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WOODPECKER EXCAVATION AND USE OF CAVITIES IN POLYSTYRENE SNAGS

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ABSTRACT.—We examined woodpecker excavation and use of artificial polystyrene snags in four forest types in eastern Texas for five years. Twenty-three of 47 artificial snags were used by Downy Woodpeckers (*Picoides pubescens*) for cavity excavation and subsequent nocturnal roosting; they did not use the artificial snags for nesting. Although six other species of woodpeckers were present in the area, only Downy Woodpeckers excavated cavities in the artificial cavity substrate. Entrances to cavities in artificial snags became enlarged within several months of excavation. Other wildlife species using abandoned cavities in artificial snags were Carolina Chickadees (*Parus carolinensis*), Prothonotary Warblers (*Protonotaria citrea*), southern flying squirrels (*Glaucomys volans*), and red wasps (*Polistes* sp.). In one instance, Carolina Chickadees excavated their own cavity and nested within a polystyrene snag. Until an artificial cavity substrate acceptable for both woodpecker excavation and nesting can be found, the utility of artificial snags as a means to augment woodpecker nesting substrate remains inadequate. *Received 18 October 1995, accepted 16 January 1996.*

Many woodpecker species and secondary cavity nesters depend on snags (standing dead trees) for cavity sites that they use for nesting and roosting (Conner 1978, Evans and Conner 1979, Thomas et al. 1979, Raphael and White 1984). Harvesting of mature forests can greatly reduce the availability of substrate for woodpeckers to excavate nest cavities (Conner 1978, Dickson et al. 1983). Thus, artificial cavity substrate may benefit nesting woodpeckers in areas where snag availability is low.

Peterson and Grubb (1983) evaluated woodpecker use of 50 artificial polystyrene snags (242-cm high × 22-cm diameter) over an 11-month period in Ohio. Downy Woodpeckers (*Picoides pubescens*) excavated 51 cavities in 42 of the snags, used them for nocturnal roosting, but failed to use the cavities for nesting. House Wrens (*Troglodytes aedon*) and Carolina Chickadees (*Parus carolinensis*) nested in cavities excavated by Downy Woodpeckers. Peterson and Grubb (1983) speculated that other larger species of woodpeckers might use polystyrene snags if snags >22-cm diameter were provided, but this idea has never been tested. Artificial polystyrene snags have also been used to explore sexual differences in selection of cavity sites by Downy Woodpeckers and to evaluate cavity entrance orientation and snag selection relative to vegetation in a regenerating clear cut (Grubb 1982, Petit et al. 1985).

We evaluated woodpecker use of 26-cm diameter × 242-cm high poly-

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TABLE 1

VEGETATIONAL CHARACTERISTICS (MEANS ± SD) OF MATURE PURE PINE, PINE-HARDWOOD, UPLAND HARDWOOD, AND BOTTOMLAND HARDWOOD FOREST STANDS WHERE ARTIFICIAL POLYSTYRENE SNAGS WERE STUDIED ON THE STEPHEN F. AUSTIN EXPERIMENTAL FOREST IN EASTERN TEXAS

Vegetation variable	Pure pine (N = 20)	Pine-hardwood (N = 20)	Upland hardwood (N = 20)	Bottomland hardwood (N = 20)
Vegetation height (m)	30.0 (3.7)	27.4 (5.5)	20.6 (2.9)	27.1 (5.3)
Pine basal area (m^2/ha)	23.5 (3.9)	22.6 (7.3)	3.8 (3.6)	0.2 (0.5)
Hardwood basal area (m^2/ha)	0.2 (0.6)	4.0 (3.2)	15.6 (3.5)	18.5 (4.8)
Tree density (#/0.04 ha)	11.5 (3.6)	18.5 (9.6)	10.1 (3.2)	14.0 (3.6)
Canopy closure (%)	73.1 (11.1)	71.2 (14.3)	69.3 (13.8)	72.5 (13.0)
Ground cover (%)	2.9 (2.8)	3.5 (2.4)	3.5 (2.7)	9.6 (6.4)
Natural snags (#/0.04 ha)	0.8 (0.8)	0.7 (0.9)	0.7 (0.8)	1.1 (1.0)

styrene snags in four forest types over a five-year period. We determined secondary cavity nester use of woodpecker cavities and evaluated cavity shape and condition with long-term use.

