A Comparison of Postburn Woodpecker Foraging Use of White Fir (*Abies concolor*) and Jeffrey Pine (*Pinus jeffreyi*)[1]

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Abstract

We examined the temporal patterns of the structural decay, insect infestation and woodpecker foraging patterns on white-fir and yellow pine following a prescribed burn in Lassen National Park, CA. Our objectives were to: 1) describe how pine and fir differ in their decay patterns and insect activity, and 2) determine how these differences reflect woodpecker foraging habitat quality. Preliminary results indicate that these two tree species differed in several aspects of structural decomposition, insect use and subsequent woodpecker foraging intensity. White fir tended to decay more quickly and was used more intensively by both wood-boring beetles and foraging woodpeckers during the first 1 to 2 yr following the fire. In contrast, Jeffrey pine was not initially used as intensively, but continued to provide foraging resources for both insects and woodpeckers throughout the entire study period (4 yr). These results suggest that prescribed burning may help to restore ecological interactions between insects, woodpeckers, and snag decomposition critical for snag-dependant wildlife species.

Introduction

Increasingly, forests are being managed using prescribed burning to reduce fuels and restore fire as an ecosystem process where it has been excluded for decades. Monitoring the short and long-term effects of prescribed burning on the biota is necessary to assess the biological outcomes and to refine prescriptions and management goals. Comprehensive monitoring programs are in place for fuels and forest structure and composition, for example, but specific information regarding the potential response of various wildlife species and specific habitat parameters is still limited.

The response of woodpeckers to prescribed burns is of particular interest because they excavate cavities in snags that ultimately serve as nesting habitat for a wide variety of other vertebrate species (Bull and others 1997). Woodpeckers are often the most conspicuous vertebrate responding to forest fires as they prey on the large influx of beetles whose larvae feed on, pupate in, and emerge from fire-damaged trees. Additionally, woodpeckers foraging on decaying snags may influence the capacity of those snags to be excavated in the future (Farris and others 2004). Understanding the nature of woodpecker response to prescribed burns is important to forest managers.

Little is known about how woodpeckers utilize different tree species after fire or how beetle infestation and woodpecker foraging interact to affect snag decay and

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woodpecker nesting habitat. In this paper we present preliminary results of a long-term study to investigate temporal dynamics of insect infestation, woodpecker foraging, and structural decomposition of Jeffrey pine and white fir. Our objectives are to describe how pine and fir differ in their decay patterns and associated insect activity and to determine how these differences affect woodpecker foraging patterns. A secondary objective is to gain a better understanding of these interactions following spring (growing season) prescribed fires.

Materials and Methods

This study was conducted in Roadside Prescribed Burn in Lassen Volcanic National Park (LAVO), which lies in the southern Cascade Range in northeastern California (lat 40°33' N, long 121°30' W). The 47 ha burn, implemented in June of 1999, ranged in elevation from 1,725 to 1,798 m (5,660 to 5,900 ft) and was one of the few spring (growing season) prescribed burns in the park. Tree species consisted primarily of Jeffrey pine (*Pinus jeffreyi*) and white fir (*Abies concolor*), with occasional incense cedar (*Calocedrus decurrens*) (Parker 1991). Resident woodpeckers of interest include the Black-backed (*Picoides arcticus*), Hairy *(P. villosus*), and White-headed (*P. albovartus*)

Immediately following the burn we established a sampling grid of 60 points across the entire area. At each grid point the nearest Jeffrey pine and white fir were selected for annual sampling, making a total of 120 sample trees. In order to be considered for our samples, all trees had to be at least 10 cm in diameter and had to exhibit bole char but did not have to be visibly dead immediately following the fire. To assess the structural and biological changes between tree species and years, we recorded the following variables at each of 120 sample trees once per year from 1999 until 2002: status (live, dead, broken, or fallen), diameter at breast height, bole char, evidence of bark and wood boring beetle activity, and woodpecker foraging sign.

To eliminate ambiguity in determining tree death, we classified a tree as dead when all the needles had died. Evidence of beetle activity was classified as belonging to either bark or wood boring beetles, based on the size and shape of the emergence holes left on the bole of the tree. Woodpecker foraging activity was classified into two categories: "scaling," which is a superficial flaking of successive bark layers in search of primary bark beetles; and "excavating," which creates distinct holes that typically penetrate the bark and outer sapwood as the birds search for wood boring beetles. Scaling was quantified by estimating the proportion of the bole in which bark was removed by woodpeckers. The amount of excavating was quantified using binoculars, scanning from the base of the tree to the tip and counting all visible foraging excavations on a randomly selected azimuth, which remained constant throughout the study period. The surface area surveyed was calculated and divided into the number of observed foraging "hits," resulting in a standardized index of foraging hits per square meter of tree surface. This index was used to compare woodpecker foraging activity between tree species and years. The index was calculated annually as the cumulative number of foraging excavations per m^2.

