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A Modification of Copeyon's Drilling Technique for Making Artificial Red-Cockaded Woodpecker Cavities

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ABSTRACT

This paper describes a modification to Copeyon's drilling technique for making highly effective artificial cavities for red-cockaded woodpeckers. The changes virtually eliminate the possibility of making a mistake in constructing cavities and reduces the learning time to less than 2 weeks. The basic change is the use of a 3-inch access hole that allows the relative position of the pith to be used to avoid breeching the sapwood and replaces routing the cavity with a single, precisely drilled hole.

Keywords: *Picoides borealis*, endangered species, Hurricane Hugo.

Introduction

The endangered red-cockaded woodpecker (*Picoides borealis*) excavates its roosting and nesting cavities in living pine trees. Excavation typically takes several years, and the birds select only pines with certain characteristics (Hooper 1988). A shortage of trees suitable for excavation and competition for existing cavities often cause a deficiency of functional cavities that limits population growth. In addition, natural disasters can destroy cavity trees, putting populations in further jeopardy (Engstrom and Evans 1990; Hooper and others 1990).

Carole K. Copeyon, while a graduate student working with Dr. Jeffrey R. Walters in the Department of Zoology at North Carolina

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State University, invented a successful drilling technique for making artificial cavities (Copeyon 1990). That achievement was a major technological breakthrough in the management of the red-cockaded woodpecker, but no one dreamed her new technique would get the immediate use that it did.

On September 22, 1989, Hurricane Hugo hit the Francis Marion National Forest in South Carolina, destroying 87 percent of the cavity trees and killing 60 percent of the birds (Hooper and others 1990). The surviving woodpeckers were critically short of tree cavities: about 700 woodpeckers survived but were left with only 225 cavities. If the storm had hit just 2 years earlier, we would have been helpless to aid those birds. However, by the summer of 1989, Copeyon's drilling technique had been perfected to the point that red-cockaded woodpeckers were successfully nesting in artificial cavities. Shortly after the storm, Copeyon, Jay H. Carter, and John S. Hammond came to the Francis Marion National Forest and taught us the technique. By February 1991, we had drilled 158 cavities in trees on the Francis Marion National Forest. Another 438 artificial cavities were made using two other techniques (see Other Types of Artificial Cavities.) In addition, we drilled 76 cavities on National Forests in Texas, Kentucky, North Carolina, Georgia, and Florida where there were shortages of cavities.

Copeyon's original technique employed portable electric generators, drills and blowers. Soon after we started using the technique, we switched to gasoline-powered equipment. The gasoline equipment is easier to transport through hurricane-damaged forest; the gas drill has less torque when bits snag, thus reducing the chance for injury; and the possibility of electrical shock is eliminated.

Other than using gasoline-powered equipment, most drilled cavities (170 of 234) were constructed using Copeyon's original method (Copeyon 1990). These cavities were very effective, and our results substantiate that Copeyon's original procedure is completely sound and essentially trouble free when executed by experienced workers. However, in trying to teach others the original procedure, we found that up to 6 weeks were required for a neophyte to become expert at making consistently trouble-free cavities. The extended experience was required to skillfully excavate a cavity chamber entirely in heartwood (Copeyon 1990, fig. 2). To reduce the learning time, we modified the original procedure by enlarging the access hole for improved visibility of the pith. As a result, the pith could be used consistently as a guide when making the cavity chamber. Also the need to rout out the cavity was eliminated. Instead, cavities were prepared by drilling out a single, precisely located hole. These changes virtually eliminated the possibility of making a mistake in constructing a cavity and reduced the learning time to less than 2 weeks.

This paper summarizes the expertise our cavity excavators developed with the drilling technique from more than 3,000 work hours of field experience. It also makes available to future workers the modifications we have made in Copeyon's technique. We believe these changes improve an already successful technique for constructing artificial cavities for red-cockaded woodpeckers. Information is presented in thorough detail so that, with sufficient study and practice, a reader can successfully excavate safe and functional cavities.

Procedures

Tree Selection

Phase 1—Selection of a suitable tree is critical to successful excavation of a safe and functional artificial cavity. Suitable trees are pines having heartwood cylinders at least 7 inches in diameter and sapwood no thicker than 3.5 inches. Unless these minimum standards are met, leakage of resin from sapwood into the artificial cavity is likely to be severe. Resin leakage will discourage use by red-cockaded woodpeckers, and it is potentially fatal to them if they use the cavity. The greater the amount of heartwood and the narrower the sapwood, the easier it is to construct a good artificial cavity. Rationale for use of these measurement criteria is provided later.

Older trees that have suffered growth stress generally have more heartwood than younger, more vigorously growing trees (Hepting 1971; Wahlenburg 1946; Wahlenburg 1960). Our experience indicates that few pines less than 75 years old meet the minimum sapwood - heartwood criteria; those that do tend to have asymmetric heartwood diameters, making it more likely that sapwood will be breached during cavity construction. Typically, suitable trees are more than 95 years old. The initial selection of a candidate for excavation is based on exterior characteristics. Old pines have flat crowns and large diameter limbs. Stress is often indicated by crowns that have been split or display unusual growth patterns. Trees with fungal conks indicating the presence of heartrot (and thus extensive heartwood) are also likely candidates. In even-aged stands, intermediate and suppressed trees are generally good choices. Because of the stress it puts on the worker, it is difficult to excavate a cavity in a tree that leans more than 10 degrees. Thus, it is well to avoid such trees until one is experienced with the technique and conditioned to the work. Even then, it is advisable to select trees without excessive lean.

Our experience suggests that artificial cavities placed near existing (or recently destroyed) cavity trees are used, on average, quicker than more distant trees in the same colony site. Thus, we usually try to select a tree for excavation that is close to a cavity tree. However, woodpeckers have used drilled cavities that were far removed from an existing colony (Copeyon 1990).

Phase 2—The next step in selecting a tree for excavation involves determining the actual amount of sapwood and heartwood at breast height. If the tree has 7 or more inches of heartwood and 3.5 or less inches of sapwood at breast height, it can then be increment bored at the height proposed for excavation of the artificial cavity.

Phase 3—The final determination of a tree's suitability is based on the sapwood-heartwood parameters at cavity height. Again, the criteria are 7 or more inches of heartwood and 3.5 inches or less of sapwood. Cavity height and aspect are selected prior to boring the candidate tree at cavity level.

Orientation and Height of Cavity Entrance

Natural red-cockaded woodpecker cavities face in all compass directions, but the birds clearly favor a westerly aspect for their cavity entrances (Locke and Conner 1983). Thus, when selecting the orientation for the entrance to an artificial cavity, a westerly exposure (250 - 290 degrees) should be favored. We make exceptions in existing colonies in which natural cavities face an opening such as a bay or road. In such cases we orient artificial cavities in the same direction as natural cavities.

