STATUS, HABITAT, HOME RANGE, AND NOTES ON THE BEHAVIOR OF THE RED-COCKADED WOODPECKER IN OKLAHOMA

By

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Bachelor of Science

Oklahoma State University

Stillwater, Oklahoma

1975

Submitted to the Faculty of the Graduate College
of the Oklahoma State University
in partial fulfillment of the requirements
for the Degree of
MASTER OF SCIENCE
December, 1977

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PREFACE

The objectives of this study were: (1) to ascertain the current distribution and population size of the red-cockaded woodpecker in Oklahoma and to evaluate its chances for continued survival in the state; and (2) to determine specific home range parameters and other habitat characteristics of the species in Oklahoma in order to better understand its limiting factors. Various aspects of the red-cockaded woodpecker's behavior, life history, and ecology in Oklahoma are also described and evaluated.

Funds for the study were provided by the Oklahoma Cooperative Wildlife Research Unit, Oklahoma State University Environmental Institute, National Wildlife Federation, and Oklahoma Ornithological Society. The Oklahoma Department of Wildlife Conservation permitted access to the McCurtain County Wilderness Area and provided a primitive cabin for housing.

Sincere appreciation is expressed to my major adviser, Dr. James C. Lewis, Assistant Leader, Oklahoma Cooperative Wildlife Research Unit, for his guidance and assistance throughout each phase of the study. I wish to thank Professor Ted Silker, Department of Forestry, and Associate Professor John Barclay, School of Biological Sciences, Oklahoma State University, for serving as members of my graduate committee.

Appreciation is extended to Eugene Woods, Manager, McCurtain County Wilderness Area, and his assistant Dale Toon, for their cooperation and

assistance during the field work phase of the study. John Monfore and Mike DeHuff, Weyerhaeuser Company, provided information about locations of red-cockaded woodpecker colonies on Weyerhaeuser lands in Pushmataha County.

I also wish to thank the following individuals for their invaluable assistance in the field: Diane Love, Victor Heller, Phillip Howell, Dan Overdeer, Mark Ports, Ron Reynolds, and Claud Wood.

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CHAPTER I

INTRODUCTION

This thesis is comprised of three manuscripts written in formats which will facilitate immediate submission to scientific journals for publication. These manuscripts are presented as chapters in the thesis and each is complete in itself without additional supporting materials. The manuscript entitled "Status of the red-cockaded woodpecker in Oklahoma" (Chapter II) was prepared according to the style and format of the Proceedings of the Annual Conference of the Southeastern Association of Game and Fish Agencies. The manuscript entitled "Habitat and home range characteristics of the red-cockaded woodpecker in Oklahoma" (Chapter III) was written in the style and format of The Auk. The manuscript entitled "Notes on the behavior of the red-cockaded woodpecker in Oklahoma" (Chapter IV) was written in the style and format of the Oklahoma Ornithological Society Bulletin.

Approval for presenting the thesis in this form is based on the Graduate College's policy of accepting a thesis written in manuscript form and is subject to the Graduate College's approval of the major professor's request for a waiver of the standard format dated 9 September 1977.

CHAPTER II

STATUS OF THE RED-COCKADED WOODPECKER IN OKLAHOMA

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Abstract: The red-cockaded woodpecker (Picoides borealis) presumably was fairly common historically in the pinelands of southeastern Oklahoma. The species requires old-growth timber for nests and roosts, and in the past century their populations have declined due to logging operations and clearing of forestland. Remnant populations of red-cockadeds were located in the McCurtain County Wilderness Area, and on Weyerhauser Company lands in Pushmataha County and may still occur in Beavers Bend State Park, McCurtain County. Between 145 and 165 birds occupy 48 to 53 colonies, with 84 to 90 percent of the population occurring in the McCurtain County Wildness Area. The population inhabiting the Wilderness Area is the only one in the state whose habitat and population density appear secure. Continued survival of the species in Oklahoma depends upon preservation of old-growth pine in the Wilderness Area.

Red-cockaded woodpeckers, one abundant throughout the southeastern United States (Audubon 1839 cited in Jackson 1971), were presumably

common in southeastern Oklahoma. Their presence in Oklahoma was first documented by Woodhouse (1853), but only occasional sightings have been recorded since then (Nice 1931, Baumgartner 1954, 1961, Carter 1965). The species once occurred in Bryan, Latimer, LeFlore, McCurtain, Pittsburg, and Pushmataha counties, but by the late 1960's Sutton (1967, 1974) reported it survived only in Bryan, Latimer, and McCurtain counties.

The species' historic range in Oklahoma may have coincided with that of shortleaf pine (Pinus echinata) (Fig. 1). However, there have been no verified observations of red-cockaded woodpeckers in northeastern Oklahoma where shortleaf pine stands are more scattered and sparser than in southeastern Oklahoma. Except for a relatively small area of loblolly pine (P. taeda) in the extreme southeastern corner of the state, shortleaf is the only southern pine found in Oklahoma. The woodpeckers are dependent upon old-growth living pines, infected with red heart fungus (Fomes pini) (Steirly 1957), for nest and roost cavity trees.

All verified reports of red-cockaded woodpeckers in Oklahoma have come from approximately the southeastern 15 percent of the state. That area is covered with pine-hardwood forest on terrain that varies from flat Coastal Plain to rugged portions of the Ouachita Mountains with 600 m changes in elevation.

The decline of the species in Oklahoma is attributed to the same factor that caused its decline in nearly all other areas of the southeastern United States, destruction or severe alteration of habitat through logging and land clearing (Jackson 1971). The intensive silviculture practiced by timber companies has eliminated or diminished areas of old-growth pine, and, thereby, precluded substantial population recovery. The clearing of forests for urban, industrial, recreational,

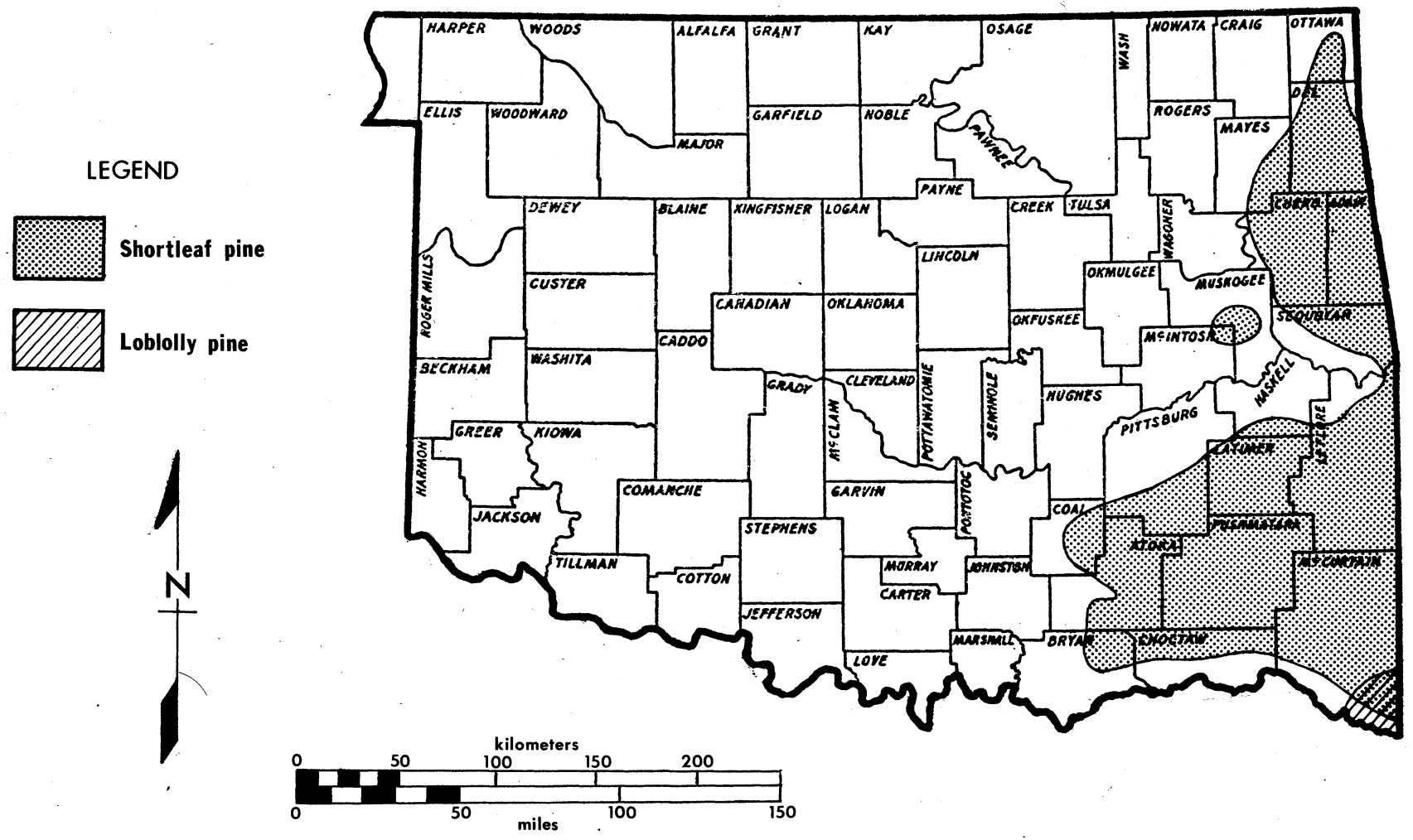

Fig. 1. Distributions of shortleaf pine and loblolly pine in Oklahoma (Szuhai 1971).

and agricultural uses has also been a factor in the species' decline.

The red-cockaded woodpecker was first listed in the United States Federal Register as an endangered species in 1970 (Anonymous 1974) and is protected under the Endangered Species Act of 1973. There is no official endangered species list for Oklahoma at the present time. This woodpecker is, however, included on a list of endangered species in Oklahoma published by the U.S. Soil Conservation Service (Lewis 1975). Oklahoma has no endangered species act and state laws make no specific provisions for endangered species. Comprehensive population surveys of red-cockaded woodpeckers had not been conducted in Oklahoma prior to the present study.