The relative amount of wood decay in each snag was quantified using an IML Resistograph® (Dunster 2000). The Resistograph® is designed to detect decay and defects in trees and wooden structures. The instrument works by inserting a fine drill (approximately 3 mm in diameter) into the wood at a constant rate and recording the amount of resistance imposed by the structural condition of cell walls. We recorded

Resistograph® measurements on each of the dead trees in 3 yr after the burn in 2002. Measurements were recorded at a constant height of 1.3 m and on three separate azimuths (120°, 240°, and 360 °). These three measures were averaged to obtain a single estimate of wood decay for each snag.

We calculated yearly fall rates following Landram and others (2002), where the number of snags falling within a year is divided by the total number standing at the start of the year. We used repeated measures ANOVA (Zar 1990) to evaluate differences in woodpecker scaling and foraging intensity between tree species and years. A nonparametric Mann Whitney U Test (Zar 1990) was used to assess differences in wood quality between Jeffrey pine and white fir. All statistical tests were conducted using SPSS Version 11.0.1 (SPSS 2001).

Results

Structural Changes

Size class distribution was similar between our sampled Jeffrey pine and white fir (*table 1*). Mean diameters of all trees did not significantly differ between species ($t=-0.609$; $p=0.544$). Both mortality patterns and fall rates varied between the two species during the first three years following the fire (*fig. 1*). Sixty-eight percent of the Jeffrey pine trees died within the first year and this number increased steadily to 78 percent of the original population by year three. In contrast, 63 percent of the white fir died within the first year, but no new snags were added to this group in subsequent years (*fig. 1a*). Surviving trees were significantly larger than those that died ($t=4.319$; $p=0.000$; and *table 2*).

Table 1—*Size class distributions of sample white fir and Jeffrey pine within the Roadside Prescribed Burn, Lassen Volcanic National Park, CA.*

Diameter class	*Abies concolor*	*Pinus jeffreyi*
10-15cm	4	6
16-28cm	15	24
29-60cm	34	21
>60cm	7	9

Table 2—*Mean diameters of white fir and Jeffrey pine by condition within the Roadside Prescribed Burn, Lassen Volcanic National Park, CA.*

Species	Condition	Mean	N	SD
Abies concolor	Dead	34.50	38	15.26
	Live	40.95	22	18.38
Pinus jeffreyi	Dead	28.60	48	12.93
	Live	83.00	12	34.22

Fall rates of snags also differed by species and year (*fig. 1b*). After the first year following the fire, fall rates for both species was zero. However, after 2 years, white fir fell at a rate of 5.3 percent per year, while the rate for Jeffrey pine remained the same. Following the third year fall rates for white fir climbed to 11.1 percent while Jeffrey pine increased to 8.3 percent (*fig. 1b*). Diameters of standing snags were similar to those that fell ($F=0.725$, $p=0.397$). Three year old Jeffrey pine snags had significantly greater wood densities than the same age white fir (Z=-2.046, p=0.041). As a reference point, wood densities for both live Jeffrey pine and white fir average approximately 24.0. In contrast, mean wood densities for fir snags averaged 10.3 (± 2.26 SE; n=32) while pine snags averaged 15.5 (± 1.70 SE; n=37).

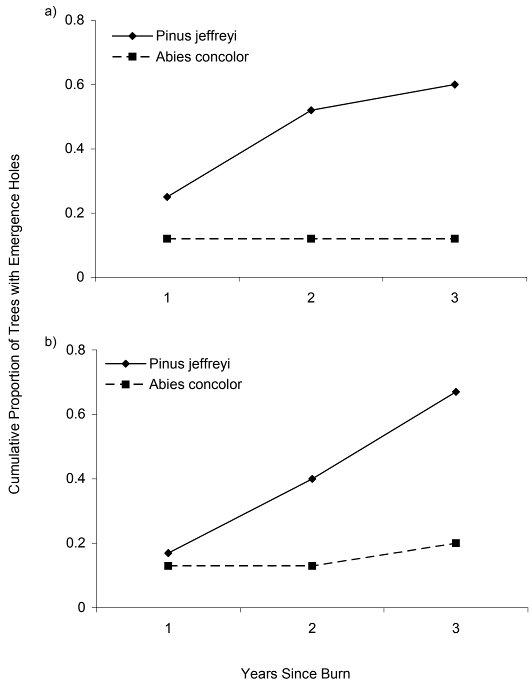

Figure 1—Recruitment (a) and fall (b) rates of Jeffrey pine and white fir following a spring prescribed burn in Lassen Volcanic National Park, CA.

