Symposium on the RED-COCKADED WOODPECKER

THE

ECOLOGY AND MANAGEMENT OF THE RED-COCKADED WOODPECKER

Proceedings of a Symposium

at

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Bureau of Sport Fisheries and Wildlife
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FOREWORD

. . . . I am fully committed to the task of insuring that the United States will assume and maintain a leadership role in preventing the irretrievable loss of any species. We are not so naive as to believe that we can halt evolution--we know, despite our best efforts, that some species will slip over the brink into oblivion. But we are dedicated to the belief that America has matured to the point that we are no longer willing to sacrifice the end product of eons of evolutions--a species or subspecies of wildlife--on the altar of the god called "progress" without putting up one darn good fight!

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OF

THE RED-COCKADED WOODPECKER

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For the next day, we will be concerned with and discussing one endangered species--the Red-cockaded Woodpecker *(Dendrocopos borealis)*. In a larger sense, our concern will and should be about the human animal, his survival and welfare; and recognizing that somehow our own destiny is interwoven and relates to what happens to this one little bird. He is a part of the whole web of life and unless we can better understand how he is to survive, then the understanding of our own survival becomes less clear.

Several weeks ago, Len Foote gave me Aldo Leopold's book, A SAND COUNTY ALMANAC, *Oxford University Press*, 1949. I had read portions previously. Since then, I have read the entire book and some chapters several times. Leopold's perception and understanding of the basic concept of ecology was far superior to that of most present-day ecologists. In writing about passenger pigeons, he said this:

> "Our grandfathers were less well housed, well fed, well clothed, than we are. The strivings by which they bettered their lot are also those which deprived us of pigeons. Perhaps we now grieve because we are not sure in our hearts that we have gained by the exchange. The gadgets of industry bring us more comforts than the pigeons did, but do they add as much to the glory of spring?
>
> "It is a century now since Darwin gave us the first glimpse of the origin of species. We know now what was unknown to all the preceding caravan of generations; that men are only fellow voyagers with other creatures in the odyssey of evolution. This new knowledge should have given us, by this time, a sense of kinship with fellow creatures; a wish to live and let live; a sense of wonder over the magnitude and duration of the biotic enterprise.
>
> "Above all, we should, in the century since Darwin, have come to know man, while now captain of the adventuring ship, is hardly the sole object of its quest and that his prior assumptions to this effect arose from the simple necessity of whistling in the dark."

He was getting closer to the real issue when, in discussing land ethics, he said:

> "There is as yet no ethic dealing with man's relation to land and to the animals and plants which grow upon it. Land, like Odysseus' slave-girls, is still property. The land-relation is still strictly economic entailing privileges but not obligations.
>
> "The extension of ethics to this third element in human environment is, if I read the evidence correctly, an evolutionary possibility and an ecological necessity. It is the third step in a sequence. The first two have already been taken. Individual thinkers since the days of Ezekiel and Isaiah have asserted that the despoliation of land is not only inexpedient but wrong. Society however, has not yet affirmed their belief. I regard the present conservation movement as an embryo of such an affirmation."

This symposium is or should be another small step toward helping establish an acceptable land ethic. Leopold has well stated the reasons why we should be concerned.

One of the first objectives for managing a Nationwide system of national wildlife refuges is to assure the survival, in a natural state, of each of the Nation's plant and animal species. The recent evolvement of an environmental conscience by the general public has focused increased attention on the Nation's endangered wildlife. We must accept our responsibility and challenge to let no native plant or animal become extinct during our tenure of stewardship on this land. The Red-cockaded Woodpecker serves a vital role in the wildlife community and as an endangered species may signal a deterioration of the environment of which man himself is an integral part.

The Bureau of Sport Fisheries and Wildlife wishes to acknowledge the efforts of the Tall Timbers Research Station in making this symposium possible. We also recognize the special contribution of the speakers who share their knowledge and expertise. We are especially pleased to have participation by those who will play an influential part in the survival of the Red-cockaded Woodpecker and sincerely desire that this symposium become a very meaningful endeavor.

The expressed purpose for this symposium is to bring together existing scientific knowledge and management expertise in an effort to perpetuate this little known, nongame bird as a continuing part of our environment. The achievement of the following goals presents very difficult but attainable challenges for this group:

1. Ascertain the current status and population trend of the Red-cockaded Woodpecker and seek means for continuing appraisal of their well-being.

2. Provide direction and guidance for research on basic ecological requirements of the bird.

3. Utilize existing knowledge to provide a sound basis for appropriate management including habitat acquisition and rehabilitation, opposition to activities and developments which threaten this species, and explore reintroduction methods.

4. Establish cooperation among Government agencies, private organizations, and individuals working on the broad spectrum of problems concerning the Red-cockaded Woodpecker.

5. Create an expanded public awareness of the needs of the Red-cockaded Woodpecker to maintain their interest and support to insure the survival of this species.

At the close of this symposium, I hope that you will have made significant progress in attaining these goals and contributing measurably to the perpetuation of this bird and perhaps to our own survival.

THE EVOLUTION, TAXONOMY, DISTRIBUTION, PAST POPULATIONS AND CURRENT STATUS OF THE RED-COCKADED WOODPECKER

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INTRODUCTION

Suitable habitat for the Red-cockaded Woodpecker *(Dendrocopos borealis)* has been decreasing in quantity and quality since colonial times due to lumbering, clearing for agriculture, and urbanization. Loss of habitat inevitably has been accompanied by the reduction or extirpation of the species. Murphey (1939) cites the disappearance of the species from many areas of the south; continued decline (Sprunt and Chamberlain, 1949; Burleigh, 1958; Sutton, 1967; Lay and Russell, 1970) has jeopardized the existence of the species to the point that the U.S. Bureau of Sport Fisheries and Wildlife (1968a) includes it on their list of rare and endangered species.

If it is to be saved from extinction, we must assemble our knowledge of the species and use this knowledge to protect and manage the remaining populations. The purpose of this paper is to comment on the evolutionary history of the Red-cockaded Woodpecker, to review the discovery and classification of the species, to describe its present and past distribution and abundance, and to comment on man's role in its future.

EVOLUTIONARY HISTORY

The only known fossil of the Red-cockaded Woodpecker is a partial left humerus reported by Woolfenden (1959) from the Pleistocene of Orange County, Florida. With no greater fossil record, we must base any discussion of evolutionary history on inference from the present physical characteristics, distribution, and ecology of the species and its close relatives.

The Red-cockaded Woodpecker is one of 33 species recognized in the widespread genus *Dendrocopos* by Peters (1948). Eight of these species (Hairy, *villosus;* Downy, *pubescens;* Arizona, *arizonae;* Strickland's, *stricklandi;* Red-cockaded, *borealis;* Ladder-backed, *scalaris;* Nuttall's, *nuttallii;* White-headed, *albolarvatus*) occur in North America. Of these, the Red-cockaded, Nuttall's, Strickland's and Ladder-backed Woodpeckers typically have the back barred. Nuttall's Woodpecker, found in southern California and northern Baja California, and the Ladder-backed Woodpecker, resident

in the southwestern United States and much of Mexico, have been considered to be the closest relatives of the Red-cockaded Woodpecker (Voous, 1947; Mayr and Short, 1970). An alternative hypothesis is that the Red-cockaded Woodpecker is most closely related to the Hairy Woodpecker.

The Red-cockaded Woodpecker has a barred back, barred outer rectrices, and streaked flanks; the Hairy Woodpecker is characteristically solid white in these areas. In addition, the white on the cheeks of the Red-cockaded Woodpecker is more extensive and distributed differently than on typical Hairy Woodpeckers.

During recent studies of geographic variation in *Dendrocopos* woodpeckers, I was impressed by a number of specimens of Hairy Woodpeckers with barred backs, streaked flanks, and spotted outer rectrices. These specimens were from the Alexander Archipelago in the Pacific northwest, Newfoundland, and the Bahamas. I also found greater than average amounts of white on the sides of the head in some specimens from Nova Scotia, Georgia, Louisiana, and the Bahamas. It is of interest that many of these atypical specimens, while from widely separated areas, are from areas that were potential refugia for the species' ancestors during the glacial maxima of the Pleistocene (Dorf, 1959) and/or are from areas where populations of this sedentary species may have been isolated since the late Pleistocene. I here suggest that these characters (barred back, streaked flanks, spotted outer rectrices) were typical of a single *Dendrocopos* species that gave rise to all New World species, and that the Hairy Woodpecker is the direct descendent of that species. Goodwin (1968) favors a monophyletic origin for New World *Dendrocopos* and acknowledges the possibility that barring on the back is a "primitive feature". Short (1971) also accepts a monophyletic origin for the New World *Dendrocopos* and considers the barred back and ventral streaking as ancestral characters.

Miller (1955) described a possible hybrid between the Ladder-backed Woodpecker and Hairy Woodpecker from the Sierra del Carmen of Coahuila, Mexico, that resembles a Red-cockaded Woodpecker but for a black cheek patch instead of solid white. Because of this similarity, Miller proposed a hybrid origin for the species.

I have examined Miller's (1955) putative *villosus X scalaris* hybrid and find it is little different in plumage from individuals from these other isolated populations of Hairy Woodpeckers and is similar in size to Hairy Woodpeckers of other montane areas at approximately the same latitude. On the other hand, it is larger than *D. scalaris* (Table 1). The Sierra del Carmen is physiographically isolated. Indeed, Miller, finding no population of the Hairy Woodpecker in the range, states that "Recolonization would have to be effected by dispersal from occupied areas 200 miles or more away to the north, west, or south, an unlikely although not impossible event..." Rather than representing a hybrid, more likely the specimen represents an isolated population of Hairy Woodpeckers that is (or was) in

the Sierra del Carmen. This requires little more credence than to invoke hybridization, which in itself requires a Hairy Woodpecker to have been there.

Assuming the characters here discussed are indicative of the phenotype of ancestral Hairy Woodpeckers, we should recall the "remarkable resemblance" of Miller's hybrid "to *Dendrocopos borealis*", a resemblance shared by individuals from other isolated populations of *D. villosus*. With this similarity as a base, it seems possible that *D. villosus* and *D. borealis* had a direct common ancestry. I suggest that *D. villosus* descended from a mainland population of this ancestral species and *D. borealis* evolved from an isolated population on one or more of the islands that were Florida during the late tertiary or either the Yarmouth or Sangamon interglacial (MacNeil, 1950). Voous (1947) places the origin of *D. borealis* prior to the first Pleistocene glaciation.

Further evidence for such a relationship between Hairy and Red-cockaded Woodpeckers can be found in the relative abundance of the species in the southeastern United States. Red-cockaded Woodpeckers within historic times have been most numerous in the pine woods of Florida, Georgia, and South Carolina (Audubon, 1839; this study); the Hairy Woodpecker is uncommon to rare in the pine woods of the Southeast (Williams, 1920; Sprunt and Chamberlain, 1949; Ligon, 1970). In more northern areas of the southeastern United States, the Red-cockaded Woodpecker becomes progressively less common as the southern pines (*Pinus echinata*, *P. taeda*, and *P. palustris*) approach their northern limits. The Hairy Woodpecker, on the other hand, becomes increasingly more common as deciduous forests replace the pines. The Red-cockaded Woodpecker, having evolved in the pines and regime of periodic fires in insular Florida, was probably able to successfully invade similar areas throughout the coastal plain of the Southeast. Ligon (1970) suggests that in the past the Hairy Woodpecker was even more uncommon in the Southeast because of the frequent fires that would have destroyed the dead trees that it requires for nesting. The Hairy Woodpecker, while a common woodpecker of the pines in the western United States (Dehnel, 1948), may be uncommon in the pines of the Southeast partly as a result of competition with its "fire-adapted" relative. The occurrence of Hairy Woodpeckers in pines on the Bahamas (Allen, 1905; Bond, 1950), where the Red-cockaded Woodpecker is absent, further supports the idea of competitive exclusion of the Hairy from the pines of the Southeast. Ligon (1970) observed two encounters between Red-cockaded and Hairy Woodpeckers in Florida; in each case the Red-cockaded Woodpecker prevailed.

Another morphological point that links these two species and distinguishes them from other North American *Dendrocopos* is the amount of red in the nuchal area of the male. Red-cockaded Woodpeckers have only a few red feathers on each side of the head forming the "cockades" that characterize the species. Male Hairy Woodpeckers in the eastern United States often

have an incomplete nuchal band (Jackson, 1970). They have a patch of red on each side of the head, larger, but homologous to that of the Red-cockaded Woodpecker. *Dendrocopos kizuki* and related Old World species also have patches of red similar to *D. borealis;* Goodwin (1968) considers these species and *D. borealis* a case of "convergence, within related stocks."

The relationship between the Red-cockaded Woodpecker and other North American ladder-backed woodpeckers is questionable. It is possible that the species are linearly related as suggested by Voous (1947) and Short (1971), but it seems equally possible that their evolution was parallel and from a common ancestry--the major North American *Dendrocopos* gene pool that is recognized today as *D. villosus*. The extent of nuchal coloration in North American ladder-backed woodpeckers other than *D. borealis* favors the hypothesis that these species are derivatives of a species with a complete nuchal band. Incomplete nuchal coloration can be seen as a result of the isolation of eastern and western populations of the ancestral species. The Red-cockaded Woodpecker came into being as a result of a later division of the eastern isolate. The occurrence of occasional complete nuchal bands in eastern Hairy Woodpeckers may be introgression following renewed contact of the east-west *D. villosus* populations.

The ladder-backed Woodpecker may be older or younger than the Red-cockaded Woodpecker, having diverged from the ancestral Hairy Woodpecker either before or after the east-west split in the gene pool. The probable role of the ancestral Ladder-backed Woodpecker as the parent species for Nuttall's Woodpecker and perhaps also for the South American ladder-backed woodpeckers (*D. mixtus* and *D. lignarius*) suggests an early divergence of the Ladder-backed and western Hairy Woodpecker stocks.

The Downy Woodpecker, suggested by Mayr and Short (1970) to be related to the Ladder-backed Woodpecker in spite of the superficial resemblance of the downy and hairy, I believe, because of their superficial similarity, evolved from a more recent isolate of the Hairy Woodpecker. Staebler (1949) and Goodwin (1968) also consider the Downy and Hairy Woodpecker sibling species. Isolation of a second "hairy" population, this time with an established "red-cockaded" population on insular Florida during a later interglacial, may have resulted in divergence of the isolated "hairy". Reunion of the mainland and island populations would have again resulted in competition between the ancestral hairy and the recently derived downy. Differences between the two would have been enhanced through natural selection to their present state.

TAXONOMIC HISTORY

Louis Jean Pierre Vieillot was a French naturalist who avoided the draft during the Napoleonic wars by fleeing to America. The date of his arrival in North America is unknown. He returned to France in the summer of 1798, and we know little of his stay in the United States since he left no journal. Oehser (1948) and Allen (1951) collate the little that is known of Vieillot's life. Vieillot's position in the history of American ornithology is secure, however, for 26 genera and 32 species of North American birds bear his name as the original describer.

The Red-cockaded Woodpecker was first described for science by Vieillot in 1807 in his "Histoire Naturelle des oiseaux de l'Amerique septentrionale." Curiously, he calls it "Le Pic Boreal", the northern woodpecker, and latinizes this common name to *Picus borealis*. Immediately this raises a question in the mind of anyone familiar with the range of the Red-cockaded Woodpecker--the species is typically a southern bird. Vieillot goes on to say that one can find the species in the northern United States ("Le Pic, qu'on recontre dans le nord des Etats-Unis..."). He describes the black and white body pattern of the Red-cockaded Woodpecker but says that it has white outer tail feathers and a band of red on the head ("...une bande rouge sur l'occiput..."). In his plate 122 (Figure 1) Vieillot portrays *Picus borealis* with no black on the outer rectrices and with a band of red across the nape. This collage of dubious affinities represents the first scientific record of the species. In his description, Vieillot mentions only the size of the species, its plumage pattern (partially in error), and its distribution (in error).

The next account of the Red-cockaded Woodpecker is that of Alexander Wilson (1810). In Volume 2 of his American Ornithology he describes the Red-cockaded Woodpecker as a new species--unaware that Vieillot had already described it 3 years previous. Wilson gave the Red-cockaded Woodpecker its now recognized common name and the scientific name of *Picus querulus*. The specific name, *querulus*, means chirping, and was assigned by Wilson because of the constant chattering of the small bands of Red-cockaded Woodpeckers that he observed.

Wilson links the species with pines and states that he found the species in North Carolina, South Carolina, and Georgia. He discusses aspects of the behavior and ecology of the species as well as its taxonomy. He provides our first knowledge of the diet of the species from an analysis of the stomach contents of the specimens he collected.

The quality of Wilson's ornithological work is suggested by Cantwell (1961) in reference to Wilson's discovery of the Red-cockaded Woodpecker: "He hunted them for some time, to secure a perfect specimen, preserving the best to place in Peale's Museum, doubly cautious because he feared the bird might be some familiar species with imperfect plumage." Wilson

Figure 1. *Picus borealis*, "Le Pic Boreal", by Louis Jean Pierre Vieillot.

accurately portrays the Red-cockaded Woodpecker in Plate 15 (Figure 2) of the American Ornithology.

Carl Illiger, unaware that the Red-cockaded Woodpecker had been described previously by both Vieillot and Wilson, described the species from a specimen in the Zoological Museum of Berlin University. This specimen was probably collected in Georgia or South Carolina about 1810 by John Abbot (Stresemann, 1953). Illiger named the species *Picus leucotis* and referred to it as the Red-streaked Headed Woodpecker.

A fourth species name was given to the Red-cockaded Woodpecker by Wagler (see Wetmore, 1941), who described the species as new in 1827 and named it *Picus vieilotti*, after Vieillot.

Latham (1822) mentions that the Red-cockaded Woodpecker is recognized by the common name "sklit", a name derived from the call note of the species. In Louisiana, the Red-cockaded Woodpecker has also been known as *"Pique bois"*, a local Louisiana name for all woodpeckers (Arthur, 1931).

An early history of our knowledge of the Red-cockaded Woodpecker would not be complete without a mention of John James Audubon. Audubon (1839) captured a male near Bayou Sara, Louisiana in 1821. He kept it for two days and was probably the first person to paint the species from a living specimen. This bird is figured in the center of plate 389 (Figure 3) in the elephant folio. The other two birds were drawn about 1836 and were cut out and pasted in position on the dead branch by the engraver, Havell. Audubon refers to the species as *Picus querulus* after Wilson.

John Cassin (1836) comments on the species described by Vieillot and Wilson: "The woodpecker described and figured by Vieillot is, in my opinion, a valid species, and quite as distinct from *P. querulus*, Wilson as *Picus harrisii* is from *P. villosus*, and the differences are as easily seen, with specimens of both under examination." [*P. harrisii* is today recognized as a subspecies of the Hairy Woodpecker and is quite different in plumage pattern. No specimens of *D. borealis* exist today that indicate the extreme geographic variation implied by Cassin (Mengel and Jackson, ms)]. Thus, both Vieillot's and Wilson's descriptions were accepted for a time, Vieillot's *P. borealis* ascribed to specimens from Pennsylvania, and Wilson's *P. querulus* to birds from South Carolina and Georgia. The first AOU checklist of birds of North America (1886) recognized only a monotypic species under Vieillot's designation of *P. borealis*.

Wetmore (1941) divided the Red-cockaded Woodpecker into two races by describing a subspecies of the Red-cockaded Woodpecker from southern Florida. This race, he states, is similar to the nominate race but has appreciably shorter wings. He called this subspecies the Southern Red-cockaded Woodpecker and gave it the subspecific name *hylonomus*, which stems from the Greek words *hyle* meaning "forest or woodland" and *-nomos* meaning "dwelling or living" (A. Wetmore, pers. comm., 1971). Wetmore's division of the

Figure 2. *Picus querulus*, The Red-cockaded Woodpecker, by Alexander Wilson.

Figure 3. *Picus querulus*, The Red-cockaded Woodpecker, by John James Audubon.

species into northern and southern races was included in the 1957 AOU checklist. Due to generic changes the species is now known as *Dendrocopos borealis* with two subspecies, *borealis* and *hylonomus*. Mengel and Jackson (ms) found variation in the species to be smoothly clinal and they recommend recognizing the species as monomorphic.

Lester Short and co-workers (Mayr and Short, 1970) have decided to lump 3-toed woodpeckers with typical *Dendrocopos* woodpeckers into a single genus which must be *Picoides* according to the rules of zoological nomenclature. Such a change, if accepted, will leave the Red-cockaded Woodpecker with the scientific name *Picoides borealis*.

Distribution and Abundance

Wilson (1810) first discovered the Red-cockaded Woodpecker in North Carolina, but later found it through South Carolina and into Georgia as far as the Altamaha River. Audubon (1839) traveled extensively in the Southeast and was able to more accurately assess the distribution of the species, stating that: "This species ... is found abundantly from Texas to New Jersey, and from as far inland as Tennessee." Audubon also pointed out the preference of the species for pines and commented that it was nowhere more abundant than in the pine barrens of Florida, Georgia, and South Carolina. Woodhouse (1853) first reported the species from Oklahoma ("Indian Territory"). Woodruff (1907, 1908) found the birds fairly common and breeding in Shannon County and unlumbered parts of Carter County in Missouri. There are records of the Red-cockaded Woodpecker from Fulton (Pindar, 1889,1925) and Muhlenberg (Brown, 1935) counties in western Kentucky though Mengel(1965) questions the validity of these early records and gives the known distribution of the species in Kentucky as the "Cliff Section of the western Cumberland Plateau" in the eastern part of the State.

There are aberrant records of the Red-cockaded Woodpecker from Tarrant County, in east Texas (a specimen) (Sutton, 1938); from Tulsa County (Morse, 1927; questioned by Sutton, 1967) and Washington County (Murphey, 1939) in northeast Oklahoma; from Franklin County (Dawson and Jones, 1903) and Butler County (Miller and Miller, 1966) in central and southwest Ohio; and from Delaware County in southeast Pennsylvania (Gentry, 1877). Though Audubon (1839) reported the species from as far north as New Jersey, the only verified record is a specimen in the American Museum of Natural History that was collected in Hoboken prior to 1866 (Bull, 1964). Hausman (1928) reported the species as "only a very casual visitant into the southern portion of New Jersey".

In addition to these western and northern records, the Red-cockaded Woodpecker is also known from several Atlantic and Gulf coast islands. Meanley (1943) reported the first breeding record for the species from Maryland, a newly fledged bird found on Assateague Island. The species has been observed on Hilton Head Island, South Carolina (Newhall, 1961), and from Blackbeard (Burleigh, 1958) and Sapelo (Teal, 1959) islands in Georgia.

In south Florida the Red-cockaded Woodpecker was once a breeding bird on Long Pine Key, though it no longer occurs there (Robertson, 1955). There is a 1906 specimen (American Museum of Natural History) from Amelia Island off northeast Florida and the species exists as a breeding bird on Merritt Island (R. Thompson and W. Baker, pers. comm., 1971). Specimen records document the past occurrence of the species off the Florida Gulf coast on Long Key (American Museum of Natural History), the Anclote Keys (Chicago Natural History Museum), and Cedar Key (Joseph Moore Museum; Museum of Comparative Zoology; University of Florida). In Alabama the species has been reported from Dauphin Island (Imhof and McCullough, 1957), and in Mississippi one individual was recently sighted on Horn Island (United States Department of the Interior, 1968b).

Figure 4 summarizes the past and present distribution records of the Red-cockaded Woodpecker. 1/ This figure excludes many of the extralimital records mentioned above. While some of the peripheral records are winter records of single individuals that were probably vagrant, contraction and increased fractioning of the species' range is a fact.

1/ The data used in preparing Figure 4 were compiled in part from complete sets (Volume 1 through current issue of July 1971) of the following journals: Alabama Birdlife, The American Midland Naturalist, Atlantic Naturalist, The Auk, Bird-Banding, Bird Lore, The Chat, The Condor, EBBA News, Ecology, The Florida Naturalist, Journal of the Alabama Academy of Science, The Kentucky Warbler, Maryland Birdlife, The Migrant, The Mississippi Ornithological Society Newsletter, The Oologist, The Oriole, The Raven, and The Wilson Bulletin.

Audubon Field Notes (American Birds) was carefully searched for the years 1960 through August 1971; prior to 1960 indexed references and only occasional other references were taken from this journal. Data were also used from many other journals, though the journals were not systematically searched.

Numerous (over 50) regional, State, and local annotated bird lists and books were used. Much of the most recent information was obtained from personal correspondence with over 30 persons from throughout the range of the species. Specimen records for approximately 600 birds from the major North American and several regional museums were included in the compilation.

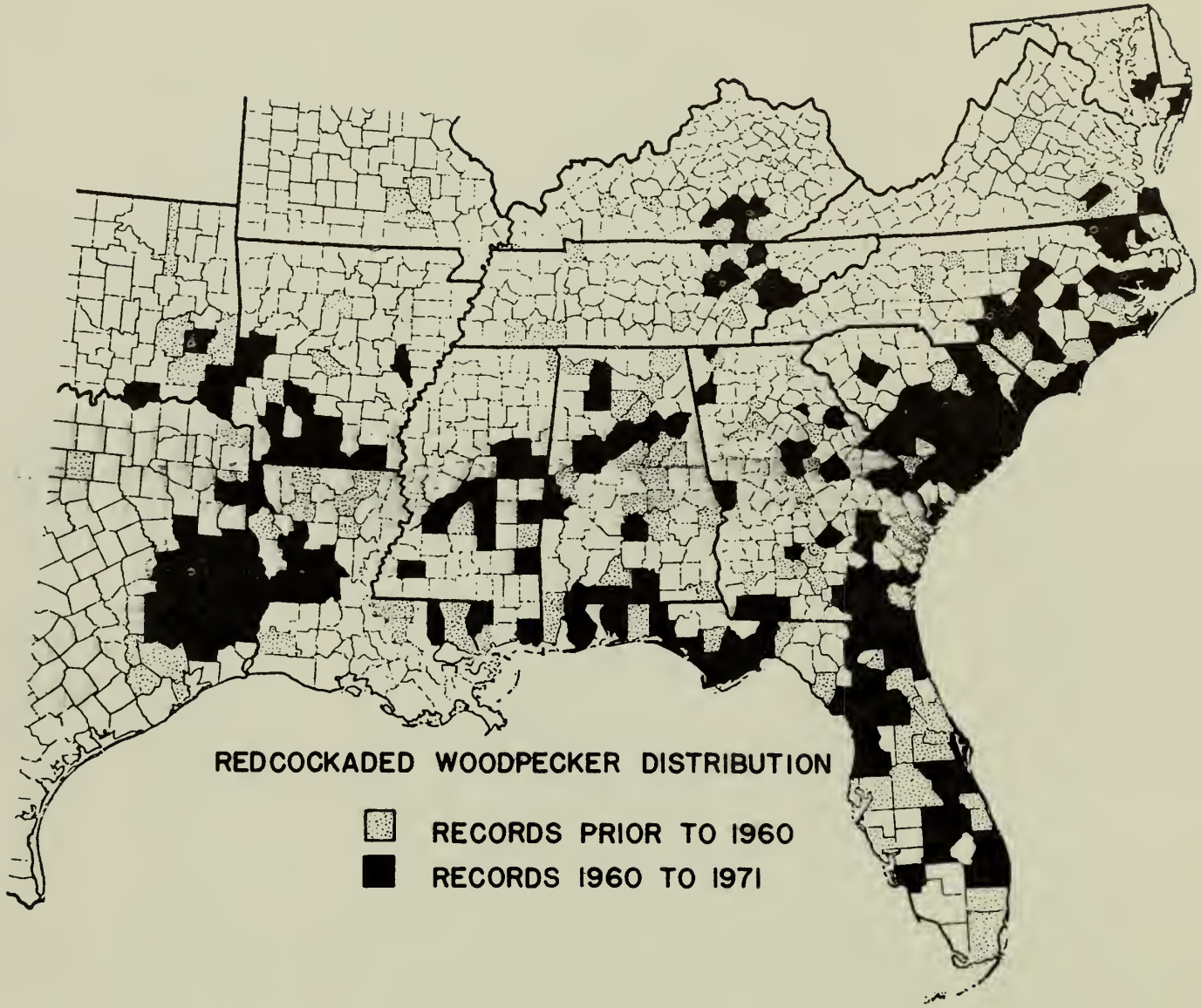

Figure 4. The known past and present distribution of the Red-cockaded Woodpecker.

The strong habitat preference of Red-cockaded Woodpeckers for open, mature pine forests and nest-site preference for pines that are infected with red heart *(Fomes pini)* has been well documented (Murphey, 1939; Steirly, 1957; Crosby, 1971). Voous (1947) points out the particular association of the Red-cockaded Woodpecker with the longleaf pine *(Pinus palustris)*, a view supported by Skinner (1928), Lowery (1960), and Crosby (1971). The birds are also known to inhabit slash pine *(P. elliottii)* (Lowery, 1960); loblolly pine *(P. taeda)* (Steirly, 1957; Stewart, 1958; Sprunt and Chamberlain, 1970); shortleaf pine *(P. echinata)* (Sutton, 1967); and occasionally pitch pine *(P. rigida)* (Mengel, 1965); and pond pine *(P. serotina)* (M. L. Hopkins and T. E. Lynn, Jr., pers. comm., 1971).

A comparison of a composite map showing the distribution of longleaf, slash, loblolly, and shortleaf pines (Figure 5) and the distribution map of the Red-cockaded Woodpecker (Figure 4) shows the expected correlation. Some correlation is also evident between the distribution of the birds (Figure 4) and the distribution of forest fires (Figure 6), since the open parklike habitat preferred by the Red-cockaded Woodpecker is maintained by the regular occurrence of fire. A third factor affecting the distribution of the birds is the proportion of land that is forested (Figure 7). Presumably, other factors being suitable, the abundance of Red-cockaded Woodpeckers will vary directly with the proportion of land forested.

Other factors influence the distribution and abundance of the Red-cockaded Woodpecker. For example, tree maturity is a critical factor since red heart disease is characteristic of trees that are at least 40 and usually over 80 years old (Steirly, 1957). Nonetheless, a synthesis (Figure 8) of the elements of tree species, tree abundance, and fire occurrence (Figures 5, 6, 7) that are most favorable to the existence of the Red-cockaded Woodpecker, may be a useful indicator of the relative abundance of the species in different parts of its range. Most of the largest concentrations of the woodpeckers (Table 2) are in areas with suitable pine species, 75% to 100% forested land, and high to very high fire occurrence rates. Southeast Mississippi is an apparent optimum area from which large concentrations of the birds have not been reported. The paucity of birds in this and similar areas is probably due to the intensive lumbering in the area and the short rotation on which trees are presently being harvested.

From the literature references and compilations of first hand information from many sources I have tried to make a conservative estimate of the number of Red-cockaded Woodpeckers in each State (Table 3). Records after 1959 were used in the tally except that from any given locality only the single highest count was used. A report of "a colony" was counted as two birds, though additional "helpers" are occasionally associated with a colony (Ligon, 1970). Reports of "sparsely scattered colonies" and "numerous colonies" were arbitrarily counted as 3 and 10

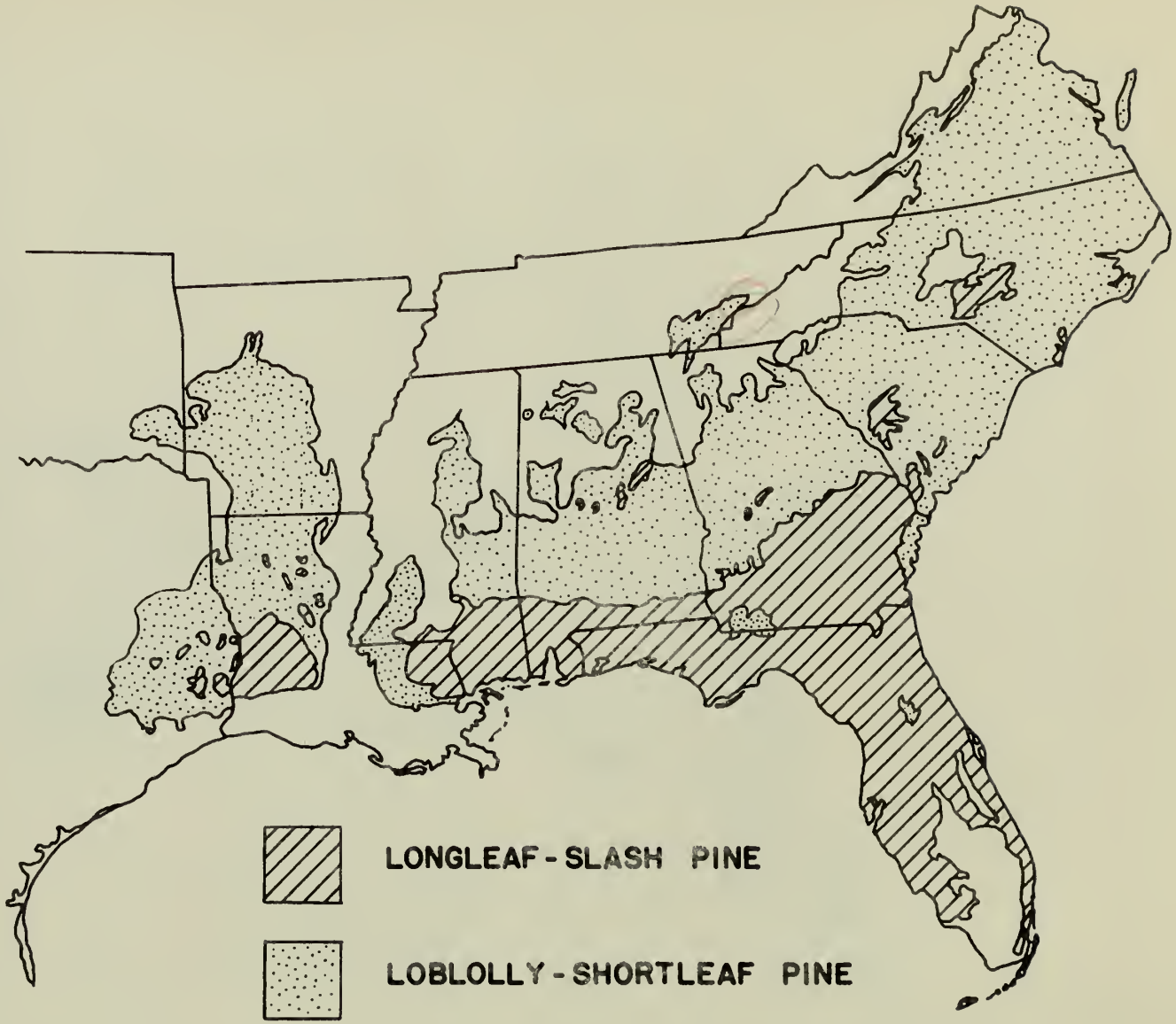

Figure 5. The distribution of longleaf, slash, loblolly, and shortleaf pines in the southeastern United States (adapted from Nelson and Zillgitt, 1969).

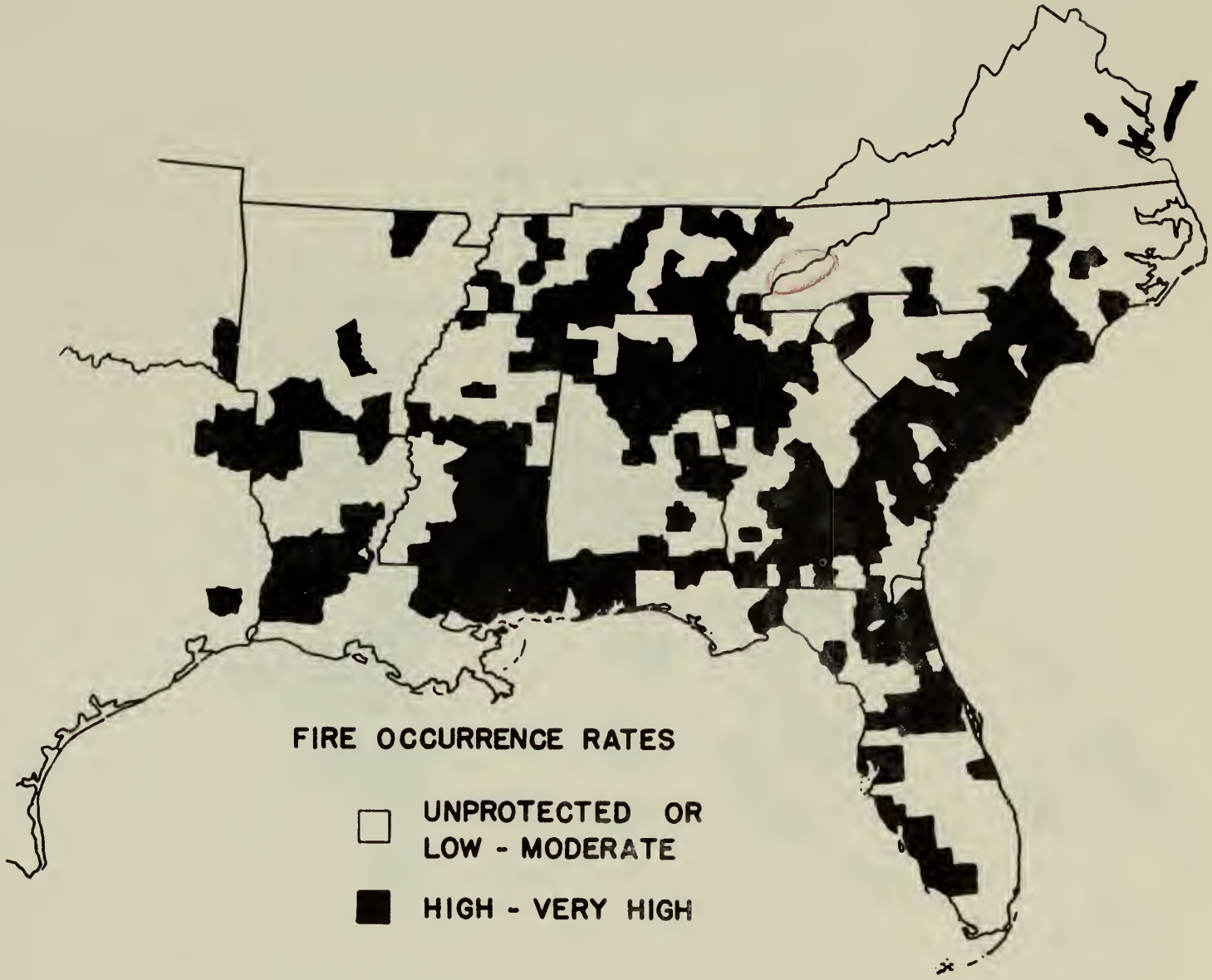

Figure 6. Fire occurrence rates in the southeastern United States (adapted from Nelson and Zillgitt, 1969).

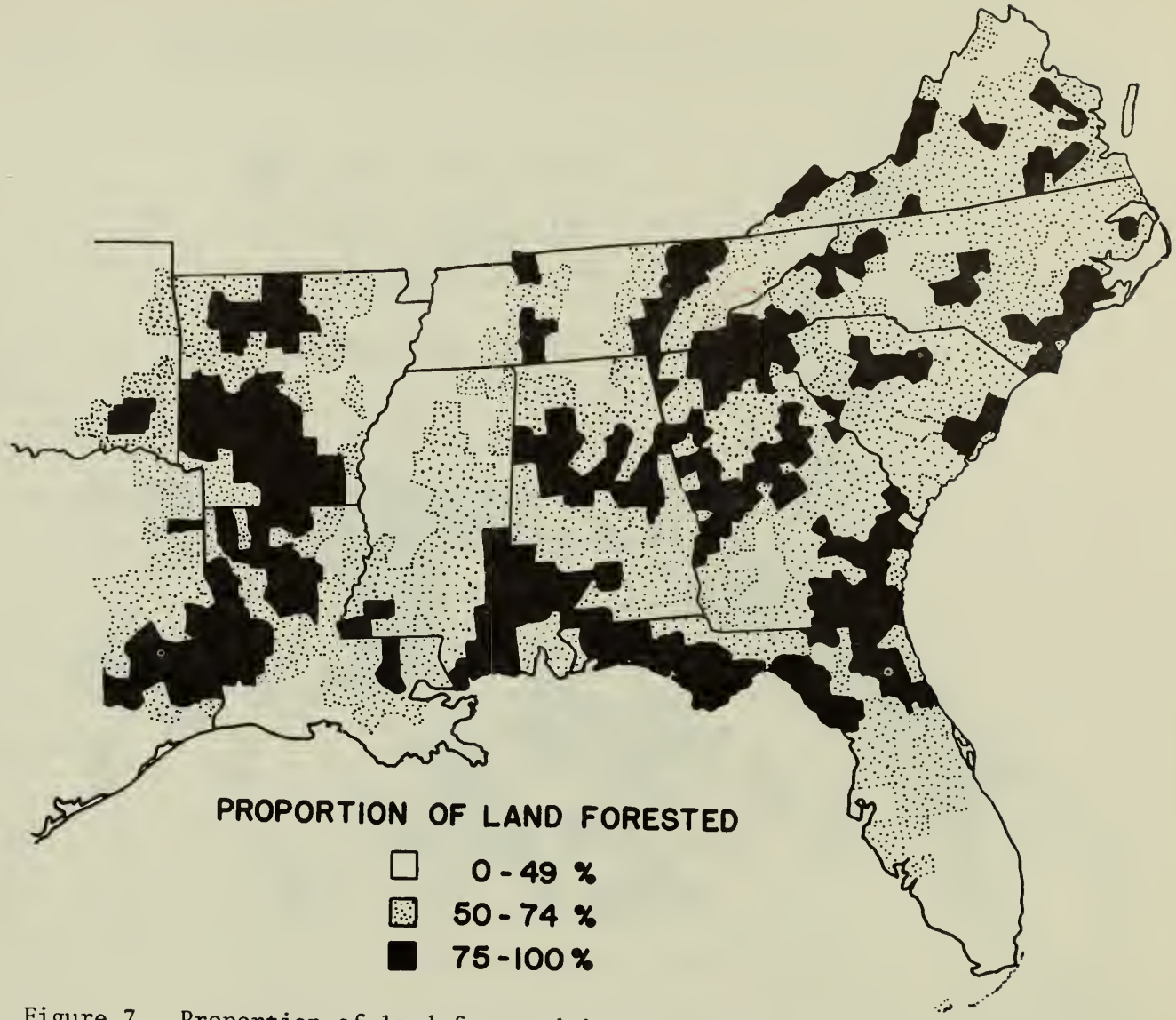

Figure 7. Proportion of land forested in the southeastern United States (adapted from Nelson and Zillgitt, 1969).