The authors gratefully acknowledge financial support provided by the Oklahoma Cooperative Wildlife Research Unit, Oklahoma State University Envirionmental Institute, National Wildlife Federation, and Oklahoma Ornithological Society. We appreciate the considerable help of C.E. Woods, McCurtain County Wilderness Area Manager for the Oklahoma Department of Wildlife Conservation, and his assistant D. Toon, and the Department's provision of housing on the Area. We also thank the following individuals for their assitance: J. Barclay, W. Carter, W. Harden, V. Heller, W. Howard, P. Howell, G. Hulsey, D. Love, B. Moser, D. Overdeer, M. Ports, R. Reynolds, T. Silker, G. Sutton, P. Vohs, and C. Wood.

MATERIALS AND METHODS

The study was initiated in November 1975 and continued through July 1977. Surveys of red-cockaded woodpeckers were conducted in selected areas of McCurtain County Wilderness Area (MCWA) and Beavers

Bend State Park (BBSP) in McCurtain County, Robber's Cave State Park in Latimer County, Ouachita National Forest in LeFlore County, Pushmataha County Game Management Area, private lands in northeastern Bryan County, and Weyerhaeuser Company lands in Latimer, McCurtain, and Pushmataha counties (Fig. 2). All reported sightings, some solicited by contacting various land owners and some volunteered, received during the study period were investigated, as were various areas of potential red-cockaded woodpecker habitat.

Two techniques were used to search for cavity trees during the status surveys: (1) walking straight parallel transect lines spaced 40 to 60 m apart, the distance determined by terrain and visibility afforded by surrounding vegetation, and (2) walking or driving along roads or fence lines and visually surveying the bordering woodland. Method 1 was the principal method used whenever large tracts of old-growth forest were being systematically surveyed. Method 2 was used mainly to search for old-growth timber and for woodpecker populations wherever such timber was uncommon.

These survey methods are reasonably efficient because red-cockaded cavity trees are unique and usually easily spotted in the field. The birds maintain a copious flow of resin on the trees several meters above and below cavities and extending around the trunks to the opposite sides. Substantial areas on cavity tree trunks are glazed and whitish and contrast sharply with nearby trees. Surveys were intensified and concentrated in certain areas where either evidence of the birds' foraging (trunks of pines with plates of bark recently scaled off) was located, or a foraging clan (a social unit generally consisting of a mated pair,

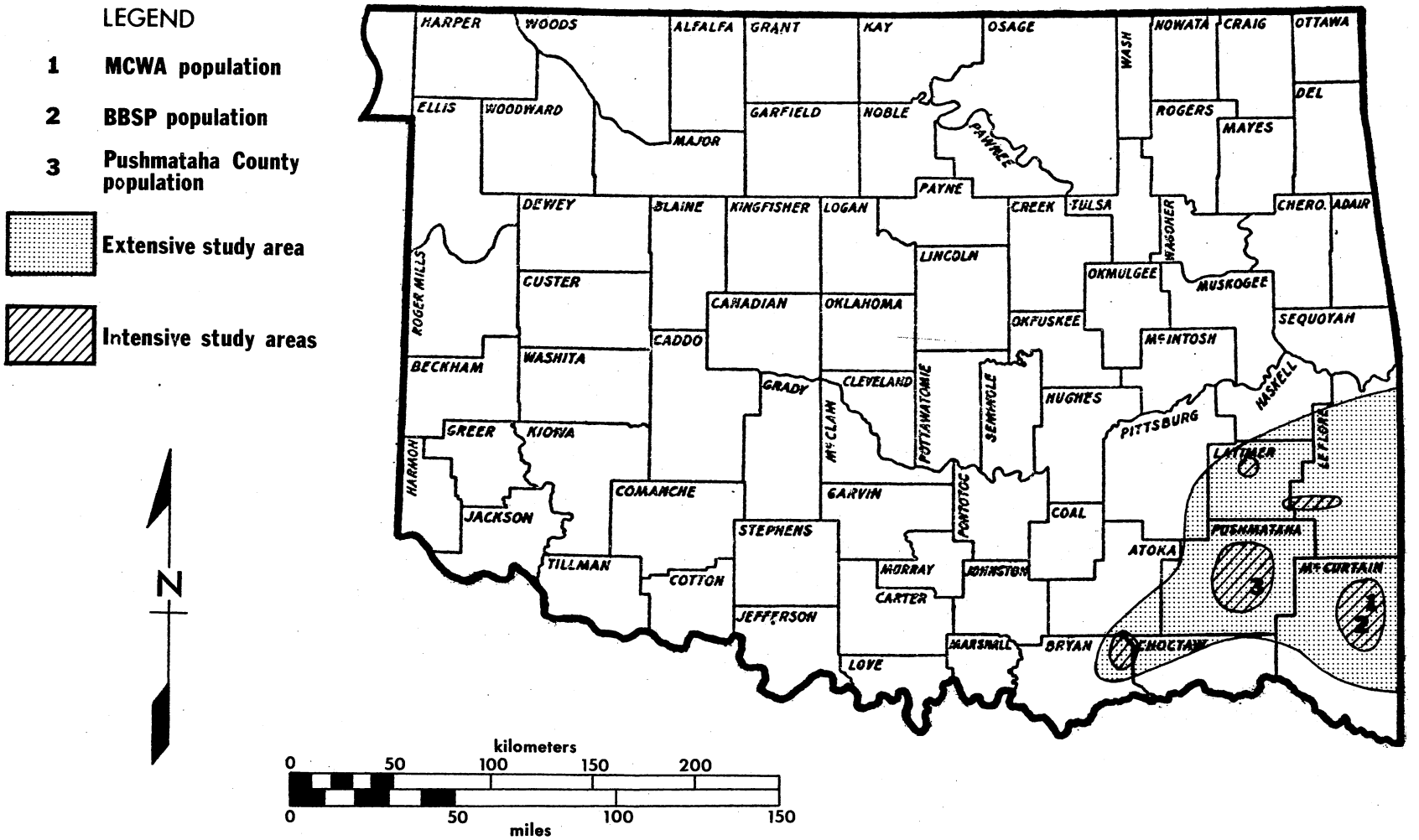

Fig. 2. Areas surveyed and location of populations of red-cockaded woodpeckers in Oklahoma.

their offspring, and associated helpers [Jackson and Thompson 1971]) was encountered.

Population counts were made in each colony (a grouping of cavity trees occupied and maintained by a single clan) either as the birds left their roosts in the morning or when they returned at night. Each clan was surveyed 2 to 10 times by 1 to 3 observers until the senior author was satisfied that a suitable count had been made. Two clans for which colonies were not located were censused at the time the birds were observed.

RESULTS AND DISCUSSION

Thirty-five red-cockaded woodpecker clans were recorded during the surveys, 31 in the MCWA, 1 in BBSP, and 3 on Weyerhaeuser Company lands in Pushmataha County (Table 1). Only 31 clans could be found at the end of the study; 2 clans on Weyerhaeuser lands and 2 in MCWA had disappeared from their respective colonies.

The colonies for three clans (4, 7, and 17, Table 1) were never located. The 32 colonies located consisted of 138 active cavity trees (4.3 trees per colony; range = 1-9). Thompson and Baker (1971) reported an average of 4.16 cavity trees per colony in 229 colonies scattered over 10 southeastern states, and 6.0 trees per colony (n = 80) were reported for colonies in South Carolina (Hopkins and Lynn 1971). The 4.3 cavity trees per colony in Oklahoma should be considered a minimum figure because some cavity trees may have been overlooked.

An estimated 145 to 165 red-cockaded woodpeckers, occupying 48 to 53 colonies, occur in southeastern Oklahoma. That population is composed of three sub-populations which are described in the following sections.

Table 1. Location and status of known red-cockaded woodpecker clans in Oklahoma, summer 1977.

Area and clan/colony	Number of cavity trees[1]	Number of birds (May - June)	Specific location (range, township, section)
Pushmataha County			
1	4	3	20E 3S 6NE
2	3[2]	disappeared	20E 2S 32SE
3	4[2]	disappeared	20E 2S 33W
Subtotal	11	3	
Beavers Bend State Park			
4	?	?	
McCurtain County Wilderness Area			
5	1	4	25E 3S 9NW
6	7	5	25E 3S 11SE
7	?	4-5	
8	4	5	26E 3S 7SW
9	6	2-3	25E 3S 10SW
10	4	2	25E 3S 9SE
11	4	4	25E 3S 10SE
12	4	4	26E 3S 18S
13	6	4	25E 3S 14NW
14	5	3-4	25E 3S 2NE
15	9	3	26 E 3S 17SW, 18SE
16	4	2	25E 3S 1SW
17	?	3-4	

Table 1. Continued.

Area and clan/colony	Number of cavity trees[1]	Number of birds (May - June)	Specific location (range, township, section)
18	5	1	25E 3S 10SE
19	3	3-4	25E 3S 12NE
20	6	5	25E 3S 11NE
21	2	3	25E 3S 24NE
22	5[2]	disappeared	25E 3S 1NW
23	1	2	26E 3S 17SW
24	3	3	25E 3S 23NE
25	8	3	25E 3S 8SW
26	5	1	26E 3S 19SE
27	6	4	25E 3S 10SE
28	4	2	25E 3S 1SE
29	5	4-5	25E 3S 24SE
30	3[2]	disappeared	25E 3S 11W
31	4	3	26E 3S 8NE
32	2	1	26E 3S 7N
33	3	3	26E 3S 29NE
34	1	1	26E 3S 20SE
35	7	2	25E 3S 13SE
Subtotal	127	86-92	
Total	138	89-95	

[1]Cavity trees per colony should be considered a minimum number because trees in some colonies may have been overloaded.

[2]Refers to number active prior to disappearance of the resident clan.