STUDY AREAS AND METHODS

We constructed 47 artificial snags from solid blocks of polystyrene (26-cm diameter × 242-cm high). The 4-cm increase in diameter of the polystyrene snags above what had been used previously (Peterson and Grubb 1983), placed the substrate diameter within the range of sizes used by Hairy (*Picoides villosus*) and Red-bellied (*Melanerpes carolinus*) woodpeckers for cavity sites (Conner 1978). Similar to Peterson and Grubb (1983), we painted the artificial snags with a thick coating of brown latex paint to enhance the snag-like appearance of the polystyrene snags. After drilling a centrally located 3-cm diameter hole (parallel to the length of the snag), 80 cm deep into the base of each artificial snag, we installed it in the field on 20 October 1986 by sliding it onto a 184-cm long "T-pole" (iron fence post) that had been driven into the ground approximately 110 cm deep. The hole drilled into the base of each artificial snag was made solely to mount (impale) the snags on T-poles. All artificial snags were installed as close to vertical as possible, i.e., no lean could be visually detected. Artificial snags were installed at 112-m intervals on four nest box trails in four forest types (ten snags per trail and one trail in each forest type: mature pure pine [*Pinus* spp.], pine-hardwood, upland hardwood, and bottomland hardwood forest habitats) located on the Stephen F. Austin Experimental Forest (31°29'N, 94°47'W) in southern Nacogdoches County, Texas. Each nest box trail was circular and approximately 1130 m in length. Cavities for secondary cavity nesters were readily available on each trail, because 20 sites with three nest boxes per site were established at 56-m intervals on each trail as a part of a different study. Seven additional artificial snags were installed on the edge of mature pine-hardwood forest next to dirt roads.

Vegetation characteristics were measured at 56-m intervals (20 points) on each of the four nest box trails (Table 1). We measured vegetation height with a clinometer, and tree basal areas were measured with a one-factor metric prism. Densities of trees and snags >15 cm diameter at breast height were counted within an 11.3-m radius circular plot. We esti-

TABLE 2

SPECIES USE OF CAVITIES EXCAVATED BY DOWNY WOODPECKERS IN ARTIFICIAL POLYSTYRENE SNAGS IN FOUR FOREST TYPES ON THE STEPHEN F. AUSTIN EXPERIMENTAL FOREST IN EASTERN TEXAS

	Number of polystyrene snags used			
Cavity occupant	Pure pine (N = 10)	Pine-hardwood[a] (N = 17)	Upland hardwood (N = 10)	Bottomland hardwood (N = 10)
Downy Woodpecker[b]	0	13	10	0
Carolina Chickadee	0	4[c]	2	0
Prothonotary Warbler	0	0	2	0
Southern flying squirrel	0	1	0	0
Red wasps	0	3	2	0

[a] Artificial snags in forest (N = 10) and edge (N = 7) pine-hardwood habitat combined.
[b] All cavities except one were initially excavated by Downy Woodpeckers.
[c] In one instance in pine-hardwood edge habitat Carolina Chickadees excavated their own cavity.

mated percent canopy closure and ground cover, using a 4-cm diameter × 12-cm long hollow tube. We recorded height and compass aspect of pecking and cavity excavation on all artificial snags from fall 1986 to summer 1991.

Occupants of cavities were determined by checking roosts with a mirror, watching occupants use a cavity, or flushing the occupant. Artificial snags were visited during the spring (March–May), fall (September–October), and winter (December–January) during each year of the study. The species of woodpeckers excavating cavities in artificial snags were determined by watching the actual excavation or by measuring the final size of the completed cavity. We also noted claw marks and their relative size to determine if they had been made by a squirrel or a possible predator (house cat [*Felis domesticus*] and raccoon [*Procyon lotor*]). We were not able to determine nesting success on all of the avian nests detected because of time and personnel constraints. Artificial snags in the bottomland hardwood area were monitored only until spring 1989 because flooding lifted the snags off the T-poles and washed them down the Angelina River.

