

Fire Effects Monitoring at Devils Postpile National Monument: Post-fire Response Five Years Following the Rainbow Fire

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Introduction

Prior to the mid-1800's, fire ignited by lightning, Native Americans, and, in some regions, volcanic eruptions had an integral role in shaping the Sierra Nevada ecosystem. Fire return intervals and intensities significantly affected plant communities by selecting for fire adaptive traits, influencing plant dominance, diversity, and mosaic patterns (i.e. spotty fire spread leading to patchy plant distribution). Fire history varies in each vegetation community, and even from one drainage to the next.

In 1992, after six years of drought, tree mortality was high in the Mammoth Lakes and Devils Postpile National Monument (DEPO) area. Within days of an extreme fire warning issued by fire officials, lightning ignited the August 1992 Rainbow Fire just three miles south of Rainbow Falls (DEPO). High winds (60+mph) and years of drought aided the fire to spread 6,000 acres within a 24-hour period (Hofmann and Strumsky 1992). The Rainbow Fire presented the National Park Service with an opportunity to monitor the post-fire response of vegetation communities within Devils Postpile National Monument (DEPO).

Located geographically near the eastern escarpment of the Sierra Nevada, Devils Postpile National Monument (800 acres) is a microcosm mixing western and eastern Sierra vegetation characteristics. Most moisture from frontal storms is released on the west side as it is being lifted over the Sierra, creating a drier climate and lower plant diversity on the east side (Anderson 1994; Millar 1998). However, the low elevation of the escarpment in this area allows moisture to pass further east, resulting in a unique region of wetter weather and richer plant diversity.

Volcanic influence is strong within the DEPO/Mammoth Lakes region. The high concentrations of ash and tephra in the region's soil can be attributed to the active Inyo/Mono Craters and Long Valley Caldera complex. In addition, some stand replacement and unusual stand age and structure in the neighboring Glass Creek region are thought to be the result of a large eruption (Millar 1998).

Information about the plant and wildlife communities present in this area before fire exclusion is largely absent and little published information exists on east-side forest

ecosystems. DEPO is dominated by red fir (*Abies magnifica*) and lodgepole pine (*Pinus contorta*) forests with patches of Jeffrey pine (*Pinus jeffreyi*), white fir (*Abies concolor*), and even some mountain hemlock (*Pinus monticola*). Red fir forests on the east side rarely exist in pure stands (Chang 1996). According to the DEPO Natural Resources Management Plan (USDI 1982), wildland fires in the valley are rare but local fire history information is not currently available.

Methods

Data were collected in eight 20-by-50 meter (0.1 hectare) plots following protocol established in the National Park Service Fire Monitoring Handbook (USDI 2001) with modifications unique to Sequoia and Kings Canyon National Parks (SEKI) fire effects monitoring program. Elevations of the eight plots range from 7284 ft to 7888 ft. The plots were distributed according to a stratified, random method that placed two plots in a high fire intensity area, two in moderate, and two in low intensity areas (based on fire intensity maps created on the Rainbow Fire incident). In addition, two unburned plots are located between 7640 ft and 7961 ft with similar slopes and aspects. Slopes ranged from 0 to 32 degrees with varying aspects.

The data collected at each plot include:

- (1) fuel load estimation (Brown 1974),
- (2) a point-intercept method for recording understory herbaceous, shrub, and seedling cover and height,
- (3) sub-sampling to estimate seedlings per hectare by species and height class,
- (4) 1-by-50 meter belt transect sampled to estimate shrub densities, and
- (5) full plot measurements of tree densities and diameters at breast height (DBH), as well as tree damage.

The plots were installed and monitored immediately after the fire (1992), one-year (1993), two-years (1994), and five-years (1997) post-fire. Further monitoring will take place at ten-year post-fire intervals unless the area burns again. Since no pre-fire data was collected, the unburned plots were originally designed to attempt to represent the pre-fire conditions within this area but are not likely to be valid due to the difference in composition between the areas that burned and those that remained unburned.

Results and Discussion

All results presented apply only to the plot areas sampled and cannot be extrapolated to other areas of the monument due to the low number of plots.

Fuel load

Post-fire fuel accumulation was slow in burned plots with the mean total fuel load going from 2.39 kg/m² immediately post-burn to 3.73 kg/m² by five years post-burn (Figure 1). As expected fuel load is much higher in the unburned plots compared to the burned plots. Variation was high among burned plots with 80% confidence intervals for mean total fuel load overlapping for all time periods (Figure 1). Variation between the two unburned plots was so high that error bars could not be displayed on the graph. The decrease in fuel load 5-years post-burn in the unburned plots is likely due to sampling effects related to the small sample size of two plots.