Beetle and Woodpecker Use

Primary bark beetles from the family Scolytidae (insects which kill trees during the process of their reproduction) and secondary wood borers from the families Buprestidae and Cerambycidae (insects requiring dead trees to reproduce) were active in both tree species after the burn. However, the pattern of beetle activity differed between tree species. Sixty-eight percent of the pines were infested with bark beetles, but only 25 percent were infested with wood boring beetles (n=60). Conversely, only 32 percent of the fir contained evidence of bark beetle use, while 75 percent were used by wood boring beetles (n=60). Primary bark beetles emerged from the Jeffrey pine with greater cumulative frequencies each year. In contrast, cumulative emergence frequencies in fir remained the same throughout the study period. Secondary wood boring beetles showed a similar emergence patterns by increasing annually in pines but not in fir (*fig. 2*).

Woodpecker scaling activity did not vary between species or years (F=0.165; p=0.848). In contrast, woodpecker excavation activity differed appreciably between tree species and across sampling years (F=3.21; p<0.04). In general, white fir was utilized intensively by foraging woodpeckers during the first year after fire, but use declined dramatically thereafter. Mean cumulative foraging intensity on Jeffrey pine was relatively low during the first year but gradually increased over the study period until levels surpassed those initially seen in white fir (*fig. 3*).

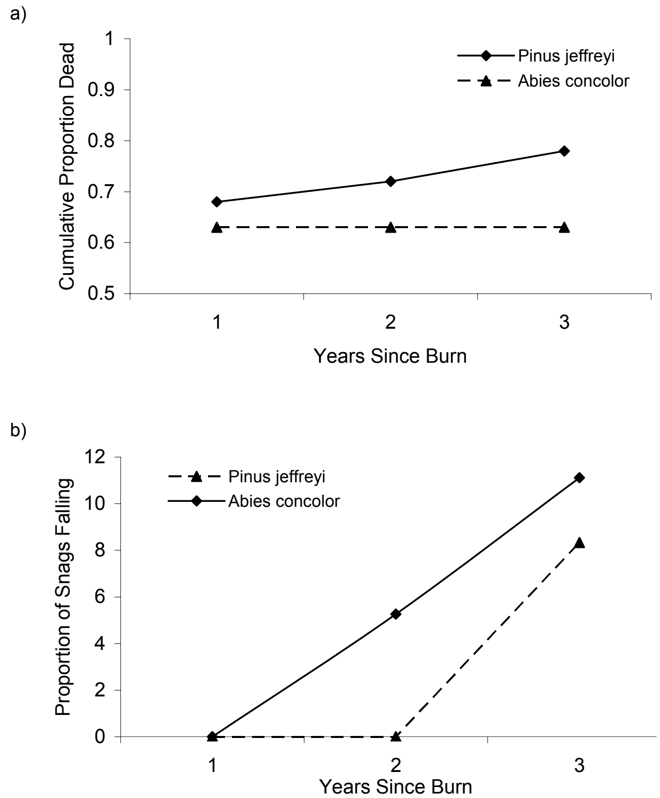

Figure 2—Emergence patterns of primary bark beetles (a) and secondary wood boring beetles (b) in Jeffrey pine and white fir following a spring prescribed fire in Lassen Volcanic National Park, CA.

Discussion

Our preliminary findings highlight potentially important differences in tree mortality, beetle colonization, woodpecker foraging, and snag decomposition between white fir and Jeffrey pine following early season fires in Lassen Volcanic National Park. All white fir mortality in our sample population occurred during the first year after the fire, with resultant snags being heavily infested by wood boring beetles. In contrast, Jeffrey pine mortality occurred throughout the study period as trees were attacked by bark beetles and subsequently colonized by wood boring beetles. Thus, white fir provided an immediate but short-lived post-burn foraging resource for woodpeckers, while Jeffrey pine provided a more prolonged foraging reserve as new pine snags were recruited into the population each year. Three years after fire, white fir snags were significantly more decayed and fell at faster rates than Jeffrey pine.

Differential morality and insect colonization of fir and pine provided different foraging opportunities for woodpeckers. In snags containing bark beetles, woodpeckers foraged by scaling away bark; in snags infested by wood boring beetles, woodpeckers foraged by excavating through bark and sapwood. Scaling activity was relatively low in both pine and fir during the first year and did not increase significantly in either species during subsequent years. Successful scaling is likely restricted to the first year of bark beetle infestation because beetles typically produce an adult brood within one year of colonization (Furniss and Carolyn 1977).

Excavation activity of wood boring beetles was common on white fir only during the first year, suggesting a complete exploitation of prey. In contrast, initial excavation activity was lower in Jeffrey pine but gradually increased each year as wood boring beetle activity increased.

