Dead tree removal after mass mortality: Effects on regeneration, fire severity, and carbon stocks

California Fire Science Consortium
"Informing Our Future With Fire"

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MANAGEMENT IMPLICATIONS

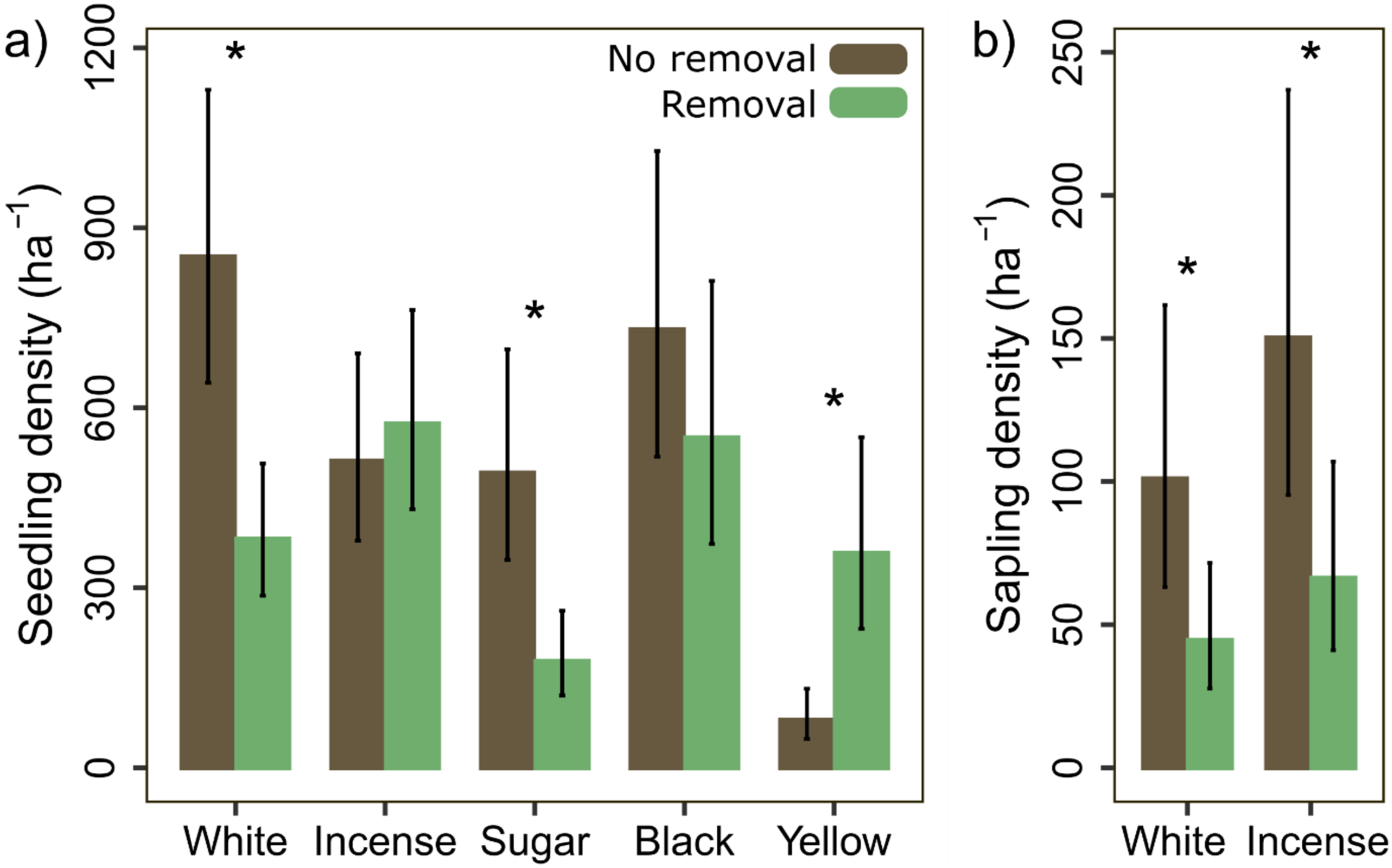
- Dead-tree removal after severe drought mortality likely confers benefits to frequent-fire forests long departed from historic disturbance conditions
- Removal had positive initial effects on the species composition of regenerating trees by favoring some fire-resistant conifers
- Decreases in mature black oak density and sugar pine seedling density with removal may be counter to management goals
- Dead-tree removal reduced modeled wildfire severity and behavior beginning two decades after disturbance
- Managers will need to weigh the short-term loss of standing dead carbon and small live trees with removal against possible protections from future carbon loss via severe wildfire and insect outbreaks

