SOUTH FLORIDA RESEARCH CENTER

Report T-613
Distribution and Habitat of the Red-cockaded Woodpecker in Big Cypress National Preserve

NATIONAL PARK SERVICE
DEPARTMENT OF THE INTERIOR

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ABSTRACT

Surveys in 1979 and 1980 revealed that pine forests of the Big Cypress National Preserve (BICY) support a sizable and largely unsuspected population of the Red-cockaded Woodpecker, a federally-listed endangered species. We located 23 colonies, 18 of which were active. Twelve of the active colonies were north of the Tamiami Trail in the Collier County portion of BICY and six were in the Lostmans Pines section in Monroe County. Because large areas of apparently prime habitat are yet to be searched, we estimate that the minimum population in BICY is 40 active colonies. It is the southernmost, and probably the largest, of the four remaining local populations of Red-cockaded Woodpeckers in southern Florida which are of viable size and have relatively secure habitat. As such, it represents a significant element in the total species population. All colony activity centers and nesting/roosting cavities were located in stands of old-growth slash pine, but birds from several colonies foraged primarily in cut-over areas of younger pines. Because pine logging operations left frequent small patches of original forest within the cut-over section, in addition to the substantial areas not touched by logging, habitat acceptable to Red-cockaded Woodpeckers now occurs throughout much of the pine forest area of BICY. However, survival of the colonies located in remnants of original forest within cut-over areas, about one-third of the known population, depends on the survival of enough of the mature pines until trees in the second-growth stands reach adequate size for woodpecker cavities. Severe fires which may kill mature pines and dense hardwood invasion of pine stands in the absence of fire seem to be the major ecological influences limiting available habitat. Habitat in BICY differs from that occupied by the species in most of its range in that the pines occur as island stands within an intricate mosaic of vegetation, rather than as extensive continuous forests. Physical characteristics of Red-cockaded Woodpecker colonies in BICY are generally similar to those reported in other studies, but preliminary observations suggest behavioral differences which may be related to the uneven distribution of foraging habitat. For example, the home range of individual clans may tend to be larger than the home ranges determined in studies elsewhere. Realization that the Red-cockaded Woodpeckers of BICY are a major, peripheral population unit of this endangered species emphasizes the need for completion of the population survey and initiation of biological studies.

INTRODUCTION

The Big Cypress National Preserve, a 230,000 ha area of wilderness wetlands in southwestern Florida (Figure 1) adjoining Everglades National Park (EVER), was established on 11 October 1974 (PL 93-440) and acquisition of land by the National Park Service began soon afterward. Following completion of an exhaustive inventory of existing information on natural resources and land use in BICY (Duever et al. 1979), the South Florida Research Center, EVER, initiated a research program in the area on 1 October 1978. The research program, designed to obtain baseline ecological data in several disciplines, included a project for study of vertebrate animal populations with particular emphasis on the federally-listed endangered species that might occur in BICY. The BICY Wildlife Project terminated on 30 September 1980. As part of the publication of work accomplished by the project, we report here our observations on the occurrence and status of the Red-cockaded Woodpecker (Picoides borealis), an endangered species found to be represented in BICY by a significant breeding population.

TERMS AND METHODS

Terminology

The ecology and behavior of the Red-cockaded Woodpecker differ considerably from the pattern usual in small landbirds. This has resulted in the use of specialized terms to describe observations and in attempts to standardize terminology so that studies could be compared accurately. The following definitions of special terms used in the report are adapted from the glossary presented by Jackson and Thompson (1971).

Cavity: Any excavation made by a Red-cockaded Woodpecker in a living pine tree. We have used the term to include start holes as well as the completed cavities used for roosting and nesting.

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

Clan: The group of Red-cockaded Woodpeckers associated with a particular colony at a given time. At minimum, a mated pair, but also including at times fledged offspring of the current year and helpers.

Colony: The area described by the group of cavity trees habitually used by a particular clan.

Glaze: The covering of fresh and dried resin on cavity trees which results from the deliberate excavation of resin wells by the woodpeckers.

Helper: Any adult member of a clan other than the current breeding pair. Helpers are generally male offspring of previous years.

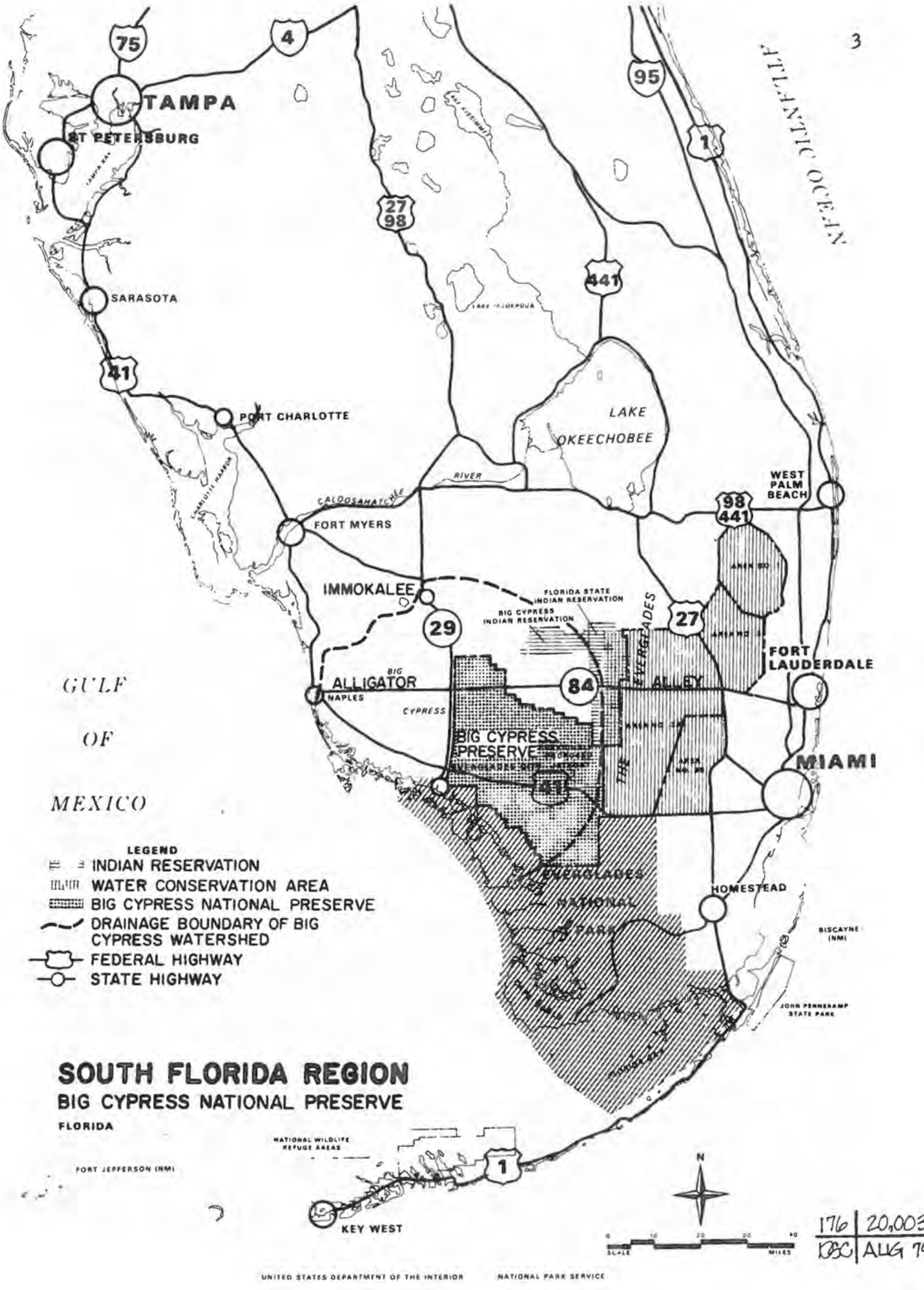


Figure 1. Southern Florida showing the location of Big Cypress National Preserve.

Plate: The area of exposed wood surrounding a cavity entrance and resulting from the long-continued scaling of bark and resin well excavation by the woodpeckers.

Resin Well: A small hole penetrating the sapwood of a cavity tree from which resin exudes. The holes are dug and maintained by the woodpeckers presumably to promote resin flow.

Start Hole: An incomplete cavity, either under construction or begun and then permanently or temporarily abandoned.

Methods

This study was primarily a preliminary search of a very extensive area. Methods employed were simple and consisted of: (1) Aerial survey of BICY pine forests to locate old-growth stands that appeared suitable for Red-cockaded Woodpecker colonies; (2) Ground search of the apparently suitable locations for cavity trees; (3) Where colonies were found, recording standard measurements of cavities and cavity trees; and, (4) Where feasible, revisiting colonies periodically to record clan size, nesting information, foraging range, and other biological data.

We did most of the surveying by helicopter which often enabled us to check promising sites at once. Efforts to look for suitable habitat from a fixed-wing aircraft were disappointing, because at the necessary flight speed and altitude we often could not locate areas on the available maps accurately enough to find them later on the ground. Not infrequently, the conspicuous resin coating on active cavity trees was visible from the helicopter and a few colonies were first located in this manner. The helicopter was especially useful and cost-effective for surveying the conspicuous, but widely scattered, stands of old-growth forest within large cut-over areas. Given a large and vegetationally complex roadless area such as BICY, the helicopter appears to provide the survey method of choice. We also often used 3-wheeled trail bikes (Honda "All-Terrain Cycles"), operating along established off-road vehicle (ORV) trails, for more intensive local surveys and to reach suspect areas that had been spotted from the air.

Aerial surveys of habitat covered the entire pine forest area of BICY except that only one survey flight was made over the Bear Island section north of Alligator Alley (State Road (S.R.) 84). However, as detailed below, we were able to make systematic ground searchs of no more than half the apparently suitable habitat located from the air. The areas not searched on the ground are mainly pine islands remote from improved roads and too closely invested by scrub cypress forest to allow safe helicopter landing.

When a cavity tree was found, we searched the surrounding area thoroughly to locate other cavity trees and determine the size of the colony. Routinely, we recorded: (1) Height and diameter at 1.37 m above ground (dbh) for each cavity tree; (2) Height and condition of each cavity and the direction the cavity opening faced; and, (3) Distance and compass bearing of each cavity tree from its nearest neighbor which permitted us to map the colony and determine the approximate area it occupied. All cavity trees were marked with numbered metal tags. Height measurements were made with a clinometer ("Suunto" model, Forestry Suppliers, Inc.) graduated in feet and were converted to the closest 0.25 m. Because of the greater accuracy of the method and because section lines have not been established in parts of BICY, we located all colonies for permanent record by Mercator points (1000 meter Universal Mercator Grid ticks) with reference to the current 7.5 minute series of orthophoto topographic maps of the region (U.S. Geological Survey 1971 1:24000). The locations given (Table 7, Appendix) are those of the nest cavity tree, if known, or of the center of the colony. Each colony or closely-spaced group of colonies was given a distinctive letter designation referrring to a local geographical or cultural feature, such as vegetation units, hunting camps, major ORV trails, survey triangulation points, air strips, and oil drilling pads.

We revisited most sites several times to determine whether the colonies were active and to obtain as much information as possible about the resident clans of woodpeckers, but most of these observations were limited and incidental to other work.

BRIEF BASIC BIOLOGY OF THE RED-COCKADED WOODPECKER

As suggested above, the ecology and behavior of the Red-cockaded Woodpecker exhibit several unusual features. A brief review of the biology of the species may be useful to facilitate understanding of observations in BICY. The basic natural history was well-known from earlier observations (e.g., Wayne 1906, Murphey 1939, Grimes 1947), but most of the information on detailed breeding biology and social behavior results from studies carried out since the species' endangered status attracted attention to it. We have referred particularly to the papers of Baker (1971a, 1978), Beckett (1971), Lay, et al. (1971), and Ligon (1968, 1970, 1971).

The Red-cockaded Woodpecker is a textbook example of a species whose evolutionary success is largely responsible for its present plight. The specializations which adapted it closely to life in the original conditions of a particular ecosystem, the pine forests of the southern United States, became highly maladaptive when man altered the system on a large scale in a brief period of time. The Red-cockaded differs strikingly from most other woodpeckers in that it excavates its roosting and nesting cavities almost exclusively in living pines. Ligon (1970) suggested that this habit may have evolved because the frequent fires typical of the habitat left few standing dead trees. Moreover, the pines it uses are almost always mature to aged trees infected with "red heart," a fungus (Phellinus pini) that causes heart rot, and presumably makes it easier for the woodpeckers to excavate the dense heartwood. Red heart seldom affects pines less than about 60 years old, the wind-disseminated spores entering the tree by way of wounds on the trunk or where larger branches have been broken (Affeltranger 1971). Because Red-cockaded Woodpeckers commonly take a year or longer to complete a cavity, authors have suggested that a rather strict symbiosis may exist between the fungus and the woodpecker. Jackson (1977b:162) stated, "The presence of red heart is probably required for the normal, complete excavation of cavities by Red-cockaded Woodpeckers and infection of pines by red heart is probably facilitated by the birds' activities."

A second extraordinary characteristic of the cavities of Red-cockaded Woodpeckers results from their habit of systematically puncturing the sapwood of cavity trees. This causes the pine to exude resin so that the area around the cavity opening and ultimately much of the tree trunk becomes coated with a sticky glaze which continues to accumulate as the birds rework their diggings to keep these resin wells open. Typically, when resin can no longer be made to flow, use of the particular cavity or cavity tree is abandoned. The dominant recent opinion (Dennis 1971a, Beckett 1971) in a long debate about the adaptive significance of this bizarre behavior is that the glaze of fresh resin tends to prevent predators, particularly snakes, from reaching the cavities. Experimental observations (Jackson 1974) indicate that a coating of fresh resin in fact repels tree-climbing snakes.

Given the time and energy required for excavation and maintenance, it is not surprising that the cavity becomes the focus of the entire life activities of a Red-cockaded Woodpecker. Usually, each established adult has its own cavity in which it roosts alone at night, and, on occasion, the cavity may also serve as a nest.

Early observers frequently referred to the Red-cockaded Woodpecker as "gregarious," because small groups of adults were often seen together. More recent studies of individually-marked birds have shown that these are cohesive social groupings rather than casual aggregations. The so-called clan operates as a unit the year around and, far from being gregarious in the ordinary sense, actively defends the colony and foraging territory against neighboring clans.

Many details of the social organization are still unknown (or not yet published), but, essentially, the clan is a group of cooperating adults of which only one pair nests in a given breeding season. Clans consisting only of the mated pair occur and may be characteristic of less favorable habitat (Ligon 1971). More commonly, however, one to several additional adult helpers are associated with the group. Clans of as many as eight or nine adults have been reported, but it is perhaps questionable whether stable groups of this size occur. The mean size of 12 clans in east Texas was 3.25 adults (Lay et al. 1971) and other authors (Baker 1971a, Beckett 1971) have reported that most clans in the populations they studied had at least one helper. In the typical case at any rate, clans include only one female, the breeder (Beckett 1971, Lay, et al. 1971). Most or all of the helpers are male offspring of previous years. They may continue as helpers for several years and, collectively, they may contribute almost as much to incubation and feeding and brooding of young as the two parents, commonly much more than the female (Lennartz and Harlow 1979, and earier work discussed there). Hooper, et al. (1979) stated that one of the helping sons may inherit the territory when the breeding male disappears and Lay et al. (1971) reported that the dominant male may be displaced and remain with the clan as a helper. As some individual colonies are thought to have been continuously occupied for 40 to 50 years (Beckett 1971), it does not seem unreasonable to imagine that the patrilineal clans may persist for long periods in little-disturbed situations.

Presumably, a helper system of this sort can exist only if each helper on the average enhances its own reproductive potential by staying home instead of dispersing. As inheriting an established colony may be the surest way for a young male Red-cockaded Woodpecker to become a breeder, the advantage for some helpers seems clear. Even helpers that eventually disperse may benefit, if experience as an apprentice serves to improve requisite skills. Any helper might also have a genetic impact, whether or not it ever bred, if its helping resulted in greater survival of genetically similar siblings (Ligon 1971). However, it seems still to be uncertain for the Red-cockaded Woodpecker whether the efforts of helpers significantly increase the likelihood of survival of the current brood. Ligon (1970) found that the nestlings tended to grow faster in the case of clans that had helpers. Lennartz and Harlow (1979) reported that in two years the mean size of fledged broods in clans with helpers was 1.6 and 2.4 as opposed to 1.3 and 1.9 in clans without helpers. But, because of possible unknown variables and small sample size, Lennartz and Harlow considered their results inconclusive.

Typically, the nest is located in the roosting cavity of the dominant male and the male parent thus assumes the night shift of incubation and brooding. Clutch size is two to five eggs, usually three or four. Mean size of 47 clutches in South Carolina (Beckett 1971) was 3.0 eggs. Only one brood is reared in a season, but a few records of late nests (Baker 1971a) suggest that replacement eggs may be laid if the first attempt fails. The incubation period is about 10 days, one of the shortest known (Ligon 1970, Baker 1978), and nearly all the eggs hatch (Ligon 1970, Beckett 1971). The young birds spend an unusually long period, about four weeks, in the nest cavity, and, commonly, only one or two young are fledged. For 12 nests in Texas of which three failed (Lay et al. 1971), the mean size of fledged broods was 1.2 per nest and 1.9 per successful nest. Fledged broods of three are apparently uncommon; fledged broods of four occur, but are extremely rare (Lennartz and Harlow 1979). Ligon (1971:34) speculated that the clutch size may be "relictual and non-adaptive," indicating that present pine forest habitats are less favorable than those in which the species evolved. When they leave the nest, juvenile Red-cockaded Woodpeckers are still largely dependent and they may continue to be fed by adult members of the clan for as long as five or six months (Ligon 1970, 1971). As they become self-sufficient at various times before the next breeding season, all juvenile females and apparently some juvenile males leave the home colony. Other juvenile males remain and become helpers.

GENERAL HISTORY AND STATUS

The Red-cockaded Woodpecker was once common and generally distributed in mature stands of various pine types throughout the South. It was perhaps most characteristic of the pine flatwoods of the southeastern coastal plain (Baker 1978), but it also ranged originally through the Gulf states to eastern Texas and inland in piedmont, plateau and lower mountain pine forests as far as southern Missouri, Kentucky, and Tennessee (Jackson 1971:14). As early as the 1930's, it was realized that the species had disappeared from many areas in the wake of lumbering. In an early and prophetic appraisal, Murphey (1939:73) wrote: "This species is so highly specialized at least in the South Atlantic States in its habits and its choice of environment that the destruction of the pine forests would probably put its existence in serious jeopardy."

From the 1940's through the 1960's, wholesale logging of mature pine and the advent of modern forestry in the South left little place for Red-cockaded Woodpeckers. Lay and Russell (1970) put the case succinctly. The South then had about 7 million acres of old-growth pine being cut at the rate of 1.1 million acres per year; new pine stands on much of the former forest area were being managed for pulpwood on cutting rotations of 20 to 30 years; areas managed for timber of larger size mostly had cutting rotations of 40 to 50 years in part to avoid the loss caused by red heart and other diseases of older pines; the minimum age of Red-cockaded Woodpecker cavity trees in a sample of 60 examined by Lay and Russell was 56 years. Not surprisingly, the Red-cockaded Woodpecker was placed on the federal list of endangered species (FR 32:4001, 11 March 1967; FR 35:16047, 13 October 1970) at a relatively early date.

Information on the trend of population over the past decade is difficult to interpret. Loss of colonies has continued in many areas. Thompson (1976) found that 41 of 312 colonies in the Southeast that were active in 1969-70 were gone or inactive in 1973-74, a loss rate of about 3.5 percent per year caused in approximately equal parts by timber harvest and land development. Conversely, more intensive population surveys have located many additional colonies. Jackson (1971:29) knew of about 390 colonies in Florida, whereas Baker, et al. (1980) reported 943 colonies and Shapiro (1980 ms) estimated a minimum of 1187 colonies. Apparent increases of this sort have led to some suggestion that the species should be declassified (Jackson 1977a). Thus Lennartz and McClure (1979:27) wrote, ". . . the actual range-wide status of the species is uncertain and controversial." Doubtless the initial specific estimates of population were substantially too low as Jackson himself suggested (1971:20), but the additional information that accumulated during the 1970's seems to have provided no basis for questioning Jackson's general estimate that the total species population numbers <10,000 individuals. It also seems clear that the occupied range has continued to shrink and that the surviving population has become increasingly fragmented in most parts of the range. It appears (Jackson 1971, Baker et al. 1980, Shapiro 1980 ms) that two-thirds or more of the remaining Red-cockaded Woodpeckers may be concentrated on several national forests, national wildlife refuges and military reservations in northern Florida and coastal South Carolina.

HISTORY AND STATUS IN SOUTHERN FLORIDA

Original Southern Range Limits

In southern Florida, Lake Okeechobee and the Everglades separate the largely pine-forested uplands of the peninsula into eastern and western branches which become narrower and more fragmented as one proceeds south. The Red-cockaded Woodpecker originally occurred south to the limits of pine forest in both south-eastern and southwestern Florida. It is not known to have occurred in the still more isolated pine forests of the Lower Florida Keys, an area of perhaps 30 square kilometers whose breeding avifauna includes none of the species characteristic of southern pine forests (Robertson 1955, Robertson and Kushlan 1974). Statements extending the range to the Florida Keys (Murphey 1939:79) or indicating occurrence on islands off southern Florida (Jackson 1971:13) evidently represent misunderstanding of the location of Long Pine Key. We also are unable to verify occurrence at "Cape Sable" (Howell 1932:312). Howell cited no reference for this report and we suspect that it is an error, as no pine forest exists in the Cape Sable area.

Concerning occurrence at or near the limit of pine forest on the southeastern mainland: A 1913 observer (Mercer 1914) reported finding Red-Cockaded Woodpeckers in pine woods south of the Miami River on the way to Coconut Grove, thus near the center of the present city of Miami; the bird collection at the University of Minnesota includes a specimen taken at Florida City, 14 May 1923 (O. T. Owre pers. comm.); and, Howell (1921:257) wrote, "Common resident in pineland between Florida City and the (Royal Palm) Hammock and on Long Pine Key in the Everglades." Holt and Sutton (1926) also reported the species common on Long Pine Key in 1924, apparently the last definite record from areas now included in EVER.

Occurrence near the southwestern limit of the mainland pine forest was poorly documented prior to the present report (Figure 2), but enough records exist to suggest that the species was generally distributed in suitable habitat. Among early observers, Phelps (1914:99) and Kennard (1915:2) mentioned encountering Red-cockaded Woodpeckers in pine forests a short distance northwest of BICY. Records from areas that are now part of BICY include: a specimen in the University of Miami Research Collection (UMRC 602) collected by O. T. Owre near Pinecrest, Monroe County, 25 July 1953; nesting birds seen by W. G. Atwater somewhere in the Lostmans Pines section of Monroe County, 5 June 1955 (Stevenson 1955); and, birds seen in the same area by the junior author, 20 March 1958 (Stevenson 1958).

The scarcity of published records doubtless accounts for the omission of the southwestern Florida range extremities from recent general statements of the Red-cockaded Woodpecker's range. Thus, Jackson's (1971:14) map of the range by counties does not indicate either historical or recent occurrence in Collier or Monroe counties. Similar maps of the entire range or of the range in Florida presented by Baker (1978:12), Hooper et al. (1979:8) and Baker et al. (1980:43) include Collier County, but not Monroe County.

Decline and Present Status

Given lumbering and land development on the relatively limited area of upland, the Red-cockaded Woodpecker undoubtedly began to decrease as soon as southeastern Florida was settled, but it apparently was still widely distributed in the 1930's. Howell (1932:312) characterized the species as, "A locally common resident in the open pine forests throughout the mainland of Florida". Twenty years later, Sprunt (1954:281) wrote, "It is definitely uncommon now anywhere in the Southern Region." The general disappearance of the species from its southeastern range limits occurred in about 1935-1950 associated with logging of the last mature stands of pine around Homestead and on Long Pine Key.

No Red-cockaded Woodpeckers seem to have persisted through the clear-cut logging of Long Pine Key from the late 1930's until around 1945. The one old-growth area of large pine left uncut, about 1.5 ha within Royal Palm State Park, doubtless was too small to hold a colony. Larger areas of uncut forest on poor sites along the north and west edges of Long Pine Key probably had too few

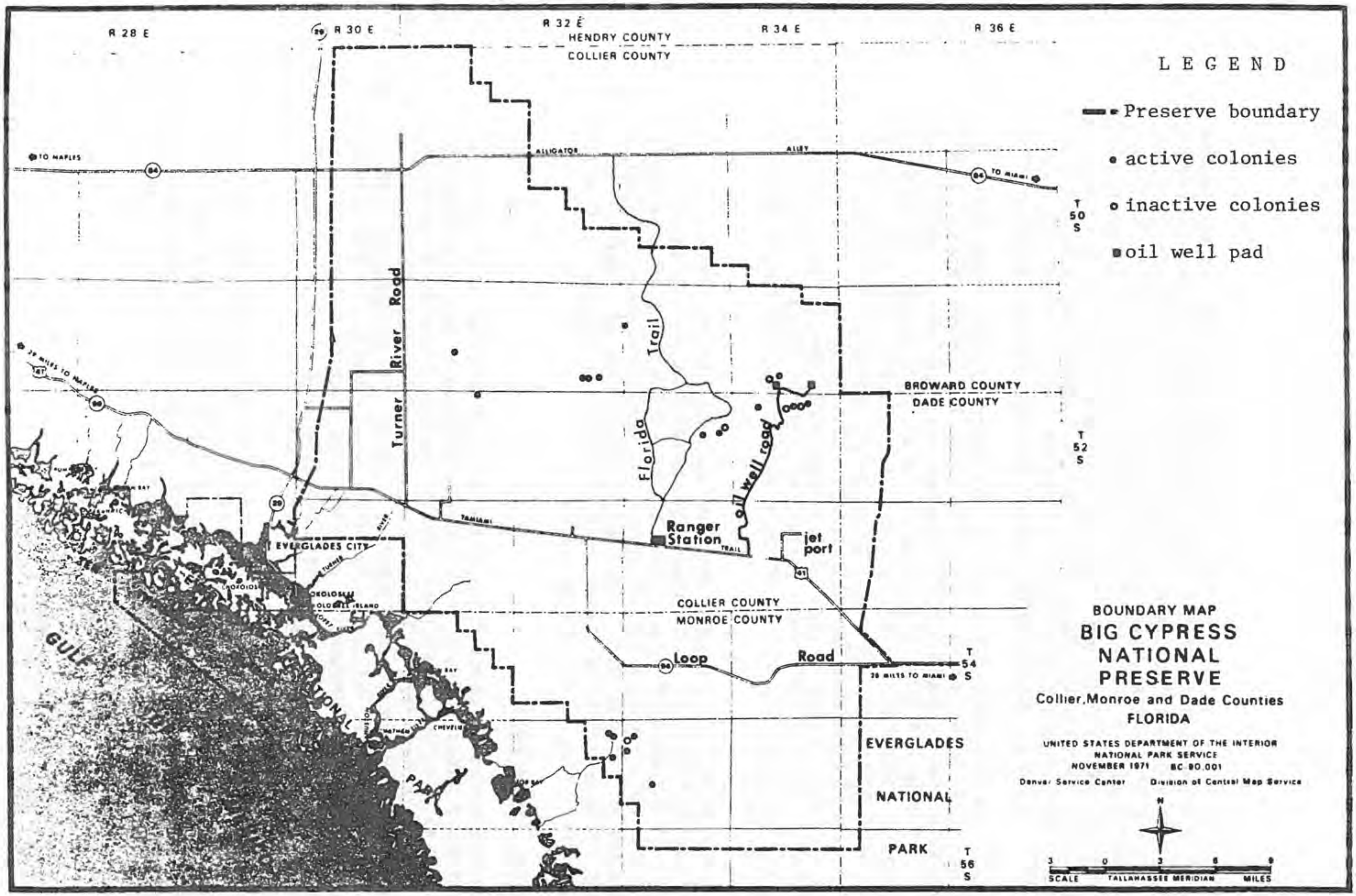


Figure 2. Big Cypress National Preserve showing localities mentioned and the distribution of Red-cockaded Woodpecker colonies.

pines of adequate size. There is thus no record of the species from the area within the history of EVER. However, its earlier occurrence is well-established and re-introduction might be possible once the second-growth forests of Long Pine Key reach adequate size.

At least one clan of Red-cockaded Woodpeckers survived in pine forests west of Florida City - roughly in the area bounded on the north by Mowry Drive, on the west by Loveland Road, on the south by Lucille Drive, and on the east by Tower Road long after the species had apparently disappeared elsewhere in southeastern Florida. C. M. Brookfield (pers. comm.) knew of their existence in this area from the late 1940's until 1963, a period when he led National Audubon Society wildlife tours based in Miami. Similarly, during the 1950's, O. T. Owre (pers. comm.) regularly took his University of Miami ornithology classes to the area to see Red-cockaded Woodpeckers. The general region of approximately 4 x 4 km was a mosaic of pine forest patches and cleared fields by the late 1940's. Clearing of pines to develop agricultural land increased rapidly after the mid-1950's, but the area still has a number of small stands of second-growth pine, including a block of about 100 ha preserved as a Dade County Park. As of the 1950's (Robertson pers. observ.) many pine stands in the area were even-aged young growth but considerable areas seemed to have been selectively cut and contained scattered trees from the original stand (see photograph in Truslow 1966:178). The only Red-cockaded Woodpecker colony ever found during the species' known disjunct existence in this area was in a patch of old-growth pines located south of Mowry Drive and west of Country Club Road and apparently not touched by logging. In mid-April 1959, when the junior author first became aware of it, the woodpecker clan numbered at least three individuals (Stevenson 1959), the colony included at least two cavity trees and the remnant old-growth forest covered about 3 ha. At least two woodpeckers were still present near the colony in the winter of 1964-65 (Robertson pers. observ.) when clearing had begun nearby. The colony site and extensive surrounding areas were denuded of pine during the following year.

If nothing else, the above history illustrates the remarkable site tenacity and conservatism of Red-cockaded Woodpeckers. The birds west of Florida City apparently persisted as an isolated group for at least 15 to 20 years. Stimson (in Sprunt 1954:281), for example, stated that the species had become "exceedingly rare" in southeastern Florida by 1943. Other than those in or near the above area, we know of no records from Dade or Broward counties later than about 1950. Thus there is little doubt that the birds were widely isolated for a long period. Because only one colony was ever found and because the maximum number of adults ever seen together was either three or four, it also seems likely that only one clan of Red-Cockaded Woodpeckers inhabited the area. Apparently they continued to do so in isolation for many years, as the pine forest disappeared around them, perhaps up to the moment when a bulldozer pushed over the cavity trees.

Disappearance of the Red-cockaded Woodpecker from the pine belt of southwestern Florida lagged that in the southeast by several decades, but it is virtually complete today outside of BICY. The species was still to be found in pine areas of the extensive "Golden Gate Estates" development as late as the early 1970's (O. T. Owre pers. comm.), but T. H. Below, Jr. (pers. comm.) now knows of no active colonies in western Collier County with the possible exception of the one reported from Collier-Seminole State Park (Baker et al. 1980). Birds were last seen in the familar colony at Corkscrew Swamp Sanctuary, southwest of Immokalee, in the spring of 1975 and J. Cutlip (pers. comm.) knows of no presently active colonies on the Sanctuary or in the surrounding area. Farther north in the region, scattered colonies probably still exist (e.g., Stevenson 1968, Ogden 1970), but most appear to have little chance of long-term survival. As shown (Figure 3), much of the species' former habitat in southern Florida has been obliterated by development for housing and agriculture.

We are greatly indebted to S. A. Nesbitt (pers. comm.) for assistance in identifying the surviving local populations of Red-Cockaded Woodpeckers in southern Florida that are thought to be of viable size and to inhabit areas that provide secure habitat. In addition to that of BICY, there appear to be only three such populations in the southern half of peninsular Florida, all located on tracts of state or federal land. The significant local populations and the reported number of active colonies are: J. W. Corbett Wildlife Management Area (WMA), Palm Beach County, 8 (Baker et al. 1980) or 14 to 15 (Shapiro 1980 ms); C. M. Webb WMA, Charlotte County, 14 (Baker et al. 1980, Shapiro 1980 ms); and Avon Park Bombing Range, Highlands and Polk counties, 21 (Baker et al. 1980) or 17 (Shapiro 1980 ms).

In southern Florida there would appear to be no grounds for uncertainty nor controversy about the status and future of the Red-cockaded Woodpecker. At best, the species will continue to exist in the region in a very few widely separated relict populations, none of which is likely to number more than about 100 adult individuals. As the southernmost, and probably the largest group likely to persist, the importance of the BICY population seems obvious.

HABITAT IN BICY

Here we consider the occurrence and general characteristics of the pine forest habitat of Red-cockaded Woodpeckers in BICY, the ecological and historical influences which seem to account for present major variations in the pine forests of the area, and the prospects and problems of maintaining habitat for Red-cockaded Woodpeckers in the near-term future. More local aspects of Red-cockaded Woodpecker habitat in particular parts of BICY are discussed in the following section.