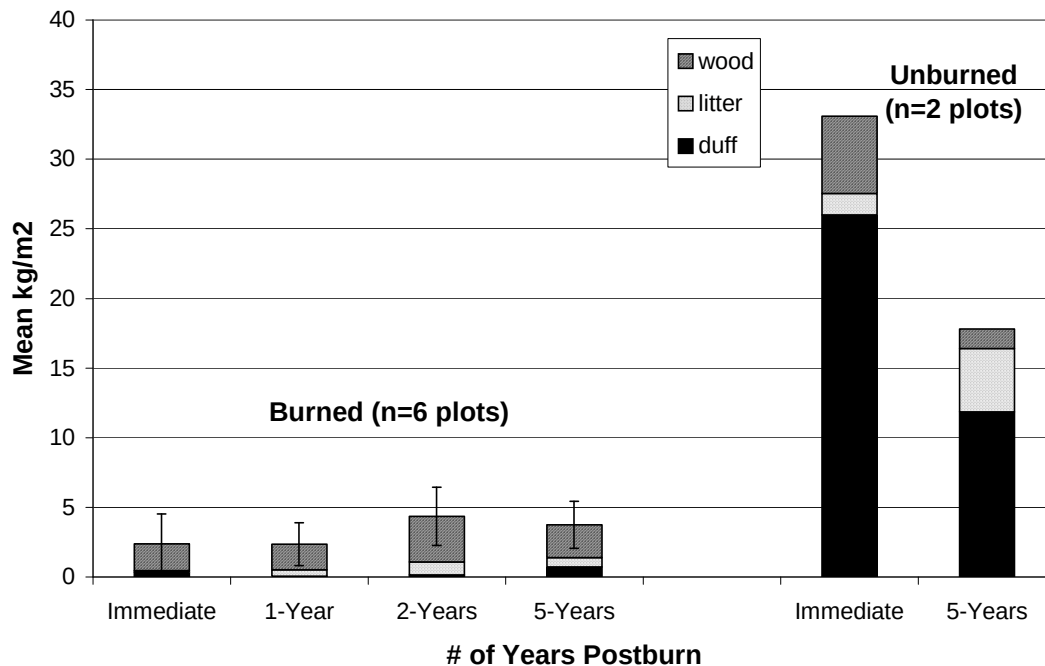


Figure 1. Fuel load in burned and unburned plots.

Although the results are inconclusive without pre-fire data, the data suggest the fire consumed much of the litter/duff but left some amount of woody material. Studies on west side red fir forests generally show large woody fuels carrying the fire and being consumed rather than the litter and duff (Skinner and Chang 1996).

Overstory Trees

Tree species composition varies between burned and unburned plots (Figure 2). The density of red fir to lodgepole (roughly 2 to 1) on unburned plots compared to burned plots (roughly 1 to 3) makes it even more difficult to compare between plot types (Figure 2). On burned plots, Jeffrey pine decreases from 5.1 to 3.4 trees per hectare, lodgepole pine decreases from 114.9 to 56.6 trees per hectare, red fir decreases from 35.2 to 18.4 trees per hectare, and white fir remains about the same. On unburned plots, species composition remains static except for a small decrease in lodgepole pine and small increase in red fir (Figure 2).

