CALIFORNIA FIRE SCIENCE CONSORTIUM

Research Brief for Resource Managers

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Prescribed fire and mastication reduced bark-beetle-caused pine mortality

Birch, Joseph D., Alicia Reiner, Matthew B. Dickinson, and Jessica R. Miesel. 2023. "Prescribed fire lessens bark beetle impacts despite varied effects on fuels 13 years after mastication and fire in a Sierra Nevada mixed-conifer forest." Forest Ecology and Management 550: 121510.

https://www.sciencedirect.com/science/article/pii/S0378112723007442

Management Implications

- Prescribed fire + mastication reduced bark beetle-caused pine mortality
- Tree radial growth had no sustained improvement from treatments
- 1 – 1000-h fuels were similar 13 years across all treatments: control, mastication, mastication + burn, and mastication + pull-back + burn
- Duff was 56% lower in prescribed fire treatments 13 years after treatment
- 13 years after treatment, prescribed fire and mastication treatments had reduced fuels, elevated canopies, and little overstory mortality.

Mastication, thinning, and prescribed fire can help shift fire-prone forests to a structure more resilient to fire and other disturbances. However, the ability to evaluate treatment effectiveness requires long-term monitoring of forest responses to disturbances and assessing changes in fuel loadings and structure. Researchers from Michigan State University and the USFS Fire Behavior Assessment Team remeasured a ponderosa pine forest 13 years after a combination of treatments were implemented: no treatment/control (C), mastication (M), mastication + burn (MB), and mastication + pull back of surface fuels + burn (MPB).

The study area was located in the Red Mountain fuel treatment area of Sequoia National Forest, CA, and was planted with ponderosa pine after a wildfire in 1970. The forest was first measured and treated as described in Reiner et al. (2009). Mastication (M) was done using a vertical shaft mastication head and on trees < 15 in diameter and a target density of 24 trees per acre. The 'pull-back' treatment consisted of masticated material being raked away from each tree bole out to each tree's dripline to minimize cambial and fine-root heating. A prescribed burn was applied in the MB and MPB treatment areas on December 5 – 6th 2007 using drip torches in spot and strip-firing patterns. In 2021, we remeasured all plots to assess how overstory structure and surface fuel loadings had changed compared to the previous 13 years.

A bark beetle outbreak in the decade following treatment caused 80% mortality in the untreated control plots (Fig. 1). In contrast, burned treatments showed modest increases in overstory biomass, diameter, and height in the decade after treatment suggesting that the prescribed fire provided protection against the outbreak. Height to live crown declined in the 13 years after treatment but remained 6.2 ft higher in burned treatments, relative to unburned treatments.

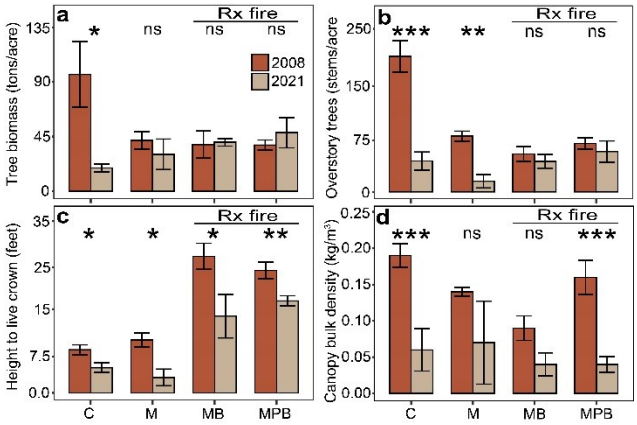

Figure 1: Mean biomass (±1 SE); (**a**), trees per acre (**b**), height to live crown (**c**), and canopy bulk density (**d**), for all living. The treatments are: control (C), mastication (M), mastication + burn (MB), and mastication + pull-back + burn (MPB). Significant differences are denoted between 2008 and 2021 values as: * = p < 0.05, ** = p < 0.01, and *** = p < 0.001.

Radial tree growth, as measured by tree-rings, showed no sustained improvement from any treatment, likely due to insufficient thinning or because bark-beetle tree mortality reduced competition for water and improved long-term growth of untreated trees.