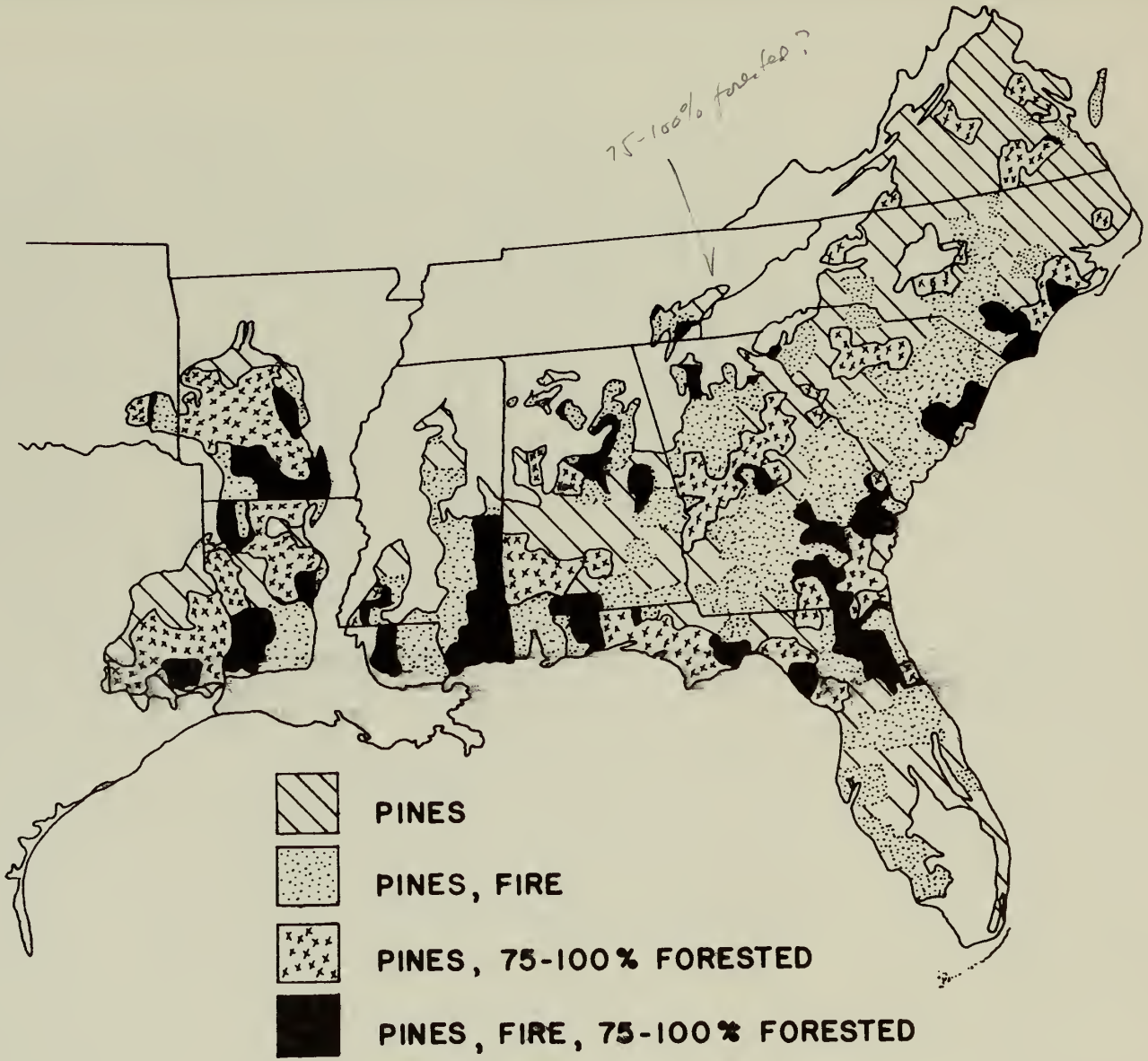

Figure 8. Distribution and interrelationships of three environmental characteristics favorable to the Red-cockaded Woodpecker: presence of pines, abundance of forest, and high-very high fire occurrence.

colonies respectively. Similar nonspecific statements, such as lists of the number of cavity trees in an area, are too numerous to list but were handled conservatively. For some areas the estimates are probably quite accurate because of continuing studies of the species (Texas - D. Lay; South Carolina - T. Beckett, M. Hopkins, and T. Lynn, Jr.) or because of the rarity of the species (Oklahoma, Kentucky, and Maryland). Other areas are probably underestimated because the birds haven't been looked for (parts of Mississippi and Alabama). An estimate for the total population of Red-cockaded Woodpeckers based on these data is 2939 birds. The actual population may be 2 or 3 times this, but probably is not as many as 10,000 birds.

THE FUTURE

The Red-cockaded Woodpecker is in danger of extinction because the mature diseased pines that it requires are uneconomical. Forest lands are now often managed to give the highest and quickest dollar return. Current practices of cutting timber on 80-year or shorter rotation generally does not allow red heart disease to progress to a stage where the infected trees are suitable nest sites for the birds. Suitable habitat is also rapidly being destroyed by urbanization, particularly in coastal areas. Fortunately, perhaps fifty percent or more of existing colonies are on federal or State land and at least potentially can be protected. Another promising fact is that some of the larger paper and lumber companies (International Paper, Georgia Pacific) have undertaken programs to protect Red-cockaded Woodpecker nest and den trees on their land.

The Red-cockaded Woodpecker is endangered because it has specialized. It evolved with the open pine forests of the south and now that these are being changed by man, the dependence of the bird on this particular environment is to the detriment of the species. Has the Red-cockaded Woodpecker overspecialized? Is the species so genetically uniform that is has reached a literal dead end on a one-way evolutionary alley? Perhaps not. In spite of the often repeated statement that it always nests in living pines, there are occasional records of the species nesting in dead pines (Audubon, 1839) and in living and dead trees of other species (Nehrling, 1882; Bendire, 1895; Morse, 1927; Ijams and Hofferbert, 1934; T. A. Beckett, pers. comm., 1971). Some of these records have been questioned, but at least that of Beckett is valid. Most of the records are from peripheral areas of the bird's range where suitable nest sites in living pines may be rare. The species may yet be labile enough to adapt to changes in its environment. The numerous records of birds outside their breeding range imply gene flow among populations that could enable the species to assimilate favorable genetic variations. If the species can be protected for a time there is hope that it will adapt to man's alteration of the environment.

Assuming that existing colonies are protected and the species in some way adapts to the changes in the environment that already have been discussed, the specter of extinction may wear a different cloak. As with many species, the Red-cockaded Woodpecker may be further endangered as a result of pesticides. Unfortunately for the Red-cockaded Woodpecker, its range coincides to a large extent with that of the imported fire ant *(Solenopsis saevissima)*, a species which the United States Department of Agriculture has been trying to eradicate (Coon and Fleet, 1970). The U.S. Department of Agriculture began a widespread attack on the fire ant in 1957 using dieldrin and in 1958 using heptachlor. The use of the chlorinated hydrocarbons resulted in massive wildlife kills (Carson, 1962) and was finally stopped. In 1961 the U.S. Department of Agriculture continued its program with Mirex, another chlorinated hydrocarbon that supposedly lacked the disadvantages of earlier pesticides. In 1969 the U.S. Department of Agriculture and cooperating agencies again decided to eradicate the fire ant and proposed to treat 120 million acres in nine southern States with Mirex (Ferguson, 1970). This program has been opposed by environmentally concerned citizens but is continuing in many areas.

The effects of Mirex on the Red-cockaded Woodpecker may be two-fold. First, Mirex may affect reproduction in birds (Baker, 1964). Due to the endangered status of the species we have not been able to examine Red-cockaded Woodpecker tissues for Mirex, but have found up to 18 parts per million of Mirex in fat from a Downy Woodpecker. Any impairment of the reproductive capacities of the Red-cockaded Woodpecker could mean a very quick end for the species. Second, Mirex not only kills fire ants, but many other arthropods as well. The Red-cockaded Woodpecker is primarily insectivorous, and ants may comprise as much as 79% of its diet (Beal, 1911). In areas where Mirex is broadcast from the air, food supplies for the bird may not only be contaminated, but may be significantly reduced in quantity. If the species is to survive we must not only provide a suitable physical environment for it, but we must provide a chemical environment that will not alter the bird's basic physiological processes or destroy its food supplies.

ACKNOWLEDGMENTS

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Table 1. Comparison of mensural characteristics of *D. villosus*, *D. scalaris*, and the putative *villosus X scalaris* hybrid. All specimens are females. The hybrid was collected in April; the Hairy Woodpeckers were collected from April through June. The Hairy Woodpeckers are from areas in Sonora, Chihuahua, and New Mexico within two degrees latitude of the Sierra del Carmen. I measured these specimens to the nearest .1 mm using dial calipers. The data for *D. scalaris* are for the race *cactophilus* as measured by Short (1968) from central and southeastern Arizona, and as measured by Oberholser (1911) from Arizona, Sonora, and northeastern Baja California. Short's specimens were collected from December through March.

Character	*D. villosus*				*"villosus X scalaris"*	*D. scalaris*[1]				*D. scalaris*[2]		
	N	Millimeters Mean	S.E.	Range	Millimeters	N	Millimeters Mean	S. E.	Range	N	Millimeters Mean	Range
Wing length (Chord)	35	119.8	± .70	(102.4-126.4)	112.7	24	100.6	± .46	(96.2-106.2)	22	100.6	(97-104.5)
Tail length	35	75.0	± .89	(56.1-81.2)	70.9	24	61.6	± .43	(58.0-66.8)	22	59.7	(56-63.5)
Gonys	33	17.1	± .22	(12.4-19.0)	16.5	25	12.9	± .13	(11.2-14.5)			

[1] Data from Short (1968)

[2] Data from Oberholser (1911)

Table 2. Localities where 10 or more Red-cockaded Woodpecker colonies are known or 20 or more of the birds have been seen in a single day since 1961.

State	County	Locality	Status	Reference
Alabama	St. Clair	near Springville	25 birds seen, Nov. 1963	La. State Univ. Museum of Zoology, Bird Distribution File
Florida	Baker and Columbia	Osceola National Forest	Probably more than 50 colonies	M. Beland, pers. comm., 1971
Florida	Bay and Watson	_____	11 colonies	R. Thompson and W. Baker, pers. comm., 1971
Florida	Lake, Marion and Putnam	Ocala National Forest	Probably between 50 and 75 colonies	M. Beland, pers. comm., 1971
Florida	Leon and Wakulla	Apalachicola National Forest, Wakulla District	Probably more than 100 colonies	M. Beland, pers. comm., 1971
Florida	Liberty	Apalachicola National Forest, Apalachicola District	Probably more than 100 colonies	M. Beland, pers. comm., 1971
Georgia	Charlton	_____	11 colonies	L. Calvert, pers. comm., 1971
Georgia	Jasper	Piedmont National Wildlife Refuge	about 12 colonies	D. Heiges, pers. comm., 1971
Georgia	Jones	Piedmont National Wildlife Refuge	about 31 colonies	D. Heiges, pers. comm., 1971
Louisiana	Grant	Kisatchie National Forest	11 colonies	D. Bethancourt, pers. comm., 1971
Louisiana	Natchitoches	Kisatchie National Forest	14 colonies	D. Bethancourt, pers. comm., 1971
Louisiana	Vernon	_____	15-18 colonies	Hamilton, 1971; Bethancourt, pers. comm., 1971
Mississippi	Noxubee, Winston, Oktibbeha	_____	probably more than 30 colonies	B. Webster, pers. comm., 1971; J. Jackson, pers. observation
North Carolina	Hoke & Moore	Southern Pines vicinity	20 birds seen Dec. 1969	Carter, 1970
South Carolina	Berkeley & Charleston	Francis Marion National Forest	250-300 colonies	T. Beckett, T. Lynn, & M. Hopkins, pers. comm., 1971
South Carolina	Chesterfield	Carolina Sandhills National Wildlife Refuge & Sandhills State Forest	150-200 colonies	J. Howe, pers. comm., 1971
South Carolina	Georgetown	Belle Baruch Foundation, Arcadia Plantation	about 25 colonies	J. Dennis, pers. comm., 1971
South Carolina	Georgetown & Williamsburg	International Paper Co. land near Hemmingway	20 colonies	T. Lynn & M. Hopkins, pers. comm., 1971
South Carolina	Horry	within city limits of Myrtle Beach	12 colonies	J. Dennis, pers. comm., 1971

Table 2 (Continued)

State	County	Locality	Status	Reference
Texas	Cherokee	_____	10 colonies	D. Lay, pers. comm., 1971
Texas	Jasper	_____	14 colonies	D. Lay, pers. comm., 1971
Texas	Newton	_____	10 colonies	D. Lay, pers. comm., 1971
Texas	San Jacinto	_____	20 colonies	D. Lay, pers. comm., 1971

Table 3. Estimated populations of Red-cockaded Woodpeckers by State. Estimates are based on the number of known colonies multiplied by two or the highest number of individuals seen in an area since 1961. The larger value was used for each locality.

State	Estimated Number of Birds
South Carolina	1074
Florida	781
North Carolina	218
Georgia	200
Texas	199
Louisiana	158
Mississippi	120
Alabama	69
Arkansas	46
Tennessee	30
Virginia	21
Oklahoma	10
Maryland	7
Kentucky	6
Total	2939

SOME FACTORS INFLUENCING NUMBERS OF THE RED-COCKADED WOODPECKER

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The Red-cockaded Woodpecker *(Dendrocopos borealis)* is perhaps the most interesting member of its genus in North America. Reasons for this are several: it is by far the most gregarious of the *Dendrocopos* woodpeckers, demonstrating such traits as "coloniality" and nest helpers; it is thought to exhibit a symbiotic relationship with a fungus *(Fomes pini)*, almost exclusively utilizing pine trees whose heartwood has been destroyed by the fungus; it is one of the most conspicuously habitat-specific of North American woodpeckers in that it is virtually confined to pine forest; and finally, it appears to be an endangered species. This report discusses certain facets of the biology of the Red-cockaded Woodpecker in an attempt to better understand the factors influencing its numbers.

I studied Red-cockaded Woodpeckers near Gainesville and Orange Heights, Alachua County, Florida, from May 4, 1962 to August 11, 1963 (see Ligon 1968, 1970 for description of methods). Habitat consisted primarily of young second-growth longleaf pine *(Pinus palustris)* with a ground cover of palmetto *(Serenoa)* and grasses. In damp, poorly drained areas, slash pine *(P. elliottii)* was present, but it was not used extensively by the woodpeckers.

Red-cockaded Woodpeckers are usually gregarious, foraging in groups of several adults (Murphey, 1939). However, six of the eight groups I studied consisted of only a pair, while two groups had additional adults (one and three). Statements concerning individuals and generalities about the behavior of each sex are based on marked birds.

In interpreting results of my earlier studies (Ligon, 1968, 1970), it should be borne in mind that the habitat in which I observed Red-cockaded Woodpeckers may have been unlike that utilized by the species elsewhere. It should be re-emphasized that my conclusions regarding foraging behavior and reproductive success, in particular, refer to woodpeckers occupying young, second-growth pine forest of North-Central Florida.

THE ROOST TREE

The roost tree appears to be the single most important feature in the life of the Red-cockaded Woodpecker. An individual Red-cockaded Woodpecker might utilize a single tree for several years (Ligon, 1970) and a given cavity may be used for at least 20 years (Lay and Russell, 1970). The presence of suitable trees for excavation may be important in determining the distribution of the woodpeckers, numbers in a group, ability of the birds to attract and retain mates, and reproductive success.

One of the most conspicuous features of the biology of this woodpecker is the site of roost and nest cavities in living pine trees infected with a fungal disease *(Fomes pini)* commonly known as red heart. Exceptions to this include a cavity in a solid undiseased pine (Lay and Russell, 1970) and one in a bald cypress (T. A. Beckett, III, in litt.). The fungus attacks the heartwood of the tree and causes it to become soft and pithy through destruction of the cell walls (Steirly, 1957). Red heart is usually considered to be a disease associated with old age, and in many regions Red-cockaded Woodpeckers are found almost exclusively in areas of large mature and over-mature pines (Steirly, 1957; Lay and Russell, 1970).

No other North American woodpecker regularly demonstrates such strict requirements for nest or roost sites. Such narrowness is an obvious limiting factor of great importance. This stereotyped behaviorism, i.e., choice of a living tree with its heartwood destroyed by *Fomes pini*, may be the most critical factor in the decrease in numbers of this woodpecker. It is certainly the most conspicuous one.

What are the specific requirements involved? Although red heart usually associated with old, and thus large trees, height of the cavity does not seem to be of great importance. Cavity sites range from about 2 to 80 or more feet above the ground. Crosby (1971) suggests that height of cavities is influenced by location of the red heart infection in the roost tree and height and density of undergrowth.

Important features apparently are a soft, easily excavated interior coupled with a living exterior. Preference for the first appears obvious; many other North American woodpeckers usually excavate in dead, relatively soft wood. Why the living outer shell? it has been suggested previously (Ligon, 1970) that an important factor might be recurring fire. Fire is of primary importance in the development and maintenance of southern pine woodlands (Stoddard, 1962). As a result of fire, standing dead timber probably was rare in prehistoric times. Use of living trees thus would be a requisite for existence in this habitat. Furthermore, the ready desertion of dying roost trees suggests that it is of survival value not to roost in such trees, possibly because of their susceptibility to destruction by fire. Adults roost in the open, high on living pines, rather than using cavities in dead trees.

Extensive utilization of small, relatively young pines only recently has been reported (Ligon, 1970; W. W. Baker, pers. comm.). Occupancy of this habitat may signify a change in the biology of *Fomes pini*, or it might merely indicate that many trees in such areas are weak for one reason or another and are thus susceptible to infection by the fungus. It represents an apparent extension of habitat utilized by the Red-cockaded Woodpecker and may signal a recently attained ecological flexibility on the part of the birds, at least in some portions of the species' range.

The choice of cavity tree is accompanied by a peculiar behaviorism. The woodpeckers peck many small chips through the bark and into the sapwood, often for several feet both above and below the cavity entrance, causing resin to flow freely. This is repeated often and usually results in a continuous flow of sap near the entrance. The function of this behavior is not understood. Some authors (e.g., Pearson, et al., 1942: 221; Steirly, 1957) feel that it serves to prevent animals from entering the cavity, whereas others (Ligon, 1970; Lay and Russell, 1970) provide evidence that this often is not fully effective in preventing entrance by a variety of animals (e.g., ants, flying squirrels, other birds). The role of snakes as predators in the southern pine woodlands needs to be investigated.

Ligon (1970) suggests that as these woodpeckers live in extremely uniform habitat, the hardened whitish resin might serve to mark the tree conspicuously, making it easy to locate from a long distance. Quick return to the cavity by Red-cockaded Woodpeckers is especially noticeable when cavities are being investigated by other species, particularly the Red-bellied Woodpecker *(Centurus carolinus)* (see below). Lay and Russell (1970) propose that the resin may serve to signal possession of a tree for the benefit of other Red-cockaded Woodpeckers.

Defense of the roost cavity from other birds, particularly Red-bellied Woodpeckers, in some instances was an important part of the daily activities of the Red-cockaded Woodpeckers that I studied. One instance illustrates the persistence of the larger species and danger of physical damage to the smaller one. On February 8, 1968, at 16:50 a Red-bellied Woodpecker entered the roost of Female A and perched for several minutes with his head at the entrance. At 17:10 I frightened the Red-bellied Woodpecker from the roost cavity. He returned at 17:20 simultaneously with Male A, who immediately entered his roost cavity about 30 feet away. Again, I drove the Red-bellied Woodpecker from the cavity. The Female A was heard and seen flying about the area. At 18:00, the Red-bellied Woodpecker flew to the roost of Male A, where the two fought by exchanging vigorous pecks until the Red-bellied Woodpecker grasped the smaller woodpecker with his bill and jerked him from his roost cavity. The Red-bellied Woodpecker then entered this cavity. Both Male and Female A scolded for a short time before Female A entered her roost and Male A disappeared for the night. The Red-bellied Woodpecker finally was collected on March 19 after having held the roost cavity of one of the other of the Red-cockaded Woodpeckers for at least six weeks. Other

episodes also resulted in loss of roost sites to Red-cockaded Woodpeckers.

Summarizing, existence of trees suitable for excavation appears to be a primary limiting factor of the Red-cockaded Woodpecker. The fidelity shown by an individual to a roost tree and use of a single tree by several generations of Red-cockaded Woodpeckers, together with vigorous defense of the cavity against the larger, stronger Red-bellied Woodpecker attest to the extreme importance of the roost tree.

REPRODUCTIVE PATTERNS

Red-cockaded Woodpeckers apparently form permanent pair bonds. Nesting, or more accurately, deposition of the eggs, normally takes place in the roost cavity of the male (Ligon, 1970).

Clutch size is from two to five eggs, with three or four being the usual number (Murphey, 1939). The predominant view regarding regulation of clutch size, at least in temperate regions, is that of Lack (1954) who maintains that clutch size is adjusted so that the parents rear as many young as possible, that is, clutch size has evolved to maximize reproductive success. Recent authors (Cody, 1966; Ricklefs, 1970) have modified this view to some extent.

Incubation begins by this woodpecker before the clutch is complete, as is true for many other woodpeckers and some other species. Thus, the young hatch at staggered intervals. This usually is viewed as adaptive in that when food is abundant, all young can be reared, whereas when it is scarce, the younger and smaller nestling or nestlings quickly starve. The older young thus receive adequate food and are not undernourished, as would be the case if the same quantity of food were being distributed equally to all young hatched.

The Red-cockaded Woodpeckers that I studied invariably laid significantly more eggs than young fledged. Three-four eggs usually were laid and one-two young were reared (Ligon, 1970). This at first seemed paradoxical. However, clutch size probably evolved under different environmental conditions than those in which the birds I studied existed (i.e., mature pine forest vs. young pineland). I earlier suggested (Ligon, 1968, 1970) that in mature pine woodlands which contained many old trees susceptible to insect infestation, food might be more abundant and/or more easily obtained with more young reared per nest than in the second-growth woodland. W. W. Baker (pers. comm.) has at least partially confirmed this hypothesis, as he has recorded grown broods of three in the old forest at Tall Timbers Research Station.

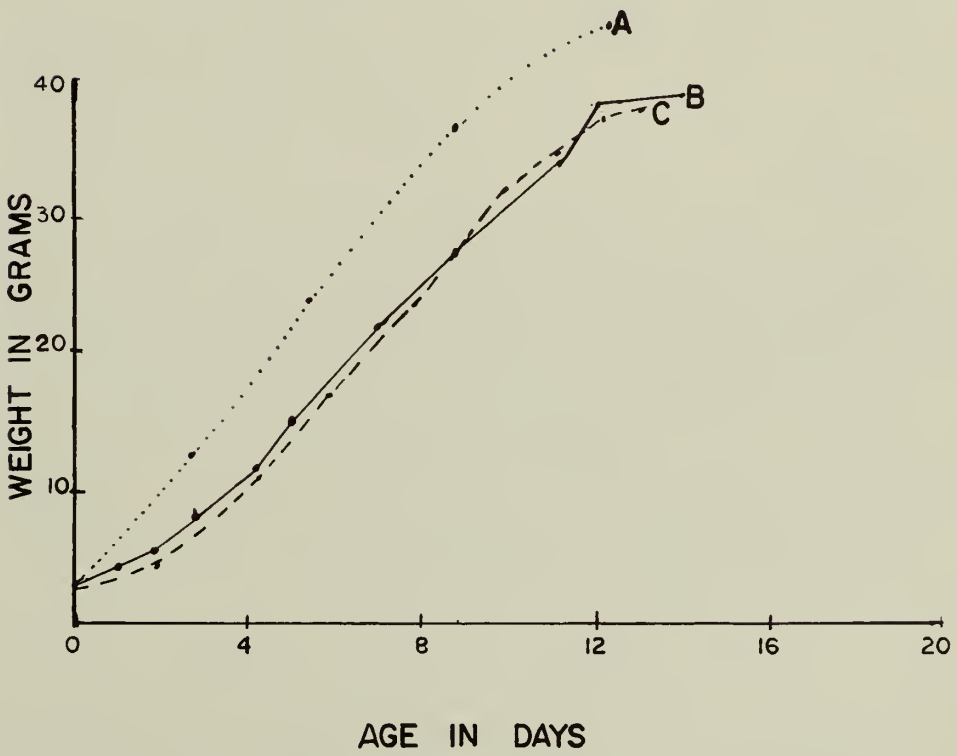
Another aspect of this interpretation is related to the phenomenon of nest helpers for this species. As mentioned earlier, I found only two groups with more than two adults (three and five). If it is assumed that older woodland has richer food resources and circumstantial evidence discussed below under "Foraging Patterns" suggests that this may be a valid assumption, it follows that groups of several birds could be supported more easily in old than in second-growth forest. Clutch size thus could have evolved in relation to the ability of the clan (parents plus helpers) to provide food. Both Ligon (1970) and Lay and Russell (1970), studying the woodpeckers in second-growth young woodland and mature pine forest, respectively, found that only one brood of young was produced per clan whether two or five or more adults were involved. Perhaps a single pair of adults normally cannot rear three or four young unaided in any pine woodland, but that with the assistance of helpers in virgin forest most nestling hatched are reared. From this viewpoint, one could consider large clutch size as a relictual and non-adaptive character of Red-cockaded Woodpeckers inhabiting young forests.

In my study area, starvation of nestlings occurred even in those groups with helpers. Helpers may not start to feed nestlings for a day or so after hatching begins, by which time starvation of newly-hatched chicks has already occurred (Table 1). Nevertheless, apparently they do contribute to the reproductive success of the parents. At two nests with helpers 2.0 young fledged per nest, whereas seven nests without helpers, the average number of young fledged was 1.4 per nest. In addition, growth of surviving nestlings may be accelerated by the presence of helpers (Figure 1). Development of nestlings is summarized in Table 2. Details of growth, as measured by weight gain, have been presented by Ligon (1970).

Juvenile Red-cockaded Woodpeckers fledged at 26 to 29 days of age. The young birds can fly fairly well at fledging and within a very few days accompany the adults on their foraging rounds.

The most interesting aspect of post-fledging care of the young is their long dependence on adults for food. Although juveniles begin to exhibit what appears to be effective foraging behavior by three days post-fledging, at about the same time the tail begins to be used as a prop, they may beg for and receive food from the adults for five months or longer. I recorded two instances of what appeared to be cooperative feeding efforts between a juvenile female and her female parent, suggesting that immatures learn foraging techniques from their parents. The extended dependency of juvenile Red-cockaded Woodpeckers itself suggests that they require a long learning period to gather food effectively, at least in the second-growth pine woodlands.

Figure 1. Mean growth of pairs of surviving Red-cockaded Woodpecker nestlings at nest with and without helpers. A, three helpers; B, one helper; C, fastest growing young at nest without helpers. (Reprinted from The Auk (Ligon, Auk 87(2):273) with permission of the editor.)



FEEDING ECOLOGY

Red-cockaded Woodpeckers are largely insectivorous. Beal (1911) examined contents of 76 stomachs taken in all months except June and July. Over 81 percent of the food items consisted of insects, principally ants. Morse (in press) examined stomach contents of a single bird taken in winter in Louisiana during a bumper seed crop of longleaf pine; the stomach contained only arthropods. However, despite this dependence on insects, the principle habitat utilized, longleaf pine forest, supports a very low density of insects according to Wahlenberg (1946, cited by Morse, 1970).

Two lines of evidence suggest that food is indeed an important limiting factor in the Red-cockaded Woodpecker, at least in some portions of the species' range. One of these, starvation of newly hatched chicks, has already been described. Thus, I will simply re-emphasize the major point: Food appears to be either so scarce or it is so widely distributed in second-growth pine forest, at least in some years, that pairs of adult Red-cockaded Woodpeckers cannot provide adequately for all young hatched. As a result, reproductive success (number of young fledged) is considerably less than the number of eggs laid and hatched. Evidence that this pattern may not hold in mature pine woodland was mentioned earlier.

The second line of evidence suggesting that food is limited in at least some second-growth forests is the partitioning of the habitat by male and female Red-cockaded Woodpeckers (Ligon, 1968). It was found that males in the Gainesville, Florida, area utilized principally the upper portion of the trunk and the limbs and branches, whereas females utilized the lower trunk most of the time and were not seen to forage on the limbs and branches at all, excluding infrequent visits to pine cones at the terminal ends of the branches. In addition to these intersexual spatial differences there appeared to be differences in foraging techniques employed. For example, females utilized their feet to remove bark from the trunk, whereas males were not seen to use the feet directly as foraging tools.

In contrast to the sexual differences in foraging behavior, I found in the Gainesville area in 1962-1963, Morse (Auk, in press) detected no differences in foraging behavior between male and female Red-cockaded Woodpeckers in Louisiana. He determined that both sexes foraged almost entirely on the trunk. His study area was composed of larger and thus presumably older pines. Morse concluded that the absence of intersexual differences in foraging behavior in the Red-cockaded Woodpeckers that he studied is related to the established presence of several other woodpecker species, particularly the Downy Woodpecker *(Dendrocopos pubescens)*.

I detected no differences in foraging positions or techniques between male Red-cockaded Woodpeckers and Downy Woodpeckers (Ligon, 1968). However, my observations of Downy Woodpeckers were few. As a result of the conflicts that I observed between the two species and statements of Howell (1932), I suggested that Downy Woodpeckers had only recently entered the pineland habitat, implying that the recent contact between the two species was the basis for the agonistic behavior that I observed (i.e., enough time for niche partitioning to occur had not elapsed). I now believe that this interpretation should be modified. I suspect that both species were adjusting to the young second-growth pine forest composing my study area. The most conspicuous adjustment of the Red-cockaded Woodpeckers probably was development of sexual differences in foraging behavior. In addition, interspecific adjustments, as between the two species here considered, had to be made. In the older more stable habitat studies by Morse, there was no evidence of antagonism between Downy and Red-cockaded Woodpeckers. Instead, partitioning of the trees by the two species was similar to that seen between the sexes of the Red-cockaded Woodpecker in Florida.

On the basis of my foraging data, in addition to other evidence (absence of marked dimorphism in bill size, for example), I suggested (Ligon, 1968:214) that: (1) sexual differences in foraging behavior probably are of recent origin and perhaps are temporary; (2) habitation of small, young forest may have occurred relatively recently; and (3) food resources are scarcer in such habitat than in older pinelands. In short, intraspecific sexual differences in foraging behavior may appear when a habitat is exploited that is poorer in food resources than that from which the population utilizing it was derived and may disappear in a given geographic area as the forest matures or otherwise becomes richer in foods.

It is here suggested that old timber can support more woodpeckers than younger timber. This is supported by the findings of Tanner (1942:46), who determined that Pileated Woodpeckers *(Dryocopos pileatus)* in northern Louisiana were more than six times as common in virgin timber as in second-growth habitat. He found this pattern to be true for several other woodpecker species as well.

Although Red-cockaded Woodpeckers typically are found in groups or clans, in my study area, seven of nine groups were composed of only a pair of adults. This difference possibly is related to the small trees which the birds I studied inhabited. Possibly a range in the young pineland usually could not support more than a pair of adults and their young of the year. Comparative time-energy budgets worked out for Red-cockaded Woodpeckers in mature and young pineland, e.g., time spent per day in foraging activities in each habitat, together with information on numbers of individuals per group and size of the area utilized might provide clear evidence for the role of food in influencing numbers and distribution of this species.

TERRITORIALITY AND SOCIALITY

Territorial behavior appeared to be highly developed in the Red-cockaded Woodpeckers that I studied. The territory includes all activities of the birds (Type A of Hinde, 1956). Defense is most pronounced near the roost or nest cavities. Both members of a pair attack a single conspecific intruder. This is in contrast to many other woodpeckers, including congeneric species such as the Hairy Woodpecker *(D. villosus)* (Lawrence, 1967: 44), where territorial males attack male intruders and females attack females.

A conspicuous feature of Red-cockaded Woodpecker biology is the long-term existence of the pair. Pairs may remain intact for several years foraging together peacefully day after day. Likewise, the birds may utilize the same roost cavities and foraging area over long periods. A major threat posed by a conspecific intruder might be to upset this stability and thus to threaten both immediate reproductive success and the continued harmonious relationship of the pair. As suitable roost cavities are rare, they are undoubtedly part of what is defended.

Possibly of even greater importance is the stable, adjusted life patterns of the pair.

If an intruder is persistent enough, defense of the territory can be so extreme, in terms of time utilized, that reproductive success in a given year is decreased. I observed a single unmarked bird invade the territory of pair A frequently from May 11-30, 1962. During periods of pursuit of the intruder, the eggs and later the small young were neglected. The great amount of time and effort pair A expended in attempting to drive this bird away might account in part for their low reproductive success; only one of three young survived to fledging age.

For such behavior on the part of the mated pair to be adaptive, it must, on the average, insure that those birds demonstrating it are more successful than less strongly territorial individuals. Although reproductive output per year is low in Red-cockaded Woodpeckers, the high survival of mated adults (Ligon, 1970) suggests that this is compensated for by longevity. The stability of the lives of these birds, including the great familiarity with the territory or range, and the availability of a safe roost site almost certainly is of significant importance in reducing predation and thus increasing life expectancy.

The extreme aggressive territoriality of pairs of Red-cockaded Woodpeckers is in striking contrast to the compatible groups or clans also seen in this species. The extra bird of the threesome I studied was an offspring of the previous year. In most such cases in birds, extras or helpers are older offspring of the breeding pair.

If the suggestion that helpers usually are older offspring of the breeding pair is valid, together with the premise that normally a single pair of adults rears fewer young than do a pair of adults plus helpers, then selective factors favoring the evolution of sociality, or at least a tolerance by the adults for their grown young can readily be seen. By not driving away grown young or yearlings, the adults gain in that these become helpers which contribute significantly to the reproductive output of the parents. In addition, it is of selective advantage for yearlings to remain with their parents, since by aiding in the provision of food for their younger siblings, they are making a significant contribution to the success of their closest genetic relatives.

The learning experiences to be gained by the yearling (and older) helpers likely are of importance as well. Red-cockaded Woodpeckers probably rarely breed at one year of age. Presumably this delay actually increases their reproductive potential. In addition, if they are contributing significantly to the rearing of their younger siblings they are further increasing their genetic success (see Williams, 1966:193-220).

THE FUTURE

Although the concern shown and the willingness of various interests to spare roost and nest trees is encouraging, this alone is not sufficient to insure the survival of the Red-cockaded Woodpecker. The birds also must have sufficient foraging range within a reasonable distance in order to exist in a given area. What the minimum adequate size of a range is, in terms of trees per acre, number of acres, etc., remains to be determined. It undoubtedly will vary with age and density of the trees and perhaps with tree species. Obtaining information of this sort is essential to development of management procedures that will guarantee the continued existence of this woodpecker.

SUMMARY

The activities of Red-cockaded Woodpeckers *(Dendrocopos borealis)* are centered about their roost cavities, which are almost always located in living pines infected with a heartwood fungus, *Fomes pini*. Each bird typically possesses a cavity which is used throughout the year. Cutting of old forest removes most trees infected with the heartwood fungus, thus eliminating roost and nest sites for this woodpecker. In some areas, e.g., near Gainesville, Alachua County, Florida, trees of about forty years, or even younger are infected and are used by Red-cockaded Woodpeckers. Use of young second-growth timber may indicate a relatively recent shift in ecological requirements by this species.

The reproductive pattern of three-four eggs laid and one-two young fledged in second-growth habitat suggests that: (1) clutch size evolved under conditions unlike those presently encountered by the birds studied; and (2) that food is limited in that habitat. Support for this interpretation of

clutch size and number of fledged young is provided by the observation that three young sometimes are reared in old forest.

Foraging behavior in second-growth habitat further suggests that food is limited. Males and females may partition the environment, presumably to increase their foraging efficiency. This pattern of sexual dimorphism in foraging behavior apparently is not seen in older forest. This suggests that such behavioral differences can be considered as special measures, making possible habitation of young woodland. These sexual differences may be temporary in place and time. The fact that mensural differences between the sexes are very slight suggests that this is the case. Evidence from other woodpecker studies also suggests that old timber is much richer than young woodland in woodpecker foods.

Territorial behavior in the Red-cockaded Woodpecker is unusual in that both sexes may attack a single intruder. It is suggested that the permanent pair bond is the principle object of defense. This is in contrast to the compatible groups or clans also, and perhaps more typically, seen in this species. Such groups probably are largely composed of grown offspring of the pair. As these help to rear younger siblings, evolution of the behavioral pattern is readily explained. In addition to contributing to the success of their siblings, the learning experiences gained by long association with adults must be of importance to the helpers. This combination of factors presumably has evolved to maximize genetic success of the Red-cockaded Woodpecker in its pineland habitat.

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Table 1. Weight[1] changes in newly hatched Red-cockaded woodpeckers from the hatching of the first egg.

	1st hatched	2nd hatched	3rd hatched	4th hatched
Nest 1 (no helpers)				
Time 0	3.3	3.3	Unhatched	Unhatched
Time 8 hours	4.6	4.0	3.2	Unhatched
Time 26 hours	5.6	4.1	2.5	3.3
Time 47 hours	- [2]	-	Gone	-
Time 49 hours	9.4	6.4		Gone
Nest 2 (one helper)				
Time 0[3]	4.3	4.2	3.3	Unhatched
Time 7 hours	5.3 (killed)	5.2	3.9	Unhatched
Time 33.5 hours		9.0	6.3	2.8
Time 48 hours		9.6	8.1	3.4
Time 73 hours		11.0	12.2	Dead at base of nest tree

1/ (g).

2/ Not weighed.

3/ Two nestlings were apparently a few hours old; time 0 thus indicates 1st weighing

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Table 2. Observations on the development of Red-cockaded Woodpecker Nestlings.

Day 0	Skin bright pink, tarsi and feet white; much loose skin; completely naked, with 10 bumps representing the rectrices. Eyes and ears closed. Mandible about two mm longer than maxilla; diamond-shaped egg tooth on the latter. Heel pad greatly developed. Wings permanently extended, used by small nestlings to attain an upright position; achieved by drawing wings forward anterior to breast.
Day 3	Dots visible where remiges will appear.
Day 4	Tail darkening; feather tracts visible on wings, back and scapulars. Bill also turning dark, except for egg tooth.
Day 5	Feather tracts visible on crown, lower neck, most of spinal, femoral, and ventral tracts. Skin darkening. No longer brooded continuously.
Day 6	Ears open. Bristles of rectrices visible. Maxilla almost as long as mandible. Feet growing rapidly.
Day 7	Crural tract visible. A few feathers beneath wing. Heel pads decreasing in relative size.
Day 8	Skin still darker. Quills of remiges and rectrices protruding from skin. Maxilla and mandibles of about equal length. Feet darkening.
Day 9	Eyes opening. Bill dark except for tip of maxilla. Rectrices exposed for a short distance. Quills of remiges 6 mm. Length of extended toes three and four 34 mm.
Day 10	Feather tracts well developed; feather tips exposed at tail, rump, and slightly on breast and lower abdominal tract. Quills of middle and lesser converts, humeral tract, spinal tract and remiges showing. Feet and tarsi dark; heel pads light, losing knobs and tubercles.
Day 11	Change in call of young to a more adult-like vocalization first noted. Feather tips of spinal, scapulars, anterior ventral and crural tracts showing. Maxilla slightly longer than mandible. Extended length of toes three and four 36-38 mm; second primary 7 mm; first secondary 8 mm; culmen 11-12 mm.
Day 13	Some outer primary quills about 25 mm long; tail 6.5-7.5 mm; longest primary 18-25 mm; culmen, 7-8 mm.
Day 15	Feathers still largely ensheathed; quills of rectrices 16-18 mm, of remiges 22-22 mm.
Day 16	Erupted feathers covering much of body surface. Culmen, 14 mm; extended toes three and four 38 mm; longest primary 27 mm (sheath 20 mm); longest retrix 20 mm (sheath 13 mm).
Day 17	Sheaths of feathers of pileum of male broken away, except for those of red crown patch.
Day 19	Body covered with feathers except for abdomen and flank. Longest primary 45 mm; largest retrix 29 mm. Quills beginning to break away. Young peck at investigator's hand and are otherwise active.
Day 22	Pileum covered with erupted feathers. Sheaths largely broken on rectrices except for central and on remiges. Young may extend head from nest.
Day 26	Wing 95-97 mm; culmen 16 mm (female); tail 53-55 mm.

PROGRESS REPORT ON LIFE HISTORY STUDIES OF THE RED-COCKADED WOODPECKER AT TALL TIMBERS RESEARCH STATION

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INTRODUCTION

The Red-cockaded Woodpecker *(Dendrocopus borealis)* is a locally common bird on Tall Timbers Research Station, located in northern Leon County, Florida, and in the surrounding annually burned, older age class pine woodland of the Tallahassee - Thomasville area. Because it is commonly associated with a fire-type forest, its life history and ecology has been of particular interest to Tall Timbers. In an unpublished manuscript on The Birds of Grady County, Georgia, the late Herbert L. Stoddard, Sr., commented, "Probably no southeastern bird offers richer reward for detailed life history studies, for its peculiarities of habits, requirements and preferences are many." The inclusion of the Red-cockaded Woodpecker on the list of rare and endangered species by the U.S. Fish and Wildlife Service (U.S.D.I., Bureau of Sport Fisheries and Wildlife, Rare and Endangered Fish and Wildlife of the United States Res. Pub. 34, 1968) provided additional incentive to obtain more information on the species as a contribution to its perpetuation.

INDIVIDUAL RED-COCKADED WOODPECKER CAVITY TREES

From the beginning of this study, an attempt was made to mark with permanent numbers, all trees with Red-cockaded Woodpecker cavities on these trees, e.g., species of pine, d.b.h., height, age and other features. Information recorded on the cavities included height, exposure, and in some cases, measurements of the dimensions of the hole and cavity. Comments relative to pitching were also noted. In a later study, other habitat and colony information was collected from these same areas (see Thompson and Baker).

Some of the basic information collected on individual trees is shown in Table 1. Most of the 2800 acres on Tall Timbers Research Station is oldfield land which is seeded mostly to loblolly *(Pinus taeda* L.*)* and shortleaf *(P. echinata* Mill.*)*, with a few scattered longleaf *(P. palustris* Mill.*)* and slash *(P. elliottii* Engelm*)* pines. This land was intermittently taken out of cultivation following the Civil War and the older class of timber is about 85 years of age.

Exposure of Cavities

The compass direction and height of 186 cavities on Tall Timbers Research Station is shown in Figure 1. These data show a strong tendency toward a western and southern exposure. Sixty-nine percent are in a westerly position as opposed to 27 percent in an easterly position. The southwest directional preference may have utilitarian significance. Glazes to the south and west would receive the most heat and the longest duration of the sun's rays favoring a more extensive resin flow. Dennis (Bird Banding 42:79-87, 1971) came to this conclusion after analyzing data gathered in South Carolina. The compass orientation of the cavities within some colonies may vary in all directions, however, when data on a large number of individual trees is analyzed, this directional preference becomes apparent.

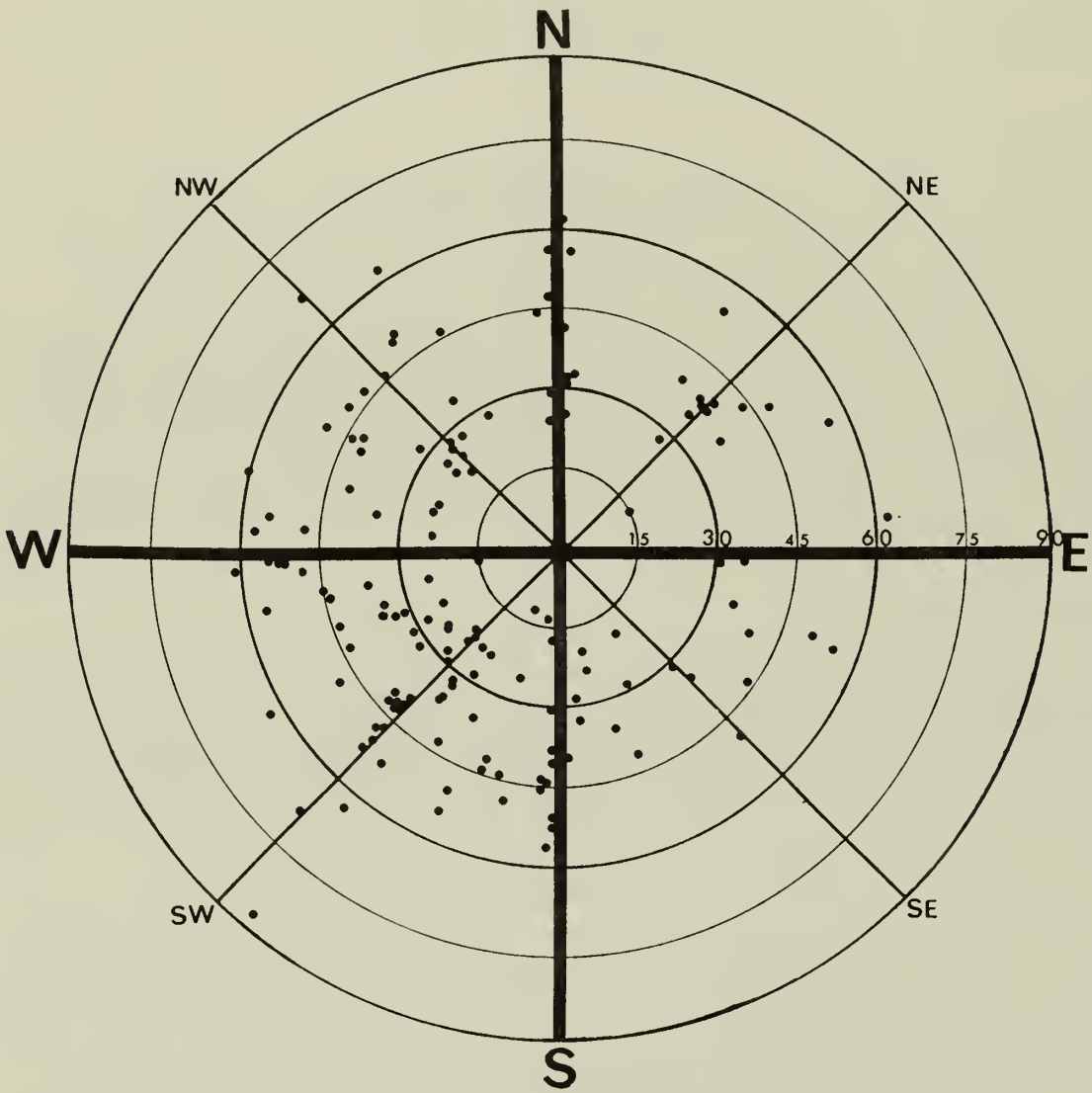
Cavity Excavation

Some cavities in a colony area can usually be found in varying degrees of completion. These are referred to as "start holes" and I have marked a number of them to record chronological development. Most have shown no additional activity. Some that have been completed are described below and where known, the history of the bird that made the hole is given.