RESULTS

Except for one case, Downy Woodpeckers were the only species detected excavating and using cavities in the artificial polystyrene snags (Table 2). We did not observe Downy Woodpeckers nesting in any of the cavities, but they regularly used the cavities as nocturnal roosts. Downy Woodpeckers excavated cavities in artificial snags only in the pine-hardwood and upland hardwood forest types. Carolina Chickadees were the most frequent secondary users of cavities excavated by Downy Woodpeckers (Table 2). In one instance, Carolina Chickadees excavated a cavity during the early spring and successfully nested in it. Prothonotary Warblers (*Protonotaria citrea*) successfully nested in two different cavities in the upland hardwood forest type. Standing water was present in parts of this area for much of the spring. Five cavities were used by red

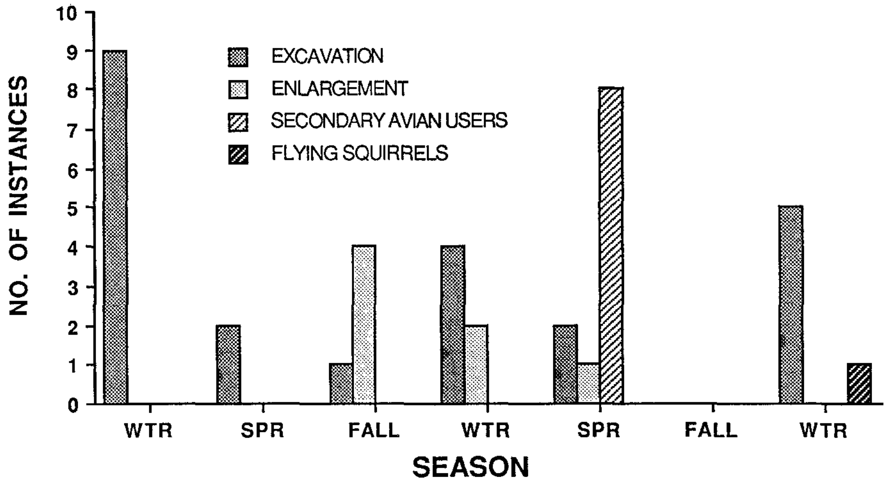

FIG. 1. Seasonal appearance of cavities completed by Downy Woodpeckers in polystyrene snags (starting in winter 15 months after snag installation), enlargement of cavities by subsequent use, and use by secondary cavity users during successive winter (WTR), spring (SPR), and fall (FALL) seasons on the Stephen F. Austin Experimental Forest in eastern Texas.

wasps (*Polistes* sp.) and one by southern flying squirrels (*Glaucomys volans*).

Artificial snags were in place five months before small holes began to appear in them in the upland hardwood and pine-hardwood areas during the early spring 1987. Downy Woodpeckers were the only woodpecker species observed excavating cavities in the artificial snags, and the first completed cavities (9) appeared in these two habitat types by early January 1988 (15 months after installation) indicating that they had been excavated during late fall to early winter 1987. Additional completions of cavities in other artificial snags occurred during the next two years (Fig. 1). Avian secondary cavity nesters did not begin to use the completed cavities until more than a year had passed (Fig. 1). Southern flying squirrels were first detected after two years.

All completed cavity entrances were excavated between 12 and 16 cm from the top of the artificial snags. It was difficult to detect visually a preference for cavity orientation. Cavity entrances appeared to be bimodal in their distribution (Fig. 2). A Rao's test indicated a non-random orientation of entrances (U = 1,591; $P < 0.01$).

Small holes that seemed to be similar to cavity starts appeared near the tops of two artificial snags in the pure pine area within five months of snag installation. Cavities in those two snags, however, were never com-

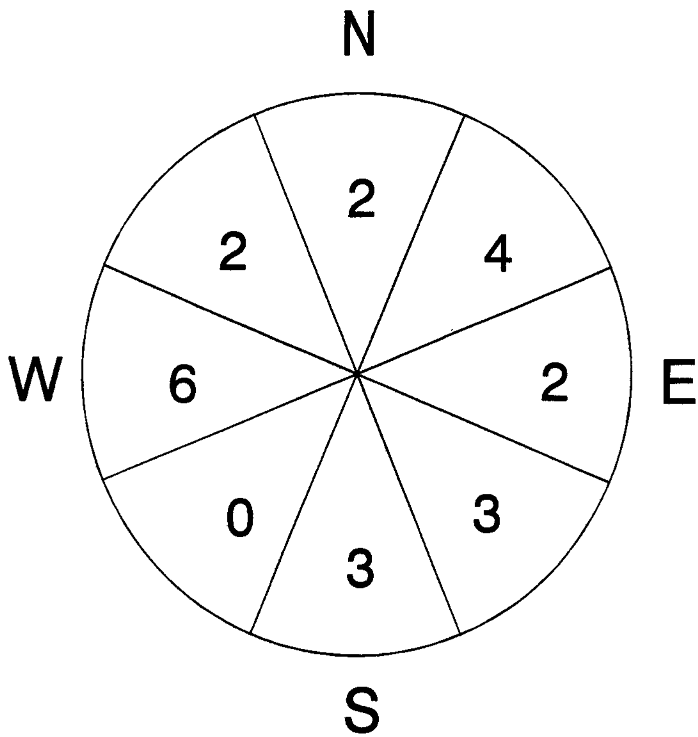

FIG. 2. Aspects of entrances to cavities excavated into artificial polystyrene snags (N = 22) in eastern Texas.

