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Red-Cockaded Woodpecker Symposium II Proceedings

Richard N. Conner
Wildlife Habitat and Silviculture Laboratory, Southern Research Station, U.S.D.A., Forest Service, Nacogdoches, Texas 75962

James Kroll
Arthur Temple College of Forestry and Agriculture, Stephen F. Austin State University, jkroll@sfasu.edu

Brian Locke
Stephen F. Austin State University, Arthur Temple College of Forestry and Agriculture

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FACTORS INFLUENCING COLONY SITE SELECTION BY RED-COCKADED WOODPECKERS

BRIAN A. LOCKE—*School of Forestry, Stephen F. Austin State University, TX (present address: Department of Biology, New Mexico State University, Las Cruces, NM 88003).*
RICHARD N. CONNER—*Wildlife Habitat and Silviculture Laboratory, Southern Forest Experiment Station, U.S. Forest Service, Nacogdoches, TX 75962.*
JAMES C. KROLL—*School of Forestry, Stephen F. Austin State University, Nacogdoches, TX 75962.*

Abstract—Discriminant function alaysis was used to examine which vegetative factors other than stand age affect habitat selection by red-cockaded woodpeckers (*Picoides borealis*). Forest stands used for nesting were compared with pine-dominated stands not occupied by red-cockaded woodpeckers. To minimize the effects of territoriality and stand age on habitat suitability, we tried to select unoccupied stands that contained trees 80+ years old and were 0.8km or farther from active colonies. The discriminant function did distinguish ($P \leq .001$) between plots found in occupied versus unoccupied stands. Colony sites were located in relatively open, pine-dominated stands with low densities of hardwood trees and less total basal area. Observed habitat preference is probably a reflection of stand conditions that produce trees suitable for cavity excavation.

Investigations of the habitat requirements of red-cockaded woodpeckers have mostly been qualitative inventories or quantitative descriptions of colony areas. The majority of studies have been conducted in the coastal plain states of the Southeast and have indicated that red-cockadeds tend to occupy mature pine forests with relatively open or sparse midstory and understory vegetation (e.g., Baker 1971; Crosby 1971; Hopkins & Lynn 1971; Thompson & Baker 1971; Carter 1974; Grimes 1977). VanBalen & Doerr (1978) supported that notion by demonstrating that active cavity trees are surrounded by fewer and shorter understory stems than are potential cavity trees in the same area.

In this study, we quantitatively compared stands in colonies with randomly selected control areas which were dominated by pine trees and contained trees of similar ages as in colonies. Our primary interest was to determine how forest structure might affect habitat selection by red-cockaded woodpeckers, and we suspected that the use of similar-aged colony and control sites would provide a more refined indication of habitat requirements than previous studies had demonstrated.

STUDY AREA AND METHODS

This study was conducted in portions of the Angelina and Davy Crockett national forests in eastern Texas. The combined forests occupy 51,851ha, dominated by pine stands but also including mixed pine-hardwood, bottomland and upland hardwood stands. Loblolly (*Pinus taeda*), shortleaf (*P. echinata*) and longleaf (*P. palustris*) are the predominant pine species present, although slash pine (*P. elliottii*) is present in some areas. All forest types are managed on an even-aged basis. During and prior to this study, longleaf, shortleaf and slash stands were on an 80-year rotation schedule, while loblolly was managed on a 70-year rotation.

Colony sites have been managed on the forests as separate stands and not cut as long as they contained a living cavity tree. A 60m buffer of uncut trees was usually maintained around colony sites. Other management activities included removing midstory crowns which blocked entrances to cavities, retention of snags in the colony sites and maintenance of 11.48-18.37m^2/ha basal area. Prescribed burning has been conducted at 3-5 year intervals to suppress understory vegetation.

Twenty active colonies, 11 in shortleaf-loblolly stands and 9 in longleaf stands, were selected for study from a map of both active and inactive colonies provided by the National Forests in Texas (NFT). The colonies were partitioned by stand type in order to compensate for obvious habitat differences between shortleaf-loblolly and longleaf type stands. The shortleaf-loblolly stands contained more hardwood species and were less open than the longleaf stands. Inactive colony sites were omitted from the sample to avoid confounding factors (e.g., disturbance, pine beetle infestations, etc.).

A subset of stands dominated by pines 80+ years old was selected from NFT data, from which 11 shortleaf-loblolly and 9 longleaf stands were randomly selected as control sites. To ensure that suitability, or lack thereof, of unoccupied stands was a function of habitat structure and not territorial exclusion, only stands

0.8km or farther from mapped colonies were selected. Only 6 of the longleaf stands met both distance and age criteria, so 3 stands of the next oldest Forest Service age class (50 years) were included. However, all 9 longleaf stands contained groups of relict trees.

Vegetative characteristics were measured within 5 0.04ha circular plots in each colony and control area with 1 plot centered on the nest tree in colony areas and on a randomly chosen point in control stands. In the 3 longleaf control areas that did not meet the age requirement, the central plot was randomly located within a group of relict trees. The other 4 plots in both occupied and control stands were located 50m from the central plot on azimuths of 72, 162, 252 and 342 degrees. The first azimuth (72°) was chosen in a random manner with the remaining azimuths orthogonal. In some cases, azimuths and/or distances were slightly altered to avoid obviously unsuited features such as a clearcut or pasture. Sample plots did not overlap.

Within each sample plot, crown position, tree species and dbh were recorded for each stem which had a dbh of at least 7cm (Table 1). Crown position in this sense meant the location of individual tree crowns in relation to the tallest (dominant and codominant) trees in the stand. Basal area (m^2/0.04ha) and density of stems (stems/0.04ha) were calculated for species groups (hardwoods, pines), crown classes (understory, midstory and overstory), crown class and species combinations, and for all trees in the plot.

Each pine at least 28cm dbh was aged by increment coring and measured to determine total tree height and bole length. The percent of total tree height represented as bole was calculated for each dominant pine and the average for all dominant pines in a plot was represented by mean ratio of bole length to height (MRBL). The average for all tree heights measured in each plot (MHGHT) was also calculated, as was mean age (MAGE) for all dominant pines in a plot. Because the mean age of 2 stands could be equal although 1 may not contain any trees old enough for cavity excavation, the maximum tree age per plot (MXAGE) and number of "old" trees per plot (NOLD) were also calculated. "Old" was defined as 94+ years old for longleaf and 74+ years old for other pine species present. Those values approximate mean ages of cavity start trees reported by Jackson et al. (1979).

Discriminant function analysis (DFA) was used to compare plots found in colonies with plots found in control areas. A stepwise DFA was calculated and any variables which did not separate groups significantly ($P \leq .1$, Rao's V [Nie et al. 1975]) were excluded. Pearson correlations between the selected original variables and the discriminant function axes were calculated to determine the relation between each variable and the discriminant function. The relative magnitude of the correlation has been demonstrated to be the best method to determine which variables are most important in discriminating between the types of habitat (Timm 1975).

RESULTS

Basal area of pines (PBA) accounted for 86.5% and 74.4% of the total basal area (TBA) in colony and control areas, respectively (Table 1). The colony and control areas also had similar aged trees (MAGE, MXAGE, NOLD). Major differences between the areas appeared to be a greater density and basal area of hardwoods on the control areas, and greater density and basal area of understory and midstory pine trees on the colony plots. Total basal area was greater on the control areas due to the greater amount of hardwood basal area; pine basal areas were approximately equal.