Clan A - Tree #34 - This hole was only a few inches deep with very little pitch around it when it was first noticed in January 1969. From early May to the last of July, an adult male, No. 49, spent considerable time pecking at this hole, both in the a.m. and p.m. On several occasions this bird worked continually at the hole for periods of an hour or more. By May 6, the hole extended as far as the heartwood, and by July 6, the hole was slanted far enough downward so that the bird stayed inside pecking. The loose chips were removed by backing out of the hole and shaking the bill containing the debris. This hole was completed enough for roosting on July 10 when the bird stayed in for the night, after working until roost time. The same male was still excavating on July 31.

By May of 1970, however, this was the roost cavity of another adult male, No. 48, and it became a nest cavity in 1970. So the first season after

Figure 1. Compass direction and height of 186 Red-cockaded Woodpecker cavities on Tall Timbers Research Station, Leon County, Florida



completion, it was taken over for nesting by a parent male which had not previously been seen excavating the hole.

Clan A - Tree #96 - This start hole was first noticed in July 1969. In July 1970, it was being actively worked mainly by the same male, No. 49, that completed hole No. 34 above. On July 1, a young male was briefly pecking on it, and on July 9, adult male No. 50 was working it. On July 9, male No. 49 stayed away from the main clan on several occasions during the day to excavate this hole. By July 14, one year later, it extended two more inches for a total of 6-1/4 inches straight in. On July 22 and 23 and October 6, 1970, No. 49 was still pecking on this hole. By October, the hole was proceeding downwards.

Clan A - Tree #4 - Tree No. 4 has a cavity which was used for nesting during 1968 and 1969. This cavity entrance is 40 feet high and faces northwest. The start hole is 27 feet high and has a southeastern exposure. This start hole was being actively worked in June and July 1969. In July 1970, there was another period of active work on this start hole. This time it was adult female, No. 58, doing the excavating. On several occasions, the young male and female in association with the adult female pecked for short periods. Male No. 50 and an unmarked bird were also observed excavating this hole.

Clan M - Tree #92 - In May 1969, a Red-cockaded Woodpecker was often seen working on this start hole. By August 12, 1969, the hole was into the redheart (7 inches) and beginning to start up and down. No noticeable amount of work has been completed since this time.

Clan K - Tree #152 - This tree had a small fresh-looking start hole in it June 1970 and by April 1971, it was completed and well glazed. In June 1971, a year after the hole was started, it became the nest cavity.

In summary, start holes are often started and temporarily discontinued. In other cases, the hole is started and worked on until completed for a roost and/or nest cavity. The shortest time I have observed is 10-11 months.

Nest Trees - Yearly Utilization

The terms "nest" and "roost cavity" have often been used interchangeably in the literature. This often leads to confusion because during a nesting season one of the roost cavities will become the nest cavity.

From the beginning of my studies, I was interested in yearly and seasonal fluctuation in utilization of Red-cockaded Woodpecker cavities. I marked all the trees and recorded height and exposure of cavities to be certain of the same cavities from year to year. The 1970 nesting season was the fourth year for some of the known nest cavities (see Table No. 2). Of

the three known nest cavities in 1967, one was used consecutively for 4 years, one for 3, one for 1 year.

Utilization of nest cavities by other species is a complicated and interesting phenomena. Between nesting seasons, even when the same cavity is used again as a nest by Red-cockaded Woodpeckers, other species will utilize these cavities at times for roosting. In 1970, I documented utilization of the Red-cockaded Woodpecker's nest cavity, after the young Red-cockaded Woodpeckers had fledged, by other species during the same season for a nest site. In one case, they fledged on June 3 and by July 2, a Red-bellied Woodpecker *(Centurus carolinus)* was feeding young in the same cavity. In another case, the Red-cockaded Woodpeckers fledged at the end of May, and a Red-headed Woodpecker *(Melanerpes erythrocephalus)* was nesting in the same cavity at the end of June. Even though other species nest in Red-cockaded Woodpecker cavities, the Red-cockaded Woodpecker will reoccupy them when vacant again, at least to roost.

UTILIZATION OF RED-COCKADED CAVITIES BY OTHER SPECIES

Unenlarged or not noticeably enlarged Red-cockaded Woodpecker cavities have been utilized by Red-bellied and Red-headed Woodpeckers, White-breasted Nuthatch *(Sitta carolinensis)*, Tufted Titmouse *(Parus bicolor)*, Bluebird *(Sialia sialis)*, and Flying Squirrel *(Glaucomys volans)*. Those species utilizing enlarged holes were Red-bellied and Red-headed Woodpeckers Flicker *(Colaptes auratus)*, Pileated Woodpecker *(Dryocopus pileatus)*, Tufted Titmouse, Crested Flycatcher *(Myiarchus crinitus)*, Screech Owl *(Otus asio)*, Wood Duck *(Aix sponsa)*, Fox Squirrel *(Sciurus niger)*, Gray Rat Snake *(Elaphe obsoleta spiloides)*, and Honey Bee *(Apis mellifera)*. All these species were known to nest in these cavities except the Pileated Woodpecker and Flicker, which were only known to use the cavities as roosts.

The older cavities that become "dry faced" and no longer flow pitch are not used as nest cavities by the Red-cockaded Woodpecker. The bird will, however, roost in old and enlarged cavities.

Ecologically then, the activities of the Red-cockaded Woodpecker makes the older age class pine forest available for other cavity nesting birds and other vertebrates. In a forest with a history of frequent fires and few hardwood trees, cavities are at a minimum. Other species of woodpeckers and birds do not have the ability to make cavities in sound, live wood and must utilize dead trees, limbs or knot holes for cavity excavation.

Roosting Behavior

Evening - As a rule, the evening roosting and morning departure times are earlier and later respectively than most of the other birds in the area. Often towards roosting time, they are still searching trees near their roost cavities and pecking and pitching up around their cavities. When the time comes, they all go to roost together, often giving a few "szrek" notes as they go. At other times, they are away from the colony and will fly directly to the roost trees and go in.

Naturally, inter or intraspecific friction (or an observer's presence) will cause delayed roosting times. Generally speaking, if an observer is quiet and not too close to the roost tree, there is little effect on the Red-cockaded Woodpecker's behavior; however, some individuals are particularly wary. The male at tree No. 90 would always act nervous at roost time, even though I have spent a lot of time in this area and sat twice as far away as I would have for other colonies.

On several occasions, I stationed people on the same evening at different colonies on Tall Timbers to see if on a given day the birds all tended to roost at the same time. There was just as much variation in roosting times between clans as within individuals of a clan or variation of the clan over several nights span.

I have verbal reports of observers seeing two Red-cockaded Woodpeckers roosting in the same cavity. I have not seen this and do not think it is common. Often a bird will come back out again or there will be an exchange of birds at the cavity.

The general pattern year round even when rearing young, is to go to roost 20-30 minutes before sunset. I have not observed a bird go to roost after sunset, even particularly wary individuals have always roosted by sunset. Under unfavorable weather conditions, the birds will roost earlier than normal and even for short durations during the daytime.

On July 8, 1970, as thunder was getting closer and the sky darker, the Red-cockaded Woodpeckers went to roost hurriedly at least one-half hour earlier than normal.

Morning - Generally Red-cockaded Woodpeckers leave their roost cavities 5 or 10 minutes before sunrise, occasionally 5 or 10 minutes after. During inclement weather, they will stay in later. On November 13, 1969, it was sprinkling and thundering at daybreak, and they stayed in their cavities one-half hour after they normally leave, although other species of birds were already active.

On July 22, 1970, two different areas were watched at daybreak to ascertain the effects of inclement weather on the Red-cockaded Woodpecker's behavior. During the early daylight hours, there was thunder, heavy rain and high winds, all the effects of tropical storm Becky in the Gulf of Mexico. Normally at this date, they would leave the roost at approximately 06.55 E.D.S.T. At one area, one came out at 08:07, over an hour late, during a heavy wind-driven rain. At Clan A, male No. 49 finally came out of his roost cavity at 09:55 (3 hours late) and the other Red-cockaded Woodpeckers followed. Within ten minutes, they were in the cornfield searching for corn earworms *(Heliothis zea)*. In this case, the birds came out of their cavities after the first main break in the rain. It rained off and on the rest of the day, but they went about feeding or perched on the side of a tree when the rain intensified. They roosted in the evening at a normal time (20:00).

Non-Cavity Roosts

Often there are more Red-cockaded Woodpeckers in a clan than there are cavities in the colony. This may be due to too few cavities, or to some other species occupying some of the cavities. Sometimes individuals roost outside, even when cavities are available.

The two types of places other than cavities where I have seen Red-cockaded Woodpeckers roost are crevices or between forks of a tree and in the canopy of a pine. Roosts in the canopy are usually at the base of a limb or where there is a slight indentation or some overhanging structure to give some protection. Both adults and young use these types of roosts.

A forked tree was a regular roosting place in April and July 1969. From late June through July 1970, the parent female roosted here regularly. On two occasions, it roosted on the same fork but the opposite side, once was during rain and the northeast side offered better protection. This female defended roost cavity No. 35 (where she was caught), but didn't roost in it during observations in July.

One regular canopy roost was utilized throughout April 1969. This roost tree was a mature loblolly pine out in the open. The bird regularly roosted in the same place which was approximately 80 feet from the ground. The bird blended in well and was partly under a limb, on the southwest side of the tree. During July, the bird roosted there during rainy nights also. The canopy type roosts always tend to be high in the larger pines.

Behavior During a Solar Eclipse

The Tallahassee, Florida, area was predicted to be in 98 percent total darkness shortly after mid-day March 7, 1970. Observations were made of Clan A to determine if the birds would go to roost during the short

period of totality. I arrived 30 minutes before the onset of totality which was scheduled for 13:17. The sky was completely overcast on arrival. No Red-cockaded Woodpeckers were heard or seen until suddenly at 13:19, at least four birds appeared, flying directly to their roost cavities. They stayed in as the eclipse began to wane and came out at 13:27. The behavior on emerging was similar to morning awakening behavior, e.g., pecking, preening, etc. After several minutes of this behavior, they flew back in the direction from which they came.

I noticed other birds such as Myrtle Warbler *(Dendroica coronata)*, Blue Jay *(Cyanocitta cristata)*, Red-winged Blackbird *(Agelaius phoeniceus)* Common Grackle *(Quiscalus quiscula)* quieting down and giving evening calls but not actually going to roost. The Blackbirds were flocking together as if getting ready to go to the evening's roost.

LIFE HISTORY NOTES

Eggs, Incubation and Nesting Time Period - Because of Ligon's work and the nest cavity heights involved in our area (av. 40/ ft.), I gathered very little data on eggs, clutch size and incubation. Nest No. 52 had four eggs, three of which hatched between 15:45 on May 19 and 16:50 on May 20, 1970. Two young (1 male, 1 female) left this nest on June 13-14. This would have been from 26-27 days from hatching to fledging which is the same as Ligon (Auk, 87:255-278, 1970) found. In the Tallahassee region during 1967-1970, Red-cockaded Woodpeckers finish nesting from the third week of May through about the first week of June. I had one record of late fledging in early July.

Copulation - Copulation or pseudocopulation has been observed only a few times. On one occasion at 20:07 on May 29, 1969, the pair copulated, dropped off the limb for 10 feet and then landed separately on the same tree. This was in the clan that had a late nest in 1969 - young fledged approximately July 8.

One other observation was made at 19:55 on June 8, 1969. In this case both birds were giving an "excited note" and flew to the same tree, went out on a short dead limb, copulated and the female flew directly to roost cavity No. 25, bobbed a few times, and went to roost. There was some friction in the area with an intruding Red-headed Woodpecker which might have triggered the excited notes and also the act of copulation. This clan also either had no young, was late, or had been disrupted.

Nest Sanitation - Nest sanitation is practiced off and on during the day. Usually the bird disappears before it is noticed where the material is dropped. At one observation, the fecal sac was dropped approximately 200 feet from the nest tree. In the two all-day watches of two different nests, nest sanitation was only carried out by the male that roosts in the nest cavity.

Feeding and Care of Nestlings - Numerous observations were made in 1967 and 1968 on rate of feeding; however, in most of these cases the number of helpers and the sex of the individuals were not known. I will describe in some detail two situations of feeding young during an all-day watch, with marked birds. One is a nest where two young fledged and there were no helpers (one pair). The other is a nest where three young fledged and there were two helpers (four adult birds).

Nest No. 52 - On June 10, 1970, male No. 65 went to roost at 20:26, with young approximately 21 days old. On June 11, this nest was watched all day. Five minutes after female No. 68 was out of her roost cavity, male No. 65 came out (06:31) of nest cavity No. 52. They came together, and the female went briefly to the hole, peered in, but didn't feed young, which were pecking at her feet. The first feeding took place at 06:56 by the female. The total number of visits per hour is shown in Figure 2. It was assumed that during most of these visits feeding took place. The male took care of the nest sanitation and visited the nest three times as often as the female. There were major gaps in time when the female did not visit the nest; from 07:55-13:35 and 18:02 to roost time (20:26). During much of this first break period, the female was chasing a Red-cockaded Woodpecker intruder. This bird was not a helper (never fed young), but did peer briefly in the cavity once. Just to the east and north of the nest tree there seemed to be a territorial line. During observations on several different days, it was noticed that major Red-cockaded Woodpecker conflicts occurred here. There is a colony to the north and to the west of this nest tree. The pair for this nest cavity also seemed to do all their feeding and searching to the east and south.

There are periods during the day when there are numerous visits (see Figure 2) and feeding of young by adults and other periods of no visits which are more than the figure would indicate when the information is arranged by the hour. There was a gap with no feeding from 09:06-10:40. There was one visit at 09:56 but no feeding. Another long gap was from 17:01-18:22 (1 hour 22 min.). The male went to roost at 20:26, almost 14 hours after leaving at daylight.

Nest No. 34 - On May 26, 1970, an all-day watch was made of Nest No. 34 in Clan A. This clan had three males, one female, and occasionally an unmarked individual, and young at least 22 days old. The parent male (No. 48) left the nest cavity at 06:24. The first bird back to the nest was male No. 50 at 07:05. Figure 3 summarizes the data on number of visits to the nest cavity per hour. As in tree No. 52, discussed previously, the male parent is the one that takes care of nest sanitation. The interesting thing here is that two male helpers visited and fed the young more than the parent male. The female never came to the nest. There were no large gaps in feedings as there was in the female visits of Nest 52.

Figure 2.--Number of visits per hour to nestlings in cavity No. 52, June 10, 1970, Tall Timbers Research Station, Leon County, Florida. The number of visits for a given time includes all visits for that time and the following hour; e.g., 6:30 = all visits from 6:30-7:29.

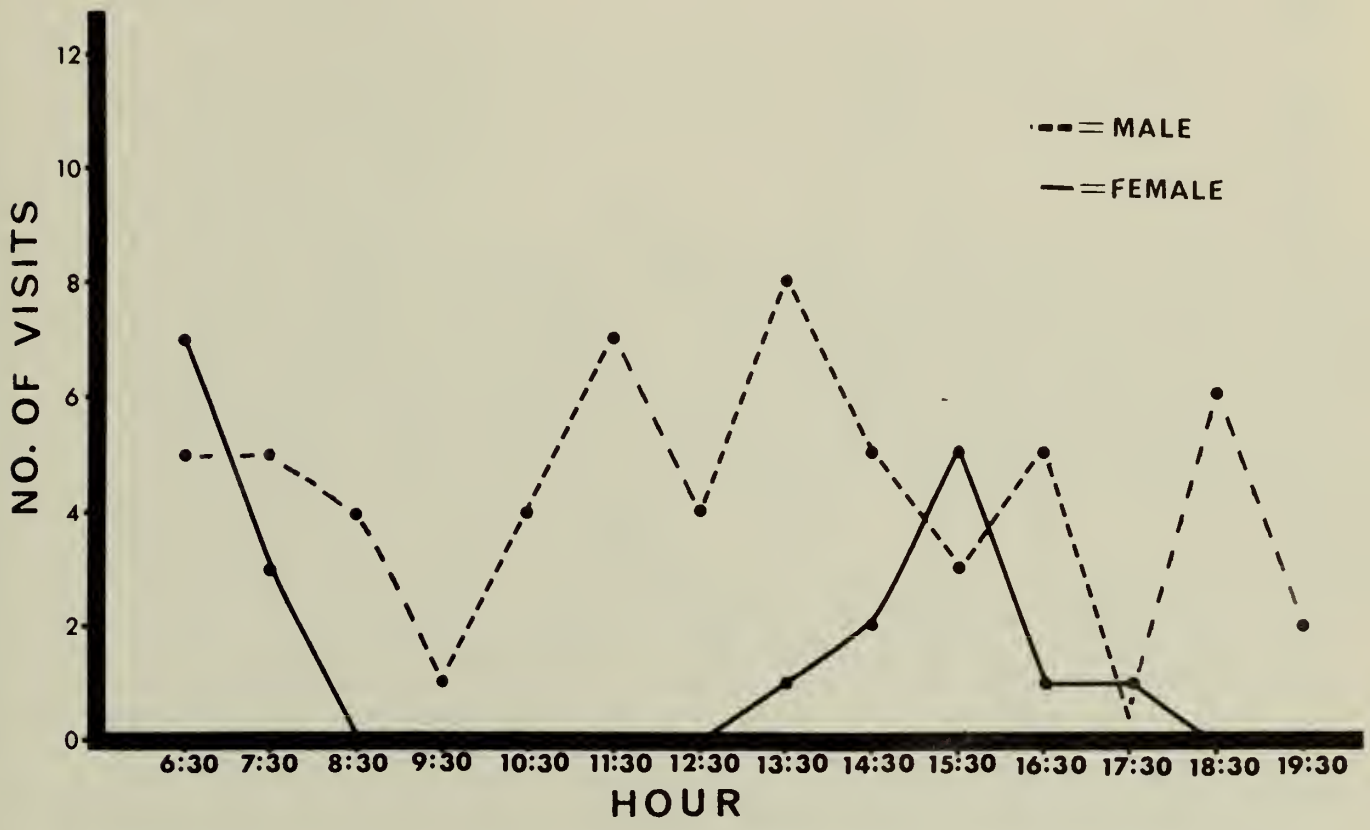
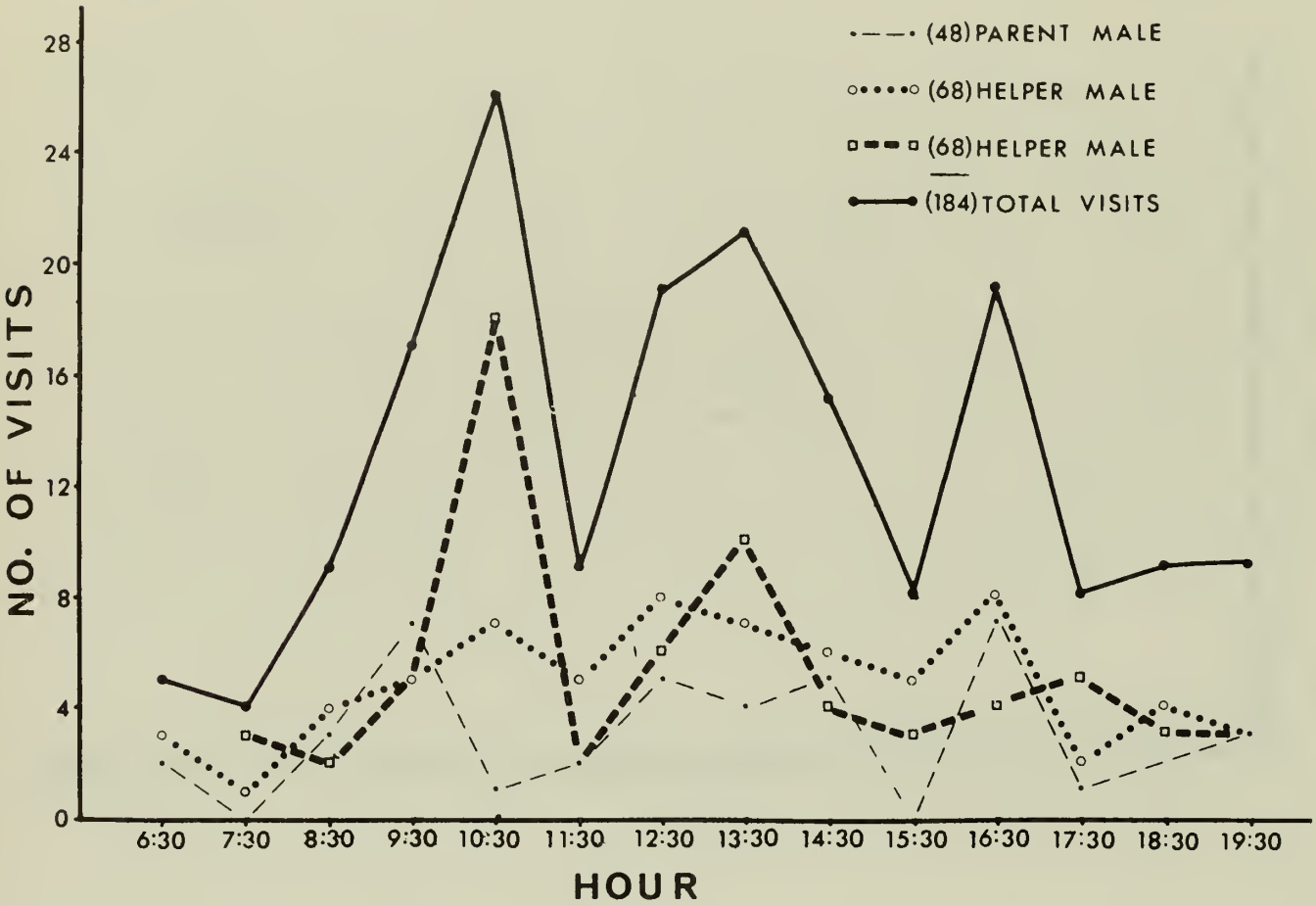


Figure 3.--Number of visits per hour to nestlings in cavity No. 34, May 26, 1970, Tall Timbers Research Station, Leon County, Florida. The number of visits for a given time includes all visits for that time and the following hour; e.g., 6:30 = all visits from 6:30-7:29.



The over-all trend was less feeding for the first and last three hours and heavy feeding through the middle of the day. Nest sanitation was carried out throughout the day with a concentrated effort from 12:30-15:30. The longest periods away from the nest was 1 hour 53 minutes for the parent male and 55 and 57 minutes for the two male helpers. Off and on all day, all three males were doing a lot of fussing and chasing of an unmarked bird. This unmarked bird never came near the nest.

The nestlings chattered almost constantly throughout the day. The longest period that they were quiet was for 21 minutes starting at 16:13.

Helpers at the Nest

As was shown in the section on feeding nestlings at tree No. 34, this clan had two helpers. Of the clans I have watched at Tall Timbers, helpers seem to be the rule rather than the exception. Nest No. 52, mentioned earlier, and a single tree nest No. 90, represented two of eleven nests watched where no helpers were observed. The absence of helpers might be an indication of the start of a new colony. The colonies having an abundance of roost cavities always had helpers; however, one colony with only the one cavity tree (the nest) and possibly one other roost cavity which was not close by, had a helper.

During the nesting season, you can often see more than two birds in the vicinity of the nest tree, but this does not mean they are helpers as shown previously in Clans A and E. Clan A regularly had five adults in the area but only two helpers. Without marked birds and sometimes even then, observations cannot be too dependable. The "intruder" at nest No. 52 peered in the hole when the parents were off and even if this bird had been marked, one could have thought it to be a helper if there were interrupted periods of observation. Clan L had six adults roosting in the area and on several occasions five were in the vicinity of the nest with no apparent friction.

Nest No. 34 fledged three birds in 1970. When I attempted to capture them on the morning of May 27, there was only one nestling female left in the nest. In the following days this female, and the unmarked male and female fledglings were seen with and being fed by the same adults. In this case, the two helpers could have made the difference between successful fledging of one, two, or all three young.

The two helpers (No. 49 and No. 50) at nest No. 34 had definite brood patches both in 1969 and 1970. During the all-day watch of this nest, neither of these helpers entered the nest; however, they were just as active as the parents in nest defense and chasing away the "intruder" Red-cockaded Woodpecker.

Territory

To determine the extent of daily movements, marked individuals in Clan A were followed throughout the day on July 1, 9, and 22 and September 23, 1970. Birds of this clan were followed on other occasions for shorter time periods. This clan consisted of 3 adult males, 1 adult female, 1 unmarked adult, 3 young [2 female (one marked) and 1 male]. At times throughout the day, the clan was together and at other times they were scattered or in two groups. Sometimes during the day, one or two individuals would leave the others and go back to the colony and work on new holes, pitching up trees, etc.

The maximum area that birds of this colony utilized is shown in Figure 4. This represents approximately 162 acres. The maximum distance these birds were seen from the colony trees was approximately 2640 feet. On any one day, maybe only one third of this area would be utilized. Some of this area is covered each day, but concentration of searching can be in different directions on different days. July 1 movement was associated with corn on the north side of the highway. By July 9, more time was spent on corn closer to the colony. On July 22, there was a hard rain which lasted intermittently all day. The birds did not leave the roost until 10:00 and went directly to the corn. By September 23, there was no corn and the birds roamed the pine woods.

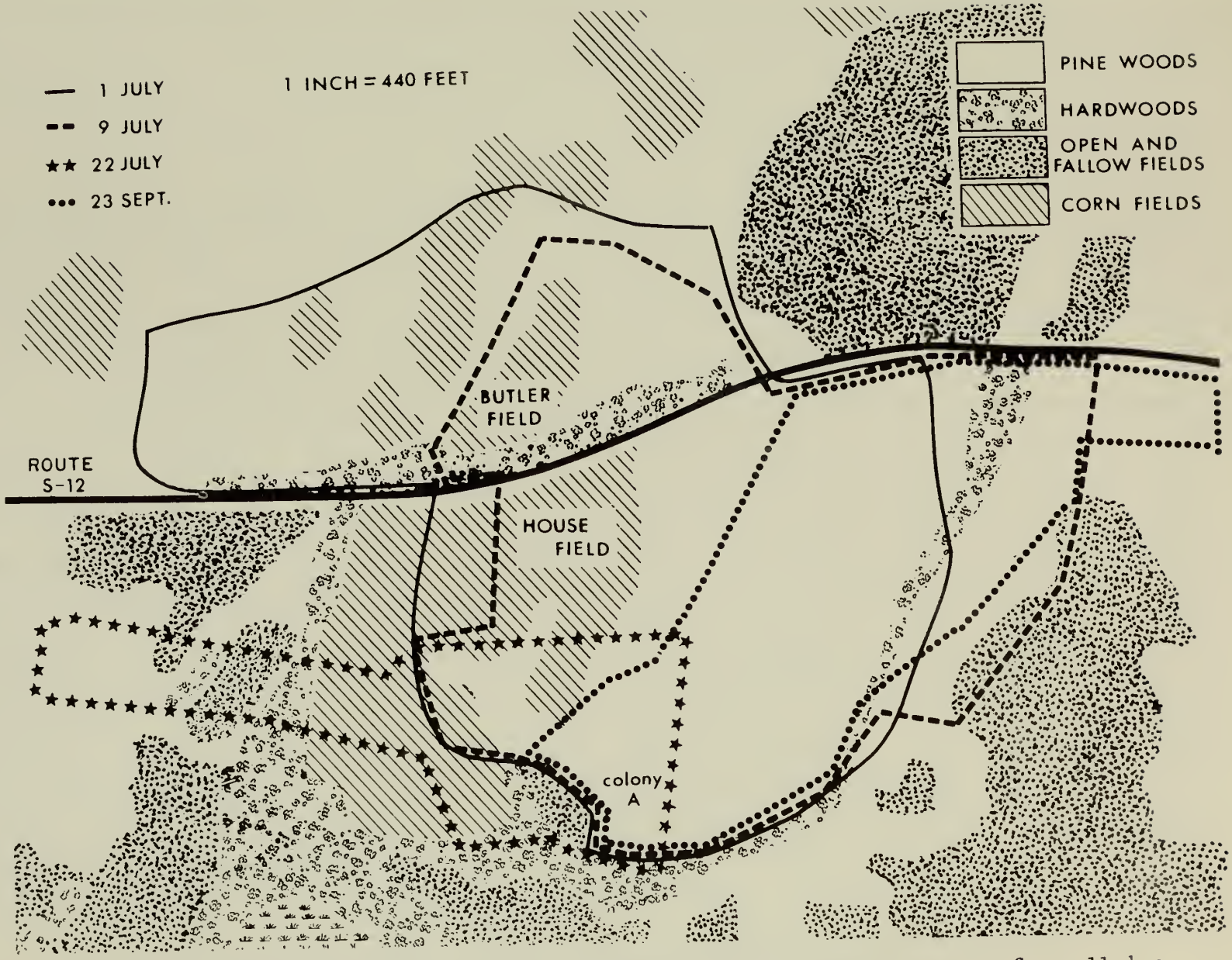


Figure 4.--Maximum area utilized by Red-cockaded Woodpeckers of Clan A on four all-day watches during July and September of 1970. Tall Timbers Research Station, Leon County, Florida

Table 1. Average d.b.h., height and age by pine species of Red-cockaded Woodpecker cavity trees on Tall Timbers Research Station, Leon County, Florida, 1969

Pine Species	D.B.H. (in.) Av.	D.B.H. (in.) Range	Ht. (ft.) Av.	Ht. (ft.) Range	Cavity ht. (ft.) Av.	Cavity ht. (ft.) Range	Age* (years) Av.	Age* (years) Range
Loblolly	20.4(107)	10.3 32.7	100(102)	69 127	44(141)	12 87	83(85)	59 107
Shortleaf	19.6(30)	13.9 27.8	90(30)	66 122	46(37)	15 62	92(24)	68 167
Longleaf	17.9(9)	11.5 23.0	92(10)	63 105	32(17)	15 42	87(11)	72 103
Slash	16.9(1)	--	96(1)	--	48(1)	--	76(1)	--
All Species	18.7(147)	--	95(143)	--	42(196)	--	85(121)	--

( ) = no. trees

* = 5 yrs. were added to each core reading

Table 2.--Number of years the same site was utilized as a Red-cockaded Woodpecker nest cavity, Tall Timbers Research Station, Leon County, Florida.

Clan No.	Tree No.	Year Used As Nest				No. of years consecutively used
		1967	1968	1969	1970	
A	2	x				1
	4		x	x		2
	34				x	1
B	36			x	x	2
C	90			x	x	2
D	21		x	x	x	3
E	52				x	1
F	32		?	?		
	91			?	x	1 / (?)
G	28		x	x		2
	109				x	1
H	23		x	?	x	2 / (?)
J	132				x	1
K	19		x			1
	15			x	?	1 / (?)
L	10	x	x	x		3
	12				x	1
M	6	x	x	x	x	4
No. Known nest/year		3	7 / (?)	8 / (?)	11 / (?)	

HOME RANGE CHARACTERISTICS OF THE RED-COCKADED WOODPECKER IN NORTH-CENTRAL FLORIDA

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The Red-cockaded Woodpecker *(Dendrocopus borealis* [Vieillot]) is a permanent resident in Florida and was reported as a common bird in the Gainesville area by both Chapman (1888) and Baynard (1913). Austin (1967) applies the term "not uncommon" to the present status of the species in Alachua County.

Until recently, little work has been done on this woodpecker. Beal (1911) examined the food habits of the species, and Murphey (1939) drew together what was known of its life history in the first third of this century. Grimes (1947) and Steirly (1957) published their observations on the species in Florida and Virginia respectively. Recently, Ligon (1970) published an account of the breeding biology of this woodpecker based on field work done in the Gainesville area. During the past few years, a great deal of interest in the species has been stimulated by its inclusion on the endangered species list (U.S.D.I., 1968).

The present study was conducted between February 5, 1970, and November 6, 1970, in Alachua, Baker, and Columbia counties, Florida. This study was undertaken to define some of the home range characteristics of the Red-cockaded Woodpecker. The objectives of the study were: to determine how large an area is required by a nesting pair of Red-cockaded Woodpeckers; and to determine the stand density and ground cover characteristics of areas inhabited by Red-cockaded Woodpeckers. I believe such information is basic to the formulation of sound land management practices to aid the species.

STUDY AREAS

Ten study sites were located in north-central Florida. Three of these areas were located in Alachua County in close proximity to Gainesville. Osceola National Forest, in Baker and Columbia counties, was the final study area and furnished a total of seven study sites.

Morningside Park

This area is a city park on the east edge of Gainesville on State Road 26. It is composed of two main vegetation types: Longleaf Pine-Turkey Oak-Sandhills and Longleaf Pine-Flatwoods. Several Cypress Domes are located within the flatwoods portion of the park.

One breeding pair of Red-cockaded Woodpeckers occurs in the park utilizing two active trees containing a total of three Red-cockaded Woodpecker cavities. These trees are located in the pine flatwoods to the west of the park road.

Sunland Training Center

This area is located on State-owned property east of Gainesville along secondary road 232 (S-232) about one mile east of State Road 24. Longleaf Pine-Flatwoods characterize the principal cover type on the Sunland study area. Limited areas of low-lying, mixed hardwoods and cypress are also present.

Five Red-cockaded Woodpecker cavity trees were located in the pine woods to the north of S-232. One of these was an active nest tree which produced two fledglings. A sixth tree, an active roost tree in the spring but later abandoned, was located in a grove of longleaf pine *(Pinus palustris)* in the edge of a pasture to the south of S-232.

Austin Cary Memorial Forest

Austin Cary Forest is situated 12 miles northeast of Gainesville on State Road 24. One active nest was located in a stand of thinned longleaf pine on the edge of an open wildlife food plot near Lake Mize in the southern part of the Forest. This nest produced one young. The vegetation in the area was low Longleaf Pine-Flatwoods interspersed with Cypress Domes.

Osceola National Forest

Located in eastern Columbia County and western Baker County, much of Osceola National Forest is second-growth Longleaf Pine-Flatwoods interspersed with Cypress Domes. This vegetative association was predominant on all sites used in this study.

A total of 13 Red-cockaded Woodpecker trees were located in the Forest; eight of these were active roost or nest trees and were used in the vegetative analysis portion of my study.

METHODS AND RESULTS

In the interest of clarity, I shall present the methods and results in two parts. The first of these parts will be concerned with the measurement of home range size, the second with the vegetative analysis of the supporting timber stand.

Measurement of Home Range Size

This portion of the study was carried out to obtain an estimate of the size of the area required by a pair of nesting Red-cockaded Woodpeckers. The information obtained was later employed in designing the sampling procedure used in the support stand analysis.

Two areas near Gainesville were used in the measurement of home range size: Sunland and Austin Cary. The study began March 23, 1970, before nesting commenced and continued until after the young had fledged at both sites (June 24, 1970).

To facilitate rapid determination of the bird's location, the nest tree served as the center of a circle with a radius of 1,000 feet. From this center, lines of wooden stakes were set at 100-foot intervals to a distance of 1,000 feet in each of eight compass directions: N, NE, E, SE, S, SW, W, and NW. These stakes were 3 to 3.5 feet tall and were topped with a streamer of plastic surveyor's flagging. The direction and distance were marked on each stake.

The birds were followed for two to five hours at a time. Each area was visited alternately at least three times a week. Each time the bird or birds being watched flew to a new location, the time, direction (to 16 compass points), and distance (to the nearest 25 feet) were noted. Locations beyond the 1,000-foot stakes were marked and the direction and distance were obtained by compass and pacing.

Extreme distances in each of the 16 directions were plotted on circular graph paper and connected in such a manner as to form polygons. The area of each polygon was calculated to the nearest tenth of an acre.

Table 1 presents the extreme distances at which an individual was observed on each of the two areas. The maximum distance observed at Austin Cary was 1,500 feet, at Sunland it was 1,475 feet.

The area used by the pair at Austin Cary is illustrated in Figure 1. This area enclosed approximately 35.5 acres. The Sunland area (Figure 2) was about 49.3 acres in size. The average of the two areas was 42.4 acres.

Support Stand Analysis

This portion of the study was undertaken to determine the gross characteristics of timber stands actually used by Red-cockaded Woodpeckers. The characteristics examined were stand density and ground cover. Measurements were taken only on areas surrounding trees believed to be active. Criteria for determining nest tree use were: 1) young known to be in the nest; 2) adult birds seen and/or heard in the immediate vicinity of the tree on one or more occasions; and 3) fresh resin flow around the

Figure 1.--Area used by a pair of nesting Red-cockaded Woodpeckers on Austin Cary Memorial Forest. Area = approximately 35.5 acres.

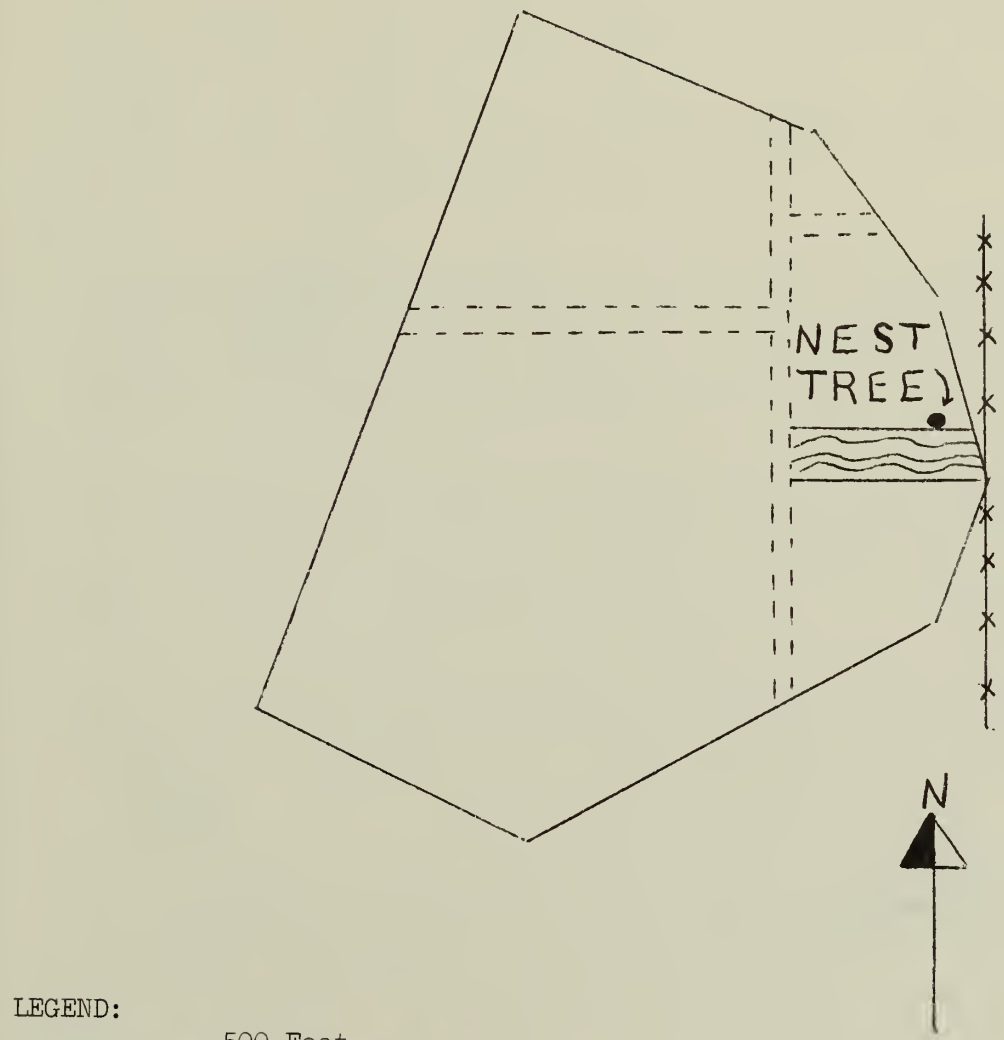
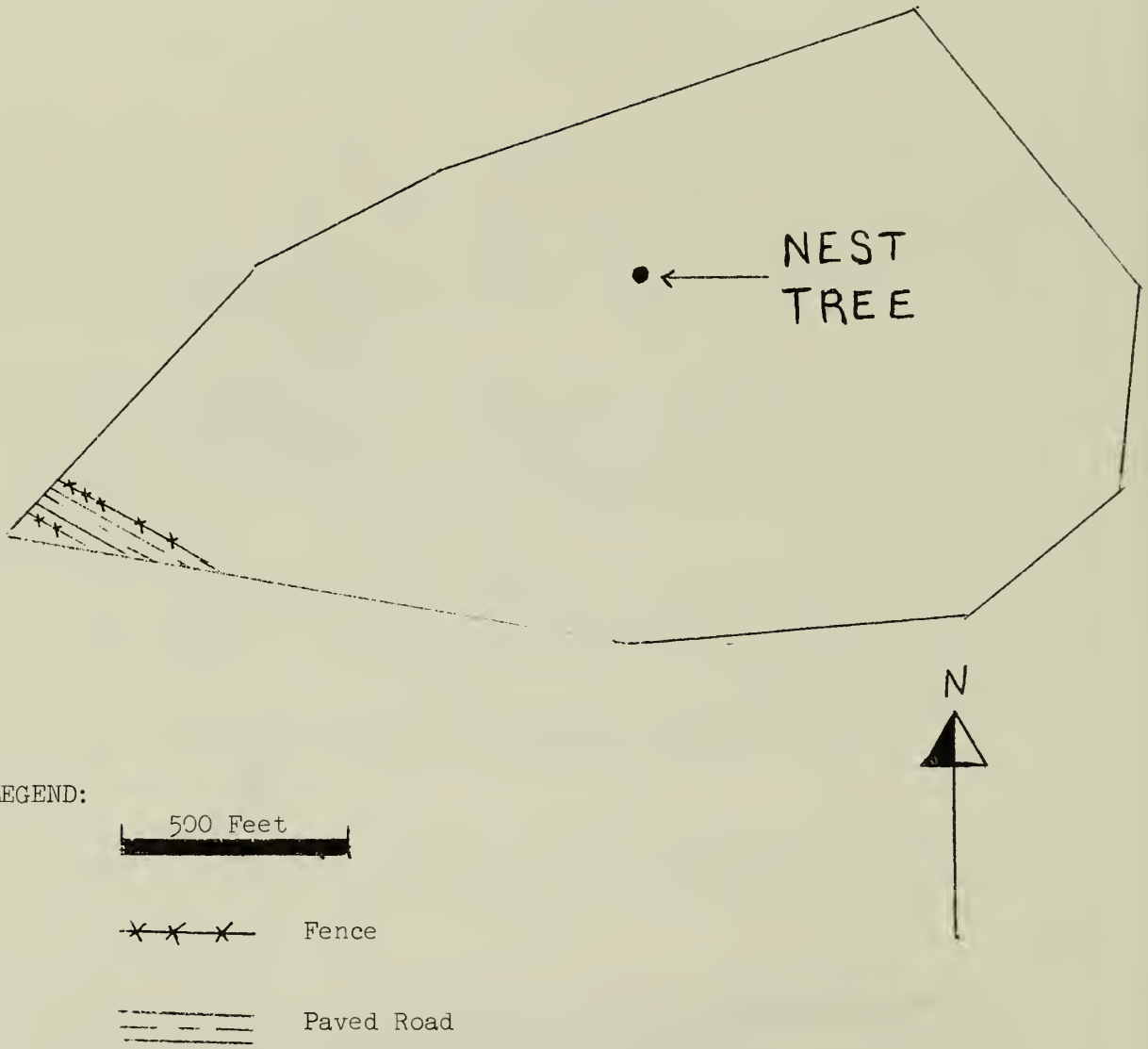


Figure 2.--Area used by a pair of nesting Red-cockaded Woodpeckers on the Sunland study area. Area = approximately 49.3 acres.



cavity and on the trunk, and feathers usually found on the pitch at the cavity entrance.

