LONG-TERM EFFECTS OF THE 1992 RAINBOW FIRE, DEVILS POSTPILE NATIONAL MONUMENT, CALIFORNIA

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INTRODUCTION

In August 1992 the Rainbow Fire burned much of Devils Postpile National Monument (DEPO). Following many decades of fire exclusion the burn resulted in large high severity patches with complete tree mortality hundreds of hectares in size. Management questions, such as whether the effects of the fire were within the natural range of variability and whether or how fire should be reintroduced, have been raised. However, little or no information exists for the area on pre-EuroAmerican settlement fire regimes or on postfire vegetation responses to such severe burns. Using fire effects plots established postfire and tree regeneration plots, we examined fuel and forest conditions and regeneration patterns at sites burned with varying severity. Additionally, fire history sampling provided information on past fire return intervals and insights on past fire severity.

The monument (322 ha/796 ac) sits astride the upper portion of the San Joaquin River. Although geographically located on the west slope of the Sierra Nevada it is situated near the eastern escarpment where the San Joaquin nearly bisects the Sierra crest creating a low spot in the range. Elevations range from about 2182 to 2485 m (7,200 to 8,200 ft). Climate is predominately Mediterranean with wet-cool winters (most moisture falls as snow) and dry-warm summers although occasional summer thunderstorms occur.

Vegetation is described in detail by Arnett and Haultain (2004). Flora is relatively rich (~360 taxa) and plant communities have affinities that mix characteristics from both the wetter western and drier eastern slopes of the Sierra Nevada. The area is dominated by mixed-conifer forests of red fir (*Abies magnifica* var. *magnifica*, ABMA), white fir (*A. concolor,* ABCO) and lodgepole pine (*Pinus contorta* ssp. *murrayana*, PICO). Jeffrey pine (*P. jeffreyi*, PIJE) is moderately widespread in patches at lower elevations and as scattered individuals elsewhere..

On August 20, 1992, after six years of drought, lightning ignited the Rainbow Fire in the Inyo National Forest. High winds (60+mph) combined with heavy fuel loads, dense conifer stands, and years of drought resulted in the fire's spreading to 2,430 ha (6,000 ac) within 24 hours (Hofmann and Strumsky 1992). By September 8, 1992 3,378 ha had burned with large areas of complete overstory mortality (**Fig. 1**). Approximately 265 ha (82%) of the monument's 322 ha were burned with varying degrees of severity (**Fig. 2**).

METHODS

<u>Fire Effects Plots</u> - Fire effects data were collected in six 20-by-50 meter (0.1 hectare) plots (**Fig. 2**) following protocols specified in the NPS Fire Monitoring Handbook (USDI 2001). The plots

Figure 1. Shrub and herbaceous species dominating areas of severe overstory mortality. Common shrub species include whitethorn, manzanita, and wild current.

