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Abstract

Population growth of red-cockaded woodpeckers (*Picoides borealis*) is often limited by the availability of suitable cavities. Structural damage to natural and artificial cavities intended for use by *P. borealis* is common. Roost and nest cavities of *P. borealis* often become occupied by other cavity-dependent species. Techniques for preventing damage to artificial cavities and for deterring southern flying squirrel (*Glaucomys volans*) use of otherwise serviceable cavities are described. Such cavity protection techniques may be necessary to prevent extirpation of small, isolated populations of *P. borealis*.

Introduction

Since the red-cockaded woodpecker (*Picoides borealis*) was listed as an endangered species in 1970, establishing viable populations of the species has been a goal of wildlife conservationists. This woodpecker is endemic to pine forests of the southeastern United States and has a limited distribution in Arkansas (James et al., 1981; James and Neal, 1986, 1989; Neal and Montague, 1991). Considerable research effort has been committed to determining the factors which limit species recovery efforts (Ligon et al., 1986). Land management activities geared toward species recovery currently emphasize providing mature pine forest habitat of a sufficient quantity and quality to meet recovery objectives (U.S. Fish Wildl. Serv., 1985). This paper describes techniques for preventing damage to artificial cavities and for deterring southern flying squirrel (*Glaucomys volans*) use of otherwise serviceable cavities. The study area where these techniques were employed included the Ouachita National Forest (Ouachita NF) in Scott County, Arkansas; the Crossett Experimental Forest, Ashley County, Arkansas; and the Arkansas Natural Heritage Commission's Pine City Natural Area, Monroe County, Arkansas.

Materials and Methods

Protection of Insert Boxes.--In order to supplement numbers of natural roost and nest cavities of *P. borealis*, 145 artificial cavity insert boxes were installed on the study area from 1991 to 1993 using Allen's (1991) technique. This technique was modified in 1993 by fitting the insert boxes with steel protectors, which functioned to prevent damage to the entrance tunnels of these artificial cavities (Fig. 1). These protectors were made from 2-mm thick exhaust pipe stock having an exterior diameter of 50 mm (2 in) and an interior diameter of 46 mm. Such steel tubes, which can be made at any custom automotive exhaust shop, were pressed to create a 12-mm flange at one end and then cut to an overall length of 50-55 mm. Because insert box entrance tunnels are drilled at an eight-degree angle, the top one-half of the flange was cut off at a similar eight-degree angle. This allowed the tube to be inserted into the entrance tunnel and pounded rearward until the remaining portion of the flange was flush against the front of the insert box. Use of 50-mm exhaust pipe stock required that all insert boxes have entrance tunnels drilled with a 50-mm diameter substituted for the 45-mm dimension described by Allen (1991). Once pounded into the drilled insert box entrance tunnel, no nails or screws were required to hold the tunnel protectors in place.

Prior to insertion of a tunnel protector, a 20 x 20-cm square of 6.4-mm mesh hardware cloth was stapled to the tree and insert box (Fig. 2). This was done by placing the upper edge of the mesh wire square flush with the entrance tunnel floor, and by centering it to allow approximately 5 cm of overlap on either side of, and below, the insert box (Fig. 2). This hardware cloth "insert box face-protector" was eventually covered with a thin layer of wood filler and served as a substitute for the special insert box cavity restrictor described by Allen (1991). It served to protect the insert box face from damage by potential cavity usurpers and sealed the gaps between the insert box walls and tree. Installation of tunnel protectors after attachment of wire face-protectors allowed the flange of the tunnel protector to secure the upper edge of the hardware cloth square (Fig.2).