Ten circular study areas with an area of 42.4 acres (radius 767 feet) were used in this study. The center of each area was an active roost or nest tree. A maximum of 15 sample plots was taken on each area (see Figure 3). The nest tree served as the center of sample plot number one. From a table of random numbers, two 2-digit numbers were chosen. The first of these (06) provided an angle to the east of north, the second number (59) was added to 200 to provide a distance. (The addition was made to avoid having plots one and two overlap.) Thus, plot number two on each study area was located 259 feet from the nest tree at an angle of N6°E. The remaining sample plots were located at 350-foot intervals on north-south and east-west axes.

Although a maximum of 15 plots was possible, when the plot center was located in a habitat of a type not utilized by Red-cockaded Woodpeckers, e.g., pastureland, Cypress Domes, or hardwood timber, a plot was not taken. This resulted in the number of plots actually taken on the sample areas ranging from 9 to 14 plots per area. All calculations were based on the number of plots actually taken.

The variable plot cruising method described by Grosenbaugh (1952) was employed using a prism with a basal area factor of ten. Measurements of stand density were expressed as basal area (square feet of stem per acre) and then converted to stems per acre by measurement of the tally trees and the use of a standard frequency table.

No precise measurements were made of the understory. At each sample plot, notes were made on the common understory species, the relative density (open or dense), and the approximate average height of the ground cover around the plot center. Height was given as low (less than three feet), intermediate (three to five feet), and high (over five feet).

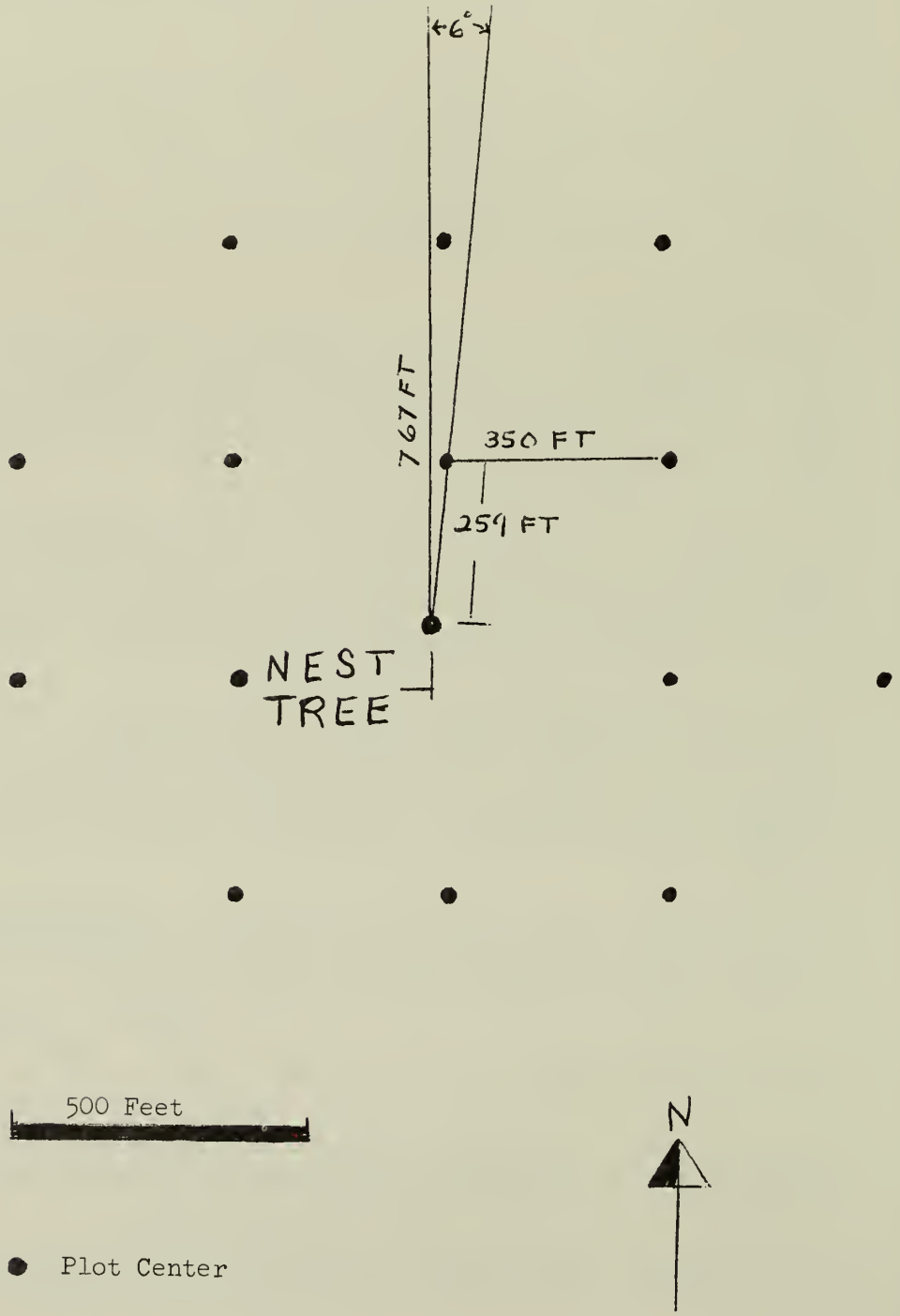
Table 2 summarizes the results of the support stand analysis. These were compared by Tukey's Procedure (Snedecor and Cochran, 1967). Using this procedure, no significant difference was found ($P = .05$) between the basal areas obtained on the ten study areas ($F = 1.91$).

The stand density of the various areas, however, showed significant variation ($F = 2.08$).

The ground cover was recorded as less than three feet in height on 80 of the 109 sample plots taken. It was over five feet on 21 plots, and of intermediate height on the remaining eight plots.

By far the most common understory species was the saw palmetto *(Serenoa repens)* which was recorded on 102 of the plots. Gallberry *(Ilex glabra)*

Figure 3.--The location of sample plot centers for the support stand analysis. The nest tree served as the center of sample plot number one.



occurred on 71 plots, wiregrass *(Aristida* sp.*)* on 48 plots, and wax myrtle *(Myrica cerifera)* on 40 plots.

A total of 21 understory species was recorded. The occurrence of these species is reported in Table 3.

DISCUSSION

The characteristics and functions of territories have been much discussed since the publication of Howard's (1920) *Territory in Bird Life*. A territory is generally considered to be an area defended against other individuals of the same species. Ligon (1970) found the Red-cockaded Woodpecker to be a territorial species but did not determine the size of the territories used by the pairs he observed. He does state, however, that they were always large, and that territorial boundaries were imposed by habitat limitations and adjacent groups of woodpeckers.

The only estimates of territorial size in the Red-cockaded Woodpecker presently available are those of Lay and Russell (1970) who present a minimum estimate of 25 acres per colony. That this value differs from the 42.4 acres obtained in the present study is not surprising. Lay and Russell based their estimate on the minimal distances between colonies rather than on actual observation of the birds' movements. It is important to note, also, that on the two areas they studied the average acres per colony (167 and 66) was actually much higher than their minimal estimate.

It is possible that a pair of Red-cockaded Woodpeckers does not require as large an area as was calculated in my study, i.e., 42.4 acres. There are several reasons for this. The most obvious of these is the small sample size employed in this study. Another is the fact that no other Red-cockaded Woodpeckers were in the vicinity, thus the only limits on the size of the area used by each pair were those imposed by habitat boundaries. It is desirable, then, that further studies be conducted on the territoriality of this species. Such studies should employ a larger number of breeding pairs than were used in this study and should be conducted in an area with a sufficient number of breeding pairs to reveal any limiting effects of neighboring birds.

RECOMMENDATIONS

At present, the protective measures being undertaken by Federal and State agencies include saving trees diseased with redheart in areas where Red-cockaded Woodpeckers are known to occur and in leaving mature pines in open stands as potential nest trees (U.S.D.I., 1968). While the nest tree is an important part of Red-cockaded Woodpecker biology, this study suggests that a sizable tract of timber should be left intact surrounding the nest tree. As reported here, a pair of Red-cockaded Woodpeckers may require as much as 40 to 45 acres of timber. Lay and Russell (1970) estimated a minimum of 25 acres is needed per colony. As I have just indicated,

the discrepancy in these figures illustrates the need for further work along these lines; both figures, however, indicate the species requires a rather large area of mature timber. Further information on the territorial requirements of the Red-cockaded Woodpecker is necessary for the development of sound management practices for the preservation of the species. Such information will make it possible to leave uncut an adequate amount of timber around a known nest tree to insure the continued use of the area.

Having determined how large an area must be left for the Red-cockaded Woodpecker, any management plan for the species must consider certain other aspects of the Red-cockaded Woodpecker's chosen habitat. Consideration must, of course, be given to the availability of nest trees; timber stocking and undergrowth characteristics should also be evaluated.

It was originally hoped that the support stand analysis portion of this study would provide information which might suggest maximal and minimal stand densities tolerated by Red-cockaded Woodpeckers. Unfortunately, the results are inconclusive in this regard. Although the variation in stand density as measured by basal area is not statistically significant, when expressed in stems per acre, the variation is quite large (range 48.67 to 142.61).

Perhaps the most striking feature illustrated by the data obtained is the preponderance of low understory vegetation. Ground cover of less than three feet was noted on 80 (74.3 percent) of the 109 sample plots. This, no doubt, reflects the fact that seven of the ten areas used in this part of the study were located in the Osceola National Forest and were regularly burned as a part of the land management practices employed on the area.

Of the 21 plots with ground cover over five feet, most were located near the edge of Cypress Domes. These areas were low and moist and were thus protected from fire.

As fire plays an important role in the ecology of southern pine flatwoods, a program of control burning should be undertaken on areas managed for Red-cockaded Woodpeckers. Such burning is probably not necessary to keep the undergrowth down for the benefit of the woodpeckers; it seems likely that they would remain in an area for some time even in the absence of fire. Steirly (1957) reported the understory on his study area was so dense as to impede "easy movement." In the course of the present study, Red-cockaded Woodpeckers were observed feeding in areas where the undergrowth was 10 to 15 feet high and so dense as to be impenetrable. (It should be noted, however, that when feeding in such areas, the birds were always using the upper trunks and crowns of their chosen trees. Indeed, while individuals were observed to feed quite low on the trunks of some trees, they were never noted to feed below the height of the

ground cover.) While fire may not be an immediate benefit to the woodpeckers, its use as a management tool will prevent the invasion of hardwoods and the replacement of the pine forest with a hardwood forest unsuitable for the Red-cockaded Woodpecker.

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Appreciation of the suggestions and guidance offered during the course of this study and during the preparation of the manuscript by the members of my supervisory committee, Dr. Stephen L. Beckwith, Chairman, Dr. Pierce Brodkorb, and Dr. Ariel Lugo, is hereby acknowledged.

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Table 1.--Extreme Distances at which individuals were observed

Direction	Location	
	Austin Cary	Sunland
N	250[a]	200
NNE	---[b]	250
NE	---	850
ENE	---	175
E	---	1100
ESE	---	1150
SE	150	1025
SSE	150	800
S	400	800
SSW	350	600
SW	1200	450
WSW	1500	1475
W	600	850
WNW	1000	500
NW	1200	300
NNW	650	225
Home Range Size	35.5 Acres	49.3 Acres

[a] Distance in feet.

[b] Open pasture not used by birds from NNE through ESE.

Table 2.--Summary of support stand analysis results

Study Area	Number of Plots	Mean Basal Area[a] (Sq. Ft./Ac.)	Mean Stand Density[a] (Stems/Acre)
Alachua County:			
Morningside Park	10	38.00 ±9.35	82.30 ±33.88
Sunland Training Center	9	40.00 ±21.21	75.11 ±54.20
Austin Cary Memorial Forest	9	42.22 ±15.17	142.61 ±59.89
Baker County:			
T3S, R19E, Sec. 2	12	55.42 ±16.26	94.88 ±48.65
T3S, R19E, Sec. 22	12	50.42 ±14.29	67.96 ±23.82
Columbia County:			
T2S, R17E, Sec. 36	10	56.00 ±17.29	132.80 ±82.25
T3S, R17E, Sec. 13	14	45.00 ±10.06	132.50 ±50.03
T3S, R18E, Sec. 19 (Center)	9	27.78 ±8.90	48.67 ±21.04
T3S, R18E, Sec. 19 (west edge)	12	36.67 ±14.11	62.25 ±34.08
T3S, R18E, Sec. 20	12	45.00 ±8.70	101.50 ±34.68
TOTAL	109		

[a] ±95 percent confidence limits.

Table 3.--Occurrence of common understory species

Species	Number of Times Recorded
Understory less than 3 feet:	80
Serenoa repens	79
Ilex glabra	49
Aristida sp.	47
Myrica cerifera	22
Befaria racemosa	8
Quercus laevis	7
Quercus chapmanii	4
Quercus incana	4
Rubus sp.	4
Lyonia lucida	2
Andropogon sp.	1
Asimina	1
Diospyros virginiana	1
Nyssa biflora	1
Quercus minima	1
Understory 3 to 5 feet:	8
Serenoa repens	7
Ilex glabra	5
Myrica cerifera	4
Aristida sp.	1
Lyonia lucida	1
Nyssa biflora	1
Rubus sp.	1
Understory over 5 feet:	21
Ilex glabra	17
Serenoa repens	16
Myrica cerifera	14
Lyonia lucida	7
Acer rubrum	1
Gordonia lasianthus	1
Magnolia virginiana	1
Nyssa biflora	1
Quercus falcata	1
Quercus laurifolia	1
Viburnum sp.	1
Total number of plots taken:	109
Total number of species recorded:	21

STATUS OF INVESTIGATIONS OF RANGE AND HABITAT REQUIREMENTS

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Nacogdoches, Texas

Ernest W. McDaniel
Kountze, Texas

Dennis N. Russell
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In 1954, H. L. Stoddard told me of his concern for the future of the Red-cockaded Woodpecker *(Dendrocopos borealis)*. In 1968, some birds I had watched for 20 years lost most of their usable trees through mortality and uncontrolled logging. I started looking for the species in Eastern Texas. Few could be found and it was obvious they were losing ground.

Correspondence was initiated with the U. S. Fish and Wildlife Service calling attention to the plight of the bird in Texas. In January 1969, Dr. John W. Aldrich answered that a similar situation was found to exist in much of the rest of the range and that the next issue of the "Red Book" would list the Red-cockaded Woodpecker as endangered. (U.S.D.I., Bur. Sport Fisheries and Wildl., Rare and endangered fish and wildlife of the United States. Res. Pub. 34, 1968).

In May 1969, an existing Federal Aid for Wildlife Restoration Project was amended to add a new job--a study of the Red-cockaded Woodpecker. The present paper is a progress report of W-80-R, Job 10.

The general objective is to find management practices which will save the species. Perspective has been gained through cooperation of the Forest Service. Since 1968, they have contributed location reports of trees occupied by Red-cockaded Woodpeckers. Many of these have been inspected periodically.

Study areas were established on 530 acres of the Fairchild State Forest (through cooperation of the Texas Forest Serive), 1338 acres of the Angelina National Forest (Compartment 50) and 780 acres at Scrapping Valley, Temple Industries. Less intensive studies have been made at Cleveland and elsewhere.

Woodpecker behavior is of interest as it relates to habitat. Banding was started in 1970, and this is yielding much good information on the units of birds related to each range. It is too incomplete for more than comments on progress in this paper.

SUMMARY OF PRESENT INFORMATION ON UNITS OF BIRDS

The logical unit of birds is the clan (family or group) that may be found regularly in association with a unit of range.

At Scrapping Valley in August 1970, there were 7 ranges with 19 adults and 5 juveniles. On Compartment 50, there were 5 ranges with 20 adults and 8 juveniles.

The productivity of these two populations with 39 adults is reflected in the 11 nests which fledged 13 birds. Four nests failed. Sex ratio of the 13 was 5 males, 7 females, 1 unknown.

The adult population includes more than the breeding pair. Ligon (Auk, 87:255, 1970) and others have discussed these helpers. We found about 3 adults per clan.

The role of the female may be obscured by their more wary habits. However, all evidence indicates the males are dominant in incubating, rearing, and in maintaining a year-round range.

On Compartment 50, only 2 females were banded in the summer of 1970 as compared with 7 males. By the spring of 1971, the total banding was 16 males and 5 females. The two 1970 banded females had been replaced by three new ones by May 1971. One banded female moved from one range to another. This totals 6 records of females moving or disappearing.

At Scrapping Valley in the summer of 1970, the ratio was 8 males to 4 females. By March 1971, a total of 18 birds had been banded of which 11 were males and 7 were females. Movement records show one male moved from one range to another and 5 females moved or disappeared.

The records show more stability for the males. The only 1970 juvenile banded was a male who retained his orange crown through September. He remains in the same cavity close to his nest tree.

Several nests have been incubated by two males. There is indication that dominance among males in a range changes with possession of the nest cavity for roosting. In several cases, the displaced male continue to feed with the group and to help with nesting.

Only one female was found in each range at a given time. Where several females were banded in a range, time intervals disclose a greater mobility or mortality for females. Certain cavities are occupied by the successive females of the family unit, but there are exceptions when a female will be trapped where a male had been caught.

The role of the females in population dynamics is one of the intriguing questions raised by these studies. More information is needed.

SUMMARY OF PRESENT INFORMATION ON UNITS OF RANGE

We will not repeat here our findings on sizes of range units or on tree characters, as recently published. (Lay, et al, Auk, 87:781, 1970) We should note that additional observations have served to enlarge our concept of the range of a clan. Several of the scattered trees on the two maps were not separate units as reported.

A comment is in order on the term "colony." We regret our previous use of the word. The groups of active and inactive trees with cavities are not always complete units of roosting and nesting range for one clan. Members of a group may roost in trees scattered over a distance of more than a quarter mile, even though some of the trees are close together.

This scattered pattern may occur where there are numerous trees that appear to be suitable, therefore, the scattered pattern is not a result of habitat limitations. We have one new cavity at the edge of two ranges which was constructed in early 1971 by one old banded male and an unbanded female. By nesting time, they had moved back to his old tree and a breeding male from the adjacent range was feeding on and around the new cavity tree. One might have considered this isolated tree a separate range without the benefit of continuing observations of banded birds. The new tree is 13, 20, and 20 chains from three 1970 nests.

Since colony is a misnomer, we question the assumption that leaving a sufficient number of trees around each occupied tree will keep the birds in a stand through a regeneration cycle. Perhaps experience will show that it will. In the meantime, it would be better to have some stands with Red-cockaded Woodpeckers left without regeneration until more is known about requirements.

Marked birds have shown a year-round fidelity to range units. Not only do they roost in the same cavity for long periods, and nest in the same cavity for several years; they also make some effort to defend or define the range at its edges.

Groups of birds have been observed to repeatedly turn back at certain places. Often these places are edges of vegetative types, as a hardwood "finger" in longleaf pine *(Pinus palustris)* type. Some of these places have been respected by birds on each side at the same or different times. There are some exceptions when feeding ranges overlap and when individual birds join adjacent clans temporarily.

Some cavity trees are alternately active and inactive. Possible causes would be increases and decreases in the population, new cavity construction, and competition for cavities by other species. In three cases, it appeared that flying squirrels were evicted by returning Red-cockaded Woodpeckers.

For the limited period of our banding, the record shows a tenacity to certain cavities. Of 28 males retrapped, 24 were in the same cavity, 2 were in the same tree, 1 was in the same range and 1 was in another range. Of 8 retraps of females, 6 were in the same cavity, 1 was in the same range, and 1 was in a new range.

There seemed to be two bachelor males in isolated trees in 1970. This year a female has joined one to establish a nest and the other was found to be a dominant male in a neighbor's nest 18 chains away.

The selection of trees for new cavities is an especially opportune study subject. We are watching birds as they abandon certain trees still alive, as they select new ones, and sometimes as they return to a previously used tree.

A critical aspect of the tree used is the slow growth rate--about 2 percent annual growth in log scale before deduction for mortality and defect. Since more than 2 percent of the trees die each year, there is a net loss for the forestry enterprise.

The future for the Red-cockaded Woodpeckers depends on land managers who will forego maximum wood production on parts of the forest. It also depends on accurate determination of what habitat is necessary in a dynamic system of birds and trees.

UTILIZATION OF PINE RESIN BY THE RED-COCKADED WOODPECKER AND ITS EFFECTIVENESS IN PROTECTING ROOSTING AND NEST SITES

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In presenting such a limited facet of the Red-cockaded Woodpecker's *(Dendrocopos borealis)* existence as resin protection of roosting and nesting cavities, I am aware that this is a subject of much less importance to this species' survival than so many of the other topics presently under discussion. This is part of the Red-cockaded's survival pattern that humans can do little or nothing about. This is a subject of academic interest but merits our consideration.

The present difficulties in which the Red-cockaded Woodpecker finds itself are closely bound to its selection of living pine for its cavity needs. Dependence upon living pine is bound up with an affinity for trees with red heart disease and will exude resin when tapped by the peculiar methods of the Red-cockaded Woodpecker.

Limiting our discussion entirely to this last habit, we may begin asking if any other avian species has similar or parallel methods of cavity protection. The sapsuckers *(Sphyrapicus)* commonly tap pines and virtually every woody plant of North America. This, so far as I am aware, is related entirely to food and not at all to cavity protection. In the Sittidae, the Red-breasted Nuthatch *(Sitta canadensis)* of boreal North America has the habit of carrying droplets of sticky resin from conifers to its nest site and smearing this material around the cavity opening. There seems to be little obvious reason for this habit, but it has been suggested that this is an archiac trait that goes back to a time when the nuthatch had a persistent enemy that may have been repelled by resin. James Tate, Cornell Laboratory or Ornithology, (pers. comm.) says the Red-breasted Nuthatch is frequently subject to persecution by red squirrels. It seems doubtful that the red squirrel, so constantly in conifers and often chewing sticky pine cones, would be deterred by a little resin around a cavity opening. The Old World Nuthatch *(Sitta europaea)* fills excess space in its cavity entrance with mud that in time hardens and serves as a barrier.

PROPERTIES OF RESIN AS A REPELLANT

Chemical

Resin is defined as a heterogeneous mixture of resin acids ($C_{20}H_{30}O_2$), fatty acids, esters of these acids, sterols, alcohols, waxes, and resenes. The melting point is 166°C. There is no evidence to indicate that ingestion of pine resin or inhalation of its fumes would be

toxic to higher forms of life; nor is it said to have any food value to such forms. Tate (pers. comm.) tells of seeing Yellow-bellied Sapsuckers *(Sphyrapicus varius)* sometimes eating the resin of conifers.

There is little information available on the repellent properties of coniferous resins to higher forms of life. It is known that rosin, a by-product from the distillation of pine resin, is effective as a rabbit and deer repellent. Apparently, the repellency lies in the taste. Few forms of animal-life can tolerate the astringent taste of piney resinous substances.

Herpetologists believe that coal tar derivative, rosins, and resins are harmful to snakes and that snakes tend to avoid coming into contact with such substances. Kauffeld (1953), for example, has reported upon the harmful effects of creosote treated woods upon captive snakes.

Physical

Physical stickiness is the quality that is most likely to make resin disagreeable or harmful to animal-life coming into contact with it. That insects were often engulfed in exudations of resin from prehistoric pine forests is seen in the fossil inclusions in amber on display in collections. Mammals can be expected to experience inconvenience or discomfort in contacts they have with sticky resin. The writer (1969) reported that a house cat was apparently repelled by fresh resin at the entrance to a Yellow-shafted Flicker *(Colaptes quratus)* cavity in a living white pine.

Several observers have reported harmful effects to birdlife. Brodkorb (1928) reported that a Yellow-shafted Flicker lost its power of flight when its wings and tail became coated with resin from a species of *Populus*. Ernest Cutts (pers. comm.), not implying that resin was the lethal agent, reports finding the mummified body of an Eastern Bluebird *(Sialia sialia)* stuck to a resin-coated surface below a Red-cockaded Woodpecker cavity. A similar discovery by him of a dead warbler provides added evidence that birds may sometimes become hopelessly entangled in resin.

RESIN CHIPPING BY THE RED-COCKADED WOODPECKER

Any kind of wound or break through the bark and cambium layer of a species of *Pinus*, *Picea*, *Larix*, or *Pseudotsuga* will result in a flow of resin. Resin canals are particularly abundant and well distributed in *Pinus*. The Red-cockaded Woodpecker makes its cavities in any of the common pines of the southeastern states. Trees most commonly utilized in South Carolina, where most of my observations were made, were longleaf *(Pinus palustris)*, loblolly *(Pinus taeda)*, and pond pine *(Pinus serotina)*.

It is generally recognized that the Red-cockaded Woodpecker makes its nest cavity only in living pine. Examples in Bent (1939) of utilization of trees other than pine were probably a result of faulty observation. Wayne (1910) reported that every one of some one thousand cavities that he observed were in living pine. Beckett (pers. comm.) in his intensive study of the Red-cockaded Woodpecker in South Carolina has recently found an active cavity in a living bald cypress *(Taxodium distichum)*. The tree contained the same resin wells around the cavity entrance as pine, but no typical resin flow.

Characteristically, a Red-cockaded Woodpecker cavity, whether for roosting, nesting, or both, has an associated pattern of small "resin wells" which may extend all the way around the trunk and up and down the tree for considerable distances. The resin well is constructed by flaking away bark and drilling into the sapwood to form a circular, more or less conical pit about one inch in diameter at its widest. Resin and sap collects at the bottom of this pit and soon begins to stream down the tree trunk. Trees that have been worked upon over a period of years tend to have trunks that are solidly coated with resin. They stand out like whitish columns among the more sombre dark gray trunks of their neighbors. Resin chipping often occurs on branches near cavity openings. Faces of neighboring pine trunks, that are no farther than six feet away, are often given the same treatment. Chippings on neighboring pines differ from those on the cavity tree in that they are not associated with a cavity and are only on the side of a trunk facing a cavity opening. Vegetation near a Red-cockaded Woodpecker tree becomes splattered with dots of whitish resin, and needles and leaves on the ground below become heavily matted.

Prolonged chipping upon a branch or portion of a tree trunk may lead to complete denudation of bark. Removal of bark is likely to be most pronounced around a cavity opening, and there appears to be a drying up of resin ducts which may require a move to a new part of the tree trunk or to a new tree.

PURPOSE OF RESIN CHIPPING

The resin diggings of the Red-cockaded Woodpecker have been called "a sticky and effective barrier against ants and flying squirrels" (Pearson et al., 1942), and much the same conclusion was reached by Steirly (1957). This writer (1968) concluded that resin workings are primarily a defense against avian usurpers. Ligon (1970) suggested protection from snakes and "certain other animals."

My present conclusion, after intensive observations at Red-cockaded Woodpecker sites in the Myrtle Beach region of South Carolina during the winter and spring nesting season of 1970, and, again, a few observations in 1971, is that resin chipping is primarily a defense against tree climbing snakes and secondarily a defense against other cavity nesting birds.

COMPETITION FOR CAVITIES

A total of 69 Red-cockaded Woodpecker cavities deep enough to be used by cavity nesting birds were found in 60 living pines. Trees were dominantly long-leaf, rarely over 18.0 inches in diameter at breast height, and growing in open park-like stands. The pine woodlands containing the Red-cockaded Woodpecker sites were at edges of residential areas, adjacent to golf courses, and, in some cases, along heavily traveled highways. The following record of usage was obtained during the winter and spring nesting season of 1970:

	No. Sites	Percent
Little or no usage	25	36.2
Nesting Red-cockaded Woodpecker	12	17.4
Exclusively flying squirrel	9	13.0
Successive users inc. flying squirrel	8	11.6
Other species	8	11.6
Recent enlarging Pileated Woodpecker	7	10.0

Usage by species other than Red-cockaded Woodpecker, flying squirrel *(Glaucomys volans)* or Pileated Woodpecker was as follows:

	No. Sites	
Gray squirrel *(Sciurus carolinensis)*	3	
Yellow-shafted Flicker	2	
Red-headed Woodpecker	2	(5 in 1971)
Red-bellied Woodpecker	1	
Great Crested Flycatcher *(Myiarchus crihitus)*	1	
Tufted Titmouse *(Parus bicolor)*	1	
Starling	1	
Wasp	1	
Honey bee	1	(3 in 1971)

Usuage by an avian species, except in the case of the roosting Red-bellied Woodpecker, was for nest sites. All work by Pileated Woodpecker, *(Dryocopus pileatus)* represented recent enlarging of cavities and openings. There was no evidence of a Pileated Woodpecker using a cavity for either roost or nest purposes. Numerous cavities showed signs of past Pileated Woodpecker work. This activity was usually limited to gashes or slits in the tree trunk a foot or so above a cavity but not necessarily on the same side as the cavity. These gashes often exuded copious quantities of resin. In all, some 24, or 40 percent of the pines with Red-cockaded Woodpecker cavities contained signs of recent or old Pileated Woodpecker activity.

Enlarging of entrances and cavity interiors by Pileated Woodpeckers made a number of sites available to birds and mammals that would have

otherwise been too large to make use of such cavities. This was particularly true availability of sites to eastern gray squirrels and raccoon *(Procyon lotor)* (evidence of past usage at one site). Excessive enlarging of the entrance hole by the Pileated Woodpecker caused flooding by rain water at some five or six sites. An additional site was rendered useless by an excessive flow of resin into the hollow interior. The small opening and upward slope of Red-cockaded Woodpecker cavities prevents this kind of despoliation. One might suspect that exploitation of living pine is a recent habit in the Pileated and that the bird lacks the finesse to turn very many such sites into usable roost or nest sites. However, Ernest McDaniel (pers. comm.) tells of actual nesting by the Pileated Woodpecker at one or two Red-cockaded Woodpecker sites in Texas.

Resin as a Deterrent to Other Birds

No less than six species of cavity nesting birds used sites in the Myrtle Beach study area during the 1970 season. A few additional species were observed making use of Red-cockaded Woodpecker cavities in nearby parts of South Carolina. Listed below are the approximate number of such sites taken by these species during the nesting seasons of 1970 and 1971:

	No. Sites
Yellow-shafted Flicker	9
Red-headed Woodpecker	4
Red-bellied Woodpecker	4
Eastern Bluebird	2
Crested Flycatcher	2
Starling	2
Tufted Titmouse	2
Carolina Chickadee *(Parus carolinensis)*	1
White-breasted Nuthatch *(Sitta carolinensis)*	1

Species not on this list but reported by McDaniel (pers. comm.) using cavities enlarged by the Pileated Woodpecker were Wood Duck *(Aix sponsa)*, Sparrow Hawk *(Falco sparverius)*, and Screech Owl *(Otus asio)* and one instance of a Starling *(Sturnus vulgaris)* but otherwise similar usage as the writer.

It would appear from these many observations of usage by other cavity nesting birds that resin was of small value in protecting sites from take-over. It must be remembered that a large percentage of the Red-cockaded Woodpecker cavities in any locality are old abandoned cavities or ones that may receive only occasional use as roosting sites. Of the cavities in the Myrtle Beach study area 82.6 percent were in this little or no-use category. The number voluntarily abandoned by Red-cockaded Woodpeckers or forcibly taken by other species is not known. The significant point is that only older sites with little, if any,

fresh resin were taken by birds or other pre-emptors. None of the cavities occupied by Red-cockaded Woodpeckers during the nesting season were taken. These were all protected to varying degrees by fresh resin. Roosting cavities appear to be more easily taken over by various usurpers inspite of the fact that these sites are sometimes given almost as much resin chipping treatment as nest cavities.

Several species appear to wait out the nesting period of the Red-cockaded Woodpecker. When the site is abandoned, they move in to take up their own nesting activities. They do this regardless of how much fresh resin there may be on the tree trunk or around the cavity opening.

Ants

Several observers have suggested that resin chipping may be a way of safe-guarding sites from invasion by ants, but others, Beckett, Ligon and myself, have noted ants crossing sticky patches of resin with complete impunity. Woodpeckers are major avian predators upon ants and several Old World Woodpeckers actually raise their young in occupied ants' nests (Baker, 1927).

On April 20, 1971, I briefly examined each tree trunk in the Myrtle Beach study area that contained a Red-cockaded Woodpecker cavity and found that 24.6 percent of the trunks contained one or more crawling ants. In several instances, ants were swarming into cavity openings. One such cavity was copiously protected by resin. The species at almost all sites was the carpenter ant *(Camponotus nearcticus)*.

Flying Squirrels

There were 17 or 24.6 percent of the cavities at the Myrtle Beach study area having a definite record of usage by flying squirrels during the winter and spring of 1970. Many of the sites were difficult to reach with a ladder so use could not be determined. It is not unlikely that about 50 percent of the Myrtle Beach cavities were utilized wholly or part of the time by flying squirrels.

Eight of the nine sites having two successive users during the winter and spring of 1970 had a record of flying squirrel usage. In seven instances sites that were used by flying squirrels during the winter were taken by some other species during the spring nesting season. In one instance, a cavity used for roosting by a Red-cockaded Woodpecker during the winter was occupied by flying squirrels during the spring.

No flying squirrels were found at cavities well protected with sticky resin in the Myrtle Beach study area, but two flying squirrels were

observed at an extremely sticky Red-cockaded Woodpecker cavity in Texas. Beckett (pers. comm.) has several times caught flying squirrels in mist nets just after they emerged from relatively sticky Red-cockaded cavities. The only resin he found on these animals was on the feet.

Apparently flying squirrels are not deterred by the presence of fresh sticky resin. If they are kept from cavities, it is probably solely through aggressive tactics employed by the Red-cockaded Woodpecker in defense of its quarters.

Snakes

Unfortunately, there is not enough evidence available to permit endorsement of the Red-cockaded Woodpecker's special methods of repelling snakes. I did observe a yellow rat snake *(Elaphe obsoleta quadrivittata)* fail in a first effort to climb a resin smooth pine trunk in an attempt to reach a flying squirrel. In a second attempt, climbing by way of rougher bark on the far side of the trunk, the snake gained the cavity, entered, and presumably devoured a whole family of flying squirrels. This same drama may have repeated itself the following year when a yellow rat snake was observed just inside a cavity entrance of a long-leaf pine in the same study area late in the day on April 20, 1971. Again, presumably the snake was after flying squirrels. Jackson (1970) tells of a black rat snake *(Elaphe obsoleta obsoleta)* sucessfully climbing the smooth, barkless trunk of a dead American elm *(Ulmus americana)* in order to reach a flicker's nest.

McDaniel (pers. comm.) has twice observed rat snakes below trees containing young Red-cockaded Woodpeckers in the nest. He was not aware of any attempts by these snakes to climb the trees in question.

SUMMARY AND CONCLUSIONS

A large number of cavity-nesting birds and other animal-life use Red-cockaded Woodpecker cavities. In a study area at Myrtle Beach, South Carolina, other cavity nesting birds, squirrels, bees, and wasps used 46.3 percent of the 69 cavities present. A number of other cavities that could not be reached with the aid of a ladder may also have contained certain of these users. The fact that so many cavities are taken by other species does not mean that resin is innefectual as a cavity protectant. There was evidence that other cavity-nesting birds were discomforted or at a psychological disadvantage in the presence of fresh sticky resin. Such a disadvantage may be of crucial importance when combined with the normal nest defense tactics of the Red-cockaded Woodpecker. In any event, there was no evidence of any other species taking over a Red-cockaded Woodpecker cavity after nesting was underway.

Cavities that are taken by other cavity-nesting birds, squirrels, and the like are usually old cavities where there is no fresh resin. Also

several species of cavity-nesting birds, especially Red-headed Woodpecker, Red-bellied Woodpecker, and Eastern Bluebird, wait until the Red-cockaded Woodpecker is through nesting and then move in to commence their own nesting activities. They have been observed to do this at sites where there was an abundance of fresh sticky resin.

As helpful as resin may be in preventing take-over of sites by cavity-nesting birds, its primary function apparently is protection of the site from predation by tree climbing snakes. Probably the Red-cockaded Woodpecker employs three methods to insure protection of sites from tree climbing snakes: (1) frequent chipping off of loose pieces of bark that might serve to deflect dripping resin or otherwise provide a grip for tree climbing snakes, (2) frequent chipping out of old resin wells and creation of new ones in order to keep the trunk coated with resin, and (3) the facing of most cavities in a westerly direction in order that they receive maximum amount of sunlight and warmth.

A tree heavily coated with smooth resin is probably invulnerable to tree climbing snakes. But resin quickly cracks and chips away so that birds must keep fresh supplies flowing if the coating is to be adequate. At the same time, it seems probable that sticky resin is a more effective repellent than hardened resin (although no observations are at hand to prove this). The fact that birds face their cavity openings in a dominatly westerly direction--around 70 to 80 percent in this direction in northeastern South Carolina suggests the importance of stickiness. To be sure, this may be as much a protection against other cavity-nesting birds as against snakes. Certainly much more data are needed on this point.

ACKNOWLEDGMENTS

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A SUMMARY OF RED-COCKADED WOODPECKER OBSERVATIONS IN SOUTH CAROLINA*

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BASIS OF NUMERIC STUDY

Over 70 colonies were located for this study. Two hundred and twenty-three trees were tagged with numbered aluminum tags. Relative information regarding each tree was secured. This included height of nest, direction, amount and rate of cavity excavation, lean, diameter, and in some cases increment boring for indication of red heart. One hundred and two birds were banded with standard U. S. Fish & Wildlife Service bands and plastic color bands for ready identification. This included a few nestlings. Sixty-two nests containing eggs or young were examined. Nests averaged three eggs per clutch.

CAVITIES AND TREES

Cavity Classification

A "start" is a site that shows evidence of pecking with the intent of cavity excavation. A roost cavity is an excation that is completed to a point where the bird will use it for roost purposes. A nest cavity is a hole that is completed and is also used as a roost cavity. It differs in old colonies in that it contains a vertical tunnel above the cavity entrance. These tunnels may be in all stages of completion. It is probable that a newly established colony nest cavity would not contain this chamber or tunnel. To date, all nests except one used for rearing young have contained this tunnel in some stage of completion. The one exception was a new cavity started in 1968 and used in 1971.

Possible Reasons for Scaling and Pecking to Secure Rosin Formation:

1. Protection from predators.
2. Prevention of overgrowth of cavity by removal of cambium layer when it is abandoned for long periods of time.
3. Indicator to others of territorial use.
4. In surrounding trees, rosin pockets may attract insects for food.
5. Probably encourages formation of "fat pine" which slows down further development of red heart in nest area of tree and may discourage enlargement by other species of woodpeckers.

*Ed Note: The outline provided by T. L. Beckett was not presented at the symposium but was considered to contain significant information and is offered with a minimum of editing or rewrite.

Factors Affecting Direction of Placement of Cavities

A vast majority of the cavities are in some relation that will receive the evening sun or some point on the compass relating to the west. If the tree has a lean, a great majority of the cavities will be on the side in which the tree leans. Trees selected for cavity excavation are usually in relatively open areas at the time cavities are initiated. As understory develops, birds may cut cavities at higher elevations in the same trees. Cavities are usually 12 to 20 feet high but may be as low as 4 feet or as high as tree will afford heart wood for a cavity--60-70 feet. Old roads usually favor cavity excavation on side of tree facing roads, due to root damage.

Reasons for Apparent Need for Mature Timber

1. A bird must have reached heart wood before the vertical portion of tunnel can be excavated, otherwise it would fill with rosin.
2. Young trees contain only sap wood.
3. Lateral tunnels have varied from 3 inches to 9 inches, or until heart wood was reached.
4. Red heart is incidental to the use by the Red-cockaded Woodpecker *(Dendrocopos borealis)* of a given tree. It is usually found in mature timber. Trees bored to date have varied in age from 65 to 110 years. In most newly cut cavities, the wood is sound, although there may be evidence of red heart.
5. The bird may abandon a lateral hole if it strikes soft decay.
6. Mature timber, if periodically burned, usually contains little understory, except pine.

Evidence Indicating Long Use of Many Sites by the Red-cockaded Woodpecker

From observed evidence, it is probable that well over half of the colonies under study have been in use 25 to 30 years. At least 6 have been in use 40 to 50 years. It is possible to age some colonies from observations by ornithologists of known colonies that age them beyond 30 years. Several can be dated back prior to development in the '30's of the South Carolina Forestry Service. Before that period, most sites were burned annually. The swellings around some of the cavities in the boles of some trees indicate attempts by the tree to overcome the excavation by the woodpeckers over a very long period of time. In a few colonies, cavities may be found that have completely healed over after long years of abandonment. In some trees, indications are that a long period of time was required. A few trees show repeated crowning of fires as a result of rosin repeatedly coating the trunk almost, or entirely, to the ground level. Boundary trees can show repeated layers of rosin and marking paint, particularly if the cavity is in this area. In some cases, the old cavities may be found in the understory. The newer cavities are repeatedly elevated as the understory continues to grow. In one colony, the picture is very graphic and the present cavities are almost in the bud - elevations 60-70 feet.

Evidence Regarding Rate and Causes of Tree or Cavity Loss

Man is by far the major factor in loss of the trees needed for nesting by this bird. Entire colonies or populations are frequently eliminated when some tracts under observation have been harvested. Local people realize that many of the trees used over many years may be almost solid "fat wood" and are quite valuable when cut and split into kindling for starting fires. Under clear cutting on some large plantations, losses may approach 100 percent.

Fire does destroy some of the trees when it occurs several times in relatively quick succession. The abundant rosin secretions on some trees cover the bole from the ground line to the lower limbs. It burns rapidly sending flames into the crown of the tree. I have no evidence of a tree actually killed but some are quite evidently weakened in the crown area. Fire does quite often burn out the cavities.

Storms will break off old trees in the cavity area if the interior is badly weakened by redheart. A close observation will usually show other trees in the area, without cavities, also broken off. My evidence shows this loss to be about 2 percent annually of the total number of trees under observation.

Another loss of use of the cavity tree, although it may be temporary, comes about by growth of the understory into the cavity area. A limb or large clump of moss falling across the cavity also may cause abandonment for several years.

A hole developing in the base of the nest chamber due to soft decay can cause abandonment, even as a roost cavity.

Vertical Tunnel

The most plausible use for the vertical tunnel would be to escape predators which would naturally reach downward toward the nest chamber for prey. One bird that had escaped observation four times previously when mirror and light were used was found in the vertical chamber. It may serve as additional roost area for adults when needed. I have observed only two instances when two adult birds were possibly in the cavity at the same time. In both cases, color bands indicated they were probably the mated pair and the male was on the eggs. It may serve the young as additional nest area when four or five young were reared to the fledgling stage. I have evidence in one instance where two young probably were in the vertical nest chamber. It may serve as a resonant chamber for sounds made around tree by predators walking around or climbing tree. The bird's sense of hearing appears to be very acute.

BREEDING BIOLOGY

Clutch Size

Number and Size of Clutches and Broods

No. of Eggs or Young	1	2	3	4	5
Eggs in Nest (No. of Clutches)	0	5	35	7	0
Young in Nest (Broods)	0	6	14	2	0

Of the above 69 nests, 2 fledged 3 young and 3 fledged 2 young. One egg is known to have failed to hatch. Thirty-three of the above nests were collected or observed during the years 1958-1961 by Ernest Cutts, Edward Blitch and Roy Baker. Thirty-one of the remaining 36 are still under observation.

Incubation Period

My observations 12 to 13 days. Cutts, Baker and Blitch data indicate 12 to 13 days. The above timing seems to apply mainly to the first egg laid, for in the theory each additional egg should hatch progressively one day later, when in fact, all may hatch in 24 to 30 additional hours.

Nestling Period

Several factors seem to influence the nestling period which appears to vary from 22 to 28 days. Availability of food seems to be a dominant factor. Larger broods require a longer period before all leave the nest. Inclement weather can reduce the number of hours the adults have for food gathering. In like manner, a "hot burn" area close to the nest tree may furnish more food than small nestlings can consume.

Pair Concentration

It is very hard to define the range needed or used by a single clan. It is quite evident that the size of range needed would be influenced by the following: (1) Number of birds in a given clan, (2) Availability of food in a particular habitat, which in turn, can vary from year to year, (3) In general, colonies are spaced about 1/2 mile apart, although this varies, and (4) there is an observed overlap in feeding ranges in winter.

