FISH AND WILDLIFE HABITAT IN MANAGED FORESTS RESEARCH PROGRAM

PROGRESS REPORTS

FY 2018

November 28, 2017

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

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Fish and Wildlife Habitat in Managed Forests

Title: Experimental evaluation of plethodontid salamander responses to forest harvesting

Investigators: Tiffany Garcia, Andrew J. Kroll, Jessica Homyack, Claudine Reynolds, David Shaw

Objectives:

A. Quantify Oregon slender salamander (OSS) and Ensatina salamander (ENES) occupancy and abundance across harvested and control treatment stands
B. Correlate the quantity and quality of CWD within stands and across treatments to identify mitigating effects of understory habitat structure

Site Selection- Our experiment uses a staggered design in which a subset of stands are harvested in each year. By the conclusion of the experiment in 2020, all of the stands will have been harvested except for 15 control stands. We implemented the pre-harvest stage of this project in 2013. Eighty-eight units from the harvest plans of Weyerhaeuser, Port Blakely, ODF, and BLM (>10 acres in size, <2500 ft. in elevation) were selected randomly to be included in the experiment. We confirmed OSS occupancy in all 88 stands, the rarer salamander species. During this past 2017 season, we sampled 76/88 units, (33 harvested, 43 control). We did not sample 12 units because they were within 12 months of being harvested.

Sampling and Analytical Methods- Our sampling program estimates both occupancy (population persistence) and abundance (population size) and how these responses vary by treatment and CWD quality and quantity. Each year, we sample seven unique 81 m2 plots in each harvest unit (except during the first year post-harvest). Observers use a light touch sampling protocol, record salamander observations, habitat and CWD data, including length, width, sapwood width, and decay class (Maser and Trappe 1984). Our analytical approach identifies the: (1) probability that a harvest unit is occupied by OSS or ENS; (2) probability that a sampling plot (site scale) is occupied by OSS or ENS; (3) abundance of OSS or ENS at a sampling plot (site scale); and (4) the association of occupancy and abundance with CWD quantity (Kroll et al. 2015).

Summary of Accomplishments toward First Objective:

Results- Occupancy Model

Using the model described in Kroll et al. (2015), we estimated treatment-specific occupancy and abundance for both OSS and ENES from 2015-2017 (table 1). We note that 2015-2017 are the post-treatment years. We did not find evidence for treatment differences in occupancy or abundance for either species (figure 1). We estimated a substantial amount of uncertainty (wide credibility intervals) in treatment estimates for both OSS and ENES. As discussed in our 2018 FWHMF proposal, additional sampling years are needed to increase precision in our occupancy and abundance estimates. This is expected to occur in 2018 as there will be a 70% increase in harvest site/years and 30% increase in control site/years.

Species/Model	Estimate (90% CI)
OSS-Occupancy	1.8 (0.7, 4.7)
ENES-Occupancy	1.0 (0.4, 2.6)
OSS-Abundance	1.2 (0.7, 2.2)
ENES-Abundance	0.9 (0.4, 1.7)

Table 1. Occupancy and abundance estimates for Oregon slender salamanders (OSS) and Ensatina salamanders (ENES). Occupancy effects are reported on a logit scale; abundance effects are reported on the log scale.

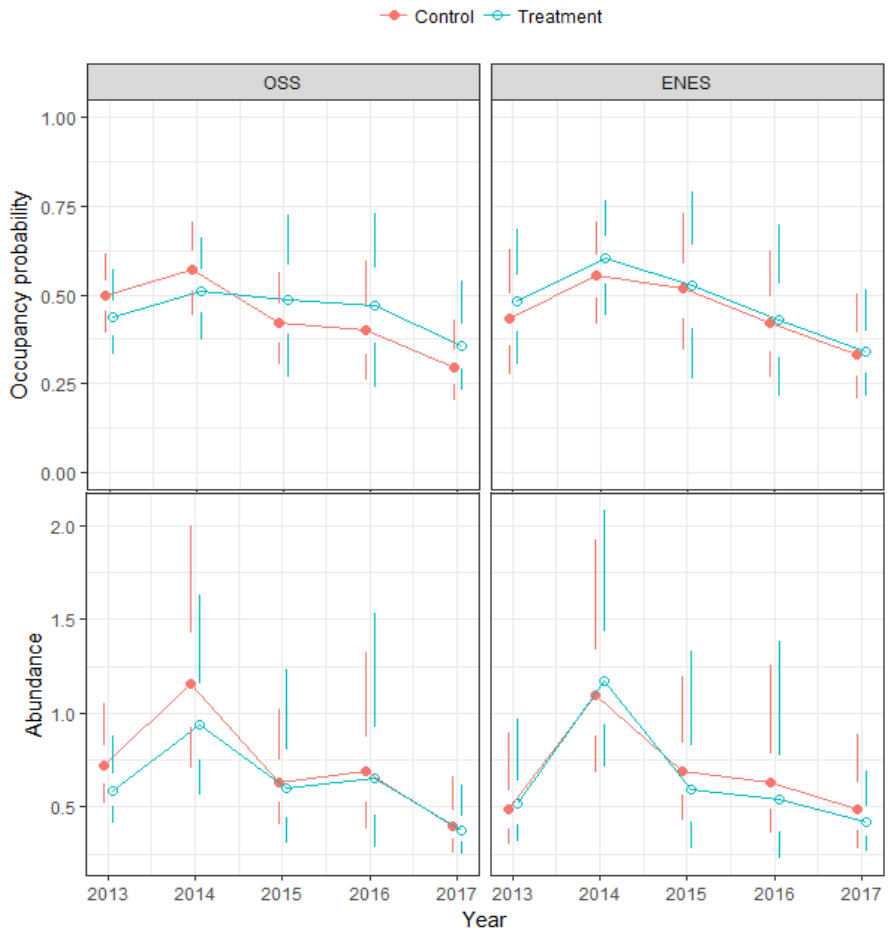


Figure 1. Occupancy (Top Panel) and Abundance (Bottom Panel) estimates for Oregon slender salamanders (OSS) and Ensatina salamanders (ENES) over the 5 years of the study. Control (red) indicate unharvested units; Treatment (blue) indicate harvested units.

Summary of Accomplishments toward Second Objective:

Results- Downed Wood Density

Occupancy and abundance probabilities increased with downed wood counts at the plot level for both OSS and ENES across the course of this study (2013-2017; figure 2). 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. Over 95% of observations had less than 7 pieces downed wood and the maximum count was 15.

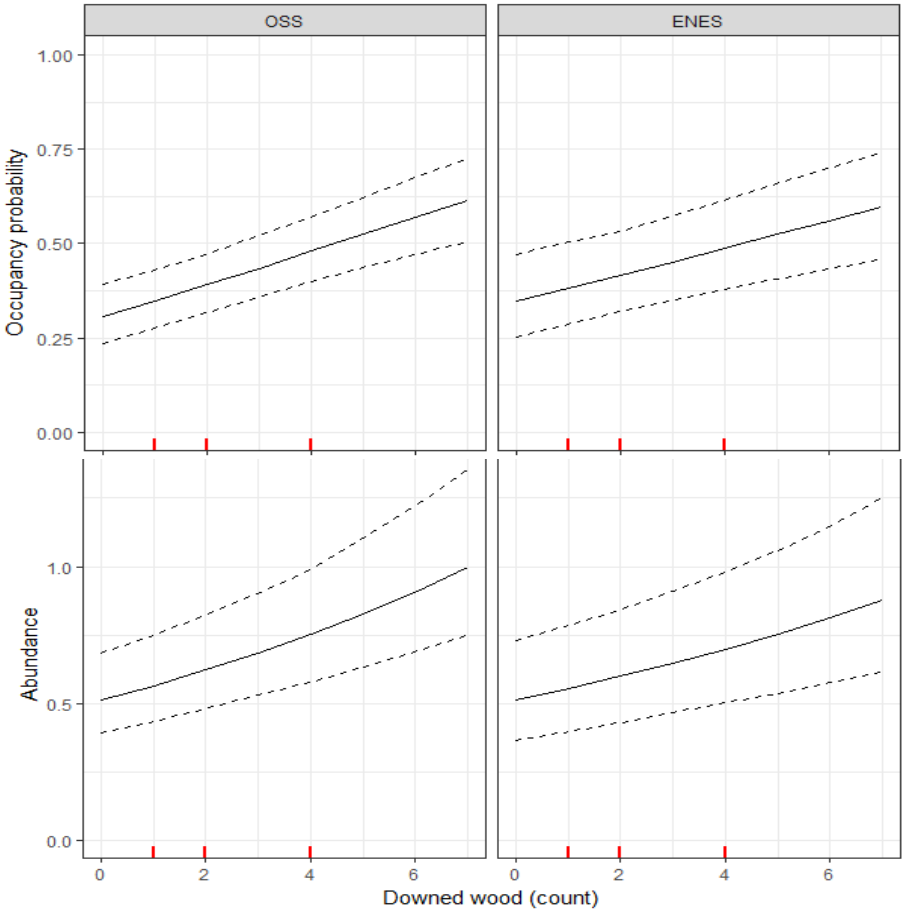


Figure 2. Plot-level occupancy (top panel) and abundance (bottom panel) estimates averaged across years and units given downed wood counts for Oregon slender salamanders (OSS) and Ensatina salamanders (ENES) over the 5 years of the study.

Results- Air Temperature

Detection probability for both OSS and ENS varied with air temperature across treatments at the time of the survey effort (figure 3). As temperatures increased, we detected a stronger treatment effect on detection for both salamander species, with lower probability of detection in harvested units relative to control units.