McCurtain County Wilderness Area Population

This population is located near the upper reaches of Broken Bow Reservoir and has probably remained relatively stable throughout recent history. The MCWA, the only area of substantial size where timber harvest has never been permitted, also provides the only large tract of favorable habitat for red-cockaded woodpeckers in Oklahoma. Consequently, most survey efforts were concentrated there. The Area, owned and managed by the Oklahoma Department of Wildlife Conservation, encompasses 5,701 ha of virgin pine-hardwood forest, 3,795 ha (66.6%) of which were surveyed for red-cockaded woodpeckers.

A minimum of 86 and a maximum of 92 birds occupied the 29 active colonies located in the MCWA (2.9-3.1 birds per colony). Clans occur fairly uniformly throughout the surveyed area (one clan per 131 ha and one bird per 41 to 44 ha). The MCWA is fairly homogeneous, and assuming woodpeckers are present in the unsurveyed area in densities comparable to the surveyed area, a reasonably accurate population estimate can be derived for the total Area. The projected total population is 130 to 139 birds occupying 44 colonies. Eighty-four to 90 percent of the state's known population occurs within the MCWA.

While clans 7 and 17 were observed five times and once respectively, their colonies were never located. Colony 17 may have been outside the MCWA because the birds were observed near the boundary fence. Clans disappeared from two colonies (22 and 30) before population counts were obtained. No apparent reason was found for their disappearance.

The MCWA population should remain stable as long as that Area is maintained as old-growth forest; an unexpected natural factor, however, now jeopardizes that habitat. The southern pine beetle (Dendroctonus

frontalis) was discovered in the Area in August 1976. Approximately 65 beetle infestation sites were found that contained from two or three trees to several hectares of timber. The infestations now represent a new northwestern extension of the beetle's range, perhaps resulting from several mild winters in succession. Staff of Weyerhaeuser and other forestry concerns proposed clearcutting large blocks of timber around each infestation to eradicate the beetle, but no cutting has been carried out to date. New infestations were not detected in the spring of 1977, and, hopefully, low temperatures during the severe winter of 1976-77 may have eliminated most or all of the beetles. The woodpecker population should be monitored for several years to ascertain the effect, if any, the beetle has on this endangered species.

Limited fire suppression has been carried out in the Area since the 1920's. Although the configuration and species composition of the vegetation have appeared stable since the early 1950's (personal communication from Eugene Woods, Wilderness Area manager), subtle vegetative changes may be resulting from the limited fire suppression. Habitat conditions in the Area should be periodically monitored to determine if any possible vegetative changes are having or will have adverse effects on the red-cockaded woodpecker. Special attention should be paid to whether or not hardwoods are threatening the dominance of pines in the overstory.

Pushmataha County Population

Three colonies were found in Pushmataha County at the beginning of the study, but two clans (2 and 3, Table 1) of 3 and 4 birds respectively, disappeared from their colonies during the winter of 1976-77.

The fate of those birds is unknown. All three colonies were found with the assistance of employees of Weyerhaeuser Company. Colony 1 is the only one now known active. This population is located near Cloudy, Oklahoma on lands owned by Weyerhaeuser Company.

The two clans which disappeared from their colonies did so soon after substantial areas were clearcut adjacent to each colony site; they may have abandoned their respective colonies due to disturbance by the clearcutting. Suitable habitat nearby where these clans could relocate, is scarce. The more than 400,000 ha of Weyerhaeuser Company lands in southeastern Oklahoma include approximately 24,000 ha (6%) of old-growth timber (personal communication from Weyerhaeuser Company official 1977). Weyerhaeuser Company officials refused to provide us with information about the distribution of old-growth timber on their lands, but this timber reportedly occurs over five counties in scattered 4- to 8-ha plots, areas considered too small to sustain a viable clan (Red-cockaded Woodpecker Endangered Species Recovery Team, draft copy Red-cockaded Woodpecker Recovery Plan 1977).

Other clans, undetected by our surveys, may exist in Pushmataha County. Time and funds did not permit a search for and complete survey of all potential woodpecker habitat. Assuming that a few clans may have escaped detection, we estimate that 12 to 20 birds (3 to 7 clans) comprise the total population.

This population is undoubtedly declining due to clearcutting operations over substantial areas (80 to 600 ha per cut) which destroy red-cockaded habitat. Colonies are isolated from each other, surrounded by poor quality habitat, and have an insufficient number of replacement cavity trees. Weyerhaeuser officials leave uncut only approximately

1 ha, including the active cavity trees, as their effort for conservation of red-cockaded woodpeckers. Such a conservation effort is inadequate and survival of the clan is wholly dependent on the close proximity of other old-growth timber. Intensive management of the habitat in Pushmataha County, even if it were initiated now, might not be sufficient to stop the population decline because of the long time period (40 to 80 years) required for recovery from clearcutting.

Beavers Bend State Park Population

This population, if it still exists, is located in McCurtain County near the dam of Broken Bow Reservoir on lands owned by the Oklahoma Tourism and Recreation Department. Suitable red-cockaded woodpecker habitat probably extended to the MCWA prior to inundation of 5,750 ha by the reservoir in 1967. Now this population is 14.5 km from the MCWA population and most of the distance is over water.

The park presumably supports at least one clan. Three birds were reported seen in the area during the Christmas bird count in 1975 by members of the Oklahoma Ornithological Society (Anonymous 1976). However, the senior author was unable to locate any cavity trees, birds, or evidence of the birds' foraging (bark scaled off the trunks of pines) during 3 days of intensive surveys in spring of 1977.

Relatively little of the park's 2,078 ha is suitable habitat for red-cockaded woodpeckers. Only 160 ha contains old-growth timber and less than 24 ha of that 160 is virgin timber. J. Bell, Park Manager, does not believe the bird occurs in the park and has never seen a red-cockaded nor one of their cavity trees in the park. He is familiar with the birds' appearance and the appearance of their cavity trees, and recalled that they were quite "common" in southeastern Oklahoma

30 to 40 years ago. The authors judge that 3 to 6 birds, occupying 1-2 colonies, is the maximum population that might occur in BBSP. Failure to find birds or their sign suggests that population may already be extinct.

CONCLUSIONS

The MCWA should remain in a wilderness status, in which timber harvest is not permitted, to ensure continued survival of the red-cockaded woodpecker in Oklahoma. Habitats supporting populations outside the Wilderness Area should also be protected using guidelines set forth in the Red-cockaded Woodpecker Recovery Plan (draft copy, Red-cockaded Woodpecker Endangered Species Recovery Plan 1977). The guidelines consist basically of the following: (1) periodic inventory of populations, (2) maintaining at least 40 ha of contiguous mature pine forest around active colonies, and (3) using only silvicultural practices that would improve red-cockaded habitat (80- to 100-year cutting rotations, limited control of hardwoods).

Pursuant to the provisions of Section 7 of the Endangered Species Act of 1973, the MCWA, BBSP, and the following locations in Pushmataha County should be designated as Critical Habitat for the species in Oklahoma: R20E T2S sections 31, 32, 33, and R20E T3S sections 4 and 5. Colonies discovered subsequent to the present study should be designated in the same manner. Such a designation would protect red-cockaded woodpecker habitat from any detrimental or potentially destructive land-use activity either undertaken or funded by any part of the U.S. Government. It is also imperative that the Oklahoma Legislature approve an endangered species act that would facilitate official recognition of

endangered species, including the red-cockaded woodpecker, and provide appropriate means for management of these species and protection against habitat destruction.

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CHAPTER III

HABITAT AND HOME RANGE CHARACTERISTICS OF THE RED-COCKADED WOODPECKER IN OKLAHOMA

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Abstract: Thirty-two red-cockaded woodpecker (Picoides borealis) colonies located in southeastern Oklahoma averaged 4.3 active cavity trees per colony. Average minimum distance between cavity trees within colonies was 58 m, and cavity tree mortality was 6.7% annually. Active cavities predominantly faced westerly, with 75.3% facing from SSW to NNW.

Characteristics of cavity trees in Oklahoma were very similar to those found in other locations except for (1) a much older average age (149 years), due to the virgin character of the McCurtain County Wilderness Area, and (2) a greater height of active cavities ($\bar{x}$ = 13.1 m) due to a relatively high midstory ($\bar{x}$ = 9.9 m) surrounding cavity trees.

Characteristics of the midstory surrounding cavity trees almost invariably allowed unobstructed access to active cavities. Cavities averaged 3.2 m above the midstory height, and those below the midstory height were unobstructed due to a relatively sparse midstory.

The measured home range of a clan of five birds totaled 52.8 ha, of which 7.1 ha (13.5%) were intensively used by the birds, 17.1 ha (32.4%) were moderately used, and 28.6 ha (54.1%) were used very little. Home range size varied with the seasons. Foraging area during the

breeding season (May-June) was 26.0 ha, and during summer (July-August) 44.1 ha. Somewhat linear-shaped intensive- and moderate-use areas resulted in a somewhat oblong total home range.

The intensive-use area was characterized by a relatively high density overstory (190.4 stems/ha), the moderate-use area by an intermediate density overstory (156.8 stems/ha), and the limited-use area by a relatively sparse density overstory (122.0 stems/ha). Red-cockaded woodpeckers preferred to forage in relatively dense overstory trees probably due to one or more of three reasons, (1) the higher density provided a more concentrated food source and thus minimized energy expended in foraging, (2) higher elevations, where pines are naturally denser, are sought out for foraging, and (3) the dense canopy may provide some protection from raptors.

Principal considerations in any intensive management scheme for red-cockaded woodpeckers should be: (1) to protect active cavity trees by prohibiting cutting and controlling the vegetation surrounding them, (2) to ensure the availability of future cavity trees by similarly protecting mature or near-mature pines in close proximity to existing cavity trees, and (3) to provide or maintain quality foraging habitat by thinning or otherwise manipulating stands of timber within home ranges.