All treatments were ineffective at producing reductions in surface fuels across 13 years. Understory vegetation, 1h – 1000-h, and litter fuels accumulated equally across all treatments between 2008 and 2021. However, duff fuels were 56% lower in burned, relative to unburned treatments, signifying enduring long-term reductions in ground fuels after prescribed fire (Fig. 2). Cumulatively, our results highlight that the coupling of prescribed fire + mastication treatments was associated with lower overstory beetle-caused mortality, elevated crown structure, and enduring duff reductions.

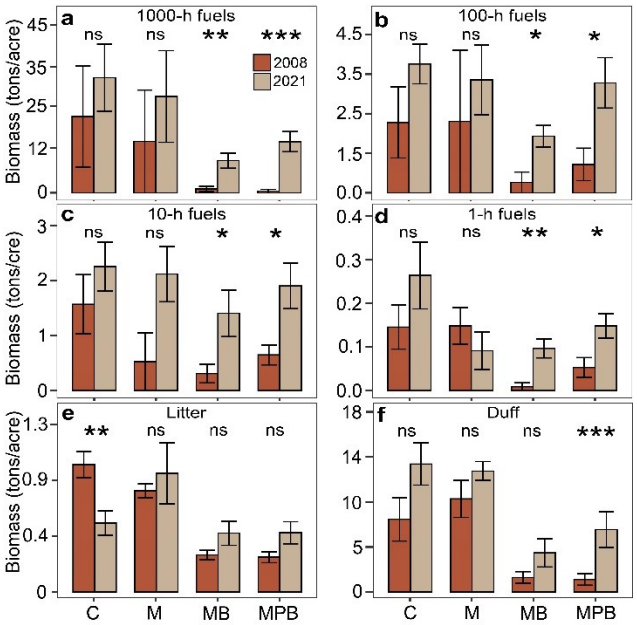

Figure 2: Mean (± 1 SE) loadings for (a) 1000-h, (b), 100-h, (c) 10-h, (d) 1-h fuels, (e) litter, and (f) duff fuels by treatment, in 2008 and 2021.

The implementation of prescribed fire + mastication improved forest resistance to attack by bark beetles, thereby safeguarding carbon retention in live biomass pools, and reducing overstory vulnerability to future wildfire. The conversion of the majority of ecosystem biomass from live to dead pools in the unburned treatments (Fig. 3) may see substantial carbon emissions with future wildfires and produce further undesirable outcomes.

Suggestions for further reading:

Reiner, Alicia L., Nicole M. Vaillant, JoAnn Fites-Kaufman, and Scott N. Dailey. "Mastication and prescribed fire impacts on fuels in a 25-year old ponderosa pine plantation, southern Sierra Nevada." *Forest Ecology and Management* 258, no. 11 (2009): 2365-2372.
https://doi.org/10.1016/j.foreco.2009.07.050

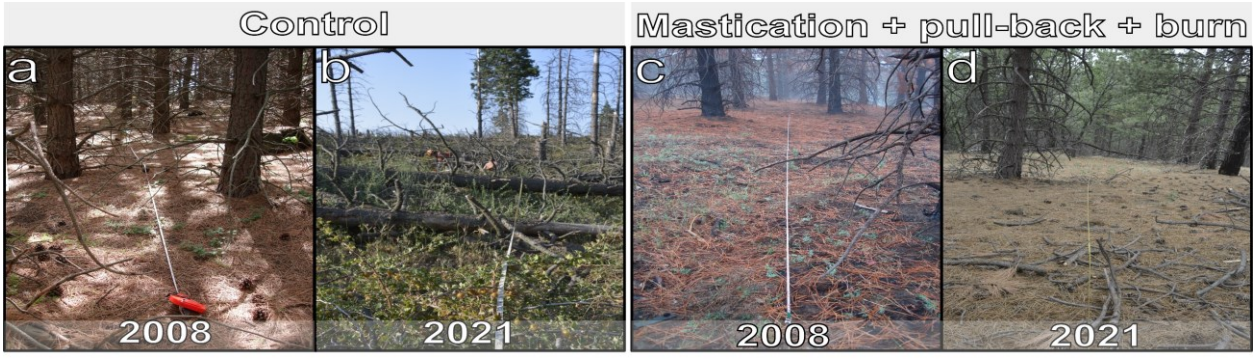

Figure 3: Paired photos showing changes in fuel structure between 2008 – 2021. Red Mountain, California, USA.