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Preliminary effects of fire and mechanical fuel treatments on the abundance of small mammals in the mixed-conifer forest of the Sierra Nevada

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Abstract

Many western conifer forests were historically affected by frequent, low- to mixed-severity fires. A legacy of fire suppression, logging, grazing and other factors has created current forest habitats that do not reflect historical conditions. The increasing size, severity, and costs of catastrophic forest wildfires are now focusing wildland management and research towards proactive fuel treatments designed to reduce fire hazards across landscapes. As part of the National Fire and Fire Surrogate (FFS) study, we researched the effects of three fuel treatments on small mammal populations within Sierra Nevada mixed-conifer forests. Twelve mixed-conifer stands were selected randomly from a set of available stands. Each stand was assigned to one of four treatment groups: controls, prescribed fire only, mechanical only, and mechanical plus fire combined. Abundance of California ground squirrels (*Spermophilus beecheyi*), long-eared chipmunks (*Tamias quadrimaculatus*), brush mice (*Peromyscus boylii*), and deer mice (*Peromyscus maniculatus*) were monitored both pre- and post-treatment. Only the deer mouse had a significant treatment effect. Deer mice abundance significantly increased from pre- to post-treatment within fire only and mechanical plus fire treatments, and declined within mechanical only treatments. All four species had a significant effect of year, with higher overall abundance in the post-treatment period. In addition to the experimental analysis, models containing stand-level covariates of vegetation and fuel characteristics were examined and compared using model selection procedures. The models only improved upon the experimental analysis for the brush mouse. Brush mice were found to have a positive association with stand-level canopy cover. Our results suggest that burning had a positive effect on deer mice and that mechanical only treatments had a negative effect. For the other three species, the dominant effect of year suggests that other, more regional factors may have affected abundance. Possible explanations included an increase in precipitation from pre- to post-treatment, a major cone crop in 2002, and a major decline in gray fox (*Urocyon cinereoargenteus*) occurrence. For the brush mouse, an evaluation of trap locations within stands indicates that this species was associated with dense clumps of tan oak (*Lithocarpus densiflorus*) or riparian areas. Leaving areas of dense low vegetation cover may benefit this species where fuel reduction treatments are implemented. Our study only documented the immediate impacts of fuel treatments and more research is needed to determine if our results will persist through time.

Keywords: Fire; Forest restoration; Fuel treatments; Small mammals; Coarse woody debris; Thinning; Timber harvest; Fire surrogates

1. Introduction

Many western conifer forests were historically affected by frequent, low- to mixed-severity fires (Biswell, 1989; Agee, 1993; Sugihara et al., 2006). Within Sierra Nevada Ponderosa pine (*Pinus ponderosa*) and mixed-conifer forest, fires historically burned at intervals of a few years to decades (Biswell, 1989; Agee, 1993; Swetnam, 1993; Skinner and Chang, 1996; Taylor and Skinner, 1998; Taylor, 2000; Stephens and Collins, 2004; Moody et al., 2006). These frequent fires were a dominant force that helped shape forest structure and ecosystem processes. A legacy of fire suppression, logging, grazing and other factors has created current forest habitats that do not reflect historical conditions (SNEP, 1996). Few reference forests exist within the U.S. that have not been impacted by management or fire suppression (Stephens and Fulé, 2005). The lack of reference sites makes it difficult to predict what effects restoration treatments will have on forest wildlife species.

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The increasing size, severity, and costs of catastrophic wildfires are now focusing wildland management and research towards proactive fuel treatments designed to reduce fire hazards across landscapes (USDA-USDI, 2000; HFRA, 2003; Stephens and Ruth, 2005). Fuel treatments are designed to reduce surface fuels, reduce ladder fuels, and open the forest canopy (Weatherspoon, 2000; Agee and Skinner, 2005). Restoration via fire is an attempt to reintroduce a natural ecological process into the ecosystem. Mechanical treatments are an attempt to reduce fire hazard without the reintroduction of fire into the landscape. A combination of both mechanical followed by prescribed fire may provide the fastest pathway to restoration of the desired forest structure (Biswell, 1989). All of these treatments have been shown to reduce modeled fire behavior attributes such as intensity, severity, and scorching (Stephens and Moghaddas, 2005a), whereas a majority of traditional silvicultural treatments do not (Stephens and Moghaddas, 2005b). These fuel treatments may result in habitat changes that could affect local small mammal populations. With a lack of reference sites for comparison (Stephens and Fulé, 2005), it is important to research the effects of fuel treatments on wildlife prior to widespread application.