A 10 x 10-cm restrictor similar to that described by Carter et al. (1989) was then applied. The restrictor effectively reduced the interior diameter of the slightly oversized tunnel protector. This reduced size prevented avian cavity usurpers larger than *P. borealis* from entering the

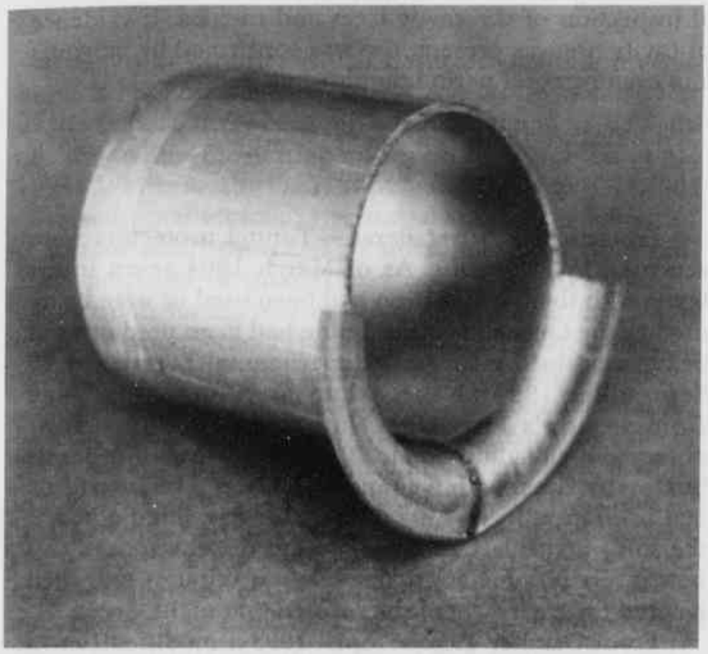

Fig. 1. A steel entrance tunnel protector used with artificial insert cavity nest and roost boxes for Red-cockaded Woodpeckers (*P. borealis*).

insert box (Raulston, 1992; Neal et al., 1992).

Finally, a thin coat (<1 mm) of wood filler was spread on all metal surfaces and pressed into all gaps around the restrictor and tunnel protector. Paint was applied to enhance the appearance of the final product (Allen, 1991; Taylor and Hooper, 1991).

Tunnel protectors were applied during all insert box installations after April 1993. Insert boxes installed prior to April 1993 were retrofitted with tunnel protectors during routine maintenance work. A portable drill with a 50-mm (2 in) Forstner drill bit was used to enlarge slightly undersized entrance tunnels of insert boxes previously installed without tunnel protectors.

Effectiveness of tunnel protectors and associated face-protectors in preventing damage to insert boxes was determined by visual inspection. Acceptance of treated artificial cavities for nesting or roosting by *P. borealis* was initially determined by visual inspection of the cavity trees and cavities. If evidence of cavity use was present, use was confirmed by morning and evening roost period observations.

Exclusion of Flying Squirrels.--*G. volans* frequently uses *P. borealis* nest and roost cavities and sometimes usurps them (Loeb, 1991; Montague et al., 1995; personal observation). A technique was employed in the Ouachita NF to attempt to deter *G. volans* from accessing serviceable cavities of *P. borealis* in 1991 (Montague et al.,

