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FIRE SEVERITY IN MECHANICALLY THINNED VERSUS UNTHINNED FORESTS OF THE SIERRA NEVADA, CALIFORNIA

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INTRODUCTION

Much debate has centered around the effectiveness of thinning as a tool to reduce fire severity. However, thinning prescriptions vary substantially and in practice on public lands often involve relatively intensive mechanical thinning. For example, this is currently the standard prescription on national forests of the Sierra Nevada. Recent research has indicated that low thinning, in which small trees less than 20-25 cm in diameter at breast height (dbh) are cut, can reduce fire severity (Omi and Martinson 2002, Perry et al. 2004). Conversely, evidence from the Biscuit Fire in Oregon indicates that more intensive mechanical thinning, which involves removing many young and mature trees, can increase fire severity (Raymond and Peterson 2005). Potential causes of increased severity include fine-fuel loading from slash debris, faster wind speeds due to a reduction in the buffering effect of mature trees, accelerated brush growth from increased sun exposure, and desiccation and heating of surface fuels due to insolation (Raymond and Peterson 2005, Rothermel 1991).

Other authors have reported reductions in fire severity following mechanical thinning in modeled simulations of wildland fire, and in a circumstance in which a wildland fire burned through plots of a silvicultural study on the Blacks Mountain Experimental Forest in the northern Sierra Nevada (Skinner et al. 2005, unpublished data). However, localized experimental conditions may not reflect actual or feasible management practices on federal lands, and the effects of wildland fires may differ from modeling assumptions, especially after several years of post-thinning brush growth. The hypothesis of this study was that mechanically thinned areas on national forests would not differ in mortality from unthinned areas.

METHODS

All areas known to have been mechanically thinned, and then burned in wildland fire from 2000 to 2005 within national forests of the Sierra Nevada outside of designated experimental forests, were included in the study. A total of seven sites (experimental units) within four different fire areas were located. All were in mixed conifer forest. These fire areas included the Power Fire of 2004 on the Eldorado National Forest, the McNally Fire of 2002 on the Sequoia National Forest, the Gap Fire of 2001 on the Tahoe National Forest, and the Storrie Fire of 2000 on the Plumas National Forest. To control for spatial autocorrelation, areas thinned to the same prescription within 2000 m of each other in a given fire were treated as subsamples, rather than independent data points. Spatial autocorrelation in fire behavior was found at distances less than 2000 m in a recent study in northern California forests (Odion et al. 2004).

Mechanically thinned areas were compared to adjacent unthinned areas in terms of fire-induced mortality and combined thinning/fire mortality (trees removed by thinning plus trees killed by fire), where mortality was measured as a function of basal area. This was done via transects 50 m on either side of the boundary of thinned units, beginning at the nearest access point. Along the transects, .01 ha square subplots, with corners facing E-W and N-S, were established at 100 m intervals, estimated by pacing. A total of 10 such subplots were established in each experimental unit, except in the case of both experimental units in the Storrie Fire area where smaller boundaries necessitated a commensurately smaller number of subplots (eight and five, respectively). In the other experimental units, this approach led to the sampling of three-quarters or more of the available boundary length. Portions of the boundaries were excluded from sampling wherein one side of the boundary was on a ridge or in a riparian area, and the other was not; or when one side was on flat ground when the other was on a slope. Boundary sections were also excluded when the two sides of the boundary were on different slope aspects. This was done in order to prevent such landscape features from influencing any observed differences in severity. We tested our hypothesis using a paired, two-sided t-test. Trees thinned prior to the fires were distinguished from trees killed by the fire, and then salvage logged, by the presence or absence of charring on top of stumps.

RESULTS AND DISCUSSION

Contrary to our hypothesis, the mechanically thinned areas had significantly higher fire-induced mortality ($p = .016$, $df = 6$) and combined mortality ($p = .008$, $df = 6$) than the adjacent unthinned areas. Thinned areas predominantly burned at high severity, while unthinned areas burned predominantly at low and moderate severity (Table 1). Basal area removed during mechanical thinning ranged from 28% to 48% (Table 1), and trees removed ranged from less than 20 cm in diameter up to 80-85 cm in diameter measured at stump height. In both experimental units in the Power Fire area, maximum stump diameter of thinned trees was 65-70 cm.

Table 1. Fire-induced and combined basal area (BA) mortality of mechanically thinned versus unthinned sites in mixed conifer forests of the Sierra Nevada.

Site	BA Removed	Fire-induced Mortality		Combined Mortality	
		Thinned	Unthinned	Thinned	Unthinned
Gap1	36%	100%	100%	100%	100%
Gap2	32%	86%	60%	91%	60%
McNally	36%	100%	51%	100%	51%
Power1	28%	40%	43%	57%	43%
Power2	34%	50%	14%	67%	14%
Storrie1	48%	74%	8%	86%	8%
Storrie2	37%	81%	40%	88%	40%

Possible explanations for the increased severity in thinned areas include persistence of activity fuels, enhanced growth of combustible brush post-logging, desiccation and heating of surface fuels from increased insolation, and increased mid-flame windspeeds. Given that sampling transects in thinned versus unthinned areas were only 100 m apart in each experimental unit, fire weather should have been the same for the thinned and unthinned areas sampled in each site. Thus, mechanical thinning on these sites appears to have effectively lowered the fire weather threshold necessary for high severity fire occurrence.

In all seven sites, combined mortality was higher in thinned than in unthinned units. In six of seven sites, fire-induced mortality was higher in thinned than in unthinned units. The one exception to this was the Power1 site, which had slightly higher fire-induced mortality in the unthinned area. This site was unique in that fuels had been masticated in the thinned unit just months prior to the occurrence of the Power fire (mechanical thinning occurred 4-5 years prior to the fire). It also had the least intensive removal of basal area among the study sites. However, the combined thinning/fire mortality in the Power1 site was higher in the thinned area.

The effects of mechanical thinning may be persistent. The McNally site was mechanically thinned 28 years prior to the McNally fire of 2002, yet the thinned area still burned at high severity while the adjacent upslope unthinned area burned with a mix of low, moderate, and high severity effects.

SUMMARY AND CONCLUSIONS

Mechanical thinning increased fire severity on the sites currently available for study on national forests of the Sierra Nevada. More study is needed to determine which factors, such as slash debris, mid-flame windspeeds, and brush growth, best explain this occurrence. Future studies may also explore whether there is a temporal aspect to this effect, as understory vegetation grows over time in response to reductions in forest canopy cover.

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