We excavate cavities at the tops of ladders that consist of 10-foot sections. Thus, our cavities can be 10, 20, or 30 feet above ground. The diameter of heartwood tends to decrease with height above ground, so most artificial cavities will be at the

10- or 20-foot level. Heights of 20 or 30 feet are desirable because they are more likely to be above the midstory and may be safer from fires. However, sufficient heartwood may not exist at the higher positions. If a tree meets the sapwood-heartwood criteria at breast height, but not at 30 feet, it is worthwhile to bore the tree at 10 or 20 feet to see if those locations meet the minimum criteria. When the tree is bored at cavity height, the increment borer should be 9 inches above the top rung of the ladder and bored horizontally. The hole created by the increment borer will serve as a future reference for locating the entrance tunnel.

Scraping the Tree

Red-cockaded woodpeckers scale the outer portions of the bark around the tree and above and below their natural cavities. When constructing artificial cavities, we use a bark knife to scrape the bark to simulate conditions created by the woodpecker (fig. 1). We scrape an area beginning from the point that can be reached by the worker standing on the top rung of the ladder and extending downward to 2 feet below the cavity. Two or three passes with the knife over a particular area of bark are sufficient. When bark is no longer easily removed, the job is complete. Gloves and protective eye wear should be worn when scraping the tree.

Figure 1 —Scraping the bark from the tree prior to drilling the cavity. Red-cockaded woodpeckers remove loose bark from areas near their cavities, and scraping the bark simulates that behavior. Scraping appears to help attract birds to the artificial cavity.

Placement of the Access Hole

At the outset, it is useful to study a cross section of a completed cavity. Figure 2 shows such a cavity with the access hole at the top plugged. Placement of the access hole is determined by the amount of sapwood found by the increment borer. The center of the access hole is located directly above the increment borer hole at a distance that is twice the width of the sapwood plus 1.0 inch. For example, if the tree has 2.25 inches of sapwood, the access hole is centered 5.50 inches above the increment borer hole ((2.25 x 2) + 1.0 = 5.50). Such placement ensures that the junction of the entrance tunnel and access hole occurs in the proper position with respect to the sapwood - heartwood boundary.

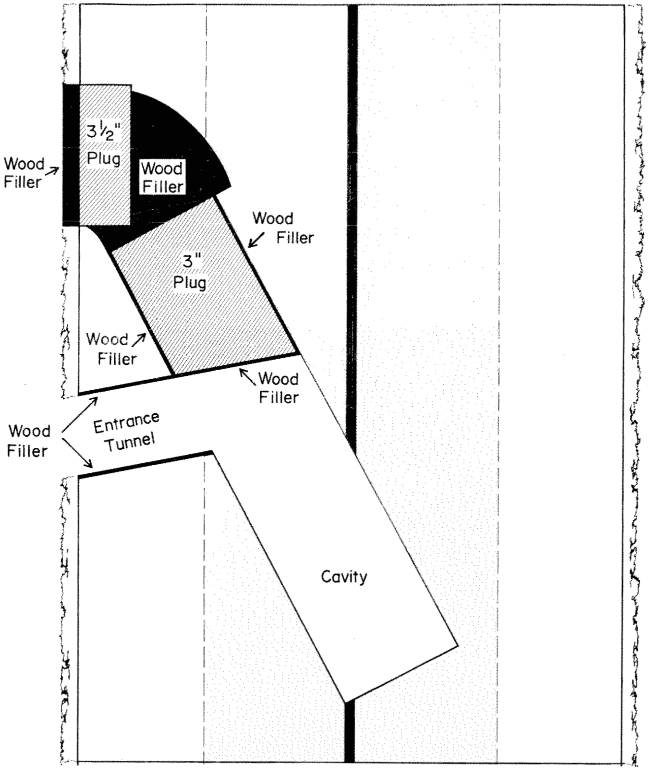

Figure 2—Completed drilled cavity with access hole plugged.

The minimum distance to place the access hole above the increment borer hole is 5.0 inches, which is the calculated distance for 2.0 inches of sapwood ((2.0 x 2) + 1 = 5.0). Even if the tree has less than 2.0 inches of sapwood, you should place the access hole 5.0 inches above the increment bore hole.

Phase 1 – It is desirable at this point to drive 4-inch nails into the tree to hang the drill and gas blower. A nail in the left side of the tree at the height of the increment borer hole is ideal for hanging the drill when it is not in use. A nail on the right side of the tree and 2 feet higher will hold the blower. Left-handed people may want to reverse this arrangement. Be sure to remove these nails when the excavation is completed.

A 3.5-inch bit is used to start the access hole. When chucking bits, the chuck key should be inserted sequentially twice in each hole of the chuck and turned firmly to be sure the bit is held secure. Always turn the drill off when changing or tightening bits.

Drill the beginning of the access hole horizontally to a depth of 0.75 inch. At that depth the back of the bit head is flush with the cambium (fig. 3). At this point, start changing the angle of the bit shaft from the horizontal to a downward angle of 50 degrees. As the drill is running and the bit is cutting, force the

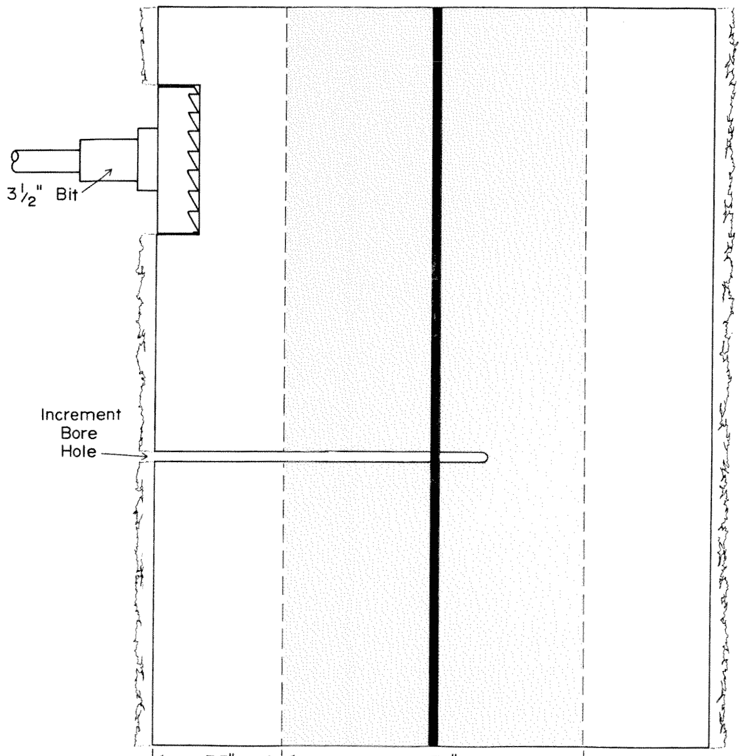

Figure 3 – Position of 3.5-inch bit prior to forcing drill towards the trees. When the bit has reached this depth, the drill is forced towards the tree as the drill is running and the bit is cutting downward.

body of the drill downward and towards the tree as fast as the bit will allow. If the drill is forced too hard, the bit will bog down. However, if the drill is not forced aggressively towards the tree, the resulting angle of the access hole will be less steep and the cavity will be shallower than is desirable. Although the cavity may be usable, it appears that steeper and deeper cavities are used much sooner.

