Fish and Wildlife Habitat in Managed Forests

Research Program
FY 2016
(July 1, 2015- June 30, 2016)

College of Forestry
Forest Research Laboratory
Oregon State University
Corvallis, Oregon
Foreword

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

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

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

The net funding available for new projects in FY 2016 is $166,143. The advisory committee evaluated nine proposals and prioritized them for recommended funding. Given available funding, I approved initiation of three new studies. Five projects continue from the prior year.

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

Thomas Maness, Dean and Director
College of Forestry and Forest Research Laboratory
July 1, 2015
Fish and Wildlife Habitat in Managed Forests
Program of Research

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

The purpose of this document is to describe the Fiscal Year 2016 activities of the Fish and Wildlife Habitat in Managed Forests (FWHMF) Research Program. The Program may fund projects in three areas: a) Research, b) Service, and c) Technology Transfer. For all research topics, the committee emphasized the need for work at the landscape/watershed scale wherever feasible, with explicit consideration for characterization of natural variability. The committee also encouraged multidisciplinary proposals that address complex topics.

The FY2016 topics recommended by the Program advisory committee as high priority are as follows:

1. Water quality standards
   a. How to tailor to a local area
   b. How to make relevant to beneficial uses
   c. How to incorporate natural variability

2. Chemicals used in Forestry
   a. Quantify direct and indirect effects on fish and wildlife species:
      i. from the frequency, magnitude, and duration of exposure expected during a typical forest management cycle.
      ii. in watershed or landscape contexts

3. Roads/ water/ sediments
   a. Scoping and development of BMPs to reduce sediment delivery from the subset of roads that connect to live water
   b. Routing and storage of road-generated sediment
   c. Linkages between road-generated sediment and beneficial use impacts

4. The response of fish and wildlife to forest management
   a. Indicators of habitat quality/quantity, especially for species of conservation concern:
      i. ODFW T&E species
         (http://www.dfw.state.or.us/wildlife/diversity/species/threatened_endangered_candidate_list.asp)
ii. Federal T&E, Proposed T&E, Candidate T&E species, or Species of Concern
(http://www.fws.gov/oregonfwo/Species/Lists/Documents/OregonSpeciesStateList.pdf)

iii. Oregon Species of Concern
(http://www.dfw.state.or.us/wildlife/diversity/species/sensitive_species.asp)

iv. ODFW Conservation Strategy Species
(http://www.dfw.state.or.us/conservationstrategy/contents.asp#spec)
   a. Early seral habitat
   b. Effects of treatments for fuels management, restoration, forest health
   c. Organism passage/population connectivity
   d. Ecological responses to disturbance (natural or human-induced)

5. Streamside management
   a. Development and testing of alternatives that balance resource protection with economic values

The following Program of Research represents new research projects and continuing projects for FY2016.

Research: New projects
1) Identifying primary and secondary controls on turbidity and sediment yield in Oregon’s long-term paired watershed studies
2) Top-down effects of wildlife and bottom-up drivers of soils and productivity in intensively managed forest plantations
3) Revisiting the CFIRP: Assessing long-term ecological value and characteristics of snags created for wildlife

Research: Continuing projects
1) Effects of Landscape-Scale Forest Management on Pacific Marten Occupancy and Population Connectivity in Coastal Oregon
2) Modeling Geomorphic Response to Large Wood Introduction as a Strategy to Restore Fish Habitat in Managed Forest Watershed
3) Natural Variability in Water Quality and Changes after Forest Harvest in the Trask Watershed
4) Assessing the Demographic Response of Early Songbird Species to Intensive Forest Management
5) Experimental Evaluation of Plethodontid Salamander Responses to Forest Harvesting

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

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

A description of each active project follows this introduction.
# Fish and Wildlife Habitat in Managed Forests Research Program

## Table of Contents

Budget for FY 2016 ........................................................................................................................................ 1

### New Research Projects

Study 1: Identifying primary and secondary controls on turbidity and sediment yield in Oregon’s long-term paired watershed studies (FY 2016-FY 2017) ............................................................. 3

Study 2: Top-down effects of wildlife and bottom-up drivers of soils and productivity in intensively managed forest plantations (FY 2016) ......................................................................................... 6

Study 3: Revisiting the CFIRP: Assessing long-term ecological value and characteristics of snags created for wildlife (FY 2016-FY 2017) ........................................................................................ 9

### Continuing Research Projects and Activities


Study 5: Modeling Geomorphic Response to Large Wood Introduction as a Strategy to Restore Fish Habitat in Managed Forest Watershed (FY 2015-FY 2016) ................................................................. 15

Study 6: Natural Variability in Water Quality and Changes after Forest Harvest in the Trask Watershed (FY 2015-FY 2016) ................................................................................................................... 18

Study 7: Assessing the Demographic Response of Early Songbird Species to Intensive Forest Management (FY 2015-FY 2016) ............................................................................................................. 21

Study 8: Experimental Evaluation of Plethodontid Salamander Responses to Forest Harvesting (FY 2015-FY 2016) ........................................................................................................................... 24

List of FRL Technical Advisory Committee Members ............................................................................... 26
# OSU Forest Research Laboratory

## Fish and Wildlife Habitat in Managed Forests Research Program

### Budget for FY 2016

**July 1, 2015 - June 30, 2016**

<table>
<thead>
<tr>
<th>Project Description</th>
<th>FY 2016</th>
<th>FY 2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identifying primary and secondary controls on turbidity and sediment yield in Oregon’s long-term paired watershed studies (FY16-FY17) -- Kevin Bladon, Catalina Segura, Arne Skaugset, Sherri Johnson</td>
<td>$63,596</td>
<td>$63,360</td>
</tr>
<tr>
<td>Top-down effects of wildlife and bottom-up drivers of soils and productivity in intensively managed forest plantations (FY16) -- Jeff Hatten, Matt Betts, Thomas Stokely</td>
<td>$52,397</td>
<td>N/A</td>
</tr>
<tr>
<td>Revisiting the CFIRP: Assessing long-term ecological value and characteristics of snags created for wildlife (FY16-FY17) -- Jim Rivers, Joan Hagar</td>
<td>$30,772</td>
<td>$27,046</td>
</tr>
<tr>
<td><strong>Subtotal:</strong></td>
<td>$146,765</td>
<td>$90,406</td>
</tr>
</tbody>
</table>

### Continuing Projects and Activities for FY 2016

<table>
<thead>
<tr>
<th>Project Description</th>
<th>FY 2016</th>
<th>FY 2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effects of Landscape-Scale Forest Management on Pacific Marten Occupancy and Population Connectivity in Coastal Oregon (FY15-FY16) -- John Bailey, Keith Slauson, Katie Moriarty</td>
<td>$42,448</td>
<td></td>
</tr>
<tr>
<td>Modeling Geomorphic Response to Large Wood Introduction as a Strategy to Restore Fish Habitat in Managed Forest Watershed (FY15-FY16) -- Catalina Segura, Christopher Lorion, Stacy A. Polkowske</td>
<td>$48,616</td>
<td></td>
</tr>
<tr>
<td>Natural Variability in Water Quality and Changes after Forest Harvest in the Trask Watershed (FY15-FY16) -- Jeff Hatten, Alba Argerich, Sherri Johnson</td>
<td>$38,821</td>
<td></td>
</tr>
<tr>
<td>Assessing the Demographic Response of Early Songbird Species to Intensive Forest Management (FY15-FY16) -- Matthew G. Betts, James W. Rivers</td>
<td>$17,528</td>
<td></td>
</tr>
<tr>
<td>Experimental Evaluation of Plethodontid Salamander Responses to Forest Harvesting (FY15-FY16) -- Barbara Lachenbruch, Tiffany Garcia, Andrew J. Kroll, Blake Murden</td>
<td>$43,132</td>
<td></td>
</tr>
<tr>
<td><strong>Subtotal:</strong></td>
<td>$190,545</td>
<td>$0</td>
</tr>
</tbody>
</table>

