CALIFORNIA FIRE SCIENCE CONSORTIUM

JOINT FIRE SCIENCE PROGRAM

Research Brief for Resource Managers

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Forest restoration and fuels reduction work: Different pathways for achieving success in the Sierra Nevada

Stephens, Scott L., Daniel E. Foster, John J. Battles, Alexis A. Bernal, Brandon M. Collins, Rachelle Hedges, Jason J. Moghaddas, Ariel T. Roughton, and Robert A. York. 2023. Forest Restoration and Fuels Reduction Work: Different Pathways for Achieving Success in the Sierra Nevada. Ecological Applications, e2932. https://esajournals.onlinelibrary.wiley.com/doi/10.1002/eap.2932

Management Implications

- The application of Mechanical, Fire, or Mechanical + Fire treatments resulted in forest conditions more resistant to wildfire.
- Mechanical + Fire treatments can enhance resilience to drought and climate change-induced stressors.
- Mechanical + Fire treatments may offer a compromise between financial feasibility and the desire to reintroduce fire.
- Long-term forest conservation requires continued treatments to maintain or improve the conditions from forest restoration.

A history of fire suppression and exclusion has increased tree density and fuel loads in California's frequent-fire-adapted forests, while selective logging of large trees has removed the most fire-resistant trees and shifted species composition to favor shade-tolerant species, leaving these forests vulnerable to catastrophic change brought on by wildfire, drought, and bark beetles, which may be further amplified by climate change. Fortunately, managers have multiple options for improving forest resiliency, including the application of mechanical treatments, prescribed fire, or a combination of both mechanical and fire treatments.

This 20-year forest restoration study in the northern Sierra Nevada measured changes in forest structure and composition, fuel accumulation, modeled fire behavior, intertree competition, and economics resulting from four treatment regimes: multiple applications of prescribed fire (Fire), multiple mechanical restoration thinnings (Mech), multiple mechanical restoration thinnings followed by prescribed fire (Mech + Fire), and untreated controls (see figure 1 below from *Stephens et al. 2023)*. This study is one of the longest running in the western US looking at fuel reduction and forest restoration. It was performed at the University of California Blodgett Forest Research Station (Blodgett Forest) in the mixed-conifer zone of the Sierra Nevada, which had a median fire return interval of 4.7 years prior to the policy of fire suppression and exclusion that began in the early 20th century. The primary objective of the study was to achieve 80% survival of the dominant and co-dominate trees in wildfires modeled under 80th percentile weather conditions after treatment. Secondary objectives were to restore forest attributes and processes including snag and coarse woody debris, species diversity, nutrient cycling, and seedling establishment.

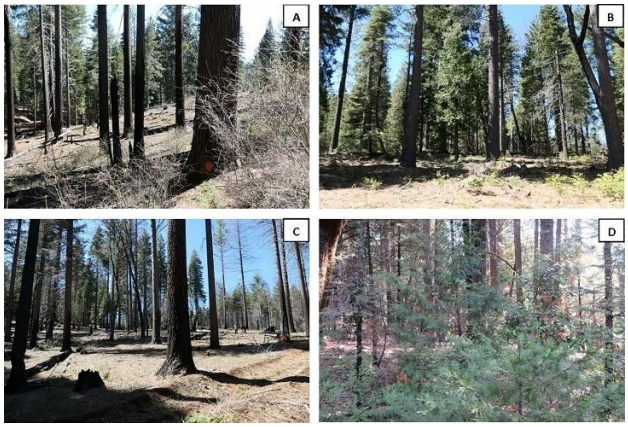

Figure 1. Photograph panel of the four fuel and restoration treatments in 2022. (A): Fire; (B): Mech; (C): Mech + Fire; (D): Control.

This study contains 12 experimental units ranging from 14 to 29 ha. Each treatment type was randomly assigned to 3 of the experimental units. Within each experimental unit, 20, 0,04 ha, circular plots were established. Data was collected within the 10-ha core at the center of each experimental unit to minimize edge effect. Plot measurements were taken in 2001 (pretreatment), in 2003 (1 year post treatment), 2009 (7 years post treatment), 2014 (12 years post treatment), and 2020 (18 years post treatment). Relative stand density index was calculated in 2020 for each plot, and fire behavior was modeled for both 2001 (pretreatment) and 2020 time periods using the Fire and Fuels Extension to the Forest Vegetation Simulator.

The three active management treatments (Mech, Fire, and Mech + Fire) all resulted in forest conditions more resistant to wildfire than the control. Treatments that included prescribed fire (Fire, Mech + Fire) resulted in the lowest modeled probability of torching and potential mortality in addition to having the lowest surface fuel loads (dead woody, litter, and duff) post-treatment. Mechanical only treatments (Mech) also produced low modeled probability of torching and potential mortality seven years after the initial treatment when most of the masticated fuels had decomposed. This study demonstrates that multiple approaches are available for reducing wildfire risk in Sierra Nevada mixed-conifer forests.

The Mech + Fire treatment resulted in lower tree growth than control units and lower intertree competition, measured by the relative stand density index (see figure 2 below from *Stephens et al. 2023*). The current stand density in the Mech + Fire treatment areas is most similar to historical conditions in California mixed-conifer forests and suggests that these stands may be more resilient to drought and climate change-caused stressors.

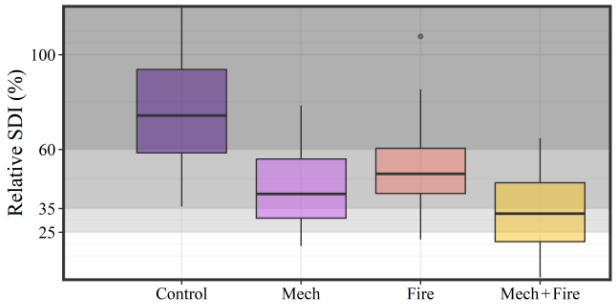

Figure 2. Current (2020) distribution of relative stand density index (% of maximum stand density index [SDI] across treatments. The gradient of gray shaded boxes indicates SDI benchmarks for free competition (in white; <25%), partial competition (25%-34%), full site occupancy (35%-60%), and imminent mortality (≥60%).

When considering economic feasibility, the study found that Mech treatments that included mastication and restoration thinning resulted in positive revenues, whereas Fire treatments came at a net cost to the landowner. Mech + Fire treatments offers a compromise, allowing landowners to maintain financial feasibility and reintroduce fire, a fundamental ecosystem process.

Under all treatment regimes, maintenance treatments are necessary for long-term forest conservation. The authors highlight the need for a strong commitment to stewardship from the landowner and suggest taking cues from many Indigenous people who speak of "active stewardship" as one of the key principles in land management. The authors encourage using the 20+ years of forest research in combination with the much longer tradition of Indigenous cultural practices and knowledge to guide frequent-fire-forest conservation.