Results of a DFA separating colonies from control areas (Table 2) suggest that red-cockaded woodpeckers avoided dense forest situations. The negative association between colony areas and increasing numbers of hardwood trees (NMHW and NHW) and increasing amounts of overstory and midstory basal area point to the avoidance of dense forests where shade-tolerant trees could prosper.

The colony sites apparently had denser overstories in the past. Red-cockadeds selected colony areas that were positively associated with increasing mean ratio of bole length to total height, yet negatively associated with mean height of pines and overstory basal area. Trees that compete for light tend to have greater ratios of bole length to total height than trees grown in more open situations. Dense overstories would limit branches to the upper portions of trees while the trees are actively growing in height. The colonies were later thinned, possibly by natural mortality or commercial forest operations.

DISCUSSION

We have quantitatively demonstrated that when stands of similar ages were available in our study area, red-cockaded woodpeckers selected those stands that were open and had less hardwood understory and midstory vegetation, supporting similar results of other studies (e.g., Beckett 1971; Grimes 1977; VanBalen & Doerr 1978; Lennartz & McClure 1979; Wood 1983). The avoidance of forests with dense hardwood understories might be related to suitability of cavities as roosting sites. As understory or midstory vegetation approaches the height of active cavities, red-cockadeds may abandon the cavity (Beckett 1971; Carter 1974). VanBalen & Doerr (1978) demonstrated that active cavity trees are surrounded by less understory than are trees without cavities, and Wood (1983) found only 15 of 126 cavities in Oklahoma situated below the height of the surrounding midstory, and, further, that the midstory surrounding those 15 trees was much sparser than that surrounding trees with cavities situated above the midstory height. Also, trees that crowd cavity trees may allow rat snakes (*Elaphe obsoleta*) or flying squirrels (*Glaucomys volans*) access to cavities without having to cross fresh resin (Dennis 1971; Jackson 1974).

Our results also demonstrated a positive association of mean ratio of bole length to total height with colony areas. That suggests that the forest stands now occupied by red-cockaded woodpeckers were once stocked at greater densities and underwent more crown competition than did the control areas. Existing cavity trees were not grown in the relatively open situations used today to optimize sawtimber production. That explains Lay & Swepston's (1973) observation that red-cockaded cavity trees tend to have diameters smaller than or equal to trees that are 30 years younger and grown in stands managed using modern silvicultural practices. Our results support Lay & Swepston's (1973) recommendation that replacement trees be grown in relatively dense stands and thinned from above. Growing sawtimber stands for 80+ years may not produce trees suitable for excavation by red-cockaded woodpeckers. Stands need to be grown in relatively dense situations until they approach an age at which red-cockadeds will begin to excavate cavities. Such conditions may be provided by seed-tree cuts in dense, mature pine stands. Seed-tree cuttings would also provide relatively open overstories and midstories. Other researchers have noted that colonies are often found in and near areas that have received seed-tree cuts (J. Jackson pers. comm., D. Lay pers. comm.).

The reasons for these documented habitat preferences are not entirely known, but simply growing pine stands to a certain age may not necessarily produce suitable habitat. Further research is needed to ensure development of adequate management policies, but as of now the most pressing need seems to be the production of trees suitable for cavity excavation.

Table 1. Mnemonic codes, means and standard errors for 100 0.04ha colony and control plots.

		Colony		Control	
Code	Parameter	$\bar{x}$	SE	$\bar{x}$	SE
TBA	Total basal area (m^2/.04ha)	.797	.026	.927	.029
PBA	Pine basal area (m^2/.04ha)	.695	.027	.697	.031
HWBA	Hardwood basal area (m^2/.04ha)	.101	.012	.229	.021
OBA	Total overstory basal area (m^2/.04ha)	.532	.023	.602	.027
OPBA	Overstory pine basal area (m^2/.04ha)	.526	.024	.572	.027
OHWBA	Overstory hardwood basal area (m^2/.04ha)	.006	.003	.030	.009
MBA	Total midstory basal area (m^2/.04ha)	.145	.014	.179	.014
MHWBA	Midstory hardwood basal area (m^2/.04ha)	.039	.007	.091	.012
MPBA	Midstory pine basal area (m^2/.04ha)	.106	.013	.088	.010
UBA	Total understory basal area (m^2/.04ha)	.119	.010	.145	.008
UHWBA	Understory hardwood basal area (m^2/.04ha)	.569	.006	.109	.008
UPBA	Understory pine basal area (m^2/.04ha)	.062	.009	.035	.004
MXAGE	Maximum tree age	82.760	3.560	113.370	17.845
MAGE	Mean age of pines > 28cm dbh	70.918	2.363	75.897	4.605
MDBH	Mean dbh (cm)	21.584	.784	20.336	.5023
MHGHT	Mean height (m) of pines > 28cm dbh	24.369	.584	26.027	.758
MRBL	Mean ratio of bole length to height of pines > 28cm dbh	.484	.013	.434	.014
NT	Total trees/.04ha	24.480	1.555	23.280	1.074
NHW	Total hardwood trees/.04ha	6.390	.663	12.810	.901
NOVT	Total overstory trees/.04ha	4.770	.288	4.670	.231
NOHW	Overstory hardwoods/.04ha	.030	.017	.250	.073
NOP	Overstory pines/.04ha	4.740	.290	4.420	.240
NOLD	Old pines/.04ha	1.750	.213	1.580	.183
NMT	Total midstory trees/.04ha	4.540	.595	4.420	.336
NMHW	Midstory hardwoods/.04ha	1.100	.217	1.850	.230
NMP	Midstory pines/.04ha	3.440	.581	2.570	.294
NUT	Total understory trees/.04ha	12.250	1.058	14.190	.870
NUHW	Understory hardwoods/.04ha	5.260	.557	10.710	.784
NUP	Understory pines/.04ha	6.890	.973	3.480	.499

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LITERATURE CITED

Baker, W.W. 1971. Progress report on life history studies of the red-cockaded woodpecker at Tall Timbers Research Station. Pp. 44-59 *in* Proc. Symp. Ecol. & Mgmt. Red-cockaded Woodpecker (R.L. Thompson, ed.), U.S. Bur. Sport Fish. & Wildl. & Tall Timbers Res. Stn., Tallahassee, FL.

Beckett, T. 1971. A summary of red-cockaded woodpecker observations in South Carolina. Pp. 87-95 *in* Proc. Symp. Ecol. & Mgmt. Red-cockaded Woodpecker (R.L. Thompson, ed.), U.S. Bur. Sport Fish. & Wildl. & Tall Timbers Res. Stn., Tallahassee, FL.

Carter, J.H. III. 1974. Habitat utilization and population status of the red-cockaded woodpecker in south-central North Carolina. M.S. Thesis, NC State Univ., 31p.

Crosby, G.T. 1971. Ecology of the red-cockaded woodpecker in the nesting season. M.S. Thesis, Univ. FL, 44p.

Dennis, J.V. 1971. Utilization of pine resin by the red-cockaded woodpecker and its effectiveness in protecting roosting and nest sites. Pp. 78-85 *in* Proc. Symp. Ecol. & Mgmt. Red-cockaded Woodpecker (R.L. Thompson, ed.), U.S. Bur. Sport Fish. & Wildl. & Tall Timbers Res. Stn., Tallahassee, FL.