Keep forcing the drill towards the tree until the shaft is forced strongly against the top of the opening to the access hole and then stop (fig. 4). At this time, the bottom of the access hole should be about 0.5 inch deep. As the shaft is being forced towards the tree, some of the lower lip of the access hole made prior to turning the bit downward, will be cut away by the bit. This is normal and will not cause a problem.

Wait a few minutes for the freshly exposed sapwood in the 3.5-inch hole to bead-up with sap droplets. This will allow a very accurate determination of the sapwood - heartwood interface. If the heartwood is visible, again proceed as outlined

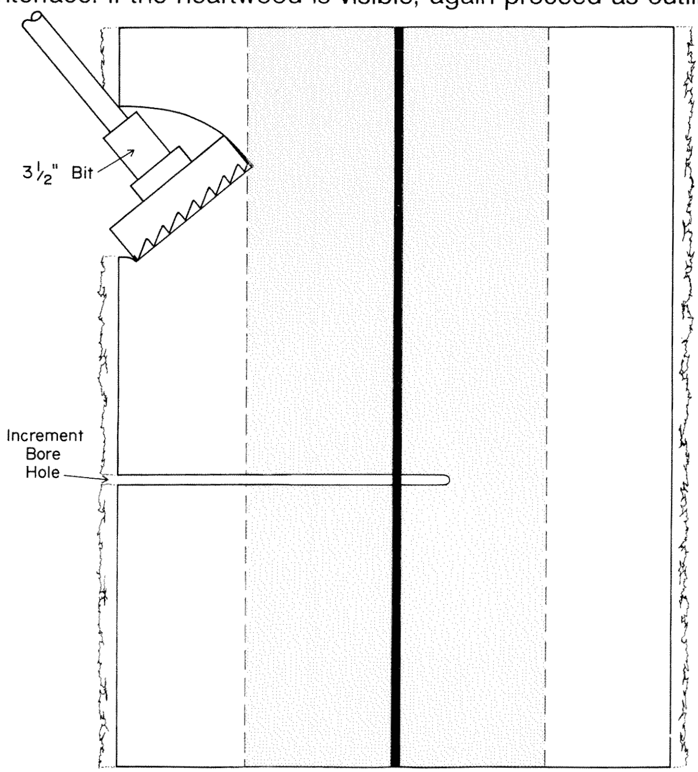

Figure 4—Position of 3.5-inch bit when Phase 1 of Drilling the Access Hole is completed.

in Phase 2. If heartwood is not visible, again proceed as outlined in Phase 2, but be attentive to when the bit finally cuts into the heartwood. At that time measure the width of the sapwood. If the sapwood is thicker than 3.5 inches, stop drilling and plug the hole because it will be difficult to complete a cavity that would be entirely in heartwood.

Phase 2—A 3-inch self-feeding bit with a 5.5-inch shaft extension should be chucked as previously described. Placement of this bit for extending the access hole is easy but critical. The 3-inch bit should be placed in the bottom of the 3.5-inch hole in such a manner that the cutting teeth at the 6 o'clock position on the drill face touch the bottom of the 3.5-inch hole at its lowest point (the 6 o'clock position of the hole bottom). Then the drill should be pushed towards the tree until the shaft of the bit rests snugly against the bark at the top of opening to the 3.5-inch hole (fig. 5). Pressing the bit shaft against the tree increases the angle of the hole from 50 to 58 degrees. It is important to continue pushing the drill towards the tree so that the drill shaft is snug against the bark. As drilling progresses, the drill shaft

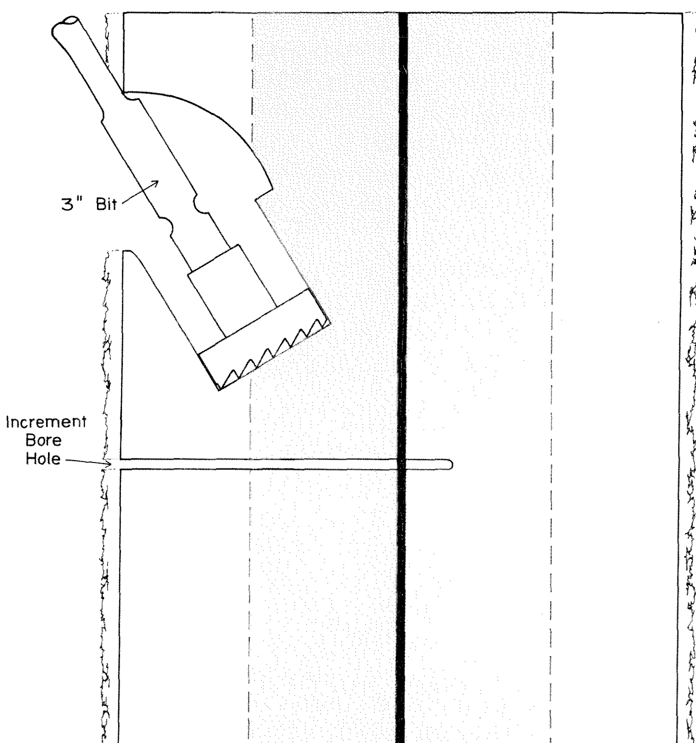

Figure 5– Position of the 3-inch bit as the access hole is being deepened. Note that the 3-inch bit was not started in the center of the 3.5-inch hole.

will soon wear away some of the bark and begin to expose the sapwood. This will help increase the angle of the bit towards 62 degrees. Access holes angled between 58 and 62 degrees are fine, but we believe that the closer to 62 degrees, the better. Also on trees with less than 7.5 inches of heartwood, deeper cavities can be made with the steeper angle.

The self-feeding bits drill downward fairly easily if the set screw that controls the exposed length of the pilot screw is properly adjusted. Lengthening the exposed portion of the pilot screw will cause the bit to cut more wood, but too fast a cut will bog the drill. Shortening the exposed portion of the pilot screw will have the reverse effect, but if too little of the pilot screw is exposed, the bit will not self-feed.

The blower should be used frequently to remove shavings. Failure to do so may result in burying the cutting face of the bit in tightly packed shavings. If this happens, it is difficult to free the bit.

Continue drilling with a 3-inch bit with a 5.5-inch shaft extension until the access hole becomes too deep for that bit to cut. Change to a 3-inch self-feeding bit with a 12-inch shaft extension and continue drilling. Remember to keep the drill shaft pushed against the top of the opening to the access hole as you drill downward. Eventually you may need to change to a 3-inch self-feeding bit with an 18-inch shaft extension.