Pine Forests of BICY

Forests of south Florida slash pine (Pinus elliottii var. densa) are a major component of the vegetation of BICY estimated to cover about 400 square kilometers, some 18 percent of the total area (McPherson 1973, Duever et al. 1979:223). To judge from existing remnants, trees of larger mature sizes, 30 to 60 cm dbh and 20 to 30 m in height, predominated in the original stands. Typically, the forests are maintained in an open park-like condition by frequent surface fires and the shrub-small tree understory is sparse and consists mostly of palms (Sabal, Serenoa). Similar forests, termed pine flatwoods, were the Red-cockaded Woodpecker's main habitat throughout the coastal plain of the southeastern United States and the decline of the species has closely paralleled the declining area of old-growth stands of this forest type (Lay and Russell 1970, Jackson 1971, Baker 1978).

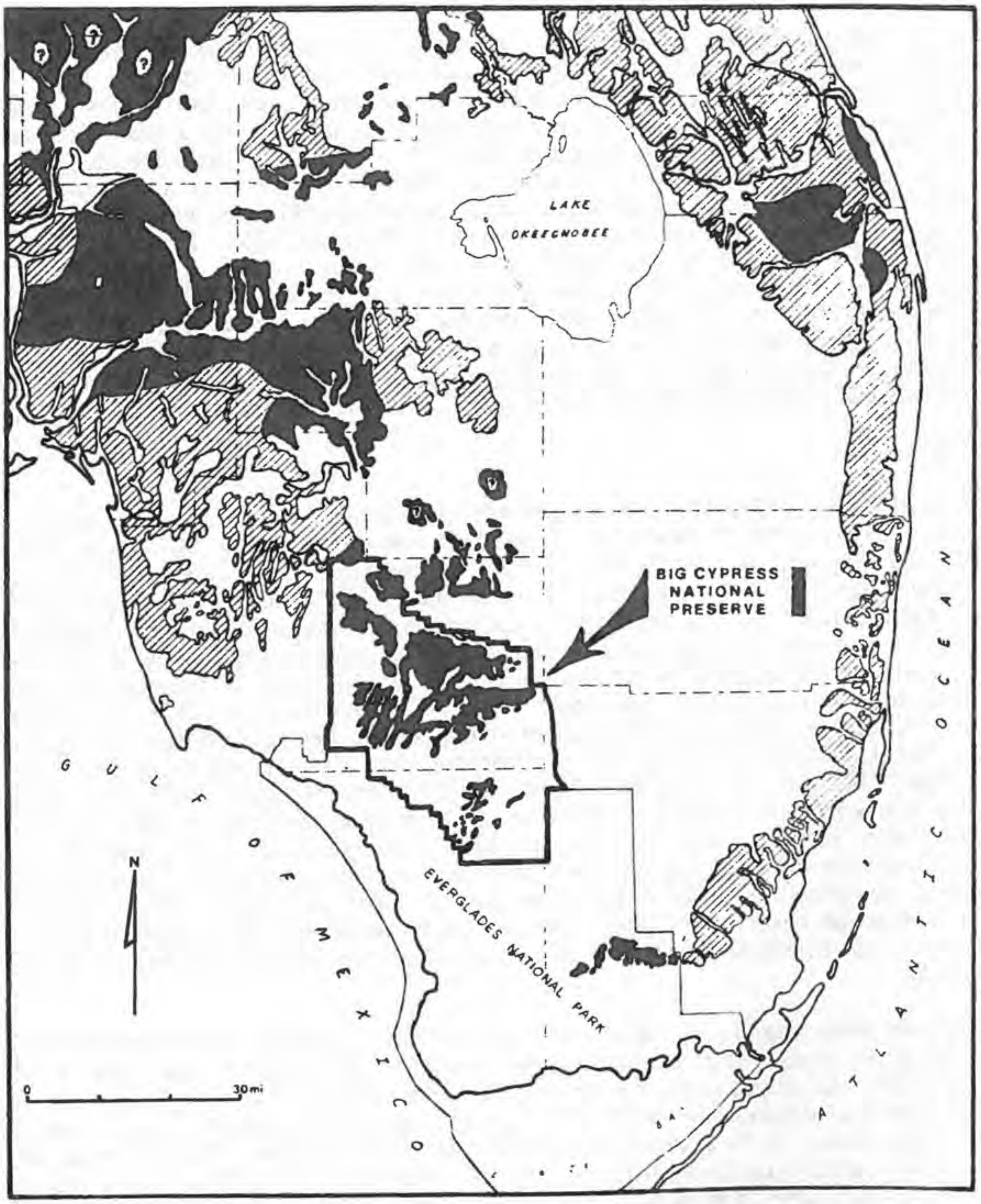


Figure 3. Original (outlined areas) and present (black) distribution of pine forest on the southern Florida mainland. Cross-hatching shows areas in which 75 percent or more of the pine forest has been obliterated by urban and agricultural development. Based on the vegetation map of J. H. Davis (1943, The natural features of southern Florida. Fla. Geol. Survey Bull. 25) with the present extent of pine forest interpreted from 3 March 1975 Landsat image of south Florida.

As a fire sub-climax vegetation in a region where natural and man-caused fires were common, pine flatwoods originally occupied most of the upland in the coastal plain, often occurring in unbroken, almost featureless expanses miles in extent. The pine flatwoods of BICY are ecologically similar but much different in distribution, because the upland area of BICY is intricately dissected by wetlands. Pine forest tends to occur as islands or in ribbon-like strands on the most elevated sites, part of a complex vegetation mosaic which also includes wet prairies, cypress (Taxodium) heads and scrub cypress forest (McPherson 1973). Tracts of continuous pine forest as large as one square kilometer occur in only a few localities and stands of 5 to 25 ha make up the greater part of the area of pine. The extreme fragmentation of the BICY pine forests has affected both logging and fire occurrence in ways which seem to account for most of the present variation in the habitat. The biology of Red-cockaded Woodpeckers in BICY may also differ considerably from that observed in areas of more continuous pine forests.

Fire

Duever et al. (1979:602-700) summarized historical information on fire occurrence and effects in BICY, Wade et al. (1980) reviewed the role of fire in southern Florida ecosystems, and Taylor (1980) analyzed fire occurrence in BICY in 1979. From these and earlier studies it is clear that the relation between fire and pine forest in BICY is basically the same as that prevailing in pinelands throughout the South. The regional pine forests are adapted to and maintained by frequent fire. In the absence of fire, or where the frequency of burning is reduced, pine stands tend to be invaded and ultimately replaced by hardwoods. Fire thus becomes critically important to Red-cockaded Woodpeckers, because the species appears to be closely adapted to the open forests produced by short-interval burning. Various authors (Beckett 1971, Jackson 1978, Lennartz and McClure 1979) have reported that the woodpeckers tend to avoid or abandon pine stands which develop a dense understory of hardwoods. In addition, fires occurring after a long interval of fuel accumulation may kill the overstory pines and so eliminate particular areas of pine forest as potential colony locations for at least 50 years. Where local fuel accumulation results in intense burning, cavity trees and other mature pines may become so fire-scarred at the base that they are easily windthrown (Figure 4 and 5).

Because pine stands in BICY are isolated in a matrix of seasonally-flooded vegetation types which normally have 5 to 7 month hydroperiods (Duever et al. 1979:228), one would predict wide variation between stands in fire frequency and in the extent of invasion by hardwoods. Such variations are readily found in the form of pine islands with a dense hardwood understory (Figure 22) and areas where dominant pines have been killed by intense fires (Figure 23, 27 and 28). However, most of the pine forests of BICY have the relatively open understory typical of stands under a regime of short-interval burning. Indeed, many poorly-stocked stands in the cut-over areas of western and northern BICY appear to have burned so frequently that few pine seedlings survived (Duever et al. 1979:642-645, Figure 11). The present understory in much of the pine forest area approximates the habitat condition preferred by Red-cockaded Woodpeckers. Thus it is of some interest to inquire how fire has been able to maintain an open understory in the hundreds of isolated stands of pine, given the abundance of natural barriers to the spread of fire.

Figure 4. Red-cockaded Woodpecker cavity tree (EMD-5) showing severe basal fire damage.

Figure 5. Windthrown mature pine (potential cavity tree) in the HaA colony. The tree was badly fire-scarred at the base.

There seems to be little doubt that the widespread Southern tradition of indiscriminate woods-burning is largely responsible for the present aspect of the pine forests in BICY. Taylor (1980) reported that 89 percent of the fires in BICY in 1979 were man-caused. These fires were usually small, their occurrence was strongly correlated with the dates of hunting seasons, and many were thought to be incendiary. Abundant anecdotal evidence suggests that deliberate fire-lighting of this sort is a long-established practice in the Big Cypress region. Thus Kennard (1915:3-4) wrote of a 1914 visit to the Deep Lake area at the western edge of BICY:

> "The natives everywhere is this region; cowboys, alligator hunters, and Indians alike, seem to travel with boxes of matches in their pockets, which they distributed impartially as they ride through the country, generally in order to make better pasturage for their cattle; but in this particular region where there are no cattle, in order to burn out the thickets and jungle, which would otherwise become impenetrable, and to supply food and convenient hunting grounds for deer and turkey which come out on the "burns" to feed on the fresh young growth."

It seems likely that burning for the above reasons and others has been common for the past century or so and that fires were usually set in the more burnable types of vegetation, such as the pine forests and prairies. It is at least conceivable that the majority of the isolated pine stands in BICY have a fairly long history of frequent, relatively light burning by man-caused fires. Larger, more intense fires which may sweep over thousands of hectares with little regard for vegetation type boundaries occur in BICY at a frequency of perhaps one or two per decade, typically late in the dry season of the driest years. These may be either man-caused or lightning fires and they probably account for most of the fire damage evident today in vegetation of the wettest sites, such as cypress heads. The occasional large fires late in the dry season doubtless have contributed to the maintenance of open pine forests, but they would appear to be too infrequent to have been a major factor. As even the largest known fires have seldom affected as much as 25 percent of the total area, the expected frequency of burning by such fires for a given isolated stand of pine might be as low as once per 20 to 30 years. It appears to us that the present overall aspect of the BICY pine forests is not consistent with a recent history of infrequent, very intense burning.

How fire-maintained upland ecosystems managed to persist under primitive, pre-aboriginal conditions when lightning was the only available ignition source is a central, unresolved question in southern Florida ecology. Taylor (in press) has recently addressed some aspects of this problem. Briefly, wetlands cover the greater part of the area and in the recent past much of the wetland was probably much wetter and more fireproof on the average than it is today. Yet, the isolated areas of upland are occupied almost entirely by ecosystems adapted to fire and compelling evidence, such as the distribution of endemic plant taxa (Robertson 1953, Avery and Loope 1980) and of Red-cockaded Woodpeckers, suggests that these ecosystems have existed for significant periods of time. Detailed pursuit of the question is not germane here, but it seems evident that an unrealistic number of independent lightning ignitions would have been necessary to maintain a regime of frequent light burning in the widely scattered pine stands of BICY. If this is true, one must assume that a lesser number of lightning-ignited fires affected more extensive areas and this can only have occurred in the driest years. Hence it may be that the primitive pattern of natural fire in the area was one of infrequent, extremely intense burning. Under such conditions severe damage to overstory pines is likely, but presumably variation in burning conditions from site to site allowed survival of enough old-growth pine to maintain a Red-cockaded Woodpecker population.

Lumbering

The historical record of commercial timber-cutting in BICY is poor, particularly so for the pine forests where many small, ephemeral logging operations existed over a period of 40 years. Duever et al. (1979:1034-1041) compiled a useful history of pine logging from the scanty records available and interviews with former loggers. They report numerous small mills that worked mainly near roads in the 1920's and 1930's and large-scale logging based on a mill at Jerome on S.R. 29 from about 1940 until the early 1950's. The former cut the pine stands most easily accessible from the Tamiami Trail and the Loop Road (S.R. 94); the latter operation extended tram railways into the interior and cut much of pine in the central and northern parts of BICY (Figure 6). Most cutting in the interior pinelands of central BICY apparently occurred in the early 1940's. Through 1942 (no later records available) 3.5×10^6 board feet of pine had been removed from this section and the stands reportedly were depleted by the mid-1940's. Pine logging then shifted to the East Hinson Strand and Bear Island areas of northern BICY.

The few details recorded indicate typical cut-out-and-get-out lumbering. All pines larger than about 25 cm dbh are said to have been cut and no seed trees were left intentionally except in the areas cut in the 1950's. The testimony of the loggers suggested that cutting of the old-growth stands was practically complete. As Duever et al. (1979:1041) reported "By the mid-1950's, virtually all the pine in the BICY had been logged and only a few inaccessible and isolated small pine islands remained in the interior." Thus the essential picture of pine logging in BICY, as reconstructed from historical sources, is that nearly all the pineland sustained a nearly complete clear-cut in a period of five to 10 years about 40 years ago.

Based on the present distribution in BICY of apparent old-growth stands of pine and Red-cockaded Woodpecker colonies we believe that several aspects of the above history need revision. First, the area not touched by lumbering appears to be substantially larger than suggested. Rather than a few small islands of virgin pine, there are in all some hundreds of stands north and east of the main interior pinelands of central BICY and in the southern part of the Lostmans Pines section which have the appearance of old-growth forest and contain no traces of logging (Figure 6). Abrupt transitions from cut-over forest to stands that are obviously much older seem to show plainly where logging stopped in various places (Figures 12, 18, 19 and 25).

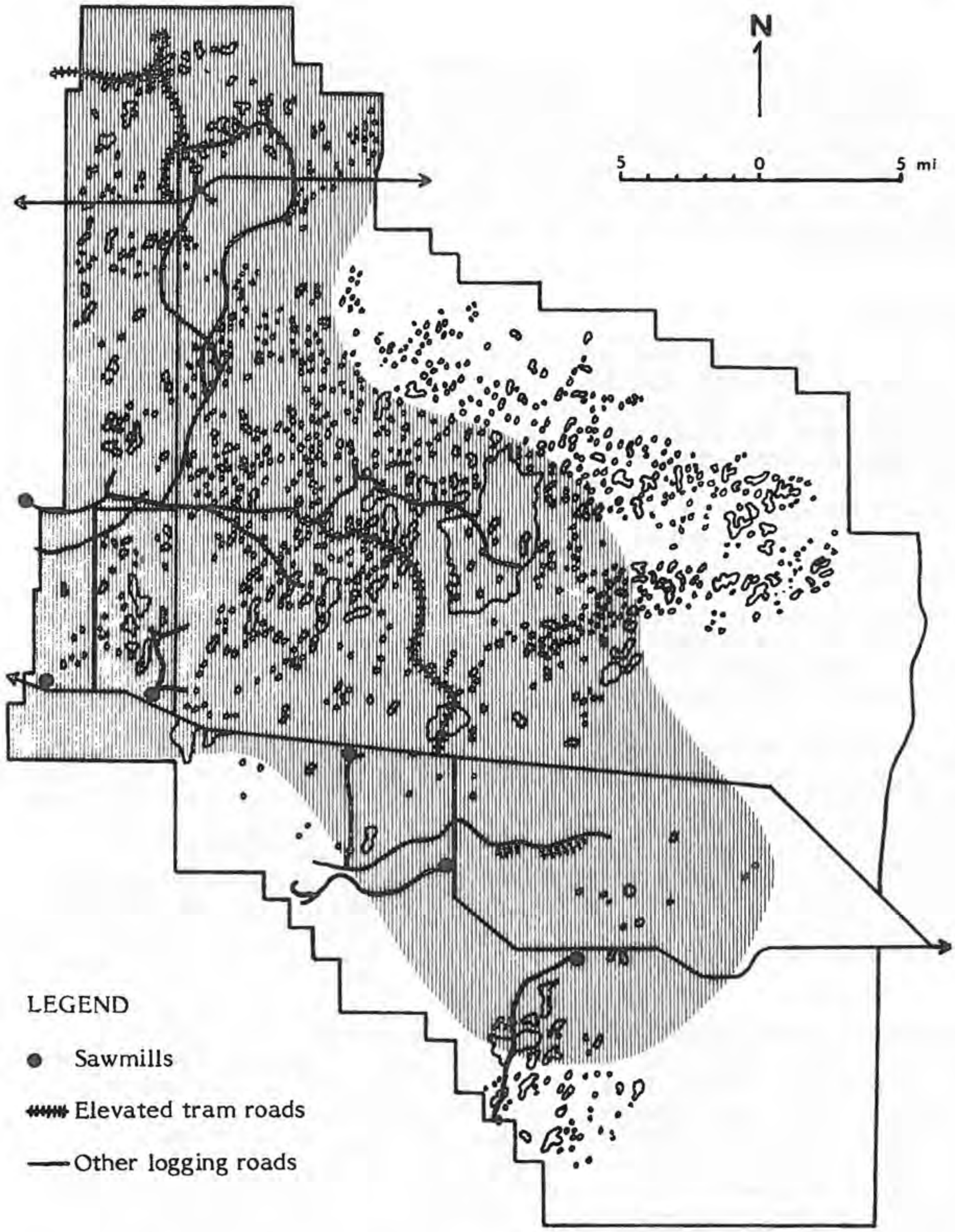


Figure 6. Pine forests (outlined) and the extent of pine logging in BICY. Hatching shows the approximate area within which most of the pine forest was logged. Location of sawmills and logging roads is from Duever et al. (1979:1035, Figure 8.91).

Second, the clear-cut in logged areas appears to have been substantially less complete than suggested. Large pines, almost certainly relict from the original forest (Table 1) occur at many places in the cut-over area in stands that include isolated singles, patches of a few dozen to a few hundred old trees and entire uncut islands as large as about 5 ha. If there was indeed no attempt to leave seed trees, we are unable to account for these remnants some of which are close to former logging roads. The apparent relict stands within the logged area now harbor several Red-cockaded Woodpecker colonies and sites that appear to provide potentially acceptable habitat for the species are widely distributed.

Future Habitat

While the habitat of Red-cockaded Woodpeckers in BICY should be secure under National Park Service management, several potential problems can be foreseen in the short-term future.

At present, fires deliberately set by hunters and others appear to play a major role in maintaining short-interval burning of pinelands and the open forest preferred by Red-cockaded Woodpeckers. This situation has probably prevailed for at least the past century. However, the practice of casual woods-burning seems likely to decline sharply in the future as National Park Service surveillance of back-country areas in BICY improves. Such a change, unless countered by specific management procedures, could result in decreased average fire frequency and loss of Red-cockaded Woodpecker habitat through either hardwood invasion of pinelands or intense fires following an extended period of fuel build-up. The likelihood of habitat loss as a result of reduced fire frequency appears to be greatest in the eastern part of central BICY where many islands of old-growth pine are isolated in areas of cypress swamp. Farther west and throughout the logged area sharp reductions in local fire frequency seem less likely, because the wetland sites between pine islands have shorter hydroperiods and are less effective barriers to the spread of fire.

About 30 percent (5 of 17) of the active Red-cockaded Woodpecker colonies so far found in BICY are located in remnants of original forest within extensive cut-over areas. It is likely that additional colonies exist in such situations, especially in western and northern BICY. The resident clans evidently forage successfully in second-growth pine, but they are able to inhabit the area only because the limited old-growth stands contain trees large enough to accommodate roosting and nesting cavities. These isolated relict pines suffer continual attrition from lightning, accumulated basal fire damage, windthrow, disease, and the activities of the woodpeckers. For example, the tree containing the nesting cavity of the RhA clan died during the 1980 nesting season. The average annual mortality rate of the old trees in not known, but the persistence of these colonies obviously depends on the survival of enough of the old-growth pines until the second-growth reaches sufficient size to provide cavity trees.

Scarcity of information on size in relation to age in south Florida slash pine and on the age of slash pines used as cavity trees by Red-cockaded Woodpeckers make it difficult to estimate when the second-growth stands may become available as

Table 1. Diameter of Old-growth, Second-growth and Logged Pines near the Rh Colony of Red-cockaded Woodpeckers.

	Sample Size	Mean Diameter (cm)	Diameter Range
Cavity trees, Rh colony	10	41.8[1]	32.9-51.4
Dominant trees in 40-year second-growth	17	20.9[1]	15.2-26.7
Cut stumps in second-growth stand	9	41.4[2]	26.7-56.6

1. Diameter 1.37 m above ground (dbh).

2. Diameter at c. 0.25 m above ground. Size of the stumps has doubtless been reduced by fire.

colony sites. Second-growth pine forests in the major cut-over areas of BICY are about 40 years old and a small sample of dominant trees in a typical stand averaged 20.9 cm. dbh (Table 1). Mean dbh of all cavity trees measured in BICY was 35.8 cm and only 15 percent of the sample (22 of 147) was < 30.0 cm dbh. Thus a diameter increase of roughly 50 percent appears necessary before many pines in the second-growth stands are large enough to serve as cavity trees, but it is highly uncertain what length of time this amount of growth may represent. Langdon (1963) reported that the mean annual increase in diameter of 15 year-old south Florida slash pines was 0.451 inches/year (1.15 cm/year), but the radial growth rate of pines tends to decline with age in a negative exponential fashion (Fritts 1976: 279). Taylor (pers. comm.) estimated the age of a 40 cm pine in BICY at 87 to 90 years based on ring counts, but pointed out that the high incidence of questionable rings made it difficult to determine age by this method (see also Tomlinson and Craighead 1972). Although the nominate variety of slash pine occurs over much of the southeastern coastal plain in several areas where Red-cockaded Woodpeckers have been studied intensively (Czuhai 1971:110), it is reportedly the pine species least preferred for cavity trees. Thompson and Baker (1971:186) reported that a sample of 15 slash pine cavity trees averaged 70 years old, 25 m in height and 40.6 cm dbh. However, it is not known to what extent these data are transferrable to south Florida slash pine growing on sites such as occur in BICY.

Pending more accurate information on age-related size in south Florida slash pine > 40 years old, we can only estimate that it will be at least 25 to 30 years before an appreciable number of pines in the present second-growth stands are large enough to serve as cavity trees. The average annual mortality rate of Red-cockaded Woodpecker cavity trees is reported to be 4 to 9 percent (Hooper et al. 1979). Some of the isolated relict stands that now have Red-cockaded Woodpecker colonies contain as few as 50 old-growth pines and only those infected with red heart are available as cavity trees. Thus it would appear that the colonies within the cut-over area of BICY merit close study and whatever specific protection is feasible.

DISTRIBUTION IN BICY

In this section, we locate all of the Red-cockaded Woodpecker colonies so far discovered in BICY as accurately as possible on McPherson's (1973) vegetation map of the region (see also Table 7, Appendix, for Mercator locations) and briefly discuss the habitat of particular colonies. Largely for convenience, but in part because the pine forest in each of the areas differs somewhat from the others, the colonies are grouped for discussion into five areas (Figure 7). Maps of the individual areas (Figure 8, etc.) are drawn to the same scale as McPherson's (1973) vegetation map and depict the pine stands as shown on that map with corrections as indicated in several areas. The areas mapped measure about 5 x 10 miles (8 x 16 km) and all Red-cockaded Woodpecker colonies presently known in each area are shown on the maps. Table 2 summarizes the principal data available for each colony and its resident clan of Red-cockaded Woodpeckers.

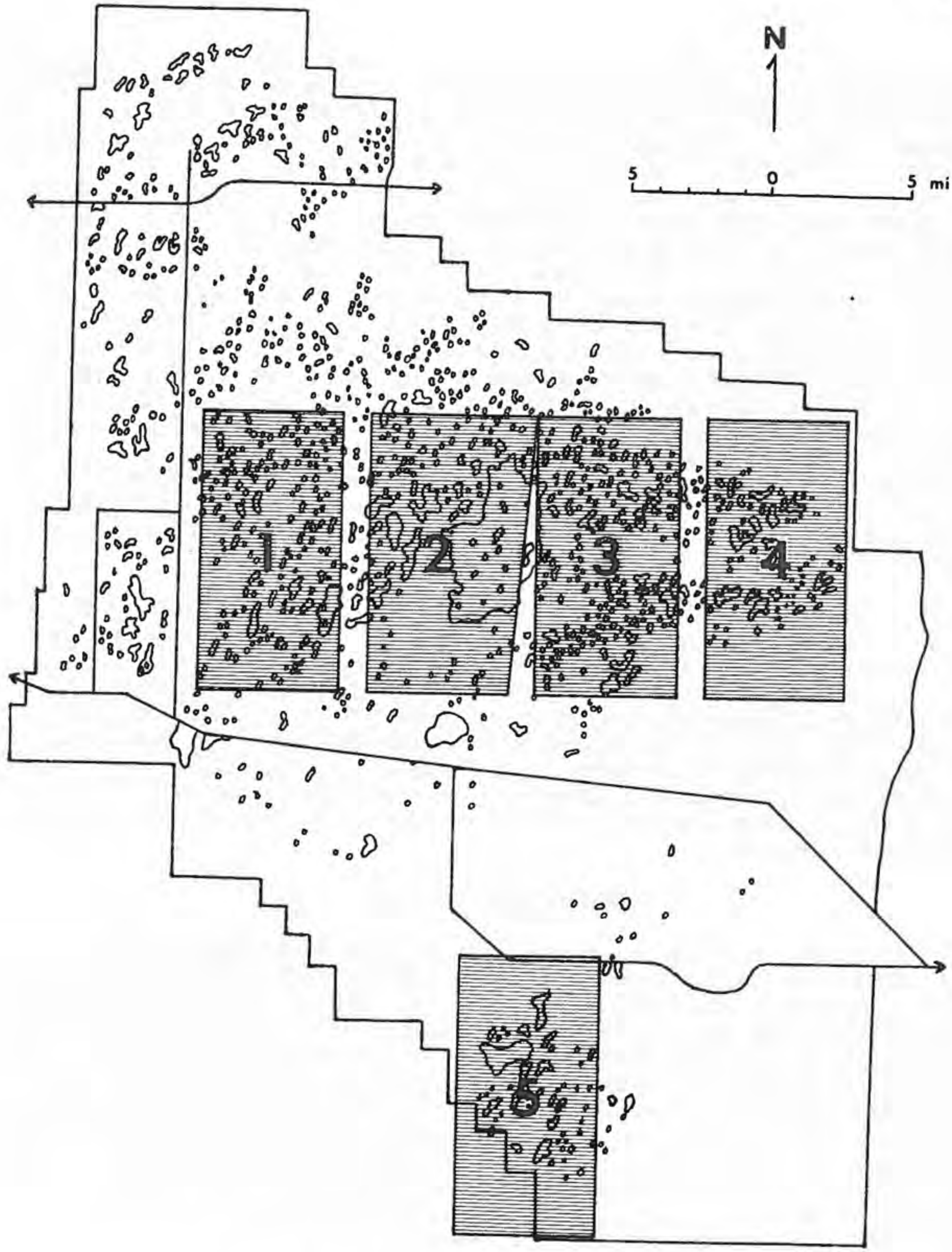


Figure 7. Five local areas of pine forest in BICY containing Red-cockaded Woodpecker colonies.

Table 2. Data Summary: Red-cockaded Woodpecker Colonies and Clans in BICY

Colony	No. of Cavity Trees	No. of Cavities Total	Type 5[1]	Clan Size	Reproduction 1979	Reproduction 1980
CC	10	13	3	3	No Data	No Data
CCA	11	13	4	3-4	No Data	5 birds observed included 1 or 2 fledged young.
Rh	10	10	4	4	No Data	No Data
RhA	7	10	4	3	No Data	2 or more young in nest, 13 June.
RhB	8	9	3	2	No Data	2 or more young in nest, 13 June.
CS[2]	-	6	-	2	No Data	No Data
Oa	10	11	2	2	No Data	1 young in nest, 2 June
OaA	7	7	2	3	No Data	Adult in cavity, 2 June Nesting success unknown
OaB	5	6	0	Inactive Colony	-	-
EM	9	11	2	2	1 young fledged	2 or more young in nest, 24 May
EMA	3	3	0	Inactive Colony	-	-
EMB	8	8	2	2	2 or more young in nest, 9 June	2 or more young in nest, 24 May
EMD	6	6	0	Inactive Colony	-	-
EMP	9	13	2	2	1 young fledged	Nested, probably failed
EMPA	4	4	0	Inactive Colony	-	-

Table 2. Continued

Colony	No. of Cavity Trees	No. of Cavities Total	Type 5[1]	Clan Size	Reproduction 1979	Reproduction 1980
HaA	11	16	2	2	No Data	Nested, success unknown
LPN	8	13	3	3	No Data	Nested[2], success unknown
LPS	9	15	4	4	No Data	Nested[2], success unknown
JR	5	5	0	Inactive Colony	-	-
SMN	7	8	3	3	Nested, success unknown	Nested[2], success unknown
SME[3]	1	1	-	3	Nested, success unknown	Nested[2], success unknown
SMW[3]	2	2	-	2	2 or more young in nest, 22 May	Nested[2], success unknown
BP[4]	3	3	-	1	No Data	No Data

1. Type 5 cavities are cavities in active use for roosting and/or nesting and are an indicator of clan size.
2. Data received from N.F. Eichholtz, Regional Wildlife Biologist, and D.B. Pylant, Wildlife Biologist, Florida Game and Fresh Water Fish Commission (in litt.).
3. Number of cavity trees and cavities include only those determined to be active; other trees and cavities exist for each colony. Data from D.B. Pylant (1979 ms.)
4. Active colony visited once; data incomplete.

General Occurrence

Although the detailed maps exclude some pine forests of BICY, we wish to emphasize that the maps merely enclose the areas where colonies have been found to date. Pending a more thorough survey, the entire pine forest area of BICY should be regarded as potential Red-cockaded Woodpecker habitat. For example, additional colonies almost certainly exist in the unsearched old-growth pine islands lying north and northwest of Areas 2 and 3 outside the apparent perimeter of logging operations (Figure 6). Areas we searched without finding evidence of Red-cockaded Woodpeckers included the following: west of Turner River Road (S.R. 839); the Loop area enclosed by the Tamiami Trail and the Loop Road (S.R. 94); north of the Tamiami Trail in a belt several miles wide east and west of Monroe Station; and, south of the Tamiami Trail west of Monroe Station. We did little searching in the Bear Island section of northern BICY, but D. B. Pylant (pers. comm.) saw no evidence of Red-cockaded Woodpeckers there in the course of a detailed survey of wildlife habitat. However, at least limited habitat that appears suitable for the species exists in all of the areas mentioned and we would not be surprised to find that we had overlooked active colonies. In fact, records by other observers suggest that there probably are colonies in one or two of the above areas.

Considering the available habitat and the coverage achieved in the survey, we suggest that 40 active colonies is a reasonable minimum estimate of the present Red-cockaded Woodpecker population in BICY. It seems highly desirable to complete the survey and accurately locate any additional colonies that may exist.

Previously Known Colony Locations

Prior to this report few colony locations had been reported. A map of the Florida range (Baker 1978) included a dot apparently signifying a colony in the northern part of BICY, but Baker (pers. comm.) told us that the symbol probably was intended merely to indicate occurrence in the general area. Duever et al. (1979: 570) said that there were "many unpublished sighting records" in the interior pinelands section (our Area 2) and that "colonies have been observed" at three locations: 3 km north of Monroe Station (Section 35, T52S, R32E); about 21 km north of Monroe Station (Section 7, T51S, R33E); and, along a section of the Florida Trail from 11 to 19 km north of Oasis Ranger Station. Letters of N. F. Eichholtz are cited as the source of information for the first two locations and a letter of J. A. Kern as the source for the third. The two colonies in BICY shown on the most recent published map of the species' Florida range (Baker et al. 1980) represent the Eichholtz records as reported by Duever et al.

The colony 21 km north of Monroe Station is the one we have designated CS (Figure 12) from its location near Mr. Calvin Stone's hunting camp. Eichholtz' letter of 15 June 1977 to Robertson explicitly mentions seeing woodpeckers and cavity trees and it is the source of all the information we have on this colony. The letter referring to the occurrence 3 km north of Monroe Station (N. F. Eichholtz to I. Mortenson, 16 February 1978), however, reports an observation of 6 Red-cockaded Woodpeckers foraging in a stand of second-growth pine, but it does not mention finding cavity trees. Although most of the pines in this area are small, occasional large trees occur along the edges of cypress strands. The record is so far from any known site that it is probable a colony exists somewhere in the vicinity, but it is yet to be definitely located. With regard to the observations along the Florida Trail, J. A. Kern (pers. comm.) told us that he had often seen Red-cockaded Woodpeckers and cavity trees near the campsite and well about 11 km by trail north of Oasis Ranger Station and had seen woodpeckers, but not cavity trees, in pine areas farther north along the trail. The former records undoubtedly pertain to the Oa colony (Figures 18 and 19), about 300 m east of the Florida Trail at the above point.

Thus, as far as we can determine, only two colony locations in BICY had been firmly established at the time the present work began.

Area 1 (Figure 8)

All of Area 1 lies within the cut-over part of BICY, but entire small islands of pine that seem not to have been touched by logging (Figure 9) and groups of large trees within stands of second-growth forest (Figure 10) occur throughout the area. Our observations suggested that there is considerably less pine in the western and northern parts of Area 1 than appears on the vegetation map (McPherson 1973) and Figure 8 was corrected accordingly. It appears that considerable areas of dense Serenoa, which may once have had pines but have none today, were mapped as pine forest. At least two of the patches of old-growth forest have active colonies of Red-cockaded Woodpeckers (Figure 8). Additional colonies may well exist, because much of the area has not been searched thoroughly on the ground. One colony, CCA (Figure 11), was located from the air when we noticed the glaze on a cavity tree in an area where the pine forest seemed much too sparse to provide acceptable habitiat.