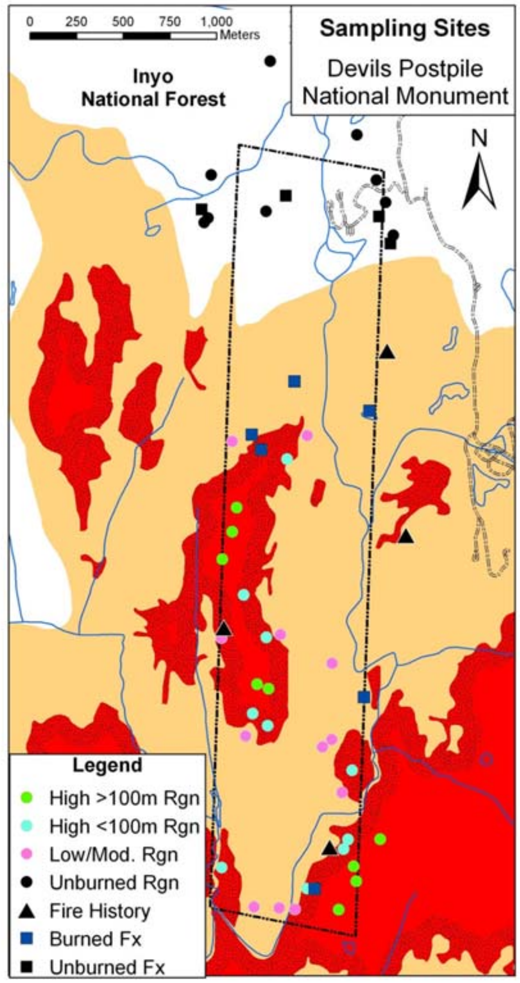

Figure 2. Sampling site locations (fire effects, fire history, regeneration) at Devils Postpile National Monument (trapezoidal boundary). The 1992 Rainbow Burn is shown as the colored area on the map, dark red for severe burn and light orange for low or moderate severity burn. The shaded area on the inside border of high severity patches show areas less than 100 m from a high severity patch edge.

were distributed according to a stratified, random sample that placed two plots each in high, moderate, and low severity areas. Four unburned comparison plots were located at sites with similar slope and aspect to the burned plots, although somewhat higher in the drainage.

Data collected at each plot included: 1) fuel load measurements, 2) understory herbaceous, shrub, and seedling cover and height, 3) seedlings densities by species and height class, 4) shrub densities, 5) tree densities (live and dead), diameters at DBH, and tree damage, and 6) repeat photo points. Burned plots have been sampled five times since the Rainbow Fire; immediately postfire (YR00 - 1992), one-year (YR01 - 1993), two-years (YR02 - 1994), five-years (YR05 - 1997), and at 10-years (YR10 - 2002) postfire.

Regeneration Plots - Tree regeneration plots sampled in 2004 captured current and preburn overstory forest composition and current tree regeneration patterns from circular 0.1 ha plots in contrasting high versus low/moderate severity areas. In burned areas 31 stratified random plots were sampled (12 low/moderate and 19 in high severity with 100% overstory mortality) plus nine plots at unburned sites (**Fig. 2**). High severity areas were further separated into areas near a seed source (<100m, 10 plots) and distant from seed source (>100m, 9 plots). Fire severity maps were based on Yosemite vegetation mapping (YOSE 2003 unpublished data): **high severity** – 0 to 10% of the original vegetation remains, **moderate severity** – 10 to 50% of the original vegetation, **low severity** – 50 to 90% of the original vegetation, **no modifier** – 90 to 100% of the

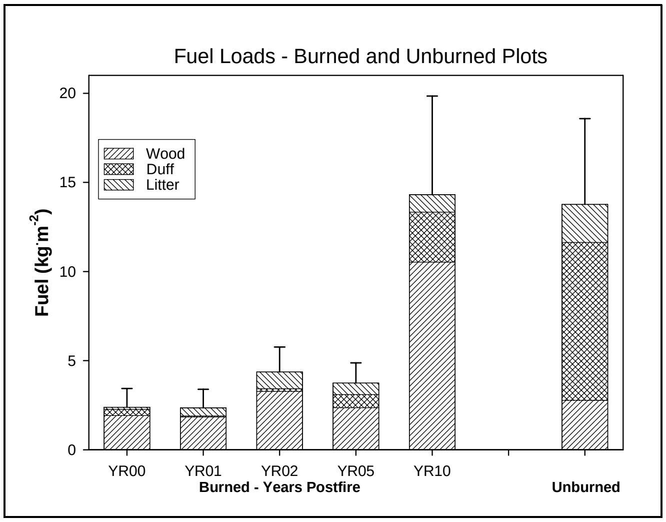

Figure 3. Change in postfire fuel load in comparison to fuel in unburned plots (error bars are ±1SE for totals).

original vegetation. Preburn overstory stand structure and composition were reconstructed from remnant dead or living trees/snags/logs greater than sapling sized. A small sample of saplings was collected to determine establishment dates.

