The longevity of large pine snags in eastern Texas

Richard N. Conner and Daniel Saenz

Abstract Habitat for cavity-nesting wildlife is closely tied to the availability of standing dead trees (snags). Large snags (>40 cm dbh) are particularly important because they provide cavity-excavation substrate for both large and small cavity excavators. Historically in the southern United States, common belief has been that the utility of pine (*Pinus* spp.) snags for cavity nesters occurs for only a short period of time after tree death because pine snags quickly decay and fall to the ground. We studied the deterioration rate and ultimate falling of large pine snags in eastern Texas over a 20-year period (1983–2003). Coinciding with our annual checks of red-cockaded woodpecker (*Picoides borealis*) cavity-tree clusters, we checked the status and height of all red-cockaded woodpecker cavity trees that died. We determined the cause of death and tree species of 136 cavity tree snags ($\bar{x}$=25.4 m at death) and monitored their height annually until they were <1 m in height. Five years after tree death, 92 snags (67.6%) were still standing and averaged 13.9 m in height. Ten years after tree death, 21 snags (15.4%) were still standing and averaged 10.0 m in height. After 15 years 4 snags (2.9%) averaging 5.3 m in height still remained standing. Two snags (1.5%), averaging 2.7 m in height, survived through 19 years but had fallen by the end of the twentieth year. Pines dying from wind snap at mid-bole survived longer as snags ($\bar{x}$=9.7 years) than pines killed by bark-beetles (*Dendroctonus* spp.) ($\bar{x}$= 5.9 years). Longleaf pine (*Pinus palustris*) snags remained standing longer ($\bar{x}$=8.0 years) than loblolly pine (*P. taeda*) snags ($\bar{x}$=6.0 years) ($P<0.05$), but not longer ($P>0.05$) than shortleaf pine (*P. echinata*) snags ($\bar{x}$=6.6 years).

Key words cavity nesters, *Picoides borealis*, pine, red-cockaded woodpecker, snags, wildlife

The use of snags (standing dead trees) by many wildlife species has been documented in many studies (Conner 1978, Raphael and White 1984, DeGraaf and Shigo 1985). In the coastal plain of the southeastern United States, snags provide habitat for more than 19 species of cavity-nesting birds (Hamel 1992), 11 species of mammals (Hamilton 1943), and 23 species of amphibians and reptiles (Martof et al. 1980). Large snags (>40 cm dbh) are particularly important for large cavity nesters such as pileated woodpeckers (*Dryocopus pileatus*) (Conner et al. 1975, Bull and Holthausen 1993, McClelland and McClelland 1999).

Red-cockaded woodpeckers (*Picoides borealis*) excavate cavities in old, living pines with heartwood decay (Conner et al. 2001). Unlike many other woodpeckers closely associated with hardwood trees (Shackelford and Conner 1997), this endangered woodpecker seems intolerant of hardwood midstory (United States Fish and Wildlife Service [USFWS] 2003) and prefers regularly burned, open pine savannah with a diverse grass-forb herbaceous layer (Conner et al. 2001). More than 30 vertebrate and invertebrate species

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use red-cockaded woodpecker cavities (Conner et al. 1997*a*, *b*). When red-cockaded woodpecker cavity trees die, usually as the result of wind snap or bark-beetle (*Dendroctonus* spp.) infestation (Conner et al. 1991, Conner and Rudolph 1995), red-cockaded woodpecker use dwindles rapidly, but use by other species continues.

Few studies have examined snag longevity. Dickson et al. (1995) and Cain (1996) examined the longevity of hardwood snags killed by herbicide injection in eastern Texas and Arkansas, respectively. In both the above studies and in Morrison and Raphael (1993), large-diameter snags (>38 cm) lasted longer than small-diameter snags (<38 cm), and half of the hardwood snags were still standing after 5 years (see also Dickson et al. 1983). In other studies half the lodgepole pines (*Pinus contorta*) killed by fire in Montana remained standing for 8 years (Lyon 1977), whereas half of the ponderosa pine (*P. ponderosa*) snags killed by fire in the Pacific Northwest lasted 10 years, with 25% still remaining after 20 years (Dahms 1949). High winds appeared to accelerate the falling rate of ponderosa pine snags (Schmid et al. 1985). Morrison and Raphael (1993) noted that pine snags fell more quickly than fir (*Abies* spp.) snags. Pine snags in the dry West are likely to remain standing longer than pine snags in the South because of differences in humidity, temperature, and resulting high rate of fungal decay in the South. There is minimal information on longevity of pine snags in the South. Moorman et al. (1999) examined snag dynamics in the South Carolina Piedmont and suggested that snag longevity was independent of diameter class but did not examine large diameter pines. They also observed that only 4% of pine snags averaging 22.1 cm dbh remained standing after 6 years.