Grimes, T.L. 1977. Relationships of red-cockaded woodpecker (*Picoides borealis*) productivity to colony area characteristics. M.S. Thesis, Clemson Univ., 53p.

Hopkins, M.L. & T.E. Lynn, Jr. 1971. Some characteristics of red-cockaded woodpecker cavity trees and management implications in South Carolina. Pp. 140-169 *in* Proc. Symp. Ecol. & Mgmt. Red-cockaded Woodpecker (R.L. Thompson, ed.), U.S. Bur. Sport Fish. & Wildl. & Tall Timbers Res. Stn., Tallahassee, FL.

Jackson, J.A. 1971. The evolution, taxonomy, distribution, past populations and current status of the red-cockaded woodpecker. Pp. 4-29 *in* Proc. Symp. Ecol & Mgmt. Red-cockaded Woodpecker (R.L. Thompson, ed.), U.S. Bur. Sport Fish. & Wildl. & Tall Timbers Res. Stn., Tallahassee, FL.

Jackson, J.A. 1974. Gray rat snakes versus red-cockaded woodpeckers: predator-prey adaptations. Auk 91:342-347.

Jackson, J.A., M.R. Lennartz & R.G. Hooper. 1979. Tree age and cavity initiation by red-cockaded woodpeckers. J. For. 77:102-103.

Lay, D.W. & D.A. Sweptson. 1973. Red-cockaded woodpecker study. Job 10 Completion Rept., TX FA Proj. W-80-R-16, TX Parks & Wildl. Dept.

Lennartz, M.R. & J.P. McClure. 1979. Estimating the extent of red-cockaded woodpecker habitat in the Southeast. Pp. 27-40 *in* Proc. For. Resour. Inventories (W.E. Frayer, ed.), CO State Univ.

Table 2. Discriminant function separating colony plots from control plots (P ≤ .001).

Variable	Classification coefficients	Correlation between variables and function
NHW	0.00318	-.5383
NUP	0.09746	.2927
MRBL	6.94088	.2638
NMHW	0.22901	-.2225
OBA	1.00704	-.1855
MHGT	-0.10940	-.1623
MBA	-6.23627	-.1598
MPBA	6.29008	.0999
NT	-0.05706	-.0891
NOLD	0.22256	.0601
Constant	0.59768	
Colony group mean	.60247	
Control mean	-.60252	
Plots correctly classified	75%	

age, cavity height and orientation, height of lowest branch, height of start holes, and the degree of slope on which the tree was situated.

Heights under 5m were estimated and those over 5m were measured with a Haga altimeter. Degree of slope was measured with an Abney level, tree diameter with a metal tree tape, and tree age with a Djon increment borer. Distances between cavity trees were paced. Statistical significances were determined using t-tests.

RESULTS AND DISCUSSION

Colonies—Thirty-two red-cockaded woodpecker colonies were located, 29 in the McCurtain County Wilderness Area and 3 on Weyerhaeuser Company lands in Pushmataha County, which consisted of 138 cavity trees being actively used (4.3 cavity trees/colony, range = 1-9). Minimum distances between nearest cavity trees within colonies averaged 58m (range = 5-240m). The maximum distance between any 2 cavity trees in the same colony was 630m.

Cavity Trees—A total of 155 active or recently active red-cockaded woodpecker cavity trees was located, 145 in the McCurtain County Wilderness Area and 10 in Pushmataha County. Active cavities predominantly faced in a westerly direction, with 75.3% facing SSW to NNW in contrast to 14.6% facing SSE to NNE (Fig. 2). A westerly orientation of active red-cockaded woodpecker cavities has also been reported from throughout the species' range (Locke & Conner 1983).

Characteristics of the midstory surrounding active cavity trees (Table 1) almost invariably allowed unobstructed flight access to active cavities. Cavities (N = 126) averaged 3.2m above midstory height, with only 15 (11.9%) situated below midstory height. But density of the midstory surrounding trees with cavities below midstory height (475.0 stems/ha) was significantly sparser ($P < 0.001$) than that surrounding trees with cavities above midstory height (723.2 stems/ha). Access to the lower cavities was thus much less

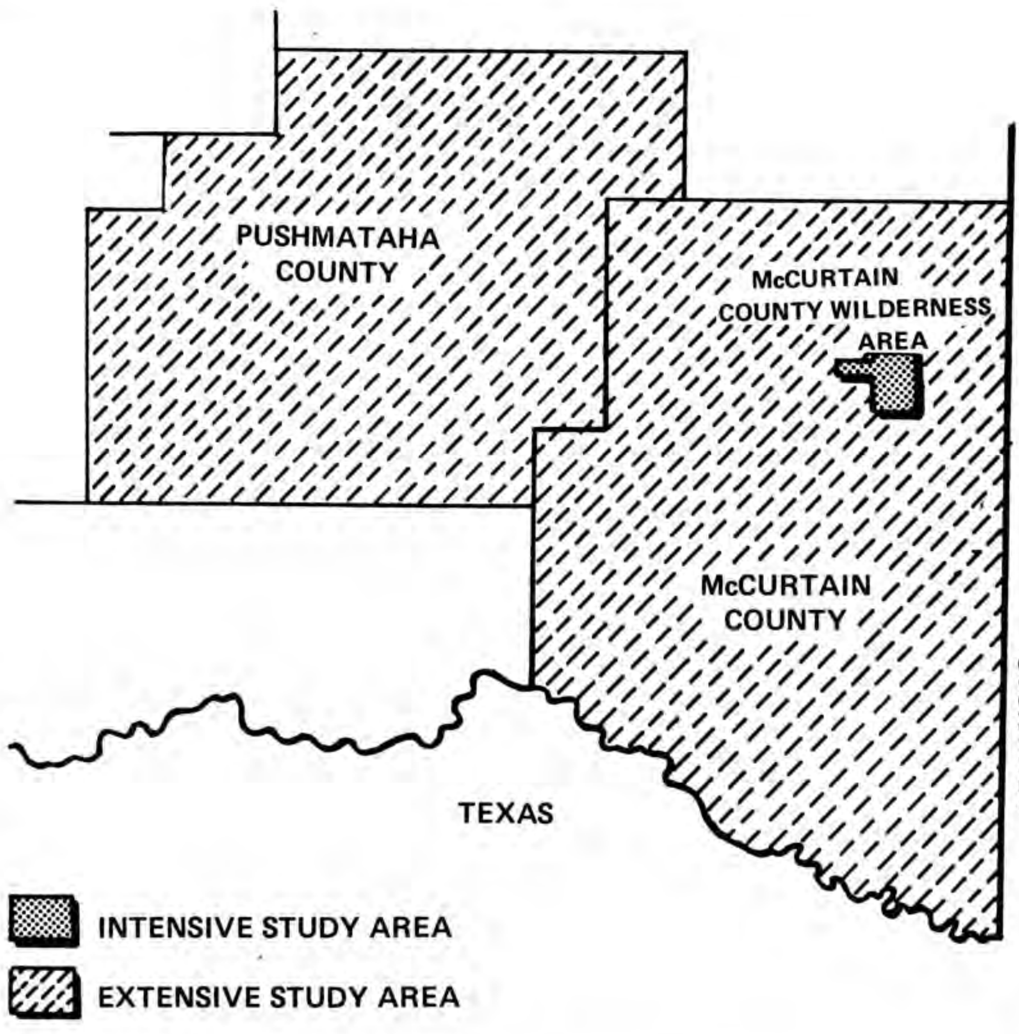

Figure 1. Red-cockaded woodpecker study areas in southeastern Oklahoma.

obstructed by midstory vegetation. VanBalen & Doerr (1978) similarly observed a preponderance of cavity excavation in trees around which the understory was either sparser or lower in height than around random potential cavity trees. Only 3 cavities (2.4%) were situated in the crowns of trees; all others were in trunks at varying distances below the crown, apparently dependent on midstory height.

