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Effectiveness Monitoring Committee
Completed Research Assessment

Project Title:	The life cycle of dead trees: Implications for forest management in the Sierra Nevada
Project Number:	EMC-2017-007
Principal Investigator:	Dr. John J. Battles, Professor of Forest Ecology, UC Berkeley
	Dr. Robert A. York, RPF, Adjunct Associate Professor of Forestry and UCB Research Forest Manager
Collaborators:	Dr. Stacy Drury, Research Fire Ecologist, Forest Service, PSW
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Date:	August 25, 2025

1. Fulfills and addresses scientific question(s) posed in proposed research?

A. Does the study inform the intended rule, numeric target, performance target, or resource objective?

The results of the research do address the scientific questions proposed by the Principal Investigators (PIs).

B. Does the study inform the Forest Practices Rules?

The results of this study could inform the Forest Practice Rules by providing data that could help refine the Snag Retention requirements (14 CCR § 919.1, 939.1, 959.1).

The stated purpose of this research was to “provide the necessary scientific basis to inform snag retention guidelines” and “to improve our understanding of the contribution of snags to carbon storage in the Sierran mixed conifer forest”. The Forest Practice rules recognize the importance of snag retention for wildlife habitat (Technical Rules Addendum No.2) and that they are important components of vegetation structure along water courses (14 CCR § 916.4, 936.4, 956.4 Watercourse and Lake Protection). Because of there importance in the forest ecosystem, there are requirements on retaining snags (14 CCR § 919.1, 939.1, 959.1

Snag Retention), but there are “multiple exemptions to the retention stipulation and there is no established practice for managing snag density”. Addendum No. 2 on Cumulative impacts assessment guidelines C4a also notes “The degree of Snag recruitment over time may be considered” in Project design, but data on these rates are sparse.

The PIs also stated this research addresses the Effectiveness Monitoring Committees (EMCs) critical question [*Are the FPRs and associated regulations effective in retaining a mix of stages of snag development that maintain properly functioning levels of wildlife habitat?*] under the theme *Wildlife Habitat: Structure*.

2. Scientifically sound?

Was the study carried out pursuant to valid scientific protocols (i.e., study design, statistical analysis, peer review)?

The study was scientifically sound. The PIs used data from a long-term study established in 1984 with repeated surveys of the study site through 2012. Surveys were conducted using established protocol (Rapheal and White, 1984; USDA Forest Service FIA guidelines) and were further refined 2018 to be more systematic in finding, recording locations, and evaluating snags across the 59-acre study area. This provided a robust sampling size.

The PIs evaluated the fall rate of of snags by building Accelerated Failure Time (AFT) models and conducted valid statistical testing of the models. They also used Monte Carlo simulations to project decay class transitions and biomass loss.

Additionally, the PIs established a long-term study within the larger project to explore decay rates of downed woody material using protocol established by Cousins et al. (2015).

3. Scalable?

What does the study tell us? What does the study not tell us? Do findings apply to other areas of the State?

The data and results presented in this study were specific to the study site, as the climate conditions, disturbance regimes, and tree species characteristics would have affected snag fall and decay rates. However, the survey and monitoring protocol (Rapheal and White, 1984; USDA Forest Service FIA guidelines) used in the study could be applied to other forest ecosystems to determine snag fall and decay rates under different climate conditions, disturbance regimes, and forest compositions. Therefore, while the conclusions are not scalable, the methods could be more widely applied. In addition, it provides a second, complimentary estimate of snag fall and decay rates in the Sierra Nevada to compare with the classic Sagehen snag study (Raphael and White 1979; Raphael and Morrison 1987; Morrison and Raphael 1993) that was previously the main source of snag demographic information available for Sierra Nevada mixed conifer forests. The substantially slower snag fall rates documented in this study allow a better understanding of the variability in snag dynamics in the Sierras.

Study Synthesis

The 2018 study was conducted at UC Berkeley's Blodgett Forest Research Station (central Sierra) in a 59 acre study area. The long-term snag monitoring study this project expanded was established in 1983 and was resurveyed multiple times using the same methods (Rapheal and White, 1984) until 2012. In 2012 and 2018, snags were characterized using decay class definitions based on the USDA Forest Service Forest Inventory Analysis protocol (2022). In 2018, a more systematic sampling design was established when the site was resurveyed. Since 1983 the forest site was managed using an uneven-aged silvicultural system. At the time of the 2018 study, the site was dominated by white fir, Douglas-fir, incense-cedar, ponderosa pine, sugar pine, and black oak. Stand density was 166 trees/acre and basal area was 169 ft^2/acre.

