CALIFORNIA FIRE SCIENCE CONSORTIUM

Research Brief for Resource Managers

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The century-long shadow of fire exclusion: Historical data reveal early and lasting effects of fire regime change on contemporary forest composition

Brodie, EG, EE Knapp, AM Latimer, HD Safford, M Vossmer, SM Bisbing. 2023. "The century-long shadow of fire exclusion: Historical data reveal early and lasting effects of fire regime change on contemporary forest composition." Forest Ecology and Management. 539: 121011. https://doi.org/10.1016/j.foreco.2023.121011.

Background

Almost a century of fire suppression and exclusion combined with historical logging practices have had outsized effects on contemporary pine populations in the Sierra Nevada. A loss of historically frequent fire with Euro-American settlement resulted in increasing populations of shade-tolerant conifers that outcompete the shade-intolerant pine. Low severity fire disproportionately affects shade-tolerant species, favoring fire-resistant pines, but without this key process pine persistence is threatened. Additionally, removal of large pines, early foresters' misunderstanding of the role of fire in promoting pine regeneration, and their perpetuation of fire exclusion further reduced pine density. Moreover, the majority of pine seed is produced by larger individual trees, while a high proportion of seed in shade-tolerant species (e.g., white fire and incense-cedar) is produced by smaller individuals that are less likely to be harvested.

Management Implications

- An absence of surviving pine seedlings over the study period underlines the scarcity of pine regeneration opportunities, which rely on appropriate timing of seed production with post-fire conditions.
- Logging-induced gaps had no effect on pine regeneration which highlights that light alone is not adequate, and pine needs the diverse impacts of fire to promote regeneration.
- Due to establishment constraints, pine could benefit from protections during logging operations such as thinning or mastication.

The composition of seedlings and saplings following a disturbance, such as logging, can have a great impact on future stand conditions. Regeneration that survives or establishes immediately after logging takes advantage of appropriate microsites and resources. This regeneration-community composition is likely to influence long-term forest trajectories, yet few datasets quantify forest structural and compositional changes

across long time periods to confirm this assumption. This study explores the effects of historical logging on tree regeneration and successive effects on stand development under a history of fire exclusion. The authors leveraged a silvicultural experiment from the 1920s in the Sierra Nevada mixed-conifer forest of the Stanislaus-Tuolumne Experimental Forest to test if silvicultural objectives of increasing pine stocking rates were met. Combining historical (pre- and post-logging in 1928-1929) and contemporary tree regeneration data along with overstory and microsite conditions, they assessed the impact of logging on pine decline.

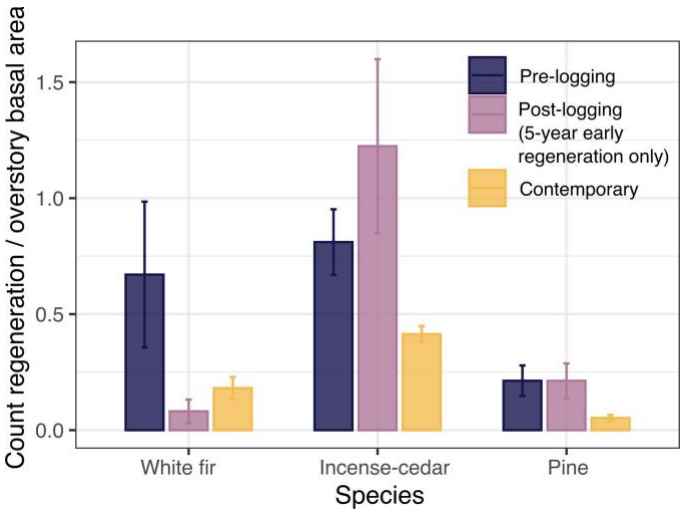

Figure 1. *Adapted from Brodie et al. 2023. Regeneration efficiency, or the ratio of regeneration count to overstory basal area in the pre-logging, post-logging, and contemporary time periods.*

Findings

The authors discovered that the objective of the 1920s experiment to increase pine regeneration was not met in the short or long term (see Figure 1 above from *Brodie et al. 2023*). Prior to logging, pines made up a small percentage (12%) of regeneration despite comprising 32% of surrounding adult trees. Five years after logging, pine seedling density had not increased, and subsequently declined to make up only 5% of contemporary regeneration. Prior to logging, incense-cedar constituted a high percentage of regeneration (32%) despite having the lowest density of trees in the overstory (17%). Post-logging, the species ultimately dominated the contemporary understory (49%). Gaps from logging did not have a positive influence on pine regeneration at any point in time although post-logging skid trails had a positive influence on regeneration of all species. Woody debris from logging negatively affected regeneration by all species.

Historical regeneration that preceded and survived logging best predicted the contemporary tree presence for all species. Post-logging regeneration contributed to new trees in the contemporary canopy only for shade-tolerant species. All mature pines in the contemporary stand had established prior to the 1928 logging. This work highlights that minimal pine regeneration as far back as 1928 influenced the current low densities of pine in the overstory, indicating that pine decline likely initiated prior to logging under early fire exclusion practices. The authors suggest that this loss of fire drove shifts in species composition, with an increase in shade-tolerant regeneration, that were early and lasting. They highlight that the decline of pine in either logged or unlogged stands of Sierra Nevada mixed-conifer forest has occurred because conditions appropriate for pine persistence have not been met, including sufficient presence of pine seed to adequately colonize and stock forest gaps, and sufficient mineral soil in such gaps to permit successful recruitment.

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