As is somewhat evident from Figure 8, two rather distinct patterns of pine forest occur. In the southern half of the area, the vegetation types are distributed in a linear pattern oriented northeast-southwest. Pines occur in elongate, often very narrow, stands interspersed with similar ribbons of wet prairie and cypress forest (Figure 9). In the northern part of Area 1, and extending north across western BICY into the Bear Island section, the pine stands typically occupy doughnut-shaped elevations surrounded by prairie and enclosing circular areas of wetter marsh (Figures 10 and 11). Possibly because of too-frequent burning, these pine stands tend to be poorly stocked and often consist of rings of densely-bedded Serenoa with widely scattered pine trees. Presumably, here as elsewhere in BICY, the differences in vegetation pattern reflect differences in the distribution of elevations on the eroded limestone surface underlying the thin soils, but this aspect has not been investigated in detail.

Pine forests of Area 1, particularly those in the vicinity of CCA colony (Figure 11), must be near the lower limit of stand density habitable by Red-cockaded Woodpeckers. Many stands are very sparsely stocked with pine and pine forest occupies a relatively small proportion of the general area. Yet, as judged by number of cavities, clan size, and records of fledged young (Table 2), the CC and

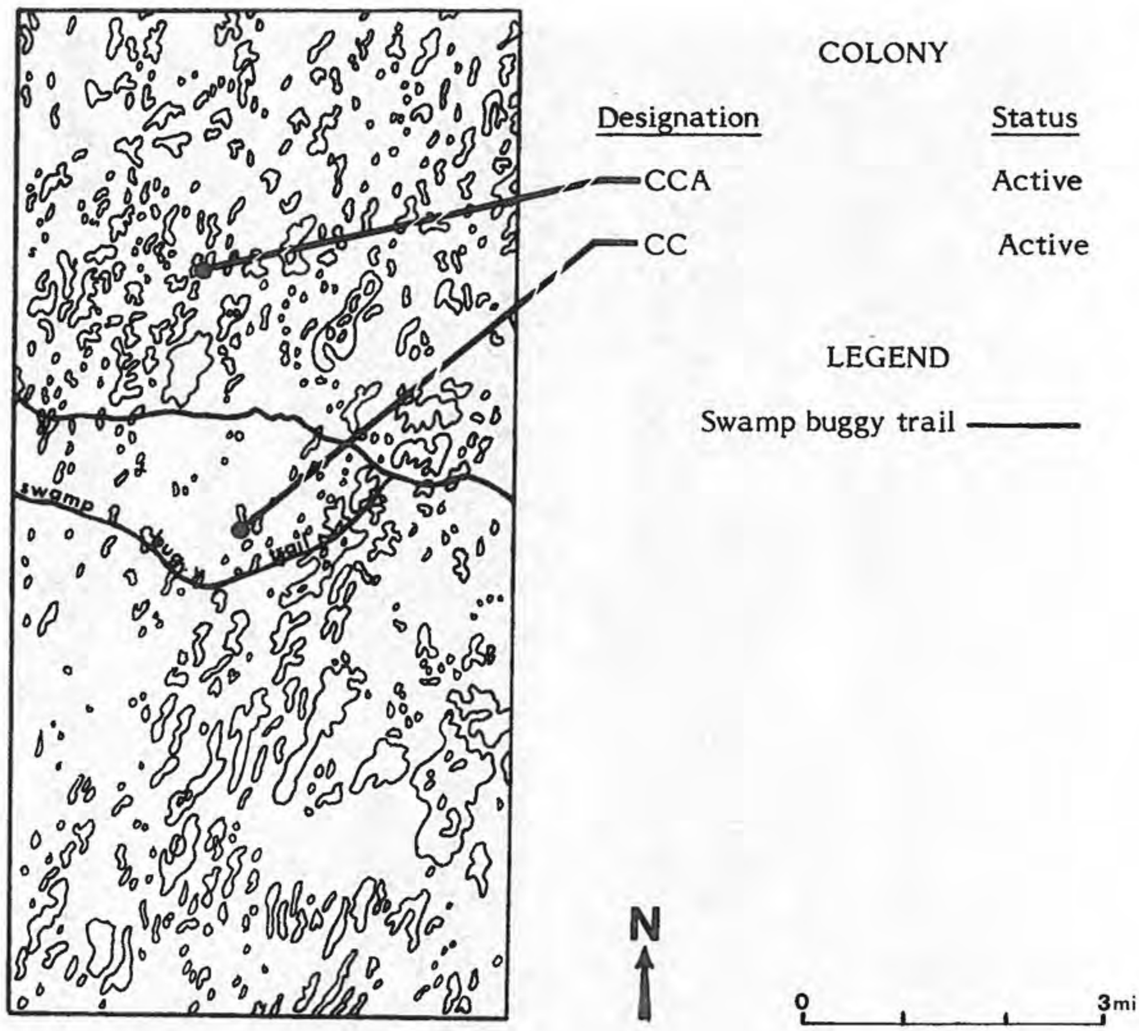


Figure 8. Area 1 showing pine stands (outlined) and location of Red-cockaded Woodpecker colonies. Distribution of pine is adapted from McPherson (1973).

Figure 9. Uncut pine islands (foreground) in Area 1. Arrows indicate location of the CC colony in the southern half of one of these elongated islands.

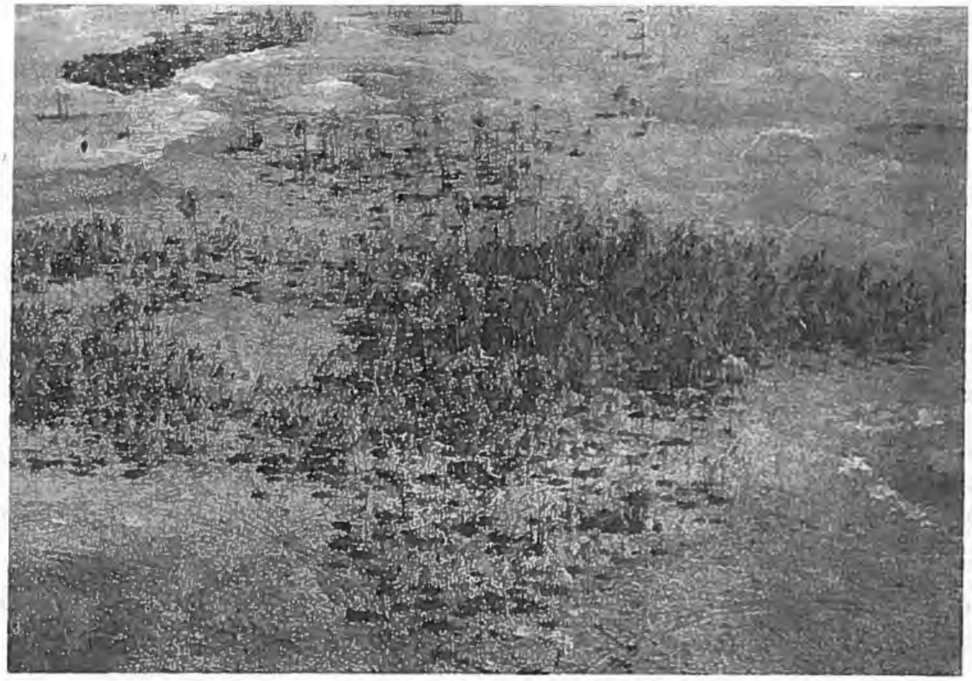


Figure 10. View near the CCA colony, Area 1, showing a relict patch of old-growth pine in a second-growth stand and the doughnut pattern of the terrain.

Figure 11. CCA colony, Area 1, showing the thin scatter of relict pines and sparse second-growth stands. Arrows indicate the 3 islands in which the 11 cavity trees are located. See Figure 46 (Appendix) for precise spacing.

CCA clans in the apparently marginal habitat of Area 1 seem to be as successful as clans in well-stocked and much more extensive old-growth forests elsewhere in BICY.

Area 2 (Figure 12)

This section includes most of the so-called interior pinelands, the largest area and most extensive continuous stands of pine occurring in BICY. Except for its northeast corner, the area was heavily logged in the early 1940's, records (Duever et al. 1979: 1037) indicating that about 12,500,000 board feet of pine had been removed from the relevant townships (T51S, R31 and 32E) by 1942. The clear-cut appears to have been more thorough in Area 2 than in most of the cut-over pine forests of BICY and present remnant stands of old-growth pine are fewer and less extensive than elsewhere. The size of both relict and second-growth pines and the well-stocked stands of second-growth (Figures 13 and 14) suggest that this area offers the most favorable site conditions for pine growth found in BICY.

Three of the Red-cockaded Woodpecker colonies in Area 2 are in very small old-growth remnants (Figures 15 and 16) - the three colonies combined contain fewer than 100 live pines of the original stand - in the northwestern part of the largest block of continuous pine forest. It is impossible to know whether these colonies have persisted in place since logging or were established more recently, but distribution of the relict stands of pine has obviously determined the present distribution of the woodpeckers. Shortage of possible cavity trees has evidently tended to overcome territorial aggression, as the 1980 nest cavity trees of two of the clans (RhA and RhB) were separated by a distance of only 330 m. Mean size of cavity trees in the three colonies is the largest we recorded (Table 3, Figure 28) and the relict stand containing the Rh colony includes the largest pine so far measured in BICY (not a cavity tree), 34.5 m in height and 63.4 cm dbh. It is particularly puzzling that these old-growth stands should have escaped when the surrounding area was clear-cut, because, as is the case of the CC colony in Area 1, major ORV trails which in part were former logging tramways pass within a few hundred meters. The large size of these relict trees may account for the unique placement of the Rh-1 cavity (Figure 17), excavated in the under side of the first live branch of the tree. The only cavity in the tree, it is an active roost cavity that appears to have a long history of use.

The CS colony for which we have only second-hand information is in the northeast corner of Area 2 just beyond the perimeter of logging. The large number of old-growth pine islands that lie farther north and northwest are yet to be searched, because the area is remote and affords few possible landing places for helicopters. It is very likely that additional Red-cockaded Woodpecker colonies exist in this area. We know of at least one other colony, because we saw a few typically resin-glazed cavity trees from the air but could not land nor locate the spot accurately on maps.

Area 3 (Figure 18)

Proceeding eastward from the interior pinelands section the pine forest area of BICY becomes increasingly fragmented and the islands of pine are more and more closely mingled with cypress domes and scrub cypress forest. Pine sites appear to

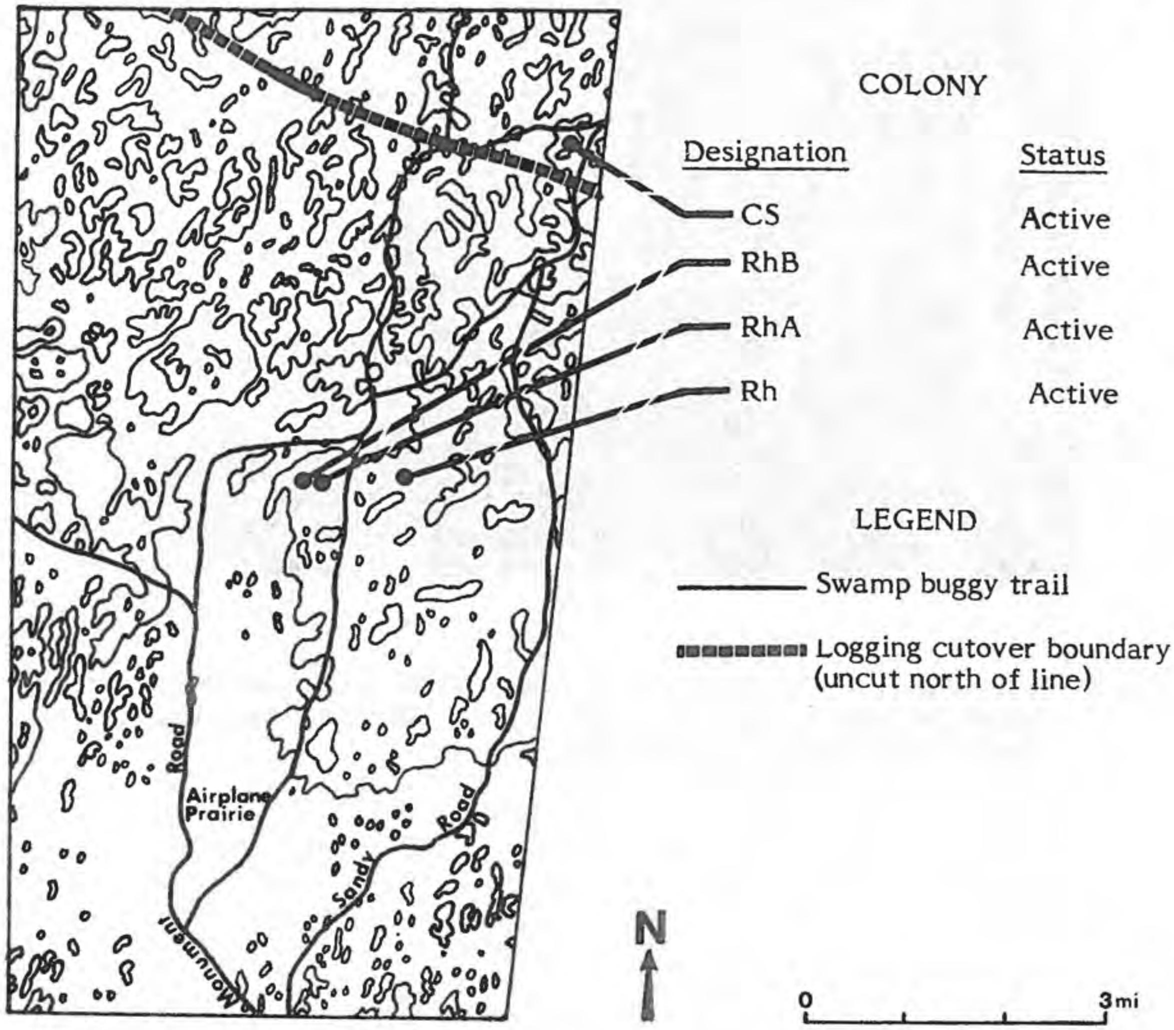


Figure 12. Area 2, showing pine stands (outlined) and location of Red-cockaded Woodpecker colonies. Distribution of pine is from McPherson (1973).

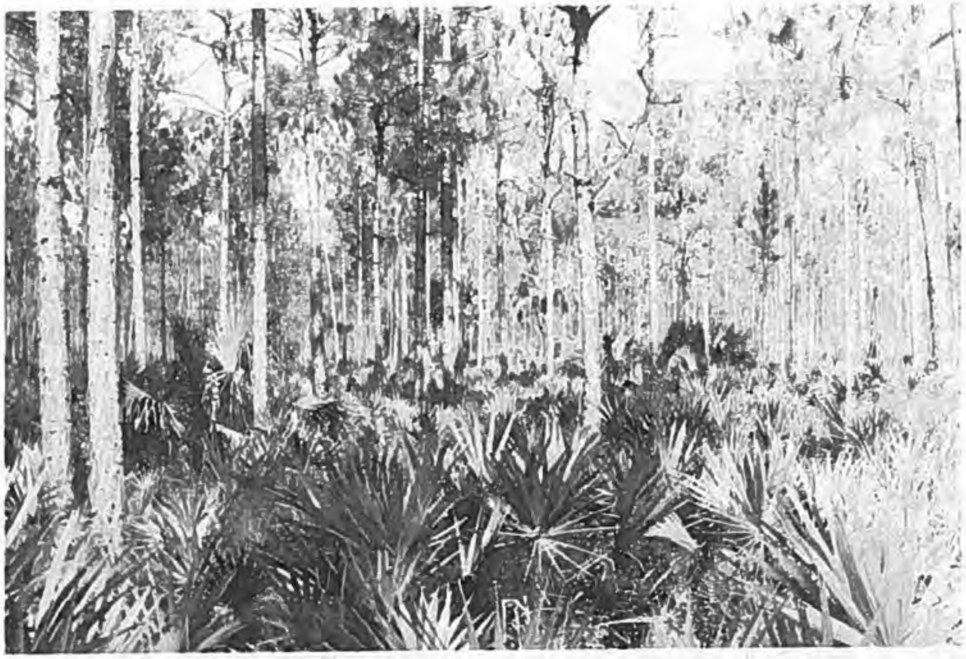


Figure 13. Second-growth pine near the Rh colony, Area 2. Dominant trees in the stand average about 21 cm dbh. Local Red-cockaded Woodpeckers forage extensively in this habitat.

Figure 14. Aerial view of well-stocked second-growth pine forest typical of the interior pinelands section, Area 2.

Figure 15. Rh colony, Area 2, showing relict pines surrounded by extensive second-growth stands.

Figure 16. Part of the RhA colony, Area 2, relict old-growth trees and adjoining second-growth forest.

Figure 17. Unique active roost cavity excavated in the first live branch of the cavity tree (Rh-1).

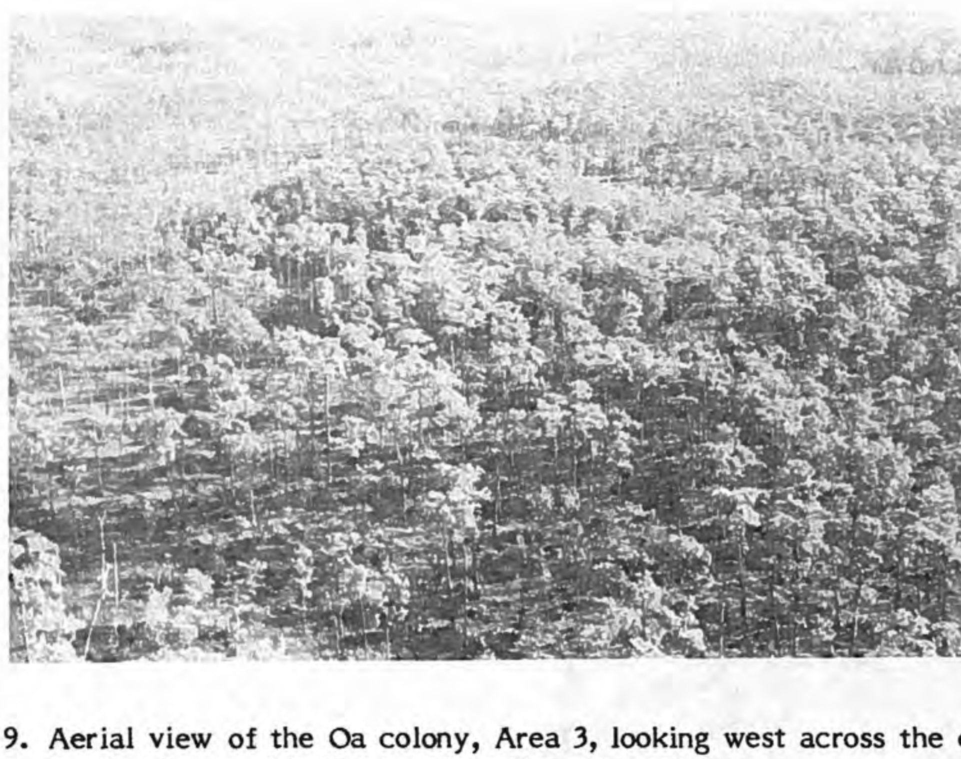


Figure 19. Aerial view of the Oa colony, Area 3, looking west across the edge of logging from original forest into the cut-over area.

become lower and more subject to wet-season flooding and the size of trees in the mature stands is smaller. These factors apparently determined a limit of economic accessibility near the middle of Area 3 (Figure 18) beyond which the old-growth pine stands were not logged. The known Red-cockaded Woodpecker colonies in Area 3 are in the unlogged portion, the Oa colony (Figure 19) located about 200 m east of the line where cutting evidently stopped. The OaA and OaB colonies, about 0.88 km apart on two small pine islands among cypress domes, probably pertain to one clan of woodpeckers. We have seen birds in both colonies, but never at the same time, and the OaB colony at present contains no active cavities. The colonies in Area 3 were found by cruising the pine stands adjacent to an ORV trail. Much of Area 3, particularly the uncut northeastern quarter, has not been searched adequately and we consider it likely that additional colonies exist in the area.

Area 4 (Figure 20)

Area 4 includes the extreme eastern reaches of pine forest in BICY. The pine islands become smaller and more isolated among wetland vegetation and ultimately disappear (Figure 21). Although we found no evidence that logging extended this far east, pine stands in the area vary considerably in age and understory vegetation. Much of the variation clearly reflects the recent fire history of particular stands. Thus many pine islands isolated in less burnable vegetation have a dense understory of hardwoods (Figure 22) and the frequent patches of fire-killed pine (Figure 23) probably resulted from intense burning after a long fire-free interval. Throughout the area even-aged stands of various ages, sometimes including scattered living relicts of the former stand, evidence the past occurrence of intense fires. Except for the fire-killed snags and the absence of cut stumps, these closely mimic cut-over stands and they may be the source of some of the confusion about the extent of pine logging in BICY.

Other variations in the present pine stands appear to result from the downhill invasion of adjacent wetlands by pine. Typically the central old-growth forests on the pine islands of Area 4 are ringed by younger stands which appear to decrease in age with decreasing elevation to an outer ring of pine seedlings growing among scrub cypress. This pattern suggests a trend of change (or, conceivably, a very long-term cyclic change) in the environment affecting fundamental boundaries between vegetation types. A trend of decreasing average water levels might account for the apparent invasion of wetland communities by pine that is so evident in eastern BICY, but the phenomenon and its significance are yet to be studied.

Because most of the pine islands are easily accessible from an oil-drilling access road and ORV trails, Area 4 is one of the few parts of BICY which we believe probably has no additional Red-cockaded Woodpecker colonies. The distribution of colonies is of interest in that colonies which at present have no active cavities are located between presently active colonies and in some cases within the foraging range of the clans inhabiting these colonies. The EMP clan, whose colony is located in a 40 ha tract where we studied bird populations (see 1980 Am. Birds 34 (1) cover, for photograph of the area) provided many of our observations on Red-cockaded Woodpecker ecology and behavior.

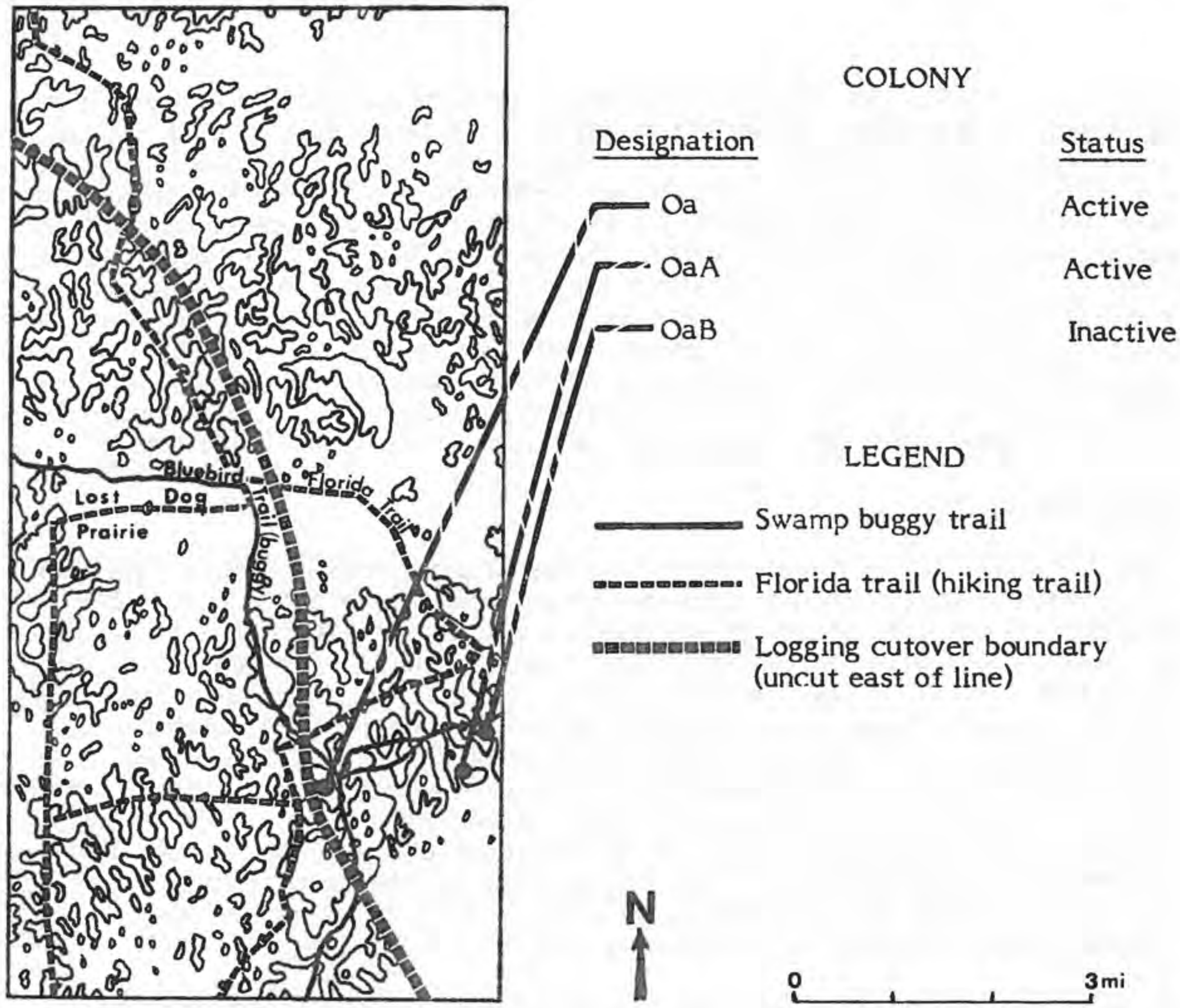


Figure 18. Area 3, showing pine stands (outlined) and location of Red-cockaded Woodpecker colonies. Distribution of pine is from McPherson (1973).

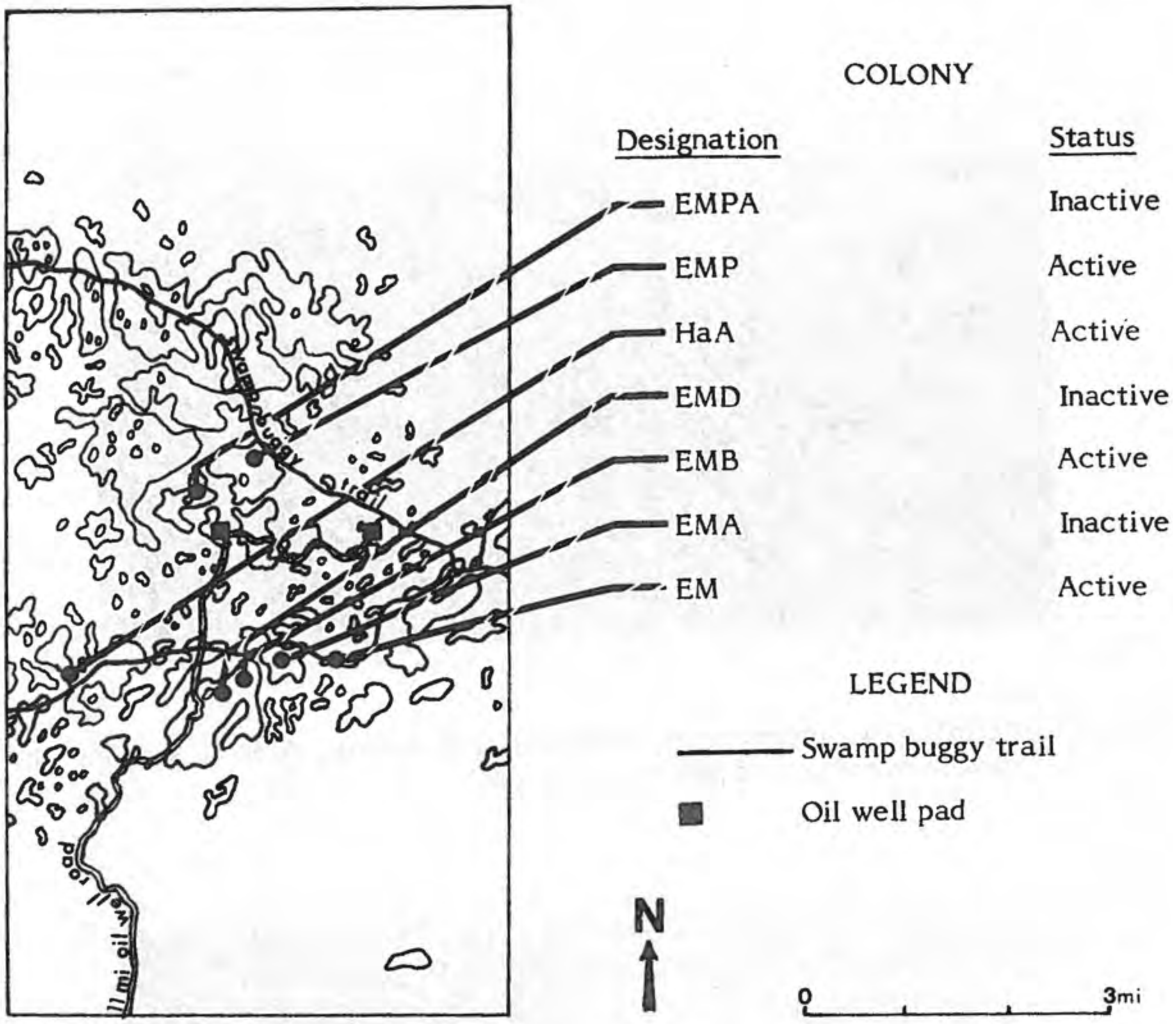


Figure 20. Area 4, showing pine stands (outlined) and location of Red-cockaded Woodpecker colonies. Distribution of pine is from McPherson (1973).

Figure 21. Aerial view looking east from the EM colony, Area 4, showing the eastern extremity of pine forest in BICY.

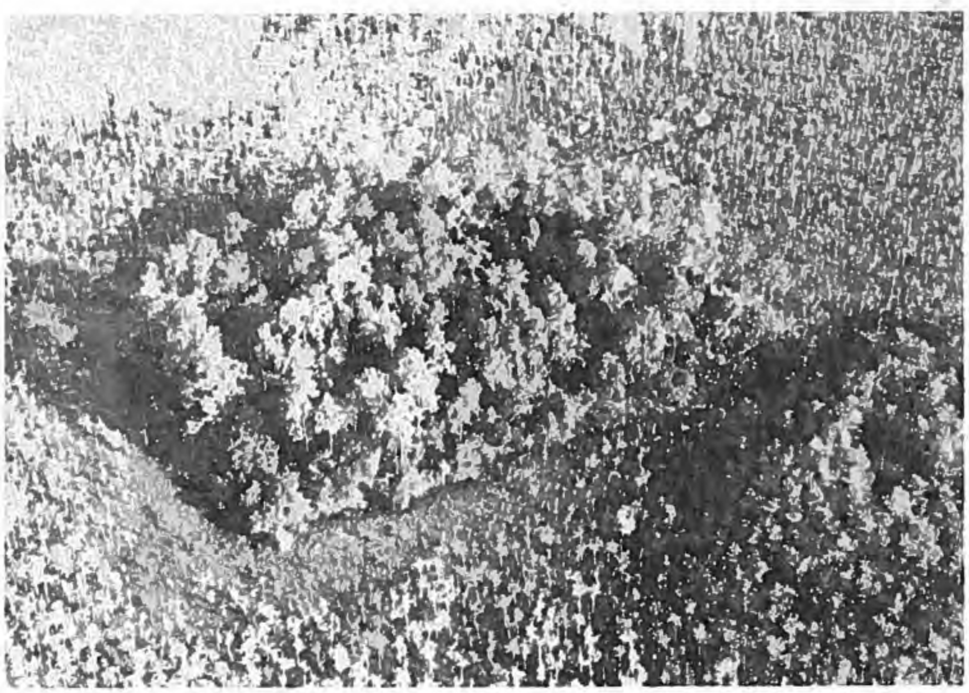


Figure 22. Isolated pine island with a dense understory of hardwoods near the HaA colony, Area 4.

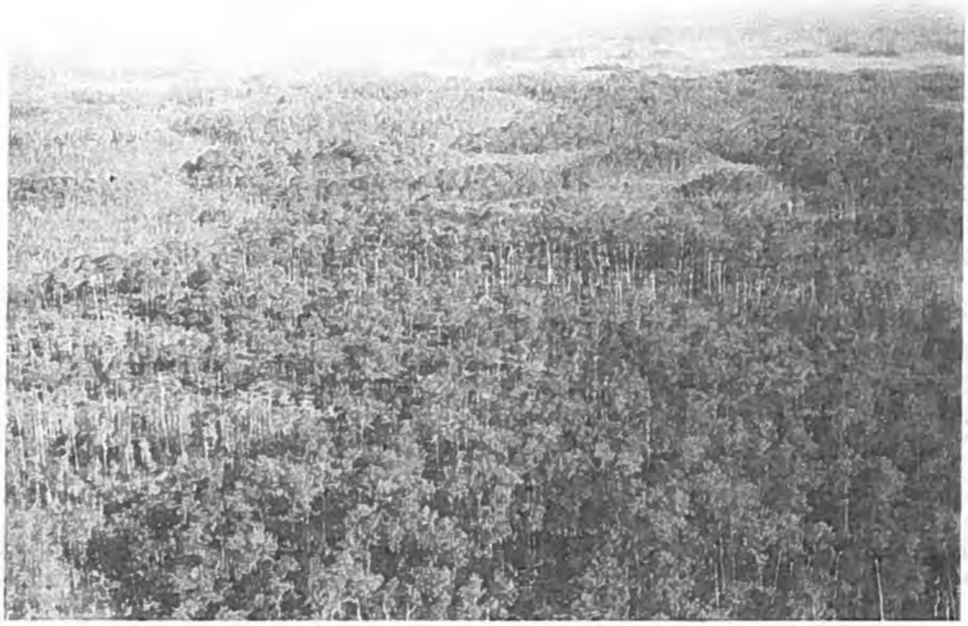


Figure 23. HaA colony, Area 4, showing mature pines killed by fire.

