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Ponderosa pine snag dynamics and cavity excavation following wildfire in northern Arizona

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Abstract

Snags are important components of wildlife habitat, providing nesting and feeding sites for over 75 species of animals in the southwestern United States. Wildfires can increase or decrease the availability of snags to wildlife by killing live trees or incinerating snags. Our objectives were to describe dynamics and spatial patterns of fire-killed snags in ponderosa pine (*Pinus ponderosa*) forests of northern Arizona and predict the probability of snag use by cavity nesters. We established six 1-ha plots following two recent fires that occurred in northern Arizona (Hochderffer fire of 1996 [H96] and Pumpkin fire of 2000 [P00]) to determine ponderosa pine snag availability and use by wildlife as evidenced by presence of excavated cavities. For comparison, six paired 1-ha plots in nearby unburned areas were sampled with burned plots. For the twelve 1 ha plots, field methods included mapping and measuring 15 characteristics for 668 snags (630 in burned and 38 in unburned plots) 4 years post-fire on the H96 fire, and 1010 snags (996 in burned and 14 in unburned plots) 1 year post-fire on the P00 fire. We remeasured characteristics of all snags in 2003. Most burned snags were standing 3 years after fire, but 7 years after fire, 41% had fallen. Snags in burned plots were clumped when initially measured and remeasured. After 7 years, snags in burned plots that were still standing were straight, large diameter trees in denser clumps. Density of excavated cavities was similar between burned (3.0 ha^{-1}) and unburned (2.2 ha^{-1}) plots, even though burned areas produced much higher densities of snags. Snags (both burned and unburned) that were most likely to contain excavated cavities were large diameter with broken tops. This evidence of cavity nester use indicates that in ponderosa pine forests in the southwest, retaining large diameter snags is important to cavity nesters regardless of snag origin. If salvage logging is to occur in severely burned ponderosa pine in the southwest, retaining straight, large diameter snags in clumps will help maintain snags for cavity-excavating species.

Keywords: Cavities; Cavity-nesting birds; Ponderosa pine; Snags; Standing dead trees; Wildfire; Wildlife

1. Introduction

Snags provide nesting, roosting, feeding, loafing, and storage sites for many wildlife species in the southwest (Scott, 1979; Cunningham et al., 1980; Rabe et al., 1998). In Arizona and New Mexico, ponderosa

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pine (*Pinus ponderosa*) forests cover about 3.2 million ha (Klemmedson and Smith, 1979) and provide nesting habitat for more cavity-nesting species than any other forest type (Scott and Patton, 1989). Prior to 1870, tree densities were thought to average ~60 ha^{-1}, with forests experiencing low intensity but high frequency (e.g., every 4 years) fires. However, fire suppression, logging, and increases in livestock grazing have altered ponderosa pine forest structure and composition over the past century (Cooper, 1960; Cochran and Hopkins, 1991; Covington and Moore, 1994; Saab et al., 1995; Touchan et al., 1996; Grissino-Mayer and Swetnam, 2000). In many areas, density of live trees has increased (e.g., to >3000 trees ha^{-1} today) and average diameter of live trees has decreased (Covington et al., 1994; Mast et al., 1999). As a consequence, wildfires in forests of the southwest have been increasing in size and severity, particularly in the last 25 years (Swetnam and Baisan, 2003).

Wildfires vary in intensity across a landscape and can have both immediate and long-term impacts on snags and snag dynamics (decay and fall rate). Low intensity fires may have little effect on live trees, but may scorch and in some cases, incinerate snags (Gaines et al., 1958; Horton and Mannan, 1988; Boucher et al., 1999). Moderate and high intensity fires may scorch and kill live trees and incinerate snags (Harrington, 1996; McHugh and Kolb, 2003). Fires can therefore affect rates of snag formation, snag density, and distribution among snag size classes. In addition, fire may affect snags by charring boles. Charred snags may decay at slower rates than unburned snags, be more difficult to excavate for some cavity nesting species, and therefore may be less useful as a nesting resource (Gaines et al., 1958).

Many factors can influence wildlife use of snags, including tree species, diameter, height, density, and spatial dispersion. Most wildlife species select large diameter snags (≥34 cm diameter at breast height [dbh] in ponderosa pine) (Scott and Oldemeyer, 1983; Rabe et al., 1998; Saab and Dudley, 1998; Lehmkuhl et al., 2003; Ganey and Vojta, 2004). Less is known about selection for other characteristics. Fire alters characteristics of snags and likely affects use by cavity nesters (Saab and Dudley, 1998). Knowing which snags will remain standing longest and are most used by cavity nesters can provide guidance in snag management.

We documented ponderosa pine snag dynamics in northern Arizona from 1 to 7 years following two wildfires that occurred in 1996 and 2000. For each snag, we determined year of origin as live tree, year the tree died and became a snag, physical characteristics (e.g., height, diameter, decay condition, spatial arrangement), and wildlife use (signs of foraging, presence of excavated cavities). Our objectives were to (1) describe characteristics, spatial patterns, density, decay rates, and dynamics of fire-killed snags in ponderosa pine forests of northern Arizona, and (2) predict the probability of fire-killed snag use by cavity nesters based on snag characteristics.

2. Methods

2.1. Study sites

We selected two areas that had been recently burned by wildfire on the Coconino and Kaibab National Forests (NFs) located in northern Arizona, approximately 26 km northwest of Flagstaff, Arizona. These areas have a mean annual air temperature of 5–6 °C and a mean annual precipitation of 500–600 mm. A drought that occurs seasonally between April and June (Anonymous, 1995) increases probability of fire during that time. The Hochderffer fire (H96) burned about 6500 ha of ponderosa pine on the Coconino NF in June–July 1996. The Pumpkin fire (P00) burned about 5300 ha on the Coconino and Kaibab NFs in May–June 2000. Both fires varied in severity from low (surface) to severe (crown).

To evaluate snag dynamics, we compared snags in severely burned and unburned areas. Selected sites had: (1) high severity burn patches (>95% of trees killed by fire) with nearby or adjacent unburned patches, (2) >1 km between plot pairs, (3) similar terrain, elevation, and pre-fire tree densities, (4) unburned snag densities of ≥5 snags ha^{-1} (based on Ganey (1999) median snag density of 5 snags ha^{-1} in unburned ponderosa pine forest in northern Arizona), and (5) a range of snag diameter classes to determine effect of diameter on decay and fall rate. Sites were randomly chosen from those meeting the criteria. Plots were paired, with one plot in ponderosa pine burned by wildfire and the second plot located in unburned forest <0.8 km from its pair. We placed three pairs of plots in