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Extent of *Phellinus pini* decay in loblolly pines and red-cockaded woodpecker cavity trees in eastern Texas

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Conner, R. N., D. Saenz, D. C. Rudolph, & R. R. Schaefer. (Wildlife Habitat and Silviculture Laboratory, Southern Research Station, Nacogdoches, TX 75965-3556, U.S.A.). Extent of *Phellinus pini* decay in loblolly pines and red-cockaded woodpecker cavity trees in eastern Texas. Memoirs of The New York Botanical Garden 89: 315–321, 2004.—To determine the prevalence of *Phellinus pini* in pines generally and red-cockaded woodpecker cavity trees specifically, we dissected 24 loblolly pines (*Pinus taeda*) with visible sporophores located in the Davy Crockett National Forest, eastern Texas, and determined the vertical dimensions and diameter of the *Phellinus pini* decay column within the heartwood. The loblolly pines, which were dissected at 1-m intervals, averaged 28.6 m in height, 30.5 cm dbh, and 52 y of age. The decay column within these pines extended from an average of 0.2 m to an average of 11.1 m above the ground and attained an average maximum diameter of 13.3 cm. Sixteen red-cockaded woodpecker (*Picoides borealis*) cavity trees (loblolly and shortleaf, *Pinus echinata*, pines which averaged 29.5 m in height, 48.6 cm dbh, and 99.9 y of age) that were blown over during a windstorm on the Sabine National Forest in eastern Texas were also dissected to determine length and position of the decay column and its diameter at the woodpecker cavity site. Woodpecker cavity excavation sites were closely associated with fungal sporophores. The decay column in red-cockaded woodpecker cavity trees, which extended an average of 4.2 m to an average 16 m above the ground, extended 4.2 m above and 7.6 m below the woodpecker cavity and averaged 15.5 cm in diameter at the cavity. Our results suggest that at least 15 years are required post inoculation for sporophore formation to commence and before a sufficient diameter of heartwood has been decayed to physically house a red-cockaded woodpecker cavity.

KEY WORDS: decay column, loblolly pine, longleaf pine, *Phellinus pini, Pinus taeda, Pinus echinata,* red-cockaded woodpecker, red heart fungus

Red-cockaded woodpeckers (*Picoides borealis* Vieillot) are a cooperatively breeding species endemic to the southeastern United States (Conner et al., 2001). The evolution of a cooperative breeding system in this endangered woodpecker appears to have been primarily driven by a critical shortage of cavities in which newly formed pairs could breed (Conner & Rudolph, 1995; Walters, 1990; Walters et al., 1988). Red-cockaded woodpeckers are relatively small woodpeckers and depending on the species of pine, excavation of completed cavities in the living pines they use for nest and roost sites averages from 2 to 6 years (Conner & Rudolph, 1995). Thus, cavities excavated by a breeding pair of red-cockaded woodpeckers (Fig. 1) are typically used for nesting by multiple generations of their offspring (Conner et al., 2001).

Many species of North American woodpeckers are dependent on species of fungi that decay and soften the heartwood (dead xylem tissue), particularly in hardwoods, which permits and/or facilitates woodpecker excavation of nest and roost cavities (Conner et al., 1976). The red-cockaded woodpecker primarily selects living pines (*Pinus* spp.) with red heart fungus (*Phellinus pini* (Thore ex Fr.) A. Ames) decay within the heartwood for nest and roost cavity excavation (Conner & Locke, 1982; Hooper et al., 1991; Jackson, 1977; Steirly, 1957). The extent of the decay column created by red heart fungus oxidation of heartwood xylem tissue in red-cockaded woodpecker cavity trees is not well known (Conner et al., 2001). Red-cockaded woodpeckers are known to be able to select a portion of the pine where red heart fungal decay is

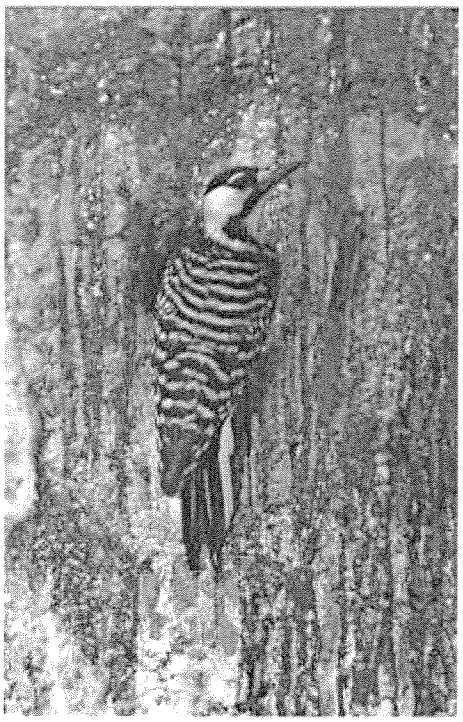

FIG. 1. A red-cockaded woodpecker (*Picoides borealis*) at its nest cavity in a longleaf pine in eastern Texas (Photo by Terry R. Steele).

