CALIFORNIA FIRE SCIENCE CONSORTIUM

Research Brief for Resource Managers

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Severe drought drives pulse of snags and fuel loads

Northrop, Hudson, Jodi N. Axelson, Adrian J. Das, Nathan L. Stephenson, Emilio Vilanova, Scott L. Stephens, and John J. Battles. "Snag dynamics and surface fuel loads in the Sierra Nevada: Predicting the impact of the 2012–2016 drought." Forest Ecology and Management 551 (2024): 121521.
https://doi.org/10.1016/j.foreco.2023.121521

Summary:
Rates of tree death soared in the Sierra Nevada during the severe 2012-16 drought. While the acute effects of drought occurred over a short period, the mass mortality event kickstarted a decades-long process of snag fall, increased fuel loads, and changed fuel composition.

Fuel loads, snag density, and snag fall rate were collected at two sites in Yosemite National Park (YOMI = mixed conifer site, YOPI = pine-dominated site) and one at Sequoia/Kings Canyon National Park (SEKI) and modeled to predict future fuel loads and snag fall rates.

1. Increased Snag Biomass and Fuel Load:
The research indicates a substantial increase in snag biomass, exceeding 150 Mg ha^{-1}. Fine woody debris more than doubled (145%), with litter and duff layers increasing by over 55% (Figure 1). These alterations in forest structure significantly enhance fuel availability, likely exacerbating wildfire severity and behavior.

2. Extended Snag Longevity Alters Predicted Fuel Dynamics
Snags fell 20-40% slower than previously documented, suggesting that snags will stand longer on the landscape before contributing to

Management Implications

- Forests impacted by drought-induced die-back in California contain >150 Mg ha−1 of snag biomass.
- From 2017 to 2021, fine woody debris increased >145 %; litter and duff fuel loads increased >55 %.
- The rates of snag fall were 20–40% slower (i.e., longer snag persistence) than previously reported.

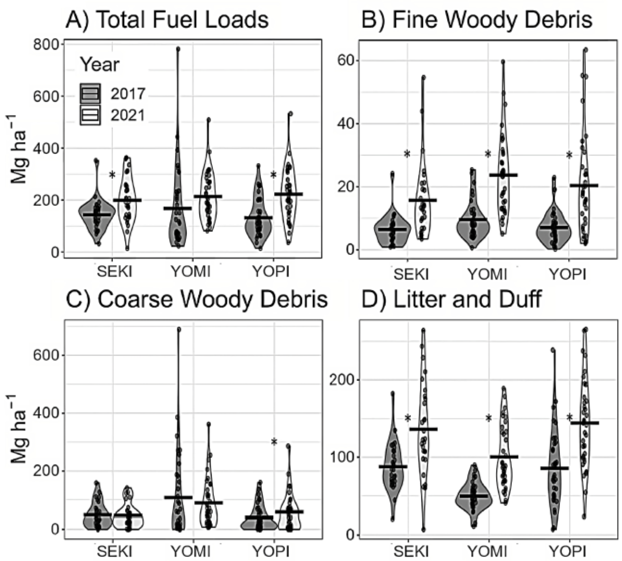

Fig. 1. Violin plots of the fuel load estimates within each stratum at SEKI, YOMI, and YOPI measured in and 2021. Horizontal lines represent mean fuel loads for each site and year. Groups marked by, '*'. signify $p < 0.05$ for the difference between 2017 and 2021.

surface fuel loads. Snag longevity varies by species and size, with larger snags typically standing for longer. Notably, yellow pine snags deviate from this pattern, with size having minimal impact on fall rates. This extended snag longevity necessitates a reevaluation of fuel management strategies and timelines.

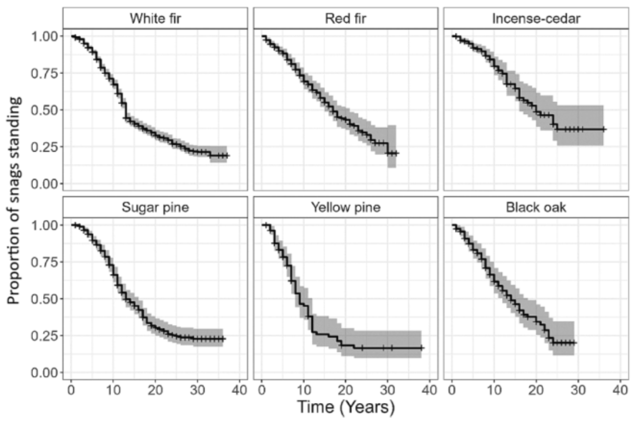

Fig. 2. Observed persistence (i.e., survival) curves using Kaplan-Meier estimator with 95% confidence intervals (shaded areas). Curves depict proportion of standing snags over time.

3. Projected Increase in Surface Fuel Loads by 2040:

Based on the current trajectory of snag fall, it is projected that by 2040, surface fuels will increase substantially, with inputs ranging from 49.4 Mg ha−1 to 136.1 Mg ha−1 across the study sites. This

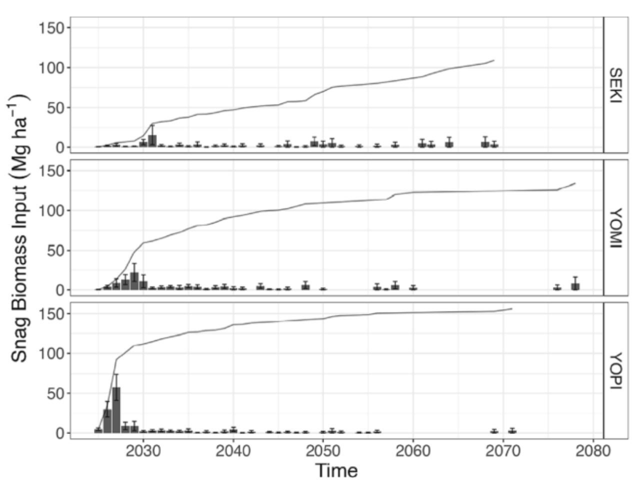

Fig. 3. Forecasted biomass inputs over time based on standing snags in 2017 and model predictions at SEKI, YOMI, and YOPI, based on median modeled fall rates. Bars depict forecasted annual biomass input from snag fall, the error bars depict standard error of annual biomass input, and the lines depict cumulative biomass input from snag fall.

forecast exceeds current levels and historical benchmarks, indicating a significant shift in fuel composition and distribution that could influence fire behavior and forest management practices. The study suggests looking into salvage operations and prescribed burns as ways to manage the increasing amount of deadwood. Each method has its pros and cons, including safety concerns, operational limits, and potential impacts on the ecosystem.

Implications for Forest Management Practices:

The findings detail the current and future amount and state of fuel loads, thereby providing a roadmap for the future makeup of fuels on the landscape and contributing guidance for management and evaluation of fire risk.

While salvage logging holds potential for reducing surface fuels and recouping economic value, the feasibility and impact of salvage logging require careful consideration regarding operational, ecological, and legal constraints.

Prescribed fire may be useful for managing fuel loads but should be assessed considering the increased hazards that a greater occurrence of snags presents during controlled burning.

Conclusion:

The recent drought-induced tree mortality event in the Sierra Nevada has led to significant changes in forest structure, notably in snag biomass and surface fuel loads. These changes present new challenges for forest management, emphasizing the need for strategic planning and the adoption of adaptive management practices. Enhanced modeling tools, informed by empirical data, will be instrumental in guiding these efforts, ensuring that management strategies are both effective and ecologically sustainable.

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