**TOTAL:** $337,310 $90,406
The net funding available for new projects in FY 2016 is $166,143. This is based on a harvest forecast of 4.0 billion board feet in FY 2016 that yields an initial gross budget of $400,000, of which $317,460 is spendable. Additional spendable funds included $60,532 in harvest tax settle-up funds based on actual FY 2014 harvest levels. Five continuing projects and one FY 2015 project drawing on FY 2016 funds resulted in a commitment of $211,849 from FY 2016 funds.

The advisory committee evaluated nine proposals and prioritized them for recommended funding. Two projects emerged as top priorities, but differentiation among the others was less clear. The committee deferred to the Dean to consider investment of the remaining approximately $70,000 in available funds. After consideration, the Dean elected to fund a third project, and carry $19,378 forward to next year.

**New Projects**

Following guidance by the Technical Advisory Committee and final approval by the Dean, three new activities will be initiated in FY 2016. New projects are intended to meet high priority needs identified during the annual advisory committee meeting.
New Research Project Study 1:

Title: Identifying primary and secondary controls on turbidity and sediment yield in Oregon’s long-term paired watershed studies

Investigators:
PI: Kevin D. Bladon (OSU FERM); Co-PIs: Catalina Segura (OSU FERM), Arne Skaugset (OSU FERM), and Sherri Johnson (USFS)

Relevance of topic to program mission: Sediment is a natural constituent of stream and river ecosystems; however, excess sediment loading and increased turbidity can have important influences on aquatic habitat.\(^1\)\(^2\) Due to the perceived impacts of sediment on aquatic ecosystems, the Oregon Department of Environmental Quality (DEQ) has established a standard for suspended sediment, which states that activities cannot result in more than a ten percent cumulative increase in natural stream turbidity. As such, accurate estimates of turbidity and sediment yields and identification of the controlling factors are critical to our ability manage the erosion and sedimentation response to forest harvesting activities in order to meet DEQ standards.

Much of the perception on forest harvesting effects on sediment at the catchment-scale originates from studies examining historical land use practices, which are presently outdated and do not accurately reflect contemporary practices.\(^5\)\(^6\) Conventional forest management practices result in slight physical water quality impacts – yet, a wide range of responses are reported.\(^2\)\(^3\) Conflicting results are partly due to different logging practices, inconsistent implementation of BMPs, and regional or geographic differences.\(^4\) In particular, regional or geographic differences such as climate, topography, geology, soils, and forest type hinder our ability to decipher the impacts of land use activities from differential background variability. The large empirical data bases collected at the multiple paired watershed studies in Oregon provide an opportunity to synthesize that data and make a substantial improvement in our understanding between natural controlling factors and patterns of sediment yield and turbidity. A better understanding of the influences of internal dynamics of upland, forested catchments on turbidity and sediment fluxes may provide a framework that that could be used to disentangle natural variability from land use effects on turbidity and suspended sediment, which would greatly improve our ability to predict downstream consequences.

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

1. Synthesize the turbidity and suspended sediment data from TWS, HCWS, and AWS.
2. Model the relationship between turbidity and sediment yield and morphometric, soils, geologic, and climatic variables at the catchment scale to identify primary and secondary controls.
3. Provide a process-based framework to classify watersheds in terms of resilience and vulnerability to sedimentation, which may be used to assess contemporary forest practices.
4. Develop testable hypotheses for identifying ‘hot spots’ for turbidity and sediment production within forested watersheds.
Methods overview: The proposed research project will systematically investigate the primary and secondary watershed controls on turbidity and sediment yield using a statistical and spatial analytical approach. The study will rely on existing data sets that have been collected from the TWS, HCWS, and AWS in a first attempt to integrate data from all three studies. Potential factors that control turbidity and suspended sediment yield will be extracted at the hydrological response unit (HRU) scale to describe sub-watershed characteristics with the geographic information system (GIS) program FRAGSTS 4.0, or similar. The extracted morphometric, climatic, hydrologic, soils, and geologic variables will provide detailed spatial patterns of the various environmental characteristics. Some potential primary and secondary controls, which will be assessed and evaluated, in addition to other likely influences, include:

**Morphometric variables**
- watershed area
- mean slope gradient of sub-watershed
- watershed relief (max elevation - outlet)
- watershed length
- relief ratio (watershed relief / watershed length)
- hypsometric (area-elevation) integral
- drainage density
- slope variability (SV = S_{max} - S_{min})
- topographic wetness index (TWI = \ln(\alpha/\tan(\beta))), \alpha = upslope area per unit contour length, \tan(\beta) = local slope
- upslope accumulated area
- aspect

**Climatic & hydrologic variables**
- precipitation
- discharge
- API (antecedent precipitation indices)

**Soil and geological variables**
- soil type
- soil organic matter
- soil erodibility
- soil hydraulic conductivity
- geology

Partial least-squares regression (PLS) models will then be constructed to identify the primary catchment characteristics that control turbidity and suspended sediment for each of the available watersheds across the three WRC studies. Models will be developed to integrate across all three studies and provide broader insights into primary and secondary order controls on turbidity and sediment. The predictive models developed in this study will provide a framework that may then be used to assess the effects of land management activities on turbidity and suspended sediment and/or to test and validate presently available tools (e.g., NetMap) that are currently being applied to assist in complex forest management decisions.
### Timeline:

<table>
<thead>
<tr>
<th></th>
<th>January</th>
<th>February</th>
<th>March</th>
<th>April</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>August</th>
<th>September</th>
<th>October</th>
<th>November</th>
<th>December</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finalize research plan</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gather data layers for analyses</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data QA/QC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preliminary data analyses and model development (focus on one watershed study)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model calibration</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Statistical analysis of results</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incorporate data from two other watershed studies into model</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extension of research and results at international conferences</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manuscript #1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manuscript #2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manuscript #3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manuscript #4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### References cited

7. FRAGSTATS v4: Spatial pattern analysis program for categorical and continuous maps (University of Massachusetts, Amherst, MA, 2012).

**Budget total:** $129,956  Year 1: $63,596  Year 2: $63,360
New Research Project Study 2:

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

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

Relevance of topic to program mission:
Intensive Forest Management alters biodiversity and biological inputs and outputs by reducing the production of native shrubs and herbs, favoring the growth of planted conifers seedlings (Wagner et al. 2004, Stephens and Wagner 2007). Such a change in community structure is likely to alter top-down and/or bottom-up processes that impact wildlife and forest productivity (Dale et al. 2000, Stephens and Wagner 2007, Swanson et al. 2011).