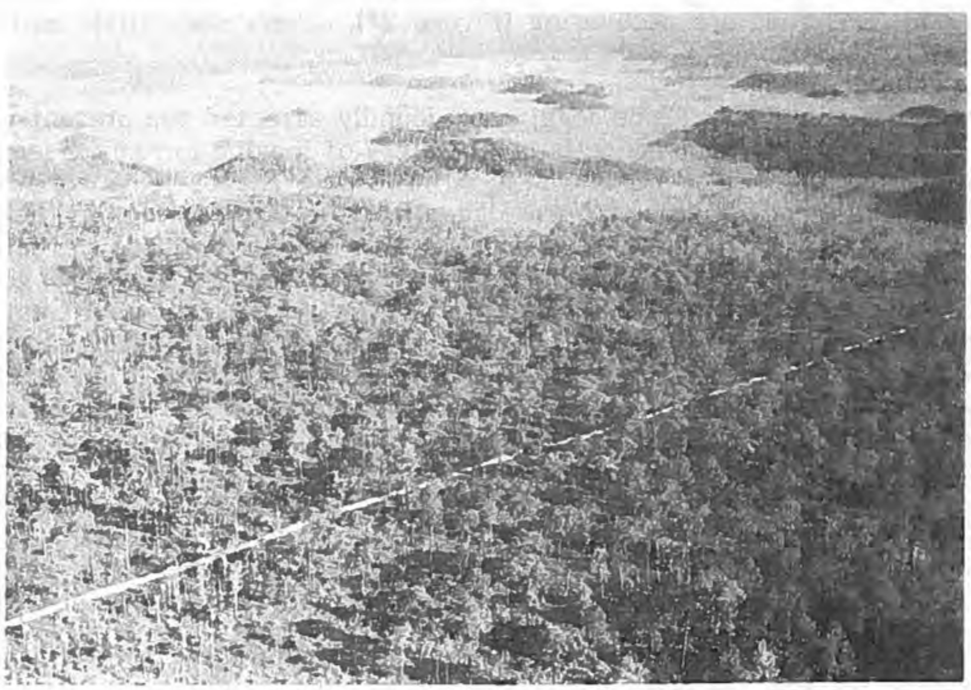


Figure 24. Mature pine forest bordering the 11-mile Oil Well Road, Area 4.

Area 5 (Figure 25)

Area 5 includes the southernmost extension of pine in the western part of peninsular Florida, the so-called Lostmans Pines section. The occurrence of fairly extensive pine forests in this area has often been overlooked in maps of forest types and of the distribution of slash pine (Czuhai 1971, Little 1978, Tomlinson 1980). Pines occur here on a number of islands surrounded by wet prairie and occupy a total area of about 1,800 ha. The recent vegetation map of the Big Cypress region (McPherson 1973) depicts substantially more extensive pine forest than actually exists in the Lostmans Pines section. The present map (Figure 25) is based on our field surveys and on the 7.5 minute series of orthophoto maps (U.S. Geological Survey 1971).

Pine sites in the Lostmans Pines section are lower and presumably more prone to flooding than those elsewhere in BICY. Elevation at the LPN colony of Red-cockaded Woodpeckers is about 1 m above sea level as compared to elevations of 3 to 4 m in the pinelands of central BICY. The lower sites probably account for the conspicuous differences in the pine forest understory. Serenoa is absent or almost so and pine stands which have burned frequently often have no shrub understory except for scattered Sabal (Figure 26). Other pine islands, especially in the eastern part of Lostmans Pines, have a dense understory of wet-site hardwoods, such as Myrica, doubtless indicating a considerable interval without fire. The well-developed hardwood understory may account for the absence of Red-cockaded Woodpeckers from a few pine islands which otherwise appear to be suitable habitat. An extensive area of burned-out pine islands (Figure 25) probably resulted from intense fires in the spring of 1971 (F. E. Dayhoff pers. comm.). Some of the severely burned stands are recovering (Figure 27), others show little evidence of recovery (Figure 28).

As elsewhere in the region, pine logging profoundly affected the present distribution of Red-cockaded Woodpeckers but the history of logging in Area 5 seems even more obscure than in other parts of BICY. The pine islands lying north of Gum Slough (Figure 25) have obviously been logged and the size of trees in the present stands suggests that cutting may have occurred in the 1930's about the same time as in the Pinecrest section a few miles farther east (Duever et al. 1979: 1035). The northernmost pine islands in the Lostmans Pines section, south of Gum Slough, have also been logged in large part. Second-growth stands here appear to be somewhat younger and it seems likely that the logging occurred in the mid-1940's when cypress was cut in Gum Slough. South of the boundary shown in Figure 25 we found no evidence of extensive logging and the pine forests have the appearance of old-growth stands. However, Duever et al. (op cit.: 1035) reported that the Lostmans Pines section was logged in the "1920's" and ORV trails, said to be old logging roads at least in part, extend through the area to the boundary of EVER. Given the distance and the difficult terrain involved, it seems likely to us that any logging at so early a date must have been limited to the high-grading of a few stands. This interpretation is compatible with the evidence of cutting now visible in the field and with the local oral tradition that swamp buggies were used in the dry season to remove a small number of pine logs from the area as late as the 1940's (F. E. Dayhoff pers. comm.).

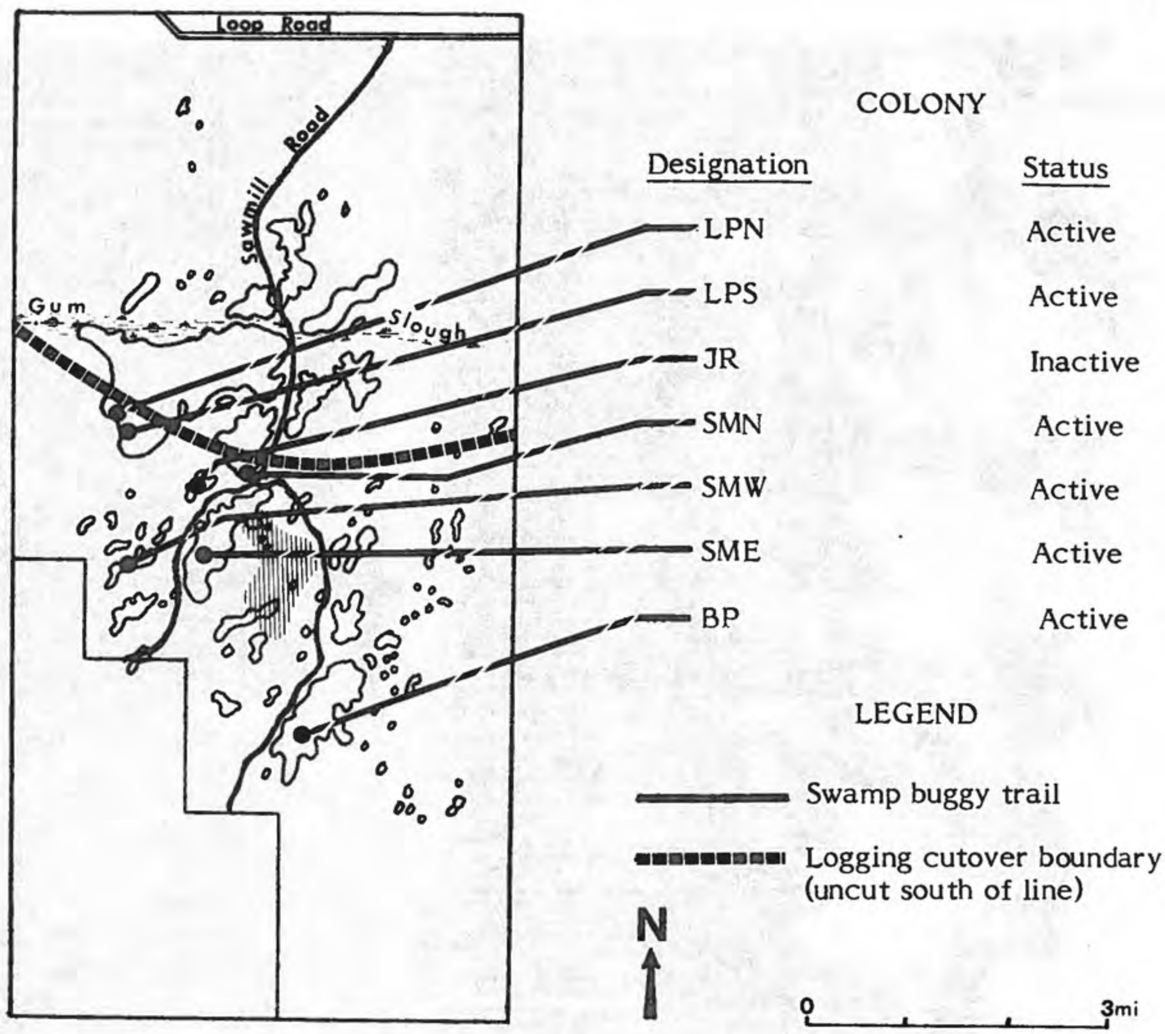


Figure 25. Area 5, showing pine stands (outlined) and location of Red-cockaded Woodpecker colonies. Distribution of pine adapted with a number of changes from McPherson (1973). The hatching indicates an area of burned-out pine islands.

Figure 26. LPN colony, Area 5, view from the adjacent prairie.

Figure 27. Burned-out pine island, Area 5, showing relict pines and young second-growth.

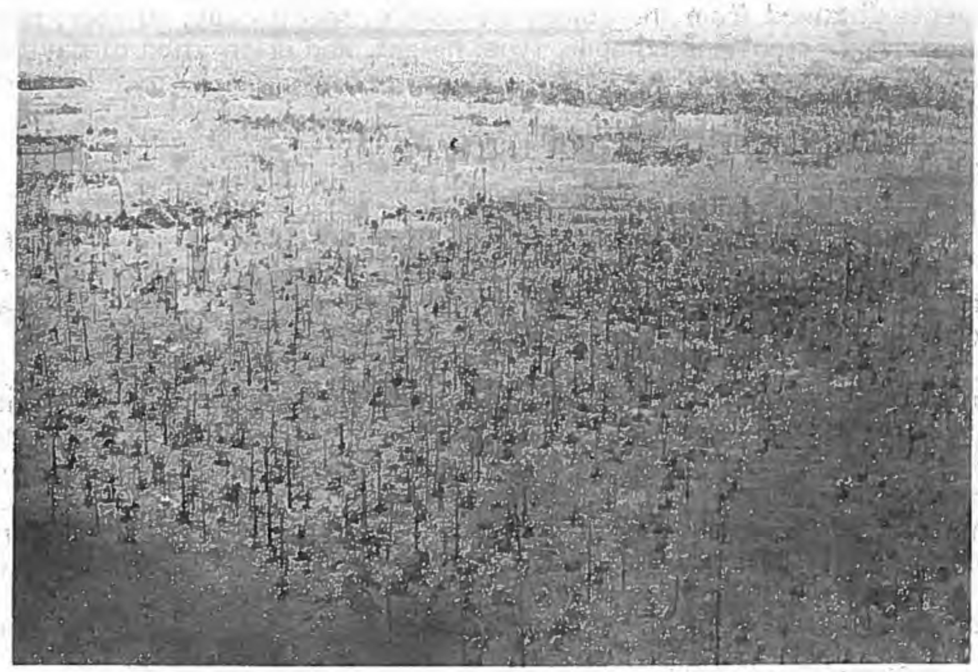


Figure 28. Large burned-out pine island with little recovery of pine, Area 5. Living trees in the photo are cabbage palms (Sabal palmetto).

The survey located six active colonies of Red-cockaded Woodpeckers in the unlogged part of the Lostmans Pines section, a surprising number in view of the few previous sighting records. We are indebted to personnel of the Florida Game and Fresh Water Fish Commission, especially D. B. Pylant (Pylant 1979 ms), for information on several of these colonies. Although the small eastern islands of Lostmans Pines have not been thoroughly searched, habitat there appears less suitable and we doubt that there are any additional colonies to be discovered. Apparently no information is available on the dispersal range of Red-cockaded Woodpeckers, but it seems likely that the Lostmans Pines colonies represent a discrete population unit. At present, a distance of 27.5 km with little pine and few or no potential colony sites separates the Lostmans Pines population from the closest known colony in central BICY. Prior to the logging, and at least as recently at 1953, the species occurred around Pinecrest and doubtless elsewhere in the intervening area. However, the distribution of pine forest habitat suggests that Red-cockaded Woodpeckers in the Lostmans Pines section must have been widely isolated even under original conditions. The clans in Lostmans Pines are presently the closest Red-cockaded Woodpeckers to Long Pine Key in EVER where the species occurred until approximately the early 1940's. A distance of about 36 km of marsh with small hardwood islands separates the southeasternmost colony in Lostmans Pines from the nearest part of Long Pine Key. Whether the species has the potential dispersal range to re-colonize Long Pine Key across that extent of inhospitable habitat is not known, but appears doubtful.

COLONY CHARACTERISTICS

Very few data are available on the physical characteristics of Red-cockaded Woodpecker colonies in southern Florida or in slash pine forests. We report here measurements obtained from the colonies in BICY, specifically, number, size, and dispersion of cavity trees and number, type, height, and orientation of cavities. In general, summary data are presented in the tables and figures in text and information for the individual colonies is included in the appendix.

Cavity Trees

Mean height of 147 cavity trees in the Red-cockaded Woodpecker colonies of BICY was 20.5 m and mean dbh was 35.8 cm. Table 3 and Figure 29 show means for each colony and Tables 8-26 (Appendix) give measurements of individual cavity trees in each colony.

Cavity trees of Red-cockaded Woodpeckers in BICY were decidedly smaller than the pines utilized by the species in most of its range. Thus Baker (1971a: 58) reported mean height of 29.0 m and mean dbh of 47.5 cm for samples of 143 and 147 cavity trees in the Tallahassee region of Florida and Hopkins and Lynn (1971) gave mean dimensions of 25.3 m and 42.7 cm for cavity trees in coastal South Carolina. Thompson and Baker (1971: 186) summarized all available data on size of cavity trees as follows: mean height in longleaf pine (*Pinus palustris*, n = 551) 21.0 m, in loblolly pine (*P. taeda*, n = 557) 27.8 m, and in slash pine (n = 15) 25.0 m; mean dbh

Table 3. Characteristics of Cavity Trees and Cavities in Red-cockaded Woodpecker Colonies

	CAVITY TREE			CAVITY			
Colony	No. in Colony	Mean Height (m)	Mean dbh (cm)	No. in Colony	No. per Tree	Mean Height (m)	Mean Bearing
CC	10	15.50	33.7	13	1.2	6.50	S 44° W
CCA	11	19.25	37.0	13	1.2	7.50	S 4° E
Rh	10	26.50	41.8	10	1.0	11.50	S 3° W
RhA	7	23.50	44.5	10	1.4	13.00	S 66° W
RhB	8	23.25	40.1	9	1.1	12.25	S 63° W
Oa	10	20.50	36.0	11	1.1	11.50	S 19° W
OaA	7	21.25	34.7	7	1.0	12.50	S 55° W
OaB	5	22.00	37.4	6	1.2	8.00	S 29° W
EM	9	19.50	34.0	11	1.2	9.00	S 48° W
EMA	3	19.25	32.7	3	1.0	7.00	S 46° W
EMB	8	18.75	31.7	8	1.0	10.25	S 23° W
EMD	6	23.25	40.1	6	1.0	9.25	S 1° E
EMP	9	21.25	38.8	13	1.4	9.00	S 8° W
EMPA	4	19.25	31.3	4	1.0	9.50	S 5° E
HaA	11	19.50	31.3	16	1.5	7.75	S 26° W
LPN	8	18.75	32.0	13	1.6	8.75	S 62° W

Table 3. Continued

	CAVITY TREE			CAVITY			
Colony	No. in Colony	Mean Height (m)	Mean dbh (cm)	No. in Colony	No. per Tree	Mean Height (m)	Mean Bearing
LPS	9	20.50	35.8	15	1.7	8.50	S 11° E
JR	5	19.50	33.9	5	1.0	11.00	S 72° W
SMN	7	18.75	36.9	9	1.3	8.50	S 10° W
Total	147	-	-	182	-	-	-
Mean (all colonies)	7.7	20.50	35.8	9.5	1.2	9.40	S 27° W

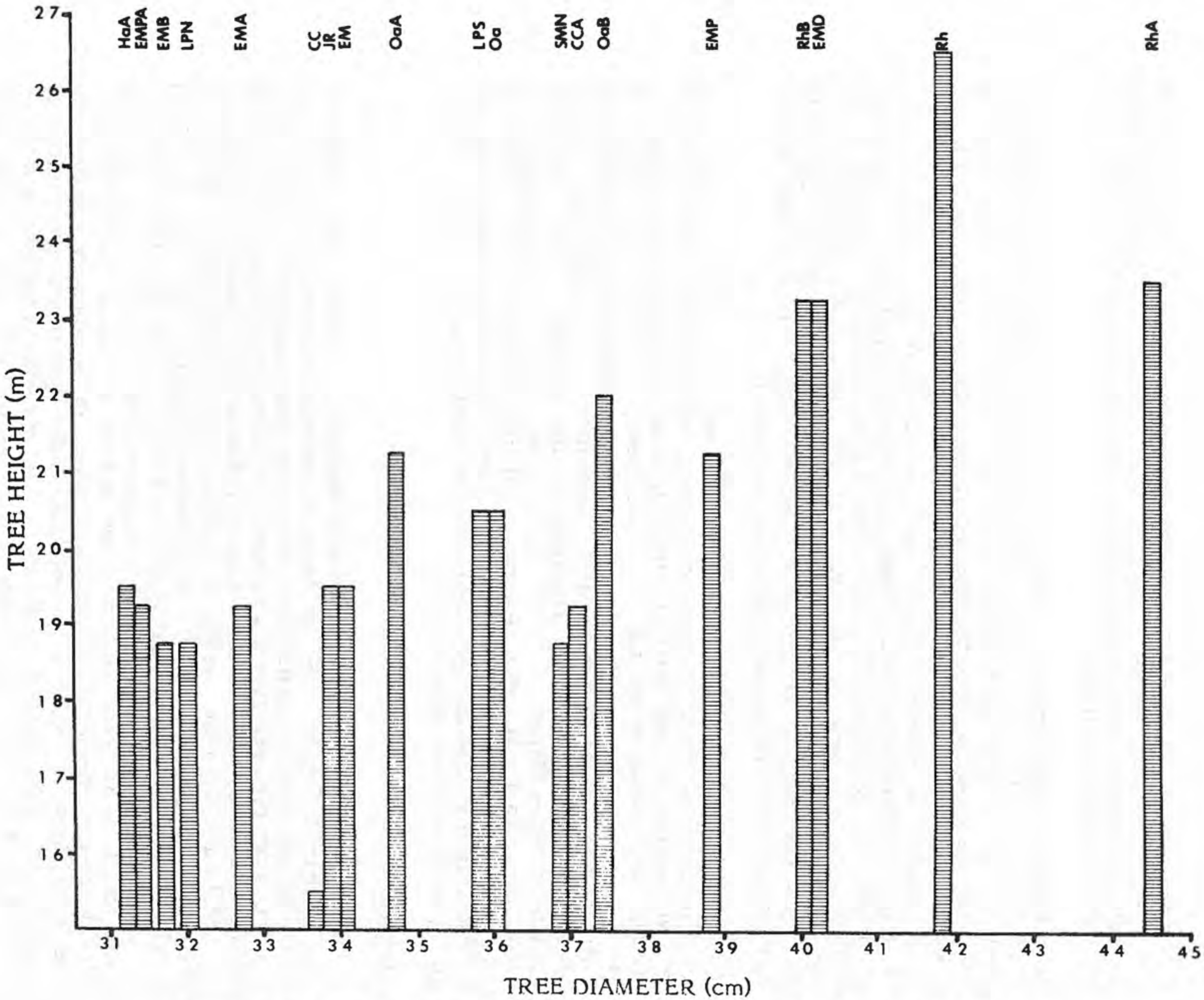


Figure 29. Mean height and diameter of cavity trees in Red-cockaded Woodpecker colonies.

in longleaf pine (n = 557) 38.8 cm, in loblolly pine (n = 572) 48.2 cm and in slash pine (n = 15) 40.6 cm. The smaller size of cavity trees in BICY doubtless reflects the fact that growth conditions for pine are less favorable than in many areas, because of low sites and thin soil.

Mean number of cavity trees per colony for all colonies was 7.7 with a range of 3 to 11 (Table 3). All active colonies had at least seven cavity trees. The BICY population seems to compare rather closely with others in this respect except for lack of the high and low extremes reported in other studies. Thus Lay and Russell (1970) found that Texas colonies included 1 to 8 cavity trees and Hopkins and Lynn (1971) noted an average of 6 cavity trees per colony (range 2 to 9) in South Carolina. Jackson (1979a) gave a range of 1 to 29 for a population in Mississippi and Thompson and Baker (1971: 180), summarizing data from a sample of 229 colonies, reported a mean of 4.16 cavity trees per colony with a range of 1 to 17. Although Jackson (op. cit.) stated that the number of cavity trees in a colony did not necessarily indicate the size of the resident clan, at least a weak positive relationship to both clan size and colony age seems likely.

About 35 percent (51 of 147) of the cavity trees in the BICY colonies were damaged at the base by fire or were otherwise in poor condition. We recorded 40 trees with significant basal fire scars and 23 of these were judged to be damaged so severely that survival of the tree was threatened. In extreme cases (Figure 4) charred areas extended as high as 4 m and more than halfway through the diameter of the trunk. The data suggest that the activities of the woodpeckers do not contribute significantly to the likelihood of fire damage. Trees containing completed cavities (Types 5, 6 and 7) made up 44.0 percent of the population of cavity trees (Table 5), 47.5 percent of all fire-damaged cavity trees and 43.4 percent of severely fire-damaged cavity trees. Eleven cavity trees in addition to those that were fire-damaged were dying or partly dead as a result of recent lighting strikes or from unknown causes.

Colony Area

The mean extent of 13 active Red-cockaded Woodpecker colonies in BICY (Table 4, see also appendix Figures 45-63 for maps of individual colonies) in which we are reasonably sure that we found all of the cavity trees was 2.32 ha. Areas were calculated from the irregular polygons formed by connecting location points of all peripheral cavity trees. The mean distance between cavity trees for all colonies (147 trees) was 54.5 m and the cavity trees (definitely associated with particular colonies) which were most distant from nearest neighbors were: OaA-2, 400 m; OaA-1, 375 m; OaB-5, 290 m; OaB-4, 260 m; EMD-4, 234 m; and, EMB-8, 213 m. Ten cavity trees had nearest neighbor distances from 100-200 m and all other cavity trees (n = 131) were >100 m (mean 36.9 m) from their nearest neighbor. Although most of the BICY colonies would appear to be relatively compact, the extreme variability of colony areas reported in other studies makes it difficult to compare them with colonies elsewhere. For example, Thompson and Baker (1971:180) gave a mean colony area of 0.55 ha (n = 229) with a range from negligible (presumably for colonies with one cavity tree) to 6.88 ha. However,

Table 4. Area Occupied by Active Red-cockaded Woodpecker Colonies

Colony	Area (ha)
CC	0.75
CCA	2.18
Rh	2.68
RhA	1.28
RhB	3.45
Oa	0.58
EM	2.43
EMB	1.76
EMP	3.26
HaA	1.68
LPN	1.24
LPS	2.23
SMN	6.69
Mean:	2.32

Hooper et al. (1979:1) wrote, "In most colonies, all cavity trees are within a circle about 1,500 feet (457 m) wide" (i.e., 16.4 ha) and Jackson (1977a:450) stated that the cavity trees of a single colony might be as much as 1 km apart.

Cavity Types

Because our opportunities to observe many colonies were limited, we undertook to obtain as much information as possible about the resident clans from close examination of cavities and cavity trees. Excavation of a cavity is an extended process seldom completed in less than a year and sometimes requiring several years (Baker 1971a). Once completed, a cavity may be used by Red-cockaded Woodpeckers for many years and the activities of the birds leave a record of the use on the cavity tree. Thus the number and condition of cavities in a colony should provide a rough history of the colony, if one is able to read it. In BICY, we found it useful to distinguish the seven cavity types described below. These correspond in general to the types illustrated by Hooper et al. (1979).

Type 1 cavities (Figure 30) are active start holes readily indentifiable by the bright color of the exposed sapwood and usually by very small amounts of fresh resin flow and scaling of bark from the pine trunk around the prospective cavity opening.

Type 2 cavities (Figure 31) are inactive start holes, begun and then at least temporarily abandoned. The holes and areas where bark was scaled away appear weathered and any resin present has dried. Cavities commonly are started, left alone for a period, and later reactivated.

Type 3 (Figure 32) and Type 4 (Figure 33) are completed cavities, active and inactive respectively. The relatively small amount of resin flow and few resin wells indicate that the cavity is fairly recent. The weathered wood and dried resin of type 4 cavities indicate that they are not in current use. As with type 2 start holes, inactive completed cavities may later be reoccupied and used.

Type 5 cavities (Figures 34,35 and 36) have been used and maintained by Red-cockaded Woodpeckers for relatively long periods for roosting and nesting. The pine trunk is coated, usually on all sides, with a continuous glaze of fresh resin flowing from conspicuous resin wells. Continued bark-scaling and drilling and maintenance of resin wells have usually created a bare plate-like area around the cavity opening. Resin may cover a section of the trunk several meters in vertical extent around the cavity opening or the entire trunk below the cavity and for some distance above it. The amount of resin accumulated may roughly indicate the length of time the cavity has been used.

Type 6 cavities (Figure 37) are those abandoned by Red-cockaded Woodpeckers after long use, generally because the tree no longer exuded resin. They are easily recognized by the conspicuous white or yellowish coating of dried resin.

Figure 30. Type 1 cavity, active start hole (LPN-13).

Figure 31. Type 2 cavity, inactive start hole (LPN-13).

Figure 32. Type 3 cavity, active completed cavity (Rh-5).

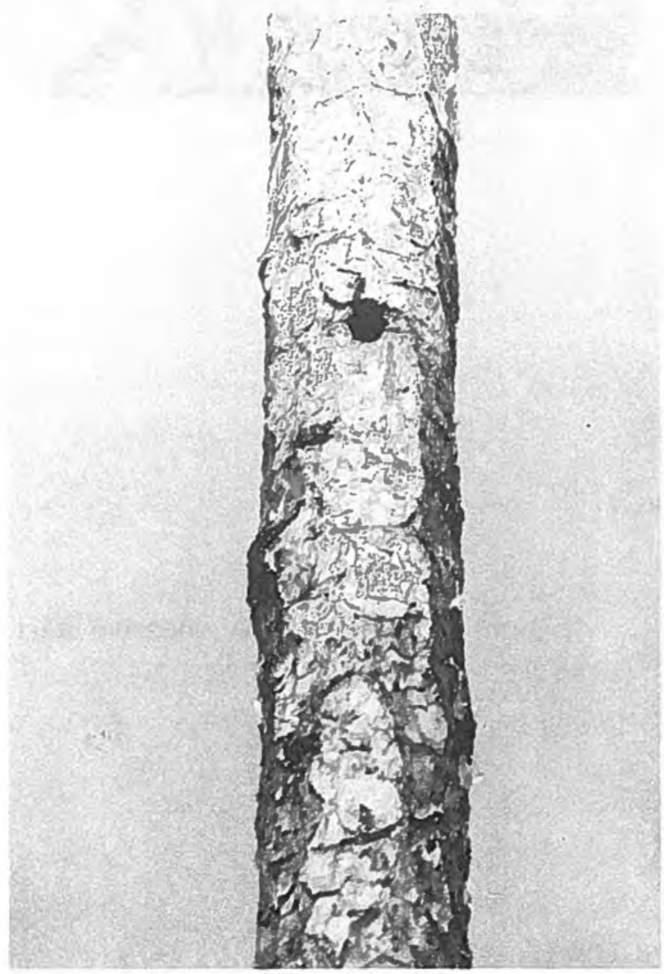


Figure 33. Type 4 cavity, inactive completed cavity (Rh-10).

Figure 34. Type 5 cavity (EM-4), showing conspicuous resin wells.

Figure 35. Type 5 cavity (HaA-9).

Figure 36. Type 5 cavity (RhB-5), showing plate of bare wood around cavity opening. This was the 1980 nest cavity of the RhB clan.

Figure 37. Type 6 cavity (LPS-8).

Type 7 cavities (Figures 38 and 39) have been enlarged by other animals, usually another species of woodpecker. These are most commonly abandoned type 6 cavities, but, on occasion, other species may occupy and re-work cavities of any type, including start holes (Figure 38).

The above cavity types represent stages of a continuum, and, inevitably, some cavities were difficult to categorize even after close study. Most cavities of types 5, 6 and 7 were easily recognizable, but decisions as to whether a cavity was completed or whether a start hole or completed cavity was inactive at times were somewhat arbitrary as viewed from the ground. However, we believe that the breakdown of cavities by type (Table 5) is reasonably accurate and provides a useful approach which could readily be improved by study of a few known situations.

In general terms, Red-cockaded Woodpecker cavities in BICY broke down as follows (Table 5): about 20 percent of the cavities were incomplete; about 40 percent were complete, but as yet little-used; about 20 percent were active and had apparently been in use for a considerable time; and, about 20 percent were abandoned, most of these showing signs of extensive earlier use. Most active colonies included cavities in all four stages. Several active colonies apparently lacked type 1 and type 2 cavities, but this may be an artifact of coverage, as start holes are much more likely to be overlooked than completed cavities. We cannot account for the greater abundance of inactive sites (types 2 and 4) among both start holes and completed cavities but suspect that in part it reflects the difficulty of distinguishing between active and inactive cavities when little resin flow is present.

The number of type 5 cavities in a colony appeared to be an extremely accurate indicator of clan size. Maximum number of adults observed in or near each active colony was the same as the number of type 5 cavities in most cases (Table 2). This observation agrees with reports that each established adult in a clan usually has its own roosting cavity. Conversely, the five inactive colonies (OaB, EMA, EMD, EMPA, and JR) were most easily recognized as such by the absence of type 5 cavities. In several cases the occurrence of type 6 and type 7 cavities in colonies that are now inactive (Table 5) seemed to indicate the former presence of a resident clan.

Such scenarios are of course highly speculative but data from the EMP colony suggested the possibilities of reconstructing colony history from existing cavities. The colony appeared to contain at least two, possibly three, successive nest cavity trees, indicating a long period of occupancy. The present nest cavity tree (EMP-2) was probably first used in 1979, because at that time the nest cavity had the appearance of a type 3 cavity with little resin flow. The EMP clan was active on the tree frequently in 1979-80 drilling and maintaining resin wells, and, by the 1980 nesting season, the tree had the usual type 5 appearance with extensive resin flow above and below the cavity opening. The only evident candidate as the nest cavity tree immediately preceding EMP-2 was EMP-5, still an active roost cavity. Although the cavity was classified as type 5, the resin had partially dried which

Figure 38. Type 7 cavity (Rh-9), an inactive start hole enlarged by another species.

Figure 39. Type 7 cavity (OaB-2), a completed cavity enlarged probably by a Pileated Woodpecker (Dryocopus pileatus).

Table 5. Cavity Types in Red-cockaded Woodpecker Colonies in BICY

Colony	Total Cavities	Type 1	Type 2	Type 3	Type 4	Type 5	Type 6	Type 7
CC	13	2	2	3	1	3	2	
CCA	13		1	2		4	5	1
Rh	10			1	3	4		2
RhA	10	1		1	2	4	2	
RhB	9			1	5	3		
Oa	11			1	5	2	1	2
OaA	7				4	2	1	
OaB	6				3			3
EM	11		4	1	2	2	2	
EMA	3				2		1	
EMB	8		1		2	2	2	1
EMD	6		2		4			
EMP	13	4	2	1	1	2	1	2
EMPA	4		1		1		2	
HaA	16	1	4		5	2	1	3
LPN	13	5	2	1	1	3	1	
LPS	15		1		6	3	5	
JR	5			1	4			
SMN	9		1	1	3	4		
Total	182	13	21	14	54	40	26	14
Percent	100	7.1	11.5	7.7	29.7	22.0	14.3	7.7

may be why the birds changed their nesting site. However, the very extensive blanket of older resin on EMP-5 reaching almost to the ground suggests that the cavity was in use for a long period. Finally, EMP-6 may be the nest cavity tree twice removed. This tree has extensive, but completely dried resin flow and contains two type 6 cavities (one is now enlarged, hence type 7), one at 5.75 m and one at 10.75 m. The lower cavity opening is covered by a cabbage palm. Beckett (1971) reported that Red-cockaded Woodpeckers tend to excavate a new cavity higher in the same tree when understory vegetation reaches the height of a cavity opening, especially in the case of nest cavities.

Detective work of the above sort is stimulating, but obviously uncertain. However, it seems plain that careful study of the history of a representative sample of cavities could greatly improve the precision of interpretations, because abundant evidence is there to be interpreted.