Forty-one (45.6%) of 90 active cavity trees selected for aging had rotten centers and their age could not be determined. The remaining 49 trees averaged 149 years old (range = 95-301). Twelve active cavity trees died during the study (6.7% per year), compared to other documented annual mortality rates of 7.0% in Texas (Lay & Swepston 1973) and 5.0% in South Carolina (Hopkins & Lynn 1971). Two of the 12 were felled by wind (each broke off at cavity entrances) and another was killed by southern pine beetles (*Dendroctonus frontalis*). Mortality causes of the other 9 trees were unknown.

Cavity tree characteristics in Oklahoma (Table 2) were similar to those in other areas in the Southeast (Table 3) except for age and height of active cavities. The advanced ages of Oklahoma trees is undoubtedly a reflection of the virgin character of the McCurtain County Wilderness Area in contrast to areas elsewhere

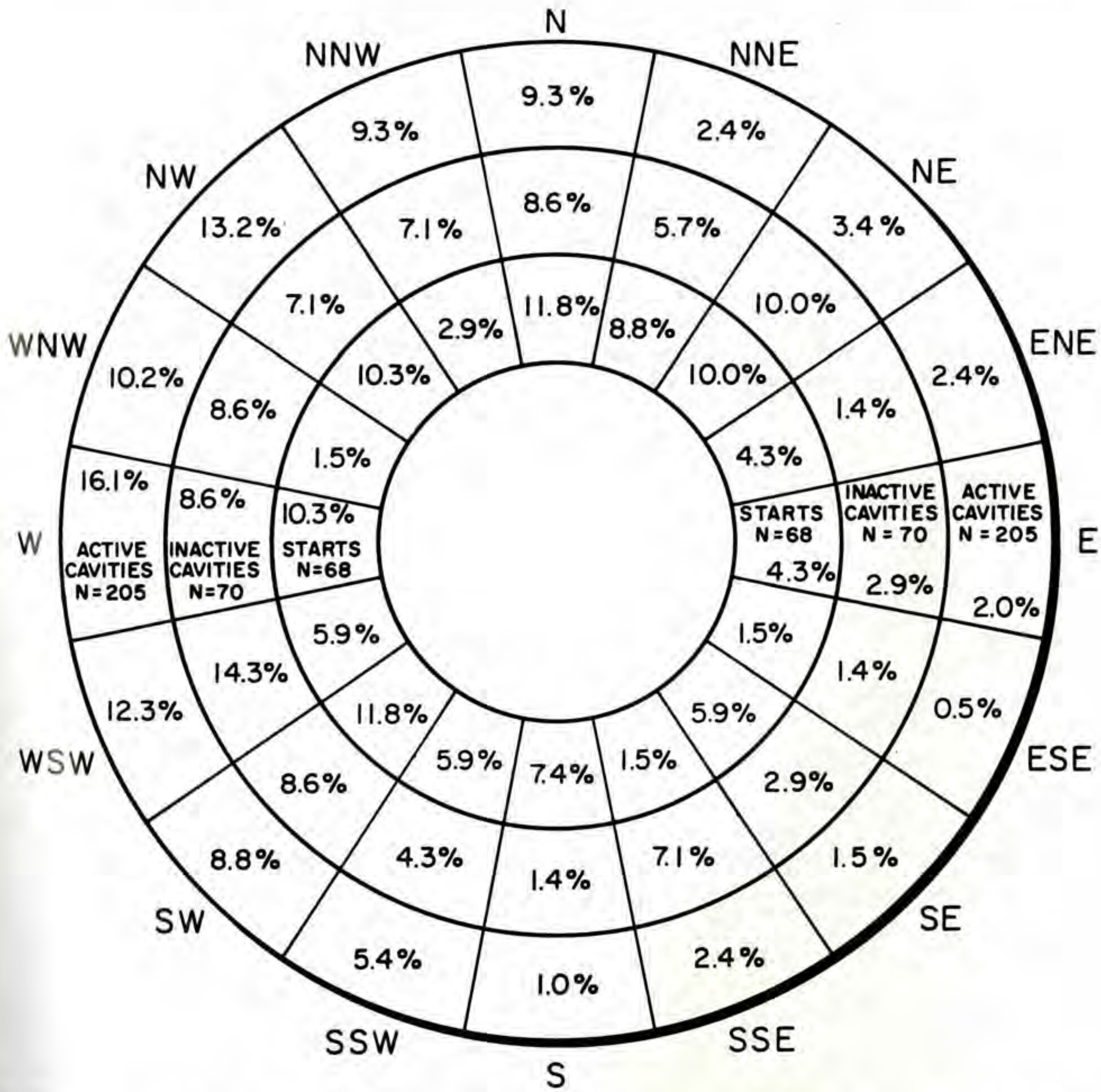

Figure 2. Orientation of cavities and starts in active red-cockaded woodpecker cavity trees in southeastern Oklahoma.

that have undergone various forms of exploitation. The higher cavity heights ($\bar{x}$ = 13.1m) in Oklahoma is probably due to the comparatively higher midstory height ($\bar{x}$ = 9.9m, Table 2) surrounding them. Midstory height in this instance is significant because it has been generally believed that red-cockaded woodpeckers require or strongly prefer park-like stands of timber with either low (1-2m) midstories or no woody vegetation at all surrounding cavity trees. However, as long as a sufficient length of trunk is exposed between the top of the surrounding midstory vegetation and the bottom of the cavity tree crown, woodpeckers should not be deterred by height of the midstory alone from excavating cavities. Height is less important when density is relatively sparse. Red-cockadeds will excavate cavities below the height of the surrounding vegetation when the midstory is sparse enough to allow unobstructed flight access to trunks.

Foraging Area—The measured minimum foraging area of the monitored clan totaled 52.8ha, of which 7.1ha (13.5%) were used intensively by the birds, 17.1ha (32.4%) were moderately used, and 28.6ha (54.1%) were used very little (Fig. 3). Some seasonality in foraging area size was evident. However, all seasonal and total size figures should be considered minimums. Due to the overall extreme ruggedness of the foraging area, it was impossible to consistently follow the birds for more than a few hours in the mornings. The dearth of afternoon foraging data may significantly bias the reported area sizes.

Shortleaf pine was dominant in the overstory throughout the foraging area, and co-dominant in the midstory with oaks (*Quercus spp.*) and hickories (*Carya spp.*), and in the understory with oaks, hickories and farkleberry (*Vaccinium arboreum*) (Table 4). The intensive-use area had a somewhat linear configuration and, to a lesser degree, so did the moderate-use area. This oblong configuration was at least partially due to the linear distribution of the higher elevations, where the birds preferred to forage.

