4.16) Red fir forest dynamics: The interaction of fine-scale disturbances and prescribed fire

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INTRODUCTION

Fire plays a major role in the dynamics of conifer forests of the Sierra Nevada. However just as the frequency and severity of fire vary with elevation, its function varies from forest to forest. In the high elevation stands dominated by red fir (*Abies magnifica*), the fire regime has been characterized as one where low-severity fires predominate (Kilgore 1973, Pitcher 1987). Fires capable of killing canopy trees are rare. According to Taylor (1993), the important ecological effects of fire in the red fir forest are the consumption of surface fuels, the exposure of mineral soil, and the thinning of understory trees. Presumably some understory trees must escape the periodic fires. These "escapees" represent the next generation of canopy trees.

Pitcher (1987) reported that red fir trees had a negative exponential age distribution, a result that suggests juvenile trees of various ages are equally susceptible to fire. However this result does not preclude the existence of spatial differences in an understory tree's susceptibility to being killed by fire. Based on our preliminary results, the density of small trees in the red fir forest is patchy with dense groups of young trees interspersed in a matrix of a relatively open understory. These patches of regeneration coincide with past canopy openings, openings that range in size from 25 m^2 to as large as 1,875 m^2. Fine fuel loads in the regeneration patches are half that of random plots in the red fir forest (**Table 4.16-1**). Thus canopy gaps may represent locations in the forest with more opportunities for establishment and less risk of mortality from fire.

Our fundamental contention is that successful recruitment to the canopy in the red fir forest depends on other disturbance agents in addition to fire, in particular agents capable of creating gaps in the canopy. According to Gordon (1973), wind, insects, and disease can all kill isolated adult trees (smaller gaps) and well as groups of trees (larger gaps) in the fir forest. Community dynamics in the red fir forest seem to be driven by two distinct disturbance and recovery processes: fire and canopy gaps. This research addresses the nature of the relationship between these two crucial processes.

PROJECT OBJECTIVES

The primary objective of this research was to answer to a single specific question – Do juvenile trees established in canopy gaps experience lower mortality during a prescribed fire than juvenile trees located in the understory matrix. Formally stated, the null hypothesis was: Prescribed fire in the red fir forest kills juvenile trees with equal probability regardless of neighborhood density.

SUMMARY OF METHODS

***Study site*.** The study area is in Mineral King Valley, Sequoia and Kings Canyon National Parks. The five plots were located near the Tar Gap Trail in red fir forest. The plots are within 2 km of each other and in the vicinity of "Pitcher Plots" 1&2 (Pitcher 1987).

Procedures. Five 1 ha plots were located in an area of the red fir forest that was designated for prescribed burning. In each plot, all patches of red fir regeneration were identified and gridded into 5x5 m quadrats. Regeneration patches were defined as areas with 1) no live canopy-sized trees; and 2) an average density of more than 2000 understory trees/ha (5 per quadrat). Trees $\leq$20 cm in diameter at

breast height (dbh: breast height = 1.37m) were considered understory trees. All live trees in the regeneration patches were measured to the nearest cm in dbh. The exterior corners of the patches were marked with stainless steel rods. In addition, we censussed all live understory trees outside of the regeneration patches. We refer to this area as the forest "matrix." Fuel loads in the regeneration patches and random locations in the forest matrix were assessed along transects with a go-no-go gauge. Measurements were completed in August 1998.Fuel loads were significantly greater in the forest matrix (ANOVA, $F = 12.23$, $p < 0.001$, **Table 4.16-1**). In the fall of 1998, a prescribed fire burned in all five plots.

Table 4.16-1. Differences in 0" to 3" fuels in the red fir forest near the Tar Gap Trail before prescribed fire. Means are reported with standard deviations in parentheses.

Fuel size	Regeneration patches (tons ha^{-1})	Forest matrix (tons ha^{-1})
0 - 0.24"	0.27 (0.11)	0.60 (0.11)
0.25 - 0.99"	0.79 (0.28)	1.9 (0.60)
1-3"	0.84 (0.44)	1.9 (0.93)
> 3" sound	120 (130)	190 (52)
> 3" rotten	48 (85)	50 (58)

WORK ACCOMPLISHED IN 2000

Last summer we returned to the site to complete the post-fire measurements. We remeasured understory trees in the regeneration patches and the matrix. We assessed fire severity by char height and percent of forest floor burned. With these data we can test for any non-random patterns in juvenile mortality. We removed all the metal stakes with the exception of the four short metal stakes to mark the plot corners.

PRELIMINARY FINDINGS AND PERTINENT DISCUSSION

(Except for those just initializing field work)

Based on our preliminary analysis, we rejected our null hypothesis. Understory trees in regeneration patches experienced a significantly higher survival rate than similar sized trees in the forest matrix (**Table** 4.16-2, ANOVA, $F = 4.16$, $p = 0.048$). The response was particularly strong for the trees

Table 4.16-2. Comparison of survival for understory red fir trees following a prescribed fire in red fir forest near the Tar Gap Trail. Means are reported with standard deviations in parentheses.