We studied the longevity of large pine snags (>38 cm dbh) in eastern Texas using snags created by the natural death of red-cockaded woodpecker cavity trees over a 20-year period. Because dead red-cockaded woodpecker cavity trees were not protected from prescribed fire, we believe their fall rate should be the same as other similarly sized snags. The infection rate of fungal heartwood decay in the snags we studied likely was similar to the rates of infection in live cavity trees. Heartwood decay in loblolly (*Pinus taeda*) and shortleaf pine (*Pinus echinata*) cavity trees is approximately twice that observed in longleaf pine (*Pinus palustris*) cavity trees (Conner and Locke 1982) and may increase falling rates for pine species with a higher frequency of decay. We asked the following questions: 1) How long do large pine snags in southern pine forests remain standing? 2) Does cause of death affect snag longevity? 3) Does pine species affect snag longevity? and 4) Does cause of death affect longevity of pine species differentially?

The red-cockaded woodpecker excavates cavities in live pines in the southeastern United States. When these pines die, they provide cavity sites for many secondary cavity users.

Study area and methods

We examined all active and inactive red-cockaded woodpecker cavity trees in longleaf and loblolly–shortleaf pine forests annually during spring (March through April) on the Angelina National Forest (31°15′N, 94°15′W) in eastern Texas from 1983 through 2003. During this 20-year study, the cause of death (Conner et al. 1991) was determined for 136 red-cockaded woodpecker cavity trees. Death of cavity trees primarily resulted from bark-beetle infestation (n=85) and wind snap (n=19) (Conner et al. 1991, Conner and Rudolph 1995).

Figure 1. The percentage of large pine snags (dead red-cockaded woodpecker cavity trees) standing versus year post-death in eastern Texas between 1983 and 2003.

Other causes of cavity-tree death included lightning ($n = 11$), suppression ($n = 7$), fire ($n = 2$), and unknown ($n = 12$). Coinciding with our annual status checks of all live red-cockaded woodpecker cavity trees, we checked the status (standing or fallen) and height of these snags each spring throughout the 20-year study. The time period measuring the longevity of each pine snag was initiated in the year the cavity tree died. Thus, some snags created by pine death during the 20-year study were still standing when the 20-year study ended, suggesting the possibility that actual longevity as presented in Figure 1 may be underestimated. We did not determine the wildlife species using snags during the course of the study because of logistical constraints.

We used a 2-way ANOVA (type III sum of squares) with interaction to examine the influence of cause of death and pine species on snag longevity. Only snags that had fallen completely during the 20-year study were included in this analysis. We used a Tukey's test to evaluate snag-longevity differences among pine species.

Results

Some large snags created by dying red-cockaded woodpecker cavity trees remained standing for nearly 20 years (Figures 1 and 2). At the time of their death, the cavity trees averaged 49 cm (±0.9 SE) dbh, 25.4 m (±0.4) in height, and had a mean bole length (height above ground to first major branch) of 16 m (±0.5). Five years after dying, 67.6% (92 of 136) snags were still standing and averaged 13.9 m in height (Figures 1 and 2). At 10 years post-tree death, 15.4% (21 of 136) of the snags remained standing and averaged 10.0 m in height. After 15 years only 2.9% (4 of 136) of the snags remained standing and averaged 5.3 m in height. Two snags (1.5%), averaging 2.7 m in height, survived through 19 years but had fallen by the end of the twentieth year (Figure 1).

Cause of pine death appeared to influence snag longevity (Figure 3). Pines dying from wind snap at mid-bole survived longer as snags (9.70 yrs ±1.52) than pines killed by bark-beetles (5.85 yrs ±0.38) ($F_{1,45} = 13.89$, $P < 0.001$). Pine species also influenced snag longevity (Figure 4). Longleaf pine snags remained standing significantly longer (8.0 yrs ±0.70) than loblolly pine snags (6.0 yrs ±0.43), but not significantly longer than shortleaf pine snags (6.6 yrs ±0.45) ($F_{2,45} = 5.27$, $P = 0.009$). Longevity of different pine species of snags was not related to cause of death; the interaction between cause of death and pine species was not significant ($F_{2,45} = 0.96$, $P = 0.389$).