Planted seedlings benefit from reduced competition for moisture and nutrients (e.g. Nitrogen, Phosphorus), which in turn modifies organic inputs (i.e. litter), by increasing the rate at which conifer needles accumulate while decreasing broadleaf inputs (Dinger and Rose 2009, Maguire et al. 2009, Devine et al. 2011). O-horizon (i.e. duff, forest floor) composition and quantity mediates detritivore communities, decomposition rates, and nutrient cycling, feeding back to influence forage for insectivorous songbirds (i.e. detrital arthropods), soil carbon and long-term soil productivity, respectively (Cardinale et al. 2011). The top-down influence of insectivory mediates arthropod abundance and composition, which in turn may alter decomposition and mineralization rates (Thebault and Loreau 2003, Handa et al., 2014). By changing the composition of arthropod forage (i.e. O-horizon), Intensive Forest Management (IFM) may also reduce forage for insectivorous songbirds, which may be a partial reason for observed declines in songbird abundances with increased IFM (Garibaldi et al. 2010). More directly, IFM reduces shrub nest-sites and songbird abundance, which may alter top-down processes associated with detritivore communities (Mazia et al. 2004).

By altering organic inputs and arthropod communities via fecal matter, Cervids may indirectly alter plant community structure and composition (Hobbs 1996). IFM decreases shrub forage for cervids, which may thereby alter foraging behavior and stand use (Stokely 2014). Such an alteration in foraging behavior may increase herbivory on less palatable species, such as conifer seedlings, changing root:shoot ratios and above/below-ground competition (Cote et al. 2004). Selective foraging by cervids should generally target broadleaf shrubs, thus increasing below-ground resources for conifers (Hobbs 1996, Cook et al. in press). As forage of early seral broadleaves serves as an output for cervids, cervid defecation is also an input to soil organic matter (Rooney and Waller 2003). Cervids’ consumption and defecation increases litter decomposition rates by breaking down less labile organic matter and increasing nitrogen availability (Hobbs 1996).

Objectives:
1. Determine the quantity and quality of O-horizon available to arthropod detritivore communities and detrital arthropod prey to songbirds. We hypothesize that herbicide treatments decrease bottom up availability of arthropod prey to songbirds by reducing broadleaf inputs and soil arthropod abundance. This will result in lower O-horizon accumulation as indicated by lower mass, higher C:N ratios (less nitrogen), and depleted $^{15}$N in O horizons and lower soil arthropod abundance higher intensity IFM.
2. Characterize the interacting effects of IFM and bird abundance on detrital arthropod communities and relative decomposition rates. We hypothesize that IFM reduces broadleaf inputs and songbirds decrease detritivore abundance, which decreases decomposition rates. Decomposition rates will be highest with songbird exclusion as indicated by lower O-horizon mass, low C:N ratios, and enriched $^{15}$N.

3. Characterize the impact of IFM on cervid use and the subsequent effects on relative decomposition rates. We hypothesize that the effect of IFM on decomposition is elevated by cervid foraging. Decomposition rates will be highest with cervid access in untreated stands as indicated by low O-horizon mass, low C:N ratios, and enriched $^{15}$N.

4. Characterize role of top-down and bottom-up processes on soil fertility and conifer growth. We hypothesize that conifer growth rates are influenced by the effect of herbicide treatments on soil fertility. As a result of the interaction between higher rates of decomposition (i.e. reduced relative nutrient availability with IFM) and reduced competition conifer growth and foliar nitrogen will be highest in moderately treated stands and lowest with cervid exclusion. Foliar nitrogen will be higher with songbird exclusion (higher detritivore abundance) across all herbicide treatments, although effects on conifer growth will be negated by increased above-ground herbivory of those seedlings.

**Basic overview of approach/methods:**

To test questions pertaining to the interactive effects of wildlife foraging and IFM, we will utilize our established wildlife exclosures and herbicide treatment stands of the IFM and Biodiversity experiment. Within the songbird exclosure, cervid exclosure and complete access plots, we will clip herbs at ground base and shrubs from the previous year growth by species (roughly 2 samples per plot). These samples will be dried and weighed to determine the interactive effect of herbicide and wildlife foraging on productivity. The samples will then be analyzed in lab for nitrogen and carbon to determine the relative nutrient availability with each treatment. In conjunction, we will carefully describe and collect O-horizons to be set in burlese funnel traps for arthropod biomass measurement. The top 10 cm of mineral soil will be collected as well. Then samples will be dried, weighed and analyzed for C, N, and $^{15}$N. Relative decomposition and mineralization rates will be assessed through examination of the O-horizon morphology, soil C:N, and soil $^{15}$N. We will determine if the planted trees are responding to differences in nutrient availability by examining foliar concentrations of N and $^{15}$N. As these measurements will be taken in conjunction with stand scale conifer growth plots, we will be able to determine the tradeoffs between cervid and songbird forage production and plantation development.

**Timeline:**

Bird, cervid, arthropod, tree growth, and competing vegetation surveys have been conducted annually for the past 5 years and will be conducted in the next year as part of other studies. Sampling of biomass and soils will take place during the summer and fall of 2015. Soil and biomass laboratory analyses will take place during the winter and spring of 2016.

**Bibliography:**


Budget Total: $52,397  Year 1: $52,397
New Research Project Study 3:

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

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

Project Background: Standing dead trees, also known as snags, are important features of the forest landscape that provide vertical structure, promote biodiversity and ecosystem function, and play critical roles in carbon budgets and nutrient cycling (Harmon et al. 1986, Hilger et al. 2012). A significant portion of forest wildlife depend on snags for critical processes throughout the annual cycle such as obtaining food, nesting cavities, and denning sites (Bunnell et al. 2002, Martin et al. 2004, Drever et al. 2008). Despite their ecological importance, snags are often removed for safety concerns or salvaged for commercial value in managed forests (Lewis 1998, Kroll et al. 2012). In addition, short-rotation harvest cycles combined with low rates of snag recruitment have also led to reductions in snag density (Rose et al. 2001, Huff and Bailey 2009). One option for mitigating snag loss and providing habitat for snag-dependent species is through the purposeful creation of snags. Despite being widely used, there virtually not studies that have evaluated snag creation as a long-term management tool by assessing temporal changes in the use and characteristics of snags created for wildlife. Nevertheless, such studies are needed for quantifying the ecological value of created snags and to insure that this technique provides long-term habitat for snag-dependent species within production forests.

In this study, we capitalize on an existing Forest Research Laboratory initiative, the College of Forestry Integrated Research Project (CFIRP), to quantify long-term changes in the ecological value of created snags for wildlife. We do this by undertaking a study that uses contemporary and historical data to measure foraging and nesting use of created snags by forest birds over a 25-year period, from the time of snag creation to the present day. The ecological value of snags can be highly dynamic in time, so this approach allows us to evaluate long-term changes in snag suitability for species that require snags as critical habitat. In addition, we evaluate how different silvicultural treatments influence rates of snag decay, cavity excavation, and use by cavity-dependent species. Quantifying how silvicultural treatments influence snag persistence and decay rate through time will provide managers with information regarding how to best implement snag creation in conjunction with silvicultural prescriptions to enhance habitat quality for cavity-dependent species.