Size class	Regeneration patches (% survival)	Forest matrix (% survival)
seedlings	40 (23)	43 (20)
0 - 5 cm	35 (21)	31 (22)
5 -10 cm	41 (23)	22 (23)
10 - 15 cm	58 (35)	33 (18)
15 - 20 cm	80 (40)	47 (35)
Total	**51 (32)**	**35 (24)**

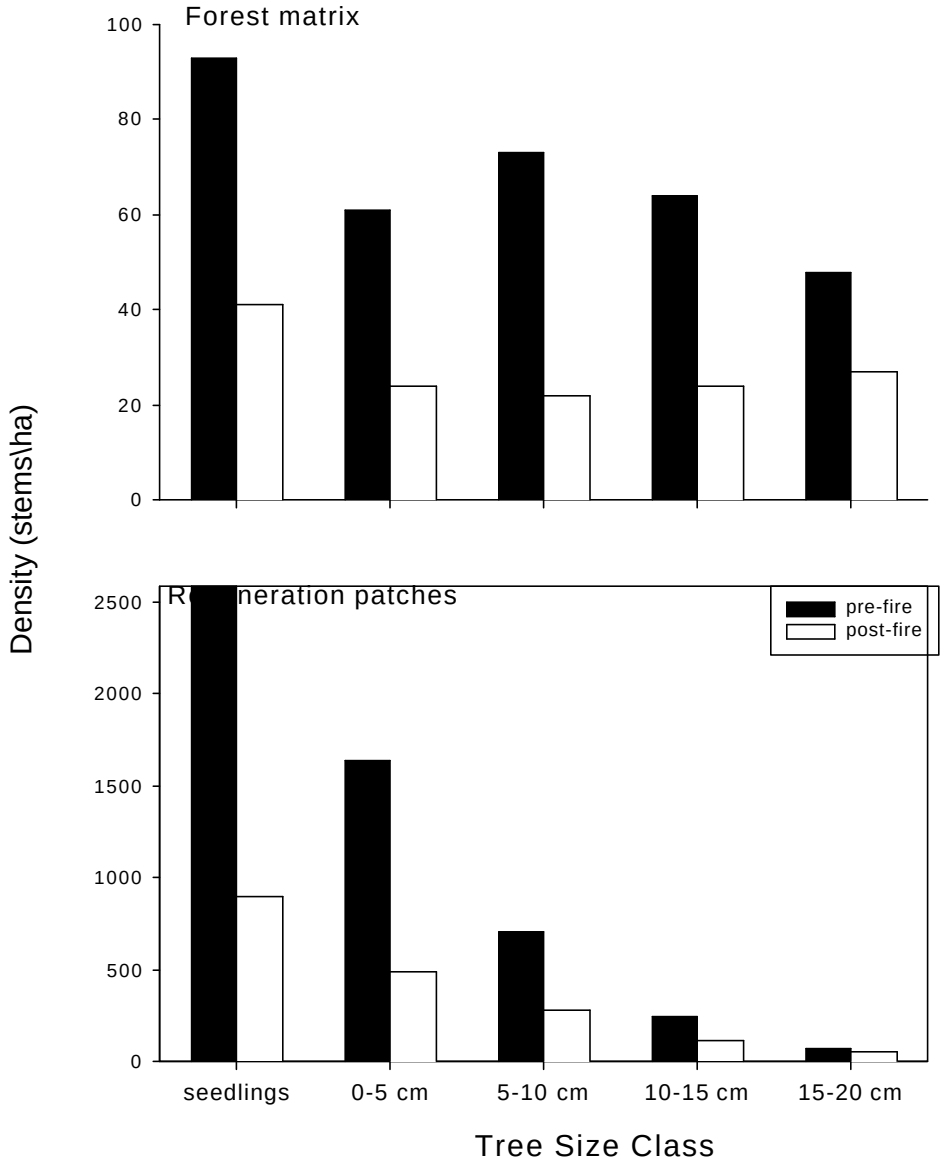

Figure 4.16-1. Comparison of red fir density before and after a prescribed fire in the red fir forests near the Tar Gap Trail.

in the larger size classes - red fir trees greater than 5 cm in dbh had a much better chance of surviving the fire if they were in regeneration patches. Thus Pitcher's (1987) prediction regarding the risk of fire mortality and size only holds for understory trees in the matrix, but not for trees in the regeneration patches.

This pattern of survival suggests that red fir establishment and recruitment are largely independent of the prescribed fire. The regeneration patches predated the fire and formed in locations where one or more canopy trees had died. These patches remain largely intact following the fire and represent the vast majority of potential canopy recruits (**Figure 4.16-1**).

PROBLEMS ENCOUNTERED

No problems encountered.

PLANS FOR THE COMING YEAR

We have completed the field work related to this research. We will complete our analyses and include estimates of plot-specific fire severity. Our plan is to incorporated the results into a peer-reviewed ecological publication on the dynamics of true fir forests in the Sierra Nevada.. All of the data and accompanying metadata will be archived as links to the project -- Landscape Analysis of Structure, Pattern and Fire Effects in the Mixed Conifer Forest of Mineral King (Menning et al.). A complete copy of this archive will be deposited at the Sequoia National Park Research Station at Three Rivers.

REFERENCES

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