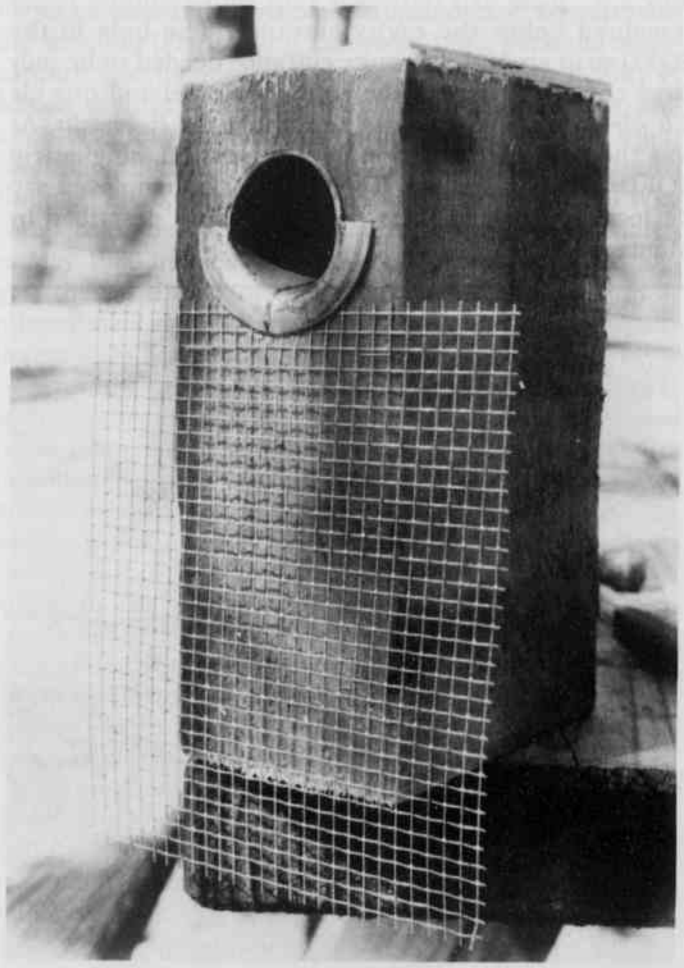

Fig. 2. A steel tunnel protector installed in the entrance tunnel of an artificial insert cavity nest/roost box for Red-cockaded Woodpeckers (*P. borealis*). The flange of the tunnel protector secures the upper edge of the hardware cloth insert box face-protector.

1995). This double-strip (or two-strip) squirrel excluder device (SQED) consisted of two bands of aluminum flashing. One band was placed above and one band was placed below the cavity entrance. This SQED was subsequently modified in a variety of ways.

The version of SQEDs adopted in November 1993 utilized a single 0.95 m-wide strip of lightweight aluminum flashing (Fig. 3). The single strip of flashing was off-centered over the cavity entrance; a slightly wider portion of the flashing extended above the cavity entrance than extended below it. The strip was then stapled to the tree. A smooth-edged, triangular-shaped hole with a 10 - 15-cm base was cut around the cavity entrance so that some flashing material remained connected below the cavity entrance. This material was then cut away so that only a 4 - 5-cm sap deflector flap with rounded edges remained below the cavity entrance. The hole in the SQED strip around the cavity entrance needed to be only large enough to expose the entrance tunnel and provide 2.5 - 5-cm of bare wood as a foothold for *P. borealis.* As was the case with the double-strip version, single-strip SQEDs were unpainted. This design also employed sap deflectors with gap flaps similar to those described by Montague et al. (1995).

Fig. 3. Single-strip Squirrel Excluder Device (SQED) with sap-deflector on the Ouachita National Forest, Scott County, Arkansas. (Cluster 1257/20 - Tree #13).

After May 1991 it became a routine procedure to periodically inspect all cavities in cavity tree clusters of *P. borealis* for presence of *G. volans.* Those *G. volans* which did not escape from a cavity were removed using the technique described by Montague et al. (1995).

Effectiveness of SQEDs to deter access to treated cavities by *G. volans* was evaluated by periodically examining cavity chambers for evidence of *G. volans* occupation. Such evidence included nuts or nutshell fragments, nest materials, or presence of *G. volans.* Use of treated cavities for roosting by *P. borealis* was initially determined by visual inspection of the cavity trees and cavities. If evidence of cavity use was present, use was confirmed by morning and evening roost period monitoring.

Results

Protection of Insert Boxes.--Tunnel protectors were accepted by *P. borealis.* As of March 1994 seven insert boxes with this modification had been used or were being used in the Ouachita NF, and nine had been used or were being used in the Crossett Experimental Forest. On 22 September 1993 at the Arkansas Natural Heritage Commission's Pine City Natural Area, the author observed a subadult female *P. borealis* arrive at an insert box cavity fitted with a tunnel protector. The insert box had been installed 3-4 hrs earlier that day. She pecked at the soft wood filler and paint around the entrance of this new insert box for approximately ten minutes and then entered the cavity where she roosted that night.