The intensive-use area had the densest overstory (190.4 stems/ha), the sparest density (122.0 stems/ha) occurred in the limited-use area, and the moderate-use area was intermediate in overstory density (156.8 stems/ha) (Table 5). The intensive-use area was approximately uniform in elevation throughout, and was generally higher than the remainder of the measured foraging area. The apparent preference for foraging in relatively dense overstory trees was probably due to 1 or more of 3 reasons: (1) the higher stand density provided a more concentrated food source and thus minimized energy expended in foraging; (2) higher elevations, which are drier and where pines are naturally denser due to less competition from hardwoods, were for some reason preferred for foraging; and (3) the denser canopy provided some protection from raptors.

The significantly ($P < 0.05$) lower midstory height in the intensive-use area was somewhat biased by the inclusion in the data of the vegetative characteristics

Table 1. Vegetative characteristics surrounding red-cockaded woodpecker cavity trees in McCurtain and Pushmataha counties, Oklahoma.

Parameter	Overstory	Midstory	Understory	Total
Average height (m)	24.9	9.9	3.0	—
Average dbh (cm)	41.8	11.6	—	—
Average density (stems/ha)	148.7	688.4	2,788	3,625
Average basal area (m^2/ha)	16.86	6.27	—	23.13

Table 2. Characteristics of red-cockaded woodpecker cavity trees in southeastern Oklahoma.

Parameter	N	$\bar{x}$	Range
dbh (cm)	155	43.8	27.4-77.5
Total height (m)	154	24.8	16.5-33.8
Height of lowest branch (m)	154	10.7	2.4-21.6
Degree of slope	155	25.6	3-55
Active cavities/tree	155	1.2	1-3
Height of active cavities (m)	224	13.1	4.9-24.1

surrounding active cavity trees, all of which were located within the intensive-use area. As previously noted, a lower midstory height immediately surrounding them was usually the case. When the data from cavity tree plots were excluded, the average midstory height (9.4m) in the intensive-use area was not significantly different than that in the moderate-use area. Overstory basal area in the intensive-use area was significantly higher ($P < 0.05$) than in either the moderate-use or limited-use areas, but that higher basal area was principally a function of the denser overstory.

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LITERATURE CITED

Hopkins, M.L. & T.E. Lynn, Jr. 1971. Some characteristics of red-cockaded woodpecker cavity trees and management implications in South Carolina. Pp. 140-169 *in* Proc. Symp. Ecol. & Mgmt. Red-cockaded Woodpecker (R.L. Thompson, ed.), U.S. Bur. Sport Fish. & Wildl. & Tall Timbers Res. Stn., Tallahassee, FL.

Lay, D.W. & D.A. Swepston. 1973. Red-cockaded woodpecker study. Job 10 Completion Rept., TX FA Proj. W-80-R-16, TX Parks & Wildl. Dept.

Locke, B.A. & R.N. Conner. 1983. A statistical analysis of the orientation of entrances to red-cockaded woodpecker cavities. Pp. 108-109 *in* Red-cockaded

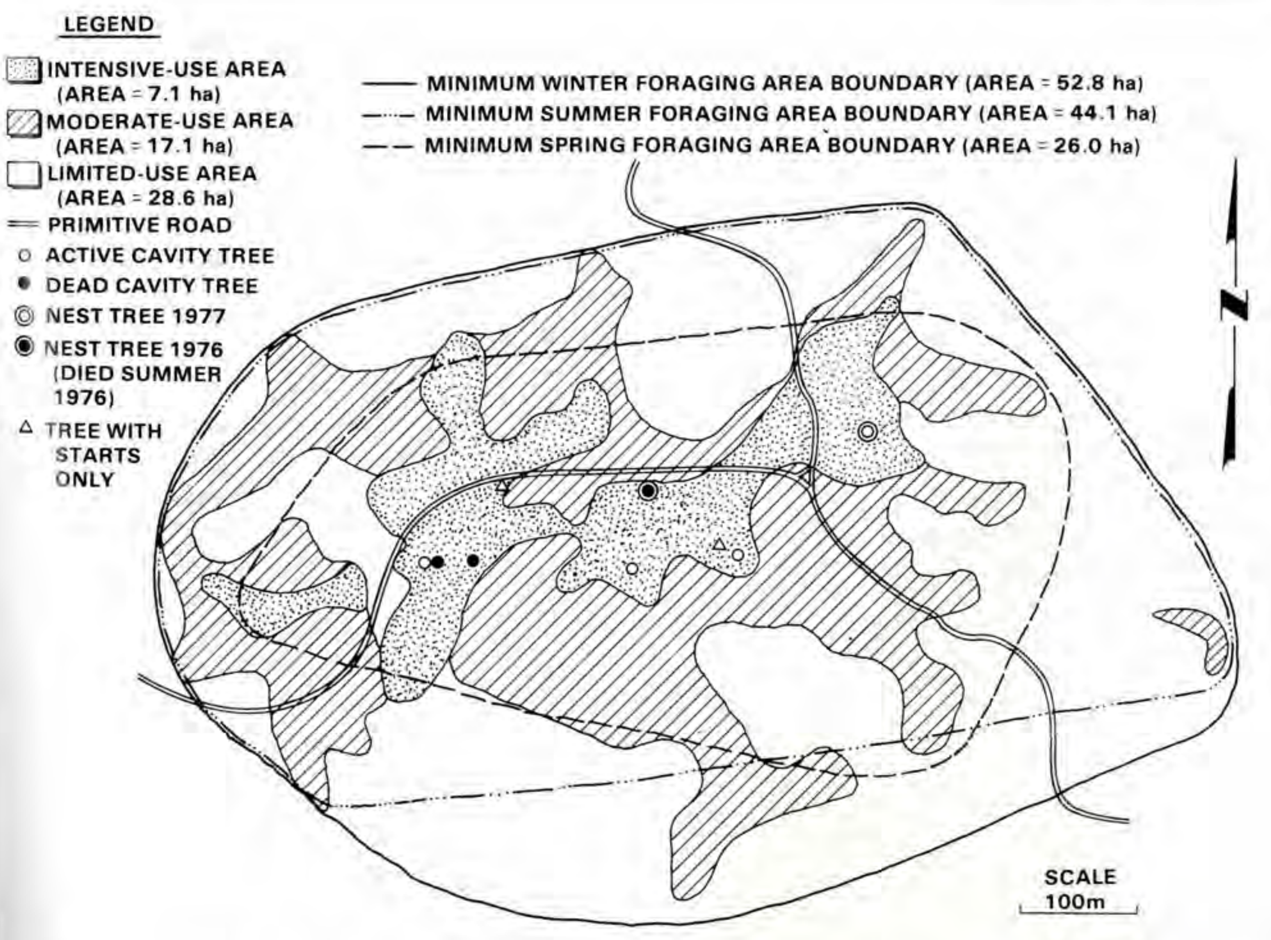

Figure 3. **Minimum foraging area of a clan of 5 red-cockaded woodpeckers in the McCurtain County Wilderness Area, Oklahoma.**

Woodpecker Symp. II Proc. (D.A. Wood, ed.), FL Game & Fresh Water Fish Comm., U.S. FWS & U.S. For. Serv.

VanBalen, J.B. & P.D. Doerr. 1978. The relationship of understory vegetation to red-cockaded woodpecker activity. Proc. Annu. Conf. SE Assoc. Fish & Wildl. Agencies 32:82-92.

Table 3. Characteristics of red-cockaded woodpecker cavity trees outside Oklahoma.

