach scale. While we were able to characterize in detail the geomorphic changes triggered by the wood over three sites, we are not yet able to estimate the overall basin response to the restoration effort nor the long term success. The results from the 3 study reaches indicated very similar responses. However, 3 reaches are not sufficient to generalize. For now, we anticipate very similar results in other plane bed sections of the stream network in Mill Creek.

Problems, barriers, proposed changes to objectives:
None to report.

Comprehensive summary of project results and impacts over life of project:
Large wood (LW) pieces are recognized as an important habitat component for salmon freshwater habitat. As such, they are often used in stream habitat restoration practices despite a lack of knowledge about their impacts on spatial and temporal hydraulic characteristics relevant to fish habitat. We use a hydraulic model to identifying patterns and magnitudes of change in aspects of the flow field that are relevant to juvenile Coho Salmon after an addition of LW. The Nays2DH model was used because of its capacity to model unsteady flows around LW structures in-stream. Flow conditions after LW addition were modeled in three alluvial plane bed gravel reaches of Mill Creek in the Oregon Coast Range, a long term salmon life cycle study site. Study streams are small, with a bankfull discharge between 2.2 and 8.7 m^3/s and bankfull widths varying from 5.5 to 10.6 m. Survivable habitat was characterized for the flow field in terms of a) velocity (v) less than critical swim speed of juvenile Coho Salmon (v_{crit} = 0.5 m/s); b) and bed refuge estimated based on the likelihood of the movement of the reach median bed particle size (D_{50}). Spatial and temporal increases in wetted area were also determined. After the addition of LW, the area of acceptable habitat increased 17-26% in terms of velocity, 31-39% in terms of substrate stability, and 24-35% in terms of wetted area at Q_{bf}. Similar magnitudes of increase were observed over an entire storm hydrograph in each site. Patterns of change in the flow field showed deep pools of slower water forming upstream of LW jams which agreed with initial field observations of geomorphic change. Newly inundated flood plains and bars represented large portions of the additional habitat after the addition of LW. These areas had low velocity and shear stress values indicating that their contributions to additional habitat will be resilient to fluctuation even if acceptable habitat metrics were to be adjusted. We found that 2D unsteady hydrodynamic flow models are a robust alternative to study the effects of LW additions to streams. Our results demonstrated that the introduction of LW to reaches in Mill Creek will increase the local area of acceptable habitat during high flow conditions. This effects could eventually lead to improved fish carrying capacity of the stream.

Preliminary results from this project were fundamental in the success of additional funding from OWEB ($17,500) and the National Science Foundation ($419,000)[2]. As part of these efforts we will monitor topographic changes in the 3 reaches for the next 3 years to assess long term restoration success. In addition, a new graduate student will complete her Masters also in Mill Creek around the question: *Where is most cost effective to conduct restoration efforts in a watershed.*

[2] Assessing the influence of lithology on the temporal-spatial variability of sediment transport and its relation to primary production in mountain streams. NSF, EAR Division.

List of names and brief overview of graduate and/or undergraduate engagement in project:

- Russell Bair, Master Student in Water Resources Engineering [7]. Russell graduated last May.
- Amelia Yeager, Master Student in Water Resources Engineering, conducted field work the summer of 2016.
- Jon Sanfilippo (field support 2014); Michael Griffith (field support 2015), Joey Tinker (field support 2015 and 2016). Part of the funds to support these students was provided by the College Mentorship Program.

List of presentations, posters, etc:

- Segura C, Bair R, Yaeger A: Qualifying fish relevant hydraulic changes triggered by Large Wood Additions, EP51D-04 American Geophysical Union, Fall Meeting, San Francisco, CA, Dec 2016 (Oral).
- Bair R, Segura, C Sticks'n'Cricks: Hydrodynamic Modeling of Salmon Habitat Around Restoration Projects, 6th Annual Water Research Symposium. Corvallis, Oregon. April 18 -19, 2016 (Oral).
- Segura C, Katz S, Bair Russell. 2016 Interactions between fluvial geomorphology and stream ecology. Geology Seminar Series PSU. Feb 10 (Oral).
- Bair R, Segura C, Modeling the Effect of Geomorphic Change Triggered by Large Wood Addition on Salmon Habitat in a Forested Coastal Watershed 2016 River Restoration Northwest symposium, Stevenson, WA, Feb 1 – 4, 2016 (Oral).
- Segura C, Katz S, Bair Russell. 2016. Sediment transport modeling. Water Resources Seminar. Feb 24 (Oral).
- Bair R, Segura C, Lorion, C, Modeling the Effect of Geomorphic Change Triggered by Large Wood Addition on Salmon Habitat in a Forested Coastal Watershed, EP43B-0972 American Geophysical Union, Fall Meeting, San Francisco, CA, Dec 2015 (Poster).
- Bair R, Segura C, Modeling Effects of Large Wood on Spatial and Temporal Distribution of Salmon Habitat, 5th Annual Water Research Symposium. Corvallis, Oregon. April 26-28, 2015 (Poster).
- Bair R, Segura C, Modeling Geomorphic Response to Large Wood Addition and Habitat Implications for Fish in a Managed Forest Watershed. Western Forestry Graduate Research Symposium. Corvallis, Oregon. April 27-28, 2015 (Poster).