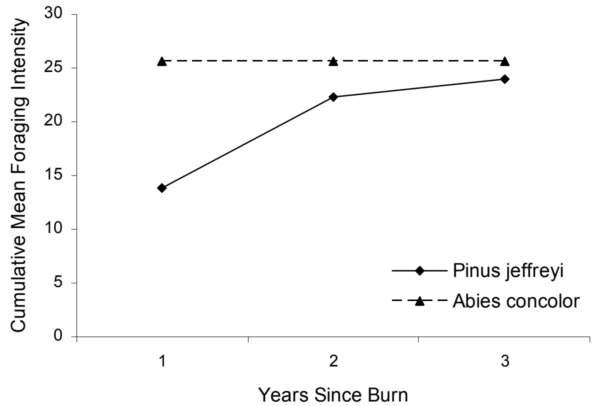

Figure 3—Mean cumulative woodpecker foraging intensities in Jeffrey pine and white fir in the first three years following a spring prescribed burn in Lassen Volcanic National Park, CA.

The observed patterns of tree mortality and insect colonization likely reflect the differential susceptibility of pine and fir to fire-caused damage. A positive correlation has been found between the amount of fire-cause tree damage, subsequent tree mortality, and beetle colonization in conifers (Agee 1993, Kelsey and Joseph 2003, Wallin and others 2003). In general, white fir is particularly susceptible to fire damage due to its relatively thin bark (Agee 1993, Laacke 1990). Trees that were weakened by fire but not immediately killed are typically attacked by phloem consuming bark beetles (McCullough and others 1998, Wallin and others 2003). Trees directly killed or severely damaged by fire are typically colonized by xylem consuming beetles (Furniss and Carolin 1977, Kelsey and Joseph 2003, McCullough and others 1998). In this study, white fir was more frequently colonized by wood boring beetles and woodpeckers excavated intensively in the snags outer sapwood.

Post-fire beetle infestation and ensuing woodpecker foraging patterns may have important long-term influences on subsequent decay in conifers and may help explain observed differences in decay patterns between Jeffrey pine and white fir in this study. Bark beetles and woodpeckers are both known carriers of fungi associated with wood decomposition (Farris and others 2004, Whitney and Cobb 1972, Paine and others 1997). Furthermore, the reproductive and foraging activity of beetles creates galleries and fragments the wood which can create microhabitats conducive to fungal invasion (Rayner and Boddy 1988). Foraging woodpeckers that respond to these beetle infestations can further modify the bark and underlying wood while they search for prey. Together, these processes may alter the local structure and microclimate of sapwood and lead to further fungal inoculation and subsequent decomposition (Rayner and Boddy 1988). Previous research has documented associations between foraging woodpeckers and greater wood decay in both hardwoods and conifers (Conner and others 1994, Farris and others 2004). In this study, a greater proportion of white fir snags were affected by both wood boring beetles and foraging woodpeckers during the first year following fire. Both high wood borer levels, followed by intense woodpecker foraging may have influenced the greater wood decomposition and subsequent attrition of this species.

Our sample population of white fir snags decayed more rapidly and fell at higher rates than the Jeffrey pine snags (*fig. 1b*). These results differ from snag attrition patterns reported elsewhere in the region, but may be difficult to compare. In both burned and unburned study areas, Jeffrey pine consistently fell at faster rates than white fir (Landram and others 2004, Morrison and Raphael 1993, Raphael and White 1984). However, the study by Raphael and White (1984) was conducted in a relatively older burn (7 to 11 yr), and none of the studies mentioned provide any information about the local bark and wood boring beetle activity, so comparisons are difficult. We suspect burn intensity and subsequent tree damage are the primary drivers of decay patterns observed in this study, but don't have adequate data at this time to evaluate these potential affects. Additionally, several studies have documented the influence of tree size on fall rates (Landram and Laudenslayer 2002, Raphael and White 1984, Morrison and Raphael 1993), with smaller trees having greater rates than their larger counterparts. We didn't detect a difference in diameters between trees that fell and those that remained standing, but small sample sizes could have precluded effective analysis.

In summary, our initial monitoring results suggest that differences in response of white fir and Jeffrey pine to an early season prescribed fire has important implications for post-fire woodpecker habitat. White fir provided a short pulse of high quality habitat for beetles and woodpeckers during the first year, while Jeffrey pine provided a more continuous supply of primary and secondary bark beetle prey for woodpeckers during the first 3 yr following the burn. However, more research in different burning and habitat conditions is needed to improve our understanding of post-fire habitat dynamics and validate the results of this case study. Our continued monitoring efforts over the next several years will help reveal how cavity generation patterns are related to species composition and early post-fire beetle and woodpecker utilization. We also plan to examine the influence of other variables such as fire severity, snag size and age on beetle infestation and subsequent woodpecker use and decay. These results contribute to our limited knowledge of wildlife habitat dynamics following spring prescribed burning in pine-fir forests of the southern Cascades. Prescribed burning may help to restore ecological interactions between insects, woodpeckers, and snag decomposition critical for snag dependant wildlife species.

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