When drilling downward with the 12- and 18-inch shaft bits, it is important to watch for the appearance of the pith in the bottom of the access hole. The pith will first appear in the bottom of the access hole at the 12 o'clock position (fig. 6). As you drill

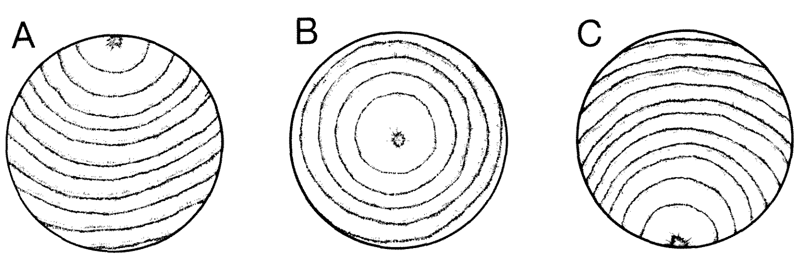

Figure 6—View of the pith in the bottom of the access hole as the hole becomes progressively deeper. (**A**) Pith is first encountered near the 12 o'clock position. (**B**) As access hole is deepened, the pith migrates to the center of the bottom. (**C**) As the hole is deepened farther, the pith moves towards the 6 o'clock position of the bottom. It is critical that drilling of the access hole stops before the pith migrates from the bottom of the access hole.

deeper, the pith will appear to migrate downwards towards the center of the bottom of the access hole. If you drill deeper yet, the pith will continue downward towards the 6 o'clock position. If the hole is off-centered, the pith will be to either the right or left of an imaginary vertical line bisecting the bottom of the access hole from the 12 o'clock to 6 o'clock positions. A somewhat off-centered access hole is not a problem if you stop drilling soon enough. As long as the pith is visible somewhere in the bottom of the access hole, you cannot breach into the sapwood: with a minimum of 7 inches of heartwood, the bottom of the access hole will always be at least 0.5 inch from sapwood, unless the heartwood is asymmetrical.

Phase 3 – The last step in drilling the access hole is to determine where to stop drilling. The rule is to continue drilling until either the ideal depth of the access hole (table 1) is reached or the pith is on the edge of the bottom of the access hole, whichever occurs first. It is critical not to let the pith migrate out of the bottom of the access hole. In trees with less than 7.5 inches of heartwood, or if the angle of the access hole is less than 62 degrees, it will be neccesary to stop drilling the access hole prior to obtaining the ideal depth, otherwise the pith will migrate outside the bottom of the access hole and you will be in danger of breaching the sapwood. In trees with at least 7.5 inches of heartwood, you will always be able to drill the access hole (assuming it is 62 degrees) to the ideal depth without the pith leaving the bottom of the access hole. Again, closely monitor the position of the pith within the bottom of the access hole to avoid any possibility of breaching the sapwood.

Table 1 – Ideal depth to drill access hole assuming tree has 7.5 or more inches of heartwood and that the access hole has a slope of 62 degrees

Width of sapwood	Ideal depth of access hole	Usable cavity depth
Inches	*Inches*	*Inches*
2.0	11.4	7.0
2.5	12.4	7.0
3.0	13.4	7.0
3.5	14.4	7.0

Depth of the access hole is measured from its lower lip at the top to its deepest part.

Usable cavity depth is defined as the distance from the lip of the entrance tunnel (which has not been drilled at this point) to the bottom of the hole. The desirable usable cavity depth is 6 to 7 inches, but birds will eventually deepen and make use of shallower cavities. The ideal drilling depth (table 1) is based on a usable cavity depth of 7 inches. The only time that more than 6 inches of usable cavity depth cannot be safely obtained is in the example above with less than 7.5 inches of heartwood and an access hole with an angle of 58 degrees. In that example, the usable cavity depth would be 5.25 to 5.50 inches—somewhat shallow but still valuable.

Placement of the Cavity Entrance

The center of the increment borer hole will be the center of the cavity entrance. The location of the cavity entrance was predetermined when the placement of the access hole was calculated. That procedure assured that the bottom of the entrance tunnel would pass into the heartwood before intersecting the access hole (fig. 7), an absolutely critical requirement. If this requirement is not met, the bottom of the entrance tunnel will be entirely in sapwood, and resin will run into the cavity, creating a major problem.

If in Phase 1 of drilling the access hole, the drill was pushed forward before the back of the 3.5-inch bit was flush with the cambium, the access hole will be steeper than 62 degrees. This can result in the bottom of the entrance tunnel terminating in sapwood. To prevent this from ever occurring, examine the intersection of the increment borer hole with the access hole. If the increment borer hole is above the sapwood - heartwood interface, the starting point of the cavity entrance should be lowered an amount equal to the distance that the increment borer hole is above the sapwood - heartwood interface.

Angle of the Entrance Tunnel

When excavating a cavity, the red-cockaded woodpecker angles the entrance tunnel upward. One apparent reason for them doing this is that the slope allows resin from the freshly exposed sapwood to drain out of the tree rather than puddle in the back of the partially excavated entrance tunnel. Also, rain is less likely to drip into the completed cavity if the entrance tunnel slopes upward. Therefore, we drill the entrance tunnel with an upward slope of 10 degrees to the horizontal. A clinometer is helpful in determining the 10-degree angle from the horizontal,

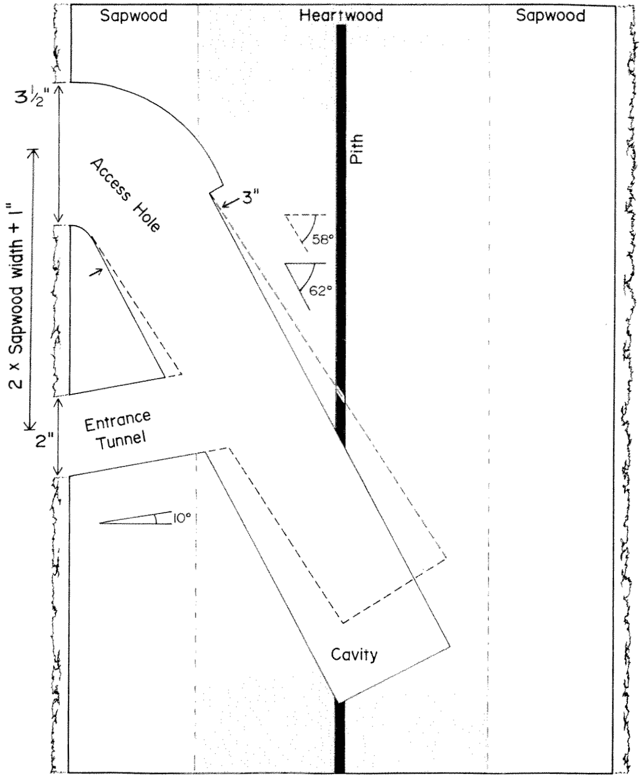

Figure 7—Cross-sectional view of a drilled cavity after all drilling has been completed and just prior to plugging the access hole. Dotted lines show access hole drilled with a 58-degree angle. Solid lines show access hole drilled with a 62-degree angle.

especially if the tree is leaning. A steeper angle, especially on a tree that leans away from the cavity entrance, can change the point where the entrance tunnel intersects the access hole, resulting in an entrance tunnel entirely in the sapwood.

Drilling the Entrance Tunnel

A 2-inch-diameter bit is used to drill the entrance tunnel. Make sure the shank of the bit is aimed toward the center of the access hole. If the access hole drifts to the left or right, the shank of the drill bit will have to be aimed accordingly. Be sure to clean out the tunnel frequently to avoid burying the bit in shavings.

Upon completion, the entrance tunnel should be clean and smooth. Any splinters in the tunnel can be removed by running the 2-inch bit back and forth within the tunnel a few times or by cutting splinters with a knife.

Finally, the outside edge of the cavity entrance should be beveled slightly. The side of an 0.5-inch bit can be used to bevel the entrance as the bit is turned by the drill.