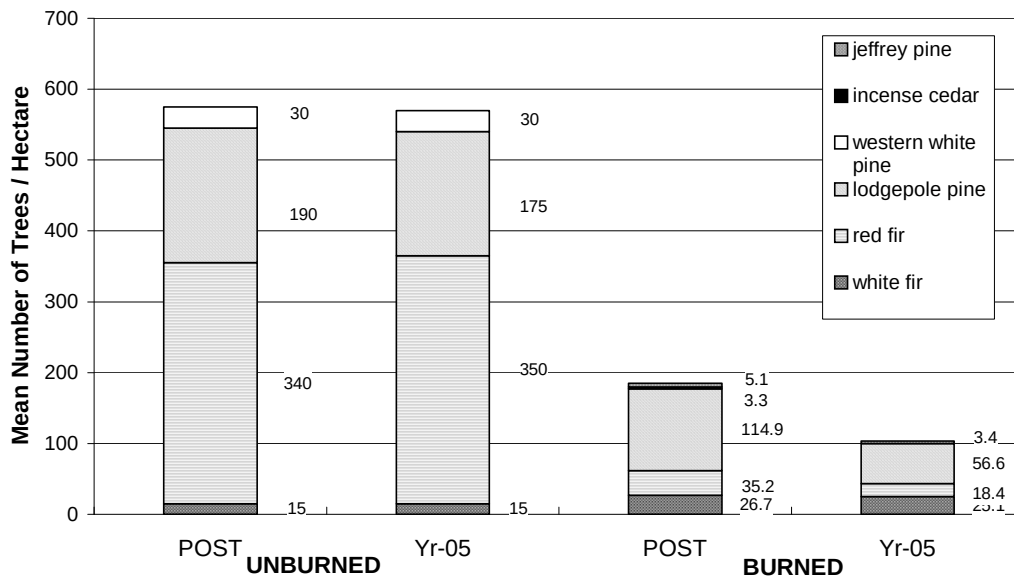


Figure 2. Overstory tree density by species for unburned (n=2) and burned (n=6) plots.

Within the burned plots, mortality is high in 0-30cm DBH classes in lodgepole pine between immediate post-burn and 5-year post-burn visits with the disappearance of all of incense cedar (*Calocedrus decurrens*, CADE). In addition, some larger tree mortality occurs by 5-years post-burn (Figure 3).

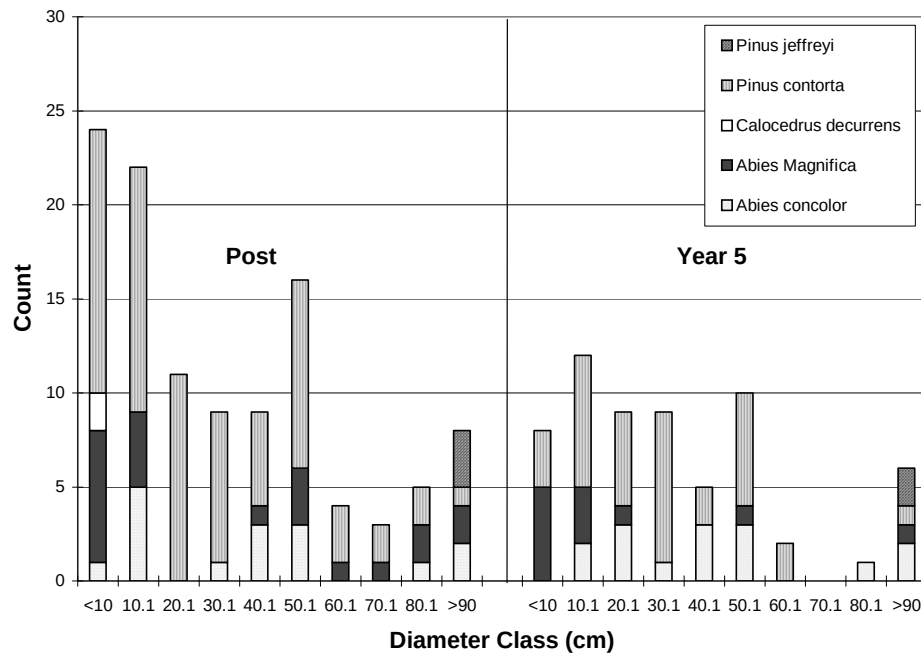


Figure 3. Overstory trees by species and diameter class in burned plots (n=6).

Seedlings

The success of tree regeneration can depend on overstory mortality (high fire intensity or severe drought eliminates the seed source) and density of the surrounding trees, as well as fire response of the species. Of the three tree species that are regenerating, fir has the highest success rate five years after fire. Red fir is doing well in unburned plots with over 5000 individuals decreasing to over 1000 seedlings five years later (Figure 4). Firs on burned plots are regenerating well with strong survival 5-years post-burn (over 360 are >60cm high) and young seedlings (< 0.15 cm in height) increasing dramatically by 5-years post-burn (Figure 5).

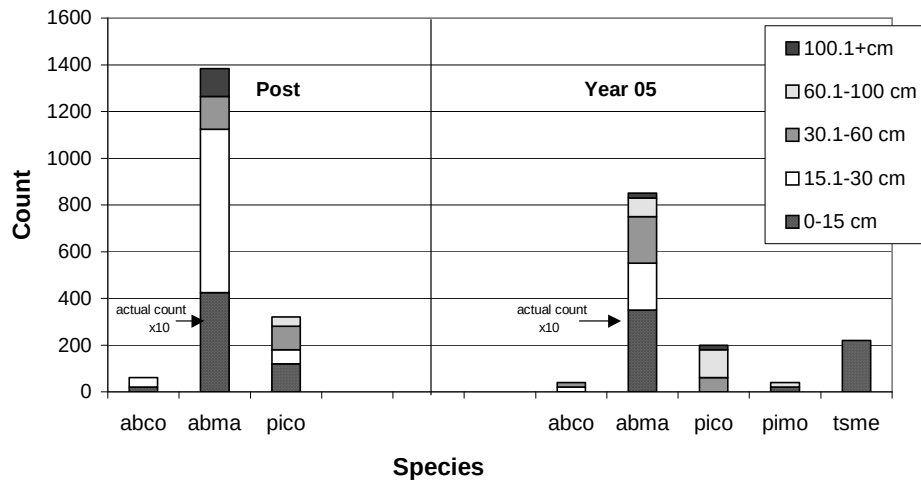


Figure 4. Seedlings by species and height class in unburned plots (n=2).