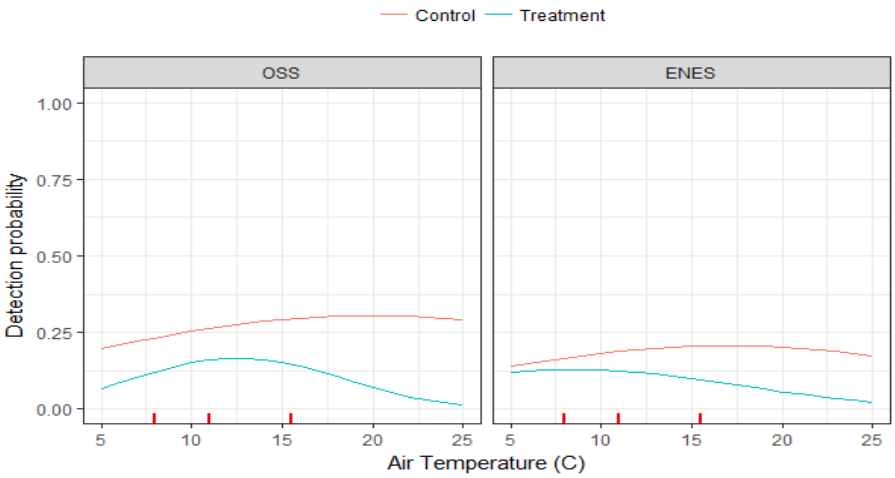


Figure 3. Modeled detection probabilities for Oregon slender salamanders (OSS) and Ensatina salamanders (ENES) as a function of ambient temperature (˚C) and harvest treatment.

Problems and Barriers:

Analyses of the field data and the simulations in Kroll et al. (2015) indicate that our sample size of 88 harvest units was sufficient to answer our research questions. However, as forecast, the number of stands harvested by 2017 was not sufficient to estimate treatment effects precisely. The estimate of the treatment effect will become more precise with each additional year of sampling as the sample size of treatment units increases.

Planned Work:

We are currently planning our 2018 field season. Crew selection will occur in January, 2018, and sampling of control and treatment units will begin in early April, 2018, and continue for 10 weeks. We plan to hire 4 technicians: two to sample the Clackamas units, and two to work the Snowpeak area.

With Dr. David Shaw on the 2018 project, we plan to collect downed wood quality information, such as decay status and heartwood availability.

Graduate and/or Undergraduate Engagement:

Jose Ruiz Jr. – Jose was employed as a field technician during the 2017 field season and is an undergraduate student in OSU's Department of Fisheries and Wildlife. Jose was recruited through the Louis Stokes Alliance for Minority Participation, a program at OSU that aims to increase diversity and the representation of minority groups in academics, particularly the STEM fields. Jose hopes to return for the 2018 field season.

A'naka Smith – A'naka was employed as a field technician during the 2017 field season, and is a recent graduate of the OSU Department of Fisheries and Wildlife. We have been successful at maintaining a 50/50 ratio of female/male technicians over the course of this study, and A'naka hopes to return for the 2018 field season.

List of Presentations, Posters, etc.:

None, as data collection/analysis/reporting for this funding cycle has not yet begun.

List of Publications, Thesis Citations:

None, as data collection/analysis/reporting for this funding cycle has not yet begun.

Fish and Wildlife Habitat in Managed Forests

Title: Does a lack of structures for nest building limit red tree vole occupancy of actively managed forest?

Investigators: Damon Lesmeister, John Bailey, Mark Linnell

Objectives: 1) test if the lack of suitable structures for nest building limits red tree vole occupancy of younger stands (lack-of-structure hypothesis); 2) quantify the latency to colonization of artificial platforms by red tree voles; and 3) quantify occupancy and visitation rates to artificial platforms by potential predators of red tree voles.

Summary of Accomplishments toward Objectives: We hired a graduate student that started to work on the project during the summer 2017. We have installed and are monitoring 616 artificial platforms in young forests. At 184 of those platforms we have installed remote cameras and started collecting photographs to quantify use patterns by red tree voles and potential predators. During 2017 we captured 67 red tree voles at platforms.

Problems and Barriers: Some platforms have become occupied by wasps, making them inaccessible to tree climbers to check for red tree vole sign.

Planned Work:
Fall 2018: photograph tagging and sorting, data analysis, report writing
Winter 2017/2018: photograph tagging and sorting, data analysis, check platforms and refine red tree vole marking techniques.
Spring–Fall 2018: check platforms and collect photographs from cameras.
Winter 2018/2019–Spring 2019: data analysis, report writing, manuscript preparation.

List of Names and Brief Overview of Graduate and/or Undergraduate Engagement in Project:
Preston Durham, MS student, Forest Engineering, Resources & Management

List of Presentations, Posters etc.: None yet.

List of Publications, Thesis Citations: None yet.

Fish and Wildlife Habitat in Managed Forests

Title: Identifying distribution boundaries at the upper extent of fish in streams using environmental DNA

Investigators: Brooke Penaluna, Ivan Arismendi, Tiffany Garcia, Jessica Homyack, Taal Levi, and Dana Warren

Objectives: We propose a comparison study that evaluates the upper end of fish distributions in streams of Oregon and Washington comparing traditional electrofishing techniques to eDNA detection. We will (1) assess whether eDNA can identify the end of fish distributions at their upper extent and (2) compare those data to electrofishing data.

Summary of Accomplishments toward Objectives:

We are working with land managers of Weyerhaeuser, Hancock Forest Management, and Port Blakely to select sampling sites on their land and to have access to their electrofishing data to compare to eDNA results. We did a pilot test of the proposed eDNA protocol during spring 2017 and we have refined it.

Problems and Barriers: We have not had any noteworthy problems or barriers to this work. During the pilot sampling of the protocol during spring 2017, we realized that we have to refine the procedure. We will collect water for eDNA sampling at 50m intervals as proposed, but because we have to take eDNA samples before electrofishing crews can begin working, to avoid contamination, we will collect samples from more potential sites than we will use in the study. Once electrofishing is completed and we know exactly where the end of fish will be from electrofishing, we can organize and process the eDNA samples accordingly.

Planned Work: Our planned work remains as outlined in the initial project proposal. We plan to understand the utility of eDNA to identify the end-of-fish. Currently, we are planning for the first field season during April-July 2018. We are coordinating with timber management companies to have access to their land for eDNA sampling and to compare their electrofishing data to eDNA results. We will hire a field crew to complete the field collections.

List of Names and Brief Overview of Graduate and/or Undergraduate Engagement in Project: During the spring 2017 pilot sampling, we provided research experience for Tim Glidden (OSU post-bachelorette). For sampling in 2018, we will have two student technicians that will be trained to take eDNA samples as part of this project.

List of Presentations, Posters etc.: We plan to give data-related presentations when the fieldwork, eDNA lab work, and data analyses have been completed. This project has provided the opportunity to interact with forest managers and landowners to discuss collaborations related to the upper-extent-of-fish and Cutthroat Trout.

Penaluna, B. E. 2016. Identifying distribution boundaries at the upper extent of fish in streams using environmental DNA. Washington Cooperative Monitoring, Evaluation, and Research Committee. Olympia, WA.

List of Publications, Thesis Citations: This work will be submitted as a final report, and as a publication. We aim for completion in 2019.

Fish and Wildlife Habitat in Managed Forests

Title: Quantifying fish response to management creating riparian forest canopy gaps

Investigators: Dana Warren, Maryanne Reiter

Objectives:

Our objective was increase our understanding of how changes in stream light associated with moderate alteration of riparian forests impact stream fish and stream ecosystem processes. We proposed to do this through a riparian forest canopy manipulation. We set-up a before-after control-impact study in which we planned to collect pre-treatment data at all sites in summer 2017, implement the gap cuts in fall 2017/winter 2018, and the collect post-treatment data in summer 2018.

Summary of Accomplishments toward Objectives:

In summer 2017, we quantified canopy cover, stream light, stream nutrient dynamics, stream habitat, algal accrual, and stream metabolism successfully at all six streams (12 reaches total). Data and sample analysis is ongoing for these metrics. Water temperature data were collected throughout the summer at five of the six sites. At the sixth site, loggers were deployed but a high flow event occurred before they could be retrieved and a number of loggers were lost – thereby diminishing the quality of the temperature data from this site. Due to a number of un-expected logistical constraints (see below), we collected data on fish at only three of our six reach pairs in 2017. To avoid impacting juvenile trout, our stream fish surveys in this region are scheduled for late summer. In the past, we have collected fish in these and other sites across the region with no issue, however, this year the timing of fish sampling coincided with multiple factors that impacted our ability to visit the study streams.

Problems and Barriers:

Fish collections went smoothly at three of the sites (the HJ Andrews site and two of the three Weyerhaeuser sites), however we encountered a number of issues with fish collections at the other three sites in summer 2017. Access to the USFS South Fork Mackenzie River tributary sites was a particular issue in summer 2017. The Rebel Fire closed the main access road to both sites before our planned fish surveys at those areas. We were able to access the closer site (Loon Creek) one time via a more remote route, which allowed us to sample one reach before the fire got too close, but we were not able to return to collect data at the reference reach. We prioritized sampling in the reach that we will manipulate for the one sampling event at Loon Creek. Fortunately, these two USFS sites are streams where we collected pre-treatment data from both reach pairs in 2014, 2015, and 2016. While it is less than ideal to be missing the 2017 data, we are confident that we will still be able to answer our study questions and address our key objectives at these sites using the other three years of pre-treatment data.

The third Weyerhaeuser site was not sampled due to herbicide spraying near that site in mid-August – about a week before we were planning to survey fish at that site. In following the recommended safety practices for herbicide, we did not enter the site for 3 weeks after herbicide (which was done "near" but not directly over our sites). By the time we could re-enter the reach, our undergraduate technicians had completed their work, and we did not have the personnel to complete fish assessments at this (our largest) site.

At the HJ Andrews gap site (McRae Creek Tributary), we surveyed fish in early August and then implemented an initial mid-summer gap cut at the lower reach to gain insight into short-term responses to increased light. This was the only mid-summer gap that we cut. At this site, we intended to return in mid-September to re-assess the size of juvenile fish at each reach to see if there was a discernable effect of the gap on relative growth of young-of-year fish (as had been suggested in an earlier correlative study). However, there were fewer young-of-year fish than anticipated in these reaches during summer 2017.

The sample sizes (2 and 4 fish respectively) were too small to be able to draw meaningful conclusions about the growth of these fish over the summer in the two reaches so we did not return.

For temperature assessments, we lost data at one of the USFS SF Mackenzie River tributary sites due the Rebel Fire. Were able to retrieve the temperature loggers at the closer site (Loon Creek) when the fish survey was conducted at the end of August, however at Chucksney Mountain Creek, we were not able to access the site until after the first major rains – that tamped down the fire. When those rains did occur, flow increased and washed out some of the temperature loggers that we had in place (all loggers were tethered but strings and housings broke in the flood). After searching the stream we found some of the loggers so we have some temperature data at this site but less than we had planned.