Red-cockaded woodpeckers (Fig. 1) excavate their nest and roost cavities almost invariably in living southern pines infected with red heart fungus (Fomes pini) (Steirly 1957, Jackson 1977). Red heart normally only attacks mature pines (Affeltranger 1971), and thus the red-cockaded woodpecker depends upon mature pine stands for nesting and

Fig. 1. Red-cockaded woodpecker near nest cavity, McCurtain County Wilderness Area, Oklahoma (Photo by Phillip Howell, Oklahoma Department of Wildlife Conservation).

roosting habitat. Many other habitat requirements of the species are little understood. Published estimates of home range size vary widely, and very little is known about specific vegetative characteristics within home ranges, and how these characteristics might affect home range size and/or shape.

This paper adds to existing knowledge concerning characteristics of red-cockaded cavity trees and provides new data on specific vegetative characteristics within a home range. The manner in which those characteristics might affect home range size, home range shape, and the foraging habits of the resident clan (a social unit usually consisting of a mated pair, their offspring, and associated "helpers") is presented.

This study is unique for three reasons: (1) the intensive study area (the McCurtain County Wilderness Area) is the only substantial area (5,071 ha) of virgin forest in which the red-cockaded woodpecker has been comprehensively studied, (2) shortleaf pine (Pinus echinata) is the only pine that occurs in the intensive study area, whereas all other studies have been conducted in mixed pine forests or forests dominated by pines other than shortleaf, and (3) habitat data have not previously been reported from the northwest extremities of the species' range.

STUDY AREA AND METHODS

McCurtain and Pushmataha counties in southeastern Oklahoma comprise the extensive study area and the McCurtain County Wilderness Area is the intensive study area (Fig. 2). The extensive area has rolling-to-rugged terrain with up to 600 m differences in elevation. Vegetation is

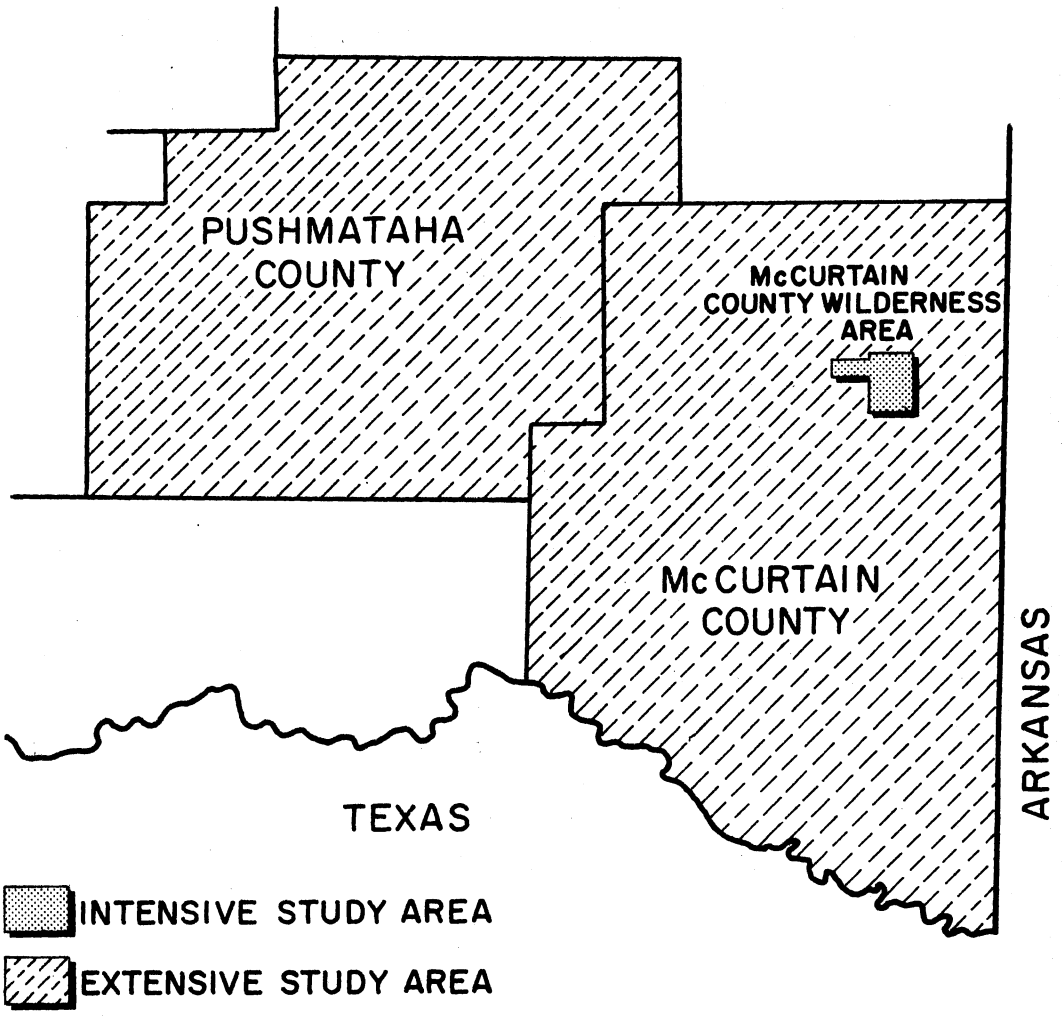

Fig. 2. Red-cockaded woodpecker study areas in southeastern Oklahoma.

predominantly pine-hardwood forest. Except for scattered, relatively small areas (up to 8 ha) of old growth timber, all of the extensive area has been severely altered by timber harvest or land-clearing for agricultural, recreational, or urban uses.

Terrain in the McCurtain County Wilderness Area is rugged to precipitous and varies in elevation from 175 to 415 m above sea level. Shortleaf pine is dominant in the overstory and co-dominant in the midstory and understory. Oaks (Quercus spp.) and hickories (Carya spp.) are co-dominant in the midstory and understory. Carter (1965) has described in detail the geology, climate, and vegetation of the Area.

The study was initiated in November 1975 and continued through July 1977. Two techniques were used to locate colonies (groupings of cavity trees occupied and maintained by single clans): (1) walking straight parallel transect lines spaced 40 to 60 m apart, the distance determined by terrain and visibility afforded by surrounding vegetation, and (2) driving or walking along roads or fence lines and surveying the bordering woodland. Method 1 was the principal method used when large tracts of old-growth timber were being systematically surveyed. Method 2 was used mainly to search for old-growth timber and for colonies wherever such timber was uncommon.

These methods are reasonably efficient because red-cockaded woodpecker cavity trees are unique and usually easily spotted in the field. The birds maintain a copious flow of resin on the trees several meters above and below active cavities and extending around the trunks to the opposite sides. Substantial areas on cavity tree trunks are thus glazed and whitish and contrast sharply with nearby normal trees (Fig. 3).

A B C

Fig. 3. Typical red-cockaded woodpecker cavity trees in Oklahoma. Note contrast between cavity tree (right) and normal tree (photo A) (Photos by Phillip Howell, Oklahoma Department of Wildlife Conservation).

The method used to determine home range size and shape was based on that of Crosby (1971), and essentially involved designating the nest tree of a colony as the center of a plot and placing marked wooden stakes at 30 m intervals in each of eight compass directions--N, NW, W, SW, S, SE, E, and NE. The resident clan was subsequently followed as they foraged. The marked stakes and various topographic features were used to pinpoint foraging sites (single trees or a group of 2-3 adjacent trees). These sites were then recorded on data sheets. When the clan foraged in one location for an unusually long time (at least 15 minutes), a special notation was made on the data sheet.

After completion of the field work information from all data sheets was transferred to a master map. Each foraging site was represented by a dot on the master map. Extra dots were added to those map locations where the clan had foraged for long periods of time. The areas on the map with dense, nearly blackened patterns of dots were designated intensive-use areas. Areas with dots clearly spaced were designated moderate-use areas, and areas with very few or no dots were designated limited-use areas. Three additional maps were made to illustrate foraging activity during the breeding season (May-June), summer (July-August), and winter (January-February) respectively.

A clan of four adults was followed for 38 hours during the breeding seasons (May-June) of 1976 and 1977. The four birds plus one juvenile were followed for 43 hours during July and August 1976 and 44 hours during January and February 1977 (one clan member disappeared in early February of this latter period). The clan was normally followed 3 to 4 hours daily but occasionally for as long as 6 to 8 hours. Plans to measure the home range of a second clan were abandoned after many

attempts to follow the birds proved futile due to their relative shyness and the extreme ruggedness of their foraging area.

Overstory, midstory, and understory vegetative data were collected from 96 sample plots, each 150 m^2, evenly spaced throughout the measured home range, and from an additional 108 plots in 29 other colonies. Individual cavity trees served as centers of plots in the latter 29 colonies. Data were collected on height of each vegetative story, tree diameter at breast height (d.b.h.), basal area, and density, and were used to determine vegetative characteristics within the measured home range and in areas surrounding cavity trees. Data collected from individual cavity trees included tree height, d.b.h., and age, cavity height and orientation, height of lowest branch, height of start holes (incompleted cavities distinguished by their shallowness, usually 2 to 8 cm deep), and the degree of slope on which the tree was situated.

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

A random sample of 55 trees was selected from a group designated "inactive cavity trees" for comparison with active cavity trees. The "inactive" trees were living shortleaf pines with cavities and starts, but without the typical signs of cavity maintenance by red-cockaded woodpeckers--bark chipped from around cavities and substantial resin flow above and below cavities (Fig. 3). Red-cockadeds were never observed roosting in or otherwise using either the "inactive cavity trees" or inactive cavities in otherwise active trees. Data were

collected on both the "inactive cavity trees" and inactive cavities in active trees because the red-cockaded has been generally considered to be the only species which excavates cavities in living pines (Dennis 1972, Lay 1973, Jackson 1974).

"Inactive cavity trees" were found throughout the extensive and intensive study areas, situated either in close proximity or many kilometers from known active colonies. These trees occurred either in groupings or as isolated individuals. Inactive cavities in otherwise active trees were very similar in appearance to those in the inactive trees.