Relevance to Program Mission: This proposal addresses several topics identified as high priority to the mission of the FWHMF Program. (4a) Indicators of habitat quality: Our study is focused on snag-dependent vertebrates including woodpeckers (family Picidae), a group that comprises an important component of the forest animal community. Woodpeckers have a disproportional influence on forest communities through their foraging and nesting activities and are therefore strong indicators of habitat quality (Martin et al. 2004, Drever et al. 2008). In particular, woodpeckers serve as primary excavators that create cavities used by other species, including secondary cavity nesters that require cavities for reproduction but cannot create them on their own (Martin and Eadie 1999). (4aiii) Oregon Species of Concern: Several bats currently listed as Oregon Species of Concern occur in Coast Range forests and use snags as roosting habitats (Thomas 1988, Humes et al. 1999), so quantifying how snag characteristics change through time has direct relevance for forest management for this ecologically important and declining group. (4c) Effects of treatments for forest health: Dead wood provides
resources and substrates for many organisms that perform vital ecosystem functions including nutrient cycling, decomposition, respiration, and other biologically-mediated processes (Edmonds et al. 1989), and these processes have far reaching effects on ecosystem health and function (Harmon et al. 1986, Franklin et al. 2000). Snag creation allows managers to improve overall forest health and enhance biodiversity, and our study explicitly focuses on understanding the snag creation-biodiversity-forest health pathway over long timescales.

It is worth noting that our study is embedded within the framework of a large-scale, long-term manipulative experiment (i.e., CFIRP) that tests how forest management practices can be undertaken to maintain values associated with late-successional forests (Maguire and Chambers 2005). Our study takes advantage of existing CFIRP project infrastructure and focuses on evaluating how snag creation benefits wildlife over long-term timescales and under natural levels of variability, a core project objective (Maguire and Chambers 2005). Importantly, snag creation and silvicultural treatments have already been implemented and we are using methods that have been previously validated on our study sites, leading to a high probability of project success and collection of ecological data that will be applicable to a wide range of managed forest habitats.

**Study Objectives:** Our goal is to conduct the first study to assess the long-term ecological value of created snags as habitat for wildlife in managed forests, with the following objectives:

1. **Quantify contemporary use of snags created 25 years ago as foraging and nesting substrates by birds.** We will undertake detailed surveys, centered on individual snags, to document the diversity and abundance of forest bird species that require snags for feeding and nesting, and use advanced video technology to quantify reproductive success of birds breeding in created snags.

2. **Measure contemporary avian community response to created snags.** We will quantify the diversity and abundance for all bird species in the forest community within stands containing created snags, including those species that depend upon snags as critical resources during the summer breeding season.

3. **Assess whether silvicultural treatments undertaken at the time of snag creation have caused differences in contemporary snag characteristics and snag use.** We will assess how current snag characteristics (e.g., status, decay) are influenced by the silvicultural treatment applied at the time of snag creation and, in turn, how these traits are linked to snag use by the broader avian community. We know of no data available on this topic, so FWHMF funding will provide the first comprehensive analysis of long-term response of wildlife to created snags and, in turn, provide information needed by managers when using snag creation to enhance habitat.

**Approach and Methods:** The CFIRP was established in the McDonald-Dunn Forest north of Corvallis Oregon in 1989. This project incorporated the purposeful creation of snags by topping live trees, most of which were Douglas-fir (*Pseudotsuga menziesii*), at a height of approximately 17 m (Maguire and Chambers 2005). Snags were created in either clumped or dispersed groups, with both configurations spread evenly across stands that were subjected to one of three silvicultural treatments (i.e., clearcut, two story, or group selection). Previous studies measured bird use of snags approximately 5 years (Chambers et al. 1997) and 10 years after their creation (Walter and Maguire 2005), and we will use the methods of these previous authors and those of Huff and Bailey (2009) to quantify snag use and characteristics. In March 2015 we will relocate snags and measure several characteristics, including
status (standing/down), total height, decay class, and number of foraging and nesting cavities. During
the 2015-16 breeding seasons (May-July) we will survey birds on treatment stands using standard point
count methods. Counts will be conducted 4 times across each breeding season to incorporate detection
probability into abundance estimates (MacKenzie et al. 2005). During the same period, on a randomly
selected subset of snags (n ≥ 50 per treatment) we will conduct standardized focal observations
(minimum of 10 min/snag/month/season) to quantify bird foraging and breeding activity. All cavity nests
will be monitored with a video inspection system (http://www.sandpipertech.com/elevated_video.html)
that allows for rapid, accurate, and safe collection of demographic data from created snags, all of which
are too hazardous to climb for data collection at the current time. Nests will be monitored every 3-4
days, and the outcome of each nesting attempt (success/fail) and number of fledglings will be
determined; in addition, aspect, cavity diameter, and cavity height will also be recorded. Given the large
number of stands (~30) and snags (~900) available for study, two technicians are needed to assist M.S.
student Amy Comstock to maximize the amount of data collected. Based on prior studies on our study
sites, we expect to find ≥150 nests per year of primary and secondary cavity nesting species (Walter and
Maguire 2005). We note that we have already received verbal confirmation from Carol Chambers and
Scott Walter for use of their historical snag use data.

**Timeline:** FWHMF funding will allow us to collect data on foraging use, breeding activity, reproductive
success, and snag characteristics during the 2015-16 field seasons; this will allow us to leverage FWHMF
support for applications being submitted to additional funding outlets, including the USGS Youth and
Education in Science Program. We expect to submit findings from this study to a peer-reviewed journal
in winter 2017.

**References**

western forests. Pp. 291-318 in Ecology and management of dead wood in western forests


Drever, M. C., K. E. H. Aitken, A. R. Norris, and K. Martin. 2008. Woodpeckers as reliable indicators of
bird richness, forest health, and harvest. Biological Conservation 141:624-634.

A. Perry, R. Meurisse, B. Thomas, and others, eds. Maintaining the long-term productivity of Pacific
Northwest forest ecosystems. Timber Press, Portland OR.

Franklin, J. F., D. Lindenmayer, J. A. MacMahon, A. McKee, J. Magnuson, D. A. Perry, R. Waide, and D.

Harmon, M. E. et al. 1986. Ecology of coarse woody debris in temperate ecosystems. Advances in


Budget Total:$57,818  Year 1:$30,772  Year 2:$27,046
Continuing Research Project Study 1:

Title: Effects of Landscape-scale Forest Management on Pacific Marten Occupancy and Population Connectivity in Coastal Oregon (FY 2015-FY 2016)

Investigators:
Dr. John Bailey, Associate Professor, FERM Department, Oregon State University
Keith Slauson, Research Ecologist, U. S. Forest Service
Katie Moriarty, PhD Candidate, Department of Fisheries and Wildlife, OSU

Relevance to Program Mission:
The Pacific marten (Martes caurina) was historically found throughout Oregon’s coastal forests, but it is currently known to only occur in two disjunct populations in the central and southern Coast Range. It is currently under review for listing under the federal Endangered Species Act as a distinct population segment in coastal Oregon and California. Martens typically require mature forest elements to meet a variety of their life history needs, and they maintain large home ranges (e.g., ~300 ha) for a mammal of their body size (800-1000g). In addition, martens have been shown to be sensitive to fragmentation of mature forest at the landscape scale, with survival rates of adults and dispersing juveniles reduced in intensively-managed forests. However, to date there have been no intensive efforts to evaluate how Pacific marten populations interact with forest structural conditions in coastal Oregon or to determine what variations in forest management may be compatible with marten persistence. New data/information is needed to inform managers how to accommodate and promote marten persistence through beneficial management of their habitat within working forest landscapes.