Planned Work:

We have implemented two gap cuts so far (HJA McRae Creek Tributary, and one of the three Weyerhaeuser sites). We plan to implement the remaining two gap cuts on Weyerhaeuser land in fall 2017 and the two USFS SF Mackenzie River tributary sites in spring 2018. We will visit all sites and re-sample in 2018. This will include an initial sampling at Weyerhaeuser site 122 for fish. We feel confident that results from this location will be valuable even in the absence of paired pre-treatment fish data as these data will allow us to assess initial effects in the context of recovery from the gap treatment as the canopy closes in coming years.

List of Names and Brief Overview of Graduate and/or Undergraduate Engagement in Project:

This project supported one graduate student and two undergraduates. The FWHMF award provided funding for one undergraduate student in summer 2017. The second undergraduate student was supported by D. Warren from other funding sources, but this student would not have been hired without the larger overall project support from our FWHMF grant. Undergraduates gained field experience in riparian ecology research and in conducting field surveys for aquatic ecology, stream habitat and fish assessments.

Students:

Allison Swartz – MS student in the department of Forest Ecosystems and Society. Allison is writing her MS thesis on this project.

Alvaro Cortes – Fisheries and Wildlife Major entering his senior year.

Cedar Mackeness – Environmental Science and Education double Major in the OSU Honors college entering his sophomore year.

Both of the students hired in summer 2017 have remained engaged in this work.

Alvaro Cortes, is doing a senior thesis that uses fish data collected during this survey. Because he is finishing soon, his project does not explicitly address the question of gaps but he is using fish data collected during these surveys to explore fish recovery to the 2015 drought.

Cedar Mackeness is planning to do his Honors College project on work with the gap study. He is particularly excited about exploring potential effects of the gaps on macroinvertebrate communities. This will be a particularly useful piece of information for our project. The current FWHMF project does not have the funding needed to explore macroinvertebrates, but understanding their responses is an important piece to account mechanistically for changes we expect to see in fish. We collected invertebrates at all sites in summer 2017 and if we can find additional support for the invertebrate identification and analysis from 2017 and 2018, Cedar will conduct a BACI study on Macroinvertebrate responses to the gaps cut in this project.

List of Presentations, Posters etc.:

None to date

List of Publications, Thesis Citations:

Aquatic ecosystem responses to riparian canopy gaps in headwater streams. Allison Swartz. MS Student Forest Ecosystems and Society, Oregon State University. *Anticipated Spring 2019.*

Continuing Research Projects
FY 2017

Fish and Wildlife Habitat in Managed Forests

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

Investigators: Alba Argerich, Kevin Bladon, Jeff Hatten, Sherri Johnson

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:

During this last year, we have:

- Finished chemical analysis from the pre-harvest Trask stream water chemistry samples from storms.
- Compiled chemistry data from storm samples with the existing Trask stream water database.
- Obtained landscape and climate metrics from the Trask using GIS tools.
- Identified relevant landscape and climate metrics that explain spatial variability in nutrient concentrations.
- Identified relevant landscape and climate metrics that explain temporal variability in nutrient concentrations.

Problems and Barriers:

- None so far.

Planned Work:

- Obtain Hinkle and Alsea stream chemistry datasets.
- Test the model derived from the Trask on Hinkle and Alsea datasets.

List of Names and Brief Overview of Graduate and/or Undergraduate Engagement in Project:

MS thesis: Casey Steadman, Natural variability of nitrogen and phosphorus in a forested headwater stream system in the Oregon Coast Range, Master of Science in Water Resources Science to be presented on December 7, 2017.

Undergraduate experience: Emilee Mowlds, undergraduate student in the Mentored Employee Program, worked on this project between Fall 2016 and Spring 2017. She assisted 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.:

- C. Steadman, A. Argerich, K. Bladon, and S. Johnson. An evaluation of nitrogen and phosphorus responses to rain events in a forested watershed. Abstract H52D-04. American Geophysical Union Fall Meeting. December 11-15, 2017. New Orleans, LA. Oral presentation.
- Steadman, C.L., Bladon, K.D., Argerich, A., and Johnson, S.L. 2017. Spatial and temporal variability of stream water nitrogen and phosphorus in a forested Oregon Coast Range Watershed. Western Forestry Graduate Research Symposium. Apr. 21, 2017. Corvallis, OR. Poster
- C. Steadman, K. Bladon, A. Argerich, and S. Johnson. Geological and hydrological influences on nitrogen and phosphorus concentrations in forested headwater catchments of the northern coast range of Oregon. 7th Annual Pacific Northwest Water Research Symposium. March 6-7, 2017. Corvallis, OR, USA. Poster.
- C. Steadman, K. Bladon, A. Argerich, and S. Johnson. Spatial and temporal heterogeneity of nitrogen in forested headwater catchments of the Northern Coast Range of Oregon. Abstract B33B-0592. American Geophysical Union Fall Meeting. December 12-16, 2016. San Francisco, CA, USA. Poster.
- Steadman, C.L., Argerich, A., Bladon, K.D., and Johnson, S.L. 2016. Early trajectory of chemical water quality response to disturbance by forest harvesting in the Northern Coast Range of Oregon. Society for Freshwater Science. May. 21-26, 2016. Sacramento, CA. Poster.
- Steadman, C.L., Argerich, A., Bladon, K.D., and Johnson, S.L. 2016. Effects of disturbance by forest harvesting on limiting nutrients in the Trask Watershed of the northern Coast Range of Oregon. Western Forestry Graduate Research Symposium. Apr. 22, 2016. Corvallis, OR. 1st runner-up: best poster presentation.
- Steadman, C.L., Bladon, K.D., Argerich, A., and Johnson, S.L. 2016. Spatial and temporal variability of nitrogen and phosphorus in headwater catchments of the northern Coast Range of Oregon. 6th Annual Hydrophiles Water Research Symposium. Apr. 18-19, 2016. Corvallis, OR.

List of Publications, Thesis Citations:

Steadman, C. Natural variability of nitrogen and phosphorus in a forested headwater stream system in the Oregon Coast Range, Master of Science in Water Resources Science to be presented on December 7, 2017.

Steadman, C., K. Bladon, A. Argerich, and S. L. Johnson. Nitrogen and phosphorus responses to precipitation and landscape characteristics in a forested headwater stream system. To be submitted TBD.

Fish and Wildlife Habitat in Managed Forests

Title: Distribution of rare forest carnivores (Fisher, Marten) in coastal southern Oregon

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

Objectives: We have three objectives to achieve the overall goal of better understanding whether and how forest management affects fisher and marten occupancy in the southern Oregon coast:

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

Summary of Accomplishments toward Objectives:

2016 – Conducted 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.
2017 – Completed detection dog surveys in Curry and Coos counties. Sent samples to genetics lab and evaluate distribution and population boundaries of each species, some preliminary results but most data in progress.

During 2016 and 2017 detection dog teams surveyed 196 sample units and collected 1,366 scats targeting fisher, marten, bobcat, lion, montane red fox, and porcupine. Of these sample units, 28 were fully funded by the Fish and Wildlife Habitat in Managed Forests Program to fill in some very difficult gaps in our distribution knowledge in the southern coast of Oregon.

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, Conservation Canines) collected 110 scats, 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.

During 2017 Conservation Canines surveyed 52 sample units in southern coastal Oregon – 12 additional locations by FWHMF and additional sample units funded by the Rogue Siskiyou National Forest and Coos Bay BLM. They collected 264 scats sent to the Levi lab at Oregon State for Illumina sequencing, which is a high powered Next-Generation sequence system, confirming both species and diet using metabarcoding.

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). During 2017 an additional 5 marten locations were genetically confirmed, extending the range both south and east including several locations in fire perimeters (Figure 2). Fisher scats were located 22km west of Cave Junction in addition to a few scats

near the coast. One fisher was detected via camera on the border of California and several scats within the Chetco Bar fire perimeter (Figure 3).

Additional information will be available following the future Illumina sequence runs.

Problems and Barriers:

Using traditional microsatellite techniques, scat amplification to sex and individual has been lower than expected. Results are in review 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).

Several scats of known radio collared martens were tested on the Next Generation Illumina sequencer to assess whether the lab could increase success for individual and sex identification as success with microsatellites as ranged between 8-17%, a depressing success rate. Sequences proved to be comprised exclusively of bi-allelic polymorphisms (e.g., CG CG CG), which are much more difficult to find differences compared to tri-allelic polymorphisms (e.g., CGA CGA CGA) suggesting that additional regions of the genome and creating a new library for those new regions would be needed (e.g., areas to test differences using Single Nucleotide Polymorphisms (SNP)). The good news was that the DNA amplified in all the tested scats providing hope that scats *could* be used to quantify the minimum number of individuals after SNP investment was completed. Dr. Levi suggested such a library would take an individual approximately a year of time due to laborious processing of tissue samples.

Conservation Canines collected 1,366 scats for all of Moriarty's projects during 2016 and 2017. Because we partnered with ncasi to evaluate diet for fisher, marten, bobcat, and lion – not all scats have been processed including some of the FWHMF samples. Only 302 scats have been completely extracted and sequenced, but all scats have been placed in tubes with a triplicate samples. The completion of all Illumina runs should be completed during winter 2017-2018.

Planned Work: We will continue using Illumina sequencing to identify species and diet for all scats.

Comprehensive Summary: Not applicable – field data is complete, but genetic sequencing is in progress.

List of Names and Brief Overview of Graduate and/or Undergraduate Engagement in Project:

We have had 4 undergraduate students working on photo-tagging and processing with the few cameras we set out in the coast range this year. Another undergraduate, Mark Stevens, sorted through scats to identify berries, seeds, and invertebrates. The Levi lab also involves >10 undergraduate students to help in both the lab and with carnivore photographs – providing valuable experience using specific scientific protocols and preparing samples for analyses.

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

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)

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 review.* Seeking efficiency with carnivore survey methods: a case study with rare and elusive martens.

Moriarty, K. M., J. Verschuyl, A.J. Kroll, R. Davis, J. Chapman, B. Hollen. *In prep.* Describing vegetation characteristics used by two sympatric, rare, forest-dependent species: assessing the efficacy of an umbrella species management strategy.