Number of Birds Composing a Clan

We have worked with no clan composed of less than three observed adults and have some with five to seven adults active during the breeding season. During the winter months, at least one clan was composed of

nine birds. It is not known at what season or for what reason some adults disappear from clans. It is quite evident that pairs must break off in order to form new clans, but there is no evidence now that any clan contains as many as two adult females.

Possible Reasons for Helpers

Adults or young of previous year without nesting sites or ranges of their own is one possible reason for helpers. The assistance of non-breeding birds in rearing young increases the probability of rearing larger broods, particularly under adverse conditions--inclement weather and in years when food is less abundant. Group work in assuring additional advanced "starts" for cavities lost, thus providing greater continuity in production of young in a clan. Additional birds in clan can protect cavities not in use for nesting purposes. Possibly clan action is needed to keep "rosin pickets" open in trees in feeding areas for the purpose of attracting insects for food. The imbalanced ratio of males over females assures continuous use of colony over long periods of time.

Care and Feeding of Young in Nest

It appears that in most clans, the female participates about equally in feeding of young, although certain males seem to dominate feeding. On some days in some clans, the females may not feed the young or be seen for an entire day. To date, I have evidence that the previous year's young participate in rearing the following year's brood in only one colony. Some helpers do not bring food to the young in nest. They bring food to the area but transfer it to the bills of other helpers that actually enter the cavity to feed young. Males brood young at night during early nestling stage. Young nestlings are fed much more frequently than older ones. The food is smaller and appears to be more quickly digested. The older young being fed fruit and large insects sometimes refuse additional food and frequency of feeding tends to decline.

Observations Made Regarding Feeding Habits

After many hundreds of hours of observations by several workers in South Carolina, there has been no observed difference in the feeding sites of the sexes.

Population Build-up Resulting from Insect Invasion

Between 1961 and 1963, there was a large increase in beetle infestation in South Carolina according to commercial and U. S. Forestry personnel. Red-cockaded Woodpeckers were seen in much greater numbers in this area. Up until 1958, there were very few records of the Red-cockaded Woodpecker on the Sandhill Wildlife Refuge at McBee, South Carolina. During

1958, when beetle build-up was great, 40 birds were present on the refuge. By 1963, at least 11 nests were located on the refuge. John Dennis reported a build-up of a large population of Red-cockaded Woodpeckers at the Baruch Plantation near Georgetown, South Carolina following a large increase in forest insects. During the winter and breeding season, the species is much more common in areas experiencing a "hot burn" even though the timber may be relatively small.

COMPETITION

Joint use of the Cavities by Other Forms of Life

Both the Red-headed *(Melanerpes erythrocephacus)* and Red-bellied *(Centurus carolinus)* Woodpeckers roost and nest in the cavities of the Red-cockaded Woodpecker. I do not believe that either species can enter the average hole (2 inches) of the Red-cockaded Woodpecker without enlarging it. Great care is needed in assuming that any cavity has not already been enlarged by one of the species. The Red-cockaded Woodpecker is capable of defending a chosen nest cavity against either of these larger species.

The flying squirrel *(Glaucomys volans)* is a frequent user of the Red-cockaded Woodpecker cavities. Frogs, bats, Bluebirds *(Sialia sialia)*, lizzards, Tufted Titmice *(Parus bicolor)*, Carolina Chickadees *(P. carolinensis)*, and Crested Flycatchers *(Myiarhus crinitus)* also use cavities for nesting and roosting. Even screech owls *(Otus asio)* have been found nesting in enlarged cavities.

There is a species of spider that in three instances has placed its egg cases on the upper portion of the lateral tunnel of cavities in use as nest sites.

Joint Use of Feeding Areas by Other Species

During the non-breeding season there appears to be little interspecific competition in feeding territories. On one occasion, five other species fed in harmony with the Red-cockaded Woodpecker. Only a Mockingbird *(Mimus polyglottos)* attempted to drive any of the woodpeckers from a "hot burn" site. I cannot agree with other observers that some of the other species so often found feeding with the Red-cockaded Woodpecker are there because of the suitable habitat alone. To date, it appears that there is a one-sided form of symbiosis that works in favor of the accompanying species. In no case, have I seen the Red-cockaded Woodpecker benefit from the presence of other species, but any careful observer with hours of constant observation will find that the Bluebird frequently catches flying insects dislodged by the scaling of the Red-cockaded Woodpecker. The Brown-headed Nuthatch *(Sitta pusilla)*, Pine Warbler *(Dendroica pinus)*, Carolina Chickadee, Tufted Titmouse, and when allowed to, the White-breasted Nuthatch *(S. carolinensis)* all benefit from the feeding habits of the Red-cockaded Woodpecker.

Several species of small birds collect feathers of the Red-cockaded Woodpecker that have been shed in the colony sites. A Pine Warbler made 12 observed trips to the ground and trees collecting feathers for nesting material at one site. In the breeding season, the Wood Peewee *(Contopus virens)*, Summer Tanager *(Piranga rubra)*, Orchard Oriole *(Icterus spurius)*, Bobwhite *(Colinus virginianus)*, Common Grackle *(Quiscalus quiscula)*, Chipping *(Spizella passerina)* and Bachman's Sparrows *(Aimophila questivlis)*, and Indigo Bunting *(Passerina cyqnea)* are common in the habitat.

Reasons Observed for Shifting Nest Trees

Rainwater entering cavities appears to be the most common reason for changing nest cavities. Flying squirrels building nests in colonies having several available nesting cavities is frequently seen. In no case have I seen a pair of Red-cockaded Woodpeckers lose their nest cavity to other forms of life if there was not an alternate nest site. There are frequent recorded losses in colonies having numerous cavities.

Evidence of Adaptions for Prevention of Rosin Sticking to Feathers

There is little positive evidence that I have observed to indicate that the species has any such adaptions; in fact, the bird frequently loses feathers to rosin on the tree. Adults, eggs and young often have patches of rosin on them.

One possible adaption is the fact that the species appears to spread the legs wider apart than most other species of woodpecker. This, of course, would probably spread the brood patch area leaving bare skin over the rosin surfaces. I cannot say that in fact this is true.

ROOSTING

Roosting Time in Evening

The most evident factor is rainy or cloudy weather when the birds may come in much earlier or else not at all. Predators in the area can delay the birds entering their cavities. Hawks are a main factor since their presence causes an alarm note that brings about the "freezing" of all birds in their positions. For some reasons, even on bright clear days, no birds return to roost in the colony area. It is possible that they may be too far in ranging for food to return. This does not happen often but has been observed in several colonies. The birds, or bird, will push forward arrival time at a cavity if it desires to prevent other species of woodpeckers from roosting in the cavity. This has been observed on numerous occasions.

Departure Time from Cavities in Morning

Indications are that some clans appear to be earlier risers than others. This has been checked under varying conditions. Some birds will leave their cavities earlier if only slight noises are made in the area. This is often true of cavities at low elevations. Cloudy, rainy weather will delay departure from cavities. A predator--hawk--in the area causing some other species of bird in the area to give an alarm note will cause the birds to remain in cavities.

FIRE

There can be little question that the species' survival and development has paralled the existence of fire in predominant pinelands. Were fire completely eliminated from the pine forests, the species would be entirely dependent on man for mechanical or chemical control of the understory. Many of the fruits consumed from mid-summer on are also dependent on fire to maintain the park-like appearance.

"Flycatching" is certainly aided by the open areas. It is quite probable an open type of habitat encourages use by dragon flies, may flies and other flying insects caught on the wing by the Red-cockaded Woodpecker.

PLUMAGE

Length of Time in Acquiring Cocades by Males

I must point out that this observation is based on only one male bird captured in the nest cavity over a six-week period beginning in early October. At the first observation in October, no sign of cocades was present. Only the red crown patch could be seen. On November 14, the young male had entirely lost its crown patch and only the cocades could be seen. Due to water entering the cavity, the young male abandoned the site a few days later. This indicates at least a partial head molt in the year of hatching.

PREDATION AND OTHER FACTORS OF MORTALITY

In the egg and nesting period, there can be little doubt that the greatest predators in South Carolina are the four-lined chicken snake and the rat snake *(A. striatus)*. Although I do not consider the Cooper's *(Accipiter cooperii)* or Sharp-shinned Hawks of much importance in natural habitat, I cannot help but believe that under present management, both species of hawks are taking an abnormal toll in our "man-made" environment for the species. The birds are forced to fly across and through clear-cut areas to feed. I have seen several strikes under such circumstances. Fire probably traps some birds in cavities at night. Water, caused by a blowing rain, can flood nests causing loss of eggs or young.

MANAGEMENT

In our National Forest, there is no reason why large tracts of timber cannot be set aside specifically for use by the species as has been done in Texas. The areas should be managed for maximum utilization by the Red-cockaded Woodpecker.

On private and public lands, there is only one method that I can see that will preserve the species to serve in its ecological niche in good forest management. This is possible only because it is now evident that the Red-cockaded Woodpecker can utilize small or immature (4-6 inches) timber for feeding sites if the needed mature trees are available for nest sites and protection in foraging its territory. Throughout this study "line trees" have been very much in evidence as trees of long usage as roost and nest trees. They are in fact permanent markers of boundaries of adjoining tracts of land. There is no reason why artificial lines of trees cannot be used along boundaries of areas to be clear cut, even under 30 year rotations. The two present methods of preserving the species, islands containing the colony, and selective or clear cutting in and around the hole trees while temporarily serving their purpose will in the end destroy the Red-cockaded Woodpecker. It is possible for the species to survive in selective cutting provided the cavity trees are kept free of the new growth of understory pine around cavity trees. From present observations, this does not appear to be very practical. Regardless of the size of clear-cut areas (present policies appear to lean to smaller cuts) it would be rather easy to leave a small band of mature timber around the borders. In this way, all areas would be accessible for feeding and yet the timber crop would have the benefit of protection by the Red-cockaded Woodpecker.

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THE RED HEART DISEASE OF SOUTHERN PINES

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Like many woodpeckers, red heart also goes by many common names. In the West, it is known as red ring rot, conk rot or ring scale. In the Southeast, of course, it is called red heart. Elsewhere white peck, honeycomb and pecky rot refer to the same disease.

Red heart is a decay of the heartwood of living Douglas-fir *(Pseudotsuga)*, larches *(Larix)*, pines *(Pinus)*, and spruces *(Picea)*. It has never been shown to attack living sapwood. This decay is caused by a wood-rotting fungus, *Fomes Pini* (Thore) Lloyd, that is widely distributed throughout the North Temperate Zone.

In order to use this fungus as a tool for improving or creating nesting habitat for the woodpecker, one must first understand the disease cycle of red heart.

INFECTION

The wind disseminates infective propagules called spores. Spore numbers are highest in spring and late fall, and they fly particularly when the temperature rises following cool but not freezing weather.

Inoculation must occur on branches with heartwood or where large wounds are present on the bole. It is thought by some pathologists that live, freshly broken branches must also be present if *F. pini* is to gain entrance into the tree. Such fresh wounds might occur after high winds. Very rarely does this fungus enter fire scars.

After infection this wood-rotter, like others, spreads within the tree by penetrating pits in wood cell walls. In addition to this indirect invasion of the wood, the organism produces enzymes which enable it to penetrate walls directly.

The incipient or initial stage of decay is called "sound redheart." At this point, the strength of the wood is not reduced, and it can be utilized. Red heart of southern pine wood as well as other woods is firm, tough and resinous in the incipient stage. During the advanced stage, however, the strength is greatly reduced, and the wood cannot be utilized. It is in this stage that the wood is said to have a white pocket rot with "pockets" parallel to the grain. Inside these "pockets" are soft masses of cellulose. Decay patterns vary with different species of trees rather than with different fungal strains.

REPRODUCTION

In the reproductive phase of the disease cycle, the red heart organism produces structures from which the spores are disseminated. These structures are called fruiting bodies, sporophores or conks. They are located on the bark at heights from four to over 50 feet.

The most distinguishing characteristic of the conks is their variability. Conks found on trees of different genera or species differ in shape and may vary on the same tree.

These structures may be shell-shaped, bracket-like, hoof-shaped or even resupinate as some workers have observed. The bottom side from which the spores emerge has a maze-like pattern. *Fomes* conks are perennial - i.e. they add on a new spore-bearing layer every year. All *F. Pini* conks are hard, almost woody when they are old.

Conks are the only foolproof external indicators of decay. According to Nelson (Va. Forest Serv. Pub 43:58-59, 1931), rot may extend as far as 35 feet below and 55 feet above a conk. He reports that in 15 loblolly pines *(Pinus taeda)* bearing conks, the average rot column was 50 feet with a minimum figure of 18 feet. In addition to the preponderance of red heart in older stands, he also says that conks are usually not present until a tree has reached merchantable size.

Another less reliable indication of red heart is swollen or sunken areas along the bole known as "punk knots." These are merely branch stubs infected by *F. Pini*. Swollen punk knots arise from the tree's effort to overgrow the infected branch stub where a conk is forming. The interior of a punk knot has the same yellowish-brown color as the interior of a conk. A rule of thumb is that decay extends roughly half as far from a punk knot as from a conk. Punk knots and conks are not as numerous on southern pine as they are on Douglas-fir in the West and spruces in the East.

The red heart fungus survives inside the tree during periods unfavorable for its growth. It also lives saprophytically on many woods. During these unfavorable times, conks may be formed, spores released, disseminated, and the disease cycle begun again.

CONCLUSION

Some conclusions about red heart disease of southern pines would be instructive in considering steps for the management of the Red-cockaded Woodpecker. Nelson (1931) and Gruschow and Trousdell (J. For. 56:220-221, 1958) showed from their works that:

1. Red heart increases with increasing stand age particularly in uneven-aged tracts. The following portions of two tables illustrate this:

FROM NELSON (1931)	Age Classes		
	40 - 90 Years	90 - 140 Years	140 - 190 Years
Total number of trees	682	86	15
Number of trees with decay *(Trametes pini)*	37	16	9
Percent of trees decayed	5.4	18.6	60.0

FROM GRUSCHOW AND TROUSDELL (1958):	Old-field stand (Age 74-160 years)	Forest-grown stand (Age 60-200 years)
Percent of trees with heartrot	6.3	21.1

2. Formation of conks increases with stand age.
3. Large and more persistent branches favor red heart infection.
4. Red heart occurs rarely in the butt log.
5. Loblolly pine is susceptible to *F. Pini*, for the most part, beginning at age 60. Shortleaf *(Pinus echinata)* is susceptible beginning at 80 years.
6. Pure southern pine rather than mixed stands of pine and hardwoods tend to increase the incidence of red heart.
7. Excessively-drained soils, shallow soils and soils with high quantities of nitrogen favor red heart.
8. According to Boyce and Wagg (Oregon Forest Products Lab. Bull. 4, 1953), Douglas-fir red heart is severe where the secondary vegetation includes vine-maple, oxalis, rose and vanilla-leaf. The last three are found in the Southeast.

RECOMMENDATIONS

In the past, red heart has had a substantial economic effect on wood production. This decay is considered to cause more heartrot in living conifers than any other wood-rotting fungus. In the near future, its importance should decline since it is most important in older stands, and the trend in southern forestry is toward shorter rotations. Also, many foresters may soon apply the principle of "pathological rotation age" which involves harvesting trees when growth roughly equals decay.

Based on some of the conclusions listed above, the following suggestions are made to manage for the woodpecker by favoring red heart:

1. Favor old growth pines, especially in uneven-aged stands.
2. Favor trees with larger and more persistent branches--i.e. favor longleaf *(Pinus palustris)*, then loblolly, then slash *(Pinus elliotti)* and shortleaf pines.
3. Manage for pure stands of pine.
4. Fertilize stands, especially with nitrogen. On private lands, the landowner might consider using urea, a ready source of nitrogen.

If we were to consider only the management of the woodpeckers, the following are a few suggestions for inoculating southern pines with *F. pini*.

1. With a hydraulic borer, make a smooth hole into the second log (16 to 32 feet above ground) of an old growth pine. Be sure that the heartwood has been reached.
2. Insert wood dowels colonized by *F. Pini* tightly into the hole thus inoculating the tree. Sawdust, similarly colonized, might also be used.
3. Maintain the organism on wood blocks in the laboratory.

OBSERVATIONS ON THE FOOD HABITS OF THE

RED-COCKADED WOODPECKER

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The Red-cockaded Woodpecker's *(Dendrocopus borealis)* habitat is the pine forests of the southeastern United States. Older age class living pines are an essential requirement for the nesting and roosting of the bird, and a large percentage of their feeding activity takes place in the pine woods. Although the Red-cockaded Woodpecker is a potential predator of many arthropods found on pines, its real economic role here is unknown. It literally combs the pine forest in its territory throughout the year in search of food, but its food habits are diverse and it feeds on fruits of hardwoods, shrubs and other plants in addition to insects.

In the field, specific identification of most arthropods is impossible, especially when seen in a bird's bill from afar. Hence, the food habits of the Red-cockaded Woodpecker are based on stomach analysis or on circumstantial evidence. When parents are feeding young, food items can be identified only to general categories, e.g. spiders, centipedes, moths, etc. During the early 1900's, the U. S. Biological Survey conducted intensive studies on the food habits of North American birds, especially those that might relate to man's agriculture. This survey forms the basis of our present knowledge of the Red-cockaded Woodpecker's food habits. Investigations by Beal (1911, 1916) were based on the analysis of 99 stomach content samples taken from Alabama, Florida, Georgia, Louisiana, Mississippi and Texas birds. These samples consisted of 86 percent insects and 14 percent vegetable matter--principally mast. Beetle larvae constituted 16 percent of the annual diet. Ants were also a common food item taken at all seasons. Insects mentioned as food items by various authors belong to the following orders: Orthoptera, Isoptera, Hemiptera, Homoptera, Coleoptera, Lepidoptera, and Hymenoptera. Other arthropods include spiders, centipedes and millipeds.

Plant material utilized for food by Red-cockaded Woodpeckers reported by Beal (1911) and Murphey (1939), included the following: wax myrtle *(Myrica cerifera)*, magnolia *(Magnolia grandiflora)*, poison ivy *(Rhus toxicodendron)*, wild grape *(Vitis* sp.*)*, pokeberry *(Phytolacca americana)*. Ligon (1970) observed them feeding on blueberry *(Vaccinium* sp.*)*.

Like many birds, the Red-cockaded Woodpecker is opportunistic and as insect populations peak and plant fruits mature, they feed intensively on these materials. I observed Red-cockaded Woodpeckers feeding heavily on the fruit of wild cherry *(Prunus serotina)*, wax myrtle, and to a

lesser extent on that of blackgum *(Nyssa sylvatica)*. Ligon (1970) noted these birds feeding in pecans *(Carya illinoensis)*. I also have seen them foraging in pecan trees regularly, especially birds of Clan B which is adjacent to a yard with pecans. Although there seems to be more utilization in the spring, they will search the trees throughout the year. Red-cockaded Woodpeckers spent considerable time searching and feeding on lightning-struck pines and dying trees when these become heavily infested with insects, e.g. *Ips* sp. This is the only time when I have noticed much Red-cockaded Woodpecker activity on dead or dying trees.

RED-COCKADED WOODPECKERS AT BIRD FEEDERS

Red-cockaded Woodpeckers visit feeding stations if these are in proximity to a colony. They have been observed to drink water and feed on suet. In one case where the birds came regularly to a feeder, the feeding station and the bird's roosting cavities were in the same block of timber. In another case, the colony area was 1/4 mile away from the feeding station but within its daily range.

WILD CHERRY

During the summer, cherries are heavily utilized by Red-cockaded Woodpeckers. They either swallow the berries whole or peck them before eating. On July 1, 1970, during an all day watch of Clan A (7 birds), one bird started feeding on cherries 17 minutes after leaving its roost in the morning. Throughout the day and just before going to roost in the evening, the birds of this clan fed on cherries. Adults of both sexes not only ate the fruit themselves but fed it to the young. The next morning four individuals worked the same cherry tree 34 minutes after leaving their roosts. On July 6 and 7, 1970, these birds were still utilizing cherry fruit.

CORN

One insect that the Red-cockaded Woodpecker readily seeks is the corn earworm *(Heliothis zea* Boddie*)*. In South Carolina, Dingle (1926) and Ward (1930) were familiar with the birds feeding on this corn pest. Where there are cornfields within the territory covered by these birds, they feed heavily on corn insects, and in fact, where conditions are suitable, these insects are the birds' major food source for several weeks. In the Southeast, corn is in the tassel and ear stage after Red-cockaded Woodpecker young have fledged. Therefore, this source of food is available to the birds when the family unit is roaming in search of food and the young are still dependent on the adults.

During the 1970 corn season, I watched Red-cockaded Woodpecker activity in corn intensively including observations of marked birds. When Red-cockaded Woodpeckers are feeding on this larva, the vast majority of their active hours of searching and feeding behavior are spent in

cornfields. The remaining hours are spent in resting, in maintenance activities and in activity associated with the roost trees.

To determine the extent and effect of Red-cockaded Woodpecker activity on the corn earworm, a count of woodpecker holes and corn earworm emergence holes per 100 foot section of corn row was made. Ten strips, 100 foot in length, were located at random excluding the rows on the edge of fields. Birds often search the outer rows first so inner rows were chosen for this count.

Typically only one corn earworm develops per ear. Observations and limited examination of corn show that usually when a woodpecker makes a well defined hole, a corn earworm was eaten, and an estimate can be made of the number of earworms taken per acre.

Observations in Cornfields

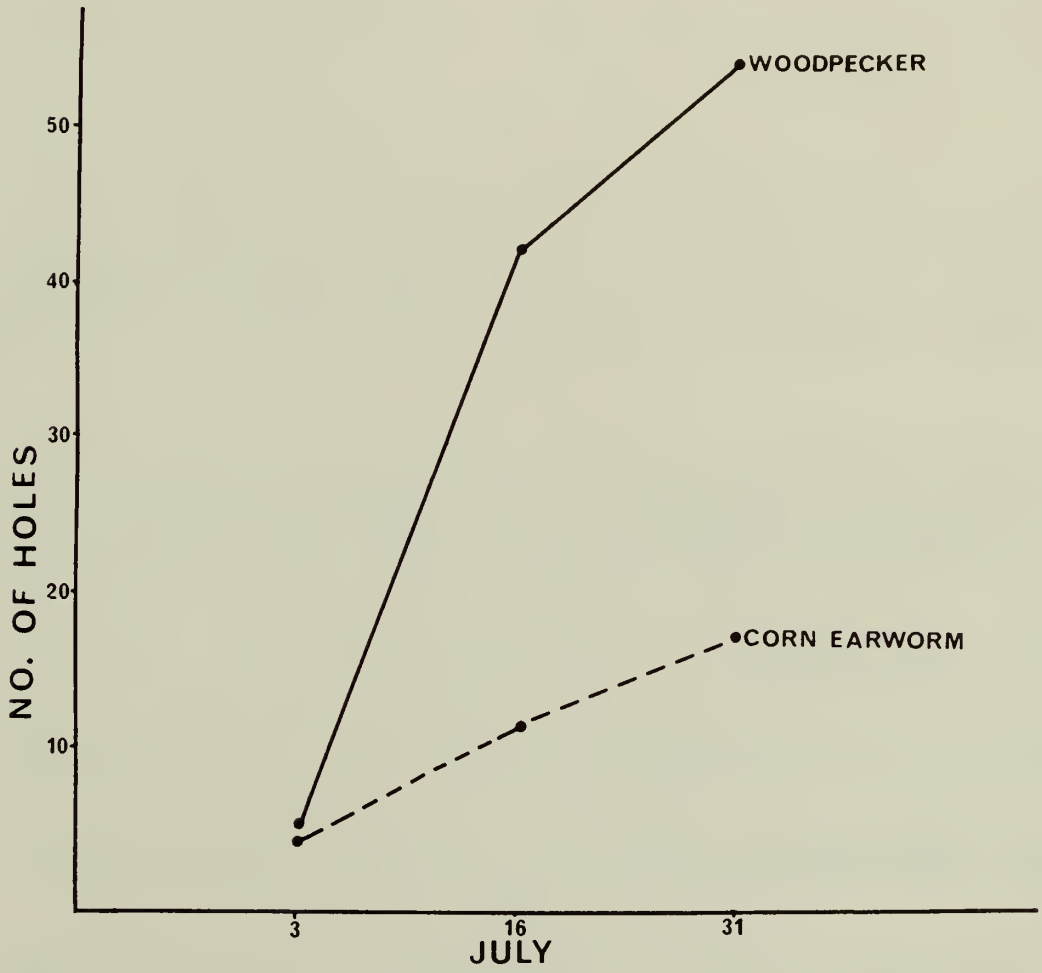
On July 3, six sections, of six rows each, were checked in Plot Field. The results are shown in Table 1. The extent of woodpecker feeding on the corn earworm is impressive. Unfortunately, this corn field was too mature for a later check on the same rows. In House Field where the corn was in an earlier stage of development, sections of rows were counted on July 3, 16, and 31 (see Table 2). Rows 3 and 4 were not surveyed on the latter date. As the corn silk darkens and the corn earworm develops, the woodpeckers feed very heavily on these caterpillars. As the worm and corn matures, the woodpecker activity in corn decreases.

Counts averaged for each row on July 3, 16, and 31, indicated 726, 6098, and 7913 corn earworms were eaten per acre respectively. Also of interest is the ratio of woodpecker holes to corn earworm emergence holes for each date. When the number of holes are plotted by date, it appears that the woodpeckers are acting as a "control" on this insect (Fig. 1). It is also noteworthy that the birds are feeding on this larva at a critical stage in the insect's life cycle, a stage when, other predators have ceased preying on the earworm and the larva is getting ready to pupate.

Other insects are also consumed in cornfields. On July 18, 1969, I watched a bird working its tongue along the leaves and base of the tassel of an ear of corn. The most abundant insect present was the corn leaf aphid *(Rhopalosiphum maidis* Fitch). In addition there were a few lady beetle larvae *(Scymmus* sp. and *Coleomegilla* sp.*)* and in the ear itself was one corn earworm.

The Red-headed *(Melanerpes erythrocephalus)* and Red-bellied *(Centurus carolinus)* Woodpeckers also spent time searching in cornfields apparently preying on insects, including the corn earworm.

Figure 1.--Average number of woodpecker holes and corn earworm holes per 100 foot section of corn rows in House Field, Tall Timbers Research Station, Leon County, Florida. 1970



The Red-bellied Woodpecker does not seem to be as proficient at finding corn earworm caterpillars as does the Red-cockaded Woodpecker. On several occasions, I have observed the Red-bellied Woodpecker chase off a Red-cockaded Woodpecker which was pecking a hole in search of earworms, and then complete the job. Once after I watched this behavior, the Red-bellied Woodpecker pecked away for a while, then gave up and flew to another plant. Later, on examination this ear indeed contained a larva. From what I have observed, if the Red-cockaded Woodpecker continues pecking the ear, it usually finds the worm. In conclusion, although other species of woodpeckers forage in corn, I believe the majority of the woodpecker holes in the corn shucks were made by Red-cockaded Woodpeckers.

BEHAVIOR OF RED-COCKADED WOODPECKER FEEDING IN CORN

In 1970, I first noticed birds from Clan M feeding in corn on June 26. Judging by the development of the corn and woodpecker "sign" they had not been working the corn for more than a few days. On this day, the birds left their roost at 06:34 E.D.S.T., then slowly but without divergence, went to a cornfield. By 06:55, at least five birds were feeding in the corn. From 06:55 to 07:55, they were in and out of the cornfield except for one 15-minute period when they were at the pines on the field's edge.

All day watches of marked birds of Clan A were made on July 1, 9, 22, 1970. During these days, a great deal of the Red-cockaded Woodpecker's time was spent in association with corn. Other observations of shorter duration were made in July watching the bird's feeding behavior in corn.

On July 1, the birds left their roost cavities at 06:34. They started feeding in corn at 09:29 and were in and out until 11:00. From 11:00 through 14:00, there was a gap in observations. Then from 14:00 - 19:29, most of the time was spent in the pine woods. They went back into the cornfield for 25 minutes and on to roost by 20:15. The period between 06:34 - 09:29 was spent in the colony area and feeding on cherries. The corn in House Field was a later planting than in the Butler Field and the corn earworm apparently was not at the "right stage" yet, so the birds worked their way north to the older corn in the Butler Field.

On July 9, departure from roosts was between 06:34 - 06:40. By this date, the earworm larvae in the House Field were advanced in development, and the birds were working the corn close to the roost area by 07:22. They were in and out of the cornfield all morning, until 11:30. Most of the time from 11:30 - 12:40 was spent in the roost area "loafing" and feeding on cherries. From 12:40 - 17:30, the birds made a large circuit of the pine woods. By 17:30, they were back into the cornfield at the House Field and fed for one hour. Then, they went back to the colony area and went to roost at approximately 20:00.

During the early morning of July 22, there was a heavy rainfall as a result of tropical storm Becky, and the Red-cockaded Woodpeckers stayed in their roost cavities until 09:55. Fifteen minutes later, however, they were actively feeding in the cornfield. These birds were in and out of the field until 14:40. Between 14:40 and 17:00 the birds were temporarily lost by the observers. By 17:00, they were back in the House cornfield and remained until 19:20. They then proceeded to roost by 20:00.

The above is the general pattern of movement associated with feeding on the corn earworm by this clan. With seven birds in the clan (Clan A), some are often away from the main group but the overall pattern appears as I have presented it. Both sexes feed on earworms in the same manner, flying from ear to ear. A bird observed pecking into the top of an ear usually indicates success in capture. Sometimes they miss on one side of the ear and go to the opposite side and pull the worm out. The young birds either stay in trees at the edge of the field and the adults bring the earworm caterpillars to them, or the young follow the adults in the field, begging to be fed. The young also attempt to find earworms on their own but I have never seen one succeed.

The corn is harvested in September so there is at least one month of a good food source in this crop. The corn earworm caterpillars, taken by the Red-cockaded Woodpeckers range in size from 12-35 mm. with an average of 20-25 mm. During the all-day watches, the corn earworm was overwhelmingly the major food item of the Red-cockaded woodpecker. My observations indicate that it is a major predator on the corn earworm and probably of local economic importance.

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Table 1.--Number of Red-cockaded Woodpecker holes and corn earworm emergence holes per 100' section of corn row, Plot Field, Tall Timbers Research Station, Leon County, Florida. July 3, 1970.

	ROW NO.							
WOODPECKER HOLES	34	34	31	42	31	39	35	5082*
CORN EARWORM EMERGENCE HOLES	3	20	9	16	6	20	12	----

*A woodpecker usually gets one larva for each hole made so this figure can be assumed to be number of larva taken per acre.

Table 2.--Number of Red-cockaded Woodpecker holes and corn earworm emergence holes per 100' section of corn row, House Field, Tall Timbers Research Station, Leon County, Florida. 1970

	July 3				July 16				July 31			
	Row No.				Row No.				Row No.			
	3	4	15	16	3	4	15	16	3	4	15	16
WOODPECKER HOLES	5	6	5	4	27	34	45	62	-	-	48	61
CORN EARWORM EMERGENCE HOLES	6	6	4	1	11	8	18	9	-	-	23	11
Calculated average woodpecker holes per acre*			726				6098				7913	

*A woodpecker usually gets one larva for each hole made so this figure can be assumed to be the number of larva taken per acre.

SYNOPTIC REVIEW OF FOREST RESOURCE AND USE WITHIN THE RANGE OF THE RED-COCKADED WOODPECKER

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RESOURCE AREA

Although the overall range of the Red-cockaded Woodpecker *(Dendrocopos borealis)* extends from the southeastern Atlantic Coast to Oklahoma and Texas, this paper is confined to the forest resources and birds' range in the following areas of the Southeastern United States: Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, East Texas, and Virginia. (See Tables 1-5). This resource area may be more readily visualized in Figures 1-5 showing the natural range and distribution of the major southern pines: loblolly *(Pinus taeda)*, slash *(P. elliottii)*, longleaf *(P. palustris)*, shortleaf *(P. echinata)* and pond pine *(P. serotina)*. Since the Red-cockaded Woodpecker is found mostly in the afore-mentioned pine types, this paper places emphasis on forest resource data relative to these species.

FOREST RESOURCE STATISTICS

Data on the number of acres in the major pine types and pond pine were extracted for (1) commercial forest land, and (2) non-commercial forest land. The latter was categorized in two forest land classes - (a) productive-reserved areas (productive public forest land withdrawn from timber utilization through statute or administrative regulation) and (b) unproductive areas (forest land incapable of yielding crops of industrial wood because of adverse site conditions). For a definition of this terminology, refer to Appendix.

Non-Commercial Forest Land

The major pine types and pond pine were found on 138 thousand acres of productive-reserved forest land and 299 thousand acres of unproductive forest land, for a total of 437 thousand acres. This acreage represents 9 percent of the 4.7 million acres of non-commercial forest land (Table 1, columns 3 and 13). No breakdown as to acres in sawtimber size-class was attempted here since little to no management was indicated on these lands by their very nature and definition.

Commercial Forest Land

The acreage of greatest magnitude and interest for this paper is the commercial forest land (CFL). All ownerships totaled 189.5 million acres as

