



# Long-term dead wood changes in a Sierra Nevada mixed conifer forest: Habitat and fire hazard implications



Eric E. Knapp\*

U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, 3644 Avtech Parkway, Redding, CA 96002, United States

## ARTICLE INFO

### Article history:

Received 4 August 2014

Received in revised form 9 December 2014

Accepted 12 December 2014

Available online 30 December 2014

### Keywords:

Coarse woody debris

Fire hazard

Mixed conifer

Reference conditions

Snag

Tree mortality

## ABSTRACT

Dead trees play an important role in forests, with snags and coarse woody debris (CWD) used by many bird and mammal species for nesting, resting, or foraging. However, too much dead wood can also contribute to extreme fire behavior. This tension between dead wood as habitat and dead wood as fuel has raised questions about appropriate quantities in fire-dependent forested ecosystems. Three plots installed in mixed conifer forest of the central Sierra Nevada in 1929 illustrate how amounts and sizes of dead wood have changed through time as a result of logging and fire exclusion. Diameter of snags was measured and CWD was mapped in the old-growth condition, prior to logging. Snags were re-measured in 2007 or 2008, and CWD was re-mapped in 2012. Snag density increased from 15.2 ha<sup>-1</sup> in 1929 to 140.0 ha<sup>-1</sup> in 2007/2008. However, average snag size declined, with 72% and 22% of snags classified as medium or large in 1929 and 2007/2008, respectively. Mechanisms of tree mortality also appear to have changed with greater mortality in smaller size classes, possibly as a result of higher live tree density. CWD volume, mass, and cover did not differ significantly between 1929 and 2012, with increased tree mortality and lack of periodic consumption by fire apparently compensating for the loss of inputs of large wood due to past logging. However, number of logs increased from 28 ha<sup>-1</sup> to 76 ha<sup>-1</sup> and average size declined substantially. Because larger-sized dead wood is preferred by many wildlife species, the current condition of more, smaller, and more decayed woody pieces may have a lower ratio of habitat value relative to potential fire hazard than it once did. Size, density, and stage of decomposition are therefore potentially better metrics for managing dead wood than mass and/or volume alone. To restore dead wood to conditions more like those found historically will require growing larger trees and reducing the inputs of dead wood from small and intermediate-sized trees. Fire, which preferentially consumes smaller and more rotten wood, would also help shift the balance to larger and less decayed pieces.

Published by Elsevier B.V.

## 1. Introduction

Dead trees play an important role in forests, both when standing as snags or on the ground as coarse woody debris (CWD). A substantial proportion of the bird and mammal biota found in temperate forest ecosystems use snags for nesting, denning, roosting, resting, or foraging (Harmon et al., 1986). Holes excavated in snags house both primary cavity nesting birds as well as secondary cavity nesting species which use or enlarge existing cavities (Raphael and White, 1984). Bats roost under the loose bark of snags (Rabe et al., 1998) and flying squirrels frequently choose snags as nest trees (Meyer et al., 2005). Snags are also a source of food, with bark beetles and wood boring insects comprising an important part of the diet of woodpeckers and other bird species (Raphael and White,

1984). Snag size is an indicator of habitat potential, with use by cavity nesting bird species greatest in snags >38 cm diameter (Raphael and White, 1984; Morrison and Raphael, 1993). However, smaller snags are a valuable resource for foraging. Raphael and White (1984) found that birds preferred to forage on snags between 23 and 53 cm dbh, but smaller and larger snags were also used.

Most snags remain standing 5 years after tree death but then begin to rapidly fall between the 5th and 15th years (Keen, 1955). Larger diameter snags with higher amounts of heartwood generally fall more slowly than smaller trees with less heartwood (Keen, 1955). Rate of snag fall varies by species, with fir snags remaining upright longer, on average, than pine (Raphael and White, 1984; Morrison and Raphael, 1993; Ritchie et al., 2013). Once lying on the ground, CWD continues to provide habitat (Harmon et al., 1986). Many mammals and amphibians use CWD for shelter (Harmon et al., 1986; Bull and Heater, 2000; Butts and McComb, 2000; Ucitel et al., 2003), and volume of CWD was found

\* Fax: +1 530 226 5091.

E-mail address: [eknapp@fs.fed.us](mailto:eknapp@fs.fed.us)

to be correlated to forest arthropod community structure (Ferrenberg et al., 2006). CWD also plays a role in forest nutrient cycling, and although the proportion of total nutrients stored in logs is often relatively small (Harmon et al., 1986; Laiho and Prescott, 2004), decomposing logs are linked to increased microbial activity (Busse, 1994).

Dry dead wood is also combustible and too much can contribute to extreme fire behavior. While larger diameter dead wood loses moisture slowly, climate in the western US is characterized by long periods with relatively little precipitation, and both snags and CWD are generally readily consumed in wildfires. Burning snags can loft embers, and the common management practice prior to the 1970s was to fell snags in order to reduce fire hazard (Show and Kotok, 1924; Oliver, 2002). Once on the ground, dry dead wood provides a receptive surface for embers to ignite. The long burnout time and amount of heat released from combustion in large woody fuels can lead to torching and crown fire (Brown et al., 2003). Large numbers of snags and down logs are an issue for management or control of fire and safety of firefighting personnel working in proximity (Page et al., 2013). Concerns have also been raised about the negative effects to soil resources when excessive amounts of CWD are burned (Monsanto and Agee, 2008).