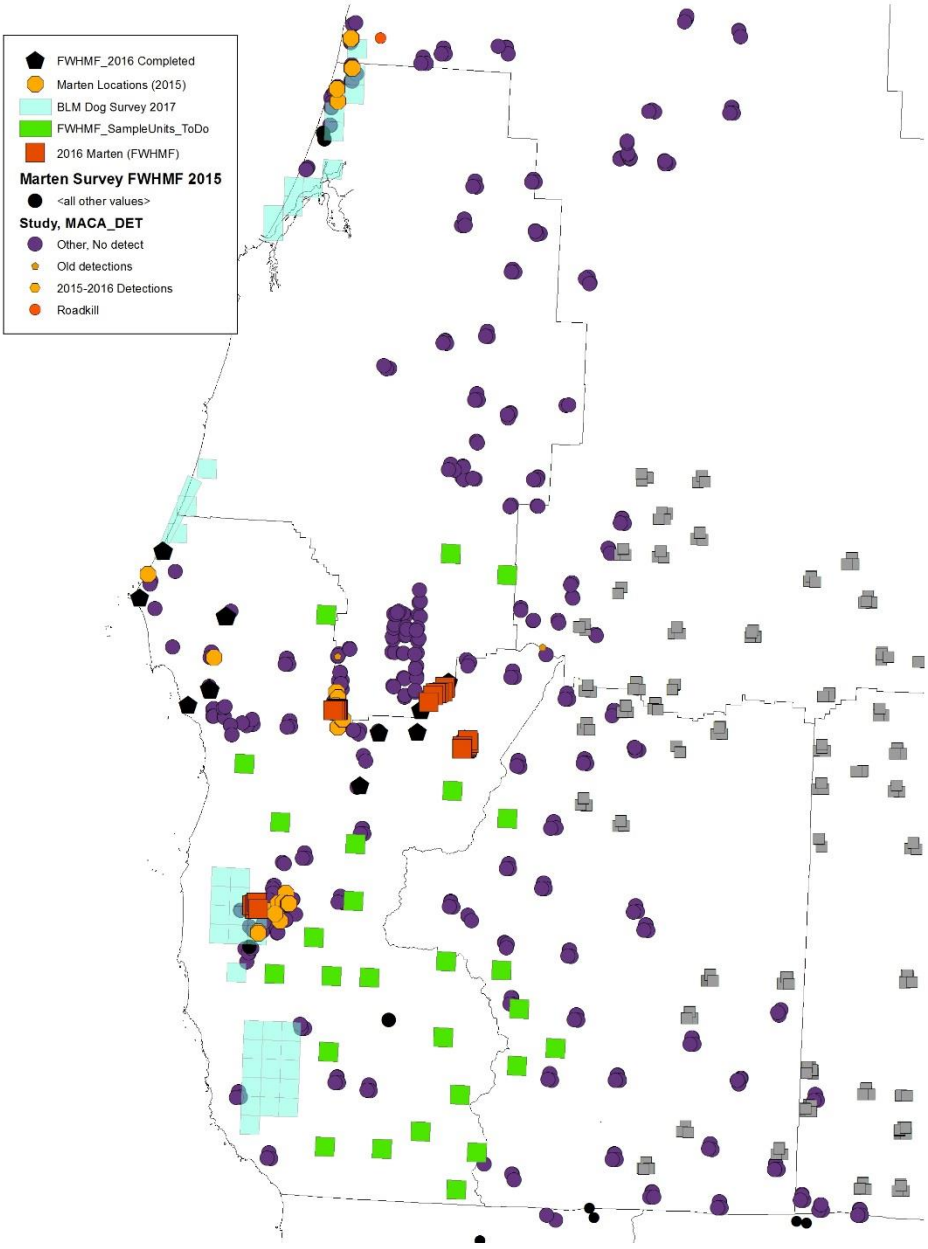
Barry, B.*, K.M. Moriarty*, and T. Levi. *In prep.* Pacific fisher distribution surveys suggests range contractions in western Oregon. **co-lead authors*

Eriksson, C.*, K.M. Moriarty*, M.A. Linnell, and T. Levi. *In prep.* Rapid ecological assessments using remote techniques: a case study with coastal marten. **co-lead authors*

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, BLM will add to the 2017 survey effort (blue squares). Detection dog teams will target fisher, marten, bobcat, and mountain lion. Scats will be send to the Levi lab (OSU) for species confirmation.



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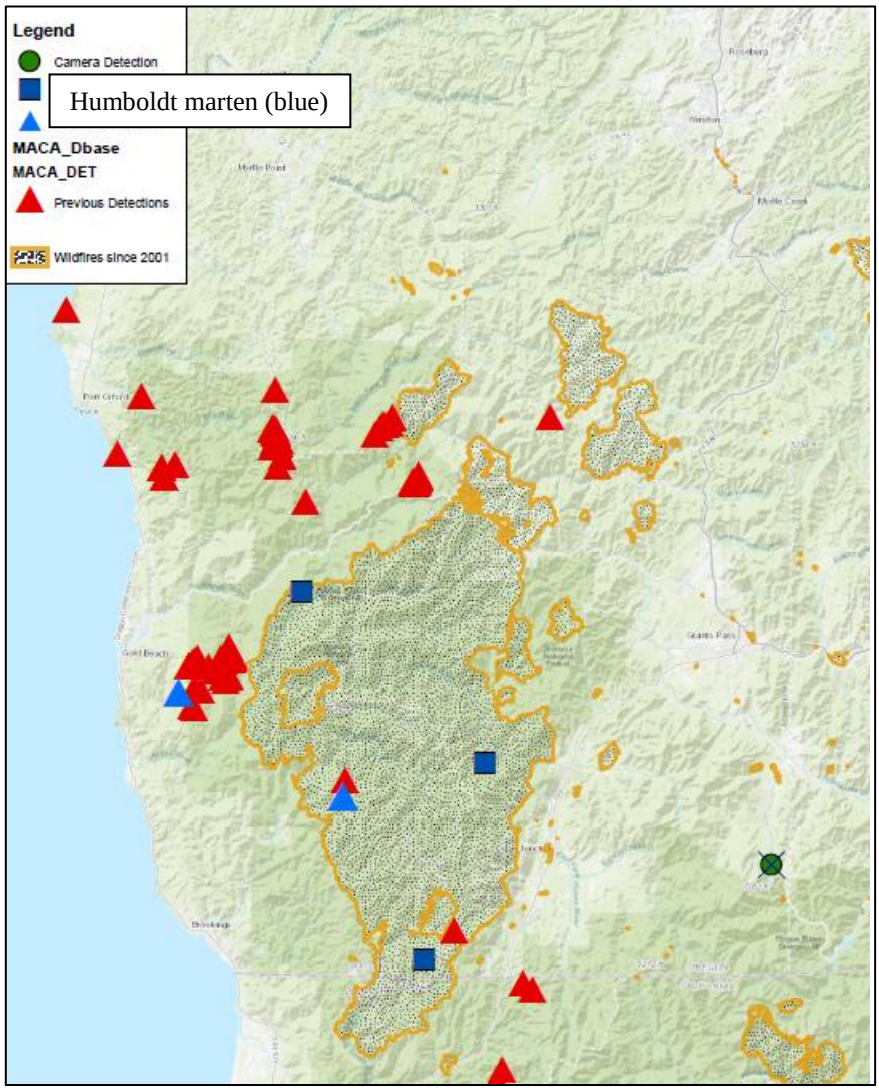

Figure 3. Diagram of previous marten detections (red triangles) and new locations from 2016-2017 surveys. Genetic designation appears to differ slightly at the 12S region of the genome, but all blue areas would be new marten detections. Four of the 5 new locations were in the perimeter of the Biscuit or Silver fires (orange polygon).

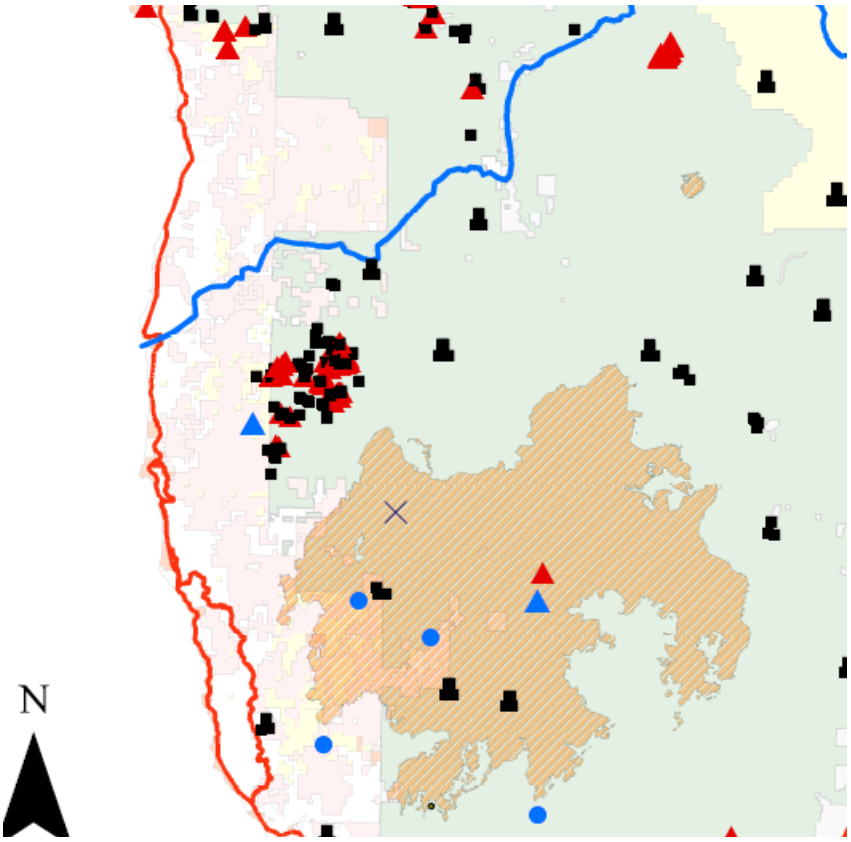

Figure 4. Diagram of previous marten detections (red triangles), new locations from 2016-2017 surveys (blue triangles – older run), and fisher scat detections (blue circles).

Fish and Wildlife Habitat in Managed Forests

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.)