Figure 1. Distribution of Loblolly Pine

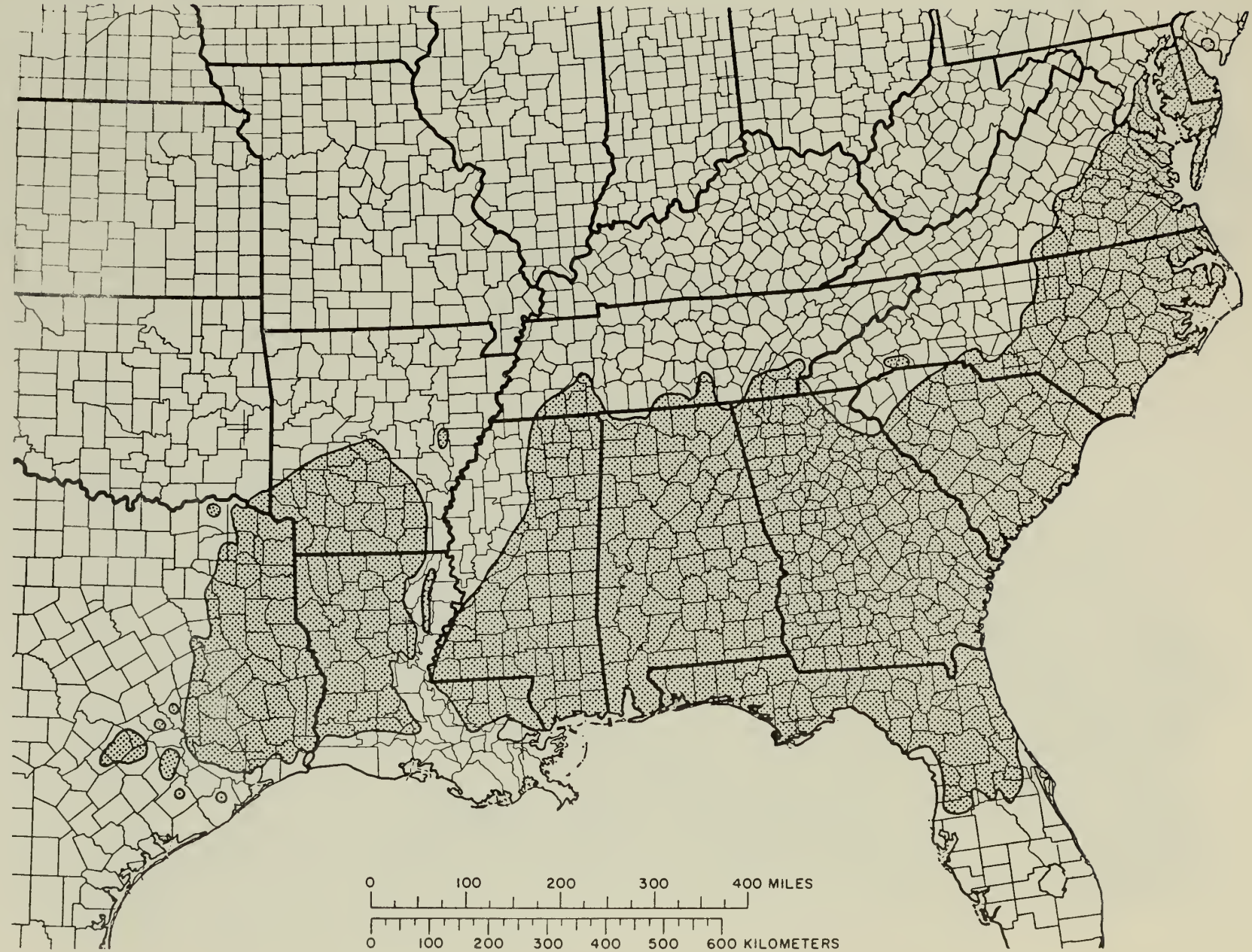


Figure 2. Distribution of Slash Pine

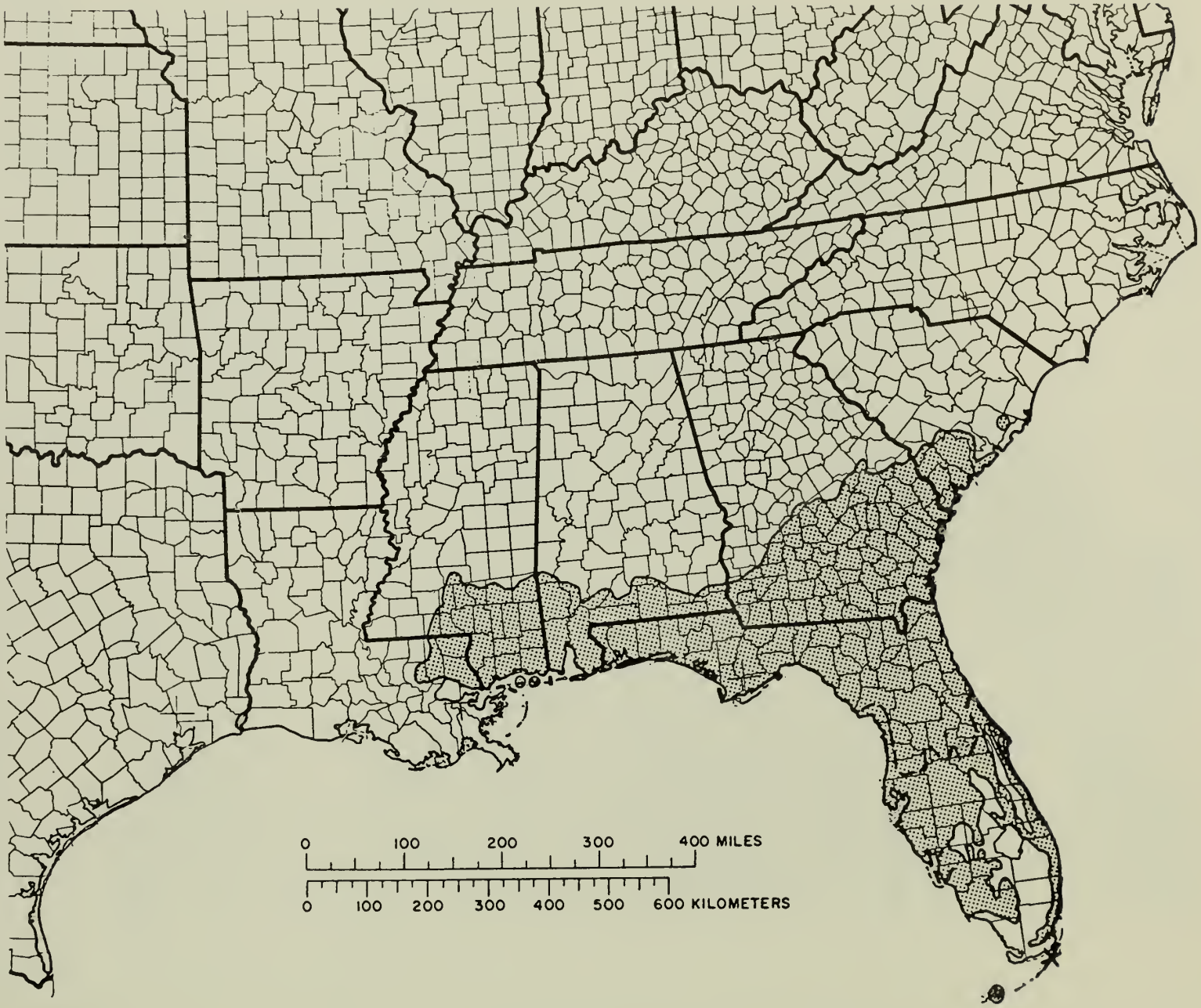


Figure 3. Distribution of Longleaf Pine

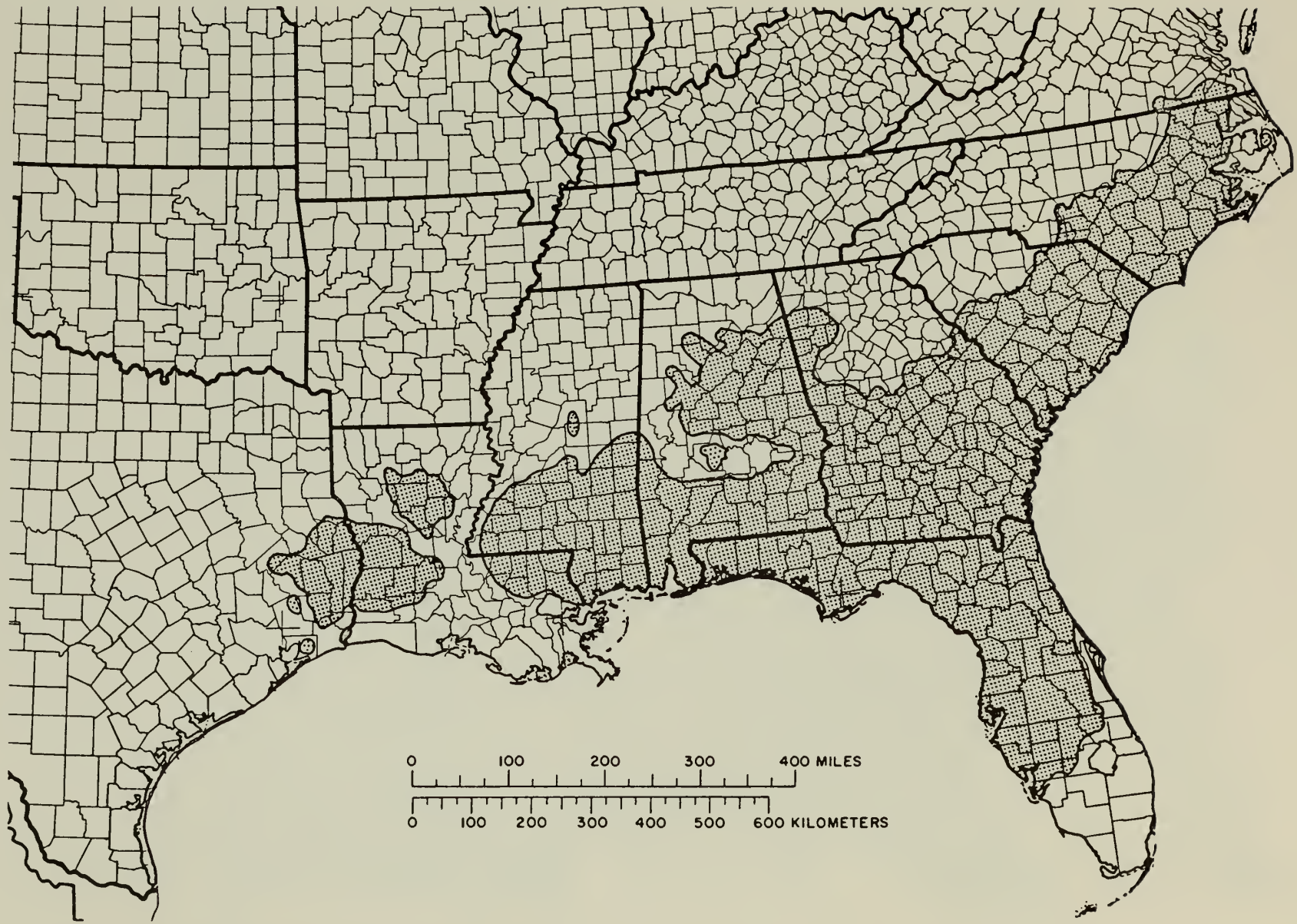


Figure 4. Distribution of Shortleaf Pine

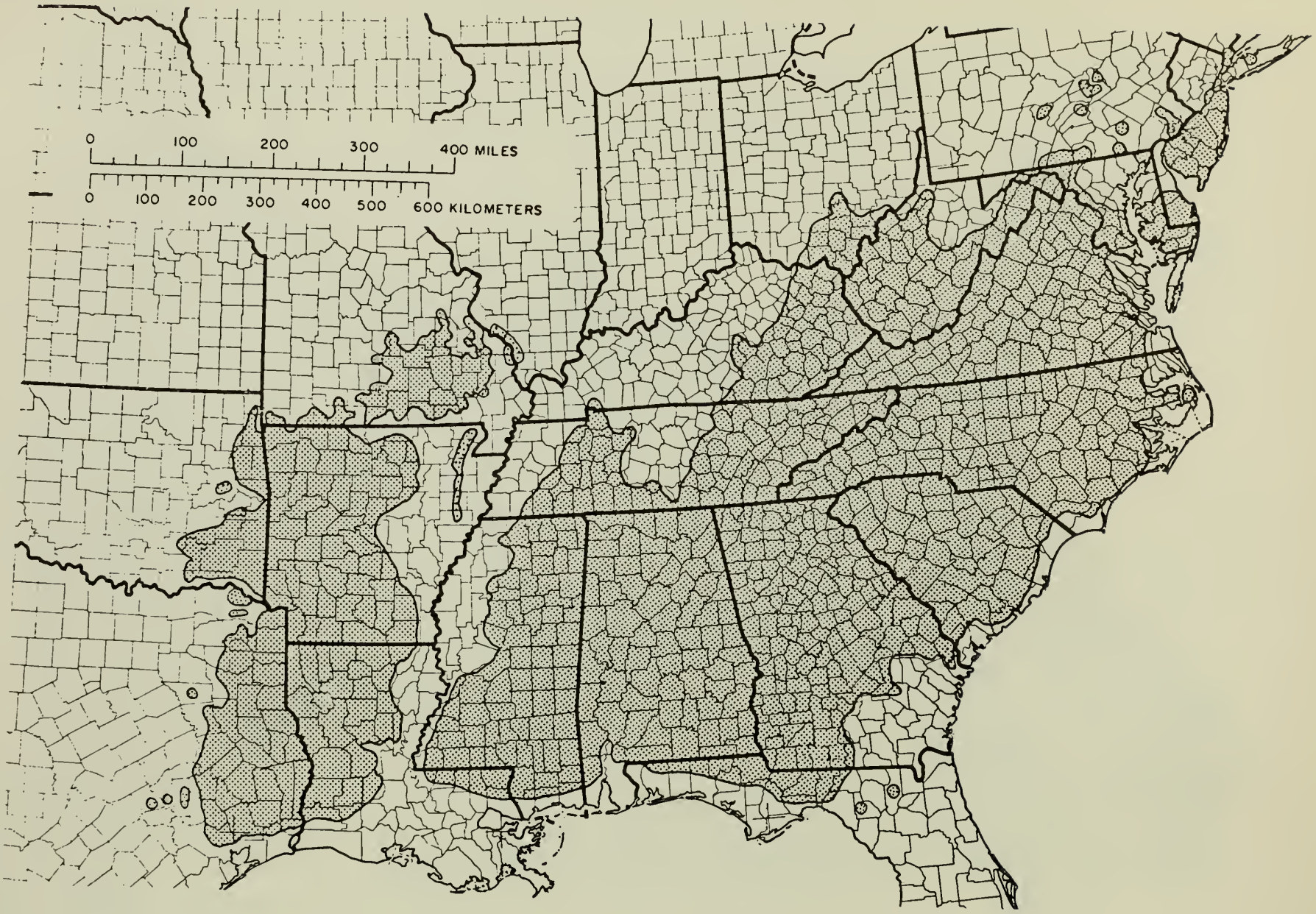
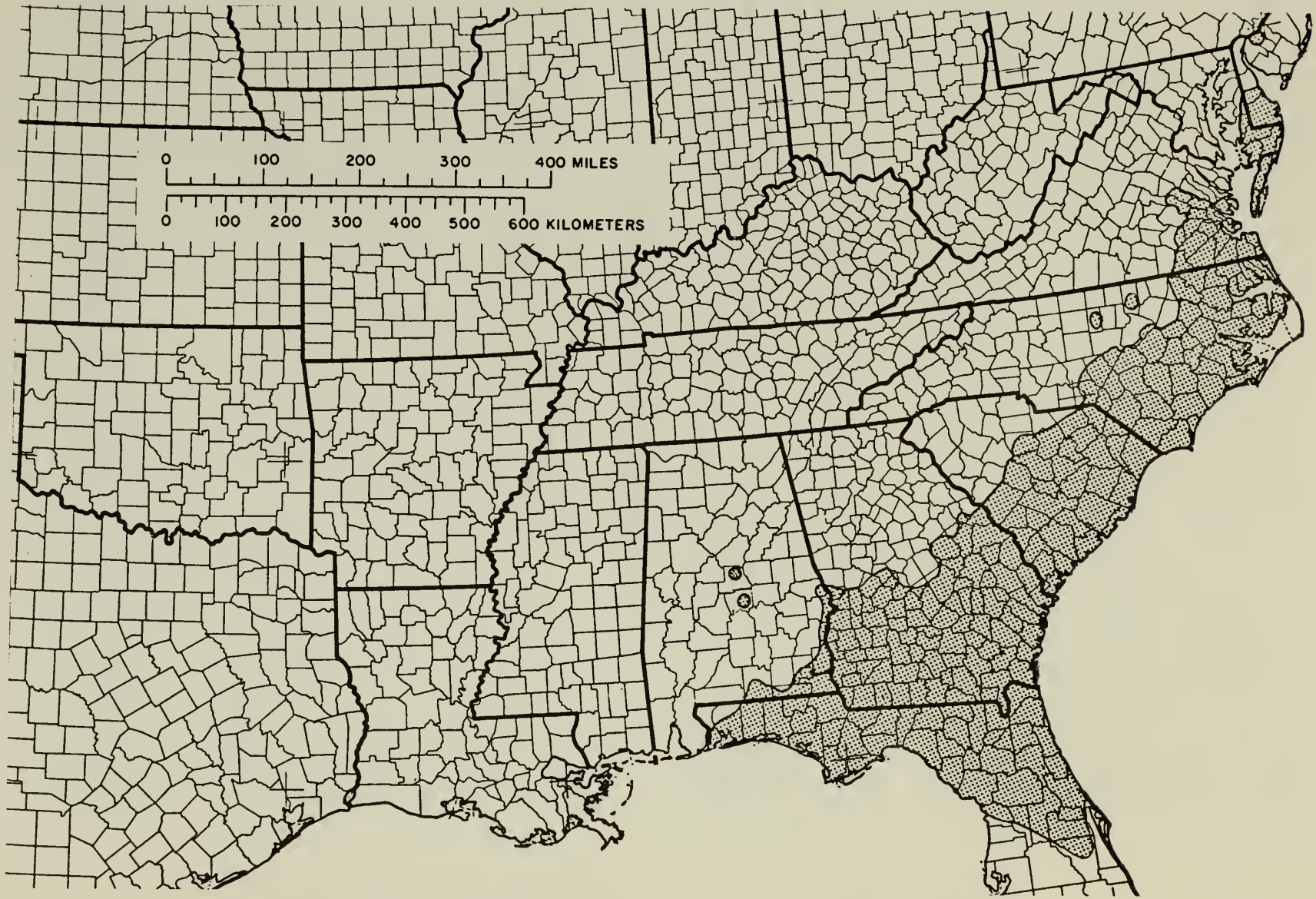


Figure 5. Distribution of Pond Pine



follows: public 17.1 million acres or 9 percent, forest industry 33.4 million acres or 18 percent, farmer 68.6 million acres or 36 percent, and miscellaneous private ownership 70.4 million acres or 37 percent (Table 1, columns 4, 5, 6, 7, and 8).

Sawtimber size-class - All ownerships in the sawtimber size class totaled 75.7 million acres (or 40% of the CFL) divided into these ownership patterns: public 8.5 million acres (11%), forest industry 14.5 million acres (19%), and farmer and miscellaneous private 52.7 million acres (70%). (Table 2).

Major pine types (including pond pine) - All ownerships in this category totaled 64.2 million acres (34% of CFL) and divided into these ownership patterns: public 5.9 million acres (9%), and private 58.3 million acres (91%). (See Table 1, columns 10, 11 & 12).

The area in sawtimber-size-class pine types, including pond pine in which the Red-cockaded Woodpecker may be found - By further extrapolation, about 25.7 million acres or 14 percent of the commercial forest land is in habitat which may be suitable for the Red-cockaded Woodpecker. The ownership pattern, again, indicates a rather small public ownership of 2.3 million acres (9%) and a large private ownership of 23.4 million acres (91%). The private holdings are mostly (70% or over) in farmer and miscellaneous private holdings (Table 2).

FOREST RESOURCE USE WITHIN THE RANGE OF THE RED-COCKADED WOODPECKER

Sawlogs lead all products and pine makes up most of this volume except in the states of Tennessee and Virginia where hardwoods made up 75 and 55 percent of their respective total sawlog output. Pulpwood volumes set record highs throughout most of this region and pulpwood ranked second in product or resource use. Pine made up most of the volume with hardwoods use climbing. [In the state of Arkansas, hardwood pulpwood accounted for most of the 47% increase in pulpwood production from 1958 to 1968 (Beltz, 1970).] Florida, Georgia, Mississippi, and South Carolina ranked pulpwood as the leading forest resource use. Third in ranking of resource use is veneer. Hardwood species made up most of the veneer volume in all states except Arkansas, Georgia and Mississippi. Poles, piling, posts, bolts, cooperage, etc., ranked fourth in forest resource or product use. Southern pine plywood is a new forest industry which has moved into this region with almost unprecedented speed.

FOREST RESOURCE GOALS AND PRACTICES

Much of the information presented by Guttenburg (1969) is applicable to the southeastern region. The following data are taken, almost verbatim from this report: (1) pine types predominate on large ownerships,

(2) upland hardwood acreage comprises less than 10 percent on industrial holdings (tree farms have most of this type--nearly 20 percent). (3) more than four out of five acres controlled by the pulp industry are being regulated to grow pine in 30 years or less, rotations of 20 to 25 years are common, and even on these rotations most managers plan to thin, (4) among private owners, the pulp industry leads in application of the most advanced techniques, (5) other forest industries are chiefly interested in growing sawlogs, veneer, bolts, poles, and piling, yet most of their acreage is being operated under rotations of no longer than 40 to 50 years, and (6) barely 7 million acres of over-mature timber remain, almost entirely in natural stands. The current rate of harvesting and clearing for regeneration is 1.1 million acres. It seems fair to assume that the largest share of this acreage is over-mature timber, and hence, will be liquidated within a decade.

CONCLUSIONS

Guttenberg (1969) says, "As the managers of today's large tracts, still chiefly industrial, further intensify their practices, they are certain to continue in their role of model for other landowners."

Larson and Spada (1963) state that studies show that those who own 500 acres or upwards are more likely to be engaged in forestry than those with smaller woodland areas. Programs beamed at holders of the smaller acreage have, to date, left these people relatively untouched.

It appears that we have a large undertaking before us if we are to preserve suitable timberland for the Red-cockaded Woodpecker.

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APPENDIX

DEFINITIONS OF TERMS

Land Use Classes

Forest Land--Land at least 10 percent stocked by forest trees of any size, or formerly having such tree cover, and not currently developed for nonforest use.

Commercial forest land--Forest land which is producing or is capable of producing crops of industrial wood and not withdrawn from timber utilization by statute or administrative regulation. Includes areas suitable for management to grow crops of industrial wood generally capable of producing in excess of 20 cubic feet per acre of annual growth. Includes both accessible and inaccessible areas.

Noncommercial forest land--Unproductive forest land incapable of yielding crops of industrial wood because of adverse site conditions, and productive forest land withdrawn from commercial timber use through statute or administrative regulation.

Productive-reserved forest land--Productive public forest land withdrawn from timber utilization through statute or administrative regulation.

Unproductive forest land--Forest land incapable of yielding crops of industrial wood because of adverse site conditions. Includes sterile or poorly drained forest land and steep rocky areas where topographic conditions are likely to prevent management for timber production.

Nonforest land--Land that has never supported forests and lands formerly forested where use of timber is precluded by development for nonforest uses, such as crops, improved pasture, residential areas, and city parks. Also includes improved roads and adjoining rights-of-way, powerline clearings, and certain areas of water classified by the Bureau of the Census as land. Unimproved roads, streams, canals, and nonforest strips in forest areas must be more than 120 feet wide, and clearings in forest areas must be more than one acre in size, to qualify as nonforest land.

Cropland--Land under cultivation within the past 24 months, including orchards and land in soil improving crops, but excluding land cultivated in developing improved pasture. Also includes idle farmland that has not been tended within the past 24 months, but is less than 10 percent stocked with trees.

Pasture and range--Land which is currently improved for grazing by cultivation, seeding, irrigation, fencing, or clearing of wood or brush growth, including land forested but developed for pasture, and open natural rangeland not 10 percent stocked with trees.

Ownership Classes

National Forest--Federal lands which have been designated by Executive order or statute as National Forests or purchase units, and other lands under the administration of the Forest Service.

Other Federal--Federal lands other than National Forests, including lands administered by the Bureau of Land Management, Bureau of Indian Affairs, and miscellaneous Federal agencies.

Indian lands--Tribal lands held in fee by the Federal Government but administered for Indian tribal groups, and Indian trust allotments.

Miscellaneous Federal--Federal lands other than National Forests, lands administered by the Bureau of Land Management and Indian lands.

State--Lands owned by States, or lands leased by States for more than 50 years.

County and municipal--Lands owned by counties or municipalities, or lands leased by these governmental units for more than 50 years.

Forest industry--Lands owned by companies or individuals operating wood-using plants.

Farmer-owned--Lands owned by operators of farms. (A farm is defined as a place operated as a unit of 10 or more acres from which the sale of agricultural products totaled $50 or more annually, or a place operated as a unit of less than 10 acres from which the sale of agricultural products totaled $250 or more annually during the previous year.)

Miscellaneous private--Privately owned lands other than forest, industry or farmer-owned.

Stand-Size Classes

Sawtimber stands--Stands at least 10 percent stocked with growing-stock trees, with half or more of this stocking in sawtimber and poletimber trees, and with sawtimber stocking at least equal to poletimber stocking.

Poletimber stands--Stands at least 10 percent stocked with growing-stock trees, with half or more of this stocking in sawtimber and poletimber trees, and with poletimber stocking exceeding that of sawtimber stocking.

Sapling-seedling stands--Stands at least 10 percent stocked with growing-stock trees with more than half of this stocking in saplings and seedlings.

Nonstocked areas--Commercial forest lands less than 10 percent stocked with growing-stock trees.

Forest Type Groups

White pine-hemlock--Forests in which 50 percent or more of the stand is eastern white pine or hemlock, singly or in combination. (Common associates include birch and maple.)

Spruce-fir--Forests in which 50 percent or more of the stand is spruce or true firs, singly or in combination. (Common associates include white cedar, tamarack, maple, birch, and hemlock.)

Loblolly-shortleaf pine--Forests in which 50 percent or more of the stand is loblolly pine, shortleaf pine, or other southern yellow pines except longleaf or slash pine, singly or in combination. (Common associates include oak, hickory, and gum.)

Oak-pine--Forests in which 50 percent or more of the stand is hardwoods, usually upland oaks, but in which southern pines make up 25-49 percent of the stand. (Common associates include gum, hickory, and yellow-poplar.)

Oak-hickory--Forests in which 50 percent or more of the stand is upland oaks or hickory, singly or in combination, except where pines comprise 25-49 percent, in which case the stand would be classified oak-pine. (Common associates include yellow-poplar, elm, maple, and black walnut.)

Oak-gum-cypress--Bottom-land forests in which 50 percent or more of the stand is tupelo, blackgum, sweetgum, oaks, or southern cypress, singly or in combination, except where pines comprise 25-49 percent, in which case the stand would be classified oak-pine. (Common associates include cottonwood, willow, ash, elm, hackberry, and maple.)

Elm-ash-cottonwood--Forests in which 50 percent or more of the stand is elm, ash, or cottonwood, singly or in combination. (Common associates include willow, sycamore, beech, and maple.)

Maple-beech-birch--Forests in which 50 percent or more of the stand is maple, beech, or yellow birch, singly or in combination. (Common associates include hemlock, elm, basswood, and white pine.)

Table 1.--FOREST RESOURCE STATISTICS* - SOUTHEASTERN UNITED STATES
By States - Areas by Thousand Acres

State and Year (1)	All Land (& water) (2)	Non-comm. Forest Land (3)	Area of Commercial Forest Land by Ownership Classes						Commercial forest land in Major Pine & Pond pine RCWP Found in			Noncommercial forest land in Major pine types & Pond pine RCWP Found in		
			All Ownerships (4)	Total Public (5)	Forest Industry (6)	Farmer (7)	Miscell. Private (8)	Total Private (9)	All Ownerships (10)	Public (11)	Private (12)	All Areas (13)	Productive Reserved Areas (14)	Un-productive Areas (15)
Alabama 1963	32,678.4	27.8	21,742.2	1,001.4 (S%)	4,073.7 (19%)	7,631.7 (35%)	9,035.4 (41%)	20,740.8	9,436.5 (43%)	449.8	8,986.7	20.7	14.1	6.6
Arkansas 1970	33,986.6	--	18,206.7	2,938.5 (16%)	3,950.7 (22%)	4,800.0 (26%)	6,517.5 (36%)	15,268.2	3,668.0 (20%)	594.2	3,073.8	--	--	--
Florida 1969-70	3S,179.4	1,701.3	16,231.6	2,145.5 (13%)	5,216.5 (32%)	2,915.8 (18%)	5,953.8 (37%)	14,086.1	7,679.0 (47%)	1,014.7	6,664.3	221.7	18.7	203.0
Georgia 1963	37,382.7	67.2	25,772.2	1,840.9 (7%)	3,946.4 (16%)	1S,053.8 (58%)	4,931.9 (19%)	23,931.3	12,824.4 (50%)	647.9	12,176.5	43.2	7.2	36.0
Louisiana 1965	28,867.9	38.2	16,036.5	883.2 (6%)	3,180.8 (20%)	2,419.6 (15%)	9,552.9 (59%)	1S,153.3	5,659.4 (35%)	429.4	5,230.0	38.2	38.2	--
Mississippi 1969	30,290.8	21.3	16,891.9	1,770.2 (10%)	2,S05.1 (15%)	6,204.6 (37%)	6,412.0 (38%)	15,121.7	5,S78.0 (33%)	807.6	4,770.4	6.7	6.7	--
N. C. 1966	31,367.3	420.8	20,027.3	1,743.0 (9%)	2,495.2 (12%)	9,332.9 (47%)	6,466.2 (32%)	18,284.3	6,104.2 (30%)	484.4	5,619.8	49.4	20.0	29.4
S. C. 1968	19,366.0	82.9	12,410.7	1,073.2 (9%)	2,047.4 (16%)	4,995.6 (35%)	4,294.5	11,337.5	5,258.4 (42%)	661.9	4,596.5	5.9	5.9	--
Tenn. 1962	26,522.1	263.5	13,432.4	1,199.1 (9%)	945.9 (7%)	5,911.8 (44%)	5,375.6 (40%)	12,233.3	1,113.0 (8%)	151.9	961.1	12.3	12.3	--
E. Texas 1967	31,528.0	1,532.1	12,924.3	82S.5 (6%)	3,496.5 (27%)	2,405.8 (19%)	6,196.5 (48%)	12,098.8	S,396.9 (42%)	607.3	4,789.6	22.2	3.2	19.0
Virginia 1966	2S,502.2	529.7	15,809.3	1,671.9 (10%)	1,562.3 (10%)	6,958.2 (44%)	5,616.9 (36%)	14,137.4	1,457.5 (9%)	53.5	1,404.0	16.1	11.4	4.7
Total 11 & Avg.	332,671.4	4,684.8	189,48S.1	17,092.4 (9%)	33,420.5 (18%)	68,619.0 (35%)	70,353.2 (38%)	172,392.7	64,175.3 (33%)	5,902.6	58,272.7	436.4	137.7	298.7

* Statistics abstracted from: 8ellamy & Herbert, 1970; 8eltz, 1970; Hedlund & Earles, 1970; Knight, 1969; Knight & McClure, 1966, 1968, 1971; Larson & Spada, 1963; McClure, 1970; Snyder & Knight, 1970; Sternitzke, 1962, 1963, 1965, 1967, 1969; Van Sickle & Van Hooser, 1969.

Table 2.--Area of commercial forest land by stand-size and ownership classes

	Sawtimber					Poletimber					Sapling & Seedling					Non-Stocked Areas				
	All Ownerships	National Forest	Other Public	Forest Industry	Farmer & Misc. Private	All Ownerships	National Forest	Other Public	Forest Industry	Farmer & Misc. Private	All Ownerships	National Forest	Other Public	Forest Industry	Farmer & Misc. Private	All Ownerships	National Forest	Other Public	Forest Industry	Farmer & Misc. Private
	Thousand acres					Thousand Acres					Thousand Acres					Thousand Acres				
Alabama 1968	8,885.3	431.5	201.4	1,885.4	6,367.0	5,224.0	116.4	76.4	888.5	4,142.7	7,468.5	81.8	93.9	1,283.3	6,009.5	164.4	. . .	. . .	16.5	147.9
Arkansas 1969	5,443.4	713.1	168.7	1,181.2	3,380.4	4,759.5	623.5	147.6	1,032.8	2,955.6	7,922.1	1,037.8	245.6	1,719.1	4,919.6	81.7	10.8	2.5	17.7	50.7
Florida 1969-70	4,987.8	319.2	349.1	1,596.1	2,723.4	4.150.9	265.7	290.6	1,328.3	2,266.3	4,529.2	289.9	317.0	1,449.3	2,473.0	,563 7	164.0	179.5	820.4	1,399.8
Georgia 1961	8,592.2	472.1	450.5	1,331.2	6,338.4	4,720.8	161.6	178.0	724.7	3,656.5	11,720.2	139.7	374.4	1,740.9	9,465.2	739.0	. . .	64.4	149.6	524.8
Louisiana 1964	9,871.0	412.5	211.6	2,196.2	7,050.7	2,017.6	53.9	20.7	292.6	1,650.4	3,952.4	103.2	74.7	669.7	3,104.8	195.5	5.2	1.4	22.3	166.6
Mississippi 1967	4,557.9	528.0	258.6	839.6	2,931.7	3,772.2	149.9	139.2	506.6	2,976.5	8,427.9	440.9	241.2	1,154.4	6,591.4	133.9	. . .	12.4	4.5	117.0
N. C. 1964	10,486.0	757.9	413.3	1,185.7	8,129.1	4,224.4	189.9	122.2	491.3	3,421.0	5,132.4	104.7	138.0	779.0	4,110.7	184.5	3.2	13.8	39.2	128.3
S. C. 1968	4,907.6	368.0	213.6	880.0	3,446.0	3,455.2	136.9	132.9	511.4	2,674.0	3,649.4	46.0	153.4	613.6	2,836.4	398.5	. . .	22.4	42.4	333.7
Tennessee 1961	5,634.8	443.4	313.5	430.0	4,447.9	4,041.6	103.2	177.5	324.1	3,436.8	3,591.3	44.7	116.8	191.8	3,238.0	164.7	. . .	. . .	. . .	164.7
E. Texas 1967	7,018.5	515.5	102.5	2,510.9	3,889.6	2,185.8	37.5	22.0	320.4	1,805.9	3,622.1	69.3	78.7	647.8	2,826.3	97.9	. . .	. . .	17.4	80.5
Virginia 1966	5,293.5	619.5	199.6	429.9	3,981.5	5,996.9	492.5	199.9	481.0	4,793.5	4,452.4	75.8	69.3	582.6	3,724.7	96.5	15.0	0.3	5.8	75.4

Table 3.--Area of commercial forest land by forest types and ownership classes

	Longleaf-Slash Pine			Loblolly-Shortleaf Pine			Pond Pine			Sand Pine			Virginia Pine			Oak-Pine		
	All Ownerships	Public	Private	All Ownerships	Public	Private	All Ownerships	Public	Private	All Ownerships	Public	Private	All Ownerships	Public	Private	All Ownerships	Public	Private
	Thousand acres			Thousand acres			Thousand acres			Thousand acres			Thousand acres			Thousand acres		
Alabama 1963	1,998.7	144.3	1,854.4	7,437.8	305.5	7,132.3	---	---	---	---	---	---	---	---	---	4,834.9	22.4	4,614.5
Arkansas 1969	---	---	---	3,668.0	594.2	3,073.8	---	---	---	---	---	---	---	---	---	3,039.6	492.4	2,547.2
Florida 1969-70	6,956.5	928.4	3,028.1	378.9	---	34.5	343.6	81.8	261.8	505.9	277.7	228.2	---	---	---	1,669.1	303.3	1,365.8
Georgia 1961	5,709.9	274.7	5,435.2	6,810.0	353.7	6,456.3	304.5	19.5	285.0	---	---	---	300.4	35.4	265.0	3,639.9	289.2	3,350.7
Louisiana 1964	1,220.1	151.5	1,068.6	4,439.3	277.9	4,161.4	---	---	---	---	---	---	---	---	---	2,169.4	135.0	2,034.7
Mississippi 1967	1,335.4	283.8	1,051.6	4,242.6	523.8	3,718.8	---	---	---	---	---	---	---	---	---	3,372.0	402.2	2,969.8
N. C. 1964	494.6	102.5	392.1	4,201.0	153.3	4,046.7	1,408.6	227.6	1,181.0	---	---	---	789.1	8.9	780.2	3,556.6	230.2	3,326.4
S. C. 1968	1,081.5	191.5	890.5	3,791.5	429.7	3,361.8	385.4	40.7	344.7	---	---	---	162.6	10.9	151.7	2,124.8	154.0	1,970.8
Tennessee 1961	---	---	---	1,113.0	151.9	961.1	---	---	---	---	---	---	---	---	---	922.7	153.7	769.0
E. Texas 1967	358.5	10.6	347.9	5,038.4	596.7	4,441.7	---	---	---	---	---	---	---	---	---	2,354.0	64.2	2,289.8
Virginia, 1966	---	---	---	1,454.9	53.5	1,401.4	2.6	---	2.6	---	---	---	1,245.7	71.3	1,174.4	2,537.3	210.5	2,326.8

Table 4.--Area of noncommercial forest land by forest types.

	Longleaf-Slash Pine			Loblolly-Shortleaf Pine			Oak-Pine		
	All Areas	Productive-reserved Areas	Un-Productive Areas	All Areas	Productive-reserved Areas	Un-Productive Areas	All Areas	Productive-reserved Areas	Un-Productive Areas
	-------Thousand acres-------			-------Thousand acres-------			-------Thousand acres--------		
Alabama 1963	---	---	---	20.7	14.1	6.6	6.2	6.2	---
Arkansas 1969	---	---	---	---	---	---	---	---	---
Florida 1970	221.7	18.7	203.0	---	---	---	5.0	1.7	3.3
Georgia 1961	20.1	0.4	19.7	23.1	6.8	16.3	11.5	1.8	9.7
Louisiana 1964	35.0	35.0	---	3.2	3.2	---	---	---	---
Mississippi 1967	2.0	2.0	---	4.7	4.7	---	9.7	9.7	---
N. C. 1964	---	---	---	49.4	20.0	29.4	11.6	10.5	1.1
S. C. 1968	3.4	3.4	---	2.5	2.5	---	12.4	12.4	---
Tennessee 1961	---	---	---	---	12.3	---	---	43.2	---
E. Texas 1967	0.1	0.1	---	22.1	3.1	19.0	21.8	2.6	19.2
Virginia 1966	---	---	---	16.1	11.4	4.7	68.8	56.0	12.8

Table 5.--Softwood types in which Red-cockaded Woodpeckers are found

	Commercial Forest Land									Non-Commercial Forest Land					
	Longleaf-Slash Pine			Loblolly-Shortleaf Pine			Pond Pine			Longleaf-Slash Pine			Loblolly-Shortleaf Pine		
	All Ownerships	Public	Private	All Ownerships	Public	Private	All Areas	Productive Reserved Areas	Un-Productive Areas	All Areas	Productive-Reserved Areas	Un-Productive Areas	All Ownerships	Public	Private
	Thousand acres			Thousand acres			Thousand acres			Thousand acres			Thousand acres		
Alabama 1963	1,998.7	144.3	1,854.4	7,437.8	30S.5	7,132.3	---	---	---	---	---	---	20.7	14.1	6.6
Arkansas 1970	---	---	---	3,668.0	594.2	3,073.8	---	---	---	---	---	---	---	---	---
Florida 1969-70	6,966.5	928.4	6,028.1	378.9	4.5	374.4	343.6	81.8	261.8	221.7	18.7	203.0	---	---	---
Georgia 1961	5,709.9	274.7	5,435.2	6,809.0	353.7	6,456.3	304.5	19.5	285.0	20.1	0.4	19.7	23.1	6.8	16.3
Louisiana 1964	1,220.1	151.5	1,068.6	4,439.3	277.9	4,161.4	---	---	---	35.0	35.0	---	3.2	3.2	---
Mississippi 1967	1,335.4	283.8	1,051.6	4,242.6	523.8	3,718.8	---	---	---	2.0	2.0	---	4.7	4.7	---
N. C. 1966	494.6	102.5	392.1	4,201.0	154.3	4,046.7	1,408.6	227.6	1,181.0	---	---	---	49.4	20.0	29.4
S. C. 1968	1,181.5	191.5	890.0	3,791.5	429.7	3,361.8	385.4	40.7	344.7	3.4	3.4	---	2.5	2.5	---
Tennessee 1961	---	---	---	1,113.0	151.9	961.1	---	---	---	---	---	---	---	2.3	---
E. Texas 1967	358.5	12.6	347.9	5,038.4	S96.7	4,441.7	---	---	---	0.1	0.1	---	22.1	3.1	19.0
Virginia 1966	---	---	---	1,454.9	53.5	1,401.4	2.6	---	2.6	---	---	---	16.1	11.4	4.7

TIMBER MANAGEMENT PRACTICES FOR RED-COCKADED WOODPECKERS ON FEDERAL LANDS

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INTRODUCTION

The Red-cockaded Woodpecker *(Dendrocopos borealis)* occurs in several locations of the Coastal Plains and Piedmont on Federally owned lands. The inclusion of the bird on the list of rare and endangered fish and wildlife of the United States has caused several man-days of anxiety for both timber and wildlife managers on these lands.

Management of this bird on Federal lands can now be considered at least a warm if not sometimes a hot issue. Some land managers feel that the timber rotation age presently established on most Federal lands in the South will automatically provide suitable habitat. Others feel that the bird can only be protected and maintained on these and other lands by making special considerations and implementing planned Red-cockaded Woodpecker habitat management.

PAST MANAGEMENT

The exact year when some Federal land manager or managers recognized the threatened condition of the Red-cockaded Woodpecker habitat is unknown, but real concern for the species probably began in the mid-1960's. National Forest lands in the South by this time were being regenerated at a relatively high rate and some managers could see the virtual elimination of old-growth or residual trees within 15 to 20 years. Enough was known about the bird to recognize that old-growth trees with red-heart disease *(Fomes pini)* were essential to meet the habitat requirements of the species and that steps must be taken to protect nest trees and provide some trees for future nesting.

The first concession made in recognition of the bird was to refrain from marking those trees which had the very evident nest cavity. This of course was, and still is, in areas where it continues to be practiced, a fraudulent attempt of management and probably done only to squelch or minimize harassment from local bird watchers or other "pseudo-conservationists."

On Federal lands where timber management activities were not as pronounced as on National Forests, areas where Red-cockaded Woodpeckers occurred were either excluded from timber sale activities or nest trees were left with variable size buffer areas around them. The buffer areas were supposed to provide future nesting habitat and also serve as a feeding area for the birds which were present.

PRESENT MANAGEMENT

Managers usually think of past management practices as being inadequate, poorly conceived, and generally inferior to what is being practiced at the moment. They usually believe that present management reflects good judgment and is adequate to get the desired job accomplished. Perhaps this is the case in many instances of present management of Red-cockaded Woodpeckers on Federal lands today.

Several timber management practices are being conducted on Southern Federal lands to insure present and future nesting habitat for the species. The following are some of these practices:

1. Leave at least 10 to 20 older trees in a cluster around single nest cavity trees for protection of the trees and for replacement if the cavity trees die. Where there is a group of cavity trees close together, leave mature trees or trees approaching maturity intermingled with the cavity trees and a buffer strip of trees around the outside of the cavity tree group about one chain wide.

2. In cases where older trees are scarce around nest cavity trees, a replacement group should be retained nearby. The decision to leave nearby replacement tree groups will depend upon the age classes of adjacent stands. If a stand in the 60/year age class is located within 1/4 mile of the active colony, it should provide the needed replacements beyond those surrounding the cavity trees. A younger stand with some older pine residuals that will be retained, may also serve this purpose.

3. In stands where nest trees are present, leave a nesting site consisting of nest trees and all other intermingled trees with a minimum area of one acre.

4. Leave a minimum undisturbed radius of 100 feet around each nest tree and provide replacement trees throughout areas inhabited by Red-cockaded Woodpeckers. The use of judgment and common sense is vital to the selection of these replacement trees.

5. Leave as a minimum, a three-chain buffer area around each nest tree.

These present timber management practices are certainly worthwhile and are assets toward the management of the Red-cockaded Woodpecker on Federal lands in the South. They do, however, lack the consideration of the total habitat needs of the species since they specifically seek to provide present and future nest habitat only.

FUTURE MANAGEMENT

Most management of Red-cockaded Woodpeckers on Federal lands in the future will be done in areas classified as "Red-cockaded Woodpecker Management Areas." In these areas, the bird will be the top priority management item and all activities will be geared for the betterment of the species. As to exactly what will be done or what timber management practices will be conducted is, at this time, non-formalized. These management areas will probably be strategically located to provide public access and observation.

A guide for managing the Ocala National Forest for the period 1971-1980 has recently been completed. One of the general policy statements in this guide states, "Establish non-consumptive wildlife areas to protect and observe wildlife and endangered species." Included under timber management policies in this same guide is the explanation of "Service Management" which is a type of timber management modified to achieve specific goals. Under this type of management, the timber is manipulated, along with other vegetation, to support management objectives not compatible with sustained yield. There will be no established rotation or acreage control. Single trees or areas of trees may be left to mature and die. Cutting may be by single tree, groups, or stands. Certainly these policy statements made in a guide for management of a National Forest shed rays of light for management of the Red-cockaded Woodpecker on all Federal lands.

TIMBER MANAGEMENT PRACTICES

FOR

RED-COCKADED WOODPECKERS ON STATE LANDS

Charles R. Shaw
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INTRODUCTION

This is a resume of information gathered for presentation at the Symposium on the Ecology and Management of the Red-cockaded Woodpecker held May 26-27 at the Visitor Center, Okefenokee Wildlife Refuge.

All States within the historical breeding range of the Red-cockaded Woodpecker were sent questionnaires as shown in Figure 1. Inquiry disclosed that there was no knowledge of these birds being present at this time in the peripheral states of Maryland, West Virginia and Kansas.

Information was requested of the activities by three state agencies: the game department, the forestry department and the parks department. In some instances, various combinations of the agencies occurred within individual states.

RESULTS

Answers to the questionnaires are shown in Tables 1, 2, 3, and 4. A brief discussion by states follows to amplify or clarify the information in the tables.

Alabama - The only information is shown in the tables.

Arkansas - The state forestry department reports that it has no timber suitable for nesting; i.e., no old growth, redheart pines.

Florida - Data indicates that the Red-cockaded Woodpecker is not endangered in Florida. Audubon Society has given lots of publicity. State parks report cutting of trees is prohibited, therefore, mature pines will be available as nest trees. Interpretive naturalists have received instruction from staff of Tall Timbers Research Station where studies concerning the Red-cockaded Woodpecker are in progress. This is being disseminated through interpretive activities.

Figure 1.--Sample questionnaire on management practices on Red-cockaded Woodpecker

QUESTIONNAIRE ON MANAGEMENT FOR RED-COCKADED WOODPECKER

1. Have any provisions been made to modify timber management plans in order to preserve Red-cockaded Woodpecker habitat on state owned lands managed by:

   a. The state wildlife agency: Yes ( ) No ( )

   b. The state forestry agency: Yes ( ) No ( )

   c. The state parks agency: Yes ( ) No ( )

2. How many areas or sites are involved if above answer is Yes?

   a. The state wildlife agency: _____

   b. The state forestry agency: _____

   c. The state parks agency: _____

3. How many known active nests of the Red-cockaded Woodpecker have been recorded on state owned lands operated by:

   a. The state wildlife agency: _____

   b. The state forestry agency: _____

   c. The state parks agency: _____

4. What publicity has been given the plight of this bird by:

   a. The state wildlife agency: _____

   b. The state forestry agency: _____

   c. The state parks agency: _____

Your helpful cooperation in filling out this questionnaire and returning it to the address below is greatly appreciated.

Georgia - The only information is shown in the tables.

Kentucky - The only information is shown in the tables.

Louisiana - The Louisiana Wild Life & Fisheries lands are hardwoods or marshes where these birds do not nest. Some publicity has been given relative to this bird in other areas.

Mississippi - Considerable publicity has been given this bird by the state game department and the Mississippi Ornithological Society in news releases, news letters, etc.

Missouri - States that the questionnaire is not really applicable since the bird is believed extirpated in Missouri. If resident, the department would modify management to preserve suitable habitat and is in fact planning to allow stands in some areas to become over-mature for various reasons.

North Carolina - Weymouth Woods - Sandhills Nature Preserve has three active nests which are featured in the interpretive program offered there.

Oklahoma - The McCurtain Co. Wilderness Area containing approximately 15,000 acres is managed as a wilderness area by the Oklahoma Department of Wildlife Conservation. This is considered the last virgin forest in Oklahoma and is the area where seven nests were reported in 1961-62.

South Carolina - In addition to developing guidelines for the preservation of the Red-cockaded Woodpeckers, much attention has been given at professional meetings, etc. They have recommended to landowners that they lease the nesting areas for their protection.

Tennessee - The Game and Fish Commission has one small population of Red-cockaded Woodpeckers on the Catoosa Wildlife Management Area. They control the timber management operation so that it is not detrimental to this population.

Texas - Although the state wildlife agency has no land occupied by Red-cockaded Woodpeckers, through news releases and magazine articles has given the birds considerable publicity.

Virginia - Forester works with private landowners to safeguard birds.

Table 1. Provisions made to modify timber management plans in order to preserve Red-cockaded Woodpecker habitat on state owned lands by: Game Dept., Forestry Dept. or Parks Dept.

	Game Dept.	Forestry Dept.	Parks Dept.
Alabama	No	No	No
Arkansas	Yes	No	Yes
Florida	No	Yes	Yes
Georgia	--	No	No
Kentucky	No	No	No
Louisiana	No	No	No
Mississippi	Yes	No	Yes
Missouri	No	No	No
North Carolina	No	No	Yes
Oklahoma	Yes	No	No
South Carolina	Yes	Yes	Yes
Tennessee	Yes	No	No
Texas	No	Yes	No
Virginia	No	Yes	Yes
Totals	61% No 38% Yes	71% No 28% Yes	57% No 42% Yes

Table 2. Areas or sites having Red-cockaded Woodpeckers: Game Dept., Forestry Dept. and Parks Dept.

	Game Dept	Forestry Dept.	Parks Dept.
Alabama	211,912.56 acres owned	N/A	18,000 acres
Arkansas	--	--	--
Florida	--	4 forests 301,000 acres	30
Georgia	--	--	--
Kentucky	--	--	--
Louisiana	--	--	--
Mississippi	Possibly 2	None Known	All state parks in pine region
Missouri	--	--	--
North Carolina	--	--	--
Oklahoma	1 (McCurtain Co. Wilderness Area)	--	--
South Carolina	All lands owned	3 state forests (123,000 acres)	4 state parks (12,000 acres)
Tennessee	1	2	Same as forestry
Texas	--	5 state forests (3 with nest trees)	--
Virginia	--	--	15

Table 3. Known active nests of the Red-cockaded Woodpecker recorded on state owned lands operated by: Game Dept., Forestry Dept. and Parks Dept.

	Game Dept.	Forestry Dept.	Parks Dept.
Alabama	1	0	?
Arkansas	?	?	?
Florida	no survey	6	none
Georgia	?	none	--
Kentucky	none	none	none
Louisiana	none	none	?
Mississippi	none known	none known	none known
Missouri	--	none	unknown
North Carolina	none known	none known	3 (Weymouth Woods)
Oklahoma	7 (1961-62 survey)	--	1 pair 1968
South Carolina	Unknown	2,300 est. nest trees, unknown # active	250 ? trees but unknown # active
Tennessee	1 (6 recorded 3 years ago)	unknown	unknown
Texas	1	45 trees w/holes being used	--
Virginia	none	none	unknown

Table 4.--Publicity given the plight of this bird by: Game Dept., Forestry Dept., and Parks Dept.

	Game Dept.	Forestry Dept.	Parks Dept.
Alabama	None	None	None
Arkansas	Normal news releases & quarterly publications.	Recording nests	Letters to all supervisors.
Florida	Not considered endangered	Verbal programs	Regular channels
Georgia	None	None	None
Kentucky	None	None	None
Louisiana	Magazine articles	None	None
Mississippi	Magazine articles, newspapers, M.O.S. newsletters	None known	None known
Missouri	--	None	None
North Carolina	None known	None known	Interpretive programs
Oklahoma	Magazine & news releases	--	--
South Carolina	Dept. only	Guidelines & meetings (See discussion)	None
Tennessee	None	None	None
Texas	Magazines & articles (color cover)	News releases	--
Virginia	None	News release	None

RED-COCKADED WOODPECKERS ON INTERNATIONAL PAPER COMPANY LANDS

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Southlands Experiment Forest
International Paper Company
Bainbridge, Georgia

We have had several colonies of Red-cockaded Woodpeckers *(Dendrocopos borealis)* under observation for the past 10 years at International Paper Company's Southlands Experiment Forest. This Experiment Forest is located in the southwest corner of Georgia, approximately 15 miles south of the town of Bainbridge. The colonies are in a 1,200-acre stand of 40- to 60-year old longleaf pine *(Pinus palustris)*. This stand is relatively free of hardwood understory and the herbaceous community is predominantly wire grass *(Aristida* sp.*)* and bracken fern *(Pteridium aquilinum)*. Twenty four trees containing nest cavities, roosting cavities or "start" holes, have been marked with a white band and an identifying number. The area has been prescribed burned each spring for the past 10 years for quail management purposes. Prior to burning, the litter has been raked away from the base of the marked trees. Last year (1970) approximately one-half of the area received a light thinning from below.

In 1968, the area contained a total of 20 to 25 Red-cockaded Woodpeckers and at least four active nests. This year (1971), there appears to be a marked decline in the overall population, and only one active nest has been observed.

On April 8, 1969, International Paper Company's Southern Kraft Division Woodlands Department issued a policy statement on the Red-cockaded Woodpecker affecting five million acres of company-owned land scattered from western Arkansas to southern North Carolina. This policy stated that the company would not cut any Red-cockaded Woodpecker nest trees, and it indicated that some surrounding trees would also be left.

At first, no one within the company had any information concerning management procedures for this species; consequently, the foresters began saving any living pine trees containing holes. These were generally left with groups of 12 to 20 surrounding trees; however, a few individual trees were left standing alone within "clearcuts." In a few instances, 20- to 40-acre blocks of land containing several nest trees were left unharvested.

A recent survey indicates that, of the single trees containing nest cavities, only a small percentage are still being used by Red-cockaded Woodpeckers; of the trees that were left in groups of 12 to 20 surrounding trees, a high percentage have died, particularly in Alabama.

At present, we have marked a total of 350 pines that are thought to be nest trees. Fifty of these were left as single trees with all surrounding trees clearcut. Two hundred were left with 12 to 20 surrounding trees, and approximately 100 were left in uncut blocks of 5 to 40 acres. Less than 1 percent of these marked trees have been struck by lightning. It is doubtful that many additional Red-cockaded Woodpecker colonies will be located on Company lands.