We propose to use a multi-scale approach (home-range- to landscape) to determine whether and how forest management pattern affects marten occupancy and population connectivity. Our proposed study design focuses on a systematic sampling approach across a gradient in management intensities in and around the edges of these extant marten populations. This design will allow us to determine the composition of habitat conditions/uses at home-range and landscape scales, required for informing management planning at multiple scales. Marten occupancy at specific survey locations would suggest local conditions capable of supporting year-round use that, when aggregated to landscape scales, support the proportion and configuration of suitable habitat capable of promoting distributional connectivity of individuals within populations. To achieve such a unique, large-scale approach we have developed a coalition of public and private land management entities in the immediate vicinities of these two known marten populations in the Oregon Coast Range to participate in this study. We have secured access to their forest lands as well as contributed in-kind support (e.g., remote cameras, field vehicles and staff time) in order to enhance the effort, scope and applicability of this study.

Objectives:

To achieve the overall goal of understanding how forest management affects marten occupancy and population connectivity we have four objectives:

1. Conduct systematic surveys for martens on a 2-km grid across a gradient in management intensities on private, federal, and state lands in the vicinity of the two marten populations in coastal Oregon.
2. Deploy hair snares at all marten detection locations to non-invasively collect genetic material for individual identification and abundance estimation.
3. Conduct habitat compositional analysis at the home-range scale at each survey location.
4. Determine the landscape patterns and compositions that facilitate connectivity within and passage between populations.

**Approach and Methods:**
We will use systematic sampling to identify areas where marten populations transition from occupied to unoccupied states. To guide initial sampling efforts, we will use the combination of recent verified records of their occurrence and an existing landscape habitat suitability model to establish our first survey locations. Surveys will be designed to begin at these putative population centers and radiate outward up to 10 km from the last established marten detection, well beyond home-range travel distances and the maximum typical dispersal distance for juvenile martens.

At each survey location we will establish a 2-station remote camera or track plate-hair snare sample unit. One station will occur at the grid point and the second 250-500m away in a random direction, in suitable riparian habitat. Each station will be baited with chicken and an olfactory lure. Sample units will be run for 21 consecutive days, checked 2 times per week. During each check, bait and lure will be replenished and photos, tracks, and hair collected. Hair samples will be sent to the U.S. Forest Service’s Wildlife Genetics Laboratory for individual identification, sex determination, and if necessary, species confirmation. Microsatellite variation at 9-13 loci will be used to determine individual identification.

Habitat analysis at the home range and landscape scales will utilize the gradient nearest neighbor (GNN) vegetation coverage. Home-range-scale compositional analysis will be conducted using a 1-km radius circle (300 ha) around each survey location. Given their important role in population growth and performance, a separate habitat analysis will be conducted at sites where females are detected. Connectivity analysis will relate how different landscape patterns and compositions affect the occupancy state of adjacent sample units.

**Timeline:**
Year 1 – Complete surveys in the landscapes within northern Coos, western Douglas, and western Lane Counties. Conduct initial analysis for Year-1 survey region and produce progress report. Promote preliminary results, refine and expand analyses in collaboration with partners.

Year 2 – Complete surveys throughout the Oregon Coast Range (into southern Coos, northern Curry, Lincoln, Polk, Tillamook, and Yamhill Counties). Conduct final habitat and population connectivity analysis for the entire area; complete final report and publish results.

**List of Cooperators and Matching In-kind Contributors:**
Private Timber Companies: Weyerhaeuser (contributing), Hancock Forest Management (contributing) and Plum Creek Timber; BLM Districts: Coos Bay (contributing) and Salem; USFS: Siuslaw and Rogue-Siskiyou (both contributing); Oregon Department of Forestry, USFS Pacific Southwest Research Station (contributing); Oregon Department of Fish and Wildlife; and US Fish and Wildlife Service.

**Budget Total:**$105,651  Year 1:$63,203  Year 2:$42,448
**Continuing Research Project Study 2:**

**Title:** Modeling Geomorphic Response to Large Wood Introduction as a Strategy to Restore Fish Habitat in Managed Forest Watershed (FY 2015-FY 2016)

**Principal Investigator:** Catalina Segura (OSU)

**Co-PIs:** Christopher Lorion (ODFW), Stacy A. Polkowske (ODFW)

**Relevance of topic to program mission:** We propose to model geomorphic response to the introduction of large wood (LW) to coastal Oregon streams and its relation to fish population dynamics in a managed watershed. Even though LW additions are often part of fish habitat restoration efforts, the relative success of these efforts is rarely reported in terms of ecological significance. The geomorphic character of river systems in northwestern coastal watersheds is heavily controlled by the interaction of the stream channel with the floodplain (Bilby and Bisson 1998). Under natural conditions and adequate sediment supply this interaction allows river systems to recruit wood and develop forced-pool-riffle (FPR) morphologies in reaches that otherwise would exhibit plane-bed (PB) characteristics (Montgomery and Buffington 1997). The level of complexity of these reaches is high and they are often associated with the best habitat for anadromous fish (Beechie and Sibley 1997; Flitcroft et al. 2014). Historic forest operations that allowed clear-cutting to the edge of river systems and in-stream clearing of stored LW strongly disturbed this interaction leading to riparian areas dominated by deciduous species such as red alder (Alnus rubra) and simplified channel complexity. Prospects for natural recruitment of LW by this alder dominated forest are low because of their small size and rapid decay. The Mill Creek Watershed (Siletz) is an ideal system to study the effectiveness of restoration efforts that included LW addition. As one of the Oregon Department of Fish and Wildlife (ODFW) salmonid life cycle monitoring sites, extensive biological information regarding fish populations has been collected since 1997 including adult coho salmon spawner and smolt estimates, freshwater and marine survival estimates for coho salmon, and fall spawning surveys. A relatively low LW abundance has been documented in most of the watershed, which is thought to limit production of coho (Anlauf-Dunn and Jones 2012). Therefore the ODFW is leading an effort to restore stream function by a system-wide addition of LW. The extensive biological dataset available in conjunction with anticipated future fish surveys will allow not only describing and modeling geomorphic changes but also linking them to changes in fish populations. This information would enhance our ability to define concrete and effective restoration targets allowing forest management while maintaining and/or recovering habitat for coho salmon. This project will complement studies in the watershed related to fish population dynamics, stream temperature, and beaver activity.