RESULTS AND DISCUSSION

Cavity Trees--A total of 155 active or once-active (recently dead) red-cockaded woodpecker cavity trees were located, 145 in the McCurtain County Wilderness Area and 10 on Weyerhaeuser Company lands in Pushmataha County. Among the 8 parameters compared between active cavity trees and "inactive cavity trees" (Table 1), 5 parameters (d.b.h., aspect, total cavities per tree, height of cavities, and start holes per tree) were significantly different at the 95% confidence level.

Active cavities predominantly faced in a westerly direction, with 75.3% facing from SSW to NNW in contrast to 14.6% facing SSE to NNE (Fig. 4). A westerly orientation of active red-cockaded woodpecker cavities has also been reported from other areas (Baker 1971, Dennis 1971, Hopkins and Lynn 1971, Lay and Swepston 1973, Carter 1974). Inactive cavities in active trees, cavities in "inactive" trees, and starts in both groups of trees were much more randomly oriented (Fig. 5) than were active cavities.

Table 1. Characteristics of Red-cockaded Woodpecker Cavity Trees and "Inactive Cavity Trees" in Southeastern Oklahoma.

Parameter	Active cavity trees	Inactive cavity trees	Significance of difference
d.b.h. (cm)			
$\bar{x}$	43.8	46.4	$P < 0.05$
N	155	55	
range	27.4-77.5	27.9-67.3	
Height (m)			
$\bar{x}$	24.8	24.0	$P > 0.5$
N	154	52	
range	16.5-33.8	15.8-33.8	
Height of lowest branch (m)			
$\bar{x}$	10.7	10.4	$P > 0.5$
N	154	55	
range	2.4-21.6	4.6-17.4	
Degree of slope			
$\bar{x}$	25.6	22.3	$P < 0.05$
N	155	55	
range	3-55	5-45	
Active cavities/tree			
$\bar{x}$	1.2		
N	155		

Table 1. Continued.

Parameter	Active cavity trees	Inactive cavity trees	Significance of difference
Height of active cavities (m)			
$\bar{x}$	13.1		
N	224		
range	4.9-24.1		
Inactive cavities/tree			
$\bar{x}$	0.6		
N	155		
Height of inactive cavities (m)			
$\bar{x}$	12.8		
N	70		
range	6.1-22.3		
Total cavities/tree			
$\bar{x}$	1.8	2.7	$P < 0.001$
N	155	55	
Height of total cavities (m)			
$\bar{x}$	13.1	12.2	$P < 0.05$
N	294	152	
range	4.9-24.1	3.9-25.0	
Starts/tree			
$\bar{x}$	0.4	1.5	$P < 0.001$
N	155	55	

Table 1. Continued.

Parameter	Active cavity trees	Inactive cavity trees	Significance of difference
Height of starts (m)			
$\bar{x}$	12.1	11.1	$P > 0.1$
N	68	84	
range	6.1-25.0	1.5-21.3	

The significant differences between active and inactive cavity trees, the differences in orientation between active and inactive cavities, the comparative isolation and long distances between some inactive trees and active colonies, and the lack of evidence indicating red-cockaded usage of inactive cavities suggest that species other than the red-cockaded woodpecker excavated the inactive cavities, and probably many of the starts. There is also evidence in the literature that supports that assumption. One foraging technique of pileated woodpeckers (Dryocopus pileatus) is to bore as deep as 13 cm into living trees (Vickers 1910), and pileated woodpeckers (Hoyt 1957, Conner et al. 1975), downy woodpeckers (Picoides pubescens) (Bent 1939), and hairy woodpeckers (P. villosus) (Lawrence 1966) occasionally nest in living trees. All three of the latter species are common in southeastern Oklahoma.

Characteristics of the midstory almost invariably allowed unobstructed access to active cavities (Table 2). Cavities (N = 126) averaged 3.2 m above midstory height, with only 15 (11.9%) situated below midstory height. Density of the midstory surrounding trees with

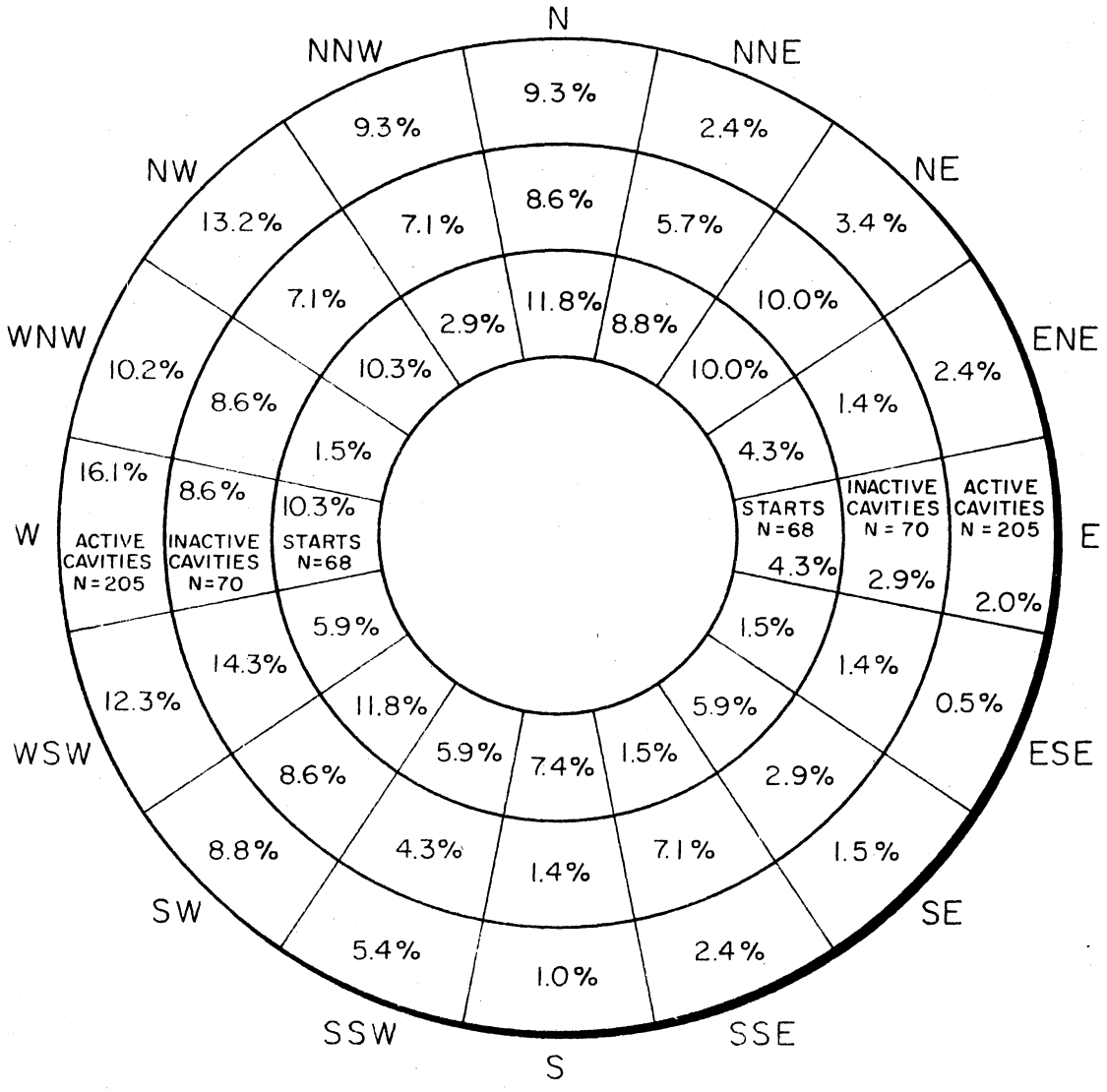

Fig. 4. Orientation of cavities and starts in active red-cockaded woodpecker cavity trees in southeastern Oklahoma.