well established (Conner & Locke, 1982; Hooper et al., 1991). However, they are known to excavate a cavity in living pines totally devoid of fungal decay (Conner & Locke, 1982; Conner et al., 2001). Cavities excavated by these woodpeckers into pines with a red heart fungal decay column take significantly less time to excavate than cavities excavated into pines totally lacking decay (Conner et al., 1994).

In order to investigate the extent of decay that occurs in pines in general and those selected by red-cockaded woodpeckers for cavity excavation specifically, we harvested and dissected 24 loblolly pines (*Pinus taeda* L.) with visible *Phellinus pini* sporophores on their boles. We also dissected and examined 16 loblolly and shortleaf pine (*Pinus echinata* Mill.) trees that had been blown over during a wind shear event to determine the extent of the decay column in pines actually containing a red-cockaded woodpecker cavity.

Study Areas and Methods

We obtained permission from the National Forests and Grasslands, Texas, March 1995, to harvest and dissect 24 loblolly pines with visible *Phellinus pini* sporophores on their boles located on the Davy Crockett National Forest. In April 1998 we obtained their permission again, as well as U.S. Fish and Wildlife Service permits, to dissect and examine 16 red-cockaded woodpecker loblolly and shortleaf pine cavity trees on the Sabine National Forest that had been blown over during a severe landscape-level wind shear event that occurred on 11 February 1998.

Each of the 24 loblolly pines on the Davy Crockett National Forest was felled during March 1995 with a chainsaw after measuring diameter at breast height (dbh, 1.3 m above ground level) and recording the compass aspect of any visible fungal sporophores on each pine's bole. With the tree on the ground, we measured total tree height and bole length with a metal tape and counted growth rings at breast height to determine tree age (number of rings plus 3 years). Starting at the base of each pine, an 8-cm thick cross section of the bole was cut out at 1-m increments upward until the fungal decay column was no longer visible. An 8-cm section was also removed at each site where a sporophore was present and the height of the sporophore recorded. Using the removed cross sections of wood, the diameter of the decay column was measured at each 1-m increment and at the sites where a sporophore was present. The maximum height of the decay column was determined by cutting cross-sections of the bole in the direction of the crown until no decay was detected within the highest 0.1-m increment on each pine bole. We examined the pines carefully at all sporophore locations and elsewhere on the bole to determine the location where the fungus most likely entered the tree. All locations where sporophores were present were vertically sectioned through the conk with a chainsaw to examine wood structure and branching in the area where the sporophore was formed. Sporophores were sectioned with a razor and growth annuli counted. We also randomly selected 100 pines from the forest stand where the 24 loblolly pines were harvested, and used an increment borer to extract a core of heartwood at breast height to see if fungal decay was present. Basal area of this stand at 1.3 m above the ground was measured with a 1-factor metric basal area prism.

Sixteen red-cockaded woodpecker cavity trees (7 loblolly pines and 9 shortleaf pines) were sectioned with a chainsaw during April 1998. Initially, a section of the

bole containing the cavity was removed to determine the diameter of the decay column at the cavity. The height of the cavity entrance above the ground and the diameter of the bole at the cavity entrance were measured. Portions of the pine's bole both above and below the cavity were then progressively removed to determine how far the decay column extended above and below the woodpecker cavity. Tree height and dbh were also measured and the presence or absence of sporophores noted. If a sporophore was present, its height on the bole was measured. Cavity trees were cross-sectioned at 1.3 m to determine their age (number of rings plus 3).

