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# Modeling wildfire risk to northern spotted owl (*Strix occidentalis* caurina) habitat in Central Oregon, USA

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**Abstract**

Natural disturbances including wildfire, insects and disease are a growing threat to the remaining late successional forests in the Pacific Northwest, USA. These forests are a cornerstone of the region's ecological diversity and provide essential habitat to a number of rare terrestrial and aquatic species including the endangered northern spotted owl (*Strix occidentalis* caurina). Wildfires in particular have reduced the amount of late successional forests over the past decade, prompting land managers to expand investments in forest management in an attempt to slow losses and mitigate wildfire risk. Much of the emphasis is focused specifically on late successional reserves established under the Northwest Forest Plan to provide habitat for spotted owls. In this paper, we demonstrate a probabilistic risk analysis system for quantifying wildfire threats to spotted owl habitat and comparing the efficacy of fuel treatment scenarios. We used wildfire simulation methods to calculate spatially explicit probabilities of habitat loss for fuel treatment scenarios on a 70,245 ha study area in Central Oregon, USA. We simulated 1000 wildfires with randomly located ignitions and weather conditions that replicated a recent large fire within the study area. A flame length threshold for each spotted owl habitat stand was determined using the forest vegetation simulator and used to predict the proportion of fires that resulted in habitat loss. Wildfire modeling revealed a strong spatial pattern in burn probability created by natural fuel breaks (lakes and lava flows). We observed a non-linear decrease in the probability of habitat loss with increasing treatment area. Fuels treatments on a relatively minor percentage of the forested landscape (20%) resulted in a 44% decrease in the probability of spotted owl habitat loss averaged over all habitat stands. The modeling system advances the application of quantitative and probabilistic risk assessment for habitat and species conservation planning.
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*Keywords:* Wildfire risk; Expected loss; Northern spotted owl; Wildfire simulation; Forest vegetation simulator; FlamMap; Conservation planning

## 1. Introduction

The Northwest Forest Plan was developed and implemented to sustain biological diversity in the Pacific Northwest, USA, via a network of late successional forest reserves (USDA Forest Service and USDI Bureau of Land Management, 1994; Lint, 2005). Management of the forest reserves is focused on the habitat requirements for the endangered northern spotted owl (*Strix occidentalis* caurina), although the reserves are a surrogate for a wide array of other old growth dependent species, and are a cornerstone of the region's ecological diversity. Since the plan was implemented, the rate of spotted owl habitat loss from timber harvest has declined sharply. However, stand replacing wildfire and other disturbances continue to erode the habitat network, especially in the interior dry forests environments east of the Cascade Mountains (Courtney et al., 2004; Lint, 2005; Spies et al., 2006). Wildfire accounted for 75% of the disturbance-caused loss of spotted owl habitat between 1994 and 2003 (Courtney et al., 2004). Decades of fire suppression and selective timber harvesting practices (Agee, 1993; Hessburg and Agee, 2003; Wright and Agee, 2004) have led to a buildup of ladder and surface fuel, and the potential for severe, stand replacing wildfires. Under the current management trajectory, the future trend for the late successional reserves appears to be continued tree mortality, increased fuel accumulation and further stand replacement wildfire events (Mendez-Treneman, 2002; Hummel and Calkin, 2005; Lee and Irwin, 2005).

There is broad consensus among forest managers and scientists that fuel treatment including mechanical thinning

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and prescribed fire may improve the long-term protection of old growth stands from wildfire losses (Agee, 2002; Spies et al., 2006) and a number of strategies have been proposed to address wildfire risk at the stand and landscape level (Spies et al., 2006). However, the efficacy of fuel treatment beyond the individual stand scale remains an experimental topic (Finney, 2001; Finney et al., 2006). Furthermore, stand treatment to mitigate long-term wildfire damage may carry significant short-term adverse effects to nesting spotted owls (Carey et al., 1992; Zabel et al., 1995; North et al., 1999; Bond et al., 2002; Lee and Irwin, 2005). The paradox of managing the dry forest of the east cascades for dense multistoried stands favored by spotted owls has been examined in several papers (Agee, 2002; Lee and Irwin, 2005; Spies et al., 2006). Wildfire risk mitigation for spotted owl habitat has been explored with simulation models in several case studies (Wilson and Baker, 1998; Hummel and Calkin, 2005; Roloff et al., 2005). However, these and related studies have yet to yield operational tools for quantifying the probability of habitat loss from wildfire and the potential benefits, if any, of mitigation efforts. As elaborated in Finney (2005), empirical data on fire size distribution in the western USA support the argument that large fire spread is a major determinant of wildfire probability. For instance, on the Deschutes National Forest in Central Oregon, USA, where ca. 90,000 ha of lands are managed to preserve and create late successional forests, the historical record for mapped fires (>1.18 ha) between 1908 and 2003 shows that a mere 10% of the fires accounted for 74% of the total burned area (156,648 ha). These data indicate that the probability that a given stand will experience a fire is primarily a question of large fire spread rather than local fuel conditions. Thus, wildfire risk analysis must account for spatial patterns of wildfire spread over areas comparable to recent large wildfires. Furthermore, since risk is the probability of actual loss or gain (Society for Risk Analysis, 2006), a wildfire risk model must also consider fire intensity and effect to be a useful tool for assessing the potential impact of fire on landscape attributes.