It is thought that the best method for us to manage these woodpeckers is to set aside blocks of 20 to 40 acres, containing one or more colonies. These blocks should be prescribed burned regularly and thinned from below, leaving obvious red heart trees.

SOME OBSERVATIONS AND COMMENTS ON THE RED-COCKADED WOODPECKER IN THE THOMASVILLE-TALLAHASSEE GAME PRESERVE REGION

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The private game preserves in the Thomasville, Georgia-Tallahassee, Florida region today have one of the higher populations of Red-cockaded Woodpeckers *(Dendrocopos borealis)* that exists for any comparable area. This can be credited primarily to the magnificent stands of older age-class timber that continue to exist in the area. A brief examination of the history of these timber stands would reveal that they consist of two basic types: (1) the longleaf pine type occurring on "virgin" soil; i.e., land that has never undergone an intense agricultural cycle, and (2) the mixed pine stands occurring on old-field land, primarily the abandoned cotton fields that were begun in the pre-civil war period. The longleaf stands are basically all-age forests with the older trees 200-400 years of age. The old-field stands are for the most part a loblolly-shortleaf mixture with the older trees 80-100 years old. These stands have been under intense forest management since 1941, when Herbert L. Stoddard, Sr., formed a consulting forestry practice, specifically directed at the complex management of the game preserve forests for their wildlife, timber, esthetic and recreational values. There are some noticeable changes after 30 years: (1) While over 250 million board feet of timber have been removed from these stands during this period, there is more timber today on these lands than before, (2) While the timber stands are 30 years older today and much of the older age-class timber remains, many of the stands have been converted to younger, average-age classes by the removal of the older trees.

My impression is that there are fewer Red-cockaded Woodpeckers today than have previously occurred in our area. While populations will surely fluctuate on any property, several of the once prime Red-cockaded Woodpecker timber stands have been eliminated. Inwood Plantation, with its magnificent stands of virgin longleaf, harbored perhaps the highest populations of woodpeckers in the area in the early 1940's when it was sold and the timber was cut. Mr. Stoddard (pers. comm.) considered the Inwood Plantation longleaf stand, where Finney General Hospital was built during World War II and where Georgia Southwestern Hospital now stands, to have had a higher concentration of Red-cockaded Woodpeckers than any other area he had ever known. Mr. N. F. Keadle, an old-time sawmill man of Thomasville who cut the Inwood timber also reported the unusually large number of woodpecker trees found when he cut this stand. There are several other properties in the area that had fine stands of old timber and high populations of woodpeckers in 1950 that no longer

exist because of the removal of the old timber.

Stoddard's management of the game preserve timber stands in the 1940's had little if any effect on the woodpeckers. His selective cutting practices were concerned with the first "culling" of these timber stands and while a red heart tree with a woodpecker cavity is certainly a "cull" tree from the usual foresters' standpoint, most of these trees were left. My management of the same timber stands in the 1950's and 1960's included the second, third and even fourth selective cuts of this timber. Each cut applies more pressure to remove any obvious defect in order to work the most income from the timber stand. In some instances, I have made the final cut as far as the removal of older trees in a stand are concerned, and where colonies of woodpeckers were established, I have left all trees with cavities and hoped that the birds could survive there until the development of more red heart trees. By removing all potential cavity trees in a stand, I have "forced" the woodpeckers into adjacent timber stands known to contain red heart trees. Also, I have "forced" the birds into different species of trees by removal of all potential cavity trees of one species while leaving known red heart trees of another species in a given stand.

To clarify this a bit, I am working on a long-term rotation on these timber stands, and all cutting is on a selective basis. The overall plan is a continuation or development of all-age forests on the shooting land in our area. Close examination of the most natural longleaf stands shows that an all-age forest exists in small even-age groups. If we can perpetuate this system on a rotation long enough to include the development of red heart, then we can perpetuate the Red-cockaded Woodpecker. This is a system that manages for the total wildlife spectrum of which the Red-cockaded Woodpecker is a very important part. This woodpecker is a major factor in the creation of nesting sites and shelter for a variety of other creatures. A brief examination of my notes shows that on March 8, 1962, on Sinkola Plantation, Thomas County, Georgia, an enlarged Red-cockaded Woodpecker cavity contained a Wood Duck *(Aix sponsa)* nest with six eggs. At dusk one evening on Sinkola Plantation after a very bitter afternoon in December 1961, I observed four Bluebirds *(Sialia sialis)* enter an old Red-cockaded Woodpecker cavity obviously to roost in a protected place. On March 29, 1971, on the 'Mitchell Place' of Greenwood Plantation, Thomas County, Georgia, we cut an old loblolly with an enlarged Red-cockaded Woodpecker cavity and found a Grey Squirrel *(Sciurus carolinensis)* nest with two young. I do not have the dates; however, I have seen wild bees *(Apis* sp.*)* occupying old Red-cockaded Woodpecker cavities on several occasions.

The long rotation system also encourages many forms of life in our timber stands that otherwise would not exist there. Why are planted slash pine plantations referred to as biological deserts? One obvious reason, even though there are many, is that there is no defect in the

trees that encourages cavity-nesting or shelter-seeking creatures. The Bluebird, to me, is not a farm land bird of apple orchards and fence rows but a component of the virgin longleaf type where it probably existed in the deep South in a pristine state. The fire scars in the trees, burned deeper in each fire by the added fuel of the previous nest, provide a perfect place to raise their families. Fire scars, coupled with deteriorating fungi, wind shake, etc., create ideal cavities that provide perfect shelters for Red-headed skinks *(Eumeces* sp.*)*, Flying squirrels *(Glaucomys volans)*, Honey bees *(Apis mellifera)* and numerous other less obvious creatures.

The "Third Forest," loudly touted by some foresters today, is a perpetuation of a previous bad mistake. I have no quarrel with the timber production goals set forth by the advocates of the "Third Forest" theme, but only with their symbolized method of management that excludes everything from a forest but the row upon row of planted slash pines. No one is more convinced than I that every acre of forest land should be in forest, but I am also convinced that every acre of forest land should be managed to include the creatures that occurred there in a state of nature. How else are we, as brief trustees of the land on which we survive, to pass on any heritage to future generations. I believe that we can produce the needed timber volume in such a way that it will not be at the expense of the other living creatures that form a forest.

To summarize, the intense management of the private game preserves in the Thomasville-Tallahassee region is designed to encourage as many life types as possible. The Red-cockaded Woodpecker is encouraged and perpetuated by the continuation of all-age forests that assures the presence of red heart fungus through long rotation and selective cutting. The Red-cockaded Woodpecker will prove to be one gauge of man's ability to exist without destroying his environment.

SOME CHARACTERISTICS OF RED-COCKADED WOODPECKER CAVITY TREES AND MANAGEMENT IMPLICATIONS IN SOUTH CAROLINA

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International Paper Company
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INTRODUCTION

The data presented in this paper were originally collected to provide the land manager with guidelines to preserve the Red-cockaded Woodpecker *(Dendrocopos borealis)*.

Red-cockaded Woodpecker populations still exist in a number of areas in South Carolina, some of which have locally high populations. Figure 1 shows the location of known populations in South Carolina. The areas studied in this project are indicated by the solid areas.

Three major areas were studied - the Francis Marion National Forest in the coastal plain, the Sumter National Forest in the piedmont, and International Paper Company's Koppers-Hemingway Tract also in the coastal plain. The data are separated by the Santee, Wambaw, and Witherbee Ranger Districts on the Francis Marion National Forests. See Figure 2 for the location of cavity trees on the Francis Marion. Two ranger districts, Edgefield and Enoree, on the Sumter National Forest have small isolated populations which were studied during this project. The Koppers-Hemingway Tract has a population that was handled as a separate entity. Figure 3 depicts the cavity tree locations on this tract.

The three study areas have a history of timber cutting and wildfires. Intermediate cutting has been carried out for 30 to 40 years on the Francis Marion National Forest in the better stocked stands. Burning is prescribed on a 3 to 5 year interval.

The cavity trees on the Sumter National Forest are located in remnants of stands left following high-grade cutting operations prior to the purchase by the U.S. Forest Service. No prescribed burning is practiced, although wildfires have occurred prior to the last 25 years.

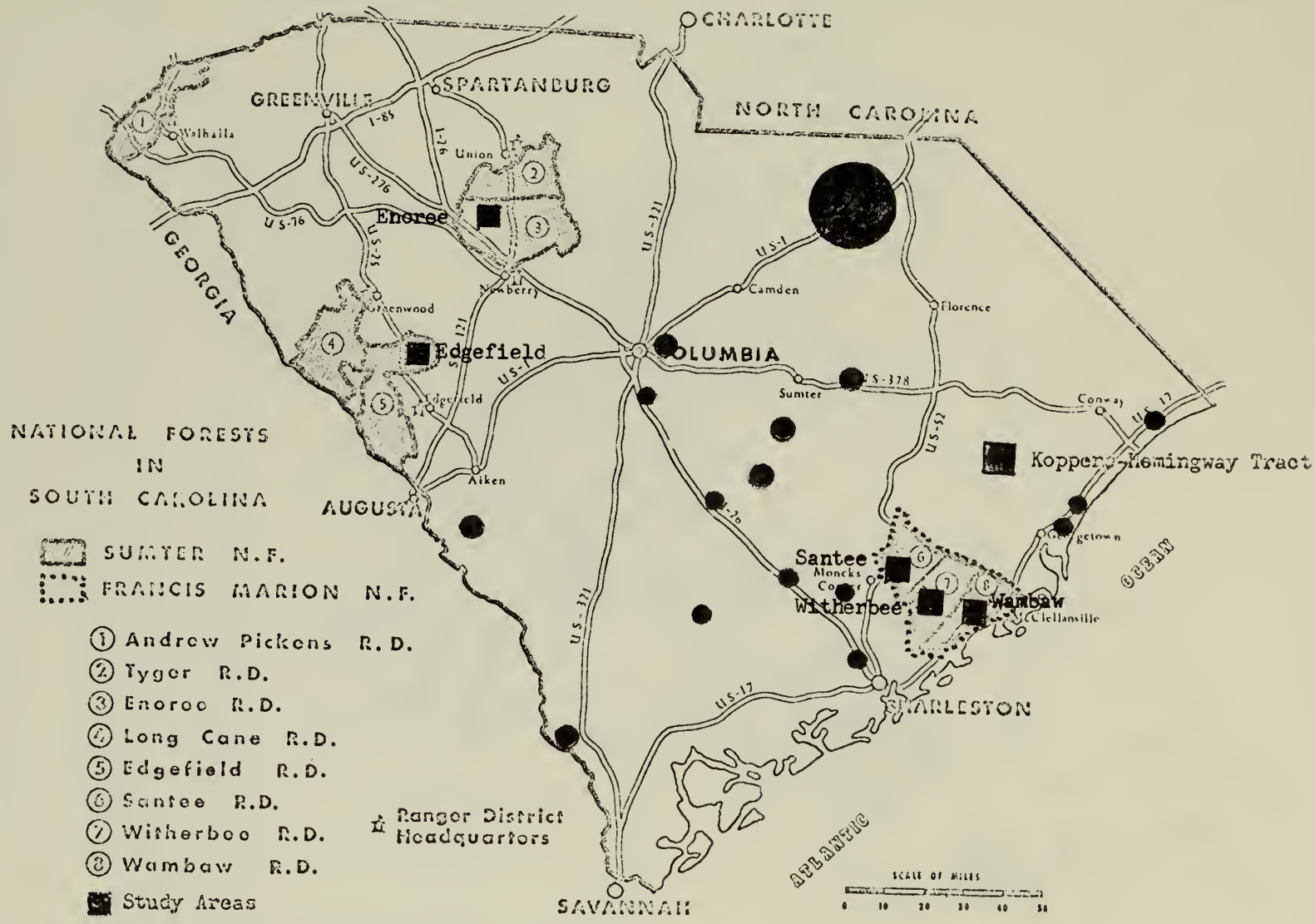

Figure 1. Locations of Known Red-cockaded Woodpecker Populations in South Carolina

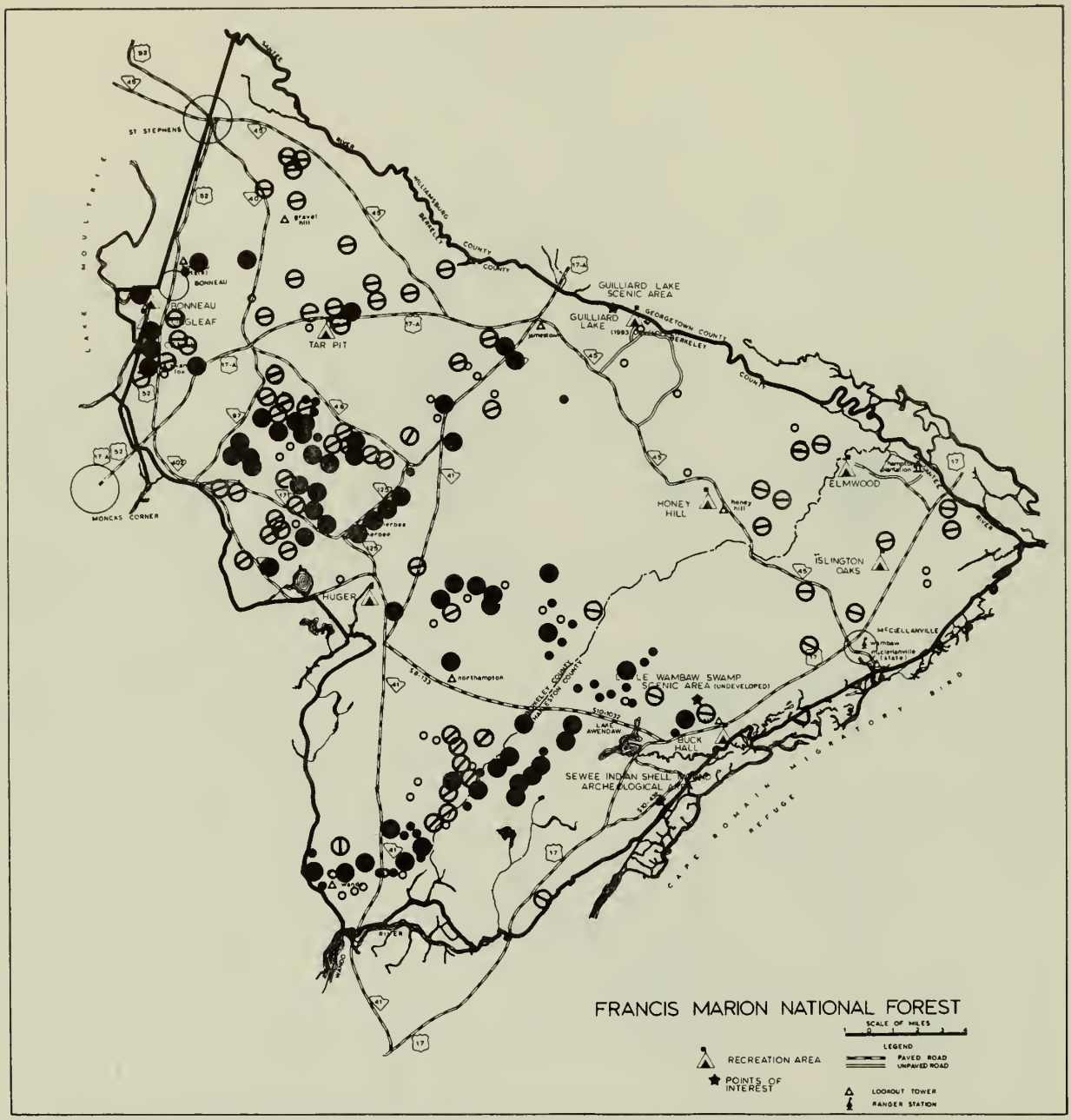

Figure 2. Location of Red-cockaded Woodpecker Cavity Trees on the Francis Marion National Forest.

- ● Colonies included in Study
- • Single trees included in Study
- ⊖ Colonies not included in Study (located after Study was made)
- ∘ Single trees not included in Study (located after Study was made)

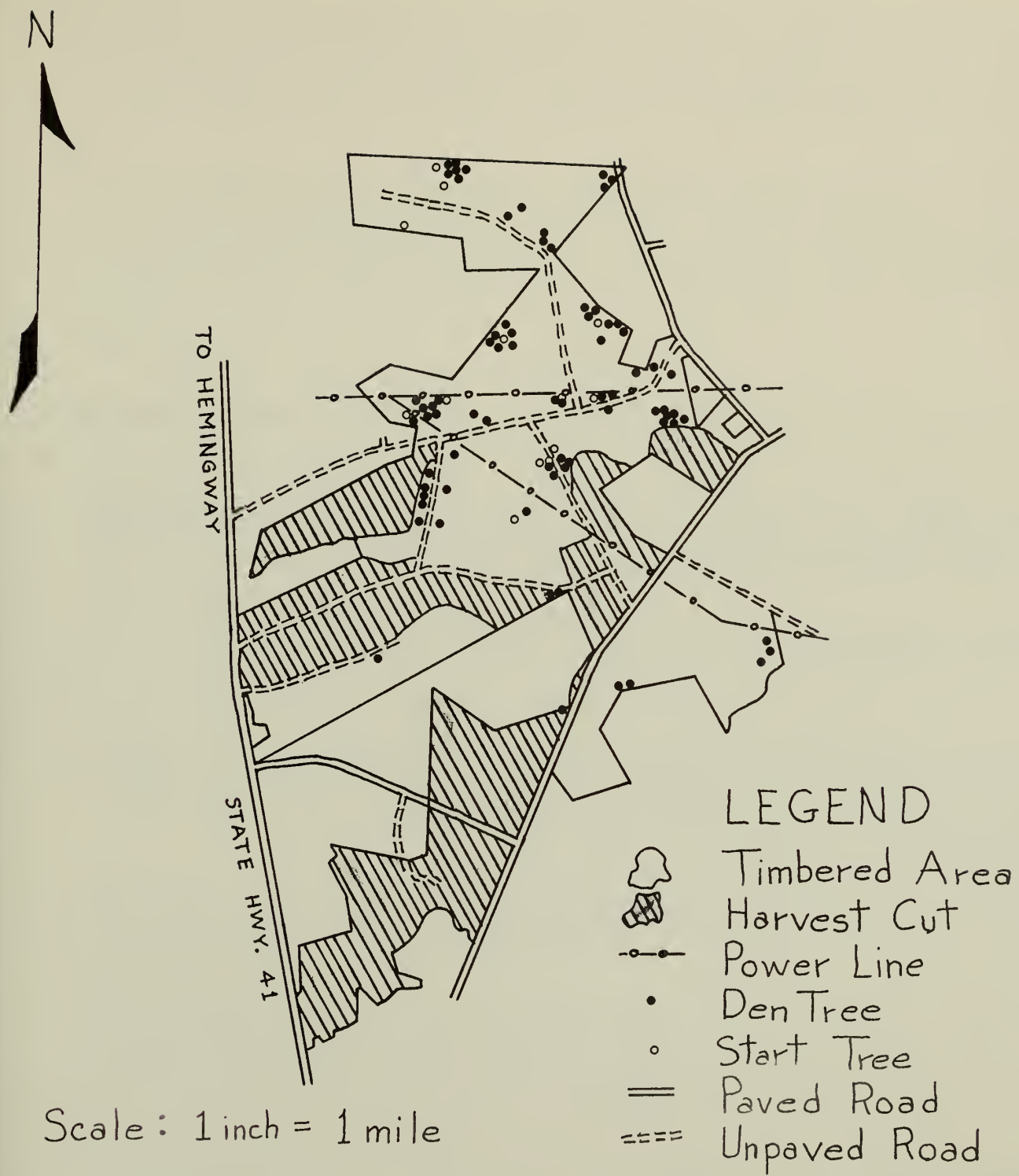

Figure 3. Location of Red-cockaded Woodpecker Cavity Trees on International Paper Company's Koppers-Hemingway Tract.

The Koppers-Hemingway Tract has a long history of quail management involving annual prescribed burning and planting of food strips and plots. Timber cutting in the past, mostly poles and sawtimber, has not been done with timber stand improvement as a major objective, but to maintain an open canopy for quail. The present use of the area is for quail hunting for customers.

A total of 382 trees was sampled on the three study areas as nest or roost cavities and start holes, or both. On a few trees all items of data were not tallied for various reasons, so in some cases the data presented represents a sample size smaller than the maximum number of trees within the sample.

METHODS

The method of data collection was standardized to permit comparisons and/or combination of data for the three areas.

A field survey card was used to tabulate the data, including the date and tree number. See Figure 4. The data card was divided into three sections--area designation and description, cavity tree information, and cavity information. A coding system was used to record the data.

The location of the nest or roost and start hole trees was plotted on forest maps for management and illustrative purposes. See Figures 2 and 3.

The following items on the data card were not used for various reasons:

Item 14. Distance from roads. Item 15. Distance from buildings. These factors did not appear to influence cavity tree location or use. In most cases, it was not known whether the roads, buildings or the cavity trees were established first. Some colonies are located on major and interstate highways within the State.

Item 16. The presence of red heart. The presence of red heart *(Fomes pini)* cannot always be determined by external characteristics. However, the authors are of the opinion that all sample trees in this study were infected by red heart to some degree.

Item 21. Den (under 2 years, over 2 years). After many observations over several years, the authors were of the opinion that aging dens this closely is impossible. Some starts within the study areas have been worked for 2 and 3 years without being completed.

All recorded data used in this study were based on actual measurements using standard field instruments with the exception of distances between cavity trees, which were paced.

Date_____ _____Tree No.

Francis Marion National Forest Red-cockaded Woodpecker Inventory

_____Colony No.

Area

1. Ranger District_____2. Compt. No._____3. Timber Type_____

4. Understory (open, light, heavy) 5. Type_____(grass, titi, myrtle, etc.)

6. Immediate Overstory Species_____ 7. Stand Condition_____

8. Basal Area_____

Cavity Tree

9. Species_____10. DBH_____11. Tree Height_____ 12. Age_____

13. Tree Deformities _____(crooked, forked, etc.) 14. Dist. from rd.___ch.

15. Dist. from buildings_____ch. 16. Red Heart present (yes, undetermined)

17. Dist. to nearest cavity tree(s)_____ch.

Cavity

18. No. in tree _____(also list starts and label them as such)

Den Number 1 19. Height above ground_____ 20. Direction of opening(compass)____

2 19. Height above ground_____ 20. Direction of opening (compass)___

3 19. Height above ground_____ 20. Direction of opening (compass)___

21. Den (under 2 yrs.; over 2 yrs.) 22. Red-cockaded seen at den_____

23. Other birds using cavity_____

24. Other remarks on back side. 25. Locate cavity trees on compartment map by number.

26. No. of recently dead cavity trees in colony_____

SC-2600-6 (8/69)

Figure 4.--Field Survey Card

RESULTS

Sample Size

The sample size data shown in Table 1 represent both nest or roost and start hole trees since some of the field observers did not make the distinction at the beginning of the field study. The separation of nest or roost cavities and start holes will be made later in the paper when pertinent to the study. The sample on the Francis Marion National Forest was an estimated one-third of the total; the Enoree Ranger District sample was 8 trees of a known 11 trees; and a one hundred percent tally of known trees was made on the Edgefield Ranger District and the Koppers-Hemingway Tract.

Colony size varies from 3.95 trees per colony on the Koppers-Hemingway Tract to 8 on the Enoree Ranger District, with an average of 6 trees per colony. The range in colony size was 2 trees to 9 trees.

Timber Type

The five timber types in which Red-cockaded Woodpeckers' cavities were encountered were longleaf *(Pinus palustris)*, loblolly *(Pinus taeda)*, shortleaf *(Pinus echinata)*, pond pines *(Pinus serotina)*, and other. See Table 2 for the breakdown of timber types by study area.

The Piedmont colonies, represented by the Edgefield and Enoree Ranger Districts, show a predominance of loblolly pine types, with one cavity tree in shortleaf. Longleaf does not occur in stands on these Ranger Districts.

On the Wambaw district where 100 percent of cavity trees are indicated in longleaf types, later observations have located some cavity trees in loblolly and pond pine types, but the majority is still in longleaf.

Longleaf pine timber types predominate in the lower coastal plain areas, with loblolly running almost half as many. Shortleaf is not represented since so few trees of this species exist in this area. Pond pine, although represented, is insignificant with only 4 trees and 1 percent in the type. These figures were not meant to indicate a preference for a certain timber type, but are merely the timber types encountered by the field observers.

Timber Types Preferred for Cavity Tree Location on the Francis Marion National Forest

To ascertain if a preference for a certain timber type is indicated, a comparison was made of the timber types occupied by Red-cockaded Woodpeckers (as presented in Table 2) with the existing stands of longleaf and loblolly pines of ages 41 years and above on the Francis Marion

National Forest. The age of 41 years was chosen as a breaking point because this is the approximate age cavity trees started appearing in the study area, and the Francis Marion Timber Management Plan, from which the existing timber type percentages were based, has a logical breaking point between 40 and 41 years. The existing stand figures include only longleaf and loblolly stands on the districts and represent 100 percent of the two stands in age groups 41 years and above, and not the total acreage.

The woodpeckers were found predominately in the longleaf pine type even though the loblolly pine type comprised a higher percentage of the suitable age timber. See Table 3. Percentage figures are used for comparison purposes in this table because acreage varies by Ranger Districts.

The total for occupied timber type on the Santee Ranger District is 96.0 percent rather than 100 percent. This is because 4.0 percent of the cavity trees were found in pond pine and other timber types. Even though there is this small discrepancy, longleaf pine still seems to be the preferred cavity tree over loblolly pine.

Understory Density

Understory density was recorded as open, light, or heavy. The observer was left to his judgment in determining this, but basically an area with predominately grass cover would be recorded as open, an area with low brush such as gallberry (*Ilex* sp.), sweet pepperbush *(Clethra alnifolia)*, runner oak *(Quercus pumila)* would be recorded as light, and an area with a heavy understory would be characterized by a dense stand of tall shrubs or young timber reproduction.

Table 4 illustrates the breakdown of understory densities per cavity tree by study areas. These figures point out the fact that the cavity trees are more prevalent in areas with open understories.

Understory Type

The type of understory was tallied in addition to the density. See Table 5. The two understory types most often found are grass (48.0 percent) and shrubs (25.9 percent). The grass type includes grass [mainly blue stems *(Andropogon* sp.*)*], forbs, and all vegetation growing close to the ground. The figures indicating heavier use in grass types could be misleading, since the total area is predominantly in the grass type. Before Tables 4 and 5 could show significance, a comparison would have to be made with total understory coverage by each type, and this information is not available. The only variance from the trend is on the Enoree District where small trees and shrubs predominated. This is probably due to the lack of prescribed burning and wildfires.

Immediate Overstory

Immediate overstory differs from the timber type in being a smaller subdivision. The timber type indicates the stands as a whole, whereas the immediate overstory is restricted to the area immediately surround-the cavity tree or colony. In most cases, the timber type and immediate overstory are the same; however, in some cases, there were loblolly pine immediate overstory situations within a longleaf pine timber type. This is reversed on the Witherbee Ranger District. See Table 6.

Stand Condition Class

The stand condition classes encountered in the study area were in regeneration, mature poletimber, mature sawtimber, immature poletimber, and immature sawtimber.

Stands classed as regeneration are adequately stocked with either natural or planted seedlings of adequate stocking (380+ seedings per acre for longleaf and 280+ for other species). Mature poletimber stands are those having a d.b.h.[1/] of 5 to 11 inches and have reached maturity.[2/] Mature sawtimber stands are comprised of mature trees with a d.b.h. of 11 inches or above. Trees in immature poletimber [3/] and immature sawtimber stands are between 5 and 11 inches d.b.h. and 11 inches d.b.h. or above respectively. Table 7 gives the breakdown encountered.

Obviously, the majority of cavity trees were in the mature sawtimber class (69.6 percent). This is to be expected since red heart manifests itself in mature or overmature stands. On the Koppers-Hemingway Tract mature poletimber stands make up 53 percent of the occupied acreage, but this is the stand class that predominates due to past cutting practices. In the remaining stands of younger condition classes, the cavities are usually in old residual trees remaining from previous logging operations.

Basal Area

One of the most important aspects of the study was the data supporting the idea that cavity trees are more numerous in the more open stands.

1/ d.b.h. (diameter at breast height) - diameter of tree measured 4-1/2 feet above the ground.

2/ Maturity age is 70 years for loblolly pine and 80 years for longleaf pine.

3/ Immature stands are at an age less than maturity.

Figure 5 bears out the fact that the woodpeckers prefer the stands of lower basal areas.[4/] The 40 and less basal area class is the most common class, except in the Sumter National Forest. Here, the Edgefield Ranger District had an equal number of cavity trees in the 40, 50, and 60 basal area classes. The Enoree Ranger District showed the largest divergence with basal areas of 80 square feet being the most common, followed by 110 square feet. There were no cavity trees with a basal area less than 80 on the Enoree District, because of a dense stand of young trees large enough to be tallied in the basal area count.

The average basal area ranged from 49 on Koppers-Hemingway to 84 on the Enoree Ranger District. The overall average basal area was 61 and the range was 10 through 150. So, it appears that maintaining stands in lower basal areas and leaving the older trees would be a good management technique if the Red-cockaded Woodpecker is the main management objective.

Diameter, Height, and Age of Nest or Roost and Start Trees

Table 8 shows the average d.b.h., d.b.h. range, average total tree height, height range, average age, and age range by species for each study area. Loblolly pines showed the largest average d.b.h. on all areas; longleaf pines were the oldest, except on the Koppers-Hemingway Tract, and loblolly pines grew the tallest on all areas, which all indicate a faster growth rate for loblolly pine.

A study of the age range to ascertain if certain tree species are more susceptible to red heart at earlier ages showed no significance. All species show individual trees with cavities around age 40 years (the youngest cavity trees encountered were a 38 year old pond pine and a 41 year old longleaf pine on the Koppers-Hemingway Tract, and a 42 year old loblolly pine on the Santee Ranger District).

Many trees sampled count not be aged with an increment borer because of the red heart condition, so the age figures are probably biased in favor of the younger trees since older trees are more likely to be decayed beyond aging.

Tree Deformities

Tree deformities were included in this survey because many observers felt that the large majority of cavity trees were of low quality and defective. The data collected during this survey indicates that this theory is not true.

4/ Basal area - the cross sectional area of the trees at breast height (4-1/2 feet) expressed in square feet.

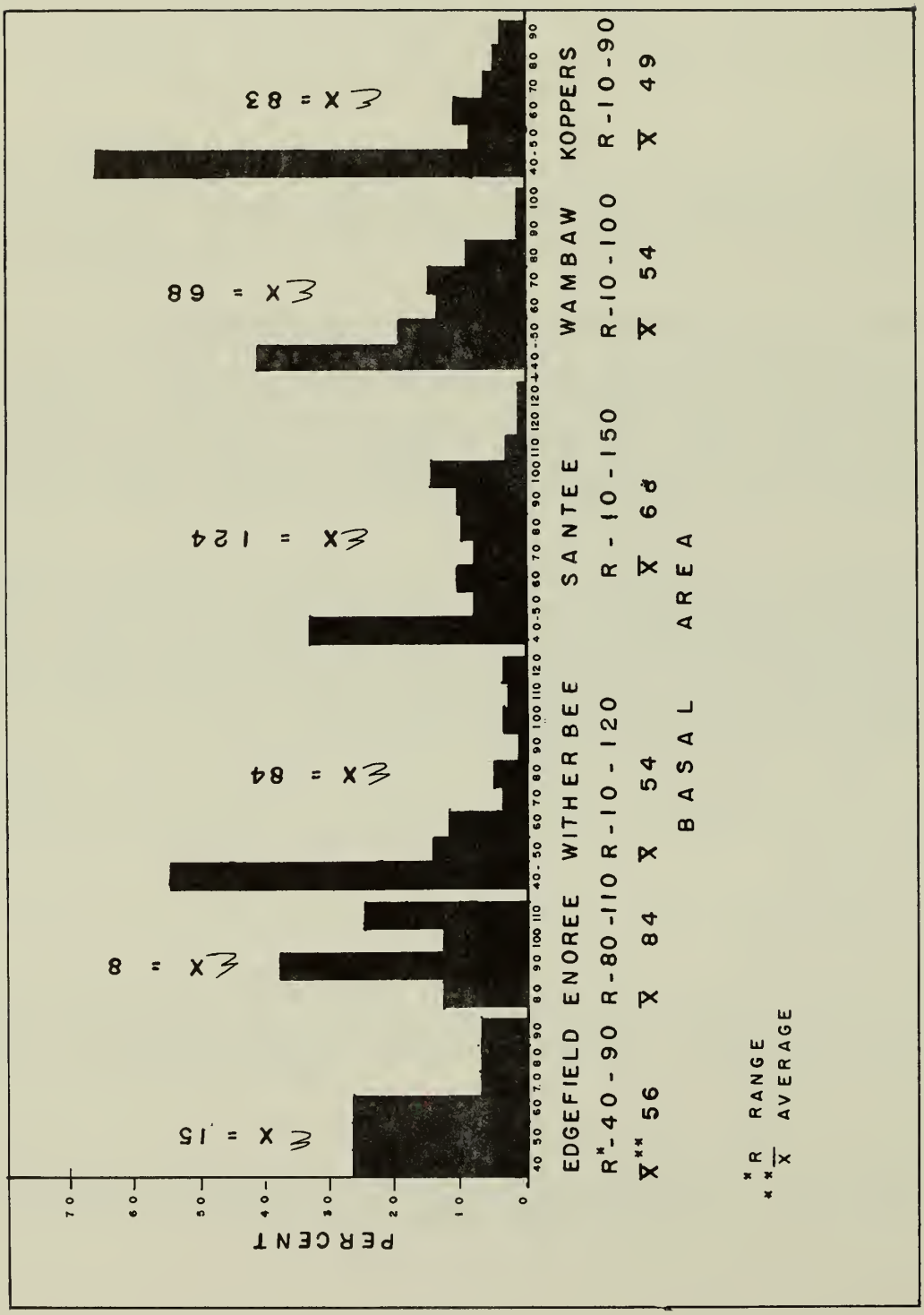

Figure 5. Basal areas by study area.

Sixty-two percent of the sample trees had no external defects. Cavity trees having crooks accounted for 21 percent of the total sample, or 56 percent of the total deformities. Forked cavity trees accounted for 5 percent of the total sample or 14 percent of the total deformities.

The remaining 30 percent did not have deformities of a serious nature. See Table 9.

Average Distance to Nearest Cavity Tree Within Colonies

After many observations and field checks, the authors assumed that colonies were made up of a grouping of cavity trees not more than approximately 10 chains[5/] apart. All trees outside of this range were recorded as singles or additional colonies unless there was sufficient evidence that cavity trees had been removed in between during past timber harvest or by natural causes.

The collected data justifies this assumption with one exception on the Koppers-Hemingway tract. See Table 10.

In this case, an active nest cavity produced young in 1970 in what was thought to be a single cavity tree in 1969, while the nearest colony, 17 chains away did not have an active nest cavity that particular year. During the previous nesting season (1969), the nesting cavity was within the colony and not in the isolated cavity tree. There is no evidence that this isolated cavity tree has ever been part of another colony, and since it is within the same timber stand it is felt that this tree is part of the colony.

In all other colonies, the cavity trees were within the range of 0.5 to 10.5 chains.[6/] There were only two single cavity trees recorded within 20 chains of known colonies (1 of 13 chains and 1 of 16 chains). Both of these appeared to be remnants of former colonies.

Number of Nest or Roost Cavities and Start Holes Per Tree

The majority of trees in the study had one cavity only, or one start hole only. See Table 11 for cavity data and Table 12 for start hole data. The next most common category for both nest or roost cavities and starts is two per tree, followed by three per tree. The Edgefield Ranger District varies somewhat from this with more trees with three cavities than two but this divergence is slight and the sample small. The trend for

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5/ 1 chain = 66 feet

6/ All measurements were taken to the nearest 0.5 chains

cavity trees from there is progressively fewer trees as the number of cavities per tree increases through nine. The average number of cavities per tree is 1.48.

The utilization of single cavities per tree seems to break down somewhat where only limited habitat is available. Colonies in the piedmont are located in isolated small stands of suitable timber, and the number of single cavity trees diminishes (66 percent), although single cavity trees still predominate.

Although the data does not indicate the trend, the authors surmise that older colonies would have a higher percentage of multiple-cavity trees. Perhaps this trend will reveal itself as the authors update their information.

An interesting study shows that 30 trees on the Francis Marion National Forest and 8 trees on the Koppers-Hemingway tract have both nest or roost cavities and start holes.

Heights of Nest or Roost Cavities and Start Openings

Heights of nest or roost cavities and start holes in this study appear to be related to total heights of trees. The highest average cavity heights are in loblolly pine followed by longleaf, pond, and shortleaf pines in that order. This is the order total heights assume. Compare the total height figures of Table 8 with the cavity and start heights in Table 13. This is not to contradict the fact that cavities are located in areas infected with red heart and red heart can be present at any position on the tree.

The average height of all nest or roost cavities and start holes in shortleaf pine is proportionately higher than its position for height to the first cavity because of the larger percentage of multiple cavity trees in the remnant stands in the piedmont.

Average height to the first cavity or start hole for all trees is 29.1 feet, and the average height for all cavities and starts is 30.4 feet. The range of cavity heights is from a 6-foot cavity in a longleaf pine on the Wambaw Ranger District to an 80-foot cavity in a longleaf pine on the Santee Ranger District. Table 13 gives a breakdown of average nest or roost cavity and start hole heights by species for the total study area. The lowest reported cavity hole in South Carolina is 18 inches above the ground.

Direction of Nest or Roost Cavity and Start Openings

The direction of each opening and start was measured with a hand compass. The majority of the measurements were recorded to the nearest degree; however, because of the volume of data these readings were grouped using the eight points of the compass.

This data indicated a strong preference for a westerly exposure. Within this exposure 141 or 26 percent were west, 92 or 16 percent were northwest and 97 or 17 percent were southwest accounting for 330 or 59 percent of the total 558 samples. There were only minor variations between study areas. Therefore this data has been grouped for all study areas.

The above preference is further supported by the lack of openings or starts with an easterly exposure. See Figure 6.

Nest or Roost Cavity Usage

A detailed study was made of Red-cockaded Woodpecker and other animal usage of cavity holes on the Koppers-Hemingway tract. This will be the only data presented in this section since there was not sufficient time to collect this data on the other study areas.

The most significant finding is the actual number of active Red-cockaded Woodpecker nest cavities. There were 12 nests in 1970 that hatched young as compared to 15 successful nests in 1969. No reason is known for this decrease of 3 nests, or 20 percent, other than normal fluctuation. Twenty colonies exist on the tract.

All 12 of the 1970 nests were within colonies that had nests in 1969. There were no barren colonies in 1969 that gained a nest in 1970, only the loss of three nests from prior nesting colonies. Most of the barren colonies are active for roosting.

There was some switching of nest trees within the colony from 1969 to 1970, but the majority of the nests were in the same cavity both years - nine colonies nested in the same cavity both years and three colonies switched trees. No colony has had more than one nest in either of the study years.

Other animals using cavities in 1970 were: Red-headed Woodpecker *(Melanerpes erythrocephalus)* nests in two cavities, red-bellied Woodpecker *(Melanerpes carolinus)* nest in one cavity, Yellow-shafted Flicker *(Colaptes auratus)* nest in one cavity, and southern flying squirrels *(Glaucomys volans)* in three cavities. All cavities used by other birds were enlarged and the flying squirrel cavities showed a stoppage of pitch flow, probably because the Red-cockaded Woodpeckers had ceased to freshen up the pitch flow. This usage by other animals was all in live pine trees with typical Red-cockaded Woodpecker cavities, other than the enlarged size, which was no doubt done by the invading animals.

Five cavities were enlarged with no apparent other animal usage and two cavity trees were recently dead. No other abberrant cavities are known. The remainder of the cavities are typical Red-cockaded Woodpecker cavities, the majority of which are for either nesting and/or

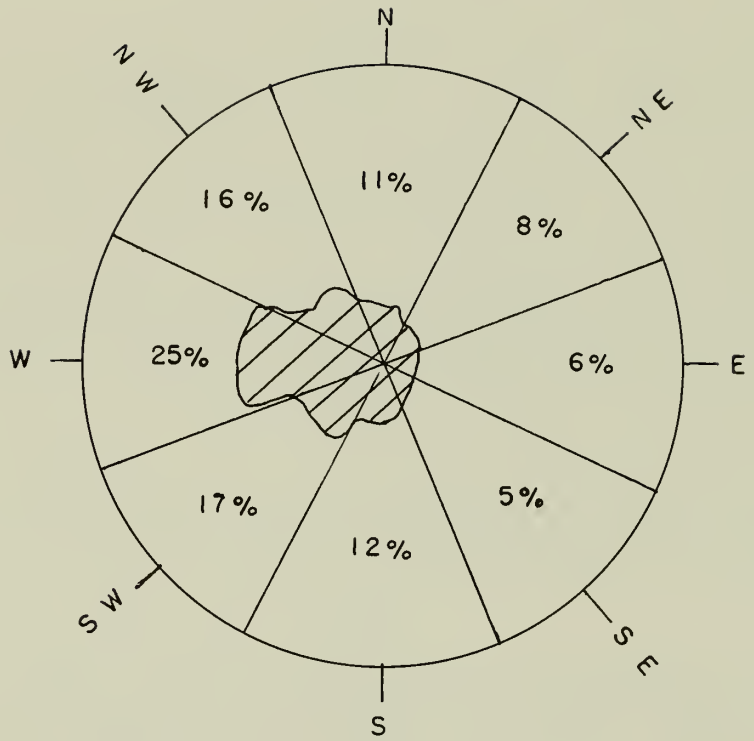

Figure 6. Compass direction of cavity and start openings.

roosting by the Red-cockaded Woodpecker. So, of the 74 cavity trees on the tract, 62 are typical cavities without other animal usage or alteration.

MANAGEMENT IMPLICATIONS

As was stated at the beginning of this paper, the study was undertaken to formulate guidelines for actual management and protection of the Red-cockaded Woodpecker. The minimum guidelines recommended are as follows:

1. Locate cavity trees on maps. These should be mapped as near to their exact location and relative position to other cavity trees as possible (this will assist in identifying colonies).

2. In areas to be cut for timber products, a 3-chain radius (2.8 acres) minimum buffer zone will be left around single trees. Where colonies exist, the 3-chain buffer zone will be based on the peripheral cavity trees (this will usually result in less acreage per cavity tree). This buffer is necessary for the protection of the cavity trees from wind throw, logging, etc. This will also provide cover, feeding areas, and hopefully future cavity trees.

3. Cavity trees and the buffer zones should be conspicuously marked.

4. When a buffer zone does not contain an adequate number of potential cavity trees, potential trees outside the 3-chain buffer zone, if available, should be incorporated into a larger buffer zone.

5. The basal area within the 3-chain buffer zone should be reduced to at least 60 square feet per acre, leaving the more mature trees.

6. Logging should be excluded from the colonies and buffer zones during the nesting season. April 1 to July 1 is nesting season in South Carolina.

7. Red-cockaded Woodpecker cavity trees and/or colonies should not be excluded from regular prescribed burning programs. This practice helps in keeping the area open, thus making it more attractive for the Red-cockaded Woodpecker. However, the area around the base of each cavity tree should be inspected before any burning is done. If there is a large quantity of resin present, the flammable material should be raked away from the base of the tree.

It is important to remember that the above recommendations are merely guidelines that appear to fit the "average" situations. In actual practice, there are few colonies which can be termed "average." It may be necessary to "bend" these guidelines to meet the existing conditions to insure the continuing survival of this species

While this management technique does not maximize timber production in areas of Red-cockaded Woodpecker populations, both International Paper Company and the National Forests in South Carolina are following these recommendations. Other private companies and public agencies are also adopting these guidelines on their lands.

CONCLUSIONS

1. The longleaf timber type appears to be the preferred habitat of the Red-cockaded Woodpecker.

2. Cavity trees are more prevalent in pine stands with an open understory. This type of understory is characterized by grasses, forbs and occasionally low shrubs typically associated with longleaf stands.

3. Composition of the immediate overstory of the stand does not appear to be significant if all other Red-cockaded Woodpecker requirements are present in the area.