From October 1992 to April 1993 a modified tunnel protector, which covered only the lower half of the entrance tunnel, was tried unsuccessfully. Structural damage to the exposed wood of the upper half of the entrance tunnel by potential cavity usurpers still occurred.

Exclusion of Flying Squirrels.--In 13 cases individual *P. borealis* chose cavities with unpainted double-strip (n = 12) or single-strip (n = 1) SQEDs for roosting. It appeared that as with the unpainted double-strip design described by Montague et al. (1995), the single-strip treated cavities were accepted for roosting by *P. borealis.* None of the five cavities (three natural cavities and two insert boxes) treated with single-strip SQEDs as of March 1994 appeared to have been occupied by *G. volans* at any time since their installation.

On 23 November 1993 single-strip SQEDs were installed on two natural cavities of *P. borealis* on the Poteau Ranger District of the Ouachita NF. These two cavities had evidence of recent *G. volans* use. One of the treated trees was located in a cavity tree cluster occupied by an unpaired, adult female *P. borealis.* The cavity tree cluster was comprised of two clean, suitable natural cavities and three clean and vacant insert box cavities. The natural cavity unoccupied by a *P. borealis* had a single-strip SQED attached to the bole of the tree. On 29 December 1993 the author observed a subadult male *P. borealis* occupy the SQED-treated natural cavity in this cavity tree cluster. The bird originated 2.4 km west of this treated roost cavity as part of an unsuccessful two-bird translocation, which occurred 17 November 1993. He and his apparent mate still occupied these roost cavities on 3 March 1994.

Discussion

General.--Studies which describe possible mechanisms for population growth of *P. borealis* frequently refer to the importance of having adequate numbers of high-quality cavities for nesting and roosting (Copeyon et al., 1991; Walters, 1991). Hooper and Lennartz (1983) observed open and extraterritorial roosting behavior of *P. borealis* when shortages of suitable cavities occurred. Such shortages of cavities may result from interspecific competition for cavities or from enlargement of cavities by other woodpeckers (Jackson, 1978; Neal et al., 1992), which makes them uninhabitable for *P. borealis*.

Protection of Insert Boxes.--Numerous techniques have been developed to provide sufficient numbers of serviceable cavities to stabilize and increase *P. borealis* populations. Artificial cavities are constructed using cavity drilling (Copeyon, 1990; Taylor and Hooper, 1991), or insert box installation (Allen, 1991) techniques. Natural cavities are protected from enlargement or, once enlarged, can be restored to serviceable condition using cavity restrictors (Carter et al., 1989; Raulston, 1992). Cavity restrictors are also used to protect insert box entrances from enlargement.

Following the installation of 145 insert boxes in the study area, damage to insert boxes fitted with cavity restrictors occurred. This damage by potential cavity usurpers was in the form of enlargement of entrance tunnel floors and sidewalls. Continued erosion of the entrance tunnel can allow rainwater or sap to flow into the cavity chamber. This could render such cavities dangerous for *P. borealis* to use or make them uninhabitable. The steel tunnel protector (Fig. 1) was designed and field-tested to prevent this structural damage from occurring.

Exclusion of Flying Squirrels.--The problems of cavity usurpation or damage to natural or artificial cavities intended for use by *P. borealis* can be virtually eliminated by using a variety of techniques including combinations of cavity restrictors and tunnel protectors. However, one species for which these techniques are not effective is *G. volans*. Cavity usurpation or use by *G. volans* has been noted in numerous studies (Dennis, 1971a; Baker, 1983; Harlow and Lennartz, 1983; Table 2 in Neal et al., 1992; Loeb, 1993). Habitat occupancy (Muul, 1968, 1974), den selection (Bendel and Gates, 1987), and population densities (Sawyer and Rose, 1985) of *G. volans* are all dependent upon availability of numerous cavities. This makes cavity tree clusters of *P. borealis* potentially ideal environments for propagating large numbers of *G. volans*.