Number of Cavities

The mean number of cavities of all types was 9.5 per colony (Table 3) with a range of 8-16 for active colonies. This figure is reasonably near the mean of 6.41 cavities per colony reported by Thompson and Baker (1971:180), but the BICY population lacks examples of the extremes represented in their large sample (n = 229, range 1-66). Perhaps because of the generally smaller size of cavity trees in BICY, trees containing more than two cavities are rare. Mean number of cavities per tree was 1.2 (Table 3), as compared with means of 1.48 in South Carolina (Hopkins and Lynn 1971:152) and 2.32 for a sample of 265 cavity trees in Mississippi (Jackson 1977b:162).

Cavity Height and Bearing

The mean height of 182 cavities of all types was 9.5 m (Table 3, Figure 40) ranging form 2.25 m (CC-8) to 21.75 m (RhA-7 (2)). Mean cavity height for individual colonies ranged from 6.5 m to 13.0 m. Although the highest cavities were found in the Rh and RhA colonies located in relict patches of unusually large pines, the overall sample showed no close correlation between cavity height and either height or dbh of cavity trees (r = 0.41 and 0.27, respectively). Elsewhere in the species' range usual cavity height is said to be 6-15 m with extremes of 1.2 m and 18 m (Hooper et al. 1979). Ligon (1970), however, found cavities as low as 0.7 m in second-growth longleaf pine forest and elsewhere (Ligon 1971:31) gave an upper limit of about 24 m.

Cavity openings of Red-cockaded Wookpecker cavities in BICY are oriented predominantly toward the south and west, the mean compass bearing of all cavity openings being S 27° W (Table 3, Figure 41 and 42). This pattern seems to be characteristic of the species throughout its range and Dennis (1971a, 1971b) has suggested that a southwesterly orientation assured maximum sunlight and warmth to promote resin flow and to keep the glaze around cavity openings sticky as a deterrent to predators. Comparison with other studies is complicated somewhat because authors have combined data in various ways. Studies which contrasted

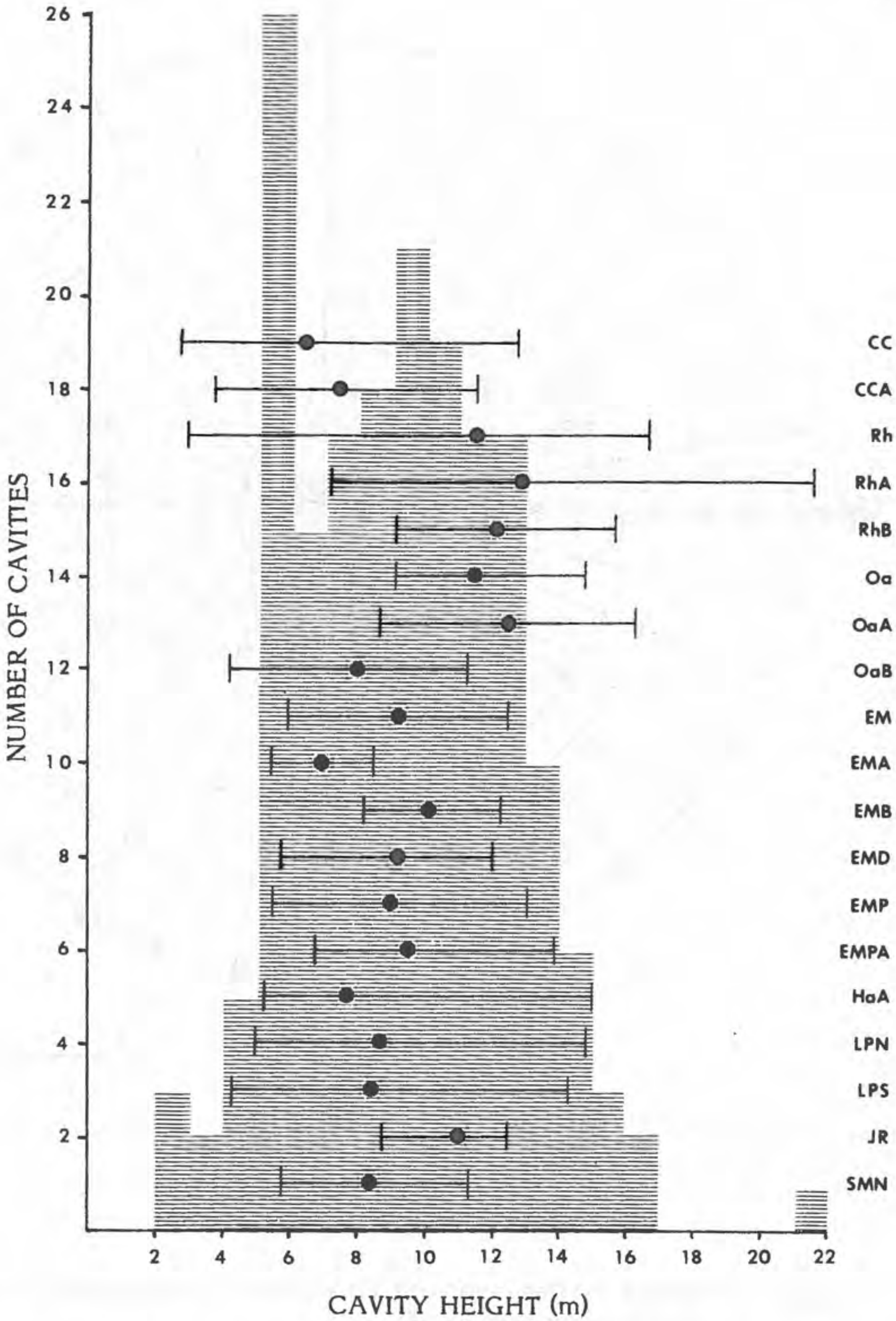


Figure 40. Frequency distribution of heights of Red-cockaded Woodpecker cavities and mean height and height range of cavities in each colony.

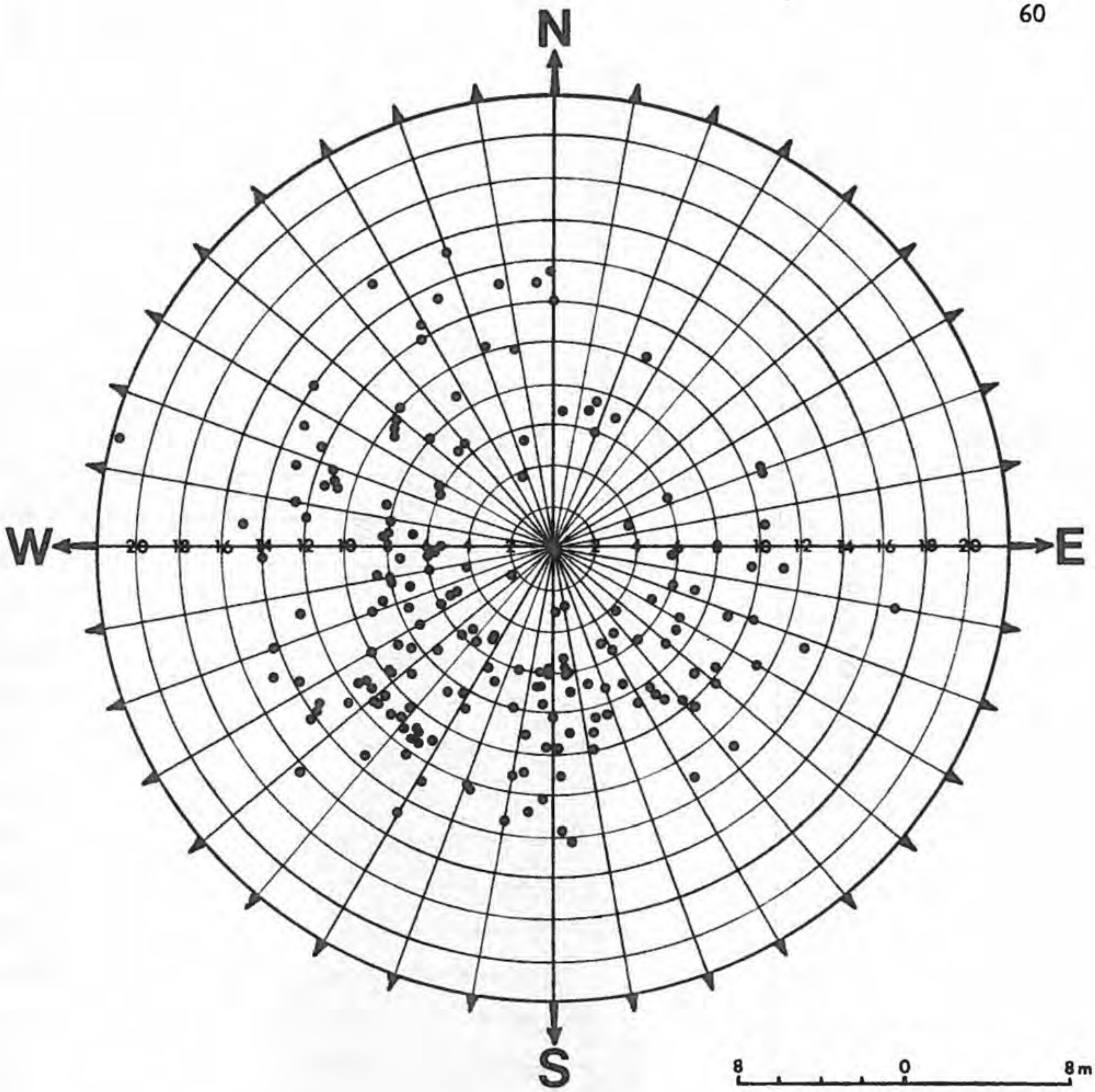


Figure 41. Height of Red-cockaded Woodpecker cavities and compass bearing of cavity openings (n = 182).

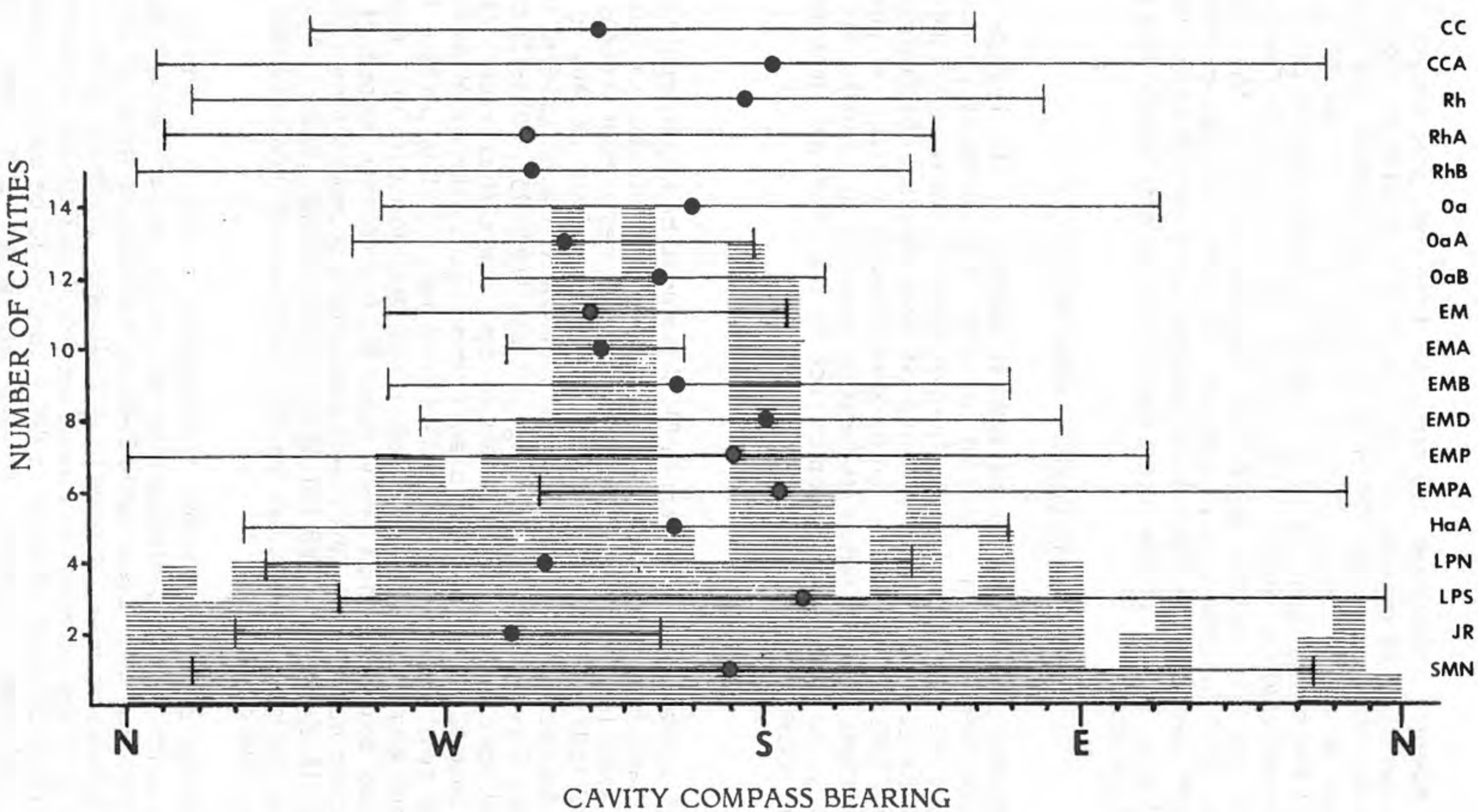


Figure 42. Frequency distribution of compass bearings of cavity openings with mean and range for each colony.

westerly and easterly orientation reported the following percentages of west-facing cavity openings: 69 percent in a sample of 186 in northern Florida (Baker 1971a); 59 percent in a sample of 558 in South Carolina (Hopkins and Lynn 1971); and 73.5 percent in another South Carolina sample of 362. In the BICY sample, 68.7 percent of the cavity openings have compass bearings from South 1° West to due North. Grimes (1947), in reporting on a sample of 53 cavities in Duval County, Florida, stated that 92.4 percent faced from southeast to west. The comparable figure for the BICY sample is 74.7 percent. Finally, bearings of the cavity openings in BICY considered on the basis of compass quadrants (North = N 44° W to N 45° E, etc.) was: North, 11.0 percent; East, 12.1 percent; South, 40.6 percent; and West, 36.3 percent.

NOTES ON ECOLOGY AND BEHAVIOR

Here we summarize data obtained on several aspects of the biology of Red-cockaded Woodpeckers in BICY. We did not undertake systematic study of the woodpeckers and the information is largely from observations recorded incidentally as we searched for colonies. We made somewhat more detailed observations of the EMP, LPN, and LPS clans whose colonies were located on tracts of pine forest where we conducted bird population studies (Patterson et al. 1980). Because we marked no birds, our comments on topics such as clan size and home range are necessarily provisional.

Reproduction

Nesting of Red-cockaded Woodpeckers in BICY seems to be largely confined to the months of May and June. As we did not examine nest contents, our information comes chiefly from hearing calls of young birds in the nest. Four records of birds giving the food calls typical of younger nestlings range from 23 May to 13 June (RhB, 1980). Six records of nestlings whose vocalizations approximated the adult type range from 2 to 24 June. According to Ligon (1970:257, 1971:43) the voice change of nestlings occurs at about 11 days of age. Our earliest record of fledged young was 23 June (CCA, 1980). It appears that nesting in the BICY population is rather strongly synchronized, with eggs laid from late April to perhaps the third week of May and young in the nest from about mid-May to early July. Presumably most or all clans attempt to nest every year. We had definite records of nesting, young heard in the nest or (in a few cases) adults making repeated nest visits with food, in 13 of 16 colonies visited during the 1980 nesting season. We have no reliable data on fledging success, but our few observations indicated that fledged broods of one or two are usual.

Timing of nesting of Red-cockaded Woodpeckers in BICY is similar to that reported from other parts of peninsular Florida, but, on present data, it appears to be more synchronous. Thus Ligon (1970:265) reported laying dates of 21 April to 4 June for a population near Gainesville and Murphey (1939:79) gave 3 April-28 May as the range of egg dates for 30 Florida records with half the sample falling in the period 29 April-20 May. Nesting in BICY appears to be almost a month later than in the Tallahassee region where Baker (1971a:51) noted that young Red-cockaded Woodpeckers generally fledge from the third week of May through the first week of June.

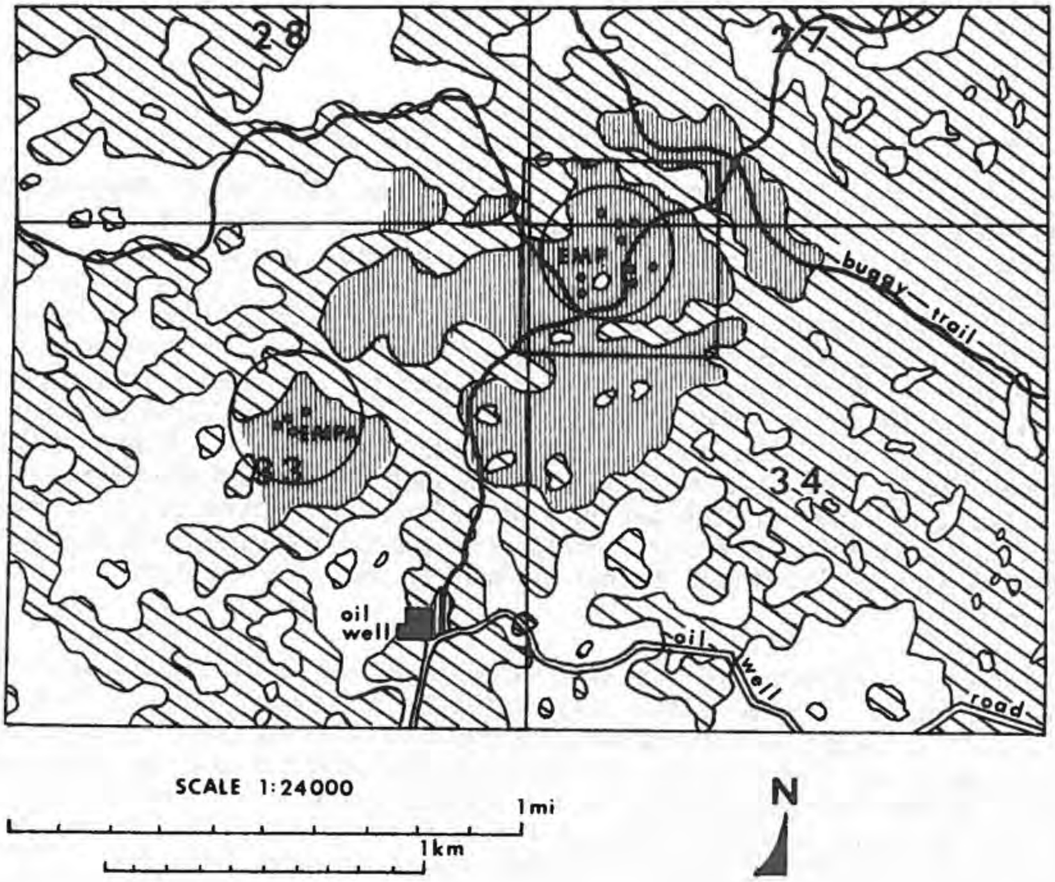
Clan Size

On data for 1979 and 1980 (Table 2), the mean size of 16 Red-cockaded Woodpecker clans in BICY was 2.75 adults. We recorded seven clans of two adults, six of three and three of four (assigning a clan size of 4 to the CCA colony), thus 56 percent of the clans (9 of 16) included helpers. Clan size in BICY appears to be decidedly smaller than in the Tallahassee region of Florida (Baker 1971a) and in coastal South Carolina (Beckett 1971), where virtually all clans have helpers and clans of five to seven adults occur. The data compare more closely with mean clan sizes of 2.5 in a sample of eight clans near Gainesville, Florida (Ligon 1971:30), and 3.25 in a sample of 12 clans in east Texas (Lay et al. 1971:75). Baker (1971a:55) cautioned that it is difficult to determine the size of Red-cockaded Woodpeckers clans except by observing the behavior of individually marked birds. However, perceived clan size in our records correlates so exactly with the number of type 5 cavities in each colony (Table 2) that we believe the reported sizes are substantially correct.

The biological significance of clan size variation in Red-cockaded Woodpeckers is poorly understood. Available data suggest that in clans with helpers growth rate (Ligon 1970, 1971) and survival to fledging (Lennartz and Harlow 1979) of nestlings are increased, but these effects are not well-documented and the relationship between helpers and productivity in the species remains an open question. It appears to be rather generally believed that clan size is positively correlated with habitat quality, recent reproductive success, and colony age. Thus Ligon (1971:34) considered that the prevalence of clans of two in his study area might be due to inadequate food resources in second-growth pine forests and Baker (1971a:55) suggested that the lack of helpers indicated a newly-established colony. Although these presumed correlates of clan size may seem reasonable, there appear to be few supporting data. Authors have also speculated that larger clans might control larger areas of habitat, but a recent study (Sherrill and Case 1980) reported no significant correlation between clan size and size of the winter home range for four clans studied in South Carolina. Our preliminary data for the BICY population suggest a negative relationship between clan size and apparent habitat quality. Mean size of eight clans (CC, CCA, Rh, RhA, RhB, LPN, LPS, and SMN) which of necessity forage largely in second-growth pine was 3.25, as opposed to a mean size of 2.5 for 10 clans which forage entirely within old-growth forest ($t = 3.64$, $p = .01$).

Home Range

Accurate determination of the area of habitat used by a clan of Red-cockaded Woodpeckers is seldom possible except by observing movement of individually-marked birds. However, for the EMP clan, the isolation of the colony (Figure 20) and approximately 120 observations covering a period of about 18 months enabled us to delineate home range with some assurance (Figure 43). The EMP clan included only the breeding pair. One young bird fledged in the 1979 season was seen regularly with its parents as late as 17 January 1980, but we could not locate it on 7 March 1980 or later. Based on thorough search of all the pine islands within about 3 km, we believe there were no other clans in the area and that the EMP clan



LEGEND

- Colony area representing 15 hectares.
- Individual cavity trees.
- 40 ha (100 acre) breeding bird census plot.
- Cypress dome and cypress prairie habitat.
- Outlined white areas represent pine forest.

Figure 43. Observed home range of the EMP clan of Red-cockaded Woodpeckers 1979-80. The vertically-barred area represents pine forest used by the woodpeckers.

was not in contact with other Red-cockaded Woodpeckers during 1979-80. Thus the observed home range represents the area used by a clan that was not constrained by territorial interactions with neighboring clans. The EMPA colony (Table 2, Figure 43), apparently inactive for some time, is included within the range of the EMP clan, and by following movement of birds between the two sites we are certain there was only one clan in this area. We repeatedly saw the woodpeckers fly from the vicinity of EMPA, and from other peripheral points in the home range, directly to or in the direction of the EMP colony.

The area described by connecting the points of all peripheral observations of the EMP clan measured 159.3 ha. This area includes 94.7 ha of pine forest with the remainder occupied by cypress domes and scrub cypress forest. In our observations, the EMP clan foraged entirely in pines and ignored cypress. The birds often flew directly across 200 to 400 m of cypress forest between pine islands and we have only one observation of a bird which landed (briefly) in a cypress. The most distant points reached by the EMP clan were about 1.4 km from the cavity tree used for nesting in 1979 and 1980. In a few other cases where we were reasonably sure of the identity of the clan, observations suggested that the clans which forage largely in second-growth stands of pine may range somewhat farther from the colony. Thus birds thought to be the CCA and LPN clans were encountered about 2 km and 1.6 km from their respective colonies.

Clan home range size would appear to be an important datum in a species as sedentary as the Red-cockaded Woodpeckers, because it provides some measure of the year-round habitat resources needed to sustain a basic unit of population. However, as discussed recently by Skorupa and McFarlane (1976) biological and methodological variables make it difficult to compare reported home range size between studies. The principal problems are seasonal variation in home range size and different methods used to calculate home range area. The area utilized by Red-cockaded Woodpeckers is most restricted in the nesting season and may be almost twice as large in winter (Skorupa and Mc Farlane 1976), when home ranges of neighboring clans may overlap broadly (Sherrill and Case 1980). The EMP clan, for example, foraged primarily within an area of about 25 ha immediately around the colony during the time nesting was in progress. Reported home range area may also vary depending upon whether the area was calculated from a regular polygon formed by connecting only the outermost points or from an irregular polygon connecting all peripheral points (Skorupa and McFarlane 1976). Table 6 compares home range of the EMP clan with home range reported in other studies which included observations outside the breeding season and areas calculated on the basis of all peripheral records.

The area ranged over by the EMP clan is much larger than home ranges recorded in other areas, 3.6 times larger the mean value for other comparable studies (Table 6). If home range size is related to the quality of the resource base, this suggests that habitat for the species in BICY may be unusually poor. However, Hooper et al. (1979:2) stated, "The total area used by a clan can be as large as 1000 acres (404.7 ha)," but did not indicate the source of the datum. It must be noted as well that the EMP clan enjoyed an altogether self-determined home range,

Table 6. Size of Home Range in Red-cockaded Woodpeckers[1]

Location	Clan Size[2]	Home Range (ha)	Source
Tallahassee Region, Florida	5	65.6	Baker 1971a
Savannah River Plant, South Carolina	2 4	33.6 31.4	Skorupa and McFarlane 1976 (minimum winter area)
Marion Co., Florida	3 4 3	91.4 58.4 59.5	Nesbitt et al. 1978
Coastal Plain, South Carolina	-	64.8 (mean for 6 clans)	Hooper et al. unpubl. (Cited by Sherrill and Case)
Francis Marion Nat'l Forest, South Carolina	-	22.6-28.7 (range for 4 clans)	Hooper unpubl. (Cited by Sherrill and Case)
Carolina Sandhills NWR, South Carolina	8 4 2 4	43.7 20.6 20.7 39.9	Sherrill and Case 1980
EMP Clan, BICY, Florida	2	159.3 (94.7 pine)	This study

1. Studies including data collected outside the breeding season and home range sizes calculated as least-area polygons.

2. Some records evidently include fledged young of the current year.

apparently not limited by contact with other clans. Sherrill and Case (1980:374) found that the home range size of a given clan showed a strong positive correlation with the average distance between its nest cavity and the nest cavities of all surrounding clans. It seems clear that additional measurements in a variety of situations and by standardized methods are needed in BICY and elsewhere before it will be possible to comment with much assurance on the general significance of home range size in Red-cockaded Woodpeckers.

Foraging Behavior

Our observations of foraging by Red-cockaded Woodpeckers in BICY agreed closely with those reported by Morse (1972) for a Louisiana population. Namely, almost all foraging activity occurred on the trunks of living pines. Occasionally, individuals foraged briefly at the base of larger pine branches near the trunk, but even the birds whose foraging range was primarily in stands of second-growth pine 15 to 25 cm dbh rarely ventured onto smaller branches. On several occasions birds of the EMP clan after feeding their young, appeared to forage on a dead pine snag next to the nest cavity tree, but this behavior may have been caused by our presence. Our only definite observation of foraging on dead pine wood involved the EM clan, two birds actively foraging on an extensively decomposed 3-4 m pine snag. Various authors (Ligon 1970, Beckett 1971, Skorupa and McFarlane 1976, Hooper et al. 1979) have noted that Red-cockaded Woodpeckers also foraged in other forest types, such as cypress, hardwoods, and pecan orchards, and that they fed on ear worms in cornfields (Baker 1971b). Foraging in cypress has been observed in BICY (O. T. Owre pers. comm.), but, despite the prevalence and availability of cypress forests, we saw this behavior only once.

Ligon (1968, 1970) reported that there was a difference of foraging niche between sexes of Red-cockaded Woodpeckers, females tending to forage on the lower trunk and males on the upper trunk and branches. Beckett (1971) and Morse (1972) detected no sexual differences in foraging behavior in the populations they studied and our records, chiefly of the EMP pair, also did not confirm Ligon's observations.

Agonistic Behavior

Red-cockaded Woodpeckers defend their nesting and foraging areas against neighboring clans the year around, but, as Sherrill and Case (1980) suggest, the intensity of agressive behavior probably tends to decrease as distance from the nesting cavity increases. As might be expected in an extremely sedentary species, territorial boundaries tend to be well-established. Defense consists primarily of ritualized posturing, drumming, and vocalization and physical contact or actual fighting are rare.

Our only observations of territorial behavior pertained to the LPN and LPS clans part of whose range boundary crossed a 40-ha tract of pine forest where we censused wintering and breeding birds in 1980. The colonies are located in the uncut southern end of a large pine island and are closer together than all except one other pair of active colonies in BICY (Figures 25 and 44), the nest cavity trees

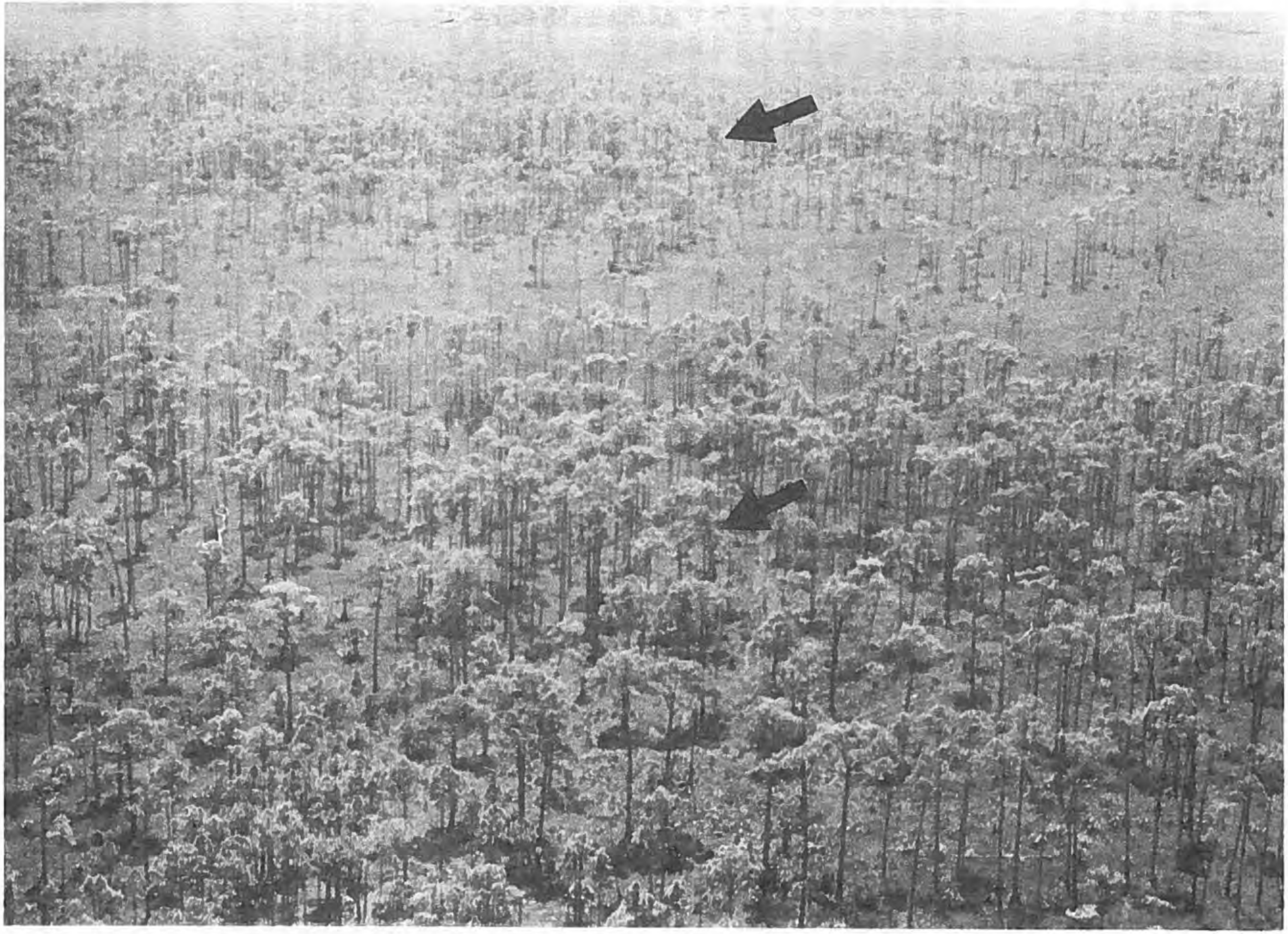


Figure 44. Aerial view of LPN (foreground) and LPS colonies. Arrows indicate the approximate location of the 1980 nest cavity tree in each colony.

separated by a distance of only 410 m. Each clan foraged mainly north of its colony primarily in second-growth pine. However, despite the close location, we saw only one boundary encounter in is approximately 50 hours of field work in the colony areas. This compares with the rate of one inter-clan agonistic encounter per 3.8 hours reported by Sherrill and Case (1980:373) for four adjacent clans in a dense population of Red-cockaded Woodpeckers in South Carolina. However, the infrequent confrontations between the LPN and LPS clans were apparently sufficient to establish their common boundary. As reported by Lay et al. (1971:76) for the species in east Texas, each clan appeared to recognize the boundary even when the neighboring clan was not in the area. The only territorial interaction we observed was in January. Contact between adjacent clans apparently becomes even less common during the breeding season when activity is more closely restricted to the vicinity of the colony. Behavior of the woodpeckers during the boundary confrontation agreed closely with the descriptions given by Ligon (1970:262) and Nesbitt et al. (1978:148-149).