Results

The 24 loblolly pines on the Davy Crockett National Forest averaged 28.6 ± 2.8 m (mean ± SD) in height, 30.5 ± 7.2 cm dbh, 52 ± 5.0 years of age, and had 1 to 4 (1.5 ± 0.8) sporophores fruiting on their boles. Basal area at 1.3 m height for this forest stand averaged 20.1 m^2/ha. Given their relatively young age, the loblolly pines contained more extensive columns of decay than we had expected (Fig. 2). Decayed xylem columns in these pines extended from a mean height of 0.2 ± 0.4 m to 11.1 ± 1.8 m above the ground and attained an average maximum diameter of 13.3 ± 3.0 cm. Often, decay in the heartwood appeared to extend down below ground level, but we could not cut sections of the pine to determine how far below the ground level the decay column extended. All 24 of these pines exhibited decay at breast height (1.3 m). In all instances where a determination could be made, *Phellinus pini* appeared to have gained access to the heartwood of the pine through a dead branch stub and all sporophores were produced where branch stubs traversed from the heartwood through the sapwood to the outer surface of the bole (Fig. 3). Sporophores averaged 3.9 ± 2.0 m above the ground. Close examination of broken branch stubs associated with sporophores indicated that approximately 27 tree growth rings (spring and summer wood counted as one ring) were added to the tree's diameter after the branch stub had formed (Fig. 3). Thus, the loblolly pines appear to have been about 25 y old when the fungus first infected the pines.

We were able to count growth annuli on sporophores of 20 of the 24 loblolly pines. Fungal sporophore ages ranged from 3 to 11 y old and averaged 5.5 ± 3.5 y old. However, we had harvested sporophores from some of the pines in this stand in 1989 for another study (Rudolph et al., 1995) suggesting that the mean sporophore age we determined in this present study may be an underestimate of what sporophore age would have been had none been previously harvested. Based on the sizes of the sporophores collected in 1989, most were likely 5 to 7 y old.

Of the 100 pines randomly selected from the forest stand for heartwood examination with an increment core at 1.3 m, only 3 pines showed evidence of heartwood decay at that height. Most of these pines did not have sporophores visible on their boles. These pines were not harvested for a more detailed examination.

The decay column in red-cockaded woodpecker cavity trees (mean age = 99.9 ± 22.8 y) was also approximately 11 m in length, but did not come in close proximity to the ground (Fig. 4). In cavity trees, the lowest portion of the decay column averaged 4.2 ± 4.5 m above the ground. Red-cockaded woodpecker cavities averaged 11.8 ± 2.7 m above the ground and decay extended an average of 4.2 ± 2.1 m above and 7.6 ± 4.3 m below the cavities. The decay column at woodpecker cavities averaged 15.5 ± 6.8 cm in diameter. Sporophores were visible on 13 of the 16 cavity trees at an average height of 12.0 ± 3.5 m. Woodpeckers typically excavated cavities at approximately the same height as the sporophores (11.8 m cavity height versus 12.0 m sporophore height). Cavities were often immediately beneath a sporophore and were never excavated immediately above a sporophore.

Discussion

How red-cockaded woodpeckers locate decay within the boles of pines is poorly understood. Conner et al. (1976) suggested that other woodpecker species that excavate cavities in hardwoods might find decayed heartwood within tree trunks by percussing the bole and listening for a particular resonance. The sapwood of hardwoods is much thinner than that of pines, so this method of detection may not be available for red-cockaded woodpeckers. The close proximity of red-cockaded woodpecker cavities to red heart sporophores suggests the possibility that the woodpeckers may be using the fungal conks as a visual cue. Rudolph et al. (1995) attempted to test this hypothesis by nailing *Phellinus pini* conks to the boles of pines lacking heartwood decay in an effort to induce woodpeckers to initiate cavity excavation. They found that the attached sporophores were not a sufficient stimulus to elicit excavation behavior.

Cavity chambers of red-cockaded woodpeckers average 11.2 cm in diameter and pines must contain at least that diameter of heartwood tissue to physically