Data from this long-term snag inventory and monitoring research project were used to model snag fall rates by size class and tree species group (incense-cedar, fir, oak, and pine), decay class transition rates, and carbon loss over time. While the numeric data collected in this study are site and species specific, the derived metrics could potentially be used to help refine the Forest Practice Rules snag retention requirements (14 CCR § 919.1, 939.1, 959.1) and provide guidelines for evaluating the effectiveness of snag management practices in achieving wildlife habitat and carbon storage goals.

Key Findings

- The median fall rate across all snag species was 14 years, but the rate varied with time since death
  - Few snags fell within the first 5 yrs after death, while fall rates accelerated in years 5-15, and then decrease after 15 years
  - Fall rates were extremely variable year-to-year, varying by an order of magnitude depending on episodic events. Characterizing interannual variability requires long term monitoring, and variation around the mean longevity was large (interquartile range 5-19 years)
- Incense-cedar snags had a longer median fall rate when compared to other species (21 years; see Figure 5)
- Larger snags persisted longer
- Median persistence for trees in decay class 2 and 3/4 (wildlife habitat) was 10 years; however, the interquartile range for persistence of decay classes was large
- The probability of decay class 1 snags falling was 2x-4x lower than other decay classes (see Figure 6)
- Decay class transition rates varied by decay class and species (See Table 2)
- Decay class transition times slow down as snags decay further
- Incense-cedar had the slowest decay transition rate
- As snags decayed, they lost mass at exponential rates (see Figure 7)
- After 14 yrs retained snags only had 58% of their mass, with estimated 70% of carbon transitioned to dead and downed wood or respired to the atmosphere

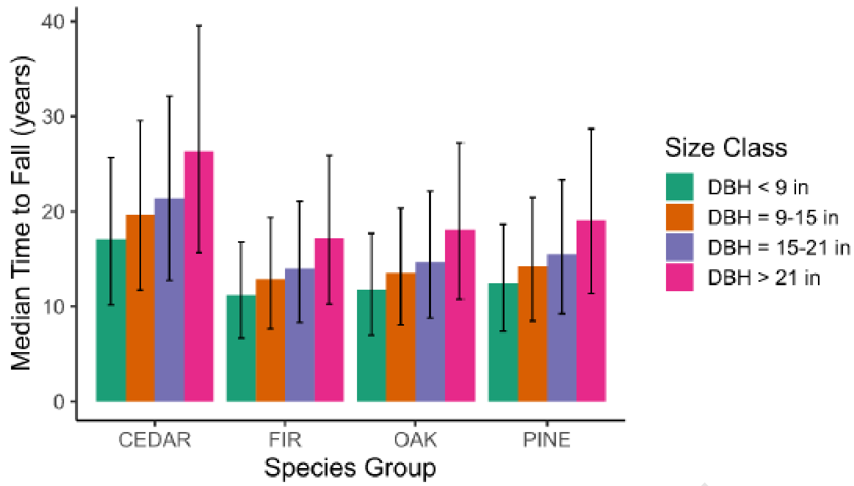

Figure 5. Predictions of median fall time for snags at Blodgett Forest Research Station by species group and size class. The error bars represent the interquartile range.

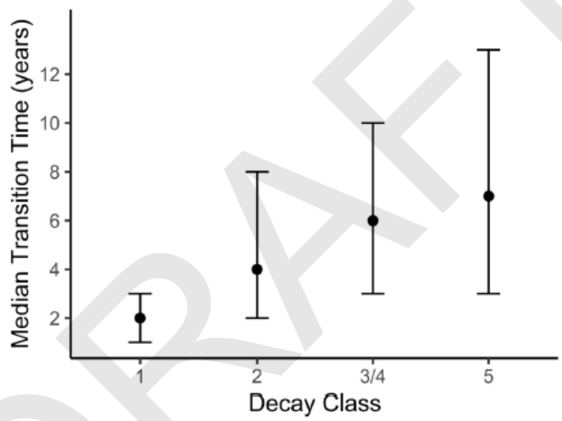

Figure 6. Predicted transition time in each decay class for snags at Blodgett Forest Research Station. Error bars represent the interquartile range. Results from Monte Carlo simulation of fall probabilities and decay rate

Table 2. The annual transition probability (%) for snag decay classes from Blodgett Forest Research Station. Note: Decay class 5 does not have a transition probability since it represents the most decayed state.