Aggressive interactions between Red-cockaded Woodpeckers and other species occur mainly in and around the colonies and most involve attempts by other birds to use Red-cockaded Woodpecker cavities. Various authors have reported about 15 other species of hole-nesting birds and several mammals (flying squirrel, gray squirrel) using the cavities for nests or roosts (Ligon 1970, Beckett 1971, Lay et al. 1971, Dennis 1971a, 1971b). Much of the use is of abandoned cavities, but on occasion other species compete for active cavities and may forcibly evict the resident Red-cockaded Woodpecker (Ligon 1971: 32). Not infrequently, cavities may be used sequentially for nesting by Red-cockaded Woodpeckers and other species, even in the same breeding season (Baker 1971: 48, Dennis 1971b).

In contrast to a number of other studies, we observed relatively little interspecific aggression around the Red-cockaded Woodpecker colonies in BICY. Ligon (1970), for example, reported that Red-bellied Woodpeckers (Melanerpes carolinus) competed intensely for Red-cockaded Woodpecker cavities and usually dominated interspecific encounters. We saw only one definite aggressive incident between these species, when a Red-bellied Woodpecker entered an active roosting cavity (EMP 5) and was quickly ejected by a Red-cockaded Woodpecker. On eight other occasions, we watched Red-bellied Woodpeckers foraging without incident as close as 10 m to the active nest of the EMP clan. The fact that most Red-bellied Woodpeckers in BICY have completed nesting by the time Red-cockaded Woodpeckers begin to nest may tend to limit interspecific aggression. The six instances we recorded of nesting or probable nesting by other species in Red-cockaded Woodpecker cavities, three each by Red-bellied Woodpeckers and Eastern Bluebirds (Sialia sialis), all involved inactive cavities and were apparently tolerated by the resident clan. One Eastern Bluebird nest was only 33.5 m from the nest of the Oa clan active at the same time. In sum, our observations suggest that interspecific aggression and competition for nesting cavities has little effect on the behavior and reproductive success of Red-cockaded Woodpeckers in BICY.

On a number of occasions we saw Red-cockaded Woodpeckers displace and chase other birds in encounters that seemed to be defense of foraging areas. Aggression was most commonly directed toward Downy Woodpeckers (Picoides pubescens), but also involved species that are not potential food competitors, such as the American Kestrel (Falco sparverius) and Great Crested Flycatcher (Myiarchus crinitus). Quite in contrast to its agonistic behavior related to foraging, the Red-cockaded Woodpecker frequently appeared to be the nucleus species in mixed-species foraging flocks in winter. Other birds which commonly joined the mobile aggregations included the Red-bellied Woodpecker, Downy Woodpecker, Brown-headed Nuthatch (Sitta pusilla), Eastern Bluebird, Blue-gray Gnatcatcher, (Polioptila caerulea), Yellow-rumped Warbler (Dendroica coronata), Pine Warbler (D. pinus), and Palm Warbler (D. palmarum). The organization of these winter flocks isn't well-understood, but Red-cockaded Woodpeckers commonly forage by scaling bark from pine trunks and Beckett (1971:92) suggested that other birds may follow them to catch flying insects disturbed by this activity.

Reaction to Disturbance

As long as the colony is intact, Red-cockaded Woodpeckers appear to have considerable tolerance of disturbance. Ligon (1970) reported that a male continued to occupy the same cavity for four years even though a fence was built a few feet away and the area converted into a park. Around Myrtle Beach, South Carolina, Dennis (1971) found colonies in longleaf pine forest adjacent to residential areas, golf courses, and heavily travelled highways. Thompson and Baker (1971:176-177) wrote, "Colonies were observed in picnic areas, developed campsites, work centers, moderately developed housing subdivisions, quail hunting preserves, and along nature trails." Baker (1971b) noted that Red-cockaded Woodpeckers had been known in several cases to visit bird feeding stations that were located near their foraging range. One contrary report suggested that nesting birds may be more susceptible to disturbance. In this instance (Skorupa and McFarlane 1976), disturbance from nearby logging was thought to have disrupted the feeding visits of adults resulting in death of a hatchling in the nest.

Perhaps the most striking evidence of the species' ability to persist in the face of disturbance is provided by the woodpeckers which continue to inhabit fragments of old-growth forest after logging has eliminated the rest of the habitat and the rest of the Red-cockaded Woodpecker population from extensive surrounding areas. This pattern seems to have been fairly general throughout the South. As suggested above, in the case of the colony west of Homestead and as may be true for some existing colonies within the cut-over parts of BICY, isolated clans may be able to hold out for decades in such situations, provided that the colony is undisturbed and adequate foraging area remains in the vicinity. Conceivably, scattered colonies of this sort might persists until recovery of the habitat permitted the population to expand. The future of present colonies in the logged areas of BICY will provide a test of this possibility.

At present, the hinterlands of BICY are not subject to heavy use and there is no obvious evidence that any of the present human activities in the back country have affected Red-cockaded Woodpeckers. A number of colonies, for example, are located near major ORV trails and hunting camps. It appears that, if the colonies are protected, casual human disturbance is not likely to be significant, even with a considerable increase in the present level of back-country use.

SUMMARY AND CONCLUSIONS

A major objective of the two-year BICY Wildlife Project (initiated FY 1979, terminated FY 1980) was to locate populations of federally-listed endangered species in the area. This paper reports information obtained on one such species, the Red-cockaded Woodpecker.

Methods employed in the study were: helicopter survey to locate suitable pine forest habitat; ground search of suitable habitat for woodpecker colonies; recording physical data for cavity trees and cavities in the colonies found; and, as feasible, revisiting colonies to observe the resident clan of woodpeckers. Special terms used in discussing the biology of Red-cockaded Woodpeckers are defined.

The Red-cockaded Woodpecker is a highly specialized endemic species of the pine forests of the southern United States. Its unusual specializations include: excavating cavities almost exclusively in mature living pines infected with a fungal disease that causes heart rot; probably as a deterrent to predators, systematically puncturing cavity trees causing them to exude resin; and, cooperative breeding in clans consisting, typically, of the breeding pair and one to five additional adult helpers.

Once ubiquitous in pine forests of the South, the Red-cockaded Woodpecker had declined noticeably by the 1930's, and, by the 1960's, logging of old-growth stands had extirpated the species in much of its former range. Its designation as an endangered species led to an apparent increase, almost threefold in Florida, as intensified search discovered previously unknown colonies. However, evidence suggests that the species is still decreasing and that the total population numbers fewer than 10,000 adults.

In southern Florida, the Red-cockaded Woodpecker occurred originally south to the limits of pine forest on the mainland. It disappeared from southeastern Florida, including Long Pine Key in EVER, mainly during the 1940's. In southwestern Florida, where early occurrence is poorly documented, it persisted into the 1970's but is now largely gone outside BICY. The clans in BICY constitute the southernmost, and probably the largest, of the four local populations in the southern half of peninsular Florida whose long-term survival seems likely.

Old-growth stands within a total pine forest area of about 400 square kilometers provide the essential habitat of Red-cockaded Woodpeckers in BICY. The area is dissected by wetlands into many hundreds of pine islands and extensive tracts of pine forest are rare. The forest type is fire-maintained, and, without fire, invasion by hardwoods soon renders pine sites unacceptable to Red-cockaded Woodpeckers. For at least the past 100 years, man-caused fires, in large part deliberatedly set, appear to have been primarily responsible for maintenance of an open understory in BICY pine stands. Pine logging in BICY was neither as extensive nor as thorough as pictured in previous accounts. Pine islands in a relatively large part of BICY apparently were not touched by logging, and, throughout the logged area, small relict stands remained uncut. Red-cockaded Woodpecker colonies now occur in both these situations. The species' potential habitat problems in BICY in the near-term future appear to be: (1) Possible sharp reduction in the rate of occurrence of man-caused fires resulting in extensive invasions by hardwoods; and, (2) Loss of mature trees by attrition from the colonies in relict stands within the cut-over area before trees in the second-growth stands are large enough to provide sites for cavities.

Survey of BICY pine areas located 23 Red-cockaded Woodpecker colonies of which 18 were active. Only two colony locations were definitely known prior to the study. Because large areas of suitable habitat are yet to be searched, we estimate that the minimum population of the area is 40 active colonies. All presently known colonies are located on detailed maps and habitat variations, due primarily to differences in fire history and logging history, in the five local areas containing colonies are discussed.

Physical data on cavity trees and cavities, as compared with information from other studies, indicated the following. Red-cockaded Woodpeckers in BICY utilize smaller pines as cavity trees, doubtless because site conditions in the area are less favorable for pine growth and mature trees are smaller. Colonies tend to be compact covering an average area of 2.32 ha. Mean height of cavities, 9.5 m, is similar to that reported elsewhere and is not significantly correlated with either height or diameter of cavity trees. As found in most studies, cavity openings mainly face west and south, mean compass bearing of all cavities being S 27° W. Seven cavity types, distinguished and described, afford a means to read colony history from the condition of existing cavities. Most colonies include cavities in all stages. The rough break-down for the entire sample of cavities was 20 percent incomplete; 40 percent complete, but as yet little-used; 20 percent active; and, 20 percent abandoned. The number of active cavities (type 5) was a close indicator of the number of adults in the resident clan.

Nesting and rearing of young occurs mainly from late April to early July and most clans apparently attempt to nest every year. Mean clan size was 2.75 adults, smaller than reported in most other studies, and 56 percent of the clans had at least one adult helper. The home range of one isolated clan measured 159.3 ha (94.7 ha of pine forest), much larger than home ranges determined by similar methods in other areas. The birds foraged almost entirely from the trunks of living pines and ignored cypress and other forest types. For the three clans we studied closely, levels of intraspecific aggression and interspecific competition for cavity sites appeared to be low. The species seems relatively tolerant of disturbance, as long as the colony is intact, and back-country use to date in BICY has had no obvious effects upon its occurrence and behavior.

ACKNOWLEDGEMENTS

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LITERATURE CITED

Affeltranger, C. 1971. The red heart disease of southern pines. Pp. 96-99 in R. L. Thompson (ed.) The Ecology and Management of the Red-cockaded Woodpecker. Bureau of Sport Fisheries and Wildlife and Tall Timbers Research Station, Tallahassee, Florida.

Avery, G. N. and L. L. Loope. 1980. Endemic Taxa in the Flora of South Florida. South Florida Research Center Report T-558. 39 pp.

Baker, W. W. 1971a. Progress report on life history studies of the Red-cockaded Woodpecker at Tall Timbers Research Station. Pp. 44-59 in R. L. Thompson (ed.) The Ecology and Management of the Red-cockaded Woodpecker. Bureau of Sport Fisheries and Wildlife and Tall Timbers Research Station, Tallahassee, Florida.

Baker, W. W. 1971b. Observations on the food habits of the Red-cockaded Woodpecker. Pp. 100-107 in R. L. Thompson (ed.) The Ecology and Management of the Red-cockaded Woodpecker. Bureau of Sport Fisheries and Wildlife and Tall Timbers Research Station, Tallahassee, Florida.

Baker, W. W. 1978. Red-cockaded Woodpecker. Pp. 11-13 in H. W. Kale, II (ed.) Rare and Endangered Biota of Florida, Volume 2. Birds. University Presses of Florida, Gainesville, Florida.

Baker, W. W., R. L. Thompson and R. T. Engstrom. 1980. The distribution and status of Red-cockaded Woodpecker colonies in Florida: 1969-1978. Fla. Field Nat. 8: 41-45.

Beckett, T. 1971. A summary of Red-cockaded Woodpecker observations in South Carolina. Pp. 87-95 in R. L. Thompson (ed.) The Ecology and Management of the Red-cockaded Woodpecker. Bureau of Sport Fisheries and Wildlife and Tall Timbers Research Station, Tallahassee, Florida.

Czuhai, E. 1971. Synoptic review of forest resource and use within the range of the Red-cockaded Woodpecker. Pp. 108-124 in R. L. Thompson (ed.) The Ecology and Management of the Red-cockaded Woodpecker. Bureau of Sport Fisheries and Wildlife and Tall Timbers Research Station, Tallahassee, Florida.

Dennis, J. V. 1971a. Utilization of pine resin by the Red-cockaded Woodpecker and its effectiveness in protecting roosting and nest sites. Pp. 78-86 in R. L. Thompson (ed.) The Ecology and Management of the Red-cockaded Woodpecker. Bureau of Sport Fisheries and Wildlife and Tall Timbers Research Station, Tallahassee, Florida.

Dennis, J. V. 1971b. Species using Red-cockaded Woodpecker holes in northeastern South Carolina. Bird-Banding 42: 79-87.

Duever, M. J., J. E. Carlson, J. F. Meeder, L. C. Duever, L. H. Gunderson, L. A. Riopelle, T. R. Alexander, R. F. Myers, and D. P. Spangler. 1979. Resource Inventory and Analysis of the Big Cypress National Preserve. Final report on National Park Service Contract No. CX5000 70 899. 1225 pp.

Fritts, H. C. 1976. Tree Rings and Climate. Academic Press, London. 567 pp.

Grimes, S. A. 1947. Birds of Duval County. Fla. Naturalist 21: 1-13.

Holt, E. G. and G. M. Sutton. 1926. Notes on birds observed in southern Florida. Annals Carnegie Mus. 16: 409-439.

Hooper, R. G., A. F. Robinson, Jr., and J. A. Jackson. 1979. The Red-cockaded Woodpecker: Notes on life history and management. General Report SA-GR 7, 8 pp. U.S. Dept. of Agriculture, Forest Service, Atlanta, Georgia.

Hopkins, M. L. and T. E. Lynn, Jr. 1971. Some characteristics of Red-cockaded Woodpecker cavity trees and management implications in South Carolina. Pp. 140-169 in R. L. Thompson (ed.) The Ecology and Management of the Red-cockaded Woodpecker. Bureau of Sport Fisheries and Wildlife and Tall Timbers Research Station, Tallahassee, Florida.

Howell, A. H. 1921. A list of the birds of Royal Palm Hammock, Florida. Auk 38: 250-263.

Howell A. H. 1932. Florida Bird Life. Tallahassee, Florida Dept. Game and Fresh Water Fish.

Jackson, J. A. 1971. The evolution, taxonomy, distribution, past populations and current status of the Red-cockaded Woodpecker. Pp. 4-29 in R. L. Thompson (ed.) The Ecology and Management of the Red-cockaded Woodpecker. Bureau of Sport Fisheries and Wildlife and Tall Timbers Research Station, Tallahassee, Florida.

Jackson, J. A. 1974. Gray rat snake versus Red-cockaded Woodpeckers: Predator-prey adaptations. Auk 91: 342-347.

Jackson, J. A. 1977a. Determination of the status of Red-cockaded Woodpecker colonies. J. Wildl. Manage. 44: 448-452.

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

Jackson, J. A. 1978. Competition for cavities and Red-cockaded Woodpecker Management. Pp. 103-112 in S. A. Temple (ed.) Endangered Birds, Management Techniques for Preserving Threatened Species. University of Wisconsin Press, Madison, Wisconsin.

Jackson, J. A. and R. L. Thompson. 1971. A glossary of terms used is association with the Red-cockaded Woodpecker. Pp. 187-188 in R. L. Thompson (ed.) The Ecology and Management of the Red-cockaded Woodpecker. Bureau of Sport Fisheries and Wildlife and Tall Timbers Research Station, Tallahassee, Florida.

Kennard, F. H. 1915. On the trail of the Ivory-bill. Auk 32: 1-14.

Langdon, O. G. 1963. Growth patterns of Pinus elliottii var. densa. Ecology 44: 825-827.

Lay, D. W., E. W. McDaniel, and D. N. Russell. 1971. Status of investigations of range and habitat requirements. Pp. 74-77 in R. L. Thompson (ed.) The Ecology and Management of the Red-cockaded Woodpecker. Bureau of Sport Fisheries and Wildlife and Tall Timbers Research Station, Tallahassee, Florida.

Lay, D. W. and D. N. Russell. 1970. Notes on the Red-cockaded Woodpecker in Texas. Auk 87: 781-786.

Lennartz, M. R. and R. F. Harlow. 1979. The role of parent and helper Red-cockaded Woodpeckers at the nest. Wilson Bull. 91: 331-335.

Lennartz, M. R. and J. P. McClure. 1979. Estimating the extent of Red-cockaded Woodpecker habitat in the southeast. Pp. 27-41 in Selected Reprints from the 1979 Workshop on Forest Resource Inventories. Colorado State University, Fort Collins, Colorado.

Ligon, J. D. 1968. Sexual differences in foraging behavior in two species of Dendrocopos woodpeckers. Auk 85: 203-215.

Ligon, J. D. 1970. Behavior and breeding biology of the Red-cockaded Woodpecker. Auk 87: 255-278.

Ligon, J. D. 1971. Some factors influencing numbers of the Red-cockaded Woodpecker. Pp. 30-43 in R. L. Thompson (ed.), The Ecology and Management of the Red-cockaded Woodpecker. Bureau of Sport Fisheries and Wildlife and Tall Timbers Research Station, Tallahassee, Florida.

Little, E. L., Jr. 1978. Atlas of United States Trees. Volume 5. Florida. GPO, Washington, D.C. Map 6.

McPherson, B. F. 1973. Vegetation map of the southern parts of subareas A and C, Big Cypress Swamp, Florida. Hydrologic Invest. Atlas Ha-402, U.S. Geological Survey, Washington, D.C.

Mercer, M. T. 1914. Florida notes. Oologist 31: 47-48.

Morse, D. H. 1972. Habitat utilization of the Red-cockaded Woodpecker during the winter. Auk 89: 429-435.

Murphey, E. E. 1939. Red-cockaded Woodpecker Dryobates borealis (Vieillot), in A. C. Bent (ed.) Life Histories of North American Woodpeckers. Bull. U.S. Nat. Mus. 174: 72-79.

Nesbitt, S. A., D. T. Gilbert and D. B. Barbour. 1978. Red-cockaded Woodpecker fall movements in a Florida flatwoods community. Auk 95: 145-151.

Ogden, J. C. 1970. Florida region, Audubon Field Notes 24: 673-677.

Patterson, G. A., W. B. Robertson, Jr., and D. E. Minsky. 1980. Slash pine-cypress mosaic (breeding-bird census). Am. Birds 34: 61-62 and cover photograph.

Phelps, F. M. 1914. The resident bird life of the Big Cypress Swamp region. Wilson Bull. 26: 86-101.

Pylant, D. B. 1979 ms. The Red-cockaded Woodpecker (Picoides borealis) in the Big Cypress Wildlife Management Area, Big Cypress National Preserve. Typewritten report, 6 pp. and appendices.

Robertson, W. B., Jr. 1953. A survey of the effects of fire in Everglades National Park. Mimeo report, U.S. Dept. Interior, National Park Service, 169 pp.

Robertson, W. B., Jr. 1955. Analysis of the breeding-bird population of tropical Florida in relation to the vegetation. Ph.D. thesis, University of Illinois, Urbana, 599 pp.

Robertson, W. B., Jr. and J. A. Kushlan. 1974. The southern Florida avifauna. Miami Geol. Soc. Memoir 2: 414-452.

Shapiro, A. 1980. Red-cockaded Woodpecker survey. Memorandum dated 26 September 1980 to F. Smith, Chief, Bureau of Wildlife Land Management, Florida Game and Freshwater Fish Commission. Typewritten, 3 pp.

Sherrill, D. M. and V. M. Case. 1980. Winter home ranges of 4 clans of Red-cockaded Woodpeckers in the Carolina sandhills. Wilson Bull. 92: 369-375.

Skorupa, J. P. and R. W. McFarlane. 1976. Seasonal variation in foraging territory of Red-cockaded Woodpeckers. Wilson Bull. 88: 662-665.

Sprunt, A., Jr. 1954. Florida Bird Life. New York, Coward-McCann. Inc.

Stevenson, H. M. 1955. Florida region. Audubon Field Notes 9: 373-375.

Stevenson, H. M. 1958. Florida region. Audubon Field Notes 12: 271-276.

Stevenson, H. M. 1959. Florida region. Audubon Field Notes 13: 363-365.

Stevenson, H. M. 1968. Florida region. Audubon Field Notes 22: 599-602.

Taylor, D. L. 1980. Summary of fires in Everglades National Park and Big Cypress National Preserve, 1979. South Florida Research Center Report T-595. 23 pp.

Taylor, D. L. In press. Fire history and man-induced fire problems in subtropical south Florida. Proceedings Fire History Workshop, Laboratory of Tree-Ring Research, Forestry Sciences Laboratory, University of Arizona, Tucson, Arizona, 20-24 October 1980.

Thompson, R. L. 1976. Change in status of Red-cockaded Woodpecker colonies. Wilson Bull. 88: 491-492.

Thompson, R. L. and W. W. Baker. 1971. A survey of Red-cockaded Woodpecker habitat requirements. Pp. 170-186 in R. L. Thompson (ed.) The Ecology and Management of the Red-cockaded Woodpecker. Bureau of Sport Fisheries and Wildlife and Tall Timbers Research Station, Tallahassee, Florida.

Tomlinson P. B. 1980. The Biology of Trees Native to Tropical Florida. Harvard Univ. Press. 480 pp.

Tomlinson, P. B. and F. C. Craighead, Sr. 1972. Growth-ring Studies on the Native Trees of Sub-tropical Florida. Pp. 39-51 in A.K.M. Ghouse and Mohd. Yumus (eds.) Research Trends in Plant Anatomy-K.A. Chowdhury Commemoration Volume. Tata McGraw-Hill Publishing Co., New Delhi, India.

Truslow, F. K. 1966. Ground-nesting Great Horned Owl: A photographic study. Living Bird 5: 177-186.

Wade, D., J. Ewel, and R. Hofstetter. 1980. Fire in south Florida ecosystems. U. S. Dept. of Agriculture, Forest Service, General Technical Dept. SE-17, 125 pp. Southeastern Forest Experiment Station, Asheville, North Carolina.

Wayne, A. T. 1906. A contribution to the ornithology of South Carolina, chiefly the coast region. Auk 23: 56-68.

APPENDIX

Table 7. Mercator Locations of Red-cockaded Woodpeckers Colonies

Colony	Status	Merator Location[1]
CC	active colony	$^{28}72.8$ N, $^{4}80.2$ E
CCA	active colony	$^{28}77.4$ N, $^{4}78.1$ E
Rh	active colony	$^{28}73.9$ N, $^{4}91.2$ E
RhA	active colony	$^{28}73.7$ N, $^{4}89.8$ E
RhB	active colony	$^{28}73.8$ N, $^{4}89.5$ E
CS	active colony	$^{28}80.0$ N, $^{4}93.7$ E
Oa	active colony	$^{28}69.1$ N, $^{4}99.4$ E
OaA	active colony	$^{28}69.4$ N, $^{5}09.1$ E
OaB	inactive colony	$^{28}70.2$ N, $^{5}02.4$ E
EM	active colony	$^{28}71.4$ N, $^{5}09.0$ E
EMA	inactive colony	$^{28}71.4$ N, $^{5}08.5$ E
EMB	active colony	$^{28}71.3$ N, $^{5}08.0$ E
EMD	inactive colony	$^{28}71.1$ N, $^{5}07.7$ E
EMP	active colony	$^{28}74.9$ N, $^{5}08.1$ E
EMPA	inactive colony	$^{28}74.2$ N, $^{5}07.1$ E
HaA	active colony	$^{28}71.3$ N, $^{5}05.0$ E
LPN	active colony	$^{28}43.1$ N, $^{4}92.3$ E
LPS	active colony	$^{28}42.8$ N, $^{4}92.5$ E
JR	inactive colony	$^{28}41.9$ N, $^{4}93.4$ E
SMN	active colony	$^{28}42.1$ N, $^{4}93.3$ E
SME	active colony	$^{28}41.0$ N, $^{4}93.3$ E
SMW	active colony	$^{28}40.3$ N, $^{4}92.2$ E
BP	active colony	$^{28}38.1$ N, $^{4}95.0$ E

1. 1000-meter Universal Transverse Mercator Grid ticks, Zone 17, 1927 North American datum. From 7.5-minute Series, Orthophoto Topographic Maps, U.S. Geological Survey, 1971, 1:24000.

Table 8. CC Colony: Cavity Tree Data

TREE			CAVITY			
Designation	Height (m)	Diameter (cm)	Number in tree	Height (m)	Type (1-7)	Bearing
CC-1	15.25	33.0	1	2.75	6	S 10° E
CC-2	13.50	37.1	2			
			#1	5.00	2	S 32° W
			#2	5.00	1	S 32° W
CC-3	13.50	35.7	3			
			#1	5.50	2	due W
			#2	5.75	4	S 88° W
			#3	6.00	1	N 66° W
CC-4	14.00	34.8	1	12.75	3	S 29° W
CC-5	17.75	38.3	1	6.00	3	S 47° W
CC-6	15.25	37.0	1	7.25	3	S 20° E
CC-7	16.25	33.8	1	9.75	5	N 53° W
CC-8	13.75	24.5	1	2.25	6	S 54° W
CC-9	20.75	36.8	1	8.25	5	S 54° W
CC-10	14.00	25.8	1	7.00	5	S 61° E
Mean	15.50	33.7	1.2	6.50		S 44° W

Table 9. CCA Colony: Cavity Tree Data

TREE			CAVITY			
Designation	Height (m)	DBH (cm)	Number in tree	Height (m)	Type (1-7)	Bearing
CCA-1	20.50	37.8	1	7.25	5	S 57° E
CCA-2	22.75	45.4	1	11.25	5	S 48° W
CCA-3	15.25	31.6	1	11.50	1.7	S 60° E
CCA-4	21.00	31.0	1	6.50	6	N 44° W
CCA-5	17.00	32.8	1	6.00	5	N 20° E
CCA-6	18.50	38.8	1	10.00	5	S 60° W
CCA-7	17.75	38.6	1	6.00	3	N 68° E
CCA-8	19.25	36.6	3			
			#1	3.75	6	N 74° E
			#2	3.75	6	N 22° W
			#3	9.50	6	N 11° W
CCA-9	21.75	42.8	1	10.75	6	S 36° W
CCA-10	18.25	33.7	1	6.50	3	S 7°W
CCA-11	21.00	37.9	1	5.50	2	S 62° E
Mean	19.25	37.0	1.2	7.50		S 4° E

Table 10. Rh Colony: Cavity Tree Data

TREE			CAVITY			
Designation	Height (m)	DBH (cm)	Number in tree	Height (m)	Type (1-7)	Bearing
Rh-1	30.25	48.8	1	16.75	5	S 80° E
Rh-2	27.50	36.3	1	12.25	5	S 3° W
Rh-3	24.50	51.4	1	15.25	4	N 20° W
Rh-4	27.50	45.9	1	11.50	5	S 49° W
Rh-5	28.00	41.7	1	13.75	3	S 6° E
Rh-6	27.50	46.5	1	3.00	7(4)	S 2° E
Rh-7	23.25	38.5	1	13.00	4	S 32° E
Rh-8	27.50	37.6	1	11.50	5	S 36° W
Rh-9	26.00	32.9	1	9.25	7(2)	S 12° E
Rh-10	22.75	38.4	1	9.75	4	S 84° E
Mean:	26.50	41.8	1	11.50		S 3° W

Table 11. RhA Colony: Cavity Tree Data

TREE			CAVITY			
Designation	Height (m)	DBH (cm)	Number in tree	Height (m)	Type (1-7)	Bearing
RhA-1	21.25	32.6	1	13.00	6	S 42° E
RhA-2	29.00	60.3	1	10.00	1	S 11° E
RhA-3[1]	19.25	29.3	1	9.00	5	S 48° W
RhA-4	24.00	49.8	1	13.50	5	N 26° W
RhA-5	22.00	46.2	1	7.25	3	S 49° E
RhA-6	23.75	45.4	3			
			#1	13.00	5	N 12° W
			#2	13.00	6[2]	N 72° W
			#3	14.00	5	N 57° W
RhA-7	25.25	48.1	2			
			#1	14.25	5	S 54° W
			#2	21.75	4	N 76° W
Mean:	23.50	44.5	1.4	13.00		S 66° W

1. Nest tree (1980) now dead from unknown cause.

2. Cavity within area of active glaze; opening nearly closed due to the sap exudation.

Table 12. RhB Colony: Cavity Tree Data

TREE			CAVITY			
Designation	Height (m)	DBH (cm)	Number in tree	Height (m)	Type (1-7)	Bearing
RhB-1	24.00	37.2	1	11.00	4	S 36° W
RhB-2	24.00	42.8	2			
			#1	12.00	5	N 32° W
			#2	13.00	5	N 4° W
RhB-3	25.25	43.3	1	15.75	4	N 34° W
RhB-4	20.00	31.4	1	12.25	4	S 52° W
RhB-5	19.50	38.7	1	9.25	5	S 4° W
RhB-6	23.50	37.9	1	15.50	3	S 10° W
RhB-7	25.00	51.3	1	10.25	4	S 42° E
RhB-8	25.50	37.8	1	11.50	4	S 36° W
Mean:	23.25	40.1	1.1	12.25		S 63° W

Table 13. Oa Colony: Cavity Tree Data

TREE			CAVITY			
Designation	Height (m)	DBH (cm)	Number in tree	Height (m)	Type (1-7)	Bearing
Oa-1	17.75	33.3	1	12.25	5	N 67° E
Oa-2	19.75	30.7	1	10.75	6	N 69° E
Oa-3	19.00	33.3	1	9.75	4	S 52° W
Oa-4	22.25	34.8	1	11.00	4	N 73° W
Oa-5	25.50	41.1	1	9.75	4	S 40° E
Oa-6	18.00	35.6	1	9.75	7(4)	S 2° E
Oa-7	19.25	32.7	2			
			#1	14.75	4	S 65° W
			#2	14.00	4	S 88° W
Oa-8	20.75	39.1	1	9.25	5	S 70° W
Oa-9	19.50	34.8	1	12.25	7(4)	S 35° W
Oa-10	22.50	44.5	1	13.75	3	S 56° W
Mean	20.50	36.0	1.1	11.50		S 19° W

Table 14. OaA Colony: Cavity Tree Data

	TREE		CAVITY			
Desig-nation	Height (m)	DBH (cm)	Number in tree	Height (m)	Type (1-7)	Bearing
OaA-1	18.25	28.7	1	12.75	4	S 6^{o} W
OaA-2	20.50	36.8	1	8.75	4	S 58^{o} W
OaA-3	22.25	37.6	1	9.75	5	S 2^{o} W
OaA-4	25.00	39.1	1	13.50	5	N 64^{o} W
OaA-5	21.00	30.2	1	16.25	6	S 48^{o} W
OaA-6	19.50	35.6	1	13.50	4	S 56^{o} W
OaA-7	22.50	35.1	1	12.50	4	N 80^{o} W
Mean	21.25	34.7	1	12.50		S 55^{o} W

Table 15. OaB Colony: Cavity Tree Data

TREE			CAVITY			
Designation	Height (m)	DBH (cm)	Number in tree	Height (m)	Type (1-7)	Bearing
OaB-1	19.75	39.6	2			
			#1	8.25	4	Due S
			#2	8.50	7(4)	S 18° E
OaB-2	23.25	48.5	1	8.50	7(6)	S 14° E
OaB-3	16.75	37.8	1	11.25	7(4)	S 43° W
OaB-4	24.00	34.3	1	7.50	4	S 86° W
OaB-5	17.25	26.7	1	4.25	4	S 78° W
Mean	22.00	37.4	1.2	8.00		S 29° W

Table 16. EM Colony: Cavity Tree Data

TREE			CAVITY			
Designation	Height (m)	DBH (cm)	Number in tree	Height (m)	Type (1-7)	Bearing
EM-1	18.00	34.8	1	8.00	6	S 78° W
EM-2	17.75	27.7	2			
			#1	6.00	2	S 8° W
			#2	6.00	2	S 86° W
EM-3	19.75	27.7	2			
			#1	8.25	5	S 35° W
			#2	11.00	3	S 52° W
EM-4	14.25	30.5	1	6.75	5	S 5° W
EM-5	21.25	29.7	1	11.25	6	S 10° W
EM-6	22.00	41.7	1	10.75	2	N 74° W
EM-7	24.75	48.5	1	12.50	4	S 76° W
EM-8	22.75	35.8	1	11.50	4	S 55° W
EM-9	14.00	29.8	1	6.75	2	S 7° W
Mean	19.50	34.0	1.2	9.00		48° W

Table 17. EMA Colony: Cavity Tree Data

	TREE		CAVITY			
Desig- nation	Height (m)	DBH (cm)	Number in tree	Height (m)	Type (1-7)	Bearing
EMA-1	18.25	29.7	1	5.50	6	S 43° W
EMA-2	22.50	34.4	1	7.00	4	S 22° W
EMA-3	16.75	34.0	1	8.50	4	S 72° W
Mean	19.25	32.7	1	7.00		S 46° W

Table 18. EMB Colony: Cavity Tree Data

	TREE		CAVITY			
Designation	Height (m)	DBH (cm)	Number in tree	Height (m)	Type (1-7)	Bearing
EMB-1	19.75	32.3	1	8.25	7(4)	N 76° W
EMB-2	19.75	31.8	1	12.25	4	S 18° W
EMB-3	16.75	29.7	1	10.25	5	S 41° W
EMB-4	18.25	33.1	1	9.00	6	S 6° E
EMB-5	14.50	25.3	1	10.75	2	S 41° W
EMB-6	16.50	31.8	1	10.25	4	S 70° E
EMB-7	20.00	32.5	1	9.25	5	S 48° E
EMB-8	23.50	36.8	1	11.50	6	N 75° W
Mean	18.75	31.7	1	10.25		S 23° W

