Project Number: EMC-2017-007

Project Name: The life cycle of dead trees: Implications for forest management in the Sierra Nevada.

Background and justification

> …standing dead trees may result from a number of agencies, such as fire, bark beetles, tree diseases, flooding and drought. Once produced, they become of concern to foresters…
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> Keen 1929[1]

Standing dead trees (aka snags) are vital but ephemeral elements of the forest. They represent the transition from living trees where entropy is actively delayed by the input of energy to downed wood where the direct contact with soil microbes speeds decay. While they remain standing, these trees provide essential habitat for wildlife; they store a significant amount of carbon; and they present potential hazards.

During the time a dead tree remains standing, a typical sequence of changes occurs leading to an overall reduction in tree size. Tree volume declines through loss of leaves, twigs, and branches, which fall to join the downed wood on the forest floor. Concurrent with these dimensional reductions are changes to the tree's physical and chemical properties caused by weathering, decomposition, and insect activity.

As a consequence of the decay process, the value of snags as resource for wildlife evolves with time since death. In the early stages, snags are an important source of food for wood boring insects, which in turn, are the primary food source for woodpeckers. With the decomposition of wood, wildlife use evolves further. As cavities form, they provide critical den and nest sites. At the same time, the carbon stored in the snag decreases along with mechanical stability. Just as foresters do with live trees, they can plan out a sustainable presence of snags if they have adequate demographic information.

However, we have limited information on the longevity of snags. The fall rates vary by species and tree size. For Sierran mixed conifer forests, annual fall rates range from 7% yr^{-1} to 14% yr^{-1}. There is even less information on the rate of decay. We know the steps but we do not know how long it takes for a recently dead tree to become a suitable wildlife habitat tree.

Finally as snags fall, they add to the downed wood in the forest. The decay rate of the downed wood then determines the longevity of this additional surface fuel. Usually this downed wood is in steady state with losses (decay) and matching additions (snag fall). However in stands in the Sierra Nevada with drought-related mortality, there is the potential for large pulses and sustained additions in downed wood that in turn increase the fire hazard. A key gap in our knowledge is that we do not have good measures of decay rates of downed wood in Sierran conifer forests that can guide management and policy decisions relating to snag retention and recruitment.

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[1] [1]Keen, F. P. 1929. How soon do yellow pine snags fall? Journal of Forestry 27:735-737.

Objectives and scope

The goal of this project is to quantify the life cycle of standing dead trees in order to inform forest management and policy development. We will rely on a rare resource -- a long-term snag inventory and monitoring study at Blodgett Forest Research Station. In 1983, all the snags (≥ 5" diameter at breast height, DBH) in a 59 ac stand (Compartment 160) were evaluated and tagged. The evaluation included several measures of decay (e.g., wood strength, presence of bark) as well as a detailed assessment of habitat elements (e.g., woodpecker holes, cavities). The inventory has been repeated at irregular intervals: 1989, 1994/95, 2005, and 2012. There are currently 1,163 snags being tracked and the study has recorded 680 tree falls. This study has proven valuable for estimating fall rates and for quantifying wildlife habitat value. However to obtain precise rates of change, we need to monitor individual snag more regularly and more frequently. Also to complete the snag life cycle, decay rates of downed wood must be added. To our knowledge, there is exactly one empirical estimate of log decay in the Sierra Nevada (white fir in Sequoia National Park).

Compartment 160 at Blodgett Forest is a mature mixed conifer forest under single-tree selection management. Stand basal area in 2013 averaged 169 ft^2/ac. White fir and Douglas-fir are the dominant species (> 20% relative dominance) but incense-cedar (18%), ponderosa pine (16%), sugar pine (12%), and black oak (9%) are common. For the entire stand, there are approximately 9,900 live trees (≥ 5" DBH) with 3,200 of these trees ≥ 20" DBH. Given prevailing mortality rates, about 100 new snags are recruited each year.

Our proposal has three major objectives:

1. Extend the record in Compartment 160 to 2018 by repeating the snag inventory and evaluation.

We last measured the snags in 2012. During this inventory, we developed a survey protocol that made the search for snags throughout the compartment more efficient. With these data, we can update and refine our existing estimates of snag fall rate.

2. Establish a new monitoring protocol that tracks cohorts of new snags on an annual basis to quantify development of cavities and other important habitat elements.

We will tag and locate all newly recruited snags with the aim of estimating two key rates: the rate of decay and the rate of development of wildlife habitat elements. During the course of this three-year study, we will survey the stand for new snags each year as well as assess earlier cohorts. An important goal would be to evaluate the best methods for conducting such a snag demography study. Annual visits may not be necessary but exactly how frequently snags need to be checked to obtain management-relevant information is uncertain. Given the challenge posed by the abundance of snags due to drought and beetle kill, we need to better understand snag dynamics and thus require robust and tested methodologies.

3. Establish a long-term study of downed wood decay rates.

We plan to install a long-term log decay study in Compartment 160. From timber operations at Blodgett, we will experimentally create sets of five logs for each of the major canopy species. The logs will be roughly 3 ft in length and members in each set will have similar diameters. These logs will be tagged and the sets will be placed together in the compartment. At established time intervals, one log from each set

will be collected for determination of wood density and carbon content. The sample intervals will be 2, 5, 8, 12, and 20 years. The timing is designed to capture the exponential nature of wood decay: more frequent intervals early when the rate of change is steep and longer intervals later when the pace of change slows. We will install five replicates with each replicate containing sets of five logs for the six major species (white fir, Douglas-fir, incense-cedar, ponderosa pine, sugar pine, and black oak).

Critical questions and Relevant Forest Practice Regulations

The critical monitoring questions are those related to the numerous regulations that influence the retention of snags and downed wood. These regulations attempt to balance the tradeoff between snag retention and fire hazard reduction. For example, 14 CCR § 1038(k)(5), which expires at the end of 2018, requires retaining 1 snag per acre that is greater than 16" DBH and taller than 20' in height. For this and other regulations that either require snag retention or that count snags for stocking compliance, key questions are: What level of snag retention during operations is sufficient, given how long they will last? Is this size of snag appropriate to use? Should all species of snags count equally? Should active snag recruitment (i.e. girdling) be an option for snag management or mitigation?

Principal Investigator and Collaborators

PI: John J. Battles, Professor of Forest Ecology, UC Berkeley.

Co-PI: Robert A. York, PhD and RPF, Adjunct Associate Professor of Forestry and UCB Research Stations Manager.

Collaborator: Jodi Axelson, PhD, and Assistant Extension Specialist in Forest Health.

Anticipated Timeline

We propose a three-year study with the majority of the effort focused on the first year (2018). In Year 1, we will complete the snag inventory, establish the first cohort of new snags, and install the dead wood decay experiment. In Year 2, we would revisit the Year 1 snag cohort and establish a Year 2 cohort. In the third year of the study, we would add an additional year to the snag cohort study and make the first decay measurements (two years since start). The main cost of the log decay study is in the set-up. Future years can be completed a modest cost (30 samples). Also by the end of the project, we will have established 3 cohorts of snags that is estimated to total 300 trees. We will check these snags annually as part of the regular Blodgett inventory.

Funding

We estimate that the direct cost of this project is $80,000. This estimate includes costs of field operations, summer salary for the PI, and lab analyses. Substantial logistical support will be provided by Blodgett Forest. Moreover this project leverages the long-term snag record in Compartment 160. If invited to submit a final proposal, UC Berkeley's sponsored projects will assist with detailed budget development and administration. The current negotiated indirect cost rate at UC Berkeley for projects sponsored by the state is 25%.

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