The objective of this study was to determine how three different fuel treatments (with a control) affect small mammal abundance within Sierran mixed-conifer forests (Mayer and Laudenslayer, 1988) of California. Treatments incorporated prescribed fire and mechanical harvesting alone and in combination. In general, treatments simplified surface fuel structure, removed a large portion of the forest midstory and understory vegetation (i.e. ‘‘ladder fuels’’), and opened the forest canopy (Stephens and Moghaddas, 2005a,c; Kobziar et al., 2006; Collins et al., 2007; Moghaddas and Stephens, 2007). The goal was to determine if these changes to forest structure would result in changes in local small mammal relative abundance. Treatment effects were tested, and a set of models containing stand-level vegetation and fuel covariates in addition to treatment effects were also tested using a model selection framework (Burnham and Anderson, 2002). This study site was part of the larger Fire and Fire Surrogate (FFS) study, in which 13 sites across the U.S. received similar experimental treatments and conducted similar research protocols within forests that were once historically affected by frequent low- to mixed-severity surface fires (Weatherspoon, 2000).

2. Methods

2.1. Study location

The study was conducted in the Sierran mixed-conifer forest region (Mayer and Laudenslayer, 1988) in the north-central Sierra Nevada at the University of California Blodgett Forest Research Station (Blodgett Forest). Blodgett Forest is located at latitude 38°54′45″N, longitude 120°39′27″W, between 1100 and 1410 m above sea level, and encompasses an area of 1780 ha. Tree species in this area include sugar pine (*Pinus lambertiana*), Ponderosa pine, white fir (*Abies concolor*), incense-cedar (*Calocedrus decurrens*) Douglas-fir (*Pseudotsuga menziesii*), California black oak (*Quercus kelloggii*), tan oak (*Lithocarpus densiflorus*), bush chinquapin (*Chrysolepis sempervirens*) and Pacific madrone (*Arbutus menziezii*). Major shrub species include: deerbrush (*Ceanothus integerrimus*), whitethorn (*Ceanothus cordulatus*), greenleaf manzanita (*Arctostaphylos patula*), and whiteleaf manzanita (*Arctostaphylos viscida*).

Fire was a common ecosystem process in the mixed-conifer forests of Blodgett Forest before the policy of fire suppression began early in the 20th century. Between 1750 and 1900, the median composite fire interval at the 9–15 ha spatial scale was 4.7 years with a fire return interval range of 4–28 years (Stephens and Collins, 2004). Forested areas at Blodgett Forest have been repeatedly harvested and subjected to fire suppression for the last 90 years reflecting a management history common to many forests in California (Laudenslayer and Darr, 1990; Stephens, 2000) and elsewhere in the Western U.S. (Graham et al., 2004).

2.2. Treatments

Twelve mixed-conifer stands (14–29 ha each) with similar stand structure, composition and management histories were selected randomly from a set of possible stands (completely randomized design). The stands considered for experimental selection were under group selection management. Group selection is a form of uneven-age silviculture where small (0.1–1.0 ha) patches are harvested periodically within a stand over a predetermined cutting cycle. Each stand had 20–30% of its area covered by group selection regeneration patches aged 0–30 years. Data from within group selection patches were not analyzed in this paper. Each selected stand was randomly assigned to four treatment groups: control (no manipulation), prescribed surface fire only, mechanical only (thinning and mastication combined), and mechanical plus fire. This resulted in three replicates for each of the four treatments. Work was conducted between July and August for 3 years from 2001 to 2003, with 2001 being the pre-treatment year. In 2002 the first stage of mechanical treatments were completed, and 2003 was the first year post-treatment. The total area for the 12 experimental units was 225 ha.

Control units received no treatment during the study period. Mechanical only treatment units had a two-stage treatment. In the fall of 2001, trees greater than 25 cm in diameter (DBH) were commercially thinned from below to maximize crown spacing while retaining 28–34 m^2 ha^{-1} of basal area. In the fall of 2002 approximately 90% of understory conifers and hardwoods between 2 and 25 cm DBH were masticated in place using an excavator-mounted rotary masticator. Masticated material was not removed from the experimental units. Mechanical plus fire experimental units underwent the same treatment as mechanical only units, but in addition, they were prescribed burned using a backing fire (Martin and Dell, 1978) after the mechanical treatment was completed. Fire only units were burned with no pre-treatment using strip head-fires (Martin and Dell, 1978) and all burning was conducted during