4. Mature sawtimber stands provide the majority of the habitat in the study areas. This is to be expected since these stands usually contain the features which the Red-cockaded Woodpecker seem to prefer.

5. When managing timber stands for Red-cockaded Woodpeckers, a basal area of 60 or slightly less is suggested.

6. Typical cavity trees are characterized by d.b.h. of at least 12 inches, a minimum height of 60 feet and an age of at least 60 years.

7. There seems to be no preference for low quality or defective trees for cavities if red heart is present to some degree.

8. Distances between cavity trees within colonies range from a few feet to 10.5 chains, with one exception. The average is 3.2 chains.

9. Trees usually contain one nest or roost cavity or start hole. Exception to this can be noted in areas of limited habitat or very old colonies.

10. The height of the cavities and start holes above the ground appear to be related to the total height of the tree and the availability of red heart.

11. The Red-cockaded Woodpecker has a strong preference for a westerly direction for cavity openings.

Table 1.--Sample size of nest or roost cavity and start hole trees by study area

	Sumter N. F.		Francis Marion N. F.			I.P. Co.	
	Enoree	Edgefield	Santee	Wambaw	Witherbee	Koppers-Hemingway	Total
Total Number Trees	8	15	124	68	84	83	382
Total Number Colonies	1	3	24	10	22	20	80
Total Number Singles	0	0	9	14	11	4	38
Average Number of Cavity Trees per Colony	8	5	4.8	5.4	6.6	4.0	6.0

Table 2.--Timber type by study area

Area	Longleaf # Trees	Longleaf %	Loblolly # Trees	Loblolly %	Shortleaf # Trees	Shortleaf %	Pond # Trees	Pond %	Other # Trees	Other %	Total # Trees	Total %
Edgefield	-	-	14	93.3	-	-	-	-	1	6.7	15	100.0
Enoree	-	-	7	87.5	1	12.5	-	-	-	-	8	100.0
Subtotal	-	-	21	91.4	1	4.3	-	-	1	4.3	23	100.0
Witherbee	64	77.1	19	22.9	-	-	-	-	-	-	83	100.0
Santee	51	41.1	68	54.9	-	-	4	3.2	1	0.8	124	100.0
Wambaw	68	100.0	-	-	-	-	-	-	-	-	68	100.0
Subtotal	183	66.5	87	31.6	-	-	4	1.5	1	0.4	275	100.0
Koppers-Hemingway	74	89.2	9	10.8	-	-	-	-	-	-	83	100.0
Total	257	67.5	117	30.7	1	0.3	4	1.0	0.5	0.5	381	100.0

Table 3.--A comparison of timber types occupied by Red-cockaded Woodpecker cavity trees with the existing stands of longleaf and loblolly pine types of ages 41 years and above on the Francis Marion National Forest

Area	Longleaf Pine Type		Loblolly Pine Type		Total	
	Occupied %	Existing %	Occupied %	Existing %	Occupied %	Existing %
Witherbee	77.1	48.3	22.9	51.7	100.0	100.0
Santee	41.1	37.7	54.9	62.3	96.0	100.0
Wambaw	100.0	43.2	.0	56.8	100.0	100.0
Total	66.5	43.6	31.6	56.4	98.1	100.0

Table 4.--Understory density by study areas

Area	Open # Trees	Open %	Light # Trees	Light %	Heavy # Trees	Heavy %	Total # Trees	Total %
Edgefield	7	46.6	6	40.0	2	13.3	15	100
Enoree	3	37.5	2	25.0	3	37.5	8	100
Subtotal	10	43.5	8	34.8	5	21.7	23	100
Witherbee	44	52.4	39	46.5	1	1.1	84	100
Santee	80	64.6	26	20.9	18	14.5	124	100
Wambaw	58	85.3	8	11.8	2	2.9	68	100
Subtotal	182	66.0	73	26.4	21	7.6	276	100
Koppers-Hemingway	44	53.1	24	28.9	15	18.0	83	100
Total	236	61.8	105	27.5	41	10.7	382	100

Table 5.--Understory type by study areas

Area	Grass # Trees	%	Shrubs # Trees	%	Pine Regeneration # Trees	%	Pine-Hdwd Regeneration # Trees	%	Scrub Oak # Trees	%	Oak-Gum # Trees	%	Other # Trees	%	Total # Trees	%
Edgefield	5	33.3	-	-	-	-	8	53.4	-	-	-	-	2	13.3	15	100
Enoree	1	12.5	3	37.5	-	-	4	50.0	-	-	-	-	-	-	8	100
Subtotal	6	26.1	3	13.0	-	-	12	52.2	-	-	-	-	2	8.7	23	100
Witherbee	40	48.3	28	33.7	2	2.4	-	-	3	3.6	2	2.4	8	9.6	83	100
Santee	28	23.0	32	26.2	2	1.6	4	3.3	15	12.3	16	13.1	25	20.5	122	100
Wambaw	58	85.3	6	8.8	1	1.5	1	1.5	2	2.9	-	-	-	-	68	100
Subtotal	126	46.2	66	24.2	5	1.8	5	1.8	20	7.3	18	6.6	33	12.1	273	100
Koppers-Hemingway	50	60.2	29	35.0	-	-	-	-	-	-	4	4.8	-	-	83	100
Total	182	48.0	98	25.9	5	1.3	17	4.5	20	5.3	22	5.8	35	9.2	379	100

Table 6.--Immediate overstory by study areas

Area	Longleaf # Trees	Longleaf %	Loblolly # Trees	Loblolly %	Shortleaf # Trees	Shortleaf %	Pond # Trees	Pond %	Other # Trees	Other %	Total # Trees	Total %
Edgefield	-	-	14	93.3	-	-	-	-	1	6.7	15	100
Enoree	-	-	5	62.5	3	37.5	-	-	-	-	8	100
Subtotal	-	-	19	82.7	3	13.0	-	-	1	4.3	23	100
Witherbee	80	96.4	3	3.6	-	-	-	-	-	-	83	100
Santee	29	23.6	63	51.2	-	-	5	4.1	26	21.1	123	100
Wambaw	63	92.7	2	2.9	3	4.4	-	-	-	-	68	100
Subtotal	172	62.8	68	24.8	3	1.1	5	1.8	26	9.5	274	100
Koppers-Hemingway	32	42.4	43	51.8	-	-	5	6.0	-	-	83	100
Total	207	54.5	130	34.2	6	1.6	10	2.6	27	7.1	380	100

Table 7.--Stand condition classes by study areas

Area	In Regeneration #	In Regeneration %	Mature Poletimber #	Mature Poletimber %	Mature Sawtimber #	Mature Sawtimber %	Immature Poletimber #	Immature Poletimber %	Immature Sawtimber #	Immature Sawtimber %	Total #	Total %
Edgefield	-	-	-	-	8	100	-	-	-	-	8	100
Enoree	-	-	-	-	15	100	-	-	-	-	15	100
Subtotal	-	-	-	-	23	100	-	-	-	-	23	100
Witherbee	5	6.0	2	2.4	48	57.1	1	1.2	28	33.3	84	100
Santee	21	16.9	-	-	89	71.8	5	4.0	9	7.3	124	100
Wambaw	1	1.5	-	-	67	98.5	-	-	-	-	68	100
Subtotal	27	9.8	2	0.7	204	73.9	6	2.2	37	13.4	276	100
Koppers-Hemingway	-	-	44	53.0	39	47.0	-	-	-	-	83	100
Total	27	7.1	46	12.0	266	69.6	6	1.6	37	9.7	382	100

Table 8.--Average d.b.h., height and age by species for each study area

		No. of Trees	%	Average d.b.h.	d.b.h. Range	Average Height	Height Range	Average Age	Age Range
Edgefield	Loblolly	14	93	16.1	12-21	81	55-88	84.1	75-90
	Shortleaf	1	7	14.0	14	68	68	75.0	75
Enoree	Loblolly	5	71	18.2	17-19	92	82-100	83.8	73-85
	Shortleaf	2	29	13.5	11-16	70	66-73	98.5	93-104
Witherbee	Longleaf	76	90	16.1	10-22	80	52-107	94.1	57-135
	Loblolly	8	10	19.1	16-24	88	72-120	82.2	47-116
Santee	Longleaf	43	34	16.3	12-23	87	72-105	91.9	62-123
	Loblolly	75	60	19.0	13-25	93	44-120	82.2	42-125
	Pond	7	6	14.8	11-19	75	51-90	84.5	65-105
Wambaw	Longleaf	62	91	14.6	11-18	75	56-88	72.0	57-86
	Loblolly	4	6	17.5	15-19	80	69-86	70.8	64-80
	Pond	2	3	14.5	13-16	70	60-77	89.0	73-105
Koppers-Hemingway	Longleaf	6	7	16.7	12-21	64	50-73	62.8	41-74
	Loblolly	59	72	18.1	13-24	88	59-86	70.5	47-96
	Pond	17	21	16.0	10-23	62	47-79	61.8	38-78
Total	Longleaf	187	49						
	Loblolly	165	43						
	Shortleaf	3	1						
	Pond	26	7						

Table 9.--Tree deformities by study areas

Area	Type of Deformities: None #	None %	Crook #	Crook %	Sweep #	Sweep %	Fork #	Fork %	Broken Top #	Broken Top %	Flat Top #	Flat Top %	Limby #	Limby %	Other #	Other %	Sample Size
PIEDMONT																	
Edgefield R.D.	11	114	2	13	1	6	-	-	-	-	-	-	1	6	-	-	15
Enoree R.C.	6	75	-	-	-	-	1	12	-	-	-	-	1	12	-	-	8
Subtotal	17	74	2	9	1	4	1	4	-	-	-	-	2	9	-	-	23
FRANCIS MARION																	
Santee R.D.	88	70	19	15	3	2	3	2	1	1	1	1	5	4	5	4	125
Wambaw R.D.	45	66	9	13	6	9	3	4	-	-	-	-	-	-	5	7	68
Witherbee R.D.	51	62	14	17	-	-	9	11	2	2	2	2	-	-	4	5	82
Subtotal	184	67	42	15	9	3	15	5	3	1	3	1	5	2	14	5	275
Koppers-Hemingway	36	43	37	45	-	-	4	5	-	-	6	7	-	-	-	-	83
Total	237	62	81	21	10	3	20	5	3	1	9	2	7	2	14	4	381

Table 10.--Average to nearest cavity tree within colonies by study areas

District	Species	COLONIES ONLY Average Distance to Nearest Den Tree	Range
Enoree	Loblolly	3.90	1.0-9.0
	Shortleaf	3.50	3.0-4.5
Santee	Longleaf	2.34	0.5-8.0
	Pond	2.67	1.0-6.0
Wambaw	Longleaf	2.39	0.5-7.0
	Loblolly	2.35	0.5-7.0
Witherbee	Longleaf	3.23	0.5-10.0
	Loblolly	5.00	5.0-10.5
Edgefield	Loblolly	2.26	0.5-6.0
	Shortleaf	2.00	2.0-2.0
IP-Koppers	Longleaf	5.83	1.5-9.0
	Loblolly	2.96	0.5-10.0
	Pond	4.44	1.0-17.0
Total		3.19	0.5-17.0

Table 11.--Number of nest or roost cavities per tree by study areas

Area	NUMBER OF CAVITIES 1 %	2 %	3 %	4 %	5 %	6 %	7 %	8 %	9 %	Total %
Edgefield	66	7	13	7	0	0	0	0	7	100
Enoree	62	38	0	0	0	0	0	0	0	100
Subtotal	66	17	9	4	0	0	0	0	4	100
Witherbee	69	16	10	5	0	0	0	0	0	100
Santee	74	13	6	3	2	2	0	0	0	100
Wambaw	82	11	3	0	0	2	0	2	0	100
Subtotal	75	13	7	3	1	+0	1	+0	0	100
Koppers-Hemingway	83	14	3	0	0	0	0	0	0	100
Total	76	14	6	2	1	+0	1	+0	+0	100

Table 12.--Number of start holes per tree by study areas

Area	1 %	2 %	3 %	Total %
Edgefield	0	0	0	0
Enoree	0	0	0	0
Subtotal	0	0	0	0
Witherbee	100	0	0	100
Santee	88	6	6	100
Wambaw	77	23	0	100
Subtotal	86	11	3	100
Koppers-Hemingway	83	17	0	100
Total	86	12	2	100

Table 13.--Average heights of nest and roost cavity and start openings for the total study area

Item	Longleaf	Loblolly	Shortleaf	Pond	Total
Average height to first cavity or start (ft.)	27.1	32.6	19.3	24.1	29.1
Average height all cavities and starts (ft.)	28.7	32.9	28.9	26.8	30.4
Range of cavity or start heights (ft.)	6-80	9-74	13-38	12-48	6-80

A SURVEY OF RED-COCKADED WOODPECKER HABITAT REQUIREMENTS

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INTRODUCTION

The Bureau of Sport Fisheries and Wildlife has a strong committment to prevent the extinction of any native plant or animal and especially those considered endangered. After the Red-cockaded Woodpecker *(Dendrocopos borealis)* was included in the "Redbook" (U.S.D.I., Bureau of Sport Fisheries and Wildlife, Rare and Endangered Fish and Wildlife of the United States. Res. Pub. 34, 1968), there developed a pressing need to provide guidelines for land managers to effectively perpetuate the bird.

To fulfill an immediate need to define Red-cockaded Woodpecker habitat requirements, a cooperative study between the Bureau of Sport Fisheries and Wildlife and the Tall Timbers Research Station was inititated in 1970. The primary objectives of the study were to develop a quantitative and qualitative evaluation of Red-cockaded Woodpecker habitat and prescribe timber management practices which would preserve and perpetuate colonies of Red-cockaded Woodpeckers at above minimum recovery levels throughout its range.

METHODS AND PROCEDURES

Study Area

The study was confined to the major pine types occurring within the historic range of the species but excluded colonies at the extremities of the range (Tennessee, Kentucky, Maryland, Oklahoma, Southern Florida, etc.) for biologic as well as economic reasons. A cursory evaluation of southern pine timber further limited the study to four primary SAF (Society of American Foresters) types: Longleaf, Loblolly, Slash, and Shortleaf. Further refinement reduced the survey to the Longleaf and Loblolly types with the additional samples being drawn from mixed stands such as Longleaf-Slash or pure stands such as Pond Pine. Initially the sample size was estimated

at one-hundred colonies each from the Longleaf, Loblolly and mixed stands. The samples were to be proportionate among the forest types and colony availability within the ten states of Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, Texas and Virginia. The best information available for located colonies and timber types was the basis for the sample proportioning. No concerted attempt was made to survey potential habitat. National Wildlife Refuges and National Forests served as the base for colonies surveyed; however, all known colonies which could be surveyed within economic reason were included.

DEFINITION OF TERMS

It became quite apparent after a set of sample data was collected that some fairly precise definitions of terms would be necessary.

Colony. A Red-cockaded Woodpecker colony included only the physical limits described by a tree or trees with cavities. At least one cavity was to have been judged as an active nest or den tree. All other types of cavities and trees were considered as being used by the bird at some time in meeting the bird's requirements during the history of the colony.

Den/roost Cavities. This type of cavity was classed primarily on size of hole and apparent intensity of use as indicated by pitch flow.

Old Cavities. Cavities that were obviously enlarged and lacking active pitch flow, and were unlikely to be used for nesting but still occasionally served as a roost cavity, were considered as old cavities.

New or Start Cavities. Any incomplete cavity was classified as a start even if the activity did not appear too recent.

Colony Support Stand. A Red-cockaded Woodpecker colony support stand was regarded as that stand of timber immediately surrounding the active colony which could be delineated on the basis of topographic features, vegetative cover types, land use, stand density, age or other characteristics. Where an apparently uniformly contiguous stand of timber supported more than one colony, no effort was made to assign acreage to each colony on a purely arbitrary basis.

Other. Other terminology used in this survey accepts the common interpretation of the forester's definition for basal area, dbh, stand density, site index, etc.

Data Collection

Colony Location. Colonies were identified by soliciting the assistance of many agencies and individuals who either provided detailed maps or volunteered to guide the investigators to known colonies. Once a colony was found, an effort was made to locate all cavity trees. Cavity trees were usually "flagged" to expedite relocation, mapping, and linear measurements.

Measurements

Colony. Measurements for describing a colony were taken using the cavity trees as plot center. Where only one tree was located, one plot was considered acceptable. Where two or more cavity trees were present, each cavity tree served as plot center and a plot was taken at approximately 50-pace intervals between each cavity tree to insure that at least 10 percent of the area was surveyed. The following data, in addition to the legal land descriptions, were collected for each colony: colony dimensions; cavity tree species; age, height and diameter of cavity tree; and number, classification, height and exposure of cavities. A tally was made of the species, number, and diameter of each tree within the plot. In the plots without a cavity tree for plot center, the age, height and diameter of the near dominant tree was used for individual tree measurements. The plot data were averaged to provide the basis for SAE type, site index, stand density, (stems per acre of both pine and hardwood), basal area, composition of stand dominance, height, age and diameter of the colony stand.

Colony Support Stand. The description of the colony support stand was essentially an extension of the mensuration techniques employed for the colony stand. Data collected for the colony was included as part of the stand description with a minimum of 10 percent cruise considered acceptable. The same characteristics; i.e., site, age, etc., compiled for the colony were also tabulated for the support stand. The understory was classified as dominant or codominant in general categories of grass, herbs, brush, hardwoods of 0-10, 11-25, 26-50 feet in height, and pine reproduction of 0-10, 11-25, 26-50 feet in height by relative densities of light (0-33%), medium (34-66%) and dense (67-100%). A general description was also made of the topographic features of the stand.

Compartment or Forest Description. A third phase of this survey was a general description of the land approximately one mile square around the colony. This description included the acreage of forested and nonforested land, topography, land use and fire history. These data were generally available for colonies on Federally-owned land, but it became apparent that the data were not comparable from area to area. It also became evident that far more time and effort would be needed to secure this information on other areas so this phase was generally deleted from the survey.

RESULTS AND DISCUSSION

General data were recorded for 232 Red-cockaded Woodpecker colonies and 160 support stands in ten states (7-Alabama, 8-Arkansas, 79-Florida, 35-Georgia, 10-Louisiana, 28-Mississippi, 9-North Carolina, 46-South Carolina, 7-Texas and 3-Virginia.) A total of 149 colonies were surveyed in Longleaf (SAF #70), 55 in Loblolly (SAF #81), 21 in Loblolly-

Shortleaf (SAF #80), 2 in Shortleaf (SAF #75), 2 in Loblolly-Hardwood (SAF #82), 2 in Slash (SAF #84), and 1 in Longleaf-Slash Pine (SAF #83). The survey resulted in fewer colonies that were proportioned differently than the initial estimate. These differences were caused by an overestimate of known colonies reported during initial contacts.

The survey results were separated into 33 variables for analysis. Preliminary analysis used all data which were then separated into the two primary forest types, Longleaf and Loblolly. The sample sizes for other forest types were considered too small for detailed analysis.

Obviously, all data collected in this survey were from timber stands having Red-cockaded Woodpecker colonies. This provided a reasonably accurate description of suitable occupied habitat but offered restricted opportunity for contrast with comparable unoccupied stands. Some of the analytical procedures are attempts to circumvent this problem. The assumption is made that as conditions of a given tree, support stand, or colony become suitable, the birds will utilize more trees for cavity excavation. This recognizes that the base for prediction has been established in a narrow portion of the entire timber stand existence; however, it does allow for identification of the most important stand characteristics and some reasonable means to predict increase or decrease of cavity trees under varied stand conditions.

Colony

Tables 1, 2, and 3 are data descriptions of variables measured in colonies during the survey. Simple t-tests were used to demonstrate that there are significant differences between variables measured in the Longleaf and Loblolly forest types. Colonies in Loblolly occupy sites with a higher index, have a higher percentage of dominant trees which grow to a greater height, have a larger diameter and contain more cavity trees with a larger number of cavities than colonies in the Longleaf type. Colonies in the Longleaf type occur in areas with a greater density of pine stems per acre composed of more codominant and suppressed trees than those in Loblolly.

Support Stand

Tables 4, 5, and 6 are data descriptions of variables measured in the support stands during this survey. Simple t-tests were used to identify meaningful differences between characteristics of the support stand and colony. The most important difference is that tree diameters in the colony are larger than the support stand. Overall results of the study would indicate that the presence of a stand of timber beyond the actual colony area is a definable entity. A regression equation was developed to estimate support stand acres per cavity tree from site quality as a means of determining the acreage required to support a Red-cockaded Woodpecker colony. This is shown in Figure 1. Site index was selected

as the single most important variable to predict acreage per cavity tree even though results from a correlation matrix based upon all variables indicated that the correlations between tree height, diameter, stems per acre, etc., would also be useful estimators.

Individual Cavity Trees

Table 7 is a summary of characteristics of individual cavity trees. Simple t-tests were used to identify differences between Longleaf and Loblolly trees because they were the main forest types studied. The primary differences occur in the cavity classification. Loblolly has more old cavities and start holes hence more total cavities while Longleaf has more den cavities per tree. Loblolly trees were taller while Longleaf trees were older but no significant differences in diameter could be found.

To better identify the individual tree characteristics which could be used to establish management guidelines, simple t-tests were used to ascertain differences between the individual tree measurements of height, age, and diameter of colony, support stand and individual cavity trees in the Longleaf and Loblolly forest types. There is a difference between diameters of individual cavity trees and the support stand in both types and between colony and support stand in Longleaf. There was a difference in the age of individual cavity trees and trees of both the colony and support stand in Loblolly.

Combined Characteristics

A correlation matrix was developed utilizing all measured variables in both the colony and support stand as a means of identifying those forest characteristics which would be useful to predict suitability of a stand for Red-cockaded Woodpecker habitation. In most cases, similar characteristics of colony and support stand are highly correlated.

Based upon results of the correlation matricies for all forest types plus the two primary types and other recognized relationships or differences, a number of variables were selected for additional analysis. The colony: site index; basal area; tree height, age, diameter; and total number of cavity trees; and the support stand: site index; basal area; and tree height, age and diameter were analyzed by a series of stepwise multiple regressions. Each variable served as the dependent variable on which all others were regressed and then each variable as dependent variable upon which only related variables of either colony or support stand were regressed. Data from all forest types were used in this test procedure, but it was recognized that there are differences between types and these totals may be biased in favor of the Longleaf condition.

In another series of regressions which first utilized all data and then the data from the Longleaf and Loblolly type separately, the colony; site index, stems per acre, basal area, tree height, tree age and tree diameter and the support stand; site index, stems per acre, basal area, tree height, tree age and tree diameter were all regressed on number of cavity trees in a stepwise regression and then each variable regressed in a simple linear regression.

The most significant result of these testing procedures, including the t-tests mentioned earlier was to identify diameter, age and height of tree as those characteristics which explain most of the variation in number of cavity trees per colony. These procedures also demonstrate other well known relationships between site, stocking, tree height, diameter and age.

Conditions measured in the Loblolly type were less variable than conditions found in Longleaf because of the absence of residual trees, trees with turpentine faces, etc. For this reason, the results for Loblolly are presented as being more representative of a forest under present management. Approximately 45 percent of the variation in number of cavity trees per colony can be explained by the equation: $y = -2.24563 + .02357X_1 - .00764X_2 + .05948X_3 - .20926X_4 + .16944X_5 - .04164X_6 - .08413X_7 - .05590X_8 + .30782X_9 - 12339X_{10} + .03817X_{11}$ where: X_1 = Colony site index, X_2 = Colony stems per acre, X_3 = Colony basal area, X_4 = Colony average tree height, X_5 = Colony average tree age, X_6 = Colony average tree diameter, X_7 = Support stand site index, X_8 = Support Stand stems per acre, X_9 = Support stand average tree height, X_{10} = Support stand average tree age and X_{11} = Support stand average tree diameter.

Substituting means from Tables 3 and 6 and comparing this data with data from a standard yield table of a well stocked stand of Loblolly on a site of 85 at age 80, the equation will predict 5.5 cavity trees per colony studied compared with 3.9 cavities trees in the well stocked stand. Substituting data from a standard yield table, it is possible to demonstrate that the chronological age at which cavity trees can be predicted decreased from over 80 years on a site of 60 to approximated 40 years on a site of 100. It is, of course, possible to substitute simulated management information such as reduced basal area, stems per acre and increased tree height and diameter as an index to predicting suitability of a stand to have Red-cockaded Woodpecker cavity trees with various site and age conditions.

Other

The data which described the understory vegetation was not subject to statistical analysis. The comments reported here are general observations based upon field examination of over three hundred colonies scattered throughout the range of the bird. Understory vegetation, with

few exceptions, seldom exceeds more than half the average clear stem height of a timber stand where active colonies are present. The majority of the colonies existed in areas where the understory grew to a height of less than six feet and contained substantial amounts of grass. Fire appears to be the primary tool in maintaining this condition.

The number of birds observed in a colony area may vary from one to seven. The relative frequency with which an average of three birds were observed may be a useful figure for estimating populations. A fairly simple inventory procedure would be to locate all colonies in a forest as the areas are cruised. A complete inventory of the forest would be accomplished over a period of years as normally only a percentage of the area is cruised annually. A percentage of known colonies can be inventoried each year using active pitch flow around holes or presence of the bird to determine if the colony is still active. As areas are cruised again, there is a basis for systematic updating of colony status on an area. The systematic survey of land area and survey of known colonies then provides the base for estimating colonies and perhaps bird population if colonies are multiplied by three (or another figure if an average number of birds per colony is established for a given locality).

CONCLUSIONS AND RECOMMENDATIONS

The study identified significant forest characteristics which can be used to develop management programs. Management recommendations can be divided into three general classifications where timber stand management practices will be essentially the same.

Sanctuaries

The most exclusive land use which could be recommended is the designation of an area specifically for preservation of the Red-cockaded Woodpecker with all other uses excluded or given nominal consideration. Such sanctuary designation may be the best alternative in those portions of the bird's range where it is considered to be threatened with extirpation. Even where the bird population is considered locally abundant, a sanctuary designation, for the present, may be desirable to insure that future land uses and programs do not obscure the bird's need for perpetuation.

Multiple Use Areas

Some Red-cockaded Woodpecker colonies observed during the course of this study exhibited an ability to exist with a broad range of other forest uses. Colonies were observed in picnic areas, developed campsites, work centers, moderately developed housing subdivisions, quail hunting perserves

and along nature trails. Areas designated for multiple uses which identify the Red-cockaded Woodpecker as part of the system offer one of the best management opportunities available. Multiple use areas where the emphasis may be placed on recreation, historic, scenic or other values may not only be logical but essential to mitigate the bird's habitat losses to imcompatible land uses. The most desirable situation is where colonies already exist on these areas and the bird population can expand or the physical area can be increased to offset the loss of colonies as they occur elsewhere. The most desirable situation is to establish a population (colony) goal and allow colonies destined for elimination to be destroyed only after a new colony has been established in the alternate area.

Individual Colonies

The most difficult management problems arise over the need to perpetuate colonies on an individual basis. This is the type of situation usually occurring in large clear cutting operations where opportunity to mitigate the loss is lacking. Two conditions are necessary to sustain the colony: 1) an adequate colony support stand including replacement habitat, and 2) safe access throughout a range of approximately one-half square mile of which one-half remains in a well forested condition.

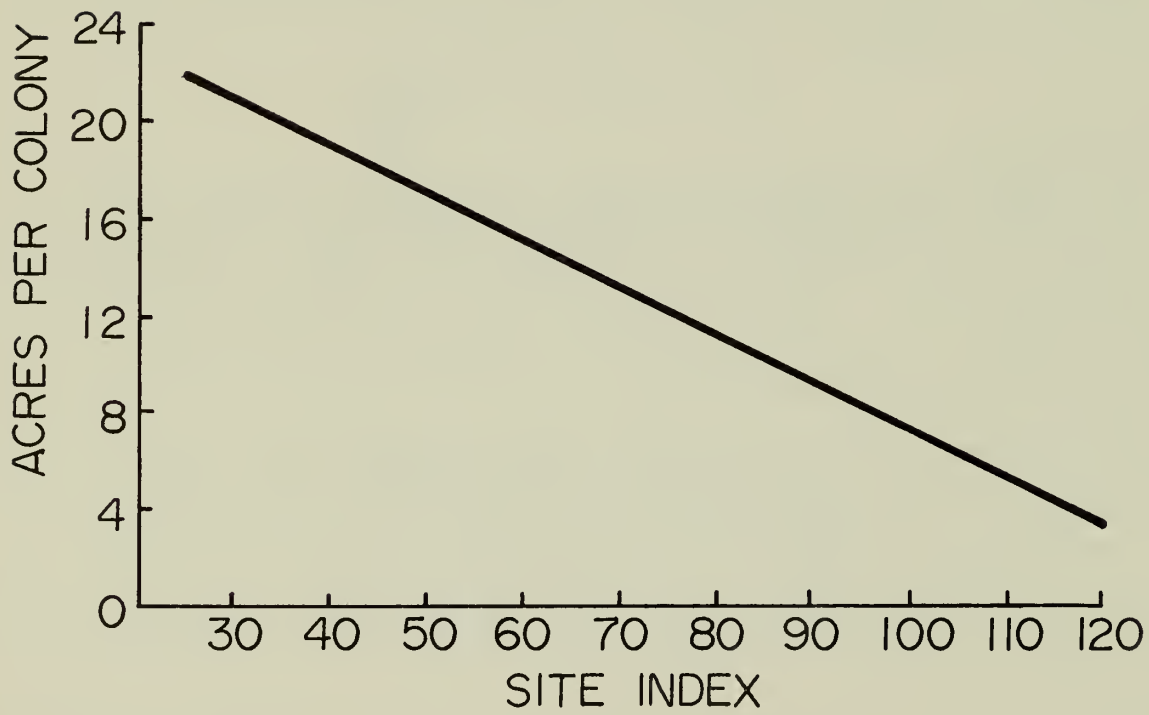
Timber Management

The colony support stand identified and measured during this study is considered the ultimate management unit to be roughly equated with any other larger forest compartment, block or unit. The colony, as identified and measured during this study, is considered as a timber stand within the colony management unit. Recommendations for timber management apply equally to areas designated as sanctuaries, multiple use units or for individual colonies.

Management of timber stands within the colony management unit is based upon the concept of even-age stands in an all-age forest. The management of each unit must be adjusted to site capability. The results of this study demonstrate (Figure 1) that the required size of this management unit would be smaller on a site of high quality than on a site of low quality. The acreages shown in Figure 1 are based upon an average of 4.16 $\pm$.34 cavity trees per colony and are recommended as a guideline to the minimal unit size.

The colony, as measured in this study, was 1.36 $\pm$.30 acres in size which is slightly less than the colony stand to be considered for management. Regression analysis did not demonstrate a significant decrease in colony stand acres from sites of low to high quality, but other study results and intuitive logic would indicate this to be true. The colony stands within the colony management unit may vary from .5 to 5.0 acres in size depending upon the site.

Figure 1.--The acres of support stand resulting from the regression estimates based on average of 4.16 ±.30 cavity trees per colony occurring on sites of various capabilities.



The results of this study would indicate that the number of years required to produce trees of a suitable height and diameter for use by the Red-cockaded Woodpecker as cavity trees is greater on a poor site than a good site. Because of the advanced state of maturity as the quality of site decreased, the longevity of the stands for habitation by the bird is materially reduced. As the quality of the site decreases, the stand rotation would necessarily be reduced to about 100-120-year period and there exists a greater need for more age classes of colony replacement stands. On the better sites, a rotation may extend well over 150 years and only three or four replacement colony stands of evenly proportioned age classes are needed.

A ten-year cutting cycle to maintain the stand basal area between 50 and 75 square feet according to the site is needed to promote satisfactory tree height and diameter growth. Frequent burning to reduce understory and maintain a park-like appearance is a recommended practice.

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We are, therefore, deeply indebted to numerous individuals of the U.S. Forest Service, National Wildlife Refuges, private industry, state forestry agencies and other individuals who provided us with information on Red-cockaded Woodpecker colonies and numbers. A special debt of gratitude is owed to Dr. Michael Johnson of Florida State University who provided statistical and computer assistance.

Table 1.--Data description of measured colony characteristics in all timber types

Characteristics	Mean	Standard Deviation	Standard Error Of Mean	Sample Size	Maximum	Minimum	Range
Site Index	70.92	15.02	.99	226	120.00	30.00	90.00
Pine Stems/Acre	53.24	32.92	2.18	229	182.00	6.00	176.00
Hardwood Stems/Acre	3.69	12.64	.84	229	102.00	0.00	102.00
Total Stems/Acre	56.93	34.98	2.31	229	242.00	6.00	236.00
Colony Acreage	1.36	2.31	.15	229	17.00	.01	16.99
Dominant Trees (%)	49.42	28.31	1.95	210	100.00	0.00	100.00
Codominant Trees (%)	25.09	19.20	1.32	210	100.00	0.00	100.00
Suppressed Trees (%)	8.42	10.86	.75	210	80.00	0.00	80.00
Remanent Trees (%)	16.50	30.05	2.07	210	100.00	0.00	100.00
Other Trees (%)	.60	2.85	.19	210	20.00	0.00	20.00
Basal Area	52.92	21.96	1.45	229	140.00	10.00	130.00
Tree Height	75.09	18.20	1.20	229	122.00	36.00	86.00
Tree Age	81.67	21.64	1.48	214	170.00	30.00	140.00
Tree Diameter	14.40	3.21	.21	229	28.00	8.40	19.60
Total # Cavity Trees	4.16	2.50	.17	229	17.00	1.00	16.00
Total # Cavities	6.41	5.66	.37	229	66.00	1.00	65.00
Den Cavities	4.00	2.94	.19	229	21.00	1.00	20.00
Old Cavities	1.22	3.95	.26	229	51.00	0.00	51.00
Start Holes	1.61	2.31	.15	229	18.00	0.00	18.00

Table 2.--Data description of measured colony characteristics in the Longleaf timber type

Characteristics	Mean	Standard Deviation	Standard Error Of Mean	Sample Size	Maximum	Minimum	Range
Site Index	64.46	12.38	1.03	145	85.00	30.00	55.00
Pine Stems/Acre	57.74	33.51	2.75	148	182.00	6.00	176.00
Hardwood Stems/Acre	1.30	9.72	.80	148	102.00	0.00	102.00
Total Stems/Acre	59.04	35.69	2.93	148	242.00	6.00	236.00
Colony Acreage	1.38	2.38	.20	148	16.00	.01	15.99
Dominant Trees (%)	39.54	24.79	2.17	130	100.00	0.00	100.00
Codominant Trees (%)	29.88	19.15	1.68	130	100.00	0.00	100.00
Suppressed Trees (%)	8.35	8.05	.71	130	30.00	0.00	30.00
Remanent Trees (%)	21.38	32.96	2.89	130	100.00	0.00	100.00
Other Trees (%)	.85	3.36	.29	130	20.00	0.00	20.00
Basal Area	50.30	21.98	1.81	148	140.00	10.00	130.00
Tree Height	66.83	14.68	1.21	148	104.00	36.00	68.00
Tree Age	82.35	24.29	2.11	133	170.00	30.00	140.00
Tree Diameter	13.32	2.68	.22	148	21.50	8.40	13.10
Total # Cavity Trees	3.61	2.14	.18	148	11.00	1.00	10.00
Total # of Cavities	5.03	2.90	.24	148	13.00	1.00	12.00
Den Cavities	3.81	2.94	.24	148	21.00	1.00	20.00
Old Cavities	.61	1.99	.16	148	20.00	0.00	20.00
Start Holes	1.22	1.80	.15	148	10.00	0.00	10.00

Table 3.--Data description of measured colony characteristics in the Loblolly timber type

Characteristics	Mean	Standard Deviation	Standard Error Of Mean	Sample Size	Maximum	Minimum	Range
Site Index	83.38	12.98	1.78	53	120.00	45.00	75.00
Pine Stems/Acre	42.21	18.99	2.61	53	102.00	6.00	96.00
Hardwood Stems/Acre	6.13	14.98	2.06	53	74.00	0.00	74.00
Total Stems/Acre	48.34	26.28	3.61	53	146.00	6.00	140.00
Colony Acreage	.99	1.22	.17	53	6.40	.01	6.39
Dominant Trees (%)	65.21	28.52	3.92	53	100.00	0.00	100.00
Codominant Trees (%)	18.26	16.87	2.32	53	50.00	0.00	50.00
Suppressed Trees (%)	5.08	7.87	1.08	53	40.00	0.00	40.00
Remanent Trees (%)	11.26	25.25	3.47	53	100.00	0.00	100.00
Other Trees (%)	.28	2.06	.28	53	15.00	0.00	15.00
Basal Area	54.13	19.37	2.66	53	105.00	16.00	89.00
Tree Height	89.91	14.12	1.94	53	122.00	42.00	80.00
Tree Age	79.04	13.01	1.79	53	115.00	53.00	62.00
Tree Diameter	15.82	2.47	.34	53	21.40	9.50	11.90
Total # Cavity Trees	4.62	2.15	.30	53	12.00	1.00	11.00
Total # of Cavities	7.47	4.14	.57	53	19.00	1.00	18.00
Den Cavities	3.91	2.56	.35	53	11.00	1.00	10.00
Old Cavities	1.38	1.86	.26	53	9.00	0.00	9.00
Start Holes	2.19	2.34	.32	53	10.00	0.00	10.00

Table 4.--Data description of measured support stand characteristics in all timber types.

Characteristics	Mean	Standard Deviation	Standard Error Of Mean	Sample Size	Maximum	Minimum	Range
Site Index	70.61	15.62	1.25	157	120.00	30.00	90.00
Total Stems/Acre	63.89	31.66	2.53	157	182.00	12.00	170.00
Stand Acreage	12.69	10.91	.87	157	75.00	.40	74.60
Dominant Trees (%)	49.78	24.72	1.98	156	100.00	0.00	100.00
Codominant Trees (%)	27.24	17.12	1.37	156	80.00	0.00	80.00
Suppressed Trees (%)	10.01	11.57	.93	156	80.00	0.00	80.00
Remanent Trees (%)	12.31	23.12	1.85	156	100.00	0.00	100.00
Other Trees (%)	.48	2.88	.23	156	20.00	0.00	20.00
Basal Area	55.96	20.01	1.60	157	140.00	10.00	130.00
Tree Height	75.12	18.63	1.49	156	122.00	36.00	86.00
Tree Age	78.85	19.05	1.58	145	133.00	37.00	96.00
Tree Diameter	13.63	3.13	.25	157	28.00	8.40	19.60

Table 5.--Data description of measured support stand characteristics in the Longleaf timber type

Characteristics	Mean	Standard Deviation	Standard Error Of Mean	Sample Size	Maximum	Minimum	Range
Site Index	63.11	12.87	1.30	98	85.00	30.00	55.00
Total Stems/Acre	70.81	32.38	3.33	98	182.00	15.00	167.00
Stand Acreage	13.48	12.46	1.26	98	75.00	.40	74.60
Dominant Trees (%)	42.40	20.34	2.05	98	100.00	0.00	100.00
Codominant Trees (%)	32.54	14.34	1.45	98	80.00	0.00	80.00
Suppressed Trees (%)	9.31	8.29	.88	98	50.00	0.00	50.00
Remanent Trees (%)	14.90	23.37	2.36	98	100.00	0.00	100.00
Other Trees (%)	.56	3.04	.31	98	20.00	0.00	20.00
Basal Area	52.34	18.01	1.82	98	140.00	10.00	130.00
Tree Height	65.71	15.35	1.56	97	104.00	36.00	68.00
Tree Age	80.37	22.63	2.44	86	133.00	37.00	96.00
Tree Diameter	12.18	2.34	.24	98	18.50	8.40	10.10

Table 6.--Data description of measured support stand characteristics in the Loblolly timber type

Characteristics	Mean	Standard Deviation	Standard Error Of Mean	Sample Size	Maximum	Minimum	Range
Site Index	83.60	12.01	1.85	42	120.00	60.00	60.00
Total Stems/Acre	46.45	19.89	3.07	42	98.00	12.00	86.00
Stand Acreage	12.15	7.85	1.21	42	40.00	.80	39.20
Dominate Trees (%)	62.74	27.69	4.27	42	100.00	0.00	100.00
Codominate Trees (%)	21.50	17.59	2.71	42	50.00	0.00	50.00
Suppressed Trees (%)	6.24	7.44	1.15	42	30.00	0.00	30.00
Remanent Trees (%)	9.05	23.12	3.57	42	100.00	0.00	100.00
Other Trees (%)	.48	3.09	.48	42	20.00	0.00	20.00
Basal Area	59.71	20.84	3.22	42	105.00	20.00	85.00
Tree Height	89.76	11.99	1.85	42	122.00	68.00	54.00
Tree Age	77.62	11.13	1.72	42	103.00	54.00	49.00
Tree Diameter	15.79	2.17	.33	42	21.20	12.00	9.20

Table 7.--Data description of individual cavity tree species.

	TREE SPECIES														
	Longleaf			Loblolly			Shortleaf			Pond Pine			Slash Pine		
Characteristics	Mean	Standard Deviation	Sample Size	Mean	Standard Deviation	Sample Size	Mean	Standard Deviation	Sample Size	Mean	Standard Deviation	Sample Size	Mean	Standard Deviation	Sample Size
Den Cavities	1.01	.91	560	.73	.87	574	.64	1.17	45	1.13	.35	8	1.00	1.51	15
Old Cavities	.15	.53	560	.56	1.28	574	.36	.61	45	.00	.00	8	.13	.52	15
Start Holes	.30	.61	560	.46	.89	574	.47	.63	45	.00	.00	8	.67	1.35	15
Total of all Cavities	1.46	.91	560	1.74	1.62	574	1.69	1.90	45	1.13	.35	8	1.80	1.57	[illegible]
Tree Height	68.81	18.61	551	91.37	17.55	557	88.34	15.21	44	72.86	12.40	7	82.13	13.31	[illegible]
Tree Age	83.11	33.87	401	71.01	27.26	460	89.10	33.62	42	85.20	19.56	5	70.15	57.34	15
Tree Diameter	15.26	30.73	557	18.97	38.86	572	18.58	35.73	44	15.40	29.95	8	16.00	31.06	15

APPENDIX

A glossary of terms used in association with the Red-cockaded Woodpecker*

Recent interest in the Red-cockaded Woodpecker *(Dendrocopos borealis)* has demonstrated that a special vocabulary is needed to avoid confusion in the discussion of the ecology of the species. The following terms and definitions are offered as a standard vocabulary to be used in discussions concerning this species. New terms are suggested to discriminate between two or more separable phenomena or to identify phenomena previously known only by lengthy description.

Cavity: An excavation used by Red-cockaded Woodpeckers for roosting or nesting at some time during the life of the colony.

Cavity Tree: A tree containing one or more Red-cockaded Woodpecker cavities.

Clan: All the Red-cockaded Woodpeckers that inhabit a colony at a given point in time; generally a mated pair of Redcockaded Woodpeckers, their offspring, and their associated helpers.

Colony: The area prescribed by an aggregation of start holes, and roost, nest, and old cavities habitually used by a clan.

Glaze: The covering of resin surrounding a Red-cockaded Woodpecker cavity entrance or on an adjacent tree facing a cavity; results from deliberate excavation of resin wells by the birds.

Helper: Any Red-cockaded Woodpecker in a clan other than the genetic parents of young raised by the clan during the most recent breeding season.

Nest Cavity: A cavity used by a pair of Red-cockaded Woodpeckers as a place in which to raise their young, usually the roosting cavity of a male.

Nest Tree: A tree containing a nesting cavity.

Old Cavity: An enlarged cavity with deteriorating glaze receiving little or no current use.

Plate: The exposed wood surrounding a Red-cockaded Woodpecker cavity entrance.

Range: The area surrounding a nest cavity required by a clan to fulfill their life cycle requirements. This may include the colony, support stand, breeding territory, seasonal foraging area, or other definable units.

Resin Well: A hole, generally circular, in the bark of a cavity tree or a tree adjacent to a cavity tree from which resin exudes.

Roost Cavity: A cavity used by a Red-cockaded Woodpecker only as a shelter, particularly at night and during inclement weather.

Start Hole: The beginning of a cavity; may never be finished, but if completed, excavation is usually over a period of several months.

Support Stand: That stand of timber in the immediate vicinity of a colony which may be ecologically definable on the basis of topography, vegetative types, land use patterns, stand conditions, or other logical entities.

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* Compiled by Jerome A. Jackson and Richard L. Thompson

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