	Species					Mixed	
Parameter	Shortleaf	Longleaf	Loblolly	Pond	Slash	Species	Total
dbh (cm)							
$\bar{x}$	44.5	39.4	50.8	39.6	40.6	43.7	43.7
N	93	770	983	34	15	729	2,378
Source[1]	4,5,7	4,5,7	3[2],4,7	4,7	7	2,5	
Height (m)							
$\bar{x}$	24.5	21.7	28.2	20.4	25.0	20.5	21.6
N	94	764	980	33	15	723	2,177
Source[1]	4,5,7	4,5,7	3[2],4,7	4,7	7	2,5	
Height of lowest branch (m)							
$\bar{x}$	13.3	—	—	—	—	11.6	11.9
N	46	—	—	—	—	235	281
Source[1]	5	—	—	—	—	5	
Cavities/tree							
$\bar{x}$	1.7[3]	1.5[3]	1.7[3]	1.1[3]	1.8[3]	1.6	1.6[3]
N	45	560	574	8	15	815	2,017
Source[1]	7	7	7	7	7	2	
Cavity height (m)							
$\bar{x}$	11.6	7.4	13.4	—	14.6	7.9	8.7
N	112	70	141	—	1	1,164	1,148
Source[1]	1,5	1,5,6	1	—	1	2,5	
Age (yr)							
$\bar{x}$	87	86	74	72	70	84	81
N	77	610	884	31	15	627	1,985
Source[1]	4,5,7	4,5,7	3[2],4,7	4,7	7	2,5	

[1] 1 = Baker 1971; 2 = Carter 1974; 3 = Jackson 1977; 4 = Hopkins and Lynn 1971; 5 = Lay and Swepston 1973; 6 = Ligon 1970; 7 = Thompson and Baker 1971.

[2] Jackson's data include 1 shortleaf pine.

[3] Includes starts.

Table 4. Woody plant composition of a red-cockaded woodpecker foraging area in the McCurtain County Wilderness Area, Oklahoma.

Vegetative story and species	Relative abundance (%)	Relative frequency (%)
Overstory		
Shortleaf pine (*Pinus echinata*)	77.8	77.1
Oak (*Quercus spp.*)	20.0	31.2
Hickory (*Carya spp.*)	1.8	4.2
Sourgum (*Nyssa sylvatica*)	0.4	1.0
Midstory		
Oak	41.5	87.5
Shortleaf pine	30.7	60.4
Hickory	25.9	80.2
Grape (*Vitis spp.*)	0.5	3.1
Sourgum	0.4	4.2
Winged elm (*Ulmus alata*)	0.4	4.2
Red maple (*Acer rubrum*)	0.2	1.0
Downy serviceberry (*Amelanchier arborea*)	0.1	1.0
Flowering dogwood (*Cornus florida*)	0.1	1.0
Understory		
Shortleaf pine	31.7	75.0
Oak	24.5	100.0
Farkleberry (*Vaccinium arboreum*)	20.1	63.5
Hickory	16.3	96.4
Flowering dogwood	2.1	15.6
Early low blueberry (*Vaccinium vacillans*)	2.1	8.3
Sourgum	0.6	2.1
Grape	0.4	8.3
Common greenbriar (*Smilax rotundifolia*)	0.4	7.3
Winged elm	0.3	7.3
Red maple	0.3	1.0
Downy serviceberry	0.2	4.2
Smooth blackhaw (*Viburnum prunifolium*)	0.1	5.2
Eastern red cedar (*Juniperus virginiana*)	0.1	4.2
Hawthorn (*Crataegus spp.*)	0.06	2.1
Deciduous holly (*Ilex decidua*)	0.06	1.0
Hornbeam (*Carpinus virginiana*)	0.02	1.0
Sassafras (*Sassafras albidum*)	0.02	1.0
Tall deerberry (*Vaccinium stamineum*)	0.02	1.0
Unidentified shrubs	0.3	9.4

Table 5. Vegetative characteristics of intensive-use, moderate-use and limited-use areas within a red-cockaded woodpecker foraging area in the McCurtain County Wilderness Area, Oklahoma.

Vegetative story and parameter	Intensive-use area	Moderate-use area	Limited-use area	Total
Overstory				
Average height (m)	23.7	22.3	24.1	23.0
Average dbh (cm)	31.8	29.2	34.0	30.9
Average density (stems/ha)	190.4	156.8	122.0	156.8
Average basal area (m^2/ha)	12.77	9.32	9.44	10.43
Midstory				
Average height (m)	8.7	10.3	11.3	9.9
Average dbh (cm)	10.7	11.7	12.3	11.6
Average density (stems/ha)	694.5	704.9	644.8	688.4
Average basal area (m^2/ha)	5.65	6.54	7.01	6.27
Understory				
Average height (m)	2.4	2.9	3.6	2.9
Average density (stems/ha)	3,161	2,444	2,036	2,559

ARTIFICIAL INOCULATION OF RED HEART FUNGUS INTO LOBLOLLY PINES

RICHARD N. CONNER—*Wildlife Habitat and Silviculture Laboratory, Southern Forest Experiment Station, U.S. Forest Service, Nacogdoches, TX 75962.*
BRIAN A. LOCKE—*School of Forestry, Stephen F. Austin State University, TX (present address: Department of Biology, New Mexico State University, Las Cruces, NM 88003).*

Abstract—Fifteen 26-28-year-old loblolly pines (*Pinus taeda*) were inoculated with hollow pine dowels infected with red heart fungus (*Phellinus pini* Thore ex. Fr.). Multiple dowels were inserted into a drill hole on the north side of each tree at a height of 3m. *Phellinus pini* was successfully inoculated into and subsequently recultured from 8 of the 15 trees. Pine resin sealed the drill hole in 3 of the unsuccessfully inoculated trees. The fungus spread 3-5cm vertically and 0.5-1.0cm horizontally each year. The technique may be useful in creating suitable sites for red-cockaded woodpeckers (*Picoides borealis*) to excavate cavities earlier in timber rotation cycles than would normally be expected.

Red-cockaded woodpeckers excavate nest and roost cavities predominantly in mature living pines infected with red heart fungus (Jackson 1977; Conner & Locke 1982). Pine trees with pockets of decay suitable for red-cockaded cavity excavation may take as long as 70 to 90 years to develop (Conner 1979; Hooper et al. 1979). Such stand ages are not compatible with forest management in the South where rotation times for pulpwood (20-30 years) and sawtimber (35-40 years) production are set to optimize timber yield (Conner 1978). Affeltranger (1971) suggested that pine trees might be made suitable for cavity excavation at younger ages than normally expected by artificial inoculation with *Phellinus pini*. We report here a moderately successful technique to artificially inoculate red heart fungus into loblolly pines.

METHODS

Hollow loblolly pine dowels, 5.0cm long, 1.1cm in diameter and with a 0.4cm hole from end to end, were autoclaved until sterile in a malt extract broth solution (2.5g malt extract per 100ml distilled water). A pine-sawdust agar medium (15g pine sawdust, 11g malt agar, 2.5g wheat bran, 1.25g corn meal and 70ml of distilled water per pint jar) was mixed, dispensed in pint jars and autoclaved until sterile, and then placed on a slanted rack so the agar would harden at an angle of about 60°. Pint jars were inoculated with *Phellinus pini*, after which 4 of the sterile hollow dowels were placed on top of the slanting growth medium. After 2 to 3 months' growth, the hollow dowels were sufficiently infected with *Phellinus pini* for inoculation into pine trees. That technique is a modification of that used by Silverborg (1959) to inoculate northern hardwoods. The *Phellinus pini* culture used for inoculation had been originally isolated and cultured from a red-cockaded woodpecker loblolly pine cavity tree in the Davy Crockett National Forest in eastern Texas.