Fire History - Fire history samples (partial cross-sections from trees, snags or logs) were collected at 10 sites in or adjacent to the monument. Sites consisted of a cluster of samples from a small area (~1 ha or less) without barriers to fire spread. Results from four sites have currently been analyzed and are reported here (**Fig. 2**). All samples were crossdated and fire event dates and season of fire events determined using standard dendrochronological methods (Stokes and Smiley 1968; Caprio and Swetnam 1995).

RESULTS AND DISCUSSION

Postfire fuel accumulation rates were low in burned plots during the first five years postfire (**Fig. 3)**. However, from five-years to ten-years postburn substantial increases in fuels occurred. The four-fold increase was primarily in woody debris and duff categories. This appears to be the result of dead standing trees falling and becoming surface fuel. Bare ground decreased rapidly postfire (by YR02) as cover of litter, woody fuels, and understory species increased (**Table 1**). Understory species cover and number increased with postfire cover exceeding unburned plots by YR02. Forbs showed the most rapid response, by YR02, with a decline by YR10. Graminoids response was more delayed but cover continued to increase through YR10.

Table 1. Percent cover and species count summaries (shaded) by life form for understory vegetation in burned and unburned plots (n=6 and n=4 respectively).

	Burned					Unburned
Category/Lifeform	YR00	YR01	YR02	YR05	YR10	
Litter + Bare Grnd. + Woody	99.7	98.9	78.5	77.6	73.3	94.5
Litter	17.6	64.3	57.9	60.6	48.1	88.5
Bare Ground	78.1	31.9	17.5	14.4	15.7	0.8
Woody Fuel	2.7	1.7	1.4	1.4	8.4	5.3
Understory Vegetation	0.3	0.9	20.8	21.4	28.2	3.6
# Understory Species	2.0	1.0	21.0	29.0	36.0	7.0
Woody Vegetation	0.0	0.0	0.3	1.3	6.7	1.8
# Woody Species	0.0	0.0	4.0	5.0	9.0	3.3
Forb	0.2	0.0	18.7	14.8	11.1	0.7
# Forb Species	1.0	0.0	12.0	16.0	21.0	4.0
Graminoid	0.1	0.9	1.8	5.4	10.4	0.6
# Graminoid Species	1.0	1.0	5.0	8.0	6.0	1.0
Exotics	0.1	0.1	0.4	0.8	1.1	0.0

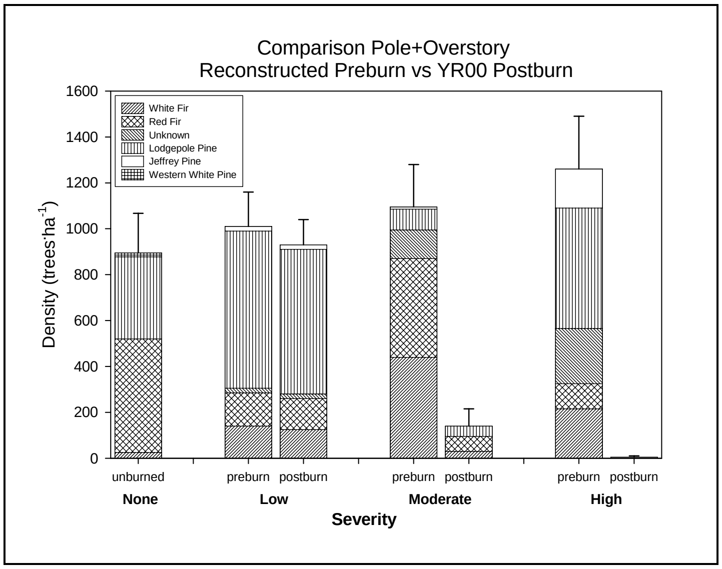

Figure 4. Comparison of reconstructed prefire overstory composition to immediate postfire composition in fire effects plots (error bars are ±1SE for totals).