**Objectives:** This study will 1) classify channel types in the alluvial stream network of the Mill Creek Watershed, 2) characterize the fluvial regime of four reaches before and after LW, 3) develop a watershed scale model of channel geomorphic response to LW additions, and 4) investigate the relations between this model and the available biological information.

**Basic overview of approach/methods:** We will conduct a geomorphic survey of the stream network to characterize the morphology of most fish bearing reaches in the catchment. A first approximation would be derived in ArcGIS based on LiDAR. Later this approximation will be verified in the field. This initial assessment will provide the geomorphic context to develop a watershed scale model. We will select three plane-bed alluvial reaches in which LW addition is anticipated to study geomorphic change.
in detail. We will monitor spatial changes in sediment size distribution in several locations across the channel bed of each reach before and after LW introduction. We will monitor channel size and form by surveying several cross-sections per reach before and after LW additions along with measurements of water surface elevation (WSE) for known discharge levels. These together with observations of discharge (Q) for at least 3 flow levels will be used to model boundary shear stress, flow velocity, and sediment transport using the quasi-three-dimensional model (iRIC) developed by the USGS (McDonald et al. 2006). This model has been successfully used in mountainous regions (Cienciala and Hassan 2013; Lisle et al. 2000; May et al. 2009; Segura et al. 2011) in the context of investigating relations between sediment transport and aquatic ecology (e.g. fish and periphyton). We will interpret the results from the model together with measurements of sediment scour and deposition obtained from a grid of buried scour chains in two of the reaches. These chains will be revisited after storm events to track changes in erosion and deposition. All this information will provide a detailed understanding of the geomorphological effect of the LW introduction. These geomorphic analyses will be interpreted together with the available fish information to investigate the effects of geomorphic change triggered by LW additions in fish populations.

**Timeline:** The activities contemplated in this proposal will be completed between the fall of 2014 and summer of 2016 (Table 1). This study will provide support for a graduate student for 2 years. Publication of the results in a peer preview journal is expected by 2017.

**Table 1: Time line of activities (blue=before and green= after the LW addition)**

<table>
<thead>
<tr>
<th>Activity</th>
<th>F14</th>
<th>W14</th>
<th>Sp15</th>
<th>Su15</th>
<th>F16</th>
<th>W16</th>
<th>Sp16</th>
<th>Su16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channel classification of alluvial network</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Geomorphic observations in selected reaches</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sediment entrainment study</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WSE and Q measurements</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data analysis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dissemination of results</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**References**


Budget Total:$99,787  Year 1:$51,171  Year 2:$48,616
**Continuing Research Project Study 3:**

**Title:**  *Natural Variability in Water Quality and Changes after Forest Harvest in the Trask Watershed* (FY 2015-FY 2016)

**Investigators:**
Jeff Hatten, Alba Argerich, Department of Forest Engineering, Resources & Management, OSU
Sherri Johnson, U.S. Forest Service, Pacific Northwest Research Station

**Collaborators:**  Jeremy Groom, ODF; Arne Skaugset, OSU FERM; Maryanne Reiter, Weyerhaeuser;
Catalina Segura, OSU FERM

**Relevance of topic to program mission:** This proposal falls into the topics *Water quality standards* and *Ecological responses to disturbances.*

According to the 2006 Oregon Water Quality Assessment, 67.5% of rivers and streams in Oregon are impaired and this number increases up to 95% when analyzing streams designated to salmonid spawning and rearing (ODEQ, 2014). Excess of nutrient concentrations is the second most important cause of impairment and forest management practices such as forest harvesting and fertilizing can increase nutrient concentrations in streams.

In an effort to improve the health of aquatic ecosystems and to prevent excess nutrient delivery to the oceans, USEPA and state agencies are developing water quality standards based on the estimation of nutrient reference conditions (USEPA, 2000). Although headwater streams comprise 70-80% of the total length of perennial channels in a catchment (Allan and Castillo, 2007), and their nutrient concentrations are highly responsive to catchment-specific factors (Argerich et al. 2013), water quality data used to identify reference conditions are usually based on large rivers and not smaller streams.

Additionally, because the ecological effects of exceeding nutrient criteria are determined not only by the magnitude but by the frequency, duration and timing of nutrient pulses in relation to their natural regime, it is essential to have adequate characterization of natural variability in nutrient concentrations to establish ecologically relevant nutrient criteria. Unfortunately, and because of the economic costs, the sampling frequency of most water quality programs has limited capacity to characterize natural temporal variability (e.g. seasonal samplings).

All these limitations have led to a poor understanding of water quality variability in headwater streams both what is achievable at reference sites and what would be expected after forest harvest. For instance, NCASI (2001), in a detailed review of stream chemistry from unmanaged forested watersheds, found that almost half of them could not meet the recommended criteria for their ecoregions. One of these basins was WS9, an old-growth reference watershed in the H.J. Andrews Experimental Forest (Oregon Cascade Range), where total phosphorus was five times greater than the ecoregion guidelines (Ice and Binkley, 2003). Rhoades et al. (2011), in an analysis of stream nitrogen data from 19 reference catchments at 8 Experimental Forest sites found that nitrogen concentrations exceeded draft criteria to varying extents at all sites.

**Objectives:** In this study we aim to improve the current understanding of patterns and causes of variability in water quality across forest watershed landscapes by characterizing natural and post-disturbance variability in stream nutrients at the Trask River watershed.
Specifically, we will characterize variability in background nutrient concentrations across time, by analyzing water chemistry samples collected over the pre-harvest period, and across space, by comparing water chemistry data across sub-catchments. Secondly, we will analyze responses in nutrient concentrations to forest harvest by comparing pre- and post-harvest nutrient concentrations. Finally, we will compare pre- and post-harvest data to nutrient criteria under consideration for this ecoregion.

**Study site:** The Trask River Watershed is located in the Coast Range and it has been site of research since 2006. It is part of the COF Watersheds Research Cooperative (WRC), with the mission to conduct research on the effects of current and expected forest practices on water quality, fisheries and other water-related values.

**Methods:** We will analyze 2010-2014 biweekly water chemistry samples from five subwatersheds for phosphorus and nitrogen species (Upper Main 1 (UM1), Upper Main 2 (UM2), Pothole 3 (PH3), Pothole 4 (PH4), and Gus 3 (GS3)). Biweekly grab samples at the five sub-watersheds have been already collected, filtered, and frozen since 2010. Selected TTS storm water samples from the downstream gages have also been collected over time and archived. A subset of samples has already been analyzed through COF water chemistry laboratory, CCAL. Biweekly grab samples and the TTS storm samples at the downstream gages for 2014 are being collected by the regular water sampling program of the Trask River Watershed Study. We will also evaluate additional water quality parameters from low flow samples collected since 2006 on 18 nested catchments (14 upstream and 4 downstream sites).

We will characterize spatial and temporal variability by estimating variability descriptors at each of the study sites at different temporal scales (monthly, seasonal, and annual variability). Response to forest harvest will be evaluated considering magnitude and duration of the response in relation to pre-harvest conditions. We will relate stream nutrient natural variability and response to disturbance with possible explanatory factors (e.g., area of the watershed, streamflow, precipitation, geology, forest treatment).