Fifteen loblolly pines (31-41cm dbh [$\bar{x} = 37.8$]; 26-28 years old [$\bar{x} = 27.1$]; 20-24m in height [$\bar{x} = 22.3$]) were randomly selected in a pine plantation on the Stephen F. Austin Experimental Forest, Nacogdoches County, Texas. On 14 December 1978, after sterilizing electric drill bits and drill sites with 70% ethanol, we drilled 1.5cm diameter holes 20-22cm deep and 3m high on the north side of each tree. We selected the north sides because they offered the dampest micro-environment. The holes were drilled slightly upward at angles of 10° above the horizontal to prevent pine gum from flowing into the holes. There was no evidence of the presence of any fungal infections in the trees prior to our drilling. We did not attempt to drill into and inoculate old knots or limb breaks because of the high probability of contamination by other fungi. Also, drill holes would have to be oriented downward in order to follow the knot hole into the heartwood of the tree. A downward orientation would increase the probability of the drill hole being sealed by pine resin.

Several *Phellinus pini* infected dowels were inserted into each hole and stacked tightly against each other, with the last dowel protruding to help prevent the tree from sealing the hole. Toole (1967) reported that success of fungal inoculations in hardwoods was much higher if the inoculation hole was kept open.

Five of the inoculated trees were cut in January 1980, 5 in January 1981, and 5 more in January 1982. The trees were horizontally and vertically sectioned to determine existence and extent of the fungal infection. Small chips of wood from areas that appeared to be infected were cultured and the fungus identified (see Conner et al. 1976 for technique).

RESULTS AND CONCLUSIONS

Phellinus pini was successfully inoculated into and subsequently recultured from 8 of the 15 trees. Pine resin appeared to have sealed the drill holes in 3 of the unsuccessfully inoculated trees, and the drill holes missed the heartwood of the other 4 unsuccessfully inoculated trees. Since *Phellinus pini* is a heartwood-decaying fungus, the lack of infection in the latter 4 cases was not surprising.

Phellinus pini spread approximately 3-5cm per year above and below the inoculation dowels in trees where the fungus was successful, reaching about 15cm above the dowels and 10cm below after 3 years of growth. Decay spread faster vertically than horizontally; 5cm of vertical growth occurred with only 0.5-1.0cm of horizontal growth.

While the technique was moderately successful, the rate of successful inoculation could probably be increased by reopening drill holes twice a year, or by inserting a 10cm hollow plastic tube into the hole immediately after inoculation to both keep resin out and prevent subsequent tree growth from sealing it. The accuracy of drilling into the heartwood could be increased by noting tree lean more carefully; the heartwood should be shifted away from the direction the tree is leaning (Kramer & Kozlowski 1979).

The technique may be useful to create suitable cavity excavation sites for red-cockaded woodpeckers earlier in timber rotation cycles than would normally be expected. When used, we suggest drilling and inoculation be done on the north sides of trees (to reduce the tendancy of the inoculum in the dowels to dry) at a height of about 7m above the ground, well within the range of red-cockaded cavity heights and easily reached with 2 sections of 3m Swedish climbing ladders.

Research is still needed to determine the choice and age of trees to inoculate. In eastern Texas, red-cockaded woodpecker cavity trees had a high bole length to crown height ratio (Locke 1980). If *Phellinus pini* spreads 5cm up and down in the heartwood each year and 1cm horizontally, pine trees should be inoculated at least 8 to 12 years prior to potential use by woodpeckers to permit sufficient lateral decay. The economic feasibility of inoculation also needs further consideration, especially since the rate of successful inoculation was only about 50%.

Potential problems may still exist with the technique. As time passes, tree growth may seal the inoculation hole. Also, oleoresins may continue to saturate the entire inoculation site and eventually kill any fungus infection. Long-term studies are needed to evaluate these problem areas.

Behavior of red-cockaded woodpeckers will also affect the utility of the technique presented in this paper. If red-cockadeds actively search for and can detect pines infected with a fungus, our technique may be useful. However, if woodpeckers have a searching image for older trees, a high bole length to crown height ratio, or some other external characteristic, benefits from artificial inoculation of a fungus would be reduced.

ACKNOWLEDGMENTS

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LITERATURE CITED

Affeltranger, C. 1971. The red heart disease of southern pines. Pp. 96-99 *in* Proc. Symp. Ecol. & Mgmt. Red-cockaded Woodpecker (R.L. Thompson, ed.), U.S. Bur. Sport Fish. & Wildl. & Tall Timbers Res. Stn., Tallahassee, FL.

Conner, R.N. 1978. Snag management for cavity nesting birds. Pp. 120-128 *in* Proc. Workshop Mgmt. S. For. Nongame Birds (R.M. DeGraaf, tech. coord.), U.S. For. Serv. GTR SE-14.

Conner, R.N. 1979. Minimum standards and forest wildlife management. Wildl. Soc. Bull. 7:293-296.

Conner, R.N., O.K. Miller, Jr. & C.S. Adkisson. 1976. Woodpecker dependence on trees infected by fungal heart rots. Wilson Bull. 88:575-581.

Conner, R.N. & B.A. Locke. 1982. Fungi and red-cockaded woodpecker cavity trees. Wilson Bull. 94:64-70.

Hooper, R.G., A.F. Robinson & J.A. Jackson. 1979. The red-cockaded woodpecker: notes on life history and management. U.S. For. Serv. Gen. Tech. Rept. SA-GR 9, 8p.

Jackson, J.A. 1977. Red-cockaded woodpeckers and pine red heart disease. Auk 94:160-163.

Kramer, P.J. & T.T. Kozlowski. 1979. Physiology of woody plants. Academic Press, NYC.

Locke, B.A. 1980. Colony site selection by red-cockaded woodpeckers in east Texas. M.S. Thesis, Stephen F. Austin State Univ., TX.

Silverborg, S.B. 1959. Rate of decay in northern hardwoods following artificial inoculation with some common heartrot fungi. For. Sci. 5:223-228.

Toole, E.R. 1967. Rates of wood decay behind open and closed wounds. Plant Disease Reporter 51:600.

LITERATURE CITED

Nesbitt, S.A., B.A. Harris, R.W. Repenning & C.B. Brownsmith. 1982. Notes on red-cockaded woodpecker study techniques. Wildl. Soc. Bull. 10:160-163.

Odom, R.R., J. Rappole, J. Evans, D. Charbonneau & D. Palmer. 1982. Red-cockaded woodpecker relocation experiment in coastal Georgia. Wildl. Soc. Bull. 10:179-203.

RON R. ODOM, *Georgia Department of Natural Resources, Route 2, Box 119-A, Social Circle, GA 30279.*

A statistical analysis of the orientation of entrances to red-cockaded woodpecker cavities—Many authors have documented that entrances to red-cockaded woodpecker (*Picoides borealis*) cavities are generally oriented toward the west, but such orientation has not been statistically verified. To effect that statistical verification we analyzed data from Florida (Baker 1971), South Carolina (Dennis 1971a; Hopkins & Lynn 1971), North Carolina (Carter 1974), Oklahoma (Wood 1983) and Texas (Lay 1973; Boone 1981; Locke unpubl. data). Our analyses were also designed to determine how red-cockaded cavity entrance orientation may vary from state to state and from eastern to western portions of the species' range. We used Rao's U statistic to test for non-random angular orientation and calculated mean angular orientation of cavity entrances (see Batschelet 1972).