Postfire decreases in density and changes in tree species composition in fire effects plots were directly related to fire severity relative to reconstructed prefire values (**Fig. 4)**. Little change occurred in areas experiencing low severity effects, either in overall density or species composition. Areas burned with moderate severity underwent declines in density and changes in species composition with most firs, particularly *A. concolor*, being killed. Even more striking were the changes observed at high severity sites where density declined from 1260 trees·ha^{-1} to five trees·ha^{-1} and only a few *P. jeffreyi* survived the fire. Changes in basal area largely mirrored changes in density of pole and overstory trees.

The larger sample size of regeneration plots provided a more detailed picture of postfire tree regeneration. Reconstructed density of preburn canopy and subcanopy trees in regeneration plots was similar among the burn categories, although greater in unburned. In contrast, postfire seedling and sapling densities differed greatly among all categories (**Fig. 5**). Regeneration was greatest in areas burned with low or moderate severity where some canopy trees survived. Lowest densities were found in high severity areas located more than 100 m from surviving trees. Number of regenerating trees was somewhat greater in high severity areas located adjacent to areas of surviving trees although overall regeneration densities were far lower than in areas burned by low or moderate severity. Average shrub cover in high severity plots was 33.3% (range 3-90%).

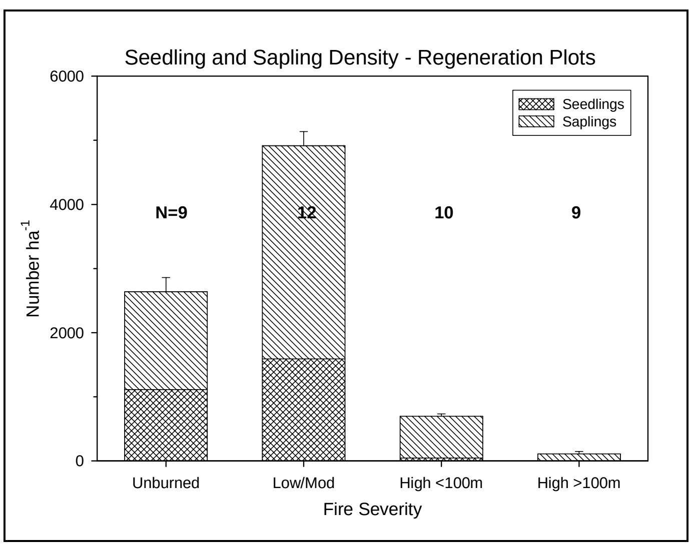

Figure 5. Number of seedlings and sapling in regeneration plots 12 years postfire (error bars are ±1SE for totals).

Nearly all regeneration in the high severity areas was *P. jeffreyi*. This regeneration frequently occurred as small clusters that appeared to have originated from buried seed caches. It is unknown whether these were caches that survived the fire or were cached afterward, although the former seems most likely. Little subsequent regeneration appears to be occurring (seedling densities were only 6.7 ·ha^{-1}). Loss of this pine regeneration in a subsequent fire would probably result in long-term shrub domination. Sparse or no establishment of *P. contorta* in moderate and high severity plots indicates the seed