<table>
<thead>
<tr>
<th>Timeline:</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010-2014</td>
</tr>
<tr>
<td>2014</td>
</tr>
<tr>
<td>J</td>
</tr>
<tr>
<td>Water sampling</td>
</tr>
<tr>
<td>Water analysis</td>
</tr>
<tr>
<td>Data analysis</td>
</tr>
<tr>
<td>Dissemination and writing</td>
</tr>
</tbody>
</table>

**References:**


Budget Total:$76,444 Year 1:$37,623 Year 2:$38,821
Continuing Research Project Study 4:

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

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

Project Background and Relevance to Program Mission: The growing demand for forest resources requires a balance between wood production and the conservation of biological diversity (Stephens and Wagner 2007). Intensive forest management (IFM) practices (e.g., herbicides, fertilizers) are used to maximize timber production and may allow for a reduction in the area needed to produce wood fiber (Hartley 2002). Nevertheless, the ecological costs of these practices remain poorly understood. Existing studies indicate that IFM can reduce biodiversity and degrade ecological communities (Stephens and Wagner 2007), and it has been suggested that long-term songbird population declines in the Pacific Northwest may be due to IFM that reduces the amount of floristically diverse early-seral forest (Hagar 2007, Spies et al. 2007, Betts et al. 2010). However, studies examining links between IFM and wildlife typically have typically suffered from two major weaknesses: (1) most are correlative and provide limited conclusions about underlying causes, and (2) nearly all focus on the density of organisms although density may not reflect habitat quality.

Recently, our group initiated a two-year (2013-14) landscape-scale manipulative experiment to assess how IFM impacts songbirds that require early seral forests; this research is supported from external grants (e.g., USDA-AFRI) as well as contributions from industry, government (ODF), and NCASI. Our findings to date indicate that species composition (Betts et al. 2013) and offspring production (Rivers et al., in prep) are inversely related to the intensity of herbicide use. In this proposal, we build upon our existing project infrastructure and expand our research in two new and significant ways. First, our study sites recently attained the age at which herbicide application ceases under operational standards, and we expect to have a short-term “green-up” as hardwood shrubs are no longer chemically controlled. This little-studied aspect of early seral habitats is ephemeral, yet it may provide strong benefits to wildlife. Thus, we seek to collect additional data on reproductive success (i.e., offspring production and juvenile survival) that encompasses the green-up period to accurately estimate these parameters. Second, population projections require data on reproductive success and adult survival. Our two-year study is focused on the former, and we are unable to quantify adult survival because doing so requires at least 3 years of data. Thus, we seek funding to collect additional data to measure adult survival which, along with reproductive success parameters, will provide the first comprehensive demographic study known to us that assesses the impact of IFM on songbirds. Thus, FWHMFRP funding will allow us to obtain long-term data and expand our project in significant ways.

This proposal addresses several topics identified as high priority for new research. (4e) Early seral habitat: Our research focuses explicitly on early seral habitats and the organisms which depend on them during critical life processes. Our focal species (white-crowned sparrow, Zonotrichia leucophrys) requires early seral habitats for breeding and serves as a proxy for other declining songbirds that also use regenerating forests during this critical life stage. (4i) Ecological responses to human-induced disturbance: Clearcut harvest is one of the most common forms of human-induced disturbance in Pacific Northwest forests, and our study is centered on understanding how IFM practices that follow clearcut harvest affect the demographic parameters of native songbirds. It is worth noting that our study is a landscape-scale manipulative experiment that incorporates natural variability with respect to our study sites (e.g., elevation) as well as local (e.g., vegetation) and large-scale environmental variation (e.g.,
Importantly, >2 years of data collection is needed to accurately estimate songbird demographic rates because of expected inter-annual variation in these measures. Because herbicide treatments have already been applied to our study sites, this project will easily transition to a long-term demographic study that explicitly assesses the effects of variability in both time and space.

**Study Objectives:** Our goal is to conduct the first comprehensive demographic study that assesses how IFM practices impact songbirds in early seral forests by using a manipulative experiment at the landscape scale, with the following objectives:

1. **Determine whether the intensity of herbicide application is linked to songbird nesting success.** We will test whether increased use of herbicides decrease nesting success via a reduction in hardwood vegetative cover that conceals nests from predators.

2. **Quantify juvenile survival during the critical period immediately after young fledge from the nest.** We will test whether herbicide intensity is linked to a reduction in juvenile survival through a decrease the amount of hardwood habitat used by young birds after they fledge the nest and before they attain independence.

3. **Assess survival of adults that depend on early seral habitats to raise their young.** We will test whether the intensity of herbicide application is related to (1) local survival of adult songbirds within and between seasons, and (2) the degree of sub-lethal physiological stress experienced while breeding.

We are currently addressing objectives #1-2 during 2013-14; however, at least 3 years of data are needed to estimate adult survival. No data are available on this topic as it relates to IFM, so FWHMFRP funding will provide the first comprehensive test of how IFM impacts songbird demography and adult physiological health.

**Approach and Methods:** We have implemented a large-scale IFM experiment in the Oregon Coast Range. We established 8 study blocks, each containing four 20-25 acre experimental units (total N=32 stands). All blocks underwent clear-cutting operations during fall 2009, were planted with Douglas-fir (*Pseudotsuga menziesii*), and were randomly assigned one of four herbicide treatments: (1) heavy (chemical removal of all shrub species), (2) moderate (a heavier operational standard), (3) light (a lighter operational standard), and (4) no-spray control. Pilot efforts revealed that 4 complete blocks (i.e., 16 stands) were adequate for detecting the effect of herbicide intensity on sparrow reproductive success (Rivers et al., in prep).

Assessment of demographic parameters will take place during early May-late July 2015, and technicians will use standard techniques to locate nests on study sites. We selected the sparrow because it requires hardwood habitat for breeding (Hagar 2007), has experienced long-term declines in the Pacific Northwest (Sauer et al. 2008), and responded negatively to herbicide intensity in the first two years of treatment (Betts et al. 2013). For a subset of nests that produce young, we will attach VHF radio tags (1 nestling/nest for statistical independence) at fledging to monitor survival, movement, and habitat use during the juvenile period (see Rivers et al. 2012). We will measure vegetation at nests and post-fledging locations to assess how vegetation use varies relative to herbicide treatment. In addition, we will capture adult sparrows, take morphological measurements, and obtain blood samples to measure stress hormone levels using standard procedures. Prior to release, we will band each adult with a unique color band combination that allows for assessing local survival without recapturing individuals. On each stand we expect to find a minimum of 15 sparrow nests (expected total: n=280) and capture a minimum of 7-10 adults (expected total: n=120).
Timeline: FWHMFRP funding will allow us to collect information on reproductive success, adult survival, and physiological health during the 2015 field season; this will allow us to leverage CoF/FRL support for applications being submitted to USDA-AFRI (spring 2014) and NSF (winter 2015). We expect to submit initial findings for publication in spring 2015 using data from the first two years of study (2013-14).