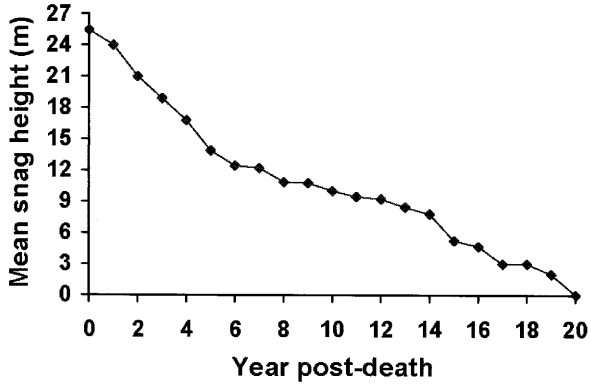

Figure 2. The average height of large pine snags (dead red-cockaded woodpecker cavity trees) that were still standing versus year post-death in eastern Texas between 1983 and 2003.

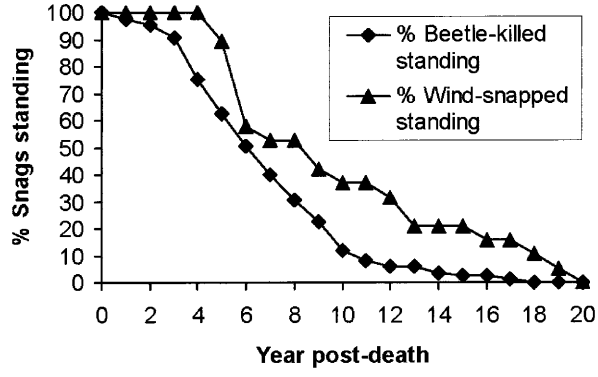

Figure 3. The longevity of large pine snags (dead red-cockaded woodpecker cavity trees) relative to cause of death by bark-beetles and wind snap in eastern Texas between 1983 and 2003.

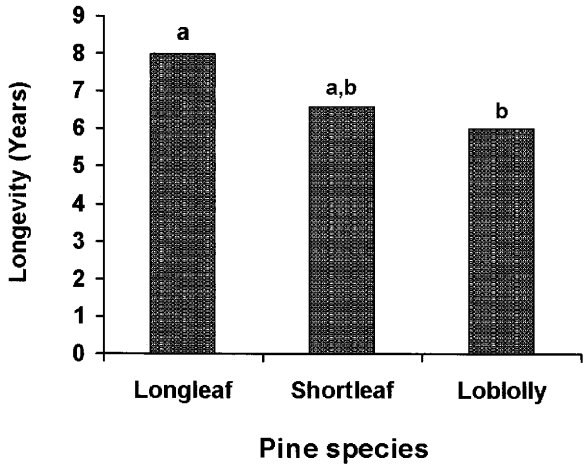

Figure 4. The longevity of large pine snags (dead red-cockaded woodpecker cavity trees) relative to pine species in eastern Texas between 1983 and 2003. Common letters above bars indicate nonsignificant differences (Tukey's test, $P < 0.05$).

Discussion and conclusions

The longevity of the pine snags we studied in eastern Texas was slightly less than that observed by other researchers in western states, but substantially longer than the longevity observed in South Carolina (Moorman et al. 1999). This was not surprising, because the diameter of pines we studied in Texas ($\bar{x}$=49.0 cm dbh) was much greater than those studied in South Carolina ($\bar{x}$=22.1 cm dbh). Lyon (1977) noted that half the lodgepole pine snags he studied remained standing for 8 years after tree death, and half the ponderosa pine snags in the Pacific Northwest lasted 10 years (Dahms 1949). Similar snag-falling rates were observed by Keen (1955) in ponderosa pines killed by bark-beetles in California. Thus, higher temperatures and humidity in the South may not have had a great influence on pine snag longevity. Longevity of hardwood snags in eastern Texas and Arkansas was similar to what we observed in pine snags in eastern Texas; half of the hardwood snags examined were still standing after 5 years (Dickson et al. 1995, Cain 1996).

We suspected that longleaf pine snags remained standing longer than loblolly and shortleaf pine snags because of the cause of cavity-tree death. Loblolly and shortleaf pine cavity trees died primarily as a result of bark-beetle attack, whereas wind snap and fire were the primary causes of longleaf pine cavity-tree death (Conner et al. 1991, Conner and Rudolph 1995). Bark-beetle attack is known to carry many species of fungi relatively deep into the pine stem during infestations, likely accelerating the rate of decay and eventual falling (Barras 1970, Klepzig and Wilkens 1997, Klepzig 1998). Fungi are not inoculated into pines when death has resulted from wind snap or fire. However, accelerated decay after bark-beetle infestation may not be the reason longleaf pine cavity-tree snags remained standing longer than loblolly and shortleaf pines, or why cavity trees dying from bark-beetle attack fell quicker than those dying from wind snap. We found no interaction between cause of death and tree species in our analysis. An alternative explanation for differential falling rates among pine species was the presence or absence of red heart fungus (*Phellinus pini*) heartwood decay. Large pines that serve as red-cockaded woodpecker cavity trees in eastern Texas have different rates of heartwood decay depending on species. The frequency of heartwood decay in longleaf pine cavity-trees (47%) was much less than in loblolly and shortleaf pines (100% and 87%, respectively) (Conner and Locke 1982), which possibly explains why longleaf pine snags remained standing longer than the other pine species.