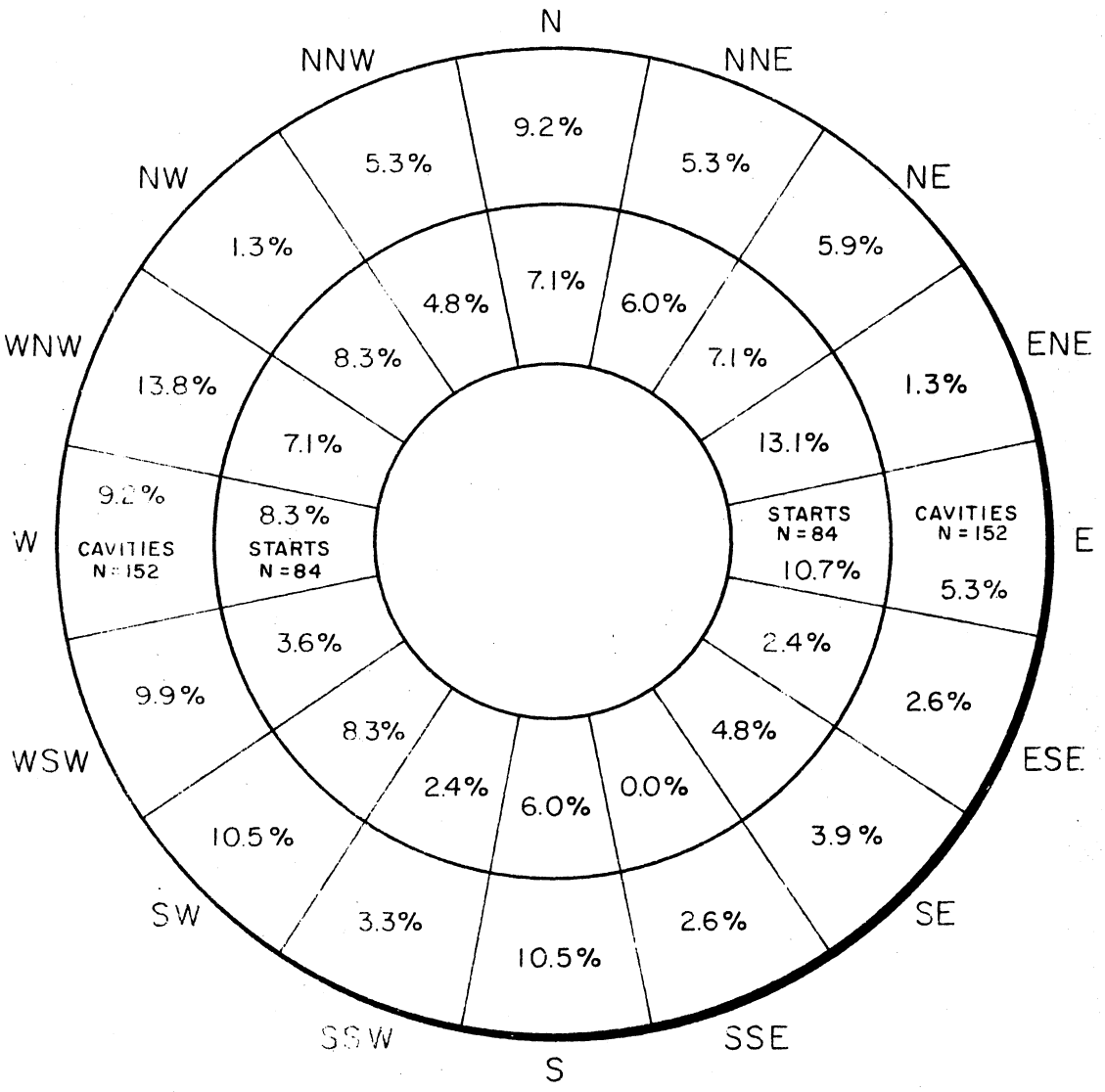

Fig. 5. Orientation of cavities and starts in "inactive cavity trees" in southeastern Oklahoma.

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 obstructed by midstory vegetation. Only three cavities (2.4%) were situated in large branches in the crowns of trees; the other cavities were in the trunks at varying distances below the crown, depending mainly on midstory height.

Table 2. Characteristics of the Vegetation 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 d.b.h. (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

Forty-one (45.6%) of the 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 annual mortality rates of 7.0% in Texas (Lay and Swepston 1973) and 5.0% in South Carolina (Hopkins and Lynn 1971). Two of the 12 were felled by wind when they

broke off at cavity entrances. One was killed by southern pine beetles (Dendroctonus frontalis). Mortality causes of the other nine trees is unknown.

Active cavity trees in Oklahoma (Table 1) are similar to those in other areas (Table 3) except for height of active cavities and age. The much older Oklahoma trees are a reflection of the virgin character of the McCurtain County Wilderness Area in contrast to areas in other states which have undergone various forms of exploitation. The higher cavity height (13.1 m) in Oklahoma trees is undoubtedly due to the relatively high midstory height (9.9 m, Table 2) surrounding cavity trees. Midstory height surrounding Oklahoma cavity trees is of importance because it has been generally believed that red-cockaded woodpeckers require or strongly prefer park-like stands of timber with low (1-2 m) midstories or no vegetation surrounding cavity trees (Murphey 1939, Lynn and Hopkins 1971, Lay 1973, Chamberlain 1974). The Red-cockaded Woodpecker Endangered Species Recovery Team has recommended maintaining vegetation surrounding cavity trees at heights of less than 4.6 m as a management policy (draft copy, Red-cockaded Woodpecker Recovery Plan 1977). However, the most important function of the height of surrounding vegetation is in its relationship to the cavity tree or potential cavity tree. As along as a sufficient length (4-6 m) of trunk is exposed between the top of the surrounding midstory vegetation and the bottom of the cavity tree crown, the woodpeckers should not be deterred, by height of the midstory, 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 has a sparse stocking rate (stems/ha) that allows unobstructed access to trunks.

Table 3. Characteristics of Red-cockaded Woodpecker Cavity Trees Outside Oklahoma as Reported in the Published Literature.

Parameter	Species					Mixed species	Total
	Shortleaf	Longleaf	Loblolly	Pond	Slash		
d.b.h. (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	

Table 3. Continued.

Parameter	Species					Mixed species	Total
	Shortleaf	Longleaf	Loblolly	Pond	Slash		
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 (years)							
$\bar{x}$	87	86	74	72	70	84	81
N	77	610	884	31	15	627	1,985

[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 one shortleaf pine.

[3]Includes starts.

Colonies--Thirty-two red-cockaded woodpecker colonies were located; these consisted of 138 cavity trees being actively used (4.3 cavity trees per colony, range = 1-9). Thompson and Baker (1971) reported an average of 4.16 cavity trees per colony in 229 colonies scattered over 10 southeastern states, and Hopkins and Lynn (1971) reported 6.0 trees per colony in South Carolina (N = 80). The 4.3 trees per colony in Oklahoma should be considered a minimum number because some cavity trees may have been overlooked.

Minimum distance between cavity trees within a colony averaged 58 m (range = 5-240 m). The maximum distance between any two cavity trees in the same colony was 630 m. Minimum distances between cavity trees within colonies in South Carolina averaged 64 m (range = 10-342 m) (Hopkins and Lynn 1971), and in Texas Lay et al. (1971) reported colonies with trees separated more than 400 m.

Home Range--The measured home range totaled 52.8 ha, of which 7.1 ha (13.5%) were used intensively by the resident clan for foraging, 17.1 ha (32.4%) were moderately used, and 28.6 ha (54.1%) were used very little (Fig. 6). Considering the clan number to be five birds (which it was for approximately 80% of the study period), foraging area per bird was 1.4 ha of intensive-use area, 3.4 ha of moderate-use area, and 10.6 ha of the total home range.

Total area used varied with the seasons. Foraging area during the breeding season (May-June) was 26.0 ha (5.2 ha/bird; 49.3% of the total home range), and in summer 44.1 ha (16.7 ha/bird; 83.5% of the total home range). The clan foraged over the entire area during winter. Skorupa and McFarlane (1976) also reported an increase in foraging area after the breeding season and a substantially larger foraging area in winter than in summer.

The intensive-use area had a somewhat linear configuration and, to a lesser degree, so did the moderate-use area (Fig. 6). This oblong configuration was partially due to the linear distribution of the higher elevations, which appeared to support preferred foraging habitat. Several factors, however, probably interact to determine home range size and shape. The number of birds per clan, the presence or absence of

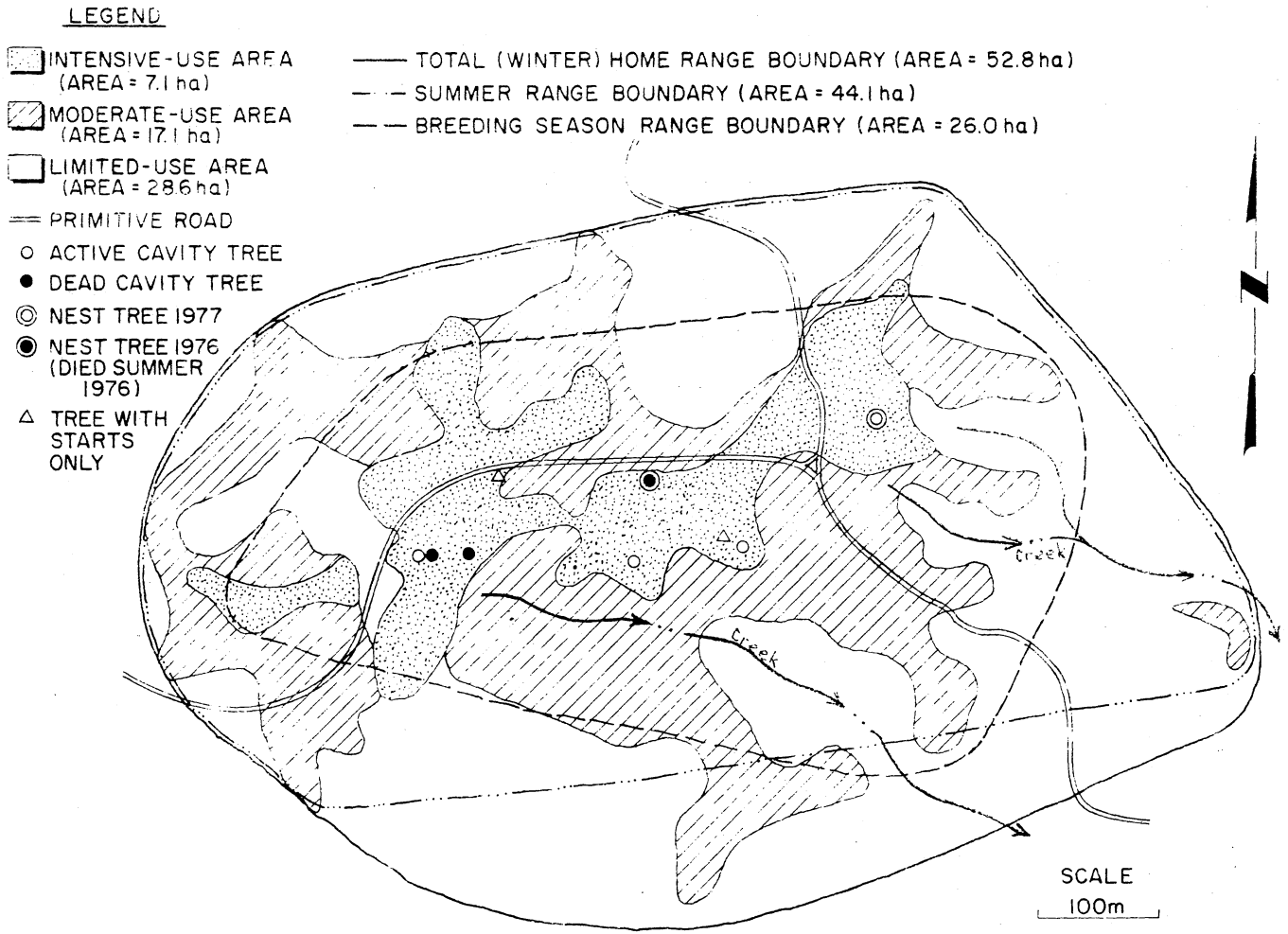

Fig. 6. Home range of a clan of five red-cockaded woodpeckers in the McCurtain County Wilderness Area, Oklahoma.

adjacent clans, and the overall quality of the habitat are all important (Ligon 1970, Beckett 1971).