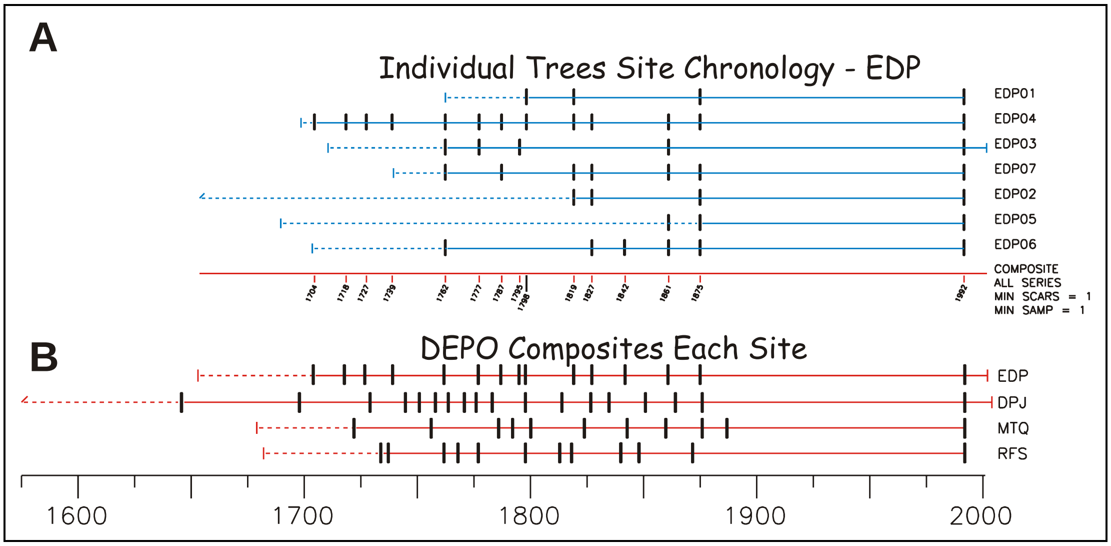

Figure 6. Example of an individual site chronology (*Plot A top*) shows reconstructed fire event occurrence from site EDP. Each horizontal line (blue) represents the period of record from a single sampled tree with vertical ticks indicating fire event dates. A composite of all fire events for the seven trees is shown at bottom (red) with fire dates. Composites (red) for all sites (*Plot B bottom*) shows fire event chronologies from all four crossdated sites.

source for PICO may have been eliminated and that there is little cone serotiny in this population.

Fire history chronologies from the four sites show repeated fire events at each site (**Fig. 6**). Average site return intervals (MFI) ranged from 14.2 to 18.3 years. Single intervals ranged from three to thirty years. The overall frequency of past fires suggests they were predominantly surface fires. MFIs were slightly longer than those found at a PIJE fire history site (9.0 years) on the east slope of the Sierra northeast of DEPO (Stephens 2001). One obstacle to obtaining high quality samples at some sites was the severity of the 1992 Rainbow Fire which burned out most fire-scar catfaces destroying the lesions containing the fire record. Results indicate fire was not an unusual event in most of DEPO’s forest communities while the absence of fire for 105 to 120 years before 1992 was unprecedented and probably contributed significantly to the severity of the Rainbow Fire.

SUMMARY AND CONCLUSIONS

Results indicated fuels (duff and dead and down woody debris) increased substantially between 5-to-10 years postfire and were approaching prefire levels at some sites. Vegetation data indicate responses or regeneration among different burn severities can be quite varied. Understory plant cover and diversity continued to increase 10 years postburn, especially the cover of grass and shrub species (high severity sites are becoming shrub dominated). Trees were regenerating, particularly at low-to-moderate severity sites with white fir the most prevalent. Lower densities of Jeffrey pine establishment was occurring in areas where high severity fire had occurred. Regeneration was lowest in areas >100 m from surviving prefire trees where a seed source seems limited.

Fire history reconstructions showed that fire frequencies were moderate (8 to 33 years between fires) prior to EuroAmerican settlement which indicates a surface fire regime predominated during the period of record. The plot data and fire history results suggest the extent of severe overstory mortality from the Rainbow Fire was unprecedented.

Results suggest application of fire to areas of low-to-moderate severity may be beneficial for restoring more natural conditions but in the large high-severity patches, it might lead to long-term persistence of shrubs where limited tree regeneration is susceptible to fire caused mortality. Fire management concerns related to the postfire recovery of the Rainbow Burn include the lack of a local seed source in areas burned by moderate and high severity fire in 1992. Of particular concern are areas where large unnatural patches of overstory were killed. In these areas another fire would kill most regenerating trees and severely limit future tree establishment because no local seed source would be present. However, areas where low severity fire occurred in 1992, or that have some seed source remaining, might benefit from a second introduction of fire. A “second entry” management fire would help maintain fuel and forest density at a pre-EuroAmerican settlement level.

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