Bull et al. (1981) used explosives to create snags in ponderosa pines similar to those created by wind snap. Bull and Partridge (1986) compared snag longevity created by topping with a chainsaw, explosives, herbicide, girdling, and pheromone application to attract bark-beetles and reported that ponderosa pines with their tops removed remained standing longer than snags created by other mortality methods that left tree tops intact, likely because they had less "sail" area for wind action. As observed by Conner et al. (1981), snags created with herbicides in the Bull and Partridge (1986) study fell relatively soon because the bark was split open by the mortality agent, permitting fungal access.

Our data suggested a long-term benefit to cavity nesters from management that retains large pine snags in mixed pine-hardwood forests of the South. Our anecdotal observations indicated that all species observed using the red-cockaded woodpecker cavities when the pines were still alive (Conner et al. 1997*b*) continued to use the cavities for at least several years after the pines died. Such snags were not lost quickly, and some were available for numerous species of wildlife to use for as long as 10-20 years (Dennis 1971, Rudolph et al. 1990, Kappes and Harris 1995, Conner et al. 1997*b*). Although our data were collected only in eastern Texas, our results likely apply to other

national forests throughout the South, particularly those managed for red-cockaded woodpeckers, because all national forests use the same habitat management plan for this species. Our results are less likely to apply to private forests, where pines are harvested at much younger ages and fire regimes are different or nonexistent.

Conner (1978) and Evans and Conner (1979) estimated that 24 large snags were required per 40 ha to support healthy populations of pileated woodpeckers. Our data suggested that half of the large snags created in 1 cohort would fall in 6 years (Figure 1). Assuming that 30 large snags initially were present and management for pileated woodpeckers was desired in an area, at least 12 new large snags would have to be created every 6 years to maintain a running average of 24 snags per 40 ha.

Protection of large snags from fire in pine–hardwood stands would likely extend their life expectancy for wildlife use. However, the longevity of large snags, similar to those we studied, likely would have been less in natural southern pine ecosystems of the past. The snags in our study were only subjected to low-intensity winter burns. Snags in the pine uplands of eastern Texas can be destroyed by fire when they occur during dry periods (Conner 1981). Unlike present-day prescribed fires, typically lit during winter, natural fires in upland pine stands ignited by lightning and American Indians burned frequently and primarily during dry periods (Bonnicksen 2000). Frequent ground fires that occurred during dry periods probably were very hot but of low profile. Fires would have destroyed many of the snags similar to those we studied but likely would not have been hot enough to kill live pines to create new snags.

Conner et al. (2001) and Saenz et al. (2002) suggested that natural fire had a substantial negative impact on the availability of snags in southern pine ecosystems during pre-Columbian times. They suggested that frequent ground fires made snags so rare historically that red-cockaded woodpeckers were a keystone species because they provided most of the cavities in the upland pine communities by excavating cavities in living pines. Prescribed fires of modern times that occur primarily during cooler and wetter periods likely have increased the number of snags across the pine uplands because the fire is unable to ignite large snags during cool-wet conditions. Thus, the presence, absence, intensity, and timing of fire in modern forests can have a profound effect on tree-species composition, snag availability and longevity, and the cavity-nesting community. If managers desire large snags in frequently burned pine stands, a steady supply of large pines may be needed, and use of techniques to create snags (Bull et al. 1981, Bull and Partridge 1986) may have to be used. However, such conditions may be atypical of the frequently burned natural upland pine forests of the historic South.

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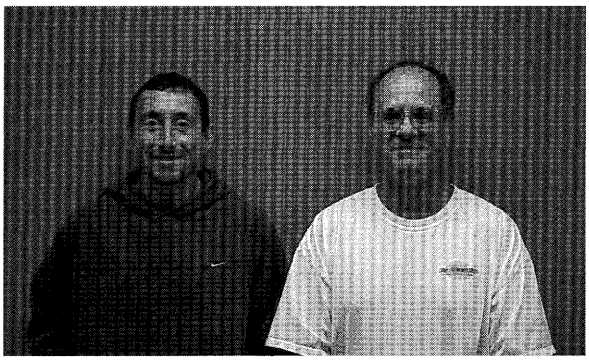

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