List of publications, thesis citations:

Bair, R., Modeling Large Wood Impacts on Stream Hydrodynamics and Juvenile Salmon Habitat, in Water Resources Engineering Graduate Program. 2016, Oregon State University: Corvallis. p. 155.

We are currently in the process of summarizing our results in a journal publication to be submitted in 2017.

References: **1.** Montgomery, D.R. and J.M. Buffington, Channel-reach morphology in mountain drainage basins. Geological Society of America Bulletin, 1997. 109(5): p. 596-611. **2**. Beechie, T.J. and T.H. Sibley, Relationships between channel characteristics, woody debris, and fish habitat in northwestern Washington streams. Transactions of the American Fisheries Society, 1997. 126(2): p. 217-229. **3**. Flitcroft, R., et al., Riverscape Patterns among Years of Juvenile Coho Salmon in Midcoastal Oregon: Implications for Conservation. Transactions of the American Fisheries Society, 2014. 143(1): p. 26-38. **4**. Glova, G.J. and J.E. McInerney, Critical Swimming Speeds of Coho Salmon (Oncorhynchus kisutch) Fry to Smolt Stages in Relation to Salinity and Temperature. Journal of the Fisheries Research Board of Canada, 1977. 34(1): p. 151-154.

5. Taylor, E.B. and J.D. McPhail, Variation in Burst and Prolonged Swimming Performance Among British Columbia Populations of Coho Salmon, Oncorhynchus kisutch. Canadian Journal of Fisheries and Aquatic Sciences, 1985. 42(12): p. 2029-2033. **6**. Montgomery, D.R., et al., Pool Spacing in Forest Channels. Water Resources Research, 1995. 31: p. 1097-1105. **7**. Bair, R., Modeling Large Wood Impacts on Stream Hydrodynamics and Juvenile Salmon Habitat, in Water Resources Engineering Graduate Program. 2016, Oregon State University: Corvallis. p. 155.

Fish and Wildlife Habitat in Managed Forests Program
FY 2016-17 Technical Advisory Committee

Jake Gibbs, *Chair*
Lone Rock Resources
PO Box 1127
Roseburg, OR 97470-0235
Phone: 541-673-0141, ext. 404
E-mail: JGibbs@lrtco.com

Jenniffer Bakke
Hancock Forest Management
955 N. Main St.
Independence, OR 97351-2505
Phone: 503-838-6928
E-mail: jbakke@hnrg.com

Seth Barnes
Oregon Forest & Industries Council
PO Box 12826
Salem, OR 97309-0826
Phone: 503-586-1243
E-mail: seth@ofic.com

Louisa Evers
Bureau of Land Management
1220 SW 3rd Ave., FL 11
Portland, OR 97204-2825
Phone: 503-808-6377
E-mail: levers@blm.gov

Cheryl Ann Friesen
U.S. Forest Service
57600 McKenzie Hwy
McKenzie Bridge, OR 97413-9612
Phone: 541-822-7226
E-mail: cfriesen@fs.fed.us

Rod Krahmer
Oregon Department of Fish and Wildlife
4034 Fairview Industrial Drive, SE
Salem, OR 97302-1142
Phone: 503-947-6083
E-mail: Rod.W.Krahmer@state.or.us

Jeff Light, *Immediate Past Chair*
Phone: 541-270-1303
E-mail: jefjudlight@msn.com

Mike Rochelle
Weyerhaeuser Company
34904 Brewster Rd.
Lebanon, OR 97355-9432
Phone: 541-258-5970
E-mail: mike.rochelle@weyerhaeuser.com

Evan Smith
The Conservation Fund
4039 N. Mississippi Ave., Suite 308
Portland, OR 97227-1477
Phone: 541- 407-0301
E-mail: esmith@conservationfund.org

Jimmy Taylor
USDA National Wildlife Research Center
Oregon State University
321 Richardson Hall
Corvallis, OR 97331-8583
Phone: 541-737-1353
E-mail: jimmy.d.taylor@aphis.usda.gov

Jake Verschuyl
National Council of Air Stream Improvement
PO Box 1259
Anacortes, WA 98221-6259
Phone: 360-293-4748, x22
E-mail: jverschuyl@ncasi.org

Jennifer Weikel
Oregon Department of Forestry
2600 State St.
Salem, OR 97310-1336
Phone: 503-945-7398
E-mail: jweikel@odf.state.or.us

John Westall
The Oregon Small Woodlands Association
12090 Rolling Hills Road
Monmouth, OR 97361-4600
Phone: 503-838-1436
E-mail: john.westall@oregonstate.edu