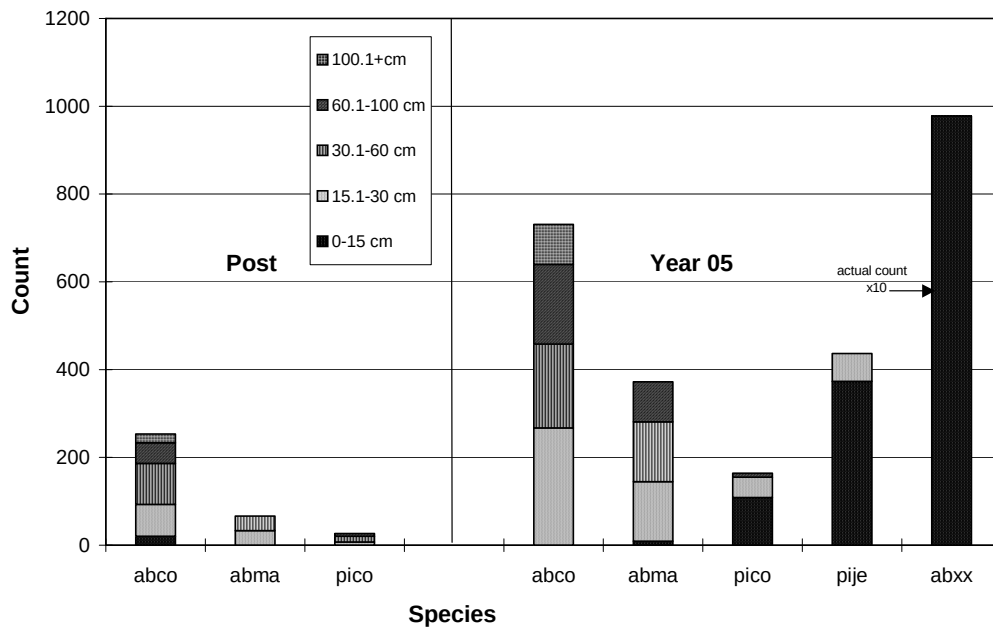


Figure 5. Seedlings by species and height class in burned plots (n=6).

Seedling regeneration is highest in low fire intensity plots immediately post-burn (Figure 6). Jeffrey pine is the only species doing well in high fire intensity plots five years following the Rainbow fire.

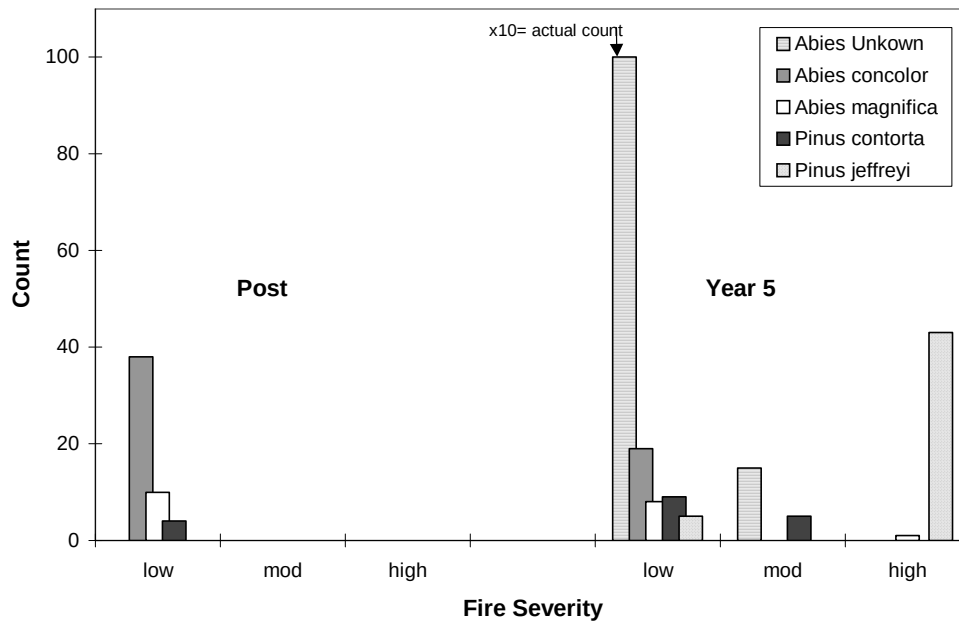


Figure 6. Number of seedlings by species and fire severity (n= 6 plots).