pleted. By January 1988, two other artificial snags in the pure pine area had small excavations in them but were also abandoned. Artificial snags in the bottomland hardwood area had small and some large holes excavated within 30 cm of the base of the snags, most likely excavated by Pileated Woodpeckers (*Dryocopus pileatus*). But, apparent start holes in both the pure pine and bottomland hardwood areas were never excavated beyond several centimeters deep. Artificial snags in all areas had varying amounts of their surface paint and polystyrene pecked away, as if woodpeckers or other bark foragers had attempted to forage on them.

Seven cavity entrances became quite enlarged within 8–10 months following cavity completion and subsequent use (Fig. 1). Although entrances enlarged in all directions, the bottom of each entrance was affected the most. Polystyrene would erode away 10–15 cm, most likely during the passage of the occupant, so that entrances gradually became elongated vertically. Downy Woodpeckers appeared to abandon enlarged cavities.

Claw marks of sufficient size to suggest attempted predation appeared on four of the artificial snags with cavities during the fall and winter. In one instance, the cavity entrance was torn open and about half of the cavity chamber exposed.

DISCUSSION

Our attempt to use large diameter polystyrene snags to encourage some of the larger woodpeckers to excavate cavities was unsuccessful. Although both Red-bellied and Hairy woodpeckers were present within the vicinity, neither species apparently excavated cavities in the artificial snags. Diameters of the artificial snags were sufficient to house cavities made by these two species (Conner et al. 1975, Jackson 1976). However, the 3-m height of the artificial snags, which was the tallest block of polystyrene commercially available, may have been too low for these two species. Hairy and Red-bellied woodpeckers typically excavate nest cavities at heights above 3 m (Conner 1978). Downy Woodpeckers often nest in dead tree stubs that are approximately 3 m in height (Conner et al. 1975). They also are known to excavate cavities in very soft, well-decayed natural snags (Conner et al. 1975, 1976). The consistency of polystyrene is very similar to that of well-decayed wood tissue found in some snags used by Downy Woodpeckers for cavity excavation. Both the polystyrene and well-decayed wood tissue can be easily excavated by a human finger nail. Substrate of such little structural strength may be too soft for the larger woodpecker species.

Although there were woodpeckers within the pure pine and bottomland hardwood study areas, none of the polystyrene snags in these study areas was used for cavity excavation. There was an abundance of natural snags in the bottomland habitat (Conner et al. 1994, Table 1); thus, the attractiveness of artificial snags was likely less. Natural snags were as common in the pure pine stand as they were in the pine-hardwood study area (Table 1). The failure of Downy Woodpeckers to use artificial snags in the pure pine stand is enigmatic.

The long term value of polystyrene snags as an artificial substrate for woodpecker cavity excavation appears to be relatively low. Only Downy Woodpeckers excavated cavities, and they did not nest in the cavities following excavation. The artificial snags do appear to have some value as roosting sites for Downy Woodpeckers, and the polystyrene material is well known for its high insulating ability, which would be particularly valuable during winter at northern latitudes. Although woodpeckers did not use the cavities for nesting, secondary cavity nesters such as Prothonotary Warblers and Carolina Chickadees successfully nested in the artificial substrate. Entrances to cavities, however, soon begin to erode away with use, rendering the cavity unusable after several years. This problem could be rectified by reinforcing cavity entrances with wire mesh or thin wood following the woodpecker's completion of the cavity chamber.

Still, artificial substrates for woodpecker cavity excavation may have value. Substrates with a stronger yet brittle structure may be needed to entice other woodpecker species to excavate cavities and Downy Woodpeckers to nest. Also, additional structure strength or hardness is needed on the surface of the artificial snags. Such strength might help deter predators and provide sufficient hardness and resonance for mutual tapping behavior and drumming which occur during cavity site selection (Kilham 1958, 1983). Also, further study using larger diameter and taller artificial snags in areas where natural snags are limited or absent may provide additional insight.

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