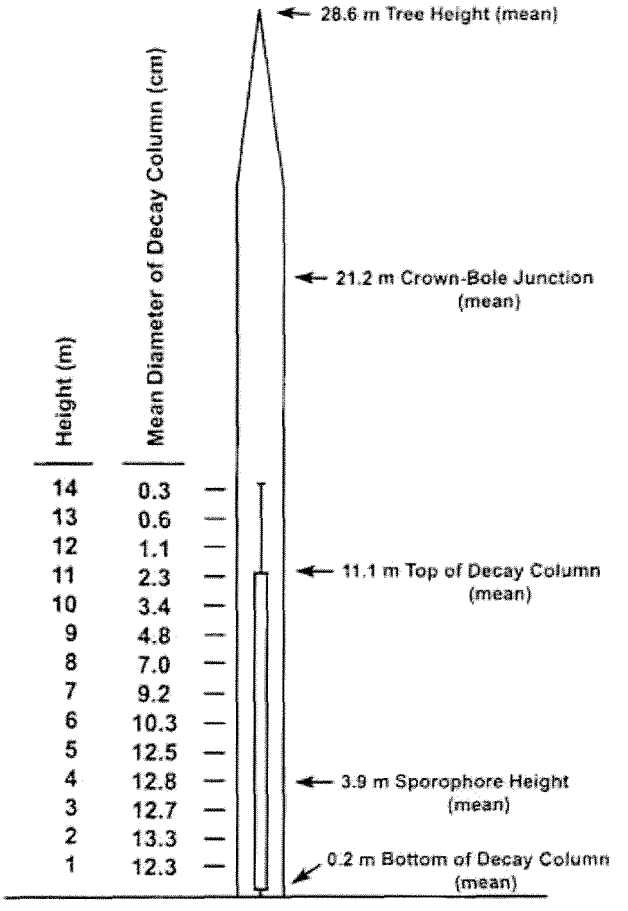

FIG. 2. Schematic diagram of the characteristics of *Phellinus pini* decay within relatively young (52 y) loblolly pines on the Davy Crockett National Forest in eastern Texas. The relatively low position of the decay column within the pine bole suggests that decay began in the pines at a fairly young age. Lines extending above and below the decay column means represent the maximum range of decay detected within the pines.

house a woodpecker cavity (Conner et al., 2001). Thus, the diameter of the decay column in the cavity trees (15.5 cm) was of sufficient diameter to provide easy excavation of complete cavity chambers. The average 13.3 cm diameter of decayed heartwood in the 24 loblolly pines that averaged 52 y of age indicates that in some circumstances *Phellinus pini* can enter loblolly pines early and cause decay of extensive amounts of heartwood tissue. However, the height of the wider portions of the decay column in these loblolly pines was lower than the average heights of red-cockaded woodpecker cavities, suggesting that the pines may have been too young to be of much benefit to woodpeckers. Red-cockaded woodpeckers typically excavate cavities into older pines (70–100 y in loblolly pines) at 6 to 25 m above the ground (Conner et al., 2001). Thus, the 24 loblolly pines we examined would likely be rejected as potential cavity sites by the woodpeckers because the region of the bole with extensive decay was too low.

The presence of sufficient red heart decay is one of the factors limiting Red-cockaded Woodpeckers to older trees for cavity excavation (Conner et al., 1994).

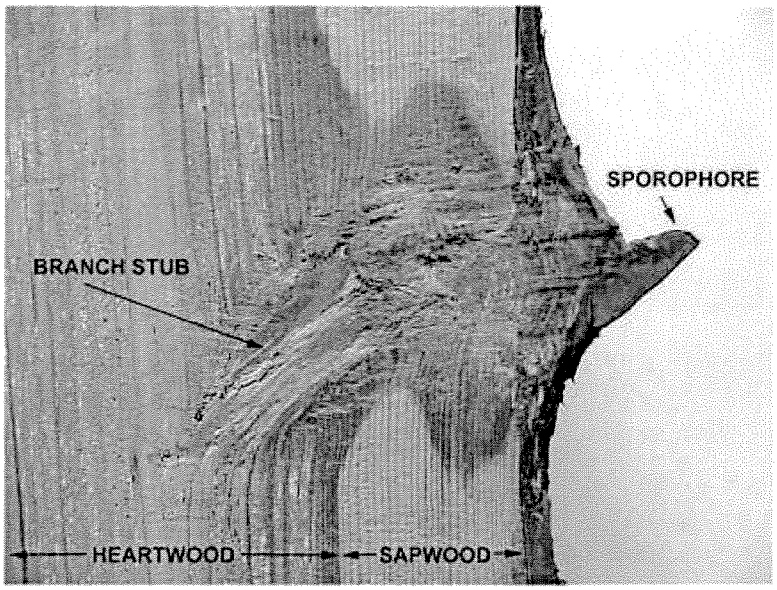

FIG. 3. Vertical section of a loblolly pine showing the association of a *Phellinus pini* sporophore with a dead branch stub, the decayed heartwood, and the undecayed sapwood.