	T1	T2	T3/4
Cedar	0.22	0.12	0.03
Fir	0.45	0.15	0.07
Oak	0.35	0.17	0.07
Pine	0.30	0.11	0.07

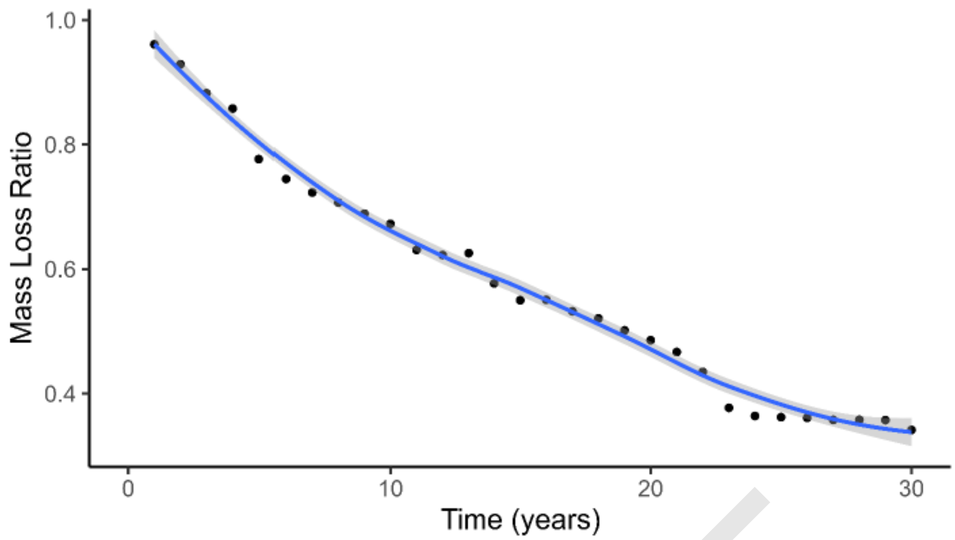

Figure 7. Trends in the loss of stem mass snags at Blodgett Forest Research Station. Results from Monte Carlo simulations of fall probabilities and decay rate. The black circles represent the mean mass loss ratio (snag stem mass:live stem mass) for remaining snags. The blue line is the locally fit smoothing spline; the gray shading represents the 95% confidence interval.

From these data and the literature review, the PIs made several observations that can inform management decisions on snag retentions in Sierran mixed conifer forests:

- Snags in the early stage of decay typically provide critical wildlife habitat elements for approximately 10 years (about five years longer than previous estimates based on Morrison and Raphael).
- The persistence of snags increases with DBH and for incense-cedar these two factors can double the median longevity of snags
- It takes from one to three years for a newly created snag to degrade and decay to the point where it provides wildlife habitat value
- Cavity-nesting birds only use snags with a DBH of least 9 in (Raphael and White 1984)
- Old-growth dependent mammals like the pine marten and pacific fisher only use snags in the largest size class (Spencer 1987, Purcell et al. 2009)

The PIs did recommend using caution when interpreting these observations since there were no significant disturbances (e.g., wildfire or forest health issues) during the study which could have affected snag fall and decay rates.

4. New EMC study recommended to advance research on this topic (e.g., to expand findings and/or temporal or spatial relevance of this study)?

A. Literature review sufficient?

The literature referenced was appropriate and robust for the topic and supported the PIs objectives.

B. Recommend funding new EMC study on this topic (e.g., extend temporal or spatial scope, or scope of study in some other way)?

It is the opinion of the CRA authors that funding additional research on this topic is not a high priority currently.

C. What is the relationship between this study and any others that may be planned, underway, or recently completed?

The CRA Authors are not aware of this project having any relationship to current or future EMC funded research projects.

5. Scientific Applications

What is the scientific basis that underlies the rule, numeric target, performance target, or resource objective that the study informs? How much of an incremental gain in understanding do the study results represent?

The long-term snag monitoring and survey study at Blodgett provides a valuable data set that furthers our understanding of snag longevity, decay progression and carbon retention and loss. These data can help forest managers better understand wildlife habitat availability and how to manage for snags to recruit and maintain valuable habitat. While the empirical data presented in this project are specific to the study site and the central Sierra's, because of factors such as climate conditions, disturbance regimes, and forest structure and composition and snag characteristics; the data collected provide a rare datapoint for a data-sparse process (snag demography). Moreover, the methods employed in this study could be replicated in other forest ecosystems: snag resurvey protocols with modern GPS geolocating allowed for >99% snag relocation and required ~240 person hours of field work (two weeks of a three person crew).

Establishing long-term snag monitoring studies on other forest ecosystems could provide a more robust and diverse data set that could be used to help inform and refine the Forest Practice Rules 14 CCR § 919.1, 939.1, 959.1 Snag Retention, specifically when addressing the life span of a snag and the periods at which it provides wildlife habitat. Currently the rule reads that "all snags shall be retained to provide wildlife habitat" except following a number of exemptions such as hazard reduction, merchantable snags provided for in the plan, or insect or disease control. This study highlights that snag longevity and utility to wildlife is greatest for large trees (DBH>21 in), varies substantially by species, and can be short (10 years median lifespan for wildlife habitat in this study), which helps inform the FPR Rule Addendum No. 2: Cumulative Impacts Assessment Guidelines C4a that "The degree of Snag recruitment over time may be considered."