In this paper, we describe a wildfire risk analysis system for quantifying potential wildfire impacts on spotted owl habitat and measuring the efficacy of landscape fuel treatment on reducing risk. We used the formal definition of risk (Brillinger, 2003; Society for Risk Analysis, 2006; Kerns and Ager, 2007), defined for wildfire as the product of: (1) the probability of a fire at a specific intensity and location, and (2) the resulting change in financial or ecological value (Finney, 2005; Scott, 2006). The risk assessment was tested on a 70,245 ha study area on the Deschutes National Forest in Central Oregon that contains a 19,888 ha late successional forest reserve managed under the Northwest Forest Plan for spotted owl habitat. The risk analysis system has broad application for conservation planning and biodiversity management where natural disturbances like wildfire pose a long-term threat to habitat management objectives, and the efficacy of mitigation strategies are in question.

## 2. Materials and methods

### 2.1. Study area

The Five Buttes Interface planning area is located 80 km south of Bend, Oregon, and contains 60,867 ha of land managed by the Deschutes National Forest (henceforth the Forest) and 9378 ha of private lands (Fig. 1). The area was identified by forest managers and staff for a fuel reduction project to mitigate wildfire hazard to the Davis Late Successional Reserve (LSR) and other resources in the area (Fig. 1). The site is within the high lava plain physiographic and geological province of Central Oregon, characterized by young lava flows and scattered cinder cones and lava buttes (Franklin and Dyrness, 1988). The vegetation varies considerably with elevation, topography and substrate, with the relatively flat pumice plains dominated by dense stands of lodgepole pine (*Pinus contorta*). Vegetation on the buttes gradually changes with elevation, with ponderosa pine (*Pinus ponderosa*) and Douglas-fir (*Pseudotsuga menziesii*) growing below approximately 2000 m, and white fir (*Abies concolor*), mountain hemlock (*Tsuga mertensiana*) and western white pine (*Pinus monticola*) growing between about 2200 and 2400 m. In the western, higher elevation portion of the study area (>2400 m), mountain hemlock, western white pine and lodgepole pine are the most common tree species. Old growth ponderosa pine forests in this area had a natural fire return interval of 4–11 years and fires were low severity. Fire frequency was considerably lower in the mesic mountain hemlock forests at higher elevations, with return intervals in the range of 50–200 years, and fires that were generally high severity, stand replacing events (Spies et al., 2006).

Approximately, 80% of the study area is administered according to the Northwest Forest Plan, including the Davis Late Successional Reserve (19,888 ha) where management goals are to sustain and create forest habitat for the spotted owl (Fig. 1). Wildfire and other disturbances are frequent within the study, most notably the June, 2003 Davis fire which burned 8268 ha, including 24% of the Davis Late Successional Reserve, two spotted owl home ranges and 2267 ha of spotted owl habitat. A recent assessment by the forest noted that the most immediate need within the late successional reserve was to reduce the loss of existing late and old structured stands that are imminently susceptible to insect attack or wildfire. This finding and other threats to late successional forests within the study area led to the initiation of the Five Buttes Interface fuel treatment project and motivated the present study.

### 2.2. Vegetation and fuels data

Vegetation and fuels data were obtained from existing forest inventory databases. Forest stands in the study area were defined using operational forest planning GIS layers and included a total of 5292 polygons. The average polygon size was 13.3 ha, ranging from a minimum of 3 ha to a maximum of 1515 ha. The forest inventory database was created using a

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