Making Resin Wells

Red-cockaded woodpeckers peck small holes called resin wells into the sapwood of their cavity tree to encourage the flow of resin down the outside of the tree. The resin may be a deterrent to a potential predator, the rat snake (*Elaphe obsoleta*) (Jackson 1974; Rudolph and others 1990). In making artificial cavities, an important step is to create resin wells and to stimulate the flow of resin down the bark (Copeyon 1990). Use of the artificial cavities improves dramatically when resin wells are added.

Resin wells are made with an 0.5-inch bit. Drill a hole through the bark until the cambium is reached. At this point, pull the rotating bit downward for 0.5 to 1.0 inch. Resin wells should not be ragged or contain splinters if they are to be utilized by the birds. Fifteen to 20 resin wells should be placed randomly on the tree above and below the cavity entrance within the area where the bark was scraped.

After drilling the resin wells, they should be punched out with a Phillips head screwdriver and hammer to encourage resin flow. Using moderate blows, tap each resin well twice.

Plugging the Access Hole

Wood filler and the wooden plugs are used to plug the upper portion of the access hole to prevent sap leakage into the cavity (fig. 8). First, liberally apply wood filler to the sides of the access hole where the entrance tunnel intersects it. This will ensure that all sapwood is covered by either the plug or putty and aid in securing a good seal around the plug.

Installing the 3-inch plug—Select a 3-inch-diameter plug angled 20 degrees on one end. Its length should equal the distance from the top of the 3-inch section of the access hole to 1 1/16 inches below the top of the entrance tunnel. If this plug is too long, it will prevent installation of the 3.5-inch plug.

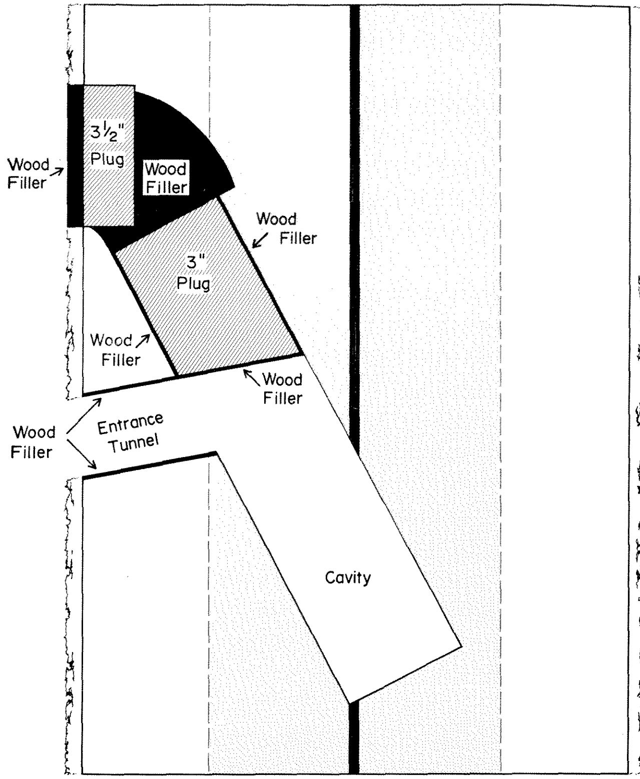

Figure 8—Completed drilled cavity with access hole plugged.

The 3-inch-diameter plug should be liberally coated with wood filler on all the sides except the bottom (20-degree face). A putty knife or a hammer handle should be stuck through the entrance tunnel and into the access hole to catch wood filler that falls off the plug. Insert the angled end of the coated plug into the access hole so that the plug will end up 1 1/16 inches below the top of the entrance tunnel. The short side of the plug will be towards you and the long side will be away from you with the angled face going in first. The plug may try to turn left or right. Prevent this so that the angled cut on the plug is facing down into the cavity, rather than canted to either side, when the job is completed. The plug will slide into the tunnel easily if the proper angle is obtained. The process can be aided with light taps from a hammer, but it should not be necessary to pound the plug into place. The plug should stop 1 1/16 inches below the top of the entrance tunnel.

At this stage, access to the cavity via the entrance tunnel is partially blocked by the 3-inch plug that extends below the top of the entrance tunnel. Therefore, it is necessary to drill through the 3-inch plug with the 2-inch multispur bit. Insert the 2-inch bit into the entrance tunnel and drill through the 3-inch plug as far as the back wall of the access hole. The tendency of the bit to wander downward as the plug is drilled can be counteracted by applying an upward angle to the bit as it is cutting the plug. It is not a problem if the bit still wanders downward somewhat.

Sealing the bottom of the 3-inch plug—It is important to create a seal with the wood filler around the bottom edge of the 3-inch plug everywhere it interfaces with the sides of the access hole. A long-handled teaspoon can be used to reach in through the entrance tunnel and apply the wood filler. Pay particular attention in getting a good seal of wood filler at the front wall of the access hole and bottom of the 3-inch plug on both sides of the entrance tunnel where it intersects the access hole.

If the initial plug does not fill the 3-inch-diameter portion of the access hole above the entrance tunnel, another 3-inch plug flat on both ends and of suitable thickness can be inserted on top of the initial plug.

Installing the 3.5-inch plug—Once the 3-inch plug is in place, put enough wood filler on top of it to fill the gap between it and the 3.5-inch plug when it is installed (fig. 8). After coating the sides of the 3.5-inch plug with wood filler, insert it into the mouth of the access hole so that its outward face is flush with the cambium. Wood filler should ooze from around the sides of the plug as it goes into place. If too much wood filler is between the two plugs, some will have to be removed to permit the 3.5-inch plug to fit flush with the cambium. During this process make sure the 3-inch plug is not driven deeper into the access hole. A hammer handle inserted inside the entrance tunnel will help prevent the first plug from slipping deeper into the access hole while the 3.5-inch plug is being installed.

Finishing the Entrance Tunnel

The entrance tunnel must now be covered with about a 1/16- to 1/8-inch coating of wood filler to help prevent the flow of resin. The roof of the entrance tunnel at the very back is formed by the bottom of the 3-inch plug. This area should be made to appear to be a solid continuation of the entrance tunnel by smoothing the joint with wood filler.

Use a putty knife or long-handled teaspoon to apply a heavy layer of wood filler to the top of the entrance tunnel. Begin at the back wall of the access hole and work forward first along the bottom of the 3-inch plug and then along the top of the entrance tunnel to the cavity entrance. Spread the wood filler onto the sides of the tunnel by pulling the instrument towards you. Finally, cover the bottom and even out the entire surface with a circular motion. The entrance tunnel should now appear as a smooth, continuous tunnel all the way to the back of the access hole. The finished surface of the tunnel should have a grainy rather than a slick appearance.

Initially, the entrance tunnel was 2 inches in diameter. The wood filler coating should reduce the diameter to slightly over 1.75 inches. It is important that the finished entrance tunnel is no smaller than 1.75 inches at any point. Otherwise, a bird may avoid the cavity or get stuck in it.