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 toward Objectives: 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). In 2017, we added another moderate-low fire severity stand to increase replication for a total of n=42 stands. We sampled bee communities using blue vane traps (BVTs) every 3-4 weeks from May-September 2016 and 2017. We collected a total of 5,209 bees representing 20 genera and approximately 100 species, with identification of the 2017 samples is still in progress. To date,

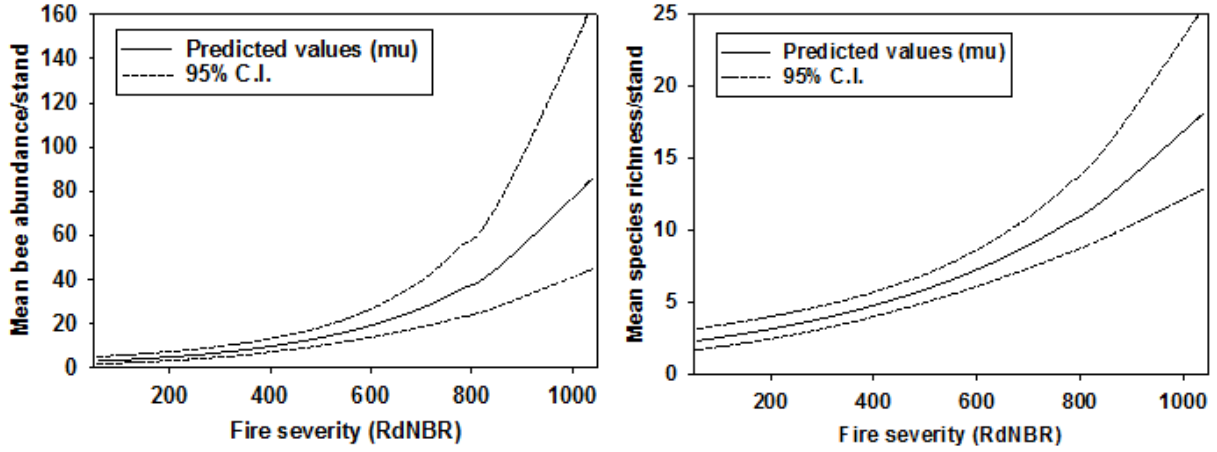

Fig. 1 | Preliminary results indicate bee diversity measures were positively linked to increases in disturbance intensity within burned forest. Both mean (± 95% CI) bee abundance (left panel) and mean (± 95% CI) bee species richness (right panel) were positively associated with fire severity. Predicted results based on GLMM show relationship between bee community metrics and fire severity when other effects are held constant. Predicted values for bee population measures.

58.5% of bees collected were in family Halictidae, 37.3% Apidae, 3% Megachilidae, 1% Colletidae, and 0.5% Andrenidae.

Results indicate that bee abundance did not differ between years, but varied with sampling date. The majority of individuals were trapped during the third collection period of both years (late July-early August, n=2,306). We found evidence for a positive relationship between fire severity and bee abundance ($P < 0.0001$; Fig. 1) and richness ($P < 0.0001$; Fig. 1), with both measures being similar for sites that did and did not undergo salvage logging (Fig. 2). Most bees captured were ground-nesting species, although a sizable number of cavity-nesting species were detected across all treatment types (Fig. 3).

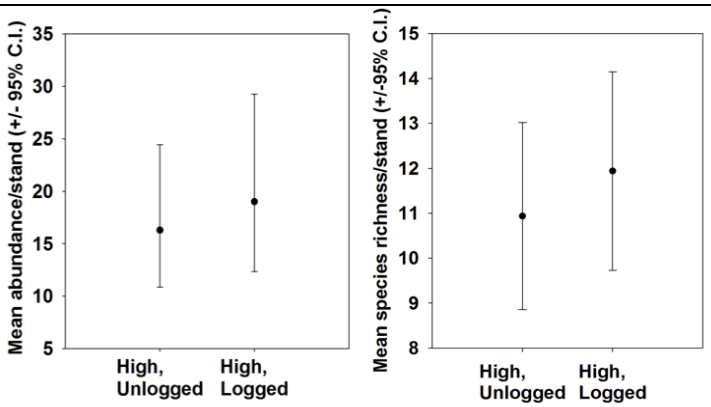

Fig. 2 | Preliminary results indicate bee abundance (left) and species richness (right) were not related to logging activity among stands that burned at high severity. Neither mean (± 95% CI) bee abundance (left panel) or mean (± 95% CI) bee species richness (right panel) differed relative to high severity sites that did and dint not experience salvage logging.

We also collected data on habitat characteristics of each stand, including canopy cover, bare ground, flowering plant density and diversity, dead wood availability, temperature, trap visibility, stand aspect, slope, and elevation. Based on GLMM results, bee abundance, but not richness, was positively related to canopy cover ($P = 0.04$) and aspect ($P = 0.01$). Floral resource availability for bees, measured as flowering plants per hectare, is positively related to RdNBR: for every 100-unit increase in RdNBR, there was a 34.9% increase in flowering plants per hectare ($P < 0.001$).

In 2016, 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. Therefore, in 2017 we modified our approach and instead used the blue orchard bee (*Osmia lignaria propinqua)* for the reproductive output experiment. We used similar methods from the previous year, seeding adult cocoons in two nesting structures per stand in April 2017. Throughout the season, we monitored nest boxes and collected video data to assess female foraging trip length, an indication of floral resource availability. We collected nest boxes in June 2017 and stored them at ambient temperature during development. After cocoons developed into adults (October 2017), we transferred nest boxes to the Pollinating Insect Research Unit in Logan, Utah and X-rayed each nest to view contents. Images are currently being analyzed to determine the number and sex ratio of offspring, which are indicative of reproductive success.

We also used 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. In 2016, 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 ground- (*Bombus, Anthophora*) and wood-nesting bees (*Xylocopa*). In 2017, we conducted the exclusion experiment on 231 salal and huckleberry (*Vaccinium ovatum)* plants. Each plant had one bagged stem and one marked stem for a control. When ripe, berries were harvested and frozen for future analysis.

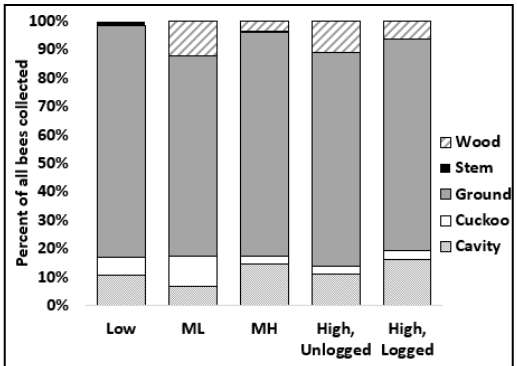

Fig. 3 | Most bees collected were ground-nesting, consistent among disturbance type. Wood = species that create tunnels within wood, Stem = species that nest in pithy plant stems, Ground = bee species that nest in exposed soil, Cuckoo = parasitic bee species lay their eggs into the nests of other species, Cavity = bee species that nest in existing holes in wood or rock.

We found that several habitat variables were significantly linked to fire severity and bee population metrics; however, field-based habitat measurements, such as flowering plant density, canopy cover, and nesting habitat, are labor-intensive to collect at large scales. In addition, it is unknown how bee diversity measures are linked to habitat variables at different scales within the landscape. Therefore, as part of study objective #3 we will use bee, flower, and habitat data collected over the course of this study to discern if remotely sensed LiDAR data can be used to predict bee diversity measures. We are currently underway with analysis to test this important, yet heretofore unaddressed component of how bees respond to landscape-scale changes in habitat within managed temperate forests. Current LiDAR-derived variables being explored include tree basal area, vegetation height, and rumple value (a proxy for canopy cover).

In addition to our research, we also organized and hosted a workshop in March 2017 titled, "*Pollinators in Managed Forest Landscapes.*" The primary goal of the workshop was 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 shared results from recent and ongoing projects focused on pollinators within managed forests, and resource managers were called upon to outline potential investigations to assess how current management actions may impact native pollinators. Our attendance far exceeded expectations, with >90 participants in the one-day event, including students, researchers, and land managers. Attendees had the option of receiving continuing education credits from Society of American Foresters and The Wildlife Society for attending. Along with other researchers who attended the event, we are currently finalizing a manuscript based on our findings.

Problems and Barriers: 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 challenging to work with under field conditions, 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 used mason bees for this experiment that were better matched to the timing of local floral resources.

In addition to addressing all of the initial research objectives we proposed, we have 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. In addition, undergraduate students collected and monitored 811 bees for escape propensity from the BVTs being used in our study. Their findings on the influence of bee identity and size on escape rate from the traps, as well as the influence of temperature and time of day, will contribute to our understanding of potential biases and limitations of the field methodologies being used in our study.

Planned Work: Our planned work remains as outlined in our project proposal. Currently, post-doctoral research associate Dr. Sara Galbraith is refining specimen identification, completing analysis of the described data, and drafting manuscripts for peer-review. We will continue to give presentations to scientists and land managers in a variety of settings to highlight our findings, including at the upcoming 2018 joint meeting of the Oregon and Washington chapters of The Wildlife Society.

List of Names and Brief overview of Graduate and/or Undergraduate Engagement in 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 were 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. Nicole Scavo is currently working on an M.S. in entomology. Two OSU undergraduate students volunteered with laboratory tasks in early spring 2017. During the 2017 field season, we employed 4 full-time young professionals: Ian Lively (crew lead), Katarzyna Szczurek (crew lead), Lisa Zander, and Sydney Watkins. We also employed 2 OSU undergraduate students: Kendra DelToro and Lacy Haig, who assisted with some fieldwork and conducted an experiment on campus to better understand bee escape propensity from the traps being employed in our field studies.

List of Presentations, Posters etc.:

"Pollinators in Managed Forest Landscapes" workshop organized by Jim Rivers and Sara Galbraith to bring together researchers and resource managers to establish a research agenda for pollinator research within managed forest landscapes.

Galbraith, S. M., J. H. Cane, and J. W. Rivers. 2017. The influence of wildlife severity and post-fire management on pollinator communities in a mixed-conifer forest. Contributed oral presentation at the annual meeting of the Oregon Chapter of The Wildlife Society, Pendleton, OR.

Galbraith, S. M, J. H. Cane, A. R. Moldenke, and J. W. Rivers. 2017. Bee diversity is linked to wildfire severity and salvage logging in Oregon mixed-conifer forest. Contributed oral presentation at the annual meeting of the Ecological Society of America, Portland, OR.