Background:
Despite the vast area and large numbers of trees affected by drought- and bark beetle-induced tree mortality worldwide, relatively little is known about how post-mortality management practices affect forest recovery, particularly in forests historically adapted to frequent fire. Cutting and removing dead trees after a mass-mortality event provides an opportunity to salvage timber and lessen wildfire risk by reducing fuel loads, but the ecological impacts of this strategy extend beyond fuel reduction. A tree mortality event of locally unprecedented extent and severity occurred in the Sierra Nevada of California, USA, during and after the exceptional 2012-2016 hot drought, providing an opportunity to evaluate the ecological effects of the management practice of dead-tree removal.

Study Aim and Methods:
The authors compared adjacent mixed conifer forest areas with and without dead-tree removal, with the aim of assessing how dead-tree removal affects: 1) the amount and composition of forest fuels; 2) tree regeneration in the form of seedling and sapling density and species composition; 3) carbon pools; and 4) fire behavior and severity and fuel loads over the following century. Data were collected in 122 paired field plots (22 m diameter) in treated and adjacent untreated areas spanning 300 km of the Sierra Nevada one to five years after the removal of recently dead trees. Sites were on the Stanislaus, Sierra, and Sequoia National Forests, private lands owned and managed by Southern California Edison, and Mountain Home Demonstration State Forest.

Key Findings:
Dead-tree removal enhanced regeneration of the historically dominant shade-intolerant yellow pines (ponderosa and Jeffrey pine: Pinus ponderosa and P. jeffreyi), while decreasing seedling regeneration of shade-tolerant white fir (Abies concolor). However, removal also decreased regeneration of the moderately shade-tolerant sugar pine (P. lambertiana), and mature black oak (Quercus kelloggii) density declined with removal. Simulations of future conditions after removal foretold meaningfully milder burn severity and fire behavior, likely as a result of massively reduced dead fuel loads persisting over a century and decreased live small tree density. Total on-site carbon at time of sampling was lower with removal, driven predominantly by the removal of aboveground dead-tree biomass, while live tree biomass was also reduced but to a smaller degree.

Combined Pinus ponderosa and P. jeffreyi (shade intolerant) seedling densities were 349% higher with removal, while P. lambertiana (moderately shade tolerant) and Abies concolor (shade tolerant) seedling densities were 64% and 55% lower with removal. Sapling density was 56% lower in treated plots but did not differ by species. Coarse woody debris mass was 51% higher with removal, but rotten coarse woody debris was not different. Litter depth and 1-hr and 10-hr fuel mass decreased with removal. Total forest carbon was 32% lower in treated sites, predominantly driven by dead-tree removal. Using the Forest Vegetation Simulator, the authors simulated future fire severity (% basal area mortality) and behavior (torch potential) over 100 years at 10-year intervals and predicted that after a 20-year lag, treatment persistently reduced simulated fire severity and behavior.



Mean (a) seedling (<1.34m tall) and (b) sapling (>1.34m tall, <7.6 cm DBH) density for the five most common tree species. Only white fir and incense cedar saplings were observed frequently enough to allow means testing. Means and standard errors are calculated from back-transformed model estimates and standard errors and were scaled to be per hectare from the 0.006 ha search area (p < 0.05, < 0.01**, < 0.001***).*

Limitations:
Young conifer seedlings commonly suffer high levels of mortality, and seed production is highly variable from year to year. Additional sampling will be necessary to evaluate whether the initial increase in yellow pine seedling abundance translates into meaningful shifts in mature tree species composition.

Current operational models of fire behavior do not appropriately account for the substantial energy release and long burning times of large diameter standing dead and downed fuels found in areas of severe drought- and bark beetle-induced tree mortality. Updated fire behavior modeling, fully incorporating these complex fuel dynamics, is needed to appropriately assess net benefits and costs of dead-tree removal on future wildfire severity and behavior.

Additional Information

This brief is based on the following article:
Sorenson, Quinn, Rebecca Bewley Wayman, Tara Ursell, and Hugh Safford. 2025. Removing dead trees after mass drought mortality enhances fire-adapted tree recruitment, reduces future fire severity, and has mixed effects on carbon stocks. Frontiers in Forests and Global Change 8, Article 1691015. https://doi.org/10.3389/ffgc.2025.1691015

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