Finishing the Outside of the Tree

The 3.5-inch plug is still exposed and should be covered with wood filler flush with the bark. Spread the wood filler to conceal the presence of the plug. Lightly spray the area of the plug with brown Rust-Oleum paint (Copeyon 1990).

To simulate resin, we apply gobs of wood filler in several spots above and below the cavity entrance and to the sides and back as high and low as we can reach and then spread it over the bark with gloved hands. We are careful not to cover the resin wells with the wood filler. This application gives the tree an off-white appearance similar to a natural cavity tree and reduces the time it takes red-cockaded woodpeckers to start using a cavity (fig. 9).

Figure 9—Finished drilled cavity.

Spray the inside of the entrance tunnel with a heavy coat of brown Rust-Oleum paint. The paint helps seal the wood filler and prevent resin leakage.

Screening

The final construction task is to nail a 6- by 6-inch piece of 1/4-inch mesh hardware cloth across the entrance to the cavity. This will prevent a red-cockaded woodpecker from using the cavity until you can be absolutely sure that it is safe for use. The screen is left up until the maintenance checks outlined below have shown the cavity (or start) to be free of dangerous resin leaks.

Maintenance Checks

Purpose and Need

Resin in drilled cavities and starts is potentially lethal to red-cockaded woodpeckers if they become stuck in it. The purpose of the maintenance checks is to be sure resin is not leaking through the wood-filler barrier. In the construction of a drilled cavity, numerous resin ducts that serve as pipelines for resin flow are severed. The resin ducts will clog in 6 months or less, eliminating the problem. But until that time, a systematic check of all drilled cavities is essential to the well-being of the red-cockaded woodpecker (Copeyon 1990).

Maintenance Schedule

Each cavity should be maintained according to the following schedule. It is important to strictly adhere to this schedule. When the schedule cannot be followed, the wire screen should be kept over the cavity entrance for at least 8 weeks. If no problems exist at that time, it is safe to remove the screen. If leakage is found, repair the cavity and replace the screen for 2 weeks. Repeat checks and repairs at 2-week intervals until the cavity is free of resin leakage.

WEEK 1: Check all cavities. Correct any problems. Replace screen.

WEEK 2: Check all cavities.

No problem: Remove screen and proceed to Week 4.

Entrance tunnel leakage: Correct, remove screen, and proceed to Week 4.

Cavity leakage: Correct, replace screen, and proceed to Week 3.

WEEK 3: Check only cavities observed in Week 2 to have cavity leakage.

No problem: Remove screen and proceed to Week 4.

Problem: Correct, replace screen, and proceed to Week 4.

WEEK 4: Check all cavities.

No Problem: Remove screen if present and proceed to Week 8.

Entrance tunnel leakage: Correct and proceed to Week 8.

Cavity leakage: Correct, replace screen, and return to schedule for Week 3.

WEEK 8: Check all cavities.

No problem: Proceed to Week 12.

Entrance tunnel leakage: Correct and proceed to Week 12.

Cavity leakage: Correct, replace screen, and return to schedule for Week 3.

WEEK 12: Check all cavities.

No problem: Check in spring when sap pressure rises.

Entrance tunnel leakage: Check monthly until solved.

Cavity leakage: Correct, replace screen, and return to schedule for Week 3.

Trouble Shooting

The purpose of our modifications to the original procedure developed by Copeyon (1990) is to simplify the construction procedure, thereby reducing the potential for problems. If the preceding directions are followed as outlined, there should be few problems. This section describes ways for correcting problems and protecting the red-cockaded woodpecker from possible harm when maintenance checks reveal problems. It is best to do maintenance checks in the morning so that the wood filler used to correct problems can dry prior to evening roosting time. Woodpeckers may temporarily avoid the cavity if the wood filler is sticky.

Breach of Sapwood in Access Hole

If the pith is not allowed to leave the bottom of the access hole (see Drilling the Access Hole, Phase 2), breaching of the sapwood is very unlikely once the access hole starts into the heartwood. If the sapwood is breached, either through carelessness or because of very asymmetric heartwood, continuing to excavate the access hole to greater depths will only add to the problem. Assuming the tree had at least 7 inches of heartwood, the cavity should have been of a usable depth when the breach occurred and is worth saving.

Solution: Finish making the cavity without drilling the access hole any deeper. Put 1 to 2 inches of wood chips in the breached cavity to soak up the resin. Screen the entrance and follow the maintenance schedule.

Bottom of Entrance Tunnel Intersects Access Hole Improperly

The bottom of the entrance tunnel should intersect the access hole through heartwood. Our procedure is designed to assure that this occurs. However, if for some reason the intersection occurs in sapwood, resin will run down from the entrance tunnel into the completed cavity.

Solution: Prior to plugging the access hole, cover the exposed sapwood where the entrance tunnel intersects the access hole with wood filler and then finish building the cavity. Screen the entrance and follow the prescribed maintenance schedule. If the resin continues to leak after the initial coating of wood filler, add water to wood filler and use a teaspoon to pour the slightly more fluid material over the affected area. A layer of wood chips should be added to the bottom of the access hole.

Resin Leakage from the Plugged Region of the Access Hole

Resin may leak into the cavity from the plugged area of the access hole. Careful attention to plugging the access hole (see Plugging the Access Hole) will reduce the likelihood of this problem. Also make sure the upper-back portion of the entrance tunnel is properly coated with wood filler following construction (see Finishing the Entrance Tunnel). This problem will not be recognized until a maintenance check is made.

Solution: Put chips into the bottom of the cavity to soak up and cover the resin. Cover the area from which the resin is leaking with additional wood filler. Screen the cavity entrance and follow prescribed maintenance schedule.

Resin Leakage in the Entrance Tunnel

Even in properly constructed cavities, resin may leak through the wood filler and paint barrier coating the entrance tunnel (see Finishing the Entrance Tunnel). In fact, minor leakage of resin into the entrance tunnel is a common problem. A better method of stopping resin flow is needed.

Solution: Scrape away accumulated resin with a knife to minimize buildup on the entrance tunnel wall. Apply a thin additional layer of wood filler at the point of leakage and repaint. Screen the cavity and follow the prescribed maintenance schedule.

Safety

All cavity excavation is performed with the driller standing on a Swedish tree-climbing ladder (Snyder and Rossoll 1958). It is assumed that the driller is an experienced climber, trained in the safe use of these ladders prior to learning how to excavate cavities. Free-standing ladders (i.e., painters' ladders) should not be used: they would be extremely unsafe for this type of work, and it would probably be impossible for the driller to get into the required positions to do the work.

Workers should be especially aware of the following hazards and the safe operating procedures to protect themselves.

Hanging Limbs

Inspect each tree before climbing to be sure that broken limbs are not hanging in the crown. While hardhats should be worn at all times, they do not offer protection from a falling limb. It should be the responsibility of both the driller and ground crew to inspect each tree: both are at severe risk from hanging limbs. Sometimes, it is possible to climb the backside of a tree and safely remove a hanging limb if another suitable tree is not available.

Small Falling Tools

The ground crew should wear hardhats at all times while assisting the excavation of cavities. Falling tools are especially hazardous to the ground crew, and hardhats offer real protection from small tools that could otherwise cause a fatality.