Table 19. EMD Colony: Cavity Tree Data

	TREE		CAVITY			
Designation	Height (m)	DBH (cm)	Number in tree	Height (m)	Type (1-7)	Bearing
EMD-1	20.75	34.5	1	7.00	2	S 8° E
EMD-2	22.50	46.5	1	11.25	2	S 84° E
EMD-3	29.25	45.7	1	5.75	4	S 30° E
EMD-4	23.75	32.0	1	12.00	4	N 83° W
EMD-5	22.50	42.4	1	8.50	4	S 29° E
EMD-6	21.00	39.6	1	10.75	4	S 48° W
Mean:	23.25	40.1	1.0	9.25		S 1° E

Table 20. EMP Colony: Cavity Tree Data

TREE			CAVITY			
Designation	Height (m)	DBH (cm)	Number in tree	Height (m)	Type (1-7)	Bearing
EMP-1	18.00	29.2	1	6.00	4	S 72° E
EMP-2	22.50	41.7	4			
			#1	7.25	5	S 73° E
			#2	10.25	1	N 84° E
			#3	12.00	1	due N
			#4	13.50	1	N 1° W
EMP-3	26.50	42.7	1	8.00	3	N 49° W
EMP-4	25.50	40.4	1	11.00	7(6)	S 54° W
EMP-5	18.25	30.5	1	5.50	5	N 17° W
EMP-6	18.00	35.8	2			
			#1	5.75	6	S 38° W
			#2	10.75	7(6)	N 71° E
EMP-7	23.25	44.2	1	8.50	2	S 36° E
EMP-8	20.50	38.4	1	13.50	2	S 42° W
EMP-9	18.25	46.0	1	5.50	1	S 66° W
Mean:	21.25	38.8	1.4	9.00		S 8° W

Table 21. EMPA Colony: Cavity Tree Data

	TREE		CAVITY			
Desig-nation	Height (m)	Diameter (cm)	Number in tree	Height (m)	Type (1-7)	Bearing
EMPA-1	16.50	33.8	1	8.25	6	S 31° W
EMPA-2	22.25	26.0	1	9.75	4	S 52° W
EMPA-3	19.50	33.0	1	6.75	2	N 14° E
EMPA-4	18.25	32.5	1	13.75	6	S 62° W
Mean:	19.25	31.3	1	9.50		S 5° E

Table 22. HaA Colony: Cavity Tree Data

TREE			CAVITY			
Designation	Height (m)	DBH (cm)	Number in tree	Height (m)	Type (1-7)	Bearing
HaA-1	17.25	35.1	1	8.75	5	N 33° W
HaA-2	18.50	31.8	1	10.25	6	S 50° E
HaA-3	16.75	27.7	2			
			#1	7.50	4	S 28° E
			#2	7.50	2	S 68° W
HaA-4	19.25	35.7	1	8.00	7(4)	S 13° W
HaA-5	17.25	29.7	1	7.25	1	S 75° W
HaA-6	22.50	30.0	1	8.00	4	S 80° W
HaA-7	22.75	35.3	1	7.50	4	S 49° W
HaA-8	22.50	38.6	2			
			#1	7.50	4	S 60° W
			#2	15.00	4	N 86° W
HaA-9	19.75	31.8	1	9.25	5	S 69° E
HaA-10	16.50	21.3	3			
			#1	5.25	2	S 7° E
			#2	5.75	2	S 7° E
			#3	6.00	2	S 7° E
HaA-11	20.75	27.2	2			
			#1	5.75	7(4)	S 1° W
			#2	6.00	7(1)	S 1° W
Mean:	19.50	31.3	1.5	7.75		S 26° W

Table 23. LPN Colony: Cavity Tree Data

TREE			CAVITY			
Designation	Height (m)	DBH (cm)	Number in tree	Height (m)	Type (1-7)	Bearing
LPN-1	18.50	33.0	2			
			#1	6.50	5	N 40° W
			#2	8.00	5	N 86° W
LPN-2	19.75	41.0	3			
			#1	6.00	1	S 80° W
			#2	8.00	1	N 81° W
			#3	9.25	1	N 51° W
LPN-3	19.25	32.0	1	10.00	4	N 48° W
LPN-4	18.25	29.1	1	10.75	5	S 32° W
LPN-13	19.50	39.4	2			
			#1	5.00	1	S 36° E
			#2	6.00	1	S 42° E
LPN-15	14.75	25.9	1	9.50	6	N 55° W
LPN-16	21.25	30.5	1	14.75	2	S 30° W
LPN-17	18.50	25.1	2			
			#1	9.25	3	S 8° W
			#2	12.25	2	S 19° W
Mean:	18.75	32.0	1.6	8.75		S 62° W

Table 24. LPS Colony: Cavity Tree Data

TREE			CAVITY			
Designation	Height (m)	DBH (cm)	Number in tree	Height (m)	Type (1-7)	Bearing
LPS-5	25.00	37.3	3			
			#1	4.25	4	S 44° E
			#2	6.75	4	N 86° W
			#3	6.75	2	S 14° E
LPS-6	23.25	37.6	2			
			#1	6.00	6	S 15° W
			#2	6.25	6	N 61° W
LPS-7	23.75	35.3	2			
			#1	14.25	6[1]	S 70° W
			#2	14.25	6[1]	S 3° E
LPS-8	20.50	33.3	1	6.75	6	N 4° E
LPS-9	21.75	42.2	1	13.00	4	S 68° E
LPS-10	19.50	35.8	3			
			#1	5.25	4	S 65° W
			#2	7.00	4	N 26° E
			#3	8.25	4	N 88° W
LPS-11	19.25	41.4	1	11.00	5	S 8° W
LPS-12	15.50	34.8	1	9.75	5	S 53° E
LPS-14	16.25	24.9	1	7.50	5	N 16° E
Mean:	20.50	35.8	1.7	8.50		S 11° E

1. As of September 1980 status check. Cavities were active (Type 5) in January 1980.

Table 25. JR Colony: Cavity Tree Data

	TREE		CAVITY			
Designation	Height (m)	DBH (cm)	Number in tree	Height (m)	Type (1-7)	Bearing
JR-1	18.00	35.8	1	11.25	4	S 39° W
JR-2	21.25	35.1	1	12.50	4	N 31° W
JR-3	20.00	36.3	1	11.50	4	S 34° W
JR-4	19.00	31.5	1	8.75	3	S 29° W
JR-5	19.00	30.7	1	11.25	4	N 71° W
Mean:	19.50	33.9	1.0	11.00		S 72° W

Table 26. SMN Colony: Cavity Tree Data

TREE			CAVITY			
Designation	Height (m)	DBH (cm)	Number in tree	Height (m)	Type (1-7)	Bearing
SMN-1	17.75	38.7	1	9.25	3	S 37° E
SMN-2	19.50	37.3	2			
			#1	11.25	4	S 3° E
			#2	5.75	2	S 87° E
SMN-3	17.00	42.7	1	6.00	4	S 62° W
SMN-4	15.25	30.7	1	6.50	5	S 28° W
SMN-5	21.75	39.4	1	8.50	5	S 81° W
SMN-6	21.00	37.8	1	10.25	4	N 19° W
SMN-7	18.25	31.5	2			
			#1	8.25	5	S 36° W
			#2	10.25	5	N 27° E
Mean:	18.75	36.9	1.3	8.50		S 10° W

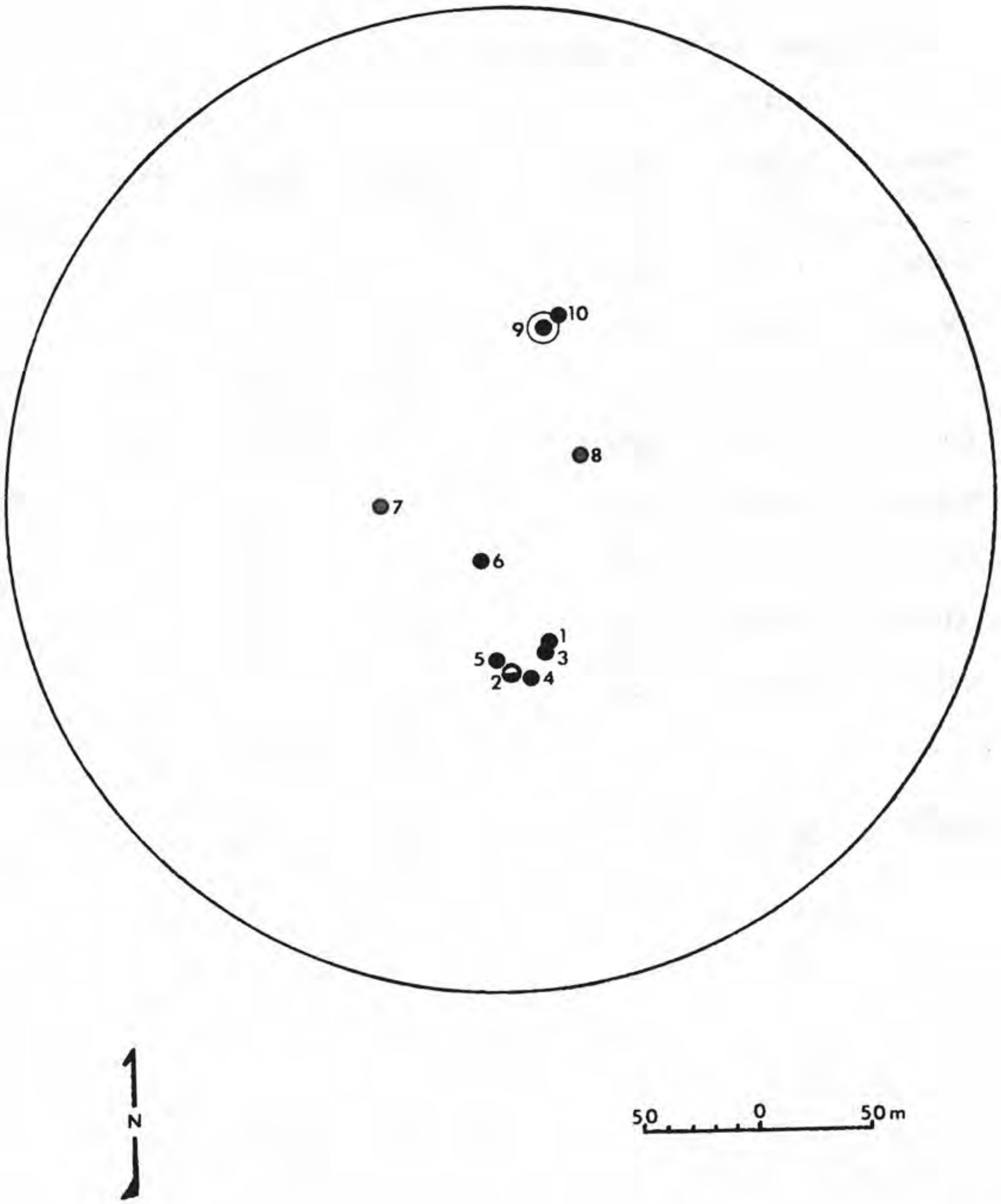

Figure 45. Spatial arrangement of cavity trees in the CC colony. Numbers indicate tree number. The large circle represents an area of 15 ha.

⊖ Tree containing start holes only.

● Tree containing one or more completed cavities.

◎ Roost cavity tree.

◉ Nest cavity tree.

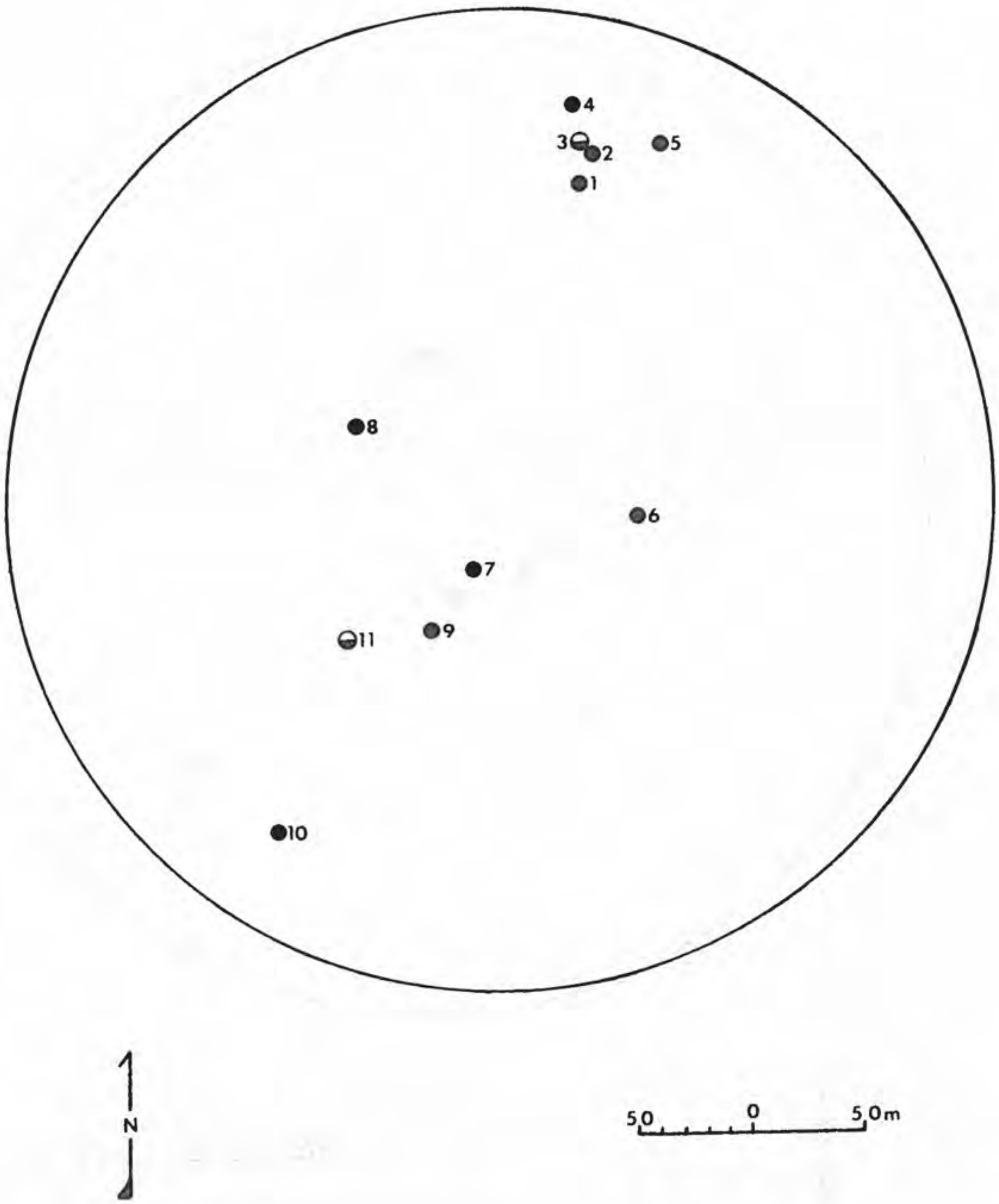

Figure 46. Spatial arrangement of cavity trees in the CCA colony. Numbers indicate tree number. The large circle represents an area of 15 ha.

- Tree containing start holes only.
- Tree containing one or more completed cavities.
- Roost cavity tree.
- Nest cavity tree.

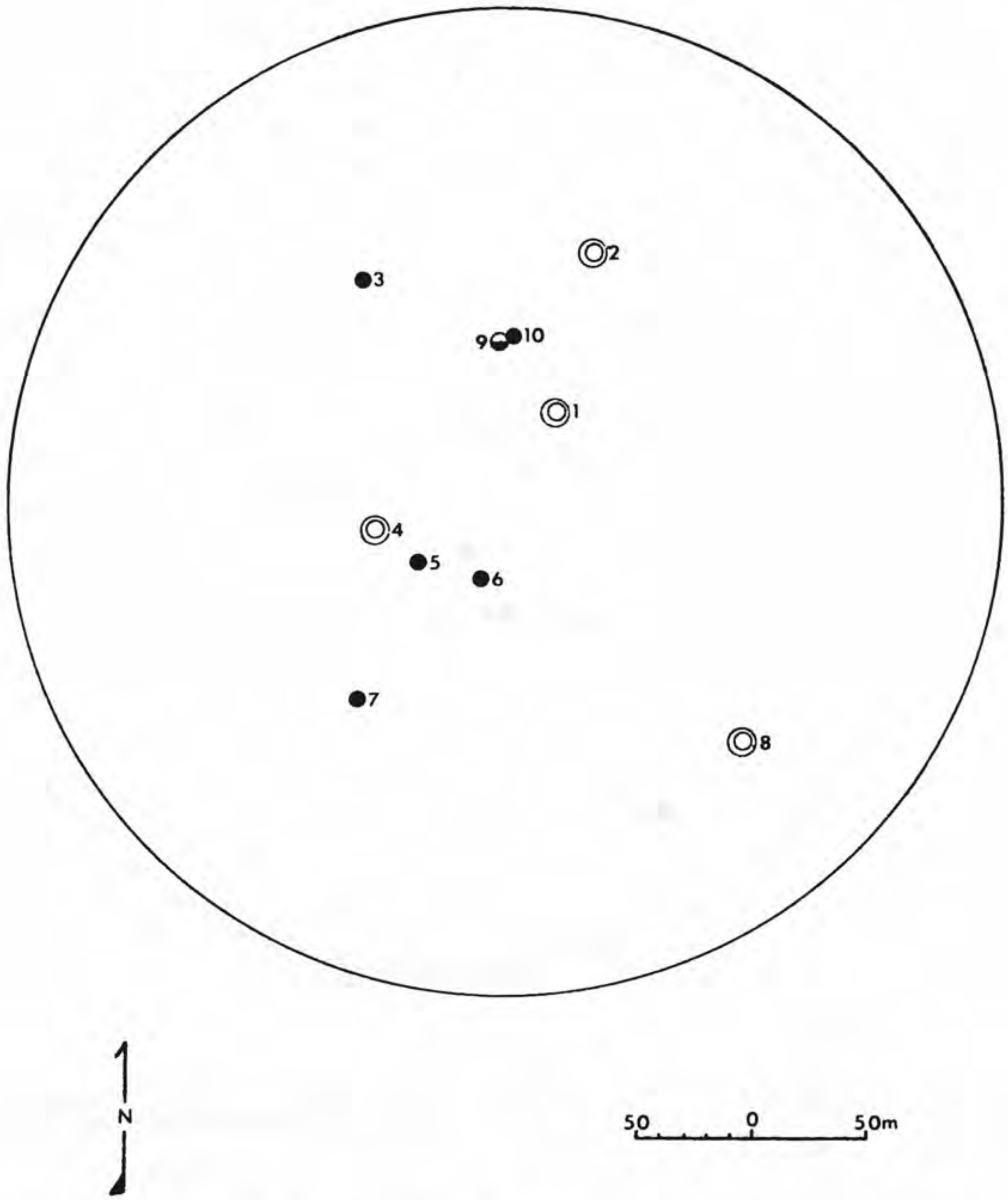

Figure 47. Spatial arrangement of cavity trees in the Rh colony. Numbers indicate tree number. The large circle represents an area of 15 ha.

- Tree containing start holes only.
- Tree containing one or more completed cavities.
- Roost cavity tree.
- Nest cavity tree.

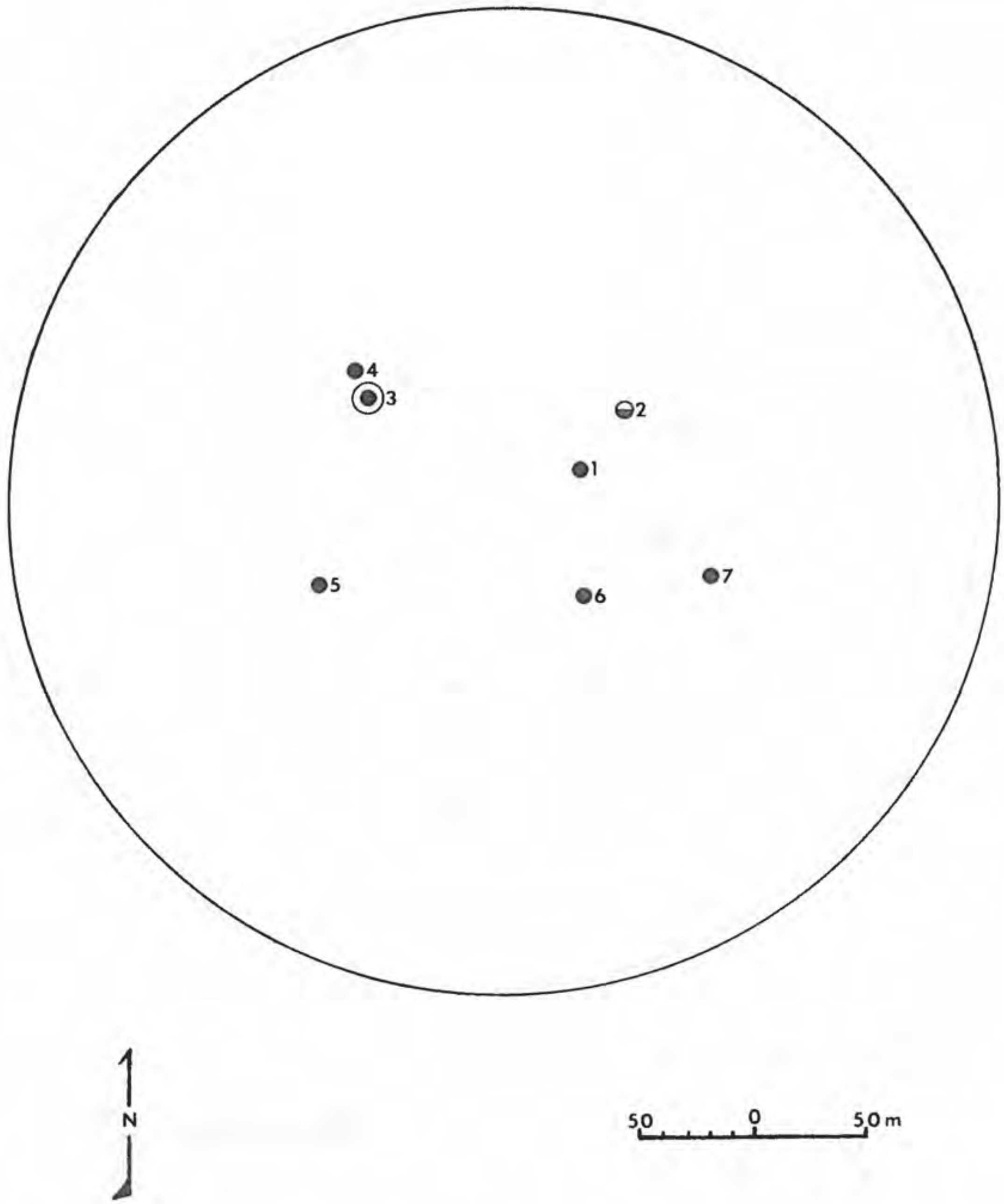

Figure 48. Spatial arrangement of cavity trees in the RhA colony. Numbers indicate tree number. The large circle represents an area of 15 ha.

- ⊖ Tree containing start holes only.
- ● Tree containing one or more completed cavities.
- ◎ Roost cavity tree.
- ◉ Nest cavity tree.

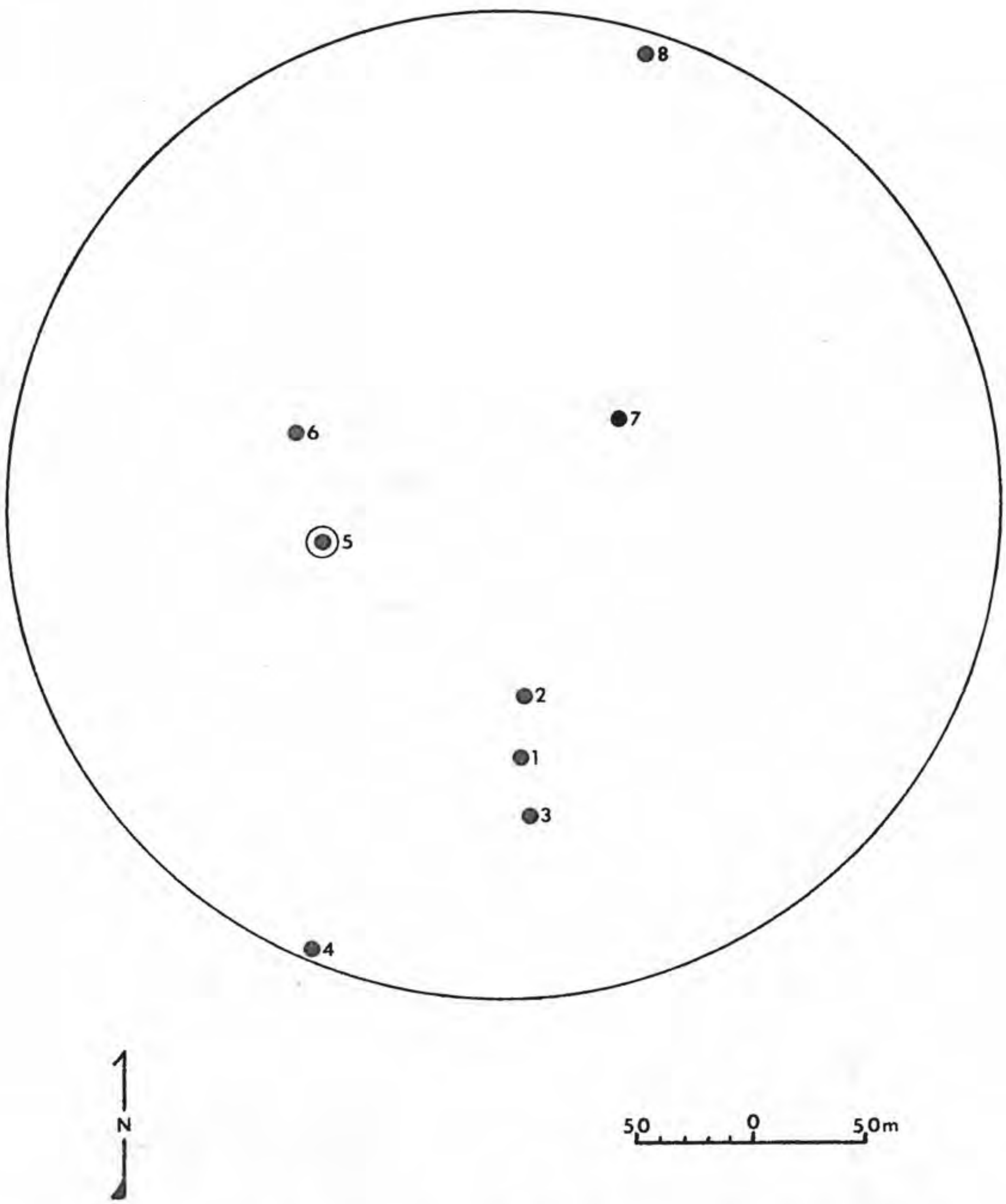

Figure 49. Spatial arrangement of cavity trees in the RhB colony. Numbers indicate tree number. The large circle represents an area of 15 ha.

- Tree containing start holes only.
- Tree containing one or more completed cavities.
- Roost cavity tree.
- Nest cavity tree.

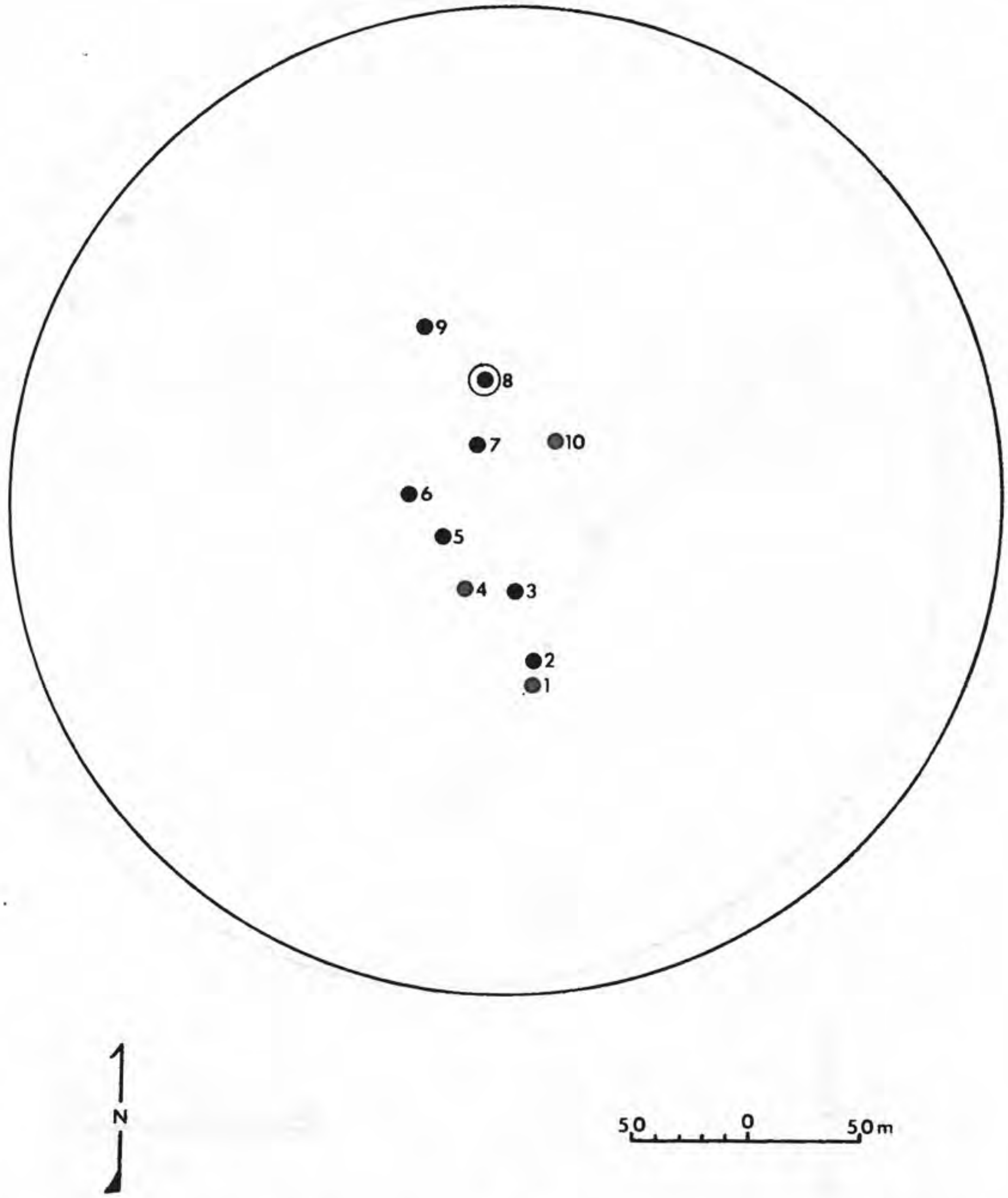

Figure 50. Spatial arrangement of cavity trees in the Oa colony. Numbers indicate tree number. The large circle represents an area of 15 ha.

Tree containing start holes only.

Tree containing one or more completed cavities.

Roost cavity tree.

Nest cavity tree.

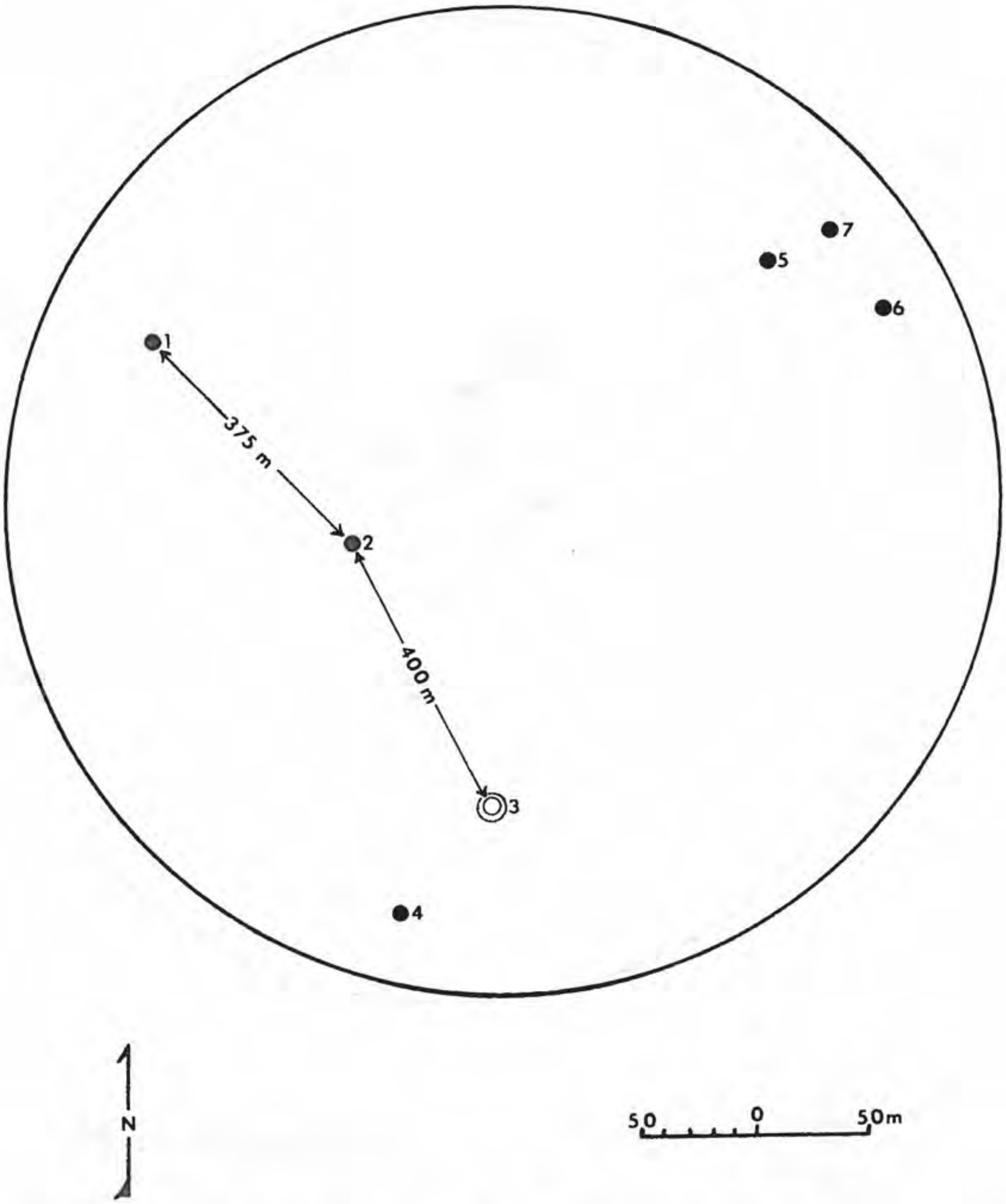

Figure 51. Spatial arrangement of cavity trees in the OaA colony. Numbers indicate tree number. The large circle represents an area of 15 ha.