Galbraith, S. M, J. H. Cane, and J. W. Rivers. 2017. The influence of wildfire burn severity and post-fire management on bee community composition in mixed-conifer forest. Invited oral presentation at the annual meeting of the Pacific Branch of the Entomological Society of America, Portland, OR.

Galbraith, S. M, J. H. Cane, and J. W. Rivers. 2017. The influence of wildfire severity and post-fire management on pollinator communities in mixed-conifer forest. Invited oral presentation at Pollinators in Managed Forest Landscapes Workshop, Oregon State University, Corvallis, OR.

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, OR.

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, A. Moldenke, and J. W. Rivers. 2018. Bee response to fire severity and post-wildfire management in a mixed conifer forest. For *Journal of Insect Conservation*.

Rivers, J. W., S. M. Galbraith, J. H. Cane, C. B. Schultz, and M. D. Ulyshen. 2018. A summary of research needs for pollinators in intensively managed forests. For *Insect Conservation and Diversity*.

Galbraith, S. M., C. J. Dunn, J.H. Cane, and J. W. Rivers. 2019. LiDAR-derived habitat variables for predicting bee diversity in mixed conifer forest after wildfire. For *Remote Sensing of Environment.*

Rivers, J. W., S. M. Galbraith, A. Moldenke, and J. H. Cane. 2019. Demographic response of solitary bees across a natural gradient of wildfire severity. For *Oecologia.*

Fish and Wildlife Habitat in Managed Forests

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

Investigators: Catalina Segura and Kevin D. Bladon

Objectives: The overall objective of the funded research was 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:

1. We collected 140 water samples during 3 field campaigns (~420 total samples) in July, August, and September 2016.
2. By January 2017, all samples have been analyzed for water stable isotopes.
3. Spring 2017 – Segura participated in a workshop entitled "Spatial Statistical Network Models" (SSNM) to develop skills to strengthen the analysis.
4. The original proposal, had intended to couple water stable isotope spatial variability and stream temperature data. However, the stream temperature data is currently under analysis by Trask scientists. Once these data are published we will complete the proposed analysis.
5. Given the delay due to point #4 (above), we decided to apply the methodology learned in the SSNM workshop to a water stable isotope data set collected in the H.J. Andrews Experimental Forest and investigate the geomorphologic controls in ground water contributions.
6. We also assessed the downstream effects of forest management on stream temperature data from the three Oregon WRC study sites.

Problems and Barriers:

- The postdoctoral scholar Nicholas Cook accepted a position in a consulting firm in Portland and left the project on August 31, 2016.
- The PhD student, Lydia Nickolas who was going to work in the project abandoned the program and will not participate in this project.
- Considering the changes in personnel, the budget has been adjusted to include salary for a lab technician who aided with the isotope analysis in the laboratory and a higher FTE to cover summer salary for the PI (Segura) and Co-PI (Bladon).
- Given that the Trask stream temperature data for 2016 is not yet published, we decided to work on a similar data set in the western Cascades (H.J. Andrews Forest).

List of Names and Brief Overview of Graduate and/or Undergraduate Engagement in Project:

Dr. Nicholas Cook (Postdoctoral Scholar), Amelia Yeager (M.S.), and 4 undergraduates (Joey Tinker, Cameron Minson, Noah Kanzig, and Ryan Cole) were involved in water sampling during the summer. Prior to Dr. Cook's departure, he was integral in the preparation of the spatial (GIS) layers across other projects ("Identifying primary and secondary controls on sediment yield in Oregon's paired watershed studies"). Johnathan Tenny (undergraduate student) aided in the preparation of the GIS data. His contribution earned him authorship in a publication (see below).

List of Presentations, Posters etc.:

*Student mentored by Segura; ¥Postdoctoral Scholar co-supervised by Bladon and Segura

- Segura, C. Noone, D., Warren, D., *Tenny, J. Ganio, L, Contrasting controls of network scale variability in isotope concentration during dry and very dryconditions in the Western Cascades," Gordon Conference, Catchment Science: Interactions of Hydrology, Biology & Geochemistry, Maine. (June 27, 2017).
- Bladon, K.D., Segura, C., ¥Bywater-Reyes, S., ¥Cook, N.A., and Reiter, M. 2017. Impacts of contemporary forest management on stream temperature in western Oregon. Oregon Forest and Industries Council Policy Committee Meeting. Sep. 20, 2017. Salem, OR.
- Segura, C., Bladon, K.D., Hatten, J.A., ¥Bywater-Reyes, S., ¥Cook, N.A., and Reiter, M. 2017. Stream temperature and sediment impacts in managed forests. California Licensed Foresters Association Fall Workshop. Sep. 8, 2017, Chico, CA.
- Segura, C., Bladon, K.D., ¥Cook, N.A., ¥Bywater-Reyes, S., and Reiter, M. 2017. Studies of the impacts of contemporary forest management on stream temperature in western Oregon. National Council for Air and Stream Improvement Annual Meeting. Jul. 14, 2017. Eugene, OR.

List of Publications, Thesis Citations:

- Segura, C, Warren, D.R., Noone, D., Tenny, J.*, Ganio, L. Water stable isotope concentration reveals network scale variability in baseflow water sources in a Western Cascades headwater stream network. In Preparation.
- Bladon, K.D., Segura, C., ¥Cook, N.A., ¥Bywater-Reyes, S., and Reiter, M. 2017. A multi-catchment analysis of headwater and downstream temperature effects from contemporary forest harvesting. In review: Hydrological Processes.

Fish and Wildlife Habitat in Managed Forests

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, Clara Llebot Lorente

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 toward Objectives: 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 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 relieved the Steering Committee (and PIs) of a considerable burden and risk associated with recruiting, housing, and supervising a data manager, and as a result a formal Steering Committee was not constituted.

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 met with a broad range of stakeholders and experts to receive input on their data management process. This includes NCASI, the H.J. Andrews LTER, USGS, and NSF protocols.
   - Dr. Llebot Lorente completed an inventory of data for all three of the paired watershed studies (Hinkle, Alsea Revisited, and Trask).
   - •Most data from the Hinkle and Alsea Revisited studies have been moved into a consolidated data framework modeled after that used for the Trask (exceptions are the macroinvertebrate and fish data). At the completion of any embargo period, data from all three studies will be moved into a common database for archiving.
   - We have identified a metadata standard, Ecological Metadata Language (EML), and a preferred EML metadata generator, Morpho (https://knb.ecoinformatics.org/#tools/morpho). Once these are completed, the datasets are submitted to the ScholarsArchive@OSU (https://ir.library.oregonstate.edu/) managed by the Valley Library. We have tested this procedure with two datasets from the Alsea studies, one using the original Alsea study sediment data and a second from the contemporary Alsea Revisited study.

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:

- Dr. Catalina Segura has completed the QA/QC workup of the Alsea Revisited streamflow data for Flynn, Deer, and Needle Branch Creeks through WY2015. We have secured funding to complete the QA/QC analyses for the WY2016 and WY2017 data, which will be done during the spring quarter, 2018. Beyond the QA/QC, this includes assessing uncertainty on the flow estimates, tagging empty cells, and saving these in an archival format.
- Two recent Alsea Revisited paper datasets have been submitted to the ScholarsArchive@OSU managed by the OSU Valley Library. These are Bladon et al. 2016, "A catchment-scale assessment of stream temperature response to contemporary forest harvesting in the Oregon Coast Range" and Hatten et al. 2017, "Effects of contemporary forest harvesting on suspended sediment in the Oregon Coast Range: Alsea Watershed Study Revisited." We are presently working through the ScholarsArchive@OSU review process. Because the Alsea Revisited streamflow data has not been completely QA/QC'd, and funding is anticipated to analyze and publish the results, any release of the Alsea Revisited streamflow data will be embargoed until January, 2019. The temperature and sediment concentration data should be available by the spring, 2018.
- We have been coordinating with Terry Bousquet at NCASI to move their Alsea Revisited datasets into the ScholarsArchive@OSU. This will include Stednick's streamflow workup, dissolved oxygen, nutrients, and temperature. Outstanding work needed to accomplish this is to generate the EML metadata, which should not be too difficult because NCASI has a good QA/QC report that contains the needed information.

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.

- Dr. Llebot Lorente recently completed the draft for the WRC Data Management Plan. This plan will be sent to stakeholders for review, and will provide the framework for archiving data collected as part of the three paired watershed studies.
- There appears to be support in the College of Forestry to insure that data collected through the WRC's paired watershed studies is suitably archived and made available to future researchers.

Problems and Barriers:

- 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 in Dr. Llebot Lorente. We recovered from her anticipated maternity leave during the winter and spring, 2017 and moved forward with the project.
- We have not resolved concerns about data ownership and intellectual property rights. While review of the WRC agreements revealed that the MOA with the funders specifically vested in the WRC ownership rights and publication clearance, 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. The conclusion of the Watershed Research Cooperative in December, 2017 leaves these questions unresolved. Our expectation is that the common policy of making data available after publication, or two years after final data collection, will likely resolve the issue.

Comprehensive Summary of Project Results and Impacts over Life of Project:

- We established an enduring relationship with the Data Managers and Archivists at the OSU Valley Library. This bodes well for future data archiving there.

- We have a good inventory of data collected in the three paired watershed studies.
- We have demonstrated success with the first two data submissions to the Scholars Archive.
- We have a clear structure and process (the data management plan) to successfully archive the paired watershed study data provided support for the policy and needed funding are obtained.

List of Names and Brief Overview of Graduate and/or Undergraduate Engagement in Project:

Rushal Sedlemyer, Mentored Employee Program. Data entry.
Alexanna Fisher, Mentored Employee Program. Data entry.
Joey Kline, Mentored Employee Program. Data entry.
Kevin Lai, Student worker. Data entry.

List of Presentations, Posters etc.:

Clara Llebot Lorente, 13th International Digital Curation Conference (IDCC18), Feb. 19 – 22, 2018, Barcelona, Spain.

List of Publications, Thesis Citations:

Lorente, Clara L. "Remediation Data Management Plans: A tool for recovering research data from messy, messy projects." Anticipated publication: International Journal of Digital Curation.