All tests for nonrandom angular orientation were highly significant ($P < .01$), indicating that cavity entrances were not randomly oriented (Table 1). While there were slight differences in the mean angular orientation of entrances among different states, all were oriented in a basic westerly direction, about 270°. Examination of the mean angular deviations indicated there were no statistical differences in orientation among states. Data from Oklahoma (Wood 1983) provided an opportunity to compare the orientation of cavity starts with completed cavities, with the result that cavity starts were northerly oriented (347°) compared to the westerly orientation of completed cavities (285°).

We combined the data from Florida, South Carolina, and North Carolina into a larger data set for the East and combined data from Oklahoma and Texas for the West, and found that their mean angular orientations were nearly identical (271° and 272°, respectively). The mean for both East and West data sets combined was 271°. Thus, our results demonstrated that red-cockaded woodpeckers tend to excavate completed cavities on the west sides of trees throughout their geographic range.

Reasons for a westerly cavity entrance orientation are, unfortunately, still unclear. The resin is known to be a deterrent to rat snakes (*Elaphe obsoleta*) (Dennis 1971b; Jackson 1974), a predator of cavity-nesting birds. Dennis (1971b) suggested that a westerly orientation would cause a maximum amount of afternoon sunlight to strike the entrance side of the cavity tree and as a result promote maximum resin flow from resin wells, thus enhancing predator deterrent qualities.

Table 1. Results of Rao's U test on nonrandom and mean angular orientation of red-cockaded woodpecker cavity entrances.

Area	Mean angular orientation(°)	N	Significance level
Florida	246 ± 64.1	149	P < .01
South Carolina	275 ± 62.2	920	P < .01
North Carolina	270 ± 66.2	835	P < .01
Texas	264 ± 68.6	1023	P < .01
Oklahoma			
Cavities	285 ± 64.4	427	P < .01
Starts	347 ± 75.4	155	P < .01
East	271 ± 64.3	1904	P < .01
West	272 ± 67.6	1450	P < .01
COMBINED	271 ± 65.7	3354	P < .01

Those portions of a tree trunk struck by sunlight are warmer than the rest of the trunk (Derby & Gates 1966), and if warming by the sun does indeed facilitate resin flow, a westerly orientation of cavity entrances would keep resin flowing later in the evening and into some of the night.

LITERATURE CITED

Baker, W.W. 1971. Progress report on life history studies of the red-cockaded woodpecker at Tall Timbers Research Station. Pp. 44-59 *in* Proc. Symp. Ecol. & Mgmt. Red-cockaded Woodpecker (R.L. Thompson, ed.), U.S. Bur. Sport Fish. & Wildl. & Tall Timbers Res. Stn., Tallahassee, FL.

Batschelet, E. 1972. Recent statistical methods for orientation data. Pp. 61-91 *in* Anim. Orientation & Navigation Symp., NASA SP-262.

Boone, D.B. 1980. Red-cockaded woodpecker study. Job 50 Completion Rept., TX FA Proj. W-103-R-9, TX Parks & Wildl. Dept.

Carter, J.H. III. 1974. Habitat utilization and population status of the red-cockaded woodpecker in south-central North Carolina. M.S.Thesis, NC State Univ., 31p.

Dennis, J.V. 1971a. Species using red-cockaded woodpecker holes in northeastern South Carolina. Bird-Banding 42:79-87.

Dennis, J.V. 1971b. Utilization of pine resin by the red-cockaded woodpecker and its effectiveness in protecting roosting and nesting sites. Pp. 78-86 *in* Proc. Symp. Ecol. & Mgmt. Red-cockaded Woodpecker (R.L. Thompson, ed.), U.S. Bur. Sport Fish. & Wildl. & Tall Timbers Res. Stn., Tallahassee, FL.

Derby, R.W. & D.M. Gates. 1966. The temperature of tree trunks—calculated and observed. Am. J. Bot. 53:580-587.

Hopkins, M.L. & T.E. Lynn, Jr. 1971. Some characteristics of red-cockaded woodpecker cavity trees and management implications in South Carolina. Pp. 140-169 *in* Proc. Symp. Ecol. & Mgmt. Red-cockaded Woodpecker (R.L. Thompson, ed.), U.S. Bur. Sport Fish. & Wildl. & Tall Timbers Res. Stn., Tallahassee, FL.

Jackson, J.A. 1974. Gray rat snakes versus red-cockaded woodpeckers: predator-prey adaptations. Auk 91:342-347.

Lay, D.W. 1973. Red-cockaded woodpecker study. Job 10 Completion Rept., TX FA Proj. W-80-R-16, TX Parks & Wildl. Dept.

Wood, D.A. 1983. Foraging and colony habitat characteristics of the red-cockaded woodpecker in Oklahoma. Pp. 51-58 *in* Red-cockaded Woodpecker Symp. II Proc. (D.A. Wood, ed.), FL Game & Fresh Water Fish Comm., U.S. FWS & U.S. For. Serv.

BRIAN A. LOCKE, ***Department of Biology, New Mexico State University, Las Cruces, NM 88003.***
RICHARD N. CONNER, ***Wildlife Habitat and Silviculture Laboratory, Southern Forest Experiment Station, U.S. Forest Service, Nacogdoches, TX 75962.***

An aberrantly-colored male red-cockaded woodpecker in Georgia—In the fall of 1982 we initiated a series of studies on habitat selection and population dynamics of red-cockaded woodpeckers (*Picoides borealis*) on the Piedmont National Wildlife Refuge and adjacent Oconee National Forest in Jones County, Georgia. During the winter of 1982-1983, Ronnie Shell, Piedmont refuge manager, and Mark Musaus, assistant manager, reported observing on the refuge a very light-colored red-cockaded woodpecker foraging in the company of 2 normally-colored red-cockadeds. At 1800 on 7 March 1983, the junior author observed at that same location what he assumed to be the same bird foraging alone in a loblolly pine (*Pinus taeda*) at a height of approximately 10m. The bird was observed from a distance of approximately 12m with 9 x 36 binoculars. Although it had the normal red-cockaded plumage pattern of barred back, white cheek patch, dark eye line and dark crown, the coloration appeared faint gray and white rather than black and white.

At approximately 1700 on 1 December 1983, the senior author, accompanied by Richard Harlow and Charles Dachelet, observed either that same bird or a similarly colored one on the Hitchiti Experimental Forest, approximately 7.1km southwest of where the previous observations on the Piedmont refuge had been made. The bird was alone and in the vicinity of its cavity tree, which was approximately 1.3km from the nearest known active red-cockaded colony, and observed with 10 x 40 binoculars from a distance of approximately 50m.

The bird was captured a few minutes later as it went to roost, and observed in hand it clearly had normally-pigmented beak, eyes, legs and feet, but the normally black contour feathers, remiges and rectrices were a pale Salmon (see Smithe 1975), very similar in color to faded khaki, with the normally black crown a slightly darker Cinnamon or pale Tawny (see Smithe 1975). The bird was a male with red cockades of normal size and color, but in contrast to the light color of the crown the cockades appeared more brightly Scarlet (see Smithe 1975) than normal.

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