Big Falling Tools

Hardhats cannot protect the ground crew from a 12-pound drill falling 20 feet. Such an accident could result in a crushed skull or a broken neck. Thus, it is essential that the ground crew keep away from the base of the tree being excavated, except at times when the driller has requested assistance and is aware of the ground crew's presence.

Lightning

Remember that aluminum ladders are an excellent conductor of electricity. When storms are threatening, stay away from trees rigged with climbing ladders. Give yourself plenty of time to get down.

Bark Hazards

Wear eye protection (goggles recommended) and gloves when scraping the bark. Failure to do so will assuredly result in bark flakes in the eye and torn fingernails.

Falling From the Tree

When climbing, wear a safety strap that is connected at both ends to the climber and passed around the tree trunk at all times. It is virtually impossible to fall from a tree when using tree-climbing ladders and a safety strap. Our crews are not permitted to climb a single rung without being correctly strapped around the tree. The strap does not slow or hamper climbing; in fact, we believe it is faster in the long run than hooking your safety strap after you have reached your proper working height. Climbing belts should be inspected prior to climbing.

The Bit Snags

Drill bits periodically snag while cutting, causing the drill to twist. An improper hold could result in a sprained wrist, a broken finger, or injury to the face from a twisting drill. To prevent these types of injuries, it is essential that the drill be properly held.

There are two safe ways to hold the drill. The first is with the support handle in the 6 o'clock position and held in the left hand, and the trigger in the 3 o'clock position held with the right hand (fig. 10). The second way is with the support handle in the 9 o'clock position and held in the left hand with the palm up, and the trigger in the 6 o'clock position. Never use the drill with the palm of the left hand facing downward.

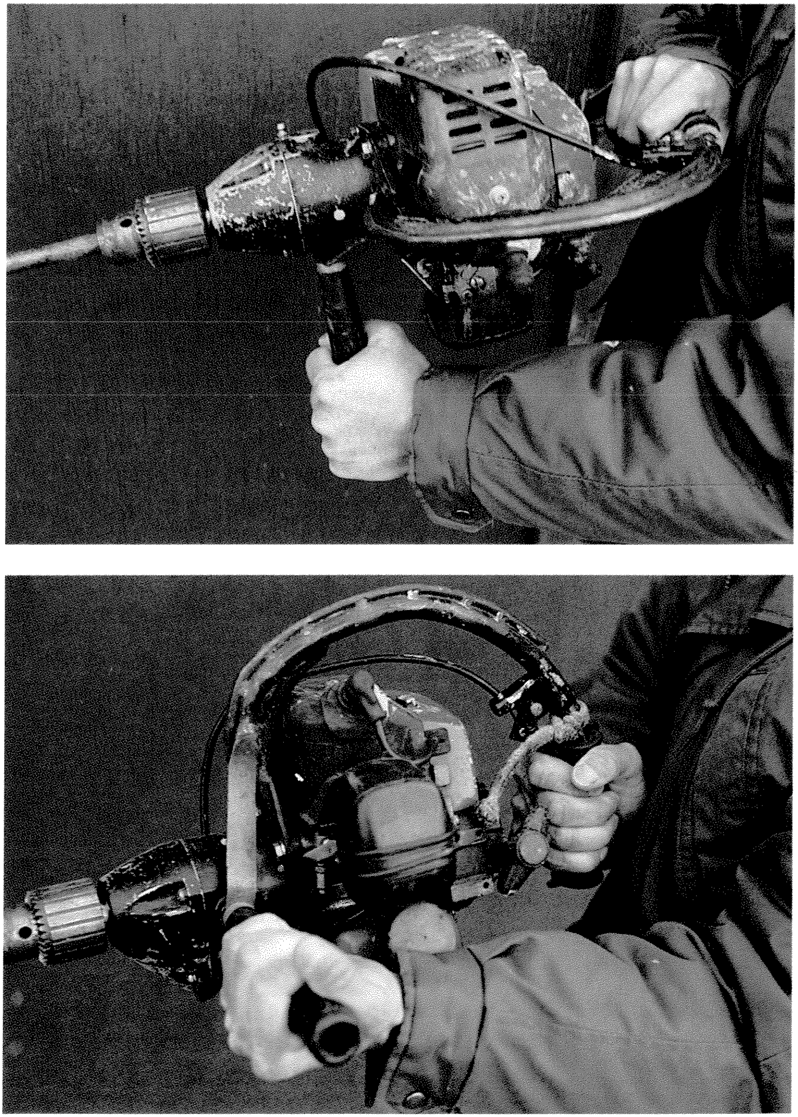

Figure 10—Proper ways to hold the drill to avoid injury when the bit snags during cavity excavation.

Hearing Protection

It is advisable for the worker to wear hearing protection when operating the drill and blower. Both the earmuff style built into some hardhats and the inexpensive foam earplugs have found favor with our crews. Both are satisfactory protectors.

Eye Protection

Eye protection (goggles recommended) should be worn when drilling the tree and blowing chips from the access hole.

Other Types of Artificial Cavities

Starts

In addition to the drilled cavity, Copeyon (1990) described a drilled start hole (incomplete cavity). We followed her original procedure with two exceptions. First, we did not make starts in trees with less than 6.0 inches of heartwood or more than 4.0 inches of sapwood. Second, we routed out the start hole with a 1 9/16-inch bit instead of a 1 3/16-inch bit. These changes allowed us to make a larger start hole, many of which could be used for roosting with no additional work.

Our goal on the Francis Marion National Forest after Hurricane Hugo was to try to have at least two completed cavities (either natural and/or artificial) and one start in each colony site as soon as possible. Of the 132 starts we constructed, most had been worked on by woodpeckers within 1 year after Hugo (5 - 11 months following construction). Several starts were completed by the birds and were used as nest cavities within 6 months of construction.

Starts have several advantages over completed artificial cavities. The greatest is that they weaken the tree no more than a natural cavity. Completed drilled cavities obviously weaken the tree but we have lost none from winds up to 50 miles per hour.

Starts must be screened and put on the same maintenance schedule as drilled cavities.

Inserts

If trees meeting the minimum sapwood and heartwood requirements for construction of drilled cavities and starts are not available, prefabricated cavities are a possibility. In this procedure, a prefabricated cavity is inserted into the tree after cutting the proper-size hole with a special chainsaw (Allen 1991). The tree does not have to have any heartwood for the insert technique to be used. However, for structural soundness after construction, the tree needs a minimum diameter at the cavity level of 15 inches. To obtain a 15-inch diameter at 10 or 20 feet requires a d.b.h. of 16 - 17 and 18 - 19 inches, respectively. The age at which trees can reach these diameters depends on site quality, stand stocking, and species.

Permits

Construction of artificial cavities for red-cockaded woodpeckers is subject to the Endangered Species Act. If the artificial cavity project is considered a Federal action, Section 7 compliance of the Act requires that the action not jeopardize an endangered species. Section 9 compliance (take and handling provisions) is required on public and private lands. Those contemplating excavating artificial cavities are advised to contact the closest field office of the U.S. Department of the Interior, Fish and Wildlife Service for specific requirements.