Literature Cited

Budget Total:$76,933  Year 1:$59,405  Year 2:$17,528
Continuing Research Project Study 5:

Title: *Experimental Evaluation of Plethodontid Salamander Responses to Forest Harvesting*

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

Introduction & Relevance to Program: Wildlife populations with low dispersal rates and restricted geographic distributions can be strong indicators of forest health in timberlands. Terrestrial salamanders are often associated with specific seral stages and understory structure, and thus can be highly susceptible to harvest practices that alter habitat or limit movement. Two species of plethodontid salamanders, the Oregon slender salamander (*Batrachoseps wrightii*) and ensatina salamander (*Ensatina eschscholtzii*), have terrestrial life histories, are found in forested habitats, and have contrasting vulnerabilities to extinction. OSS occur in mature forest stands and are endemic to the Oregon Cascade Mountains (Bury and Corn 1988, Vesely 1999) while ENS are more widespread. Both species use coarse woody debris (CWD), including snags, downed logs, and stumps, for overwintering and breeding sites. Adequate CWD retention may reduce impacts of timber harvest on these terrestrial salamanders by providing suitable habitat in harvested stands (McKenny et al. 2006, Riffell et al. 2011, Otto et al. 2013). Although many studies have examined wildlife associations with CWD, few have quantified how CWD quality and quantity influence species dependent upon this habitat component.

Snags and downed logs are a readily-measured and manageable target for intensive forest management (IFM), including Sustainable Forestry Initiative (SFI) performance measures for biological diversity (Objectives 4.1, 4.2, and 4.4; Sustainable Forestry Initiative 2010). Growing demand for forest residuals for energy feedstocks (Berger et al. 2013) may reduce stand level distributions of CWD, which may lead to declines in CWD associated species such as OSS and ENS (Cook et al. 1991, Fletcher et al. 2011). Additionally, reduced rotation lengths can lead to lower input of total CWD and CWD heartwood at both the harvest unit and landscape scale (Bunnell and Houde 2010, Maguire and Batista 1996). Heartwood is more durable but has lower initial moisture content than sapwood, thus the overall effect of reduced heartwood on OSS or ENS habitat quality is unclear. Conceptual and empirical models for understanding the role of CWD in maintenance of biological diversity and ecosystem function in managed forests are needed to predict direction and quantify magnitude of ecological responses to current and prospective management practices.

Our central research question is: How do two species of wood-dwelling Plethodontid salamanders respond to post-harvest CWD quantity and quality? We hypothesize that reduced CWD recruitment rates in intensively managed plantations will lead to reduced occupancy rates and abundance of these indicator populations. The Oregon slender salamander is classified as G2/G3 (Imperiled/Vulnerable; NatureServe), and was proposed for federal listing under the Endangered Species Act in 2001 because its conservation status is considered sensitive throughout its range. Ensatina is relatively common, known to occur in younger forests, and uses a range of cover types besides CWD. Experimentally examining species with differential reliance on CWD in harvested stands will clarify the role these structures play in maintaining biodiversity in these systems.

This proposal addresses several of the FWHMFP priority funding topics. (4) The response of fish and wildlife to forest management: Our experimental design allows us to draw inference about effects of forest harvesting on two species of plethodontid salamanders, one of which is endemic to the Oregon Cascade Mountains. In addition, our experimental design allows us to address: (4e) Early seral habitat; (4i) Ecological responses to
disturbance (natural or human-induced); and (4g) Effect of treatments for biomass energy, fuels management, restoration, habitat, forest health.

Objectives & Hypotheses: The main goal is to acquire crucial information on responses of sensitive taxa to intensive forest management practices, specifically CWD quality and quantity in harvested timberlands. Our experimental design includes pre- and post-treatment sampling, which will provides strong inference on potential effects of biomass treatments on wood-dwelling species. This information can be used for development of management prescriptions to ensure adequate spatial and temporal distributions of CWD.

1. Correlate salamander occupancy and abundance with CWD density and distribution at both the site and landscape scale. We hypothesize species-specific effects of forest harvesting. OSS are likely to reduce occupancy and abundance in harvested sites regardless of landscape metrics, while ENS response will be in proportion to amount of harvest across the landscape and distributions and quality of CWD within the harvest units.
2. Quantify relationship between salamander occupancy and abundance with heartwood quantity. We hypothesize that heartwood content will be positively associated with both OSS and ENS occupancy and abundance, particularly as time since harvest increases.

Methods:
Site Selection: We implemented the pre-harvest stage of this project in 2013. Sixty units from the harvest plans of Port Blakely and Weyerhaeuser (>10 acres in size, <2500 ft. in elevation within western Cascade Range, OR) were randomly ordered for selection in the experiment. Fifteen stands were designated as controls (not to be harvested during the first 6 years of the project); 45 stands will be harvested within the first 6 years (2013-2018). All 60 stands are known to be occupied by OSS, the rarer of the two species.

Sampling Protocol: Our sampling program is designed to estimate both occupancy (population persistence) and abundance (population size) and how these responses vary with CWD quality and quantity over time. We will sample seven randomly selected 81 m² plots in each harvest unit every year except the first year post-harvest. Observers will use a light touch sampling protocol in which cover objects are returned to their original position and in which disturbance to habitat features such as decayed logs is minimized. Crews will count CWD based on length (1-5, 6-15, >15 m), width (large end; 25-50, >50 cm), sapwood width (none, <3 cm, > 3 cm), and decay class (none, Stage 1, Stage 2) (Maser and Trappe 1984). Our analytical approach will identify the: (1) probability that a harvest unit (landscape scale) 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 with heartwood amount. Details on the statistical models used to estimate these quantities are provided in Royle and Nichols (2003), Nichols et al. (2008), Mordecai et al. (2011), and Pavlacky et al. (2012).

Pre-treatment Results: Our first year of pre-treatment sampling indicated that OSS showed a strong association with CWD: 23% (95% credibility interval: 6–43%) greater OSS abundance, and approximately 46% (11–102%) greater odds of plot-level occupancy, for each 2 unit difference in downed wood (pieces >25 cm in diameter). In contrast, ENS responses were not associated with CWD: ENS had 5% (-27–23%) lower relative abundance and 12% (-43–33%) lower odds of occupancy for each 2 unit difference in downed wood. Heartwood was not assessed in the first year. Full references available upon request.

Timeline: Funding from FWHMFRP will allow us to collect data in 2014 and 2015 field seasons. We expect to publish findings on short-term responses (2-3 years post-harvest) in 2017. An additional $60K has been secured for the next 4 years for this project from the Oregon Forest Industry Council as well as in-kind and cash funds from Weyerhaeuser and Port Blakely. An annual budget of $65K is needed for this study.

Budget Total:$85,412 Year 1:$42,280 Year 2:$43,132
Technical Advisory Committee

Jeff Light, Chair
Plum Creek Timber Company
PO Box 216
Toledo, OR 97391-0216
Phone: 541-336-6227
E-mail: jeff.light@plumcreek.com

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

Bob Danehy
National Council of Air & Stream Improvement
West Coast Regional Center
P.O. Box 458
Corvallis, OR 97339-0458
Phone: 541/752-8801
E-mail: bdanehy@ncasi.org

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

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

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

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

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

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

Evan Smith
The Conservation Fund
4039 N. Mississippi Ave., Suite 308
Portland, OR 97227-1477
Phone: 503-407-0301
E-mail: esmith@conservationfund.org

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

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

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

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