Continuing Research Projects
FY 2016

Fish and Wildlife Habitat in Managed Forests

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

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

Objectives: The overall objectives of the funded research were to:

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

Summary of Accomplishments toward Objectives:

- Considerable efforts were required to assess data usability and undertake additional QA/QC of data from the three WRC study sites. From the initial analysis of usability, it was determined that the Trask data could be analyzed immediately (see "Problems, barriers, proposed changes to objectives" for more details). As a result, we used the Trask data to develop an initial framework for analysis and testable hypotheses that could be validated at other locations.
- The analysis investigated trends in suspended sediment yields in reference and harvested catchments of the Trask. Trends were related catchment morphometry, soils, geology, and climate to identify primary and secondary controls.
- 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). As such, it was proposed that geology could potentially be used as an indicator of catchment resilience to sedimentation, but required further testing.
- This analysis and framework were summarized in a manuscript that was published in the Journal of Hydrology (IF: 3.483).
- We then used longer-term sediment data from the Long Term Ecological Research Network site, the H.J. Andrews Experimental forest, to test the framework. Results were mostly consistent with data from the Trask. This analysis was summarized in a manuscript that is currently under review at Water Resources Research.
- The post-doctoral scholar who was hired for this project also assisted with a publication, which is currently under review at Hydrological Processes, assessing the downstream effects of forest management on stream temperature data from the three Oregon WRC study sites. Similarly, the post-doc assisted in a novel analysis investigating the effects of the forest pathogen, Swiss Needle Cast, on the hydrology of the Oregon Coast Range. A manuscript will likely be submitted in winter 2018.

Problems and Barriers:

- Initial assessment of data quality, indicated quality issues with the turbidity data, which we had planned to utilize, 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 with other variables,

including discharge, suspended sediment concentration, and lab turbidity. As such, the turbidity data was not usable for any robust analyses.
- The Alsea Watershed Study discharge and climate data were undergoing rigorous quality assessment throughout our project. As such, this data was not usable to undertake rigorous analyses.
- Suspended sediment data at the Trask Watershed Study was collected by different methods at different spatial scales, which created substantial challenges for comparisons and limited the inferences that could be made.
- Data quality/accessibly issues in year two 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.

List of Names and Brief Overview of Graduate and/or Undergraduate Engagement in Project:

- Dr. Nicholas Cook (Postdoctoral Scholar), Casey Steadman (M.S. candidate), Mulugetta Fratkin (M.S. 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. The post-doc also contributed to the research that Fratkin is conducting about the control of lithology in longitudinal trends of transport capacity. 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.:

*Graduate Student mentored by Bladon; **Graduated Student mentored by Segura; [¥]Postdoctoral Scholar co-supervised by Bladon and Segura

- **Fratkin M, Segura C, [¥]Bywater-Reyes S. Longitudinal transport capacity trends in steep unglaciated basins with contrasting lithology in the Oregon Coast Range. American Geophysical Meeting Fall Meeting. Dec. 11-15, 2017, New Orleans, LA.
- *Rachels, A.A., Bladon, K.D., and [¥]Bywater-Reyes, S. 2017. Quantifying ratios of suspended sediment sources in forested headwater streams following timber-harvesting operations. American Geophysical Meeting Fall Meeting. Dec. 11-15, 2017, New Orleans, LA.
- Bladon, K.D., [¥]Bywater-Reyes, S., LeBoldus, J.M., Segura, C., Ritokova, G., and Shaw, D.C. 2017. Increased annual runoff ratios in Pacific Northwest catchments impacted by epidemic foliage disease of Douglas-fir. American Geophysical Meeting Fall Meeting. Dec. 11-15, 2017, New Orleans, LA.
- Bladon, K.D., [¥]Bywater-Reyes, S., LeBoldus, J.M., Segura, C., Ritokova, G., and Shaw, D.C. 2017. Annual water yield response in Oregon catchments affected by Swiss needle cast. Swiss Needle Cast Annual General Meeting. Nov. 7, 2017. Corvallis, OR.

- [Y]Bywater-Reyes, S., Bladon, K.D., and Segura, C. 2017. Relative influence of landscape variables, discharge, and forest management on sediment yields in temperate mountain catchments. Geological Society of America Annual Meeting. Oct. 22-25, 2017, Seattle, WA.
- *Rachels, A.A., Bladon, K.D., and [Y]Bywater-Reyes, S. 2017. Determining the sources of suspended sediment in Oregon Coast Range headwater streams following forest-harvesting operations. Geological Society of America Annual Meeting. Oct. 22-25, 2017, Seattle, WA.
- **Fratkin M , Segura C, [Y]Bywater-Reyes S. Investigating the Hillslope and In-Channel Drivers of Transport Capacity in Variable Lithology: A Case Study in the Oregon Coast Range. Geological Society of America Annual Meeting. Oct. 22-25, 2017, Seattle, WA.
- Bladon, K.D., Segura, C., [Y]Bywater-Reyes, S., [Y]Cook, N.A., and Reiter, M. 2017. Impacts of contemporary forest management on stream temperature in western Oregon. Oregon Forest and Industries Council Policy Committee Meeting. Sep. 20, 2017. Salem, OR.
- Segura, C., Bladon, K.D., Hatten, J.A., [Y]Bywater-Reyes, S., [Y]Cook, N.A., and Reiter, M. 2017. Stream temperature and sediment impacts in managed forests. California Licensed Foresters Association Fall Workshop. Sep. 8, 2017, Chico, CA.
- LeBoldus, J.M., Bladon, K.D., [Y]Bywater-Reyes, S., Segura, C., Ritóková, G., and Shaw, D.C. 2017. The effects of Swiss needle cast foliage disease on annual streamflow in western Oregon. Swiss Needle Cast Cooperative Quarterly Meeting. Jul. 27, 2017. Corvallis, OR.
- Segura, C., Bladon, K.D., [Y]Cook, N.A., [Y]Bywater-Reyes, S., and Reiter, M. 2017. Studies of the impacts of contemporary forest management on stream temperature in western Oregon. National Council for Air and Stream Improvement Annual Meeting. Jul. 14, 2017. Eugene, OR.
- [Y]Bywater-Reyes, S., Segura, C., and Bladon, K.D. 2017. Relative influence of landscape physiography, hydrologic conditions, and land management on sediment yield in a temperate mountain watershed. U.S. Geological Survey Assessing Trends in Sediment Processes in Puget Sound Watersheds Workshop. Apr. 11-12, 2017, Seattle, WA.
- *Rachels, A.A., Bladon, K.D., and [Y]Bywater-Reyes, S. 2017. Quantifying ratios of suspended sediment sources in forested headwater streams following timber harvest operations. Western Forestry Graduate Research Symposium. Apr. 21, 2017. Corvallis, OR.
- *Rachels, A.A., Bladon, K.D., and [Y]Bywater-Reyes, S. 2017. Identifying the primary sources of suspended sediment in Oregon Coast Range headwater streams following forest harvesting. 7th Annual Pacific Northwest Water Research Symposium. Mar. 6-7, 2017. Corvallis, OR.
- [Y]Bywater-Reyes, S., Segura, C., and Bladon, K.D. 2016. Non-stationary suspended sediment dynamics in western Oregon: From temporal patterns to processes and controls. American Geophysical Union Fall Meeting. Dec. 12-16, 2016. San Francisco, CA.

List of Publications, Thesis Citations:

- [Y]Bywater-Reyes, S., Segura, C., and Bladon, K.D. 2017. Geology and geomorphology control suspended sediment yield and modulate increases following timber harvest in Oregon headwater streams. Journal of Hydrology. 548:754-769.
- [Y]Bywater-Reyes, S., Segura, C., and Bladon, K.D. 2017. Relative influence of landscape variables, discharge, and forest management on sediment yields in a temperate mountain catchments. In review: Water Resources Research.
- Bladon, K.D., Segura, C., [Y]Cook, N.A., [Y]Bywater-Reyes, S., and Reiter, M. 2017. A multi-catchment analysis of headwater and downstream temperature effects from contemporary forest harvesting. In review: Hydrological Processes.

Fish and Wildlife Habitat in Managed Forests

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

Investigators: Jeff Hatten, Matt Betts, and Thomas Stokely

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:

- Foliar and soil physical and chemical analyses have been completed
- Preliminary statistical analyses exploring the effects of wildlife and herbicide application intensity on litter layer accumulation/quality, soil fertility, and Douglas-fir nutrition have been performed
- Graduate student (Dave Frey (FERM)) will defend his thesis at the end of Winter Quarter 2018
- A litterbag study was initiated 18 months ago in order to examine trends in decomposition across the study treatments. This will be completed March, 2018.

Preliminary results indicate that herbicide applications decrease litter layer accumulation in light and intensive treatments, with the most intensively treated plots containing the least litter mass (Fig. 1). Wildlife had no effect on litter layer accumulation. We found no evidence of effects of wildlife or herbicide application intensity on mineral soil C:N ratios, carbon concentrations, or nitrogen concentrations to depths of 30 cm.

However, preliminary analysis of Douglas-fir productivity indicates that increasing IFM intensity leads to increased crop tree growth five years after planting. Additionally, we found that Douglas-fir growth was greatest with cervid access in intensively treated stands, suggesting that cervids may be reducing competition for resources for conifers in these stands (Fig. 2). However, despite increased tree growth with increasing IFM intensity, we do not see evidence of effects of herbicide application intensity on Douglas-fir foliar nutrient (N, P, or cations) concentrations. Additionally, we did not detect increased foliar nutrient concentrations where deer and elk were allowed access in intensively treated stands, suggesting that the mechanism by which cervid access and IFM increased crop tree productivity may not have been increased access to nutrients, at least early in stand development in our region.

Interestingly, Douglas-fir foliar ^{13}C data suggest that herbicide applications may increase access to light for conifer seedlings, presumably by reducing leaf shading from competition (Fig. 3). Hence, it is possible that the reason that increased herbicide application intensities resulted in increased crop tree growth was due to increased access to light for crop trees, rather than increased access to nutrients.

However, we do not have access to soil moisture data, so it may be difficult to assess the role that water availability played in changes to productivity as a result of herbicide applications and wildlife exclusion.