Equipment

Drill

We used a Tanaka 232 gas-powered drill. It has an air-cooled two-cycle engine with a displacement of 1.4 cubic inches, turns at 250 - 375 revolutions per minute, and has an 0.5-inch chuck. Its fuel tank holds 0.25 gallon, sufficient for 60 minutes of drilling. Dry weight is 8.8 pounds. This model is being replaced by the manufacturer with the Tanaka 262. The 262 is similar to the earlier model, except that it has a displacement of 1.6 cubic inches, weighs 1 additional pound and will run for 40 minutes on a tank of gasoline. The new model does not snag as often as the old model. Other gas-powered drills meeting these specifications would probably be suitable.

We do not recommend electrical drills because of the problems with transporting generators, the potential shock hazard, and because the electric drills produce greater torque when the bit snags.

Bits

The drill bits are critical pieces of the equipment. We had considerable problems with bits for various reasons. The ones we describe here are the most trouble free and best performing of the various bits and modifications we have tried.

The 2- and 3.5-inch multiple spur bits are made by Forest City Tools, Hickory, NC. One bit of each type is needed. They come with a 6-inch shaft, which needs to be extended 2 inches. The extension should be made of 4140 ground, polished, heat-treated steel. It should be welded to the original shaft with a 11018 Tig weld. Three flats, 0.63-inch wide and 1.25-inch long, should be ground 120 degrees apart on the extended shaft so the chuck can maintain a secure grip on the bit. Finally, the last 2 inches of the extended shaft with the ground flats should be hardened. We had a professional machine shop modify these bits.

The 3-inch self-feeding bits are made by Milwaukee Electric Tool Corp., Brookfield, WI. Three of these bits are needed. These bits are used with an extension manufactured by the same company. The three extensions are 5.5 inches, 12 inches, and 18 inches. These extensions should be welded to the 3-inch self-feeding bits.

All the bits can be sharpened by hand, but careful attention must be paid to maintain the proper angles on the cutting edges of the shaver and the outside teeth. The bits should be sent back to the respective factories for sharpening periodically. Thus, if continuous excavation is planned, several sets of bits are needed to keep one crew operational.

Blower

We used a Toro model 30935 gasoline-powered blower. It has a 2.3-cubic-inch air-cooled engine. The machine can blow up to 160 miles per hour. Other makes of blowers may work as well, but be sure that a homemade hose connection can be added to the model you select.

The hose assembly is made by inserting an 8.5-inch-long section of 1.5-inch PVC pipe into the blower. Wrap the PVC with a few layers of duct tape to effect a tight fit in the blower. Use a hose clamp to hold the PVC pipe in the blower. Before operating the blower, make sure the PVC pipe is short enough to clear the fan blades inside the blower. Next, insert a 48-inch section of 1-inch flexible plastic hose through a 1.5-inch PVC male to female adapter. Wrap the end of the hose protruding out the female side of the adapter with duct tape until the hose fits tightly into the 1.5-inch end of the coupling. Finally, glue the female end of the adapter on to the 1.5-inch PVC pipe that is attached to the blower.

Plugs

Plugs for closing the access hole should be made out of yellow-poplar. Pine plugs are too unstable. The 3-inch-diameter plugs should be of variable lengths from 2 to 3 inches long. One end must be cut at a 20-degree angle. Some 3-inch-diameter plugs 1-inch thick and without the 20-degree angle are also useful to help fill long access holes. The 3.5-inch-diameter plugs should be flat on both ends (no angle) and 1.25 inches thick. We had our plugs made by a professional woodworking shop. It is a good idea to have a surplus of the various sizes.

Wood Filler

We used Elmer's Professional Carpenter's Wood Filler. A nontoxic product is required. Two pints are needed to do one cavity.

Paint

We used brown Rust-Oleum in 1-pint spray cans. A nontoxic product is required. One pint will do about 20 cavity trees.

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Appendix 1

Specialized Tools Needed for One Crew to Drill Woodpecker Cavities

	Number	Model Used	Cost	Manufacturer
POWER TOOLS				
Gas-powered drill	1	Tanaka 232/262	$235	
Gas-powered blower	1	Toro 30935	200	
DRILL BITS				
2-inch multispur (with 6-inch shaft)	1	62760	38	Forest City Tools, Hickory, NC
3.5-inch multispur (with 6-inch shaft)	1	62776	180	Forest City Tools, Hickory, NC
3-inch self-feed	3	48-25-3001	285	Milwaukee Electric Tools, Brookfield, WI
0.5-inch machine bit	1		6	
SHAFT EXTENSIONS				
5.5-inch extension	1	48-28-4000	12	Milwaukee Electric Tools, Brookfield, WI
12-inch extension	1	48-28-4005	12	
18-inch extension	1	48-28-4010	12	

NOTE: To make drilled starts, one needs an additional multispur bit 1 9/16-inch-diameter with a 6-inch shaft. (Model 62753, $32, Forest City Tools). The shaft needs to be extended to 14 inches (8-inch extension) by welding and treating as described in the text.

Appendix 2

Standard Tools and Equipment Needed for One Crew to Drill Woodpecker Cavities

STANDARD TOOLS AND MATERIALS	Number
Bark knife	1
Carpenters tape	1
Carabiner	1
Climbing belt	1
Climbing ladders	3
Clinometer	1
Compass	1
Diameter tape	1
Gloves (pair)	2
Goggles	1
Hammer	1
Hardhat	2
Hardware cloth (1/4-inch mesh: 6 by 6-inch squares)	1 per cavity
Hearing protectors	2
Increment borer	1
Paint brown (nontoxic, spray)	1 pint
Pliers	1
Putty knife	1
Rope (25-foot 5/16-inch)	1
Safety strap	1
Toolbox	1
Tool pouch	1
Wood filler (nontoxic)	2 pints per cavity

PLUGS	Number
3-inch by 2 inch (20 degree face)	1 per cavity
3-inch by 3-inch (20 degree face)	1 per cavity
3-inch by 1-inch (flat faces)	1 per cavity
3.5-inch by 1.25-inch (flat faces)	1 per cavity

BLOWER ASSEMBLY PARTS	Number
PVC Pipe (1.5- by 8.5-inch)	1
PVC 1.5-inch male/ female adapter	1
Flexible plastic hose (1.0-inch by 48-inch)	1
Hose clamp	1
PVC pipe glue	
Duct tape	

Tradenames are mentioned in this publication solely to identify materials and equipment that have been successfully used to make artificial woodpecker cavities. Mentioning tradenames does not imply endorsement by the U.S. Department of Agriculture or suggest superiority over other comparable products.

Taylor, William E.; Hooper, Robert G. 1991. A modification of Copeyon's drilling technique for making artificial red-cockaded woodpecker cavities. Gen. Tech. Rep. SE-72. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station. 31 pp.

A modification to Copeyon's drilling technique for making highly effective artificial cavities for red-cockaded woodpeckers is described. The changes virtually eliminate the possibility of making a mistake in constructing cavities and reduces the learning time to less than 2 weeks. The basic change is the use of a 3-inch access hole that allows the relative position of the pith to be used to avoid breeching the sapwood and replaces routing the cavity with a single, precisely drilled hole.

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