This tension between dead wood as habitat and dead wood as fuel has raised the question of how much wood is appropriate in fire-dependent forested ecosystems (Brown et al., 2003; Ucitel et al., 2003; Lehmkuhl et al., 2007; Scheller et al., 2011; Ritchie et al., 2013). Because wood is readily consumed by fire, one likely consequence of fire exclusion in unlogged forests where fire was historically frequent is an excess of coarse woody debris (Skinner, 2002). This is particularly true for heavily rotted wood, which is most readily consumed by fire (Kauffman and Martin, 1989; Skinner, 2002; Stephens and Moghaddas, 2005; Uzoh and Skinner, 2009). Historically, frequent fire would have likely resulted in rotten wood being maintained at relatively low levels (Stephens and Moghaddas, 2005). Conversely, in previously logged stands, past removals can influence future inputs of dead wood. Fewer large snags and logs may now be present in many areas because historical cutting typically targeted larger trees (Stephens, 2004; Stephens et al., 2007).

Information on appropriate quantities of snags and CWD, from which management targets are developed, can be gleaned from studies of historical forests, prior to logging and fire exclusion (Keen, 1929, 1955), or from contemporary reference stands with relatively intact fire regimes (Stephens, 2004; Stephens et al., 2007). Unfortunately, such records are scarce, and even what is available may not be applicable to the many different forest types of the western US where fire was historically common. In the absence of good reference information, Harrod et al. (1998) estimated historical snag density in dry ponderosa pine forests using historical size distributions of live trees and making assumptions about rates of snag creation and fall.

In this paper, I use re-measurement of historical plots installed in the old-growth condition in 1929 to evaluate how past logging and fire exclusion have influenced the dynamics of snags and downed wood over time.

## 2. Methods

### 2.1. Study area

Three large (3.9–4.4 ha) plots were established in 1929 in unlogged old-growth mixed conifer stands on the Stanislaus National Forest in the central Sierra Nevada (Fig. 1 in Knapp et al., 2013). Plots were located on a gentle NW slope in mixed conifer forest at elevations ranging from 1740 to 1805 m. The site is highly productive, with deep and well-drained loam to gravelly loam soils

(Wintoner-Inville families complex) derived from granite or weathered from tuff breccia. Climate is Mediterranean, with the majority of the annual precipitation occurring during fall, winter, and spring, and more than half falling as snow. Fire was historically frequent in the study area, with a median return interval of 6 years (Knapp et al., 2013). The last fire occurred in 1889, 40 years prior to plot establishment. While some effects of fire exclusion were likely therefore already apparent in 1929, growth rate data from nearby plots (Stark, 1965) suggest that the majority of trees establishing due to the absence of fire would have been smaller than the minimum size cut-off used in this study (Knapp et al., 2013).

### 2.2. History

The 1929 plots were part of a network of “Methods of Cutting” plots established in different timber types and sites varying in productivity throughout national forests of California (Dunning, 1926), and are similar to plots established by U.S. Forest Service Research in other regions of the United States as early as 1909 (Moore et al., 2004). The three being studied here (hereafter designated as MC9, MC10 and MC11) were designed to “determine the growth rate and net growth, and to determine the rate of restocking after a light, a moderate and a heavy selection cutting” (Hasel et al., 1934). During the spring and early summer of 1929, locations of all trees within the plots with a diameter  $\geq 9.1$  cm at breast height were surveyed using a transit and steel tape according to instructions outlined by Dunning (1926). Species was noted, diameter at breast height (dbh) measured, and a stem map was produced (example shown in Fig. 2 of Knapp et al., 2013). Diameter of snags was only recorded for slightly more than half of MC11 and a portion of MC10, or approximately 33% of the total plot area. Because the methodology was consistent within these areas on the map, I assumed that some crews noted the diameter of snags and others did not, and that the values should be roughly representative of old-growth forest in the study area in 1929. Also mapped were large downed logs. Plots were then logged later the same year using three different methods. MC9 was marked for cutting according to standard USFS practice at the time (“USFS cut”), removing larger overstory trees of all species. MC10 was marked according to a “light economic selection” system, removing only the largest and highest value pines and leaving the other species. MC11 was marked with a “heavy cut”, removing all merchantable trees (see Hasel et al., 1934; Knapp et al., 2013 for additional details). Tree data were again collected in the fall of 1929, after logging.

### 2.3. Tree/snag re-measurement

Digitized 1929 plot maps were registered to location using data from plot corners determined with a global positioning system (GPS) with external antenna and later differentially corrected to obtain sub-meter accuracy. Boundaries were marked at two chain (40.2 m) intervals with a section of metal pipe in 1929 and most of these markers were still present. In the summer of 2007 and 2008, a field crew re-mapped the plots, measuring the diameter at breast height (dbh) of all trees  $\geq 10$  cm, determining the status (dead or live), and noting the species (Knapp et al., 2013). I combined data for ponderosa and Jeffrey pine in the 2007/2008 census, because Jeffrey pine is uncommon (5% of “yellow pines” in 2007/2008), and was either not present in 1929, or the two species were not differentiated.

### 2.4. Coarse woody debris

The original numerical data for downed logs could not be relocated and the number and size of logs was therefore reconstructed from the 1929 plot maps. All features, including logs, were drawn

Download English Version:

<https://daneshyari.com/en/article/86403>

Download Persian Version:

<https://daneshyari.com/article/86403>

[Daneshyari.com](https://daneshyari.com)