The stand from which the 52 year-old loblolly pines were harvested, first came to our attention as a stand with abundant signs of red heart decay at an unusually young age. Our subsequent examinations of selected trees with red heart sporophores confirmed substantial amounts of decay in these pines. It is likely that pine species, tree spacing, and growth conditions all influence the incidence and age of infection by red heart fungus. Red heart fungal decay in Texas longleaf pines (*Pinus palustris* Mill.) was not common until pines exceeded 120 years old (Conner et al., 1994). Combined with the above observations on the insufficient extent of decay at average Red-cockaded Woodpecker cavity height in the young loblolly pines, the necessity of older trees for cavity excavation is clear. Fifty-two years is approximately the age of the youngest cavity trees reported in an extensive survey of cavity tree ages in Texas (Rudolph and Conner, 1991). Average tree age and incidence of red heart infection in Red-cockaded Woodpecker cavity trees in Texas suggest that adequate pines several decades older than these minimums are required for Red-cockaded Woodpeckers to excavate cavities at a rate sufficient to replace losses (Conner et al., 1994; Rudolph and Conner, 1991).

Our results may provide some insight into the length of time from when pines become first infected with *Phellinus pini* to when the first sporophores appear. Seeds of the pines in the stand likely germinated around 1943. In 1968 broken branch stubs had formed on the lower boles of the pines and permitted fungal spores access to heartwood tissue. If the sporophores first collected in 1989 were 5 to 7 years old, red heart fungus grew within the heartwood of the pines for at least 15 years before sporophore growth first commenced. Based on the within tree growth rate of *Phellinus pini* that had been experimentally inoculated into 28 y old loblolly pines, Conner and Locke (1983) estimated that it could take as long as 12 years for *Phellinus pini* to sufficiently decay the heartwood of pines to physically house a completed red-cockaded woodpecker cavity. Thus, the appearance of a sporophore on the bole of a pine may serve as a partial indicator to red-cockaded woodpeckers that sufficient heartwood decay has occurred to facilitate cavity excavation. Since our dissections of pines with red heart fungus indicate that the largest diameter of the decay column is found at the region of the bole closest to the sporophore, red-cockaded woodpecker excavation of cavities immediately under sporophores would place

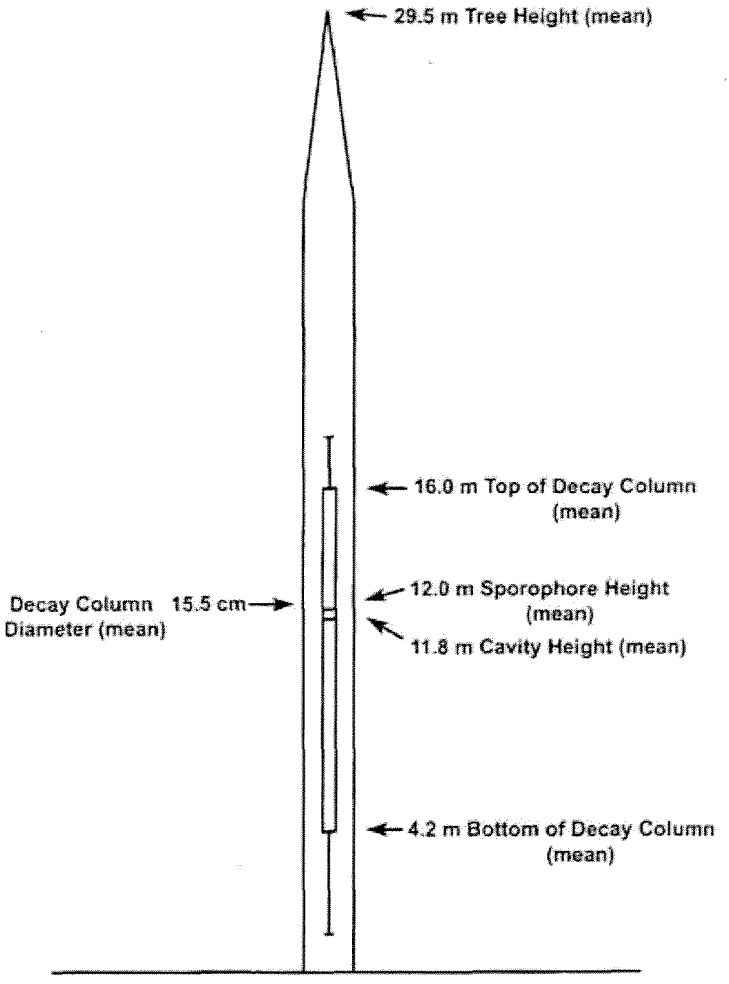

FIG. 4. Schematic diagram of the *Phellinus pini* decay column present within loblolly and shortleaf pine red-cockaded woodpecker cavity trees averaging 99.9 y of age on the Sabine National Forest in eastern Texas. Lines extending above and below the decay column means represent the maximum range of decay detected within the cavity trees.

the cavities in the portion of the bole with the greatest decay column diameter.

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determine what species of fungi were causing the decay 30 years ago.

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