In Florida, Nesbitt et al. (1977) measured three home ranges in the fall that averaged 69.8 ha (20.6 ha/bird). All three of the latter home ranges contained disturbed areas in the form of clearcuts, pastures, cultivated fields, and/or young pine plantations. Two other home ranges in Florida averaged 17.2 ha (8.6 ha/bird) during the breeding season (Crosby 1971) and parts of these ranges had also been disturbed. Two home ranges in South Carolina averaged a maximum of 57.1 ha (14.3 ha/bird) in winter and 26.7 ha (6.7 ha/bird) in summer (Skorupa and McFarlane 1976). Parts of the latter home ranges had been distrubed by ongoing or past logging operations.

Foraging area requirements of the red-cockaded woodpecker are less in the McCurtain County Wilderness Area than in other locations, presumably due to the undisturbed nature of the habitat in the Wilderness. All other locations where home ranges have been measured had undergone some form of human exploitation, which had undoubtedly eliminated or damaged quality foraging habitat and forced resident clans to forage over larger areas in order to fulfill their food requirements.

The intensive-use area had the densest overstory (190.4 stems/ha), the sparsest density (122.0 stems/ha) occurred in the limited-use area, and the moderate-use area (156.8 stems/ha) was intermediate in density (Table 4). The intensive-use area was approximately uniform in elevation throughout, and was generally higher in elevation than the remainder of the home range. The preference that red-cockaded woodpeckers show for foraging in relatively dense overstory trees is probably due to one or more of three reasons: (1) the higher stand density provides a

Table 4. Vegetative Characteristics of Intensive-use, Moderate-use, and Limited-use Areas Within a Red-cockaded Woodpecker Home Range in 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 d.b.h. (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 d.b.h. (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

more concentrated food source and thus minimizes energy expended in foraging, (2) higher elevations, which are drier and where pines are naturally denser due to less competition from hardwoods, are sought out for foraging, and (3) the dense canopy provides some protection from raptors. Some limited predation on red-cockadeds by accipiters probably occurs (Ligon 1970, Beckett 1971), and for several minutes on two occasions in August 1976 I observed an American kestrel (Falco sparverius) chase and otherwise harass members of a foraging clan. On both occasions the kestrel seemed deterred when an individual it was chasing flew into the relatively dense crown of an overstory pine.

Both midstory and understory heights in the intensive-use area were significantly lower (at the 95% confidence level) than in the moderate- and limited-use areas. Differences in understory heights, however, likely is inconsequential to the foraging habits of red-cockaded woodpeckers. The birds almost never forage at or below understory height (Crosby 1971, Lynn and Hopkins 1971, personal observation), and are probably little affected by understory characteristics as long as the midstory is not being crowded out or otherwise affected.

The significantly lower midstory height in the intensive-use area was somewhat biased by the inclusion in the data of the vegetative characteristics surrounding cavity trees, all of which were located within the intensive-use area. As discussed previously red-cockadeds select as cavity trees only those that would allow unobstructed access to cavities. That usually means a lower midstory height immediately surrounding them. When the data from cavity tree plots were excluded, the average midstory height in the intensive-use area (9.4 m) was not

significantly different at the 95% confidence level than that in the moderate-use area.

Overstory basal area in the intensive-use area was significantly higher (at the 95% significance level) than in either the moderate-use or limited-use areas. That higher basal area is principally a result of a denser overstory in the intensive-use area.

Only limited data have been published on specific vegetative characteristics within home ranges in other locations, but those limited data are similar to those found in the measured home range in the McCurtain County Wilderness Area (overstory density = 156.8 stems/ha; overstory height = 23.0 m; average overstory d.b.h. = 30.9 cm; overstory basal area = 10.43 m^2/ha). Crosby (1971) reported an overstory density of 234.0 stems/ha and an overstory basal area of 10.12 m^2/ha in Florida, and Thompson and Baker (1971) reported the following overstory characteristics in home ranges in 10 southeastern states: density = 157.9 stems/ha; height = 22.9 m; average d.b.h. = 34.6 cm; basal area = 12.85 m^2/ha.

CONCLUSIONS

There should be three principal goals in any intensive management scheme for the red-cockaded woodpecker: (1) protect existing cavity trees, (2) provide for future cavity trees, and (3) provide or maintain quality foraging habitat. Existing cavity trees can be protected by prohibiting their removal and removing or trimming midstory trees when they threaten access to cavities. Protecting all large trees in the immediate vicinity of existing cavity trees would lessen the chances for cavity tree mortality through windfall.

When possible, potential cavity trees should be mature or approaching maturity (at least 60 years old), be at least 25 cm in diameter at breast height, and be scattered between and/or in fairly close proximity (within 100 m) to existing cavity trees. Where suitable potential cavity trees are relatively scarce (5/ha or fewer), all such trees within 350 m of existing cavity trees should be protected. An annual mortality rate of cavity trees of at least 7% must be allowed for, as well as the fact that red heart does not attack all mature pines, and that red-cockadeds do not excavate cavities in all red heart-infected trees. A minimum of 20 potential trees per existing cavity tree probably should be protected.

Midstory trees surrounding potential cavity trees should be removed or trimmed as needed to provide exposed trunks for potential cavity sites. Constructing artificial start holes 4-8 cm deep in potential cavity trees may increase the likelihood of red heart infection. Jackson (1977) has shown that one method of initial red heart infection is probably from the fungal spores entering red-cockaded woodpecker start holes. Such artificial starts should have a westerly exposure.

Where mature or near-mature potential cavity trees are absent or nearly absent, then more intensive, long-term management techniques should be initiated. Thinning dense stands of relatively young pines would promote more rapid growth rates in the pines left standing, thereby preventing much retardation and stunting. Younger pines would thus reach their full size potential and become suitable for cavity trees as early in their life cycle as possible. Populations of woodpeckers occupying areas in which potential replacement cavity trees will not be available for a substantial number of years are almost certainly doomed to

extinction. The practicality of transplanting such doomed populations to more suitable habitat should be studied and considered.

Management units for single home ranges should allow for at least 11 ha per clan member in good habitat and at least 22 ha per member in poor quality habitat (ranges containing severely disturbed areas). Overstory density should be maintained at 150 to 200 stems/ha in as much of the home range as possible. Overstory basal areas of 10 to 14 m^2/ha should likewise be striven for. Selective cutting is probably the most applicable method for striving for that density and basal area.

Such intensive management techniques, however, should be carried out only in areas which have undergone past exploitation, or where continued survival of the resident population is in jeopardy. Areas with stable populations of red-cockaded woodpeckers should only require protection from alteration and periodic surveys of habitat conditions.

ACKNOWLEDGEMENTS

Funds for this project were provided by the Oklahoma Cooperative Wildlife Research Unit, Oklahoma State University Environmental Institute, National Wildlife Federation, and Oklahoma Ornithological Society. Appreciation is expressed to C.E. Woods, Manager, McCurtain County Wilderness Area, and his assistant D. Toon for their cooperation, and to the Oklahoma Department of Wildlife Conservation for permitting access to and providing housing on the Area. I owe special thanks and appreciation to Dr. James C. Lewis, Oklahoma Cooperative Wildlife Research Unit, for his concern and assistance throughout the project. The following individuals provided valuable assistance in the field and I am indebted to each one: V. Heller, P. Howell, D. Love, D. Overdeer, M. Ports, R. Reynolds, and C. Wood.

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CHAPTER IV

NOTES ON THE BEHAVIOR OF THE RED-COCKADED WOODPECKER IN OKLAHOMA

By Don A. Wood

This paper presents data collected while studying the status and home range characteristics of the red-cockaded woodpecker (Picoides borealis) in Oklahoma. Observations on various aspects of the species' daily activities, interspecific relationships, intraspecific relationships, and breeding biology are reported.

The McCurtain County Wilderness Area in extreme southeastern Oklahoma, the study area, encompasses 5,701 ha of virgin pine-hardwood forest. Shortleaf pine (Pinus echinata) is the only pine which occurs in the Area and is dominant in the overstory and codominant in the midstory and understory. Oaks (Quercus spp.) and hickories (Carya spp.) are codominant in the midstory and understory. Terrain is rugged to precipitous and ranges in elevation from 175 to 415 m above sea level. Carter (1967, Wilson Bull., 79: 259-272) describes in detail the geology, climate, and vegetation of the Area. The Wilderness Area is the only substantial area left in the state where timber harvest has never been permitted, and where the red-cockaded woodpecker is still a common species.

This study was initiated in November 1975 and continued through July 1977. Approximately 300 hours were spent directly observing red-cockaded woodpeckers. The birds were observed (1) while they foraged,

(2) prior to their going to roost in the evening, (3) after leaving their roosts in the morning, (4) while they fed nestlings, and (5) as they maintained cavity trees. Twenty-eight clans (social units usually comprised of a mated pair and up to 5-6 "helpers") were observed. Interactions between clan members and with other species were recorded, along with any behavior which seemed unusual.

Nesting surveys were conducted by visiting colonies (groupings of cavity trees occupied and maintained by single clans) and searching for nests. Nests were found by listening for nestlings, who are very vocal, or observing adults, who returned to the colony every 10-30 minutes to feed nestlings. To ensure that nests were not overlooked, one or two additional visits were made at 10- to 14-day intervals to colonies in which nestlings had not been detected in the initial visit. All nesting surveys were conducted between 25 April and 20 June 1977.