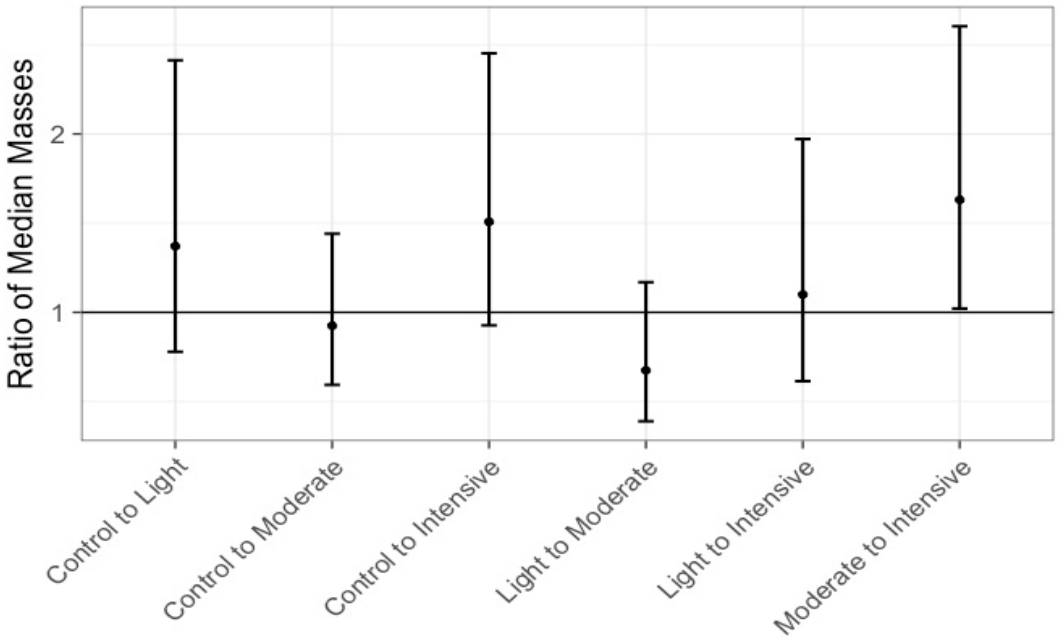

Figure 1: Ratios of median litter layer mass for herbicide treatments. Ratio numerators correspond to the treatment listed first.

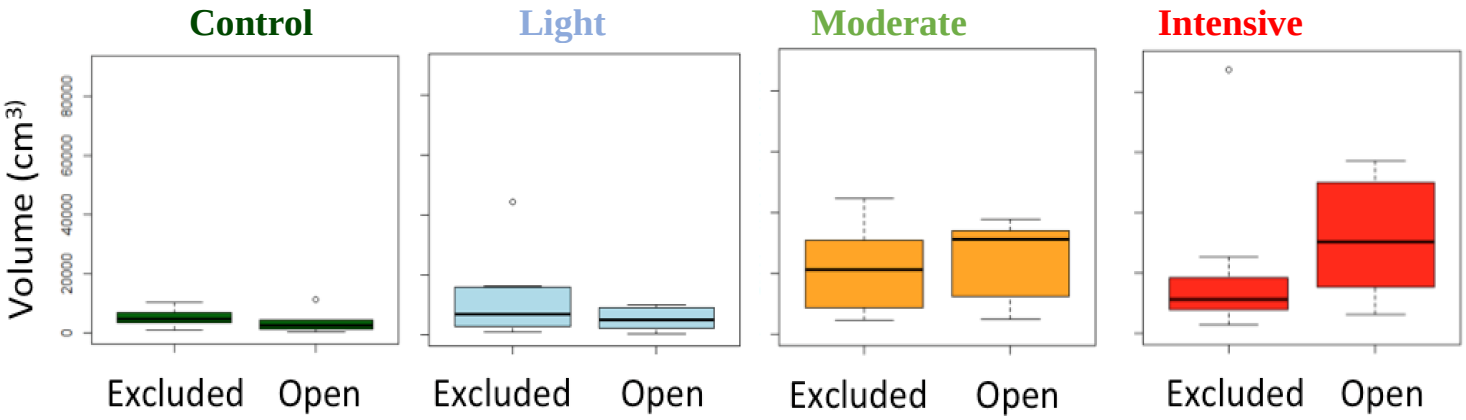

Figure 2: Douglas-fir volume in 2015 (five years after planting) by herbicide treatment, with and without cervid access.

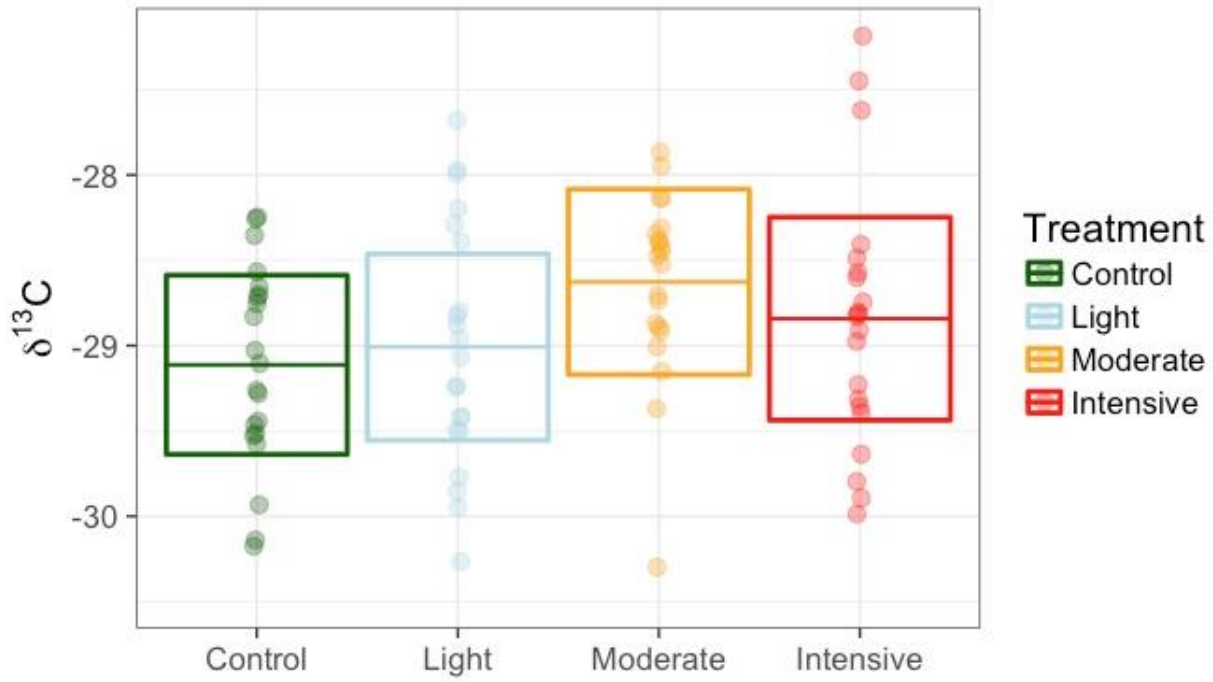

Figure 3: Douglas-fir foliar $\delta^{13}C$ by herbicide treatment.

Problems and Barriers:

- 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:

- Graduate student (Dave Frey (FERM)) will defend his thesis at the end of Winter Quarter 2018
- We optimistically expect one publication (foliar chemistry and Douglas-fir growth) to be submitted prior to Dave's defense.
- Second publication which contains results from additional litterbag decomposition study will be submitted after Dave's thesis defense.

List of Names and Brief Overview of Graduate and/or Undergraduate Engagement in Project:

- Dave Frey has taken the lead on soil and Douglas-fir foliar sample collection, lab processing, and lab analyses, as well as preliminary data analyses. He is working with Thomas Stokely and other collaborators to integrate soil and foliar nutrition data into the overarching goals of the project. He plans to have all data analyses, reduction, and presentation complete by March 2017 and will defend his thesis at the end of spring quarter.

- Thomas Stokely worked with Dave to collect soil and vegetation samples and has assisted in the process of integrating soil and Douglas-fir nutrition data into the project at large.
- Mandy Allen-Kahl, Ethan Donohue, Hayden England, and Chantal Jorgensen are undergraduate students who have assisted in preparing and processing samples for laboratory analysis.

List of Presentations, Posters etc.:

Frey, D. W., Hatten, J. A., Betts, M. G., Stokely, T. S. Top-down effects of wildlife and bottom-up drivers of soils on productivity in intensively managed forest plantations. 2017. Soil Science Society of America Annual Meeting, Tampa, Florida. (*Oral*).

Frey, D. W., Hatten, J. A., Stokely, T. S, Betts, M. G. Top-down effects of wildlife and bottom-up drivers of soils on productivity in intensively managed forest plantations. 2016. Vegetation Management Research Cooperative Annual Meeting, Corvallis, Oregon. (*Oral*).

Frey, D. W., Hatten, J. A., Stokely, T. S, Betts, M. G. 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, Arizona. (*Poster*).

Frey, D. W., Hatten, J. A., Stokely, T. S, Betts, M. G. 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, Florida. (*Poster*).

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. (*Poster*).

List of Publications, Thesis Citations:

None to date.

Fish and Wildlife Habitat in Managed Forests

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)

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 toward Objectives:

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.

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 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	---

* Total does not sum to 100% because of rounding error.

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%	71%
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 and Barriers: 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: Final report so not applicable.

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 2015-2016 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. Amy successfully defended her M.S. in March 2017.

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 organized a symposium on cavity-nesting bird ecology at the joint 2017 meeting of the American Ornithological Society and Canadian Society of Ornithologists. This symposium brought 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 etc.:

Barry, A. M., J. C. Hagar, and J. W. Rivers. 2017. If you build it, who will come? Assessing use of created snags by cavity-nesting birds across 25 years. Invited oral presentation as the annual meeting of the American Ornithological Society, East Lansing, MI.

Barry, A. M., J. C. Hagar, and J. W. Rivers. 2017. Created snag dynamics and influence on cavity-nesting bird communities over 25 years in western Oregon. Contributed oral presentation at the annual meeting of the Oregon Chapter of The Wildlife Society, Pendleton, OR.

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. March 2017.

Barry, A. M., J. C. Hagar, and J. W. Rivers. 2017, Long-term dynamics and physical characteristics of snags created for wildlife habitat. *Forest Ecology and Management* 403:145-151.

Barry, A. M., J. C. Hagar, and J. W. Rivers. In review. Created snags provide long-term ecological value for birds breeding in managed Douglas-fir forests. *Journal of Wildlife Management.*