While some studies have revealed insignificant amounts of animal matter in the diets of *G. volans* (Harlow and Doyle, 1990), other studies have implicated *G. volans* as an occasional predator of birds eggs and nestlings (Stabb et al., 1989). Potential predatory behavior of *G. volans*, its possible disruption of *P. borealis* nesting activities (Harlow and Lennartz, 1983; personal observation), and its apparent preference for high quality *P. borealis* cavities with small entrances (Loeb, 1993; personal observation) increases the probability that these squirrels may adversely impact populations of *P. borealis*. Rudolph et al., (1990) dismissed the importance of cavity competition between *G. volans* and *P. borealis* from March to May 1986 in their Texas study. However, they did suggest the possibility of significant cavity competition at other times, especially during the immediate post-fledging period when cavities are in short supply.

During the *P. borealis* breeding season of 1991, attempts began in the Ouachita NF to deter *G. volans* from accessing serviceable cavities of *P. borealis* (Montague et al., 1995). *G. volans* was frequently able to evade the double-strip SQEDs used in that study. Even with sap deflector flaps to prevent formation of sap "bridges", and removal of some offending individual *G. volans*, squirrels still reoccupied some of the treated cavities. Some of this difference in effectiveness between single and double-strip SQEDs may be attributed to the lack of sap deflectors in earlier double-strip SQED designs and to the fact that *G. volans* were not routinely removed from cavity tree clusters until after May 1991.

The ability to circumvent the double-strip SQED design is in keeping with Muul's (1968) description of the ability of *G. volans* to glide to and from isolated trees and use specific, well established travel and escape glide paths. Loeb (1993) determined that around cavity trees, wider tree spacing by clearing midstory was not sufficient to keep flying squirrels from using *P. borealis* cavities. These behavioral characteristics of *G. volans* and the apparent inability of the original double-strip SQED design to deter *G. volans* occupation of cavities prompted development of the single-strip SQED.

The preliminary results of this field test of the single-strip SQED design have management implications which go beyond their potential to exclude *G. volans*. The 0.95-m wide SQED version may provide additional protection from predation by black rat snakes (*Elaphe obsolete obsoleta*). Single-strip SQEDs are scaled-down versions of devices tested by Neal et al. (1993) and Withgott et al. (1995), which are used to deter climbing of cavity trees by rat snakes.

The SQED technique may also serve to provide some visual stimulation of *P. borealis*. In 13 cases cavities with unpainted double-strip or single-strip SQEDs were selected for roosting when other untreated cavities were also available, suggesting there may be some visual attraction involved. If so, SQEDs could serve a dual purpose by deterring use of cavities by *G. volans* and by assisting dispersing *P. borealis* in locating vacant cavity tree clusters with serviceable cavities. The concept of visual attraction relates to the original debate about the functions of cavity tree resin flows and the resulting candlestick appearance of fully developed cavity trees. These ascribed functions included protection from snakes and other animals (Ligon, 1970; Dennis, 1971b). Ligon (1970) and Lay and Russell (1970) suggested that resin flows might provide visual cues to *P. borealis*. This needs to be tested by deploying SQEDs in recruitment stand clusters of artificial cavities.

Conner and Rudolph (1989) suggested that the presence of hardwood midstories in and around *P. borealis* cavity tree clusters might increase competition for cavities with *G. volans*. Habitat managers throughout the range of *P. borealis* are striving to create open forest habitat: a condition with little midstory which favors this endangered woodpecker. However, it will be a slow process to reverse the effects of the decades of fire suppression, which has allowed these dense midstories to develop on extensive acreages of pine forests in the southeastern United States. In the interim period of habitat restoration or renewal, more intensive cavity protection techniques are necessary to prevent extirpation of small, isolated populations of *P. borealis*.

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