Unlike its Rocky Mountain counterpart, the opportunistic lodgepole pine has non-serotinous cones, and is therefore less dependent on fire for regeneration. Instead of establishing after large stand fires, Sierra lodgepole often establishes in openings from wind throw and small fires (Parker 1986). The lodgepole seedlings within the plots show a slow recovery compared to the fir but nearly reach 200 individuals by year five (Figure 5). The lodgepole seedlings only occur in low to moderate intensity fire plots which again demonstrates that they respond differently to fire than the Rocky Mountain lodgepole.

Understory Vegetation

The burned plots have a greater number of herbaceous and brush species than the unburned plots and plant cover has increased by five years following fire (Table 1). No brush was recorded in the unburned plots while four species were recorded in the burned plots. No strong conclusion can be drawn from this due to the small sample size but the data suggest fire disturbance increased diversity. By the point-intercept method, both burned and unburned plots showed a high frequency of litter with a jump from 18% to 64% in litter on burned plots between immediate post-burn and 1-year post-burn. Bare ground on unburned plots fluctuated between 5-10% while burned plots dropped from 78.9% immediate post-burn to <15% five years post-burn. Non-native species were not detected in any of the plots.

Table 1. Percent cover in burned and unburned plots.

<i>Percent Cover by Species on Unburned Plots (n=2)</i>				
Species		Post	Year 1	Year 5
Non-plant		98.49	100	96.39
Abies Magnifica		1.21		1.2
perennial (D)		0.15		
Unknown		0.15		
Eriogonum nudum				1.2
Pinus contorta				0.6
Gayophytum xx				0.3
Arabis xx				0.15
Hieracium horridum				0.15
Pedicularis semibarbata				0.15
Ribes viscosissimum				0.15
Ribes xx				0.15
<i>Percent Cover by Species on Burned Plots (n=6)</i>				
Species		Post	Year 1	Year 5
Non-plant		99.7	99.04	77.84
Arenaria congesta		0.15		0
Grass xx		0.1	0.86	1.16
Perennial(D)		0.05	0.05	0.1
unknown			0.05	0.7
Gayophytum racemosa				8.74
Gayophytum diffusum				2.51
Carex rossii				2.06
Eriogonum nudum				1.81
Acnatherum xx				1.21
Ceanothus cordulatus				0.45
Abies Magnifica				0.35
Chrysothamnus parryi				0.3
Phacelia mutabilis				0.3
Stephanomeris tenuifolia				0.3
Acnatherum occidentalis				0.25
Elymus elymoides				0.25
Linanthus montanus				0.25
Arabis platysperma				0.2
Chaenactis douglasii				0.15
Eriodictyon californicum				0.15
Hordeum xx				0.15
Abies concolor				0.1
Carex geeyeri				0.1
Antennaria corymbosa				0.05
Apocynum xx				0.05
Carex xx				0.05
Gayophytum eriospermum				0.05
Linanthus ciliatus				0.05
Lupinus fulcratus				0.05
Pinus jeffreyi				0.05
Streptanthus tortuosus				0.05

Summary

Crown fires or those that kill the overstory trees in red fir dominated forests are rare (Kilgore and Briggs 1972) except in high winds (a major component in the Rainbow Fire). The DEPO management plan states that the occurrence of fires in the valley are practically “nil”. One fire history study has been conducted in the Glass Creek area with cores samples, paleoclimatology, and paleobotany (Millar 1998) but local studies would be useful to determine past fire history of DEPO. The large clusters of lodgepole, wind patterns, and vertical build-up of fuels (brush and fir understory) within a forest community may increase the fire intensity and spread (Skinner and Chang 1996).

The results from these monitoring plots indicate that fuels are accumulating slowly, tree seedlings are establishing, and understory plant cover and diversity has increased five years following the Rainbow Fire. Unfortunately, the lack of pre-fire data makes it difficult to draw conclusions about changes from pre-fire to post-fire conditions and the small sample size does not allow for inference to areas larger than the plots sampled. It is likely that the vegetation in the burned plots was different from that in areas that remained unburned. The information collected displays trends within the plots and acts as a baseline for future fire effects monitoring. Data from the 10-year visit may help us to further understand vegetation regeneration patterns in the area.

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