DAILY ACTIVITIES

Birds left their roosts 20-30 minutes after sunrise and returned 15-20 minutes before sunset (Table I). They left their roosts later in the morning and returned to them earlier in the evening when skies were cloudy or overcast. These differences in roosting times between clear to partly cloudy and cloudy to overcast skies were significant at the 95 percent confidence level. Members of a clan usually entered their roosts within a few minutes of each other, and left their roosts almost simultaneously in the morning. Baker (1971, Symp. Ecol. Manage. Red-cockaded Woodpecker, pp. 44-59) reported similar evening roosting times in Florida, but a morning departure time of 5-10 minutes before sunrise.

Table I

Time of morning departure and evening return of red-cockaded woodpeckers to their roosts in McCurtain County Wilderness Area, Oklahoma.

Roosting activity	Clear to partly cloudy sky	Cloudy to overcast sky
Morning departure (minutes after sunrise)		
$\bar{x}$	23	28
range	3-33	12-48
N	44	31
Evening entry (minutes before sunset)		
$\bar{x}$	16	19
range	31 before to 23 after	42-5
N	37	24

Clans usually spent the first and last 15-30 minutes of each day maintaining cavity trees, but occasionally they began foraging immediately after leaving their roosts and/or continued to forage until re-entering them. Red-cockadeds maintain a copious flow of resin several meters above and below cavities by drilling numerous small, usually conical holes into the sapwood. Daily maintenance prevents the holes from healing over. The resulting resin glaze surrounding cavities protects against rat snakes (Elaphe obsoleta) (Jackson, 1974, Auk, 91: 342-347) and possibly other nest predators.

Clans spent the majority of each day foraging, and members of a clan usually remained together the entire day. Occasionally, however, one or two clan members returned to the colony area to either maintain existing cavity trees or work on new excavations. The entire clan usually returned to the colony area one to three times during a day, but occasionally would not return, after leaving in the morning, until near roosting time in the evening. While nestlings were present, one or two clan members returned to the nest tree to feed the young at 10- to 30-minute intervals throughout a day.

The birds foraged approximately 85 percent of the time in pines and the remainder of the time in hardwoods. Foraging in hardwoods was mainly restricted to branches but all sections of pines were used. Birds were never seen on the ground and only twice was an individual observed foraging on a trunk within 1 m of the ground. No significant differences were detected in foraging habits or behavior from those reported in other portions of the species' range (Baker, 1971, Symp. Ecol. Manage. Red-cockaded Woodpecker, pp. 44-59, 100-107; Beckett, 1971, Symp. Ecol. Manage. Red-cockaded Woodpecker, pp. 87-97; Nesbitt et al., 1977, Auk, in press).

BREEDING BIOLOGY

Fifteen (62.5 percent) of the 24 clans surveyed for nesting produced young. The actual nesting rate was probably somewhat higher. Nest predators and other factors may have either prvented some clutches from hatching or destroyed nestlings before they were detected. However, some clans undoubtedly did not nest. Some clans in other areas have not nested every year (Hopkins and Lynn, 1971, Symp. Ecol. Manage. Red-cockaded Woodpecker, pp. 140-169; Lay and Swepston, 1973, Texas FA Proj.

W-80-R-16), and may go several years in succession without nesting (Beckett, 1975, personal communication).

Four colonies, in addition to those surveyed for nests, were occupied by single birds. These single birds may have been non-breeding females. Clans never contain more than one female during the breeding season (Lay and Swepston, 1973, Texas FA Proj. W-80-R-16), and the fate of the excess females has not been determined.

The earliest fledging date detected was 3 June and the latest was 18 June. The nesting season in Oklahoma, considering an incubation period of 10-13 days and a nestling period of 22-29 days (Ligon, 1970, Auk, 87: 255-278; Beckett, 1971, Symp. Ecol. Manage. Red-cockaded Woodpecker, pp. 87-95), is from the last week in April through the first three weeks of June. Nesting seasons in other areas include late April to early June in Florida (Ligon, 1970, Auk, 87: 255-278; Baker, 1971, Symp. Ecol. Manage. Red-cockaded Woodpecker, pp. 44-59), and early May to mid-July in east Texas (Lay and Swepston, 1973, Texas FA Proj. W-80-R-16).

INTRASPECIFIC RELATIONSHIPS

Clan members communicated with each other mainly through three principal vocalizations: (1) the "foraging call", (2) the "alarm call", and (3) the "welcoming call". The foraging call was a single high-pitched note repeated at irregular intervals (from a few seconds to several minutes apart) as the birds foraged, and was the most frequent vocalization heard. The alarm call was similar to the foraging call but somewhat higher in pitch and longer in duration. It was usually sounded once or twice at the approach of a raptor, presumably to warn

other clan members of impending danger. The welcoming call was a loud chatter sounded when two or more birds congregated on the same branch or trunk. Ligon (1970, Auk, 87: 255-278) reported and phoneticized a total of 13 vocalizations but did not name them.

Territorial conflicts were not observed between adjacent clans but the species is strongly territorial (Ligon, Auk, 87: 255-278; Nesbitt et al., 1977, Auk, in press) and interactions between resident clans and intruders undoubtedly occur. Open-wing display and/or drumming by one or more members of a clan were occasionally observed. That behavior is most often associated with territorial defense (Ligon, 1970, Auk, 87: 255-278) and may have been a response to my observing the birds too closely. On most occasions, however, the birds either showed no visible response to my presence or simply appeared nervous and/or flew away.

On 1 February 1977 I followed a clan of four adults and one juvenile male for 6 hours as they foraged. Throughout that time one clan member persistently chased and harassed another. The chase was accompanied by much drumming and open-wing displays by the pursuing bird. When the clan was next observed on 8 February, the clan contained only four birds and it was assumed the hostile behavior observed earlier was the juvenile being driven away. Ligon (1970, Auk, 87: 255-278) reported an unsuccessful attempt by a pair of adults to drive away a juvenile in Florida.

INTERSPECIFIC RELATIONSHIPS

On one occasion some agonistic behavior was evident toward three hairy woodpeckers (Picoides villosus), who were foraging together in the same tree as a red-cockaded, and on two occasions toward blue jays (Cyanocitta cristata). At other times, however, red-cockaded woodpeckers foraged in close proximity to hairy woodpeckers and blue jays, and also

to brown-headed nuthatches (Sitta pusilla), white-breasted nuthatches (S. carolinensis), great-crested flycatchers (Myiarchus crinitis), pileated woodpeckers (Dryocopus pileatus), and yellow-bellied sapsuckers (Sphyrapicus varius) without any evidence of aggressive interactions.

Red-cockadeds were always aggressive toward downy woodpeckers (Picoides pubescens) on the approximately 15 occasions when interactions between the two species were observed, and never allowed them to forage in the same tree with them. Ligon (1970, Auk, 87: 255-278) also reported strong aggression of red-cockadeds toward downy woodpeckers and noted that the two species have very similar foraging techniques. Chasing downies from foraging sites probably reduces competition for food and favored foraging locations.

On the evening of 7 June 1977 I observed a ruby-throated hummingbird (Archilochus colubris) chase a red-cockaded woodpecker for 5-6 minutes in the vicinity of the woodpecker's cavity tree. At 2000 the woodpecker entered its roost cavity with the hummingbird in close pursuit. The hummingbird hovered at the cavity entrance for a few seconds and then flew away and was not seen again. The red-cockaded did not leave its cavity that evening although normal roost time at that time of year was 2020 to 2030. Reasons for the hummingbird's agonistic behavior are not known. That incident was the only time I observed a red-cockaded and a ruby-throated hummingbird in close proximity to each other.

Various authors have reported the use of red-cockaded woodpecker cavities by other cavity-nesting species, that often results in intense competition and the expenditure of much energy in cavity defense by the resident red-cockadeds (Ligon, 1970, Auk, 87: 255-278, Dennis, 1971,

Bird-Banding, 42: 79-87; Jackson, 1977, Symp. Manage. Tech. Preserv. Endangered Birds, in press). I never observed another species attempt to use active red-cockaded woodpecker cavities. This lack of competition may have been due to the virgin character of the McCurtain County Wilderness Area. Snags in all stages of decay were abundant, providing ample nest sites for other cavity-nesting species. All other areas of substantial size where the red-cockaded has been studied have undergone some form of exploitation, and usually dead and dying trees were removed which eliminated normal nest sites of other species.

For a few minutes on 8 August 1977, and again on 9 August, I observed an American kestrel (Falco sparverius) chase and dive at members of a foraging clan of red-cockaded woodpeckers. Presumably the chases were attempts at predation by the kestrel. The woodpeckers eluded the kestrel by flying into the crown of a mature pine in the overstory. No other attempts at predation were observed, but some limited predation by accipiters probably occurs (Ligon, 1970, Auk, 87: 255-278; Beckett, 1971, Symp. Ecol. Manage. Red-cockaded Woodpecker, pp. 87-95). While foraging, individual red-cockadeds usually sounded an alarm note at the approach of a raptor and all members of the clan flattened themselves against a branch or trunk and remained immobile until the raptor left. Evidence of nest predation was not detected, but rat snakes, which occasionally prey or attempt to prey on red-cockaded nests (Beckett, 1971, Symp. Ecol. Manage. Red-cockaded Woodpecker, pp. 87-95; Jackson, 1974, Auk, 91: 342-347), are common in southeastern Oklahoma.

Funds for this project were provided by the Oklahoma Cooperative Wildlife Research Unit, Oklahoma State University Environmental Institute, National Wildlife Federation, and Oklahoma Ornithological Society.

Appreciation is expressed to the Oklahoma Department of Wildlife Conservation for permitting access to the McCurtain County Wilderness Area and providing a cabin for housing. I owe special thanks to Dr. James C. Lewis, Oklahoma Cooperative Wildlife Research Unit, for his concern and assistance throughout the project. I thank the following individuals for their invaluable assistance in the field: V. Heller, P. Howell, D. Love, D. Overdeer, M. Ports, R. Reynolds, and C. Wood.

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APPENDIX

WOODY PLANTS ENCOUNTERED IN A RED-COCKADED WOODPECKER HOME RANGE IN 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

Vegetative story and species	Relative abundance (%)	Relative frequency (%)
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

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