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

B. Names of Principal and Co-principal Investigators
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C. 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 (OSS; *Batrachoseps wrightii*) and ensatina salamander (ENS; *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**.
D. 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 provide 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.

E. 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: (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), Maser and Trappe (1984), Pavlacky et al. (2012), and Mordecai et al. (2011).

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.

F. 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