Tree containing start holes only.

Tree containing one or more completed cavities.

Roost cavity tree.

Nest cavity tree.

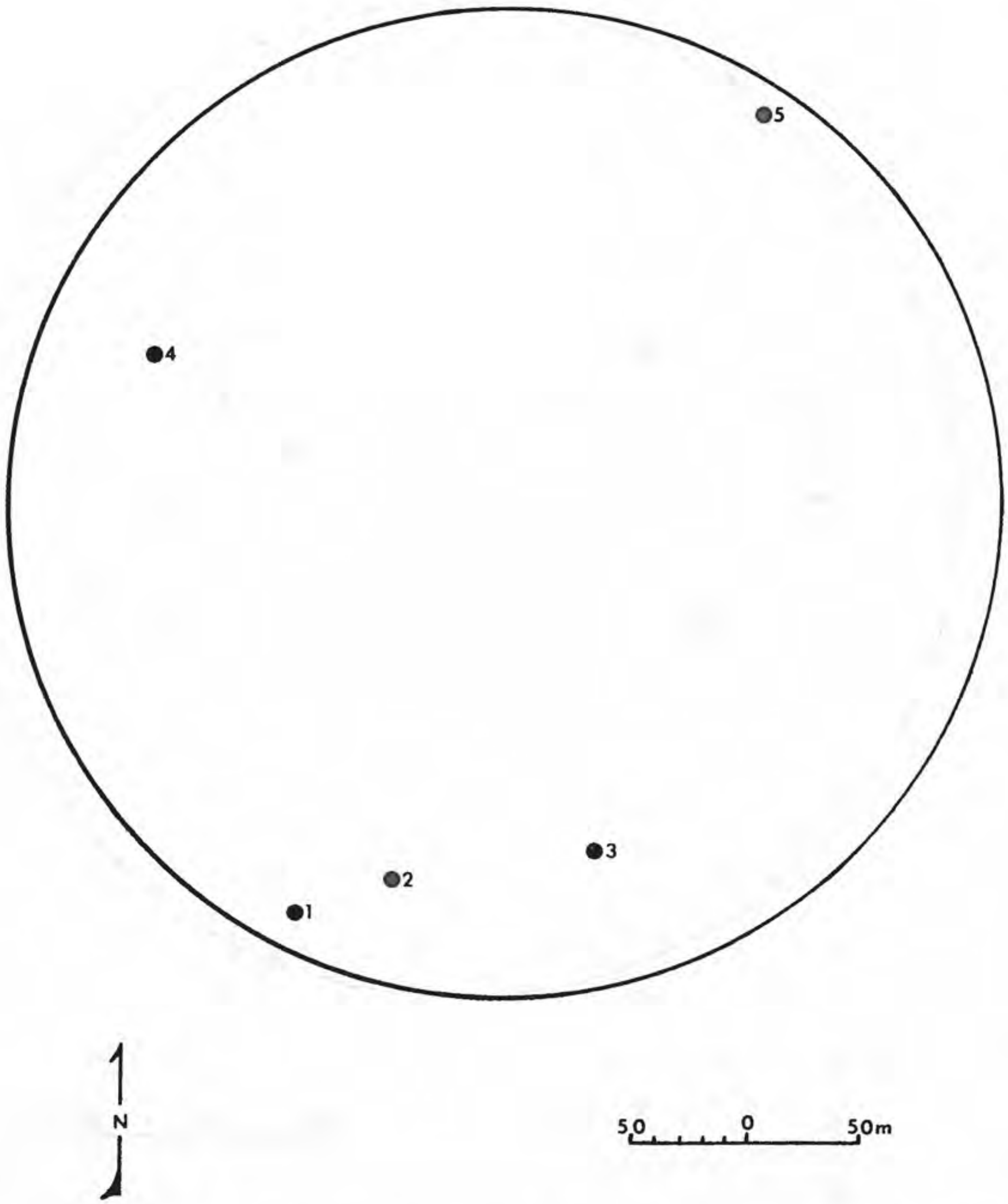

Figure 52. Spatial arrangement of cavity trees in the OaB colony. Numbers indicate tree number. The large circle represents an area of 15 ha.

- Tree containing start holes only.
- Tree containing one or more completed cavities.
- Roost cavity tree.
- Nest cavity tree.

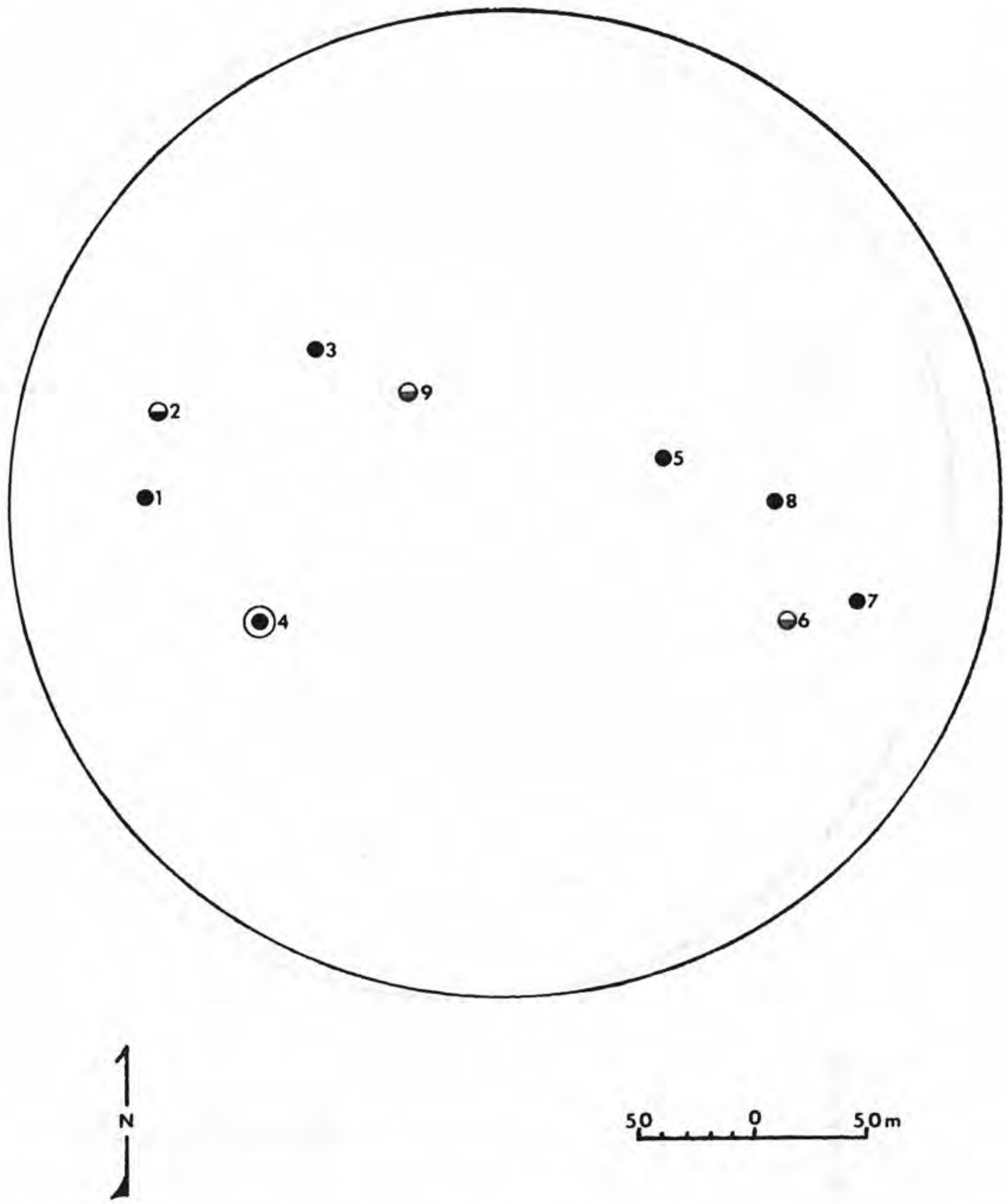

Figure 53. Spatial arrangement of cavity trees in the EM colony. Numbers indicate tree number. The large circle represents an area of 15 ha.

⊖ Tree containing start holes only.

● Tree containing one or more completed cavities.

◎ Roost cavity tree.

◉ Nest cavity tree.

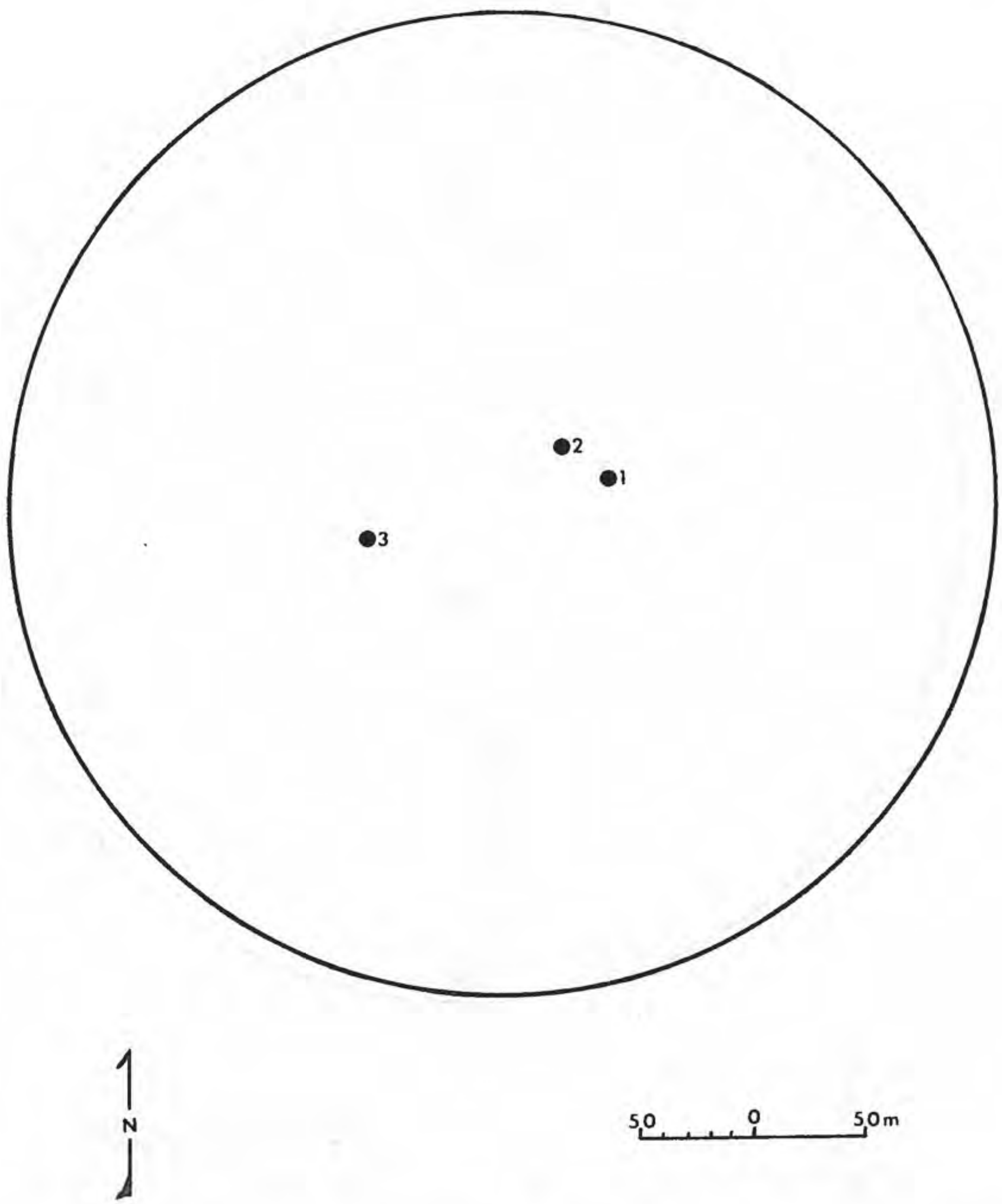

Figure 54. Spatial arrangement of cavity trees in the EMA colony. Numbers indicate tree number. The large circle represents an area of 15 ha.

- Tree containing start holes only.
- Tree containing one or more completed cavities.
- Roost cavity tree.
- Nest cavity tree.

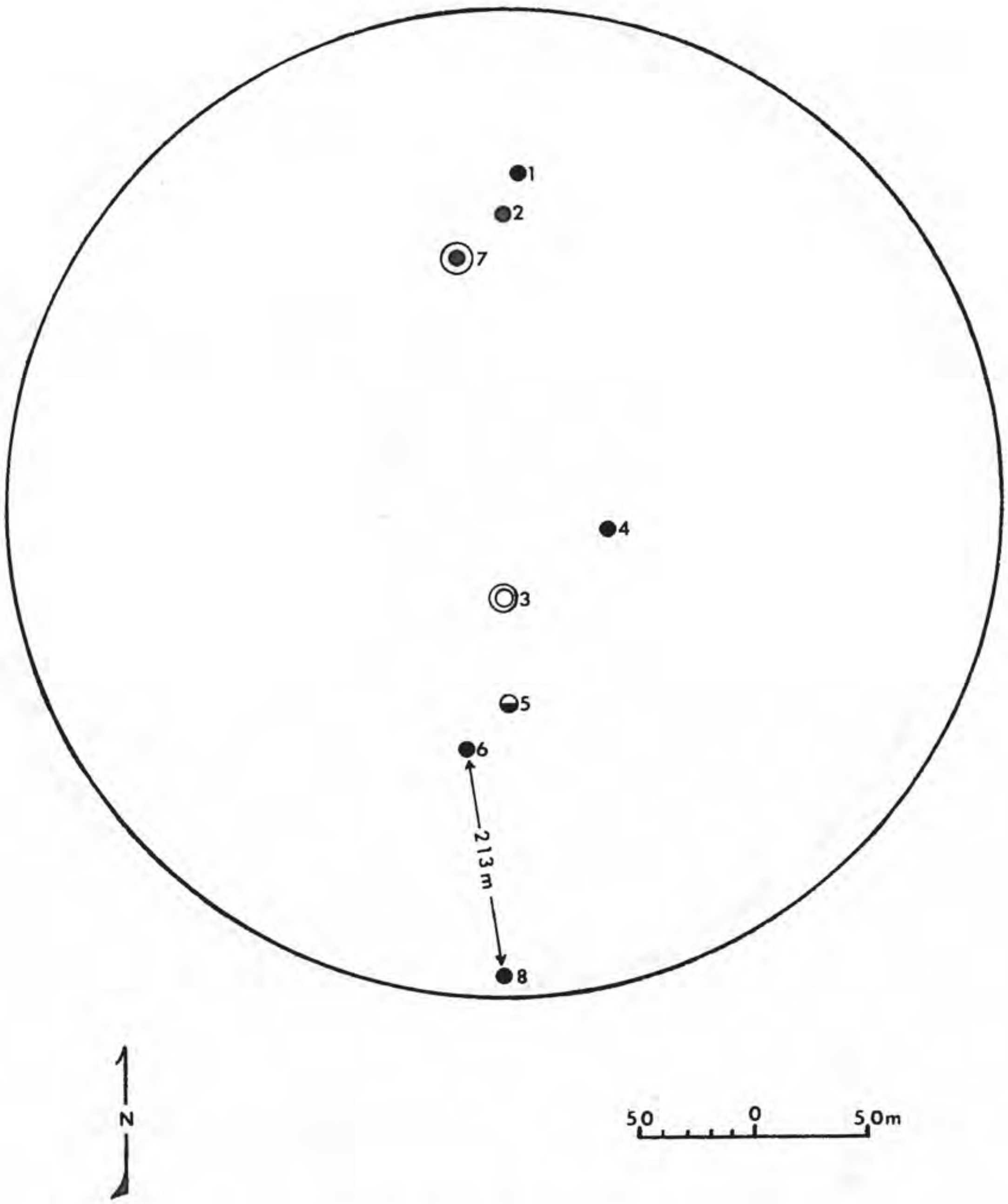

Figure 55. Spatial arrangement of cavity trees in the EMB colony. Numbers indicate tree number. The large circle represents an area of 15 ha.

- Tree containing start holes only.
- Tree containing one or more completed cavities.
- Roost cavity tree.
- Nest cavity tree.

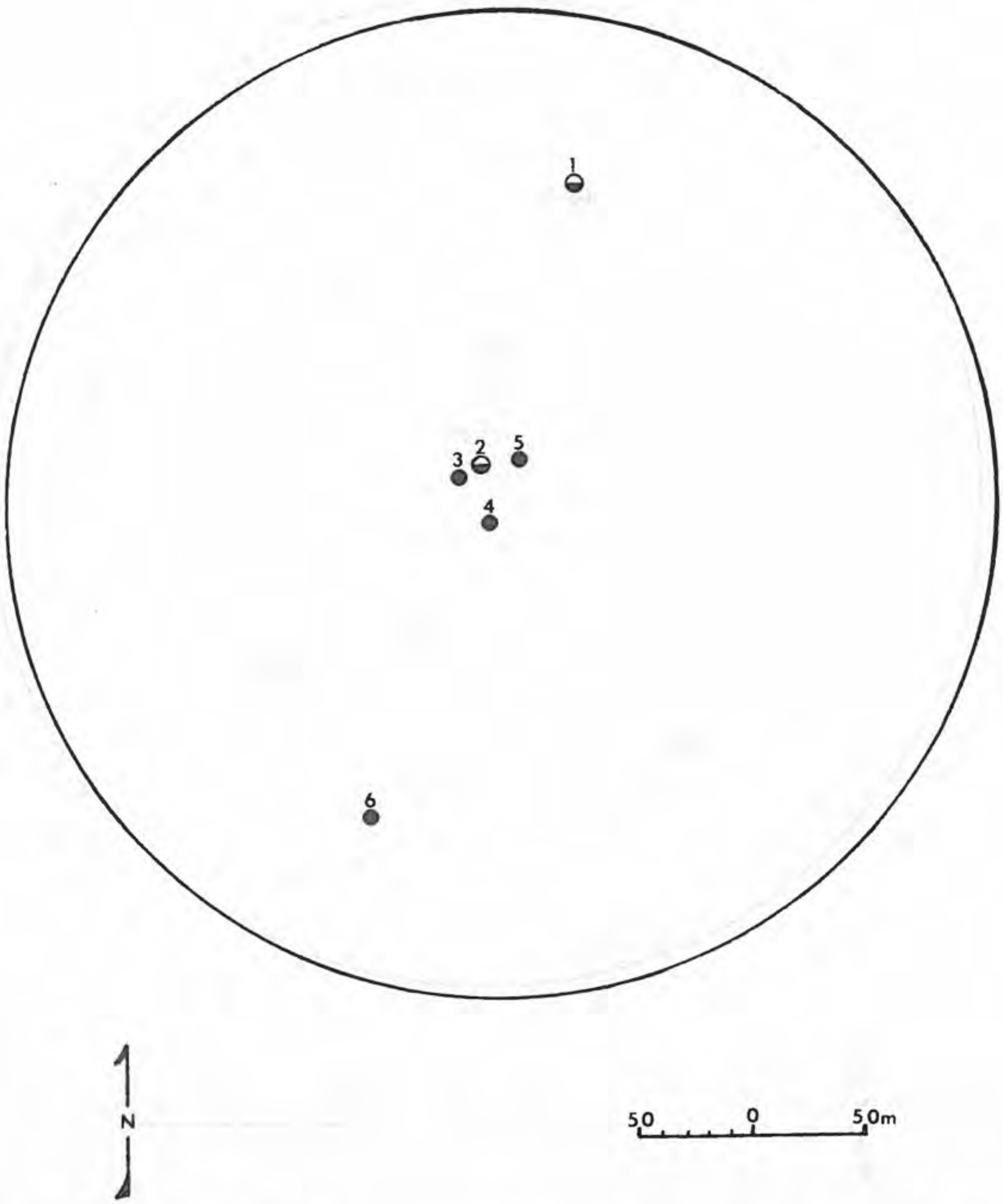

Figure 56. Spatial arrangement of cavity trees in the EMD colony. Numbers indicate tree number. The large circle represents an area of 15 ha.

Tree containing start holes only.

Tree containing one or more completed cavities.

Roost cavity tree.

Nest cavity tree.

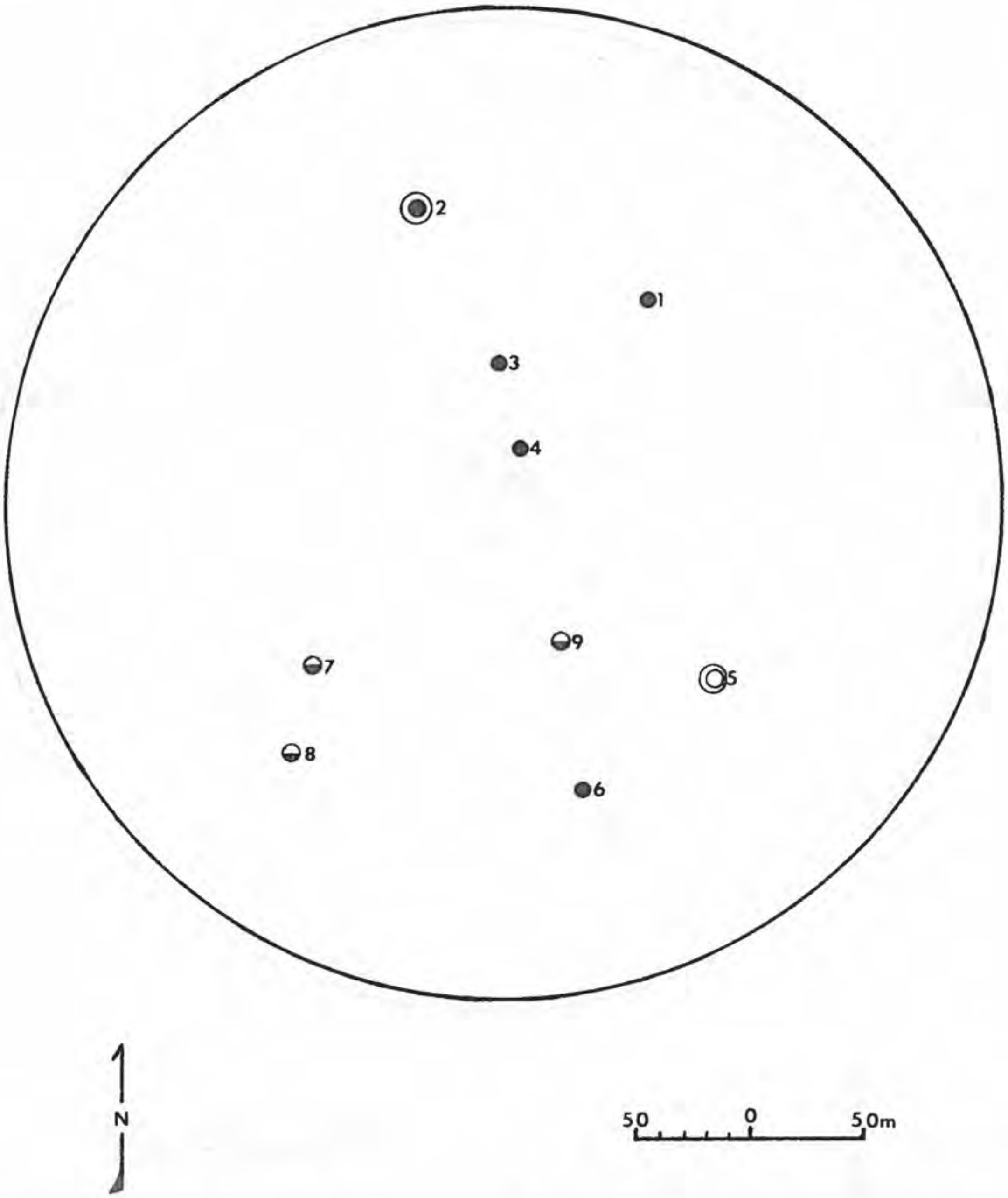

Figure 57. Spatial arrangement of cavity trees in the EMP colony. Numbers indicate tree number. The large circle represents an area of 15 ha.

Tree containing start holes only.

Tree containing one or more completed cavities.

Roost cavity tree.

Nest cavity tree.

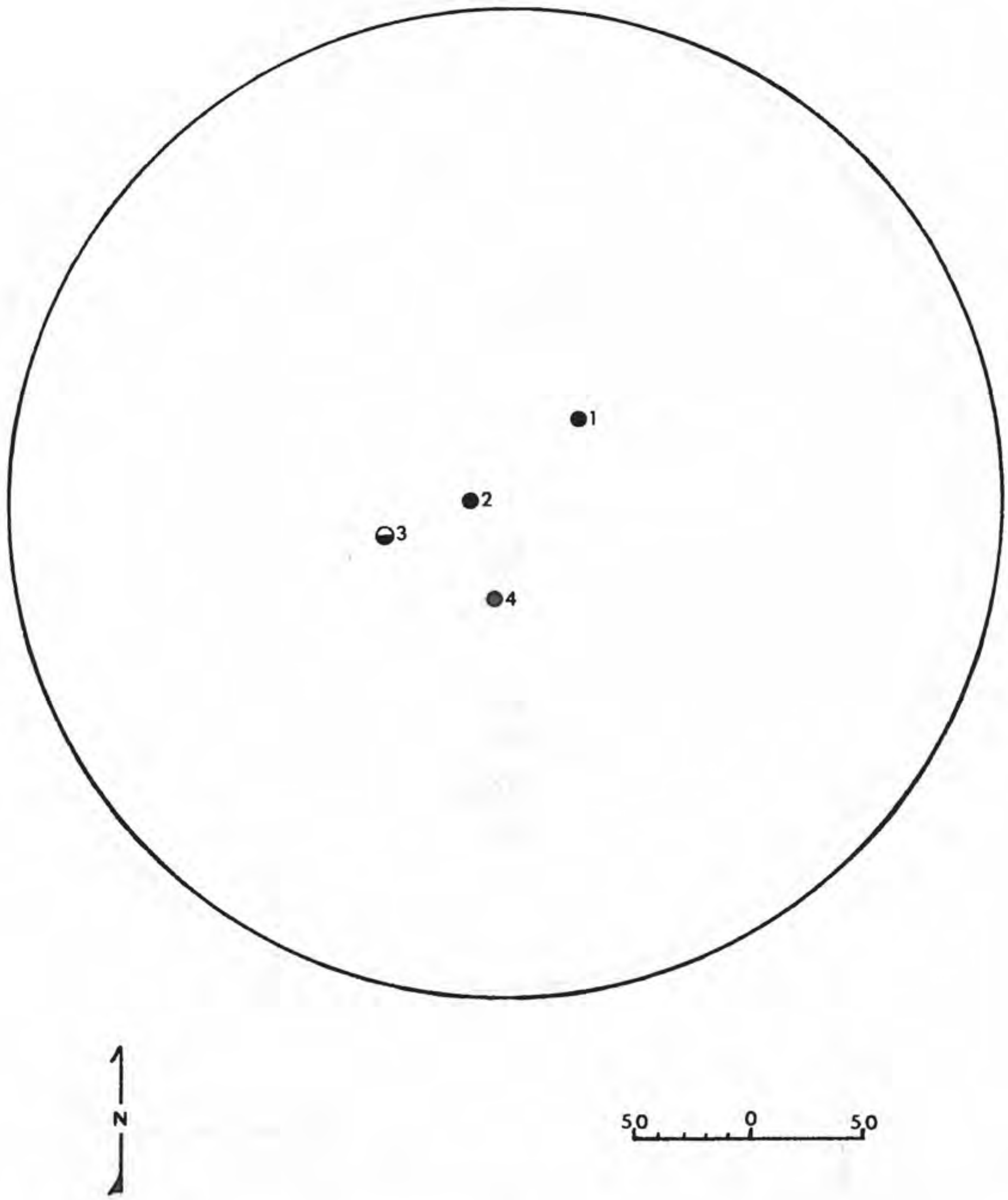

Figure 58. Spatial arrangement of cavity trees in the EMPA colony. Numbers indicate tree number. The large circle represents an area of 15 ha.

Tree containing start holes only.

Tree containing one or more completed cavities.

Roost cavity tree.

Nest cavity tree.

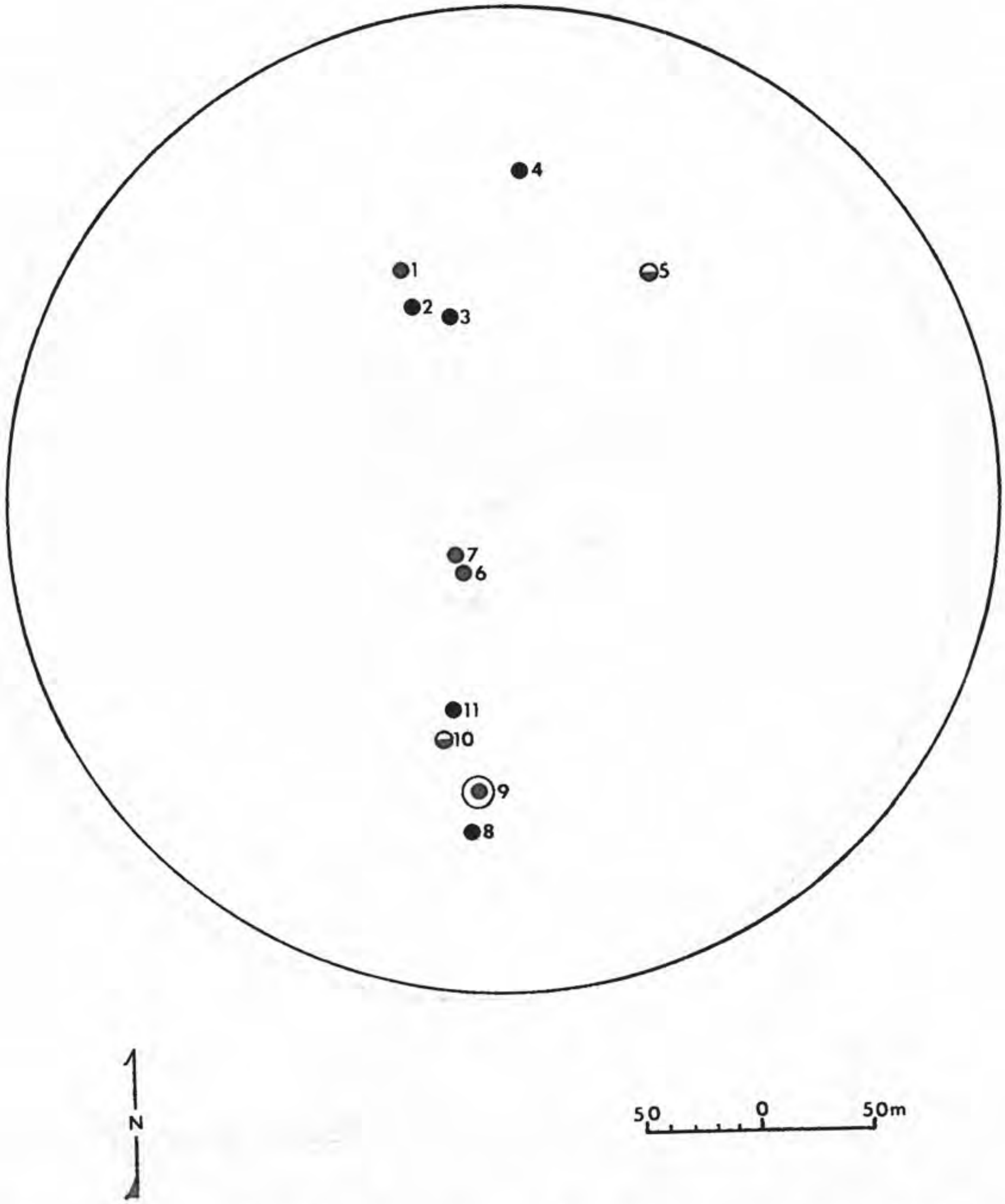

Figure 59. Spatial arrangement of cavity trees in the HaA colony. Numbers indicate tree number. The large circle represents an area of 15 ha.

Tree containing start holes only.

Tree containing one or more completed cavities.

Roost cavity tree.

Nest cavity tree.

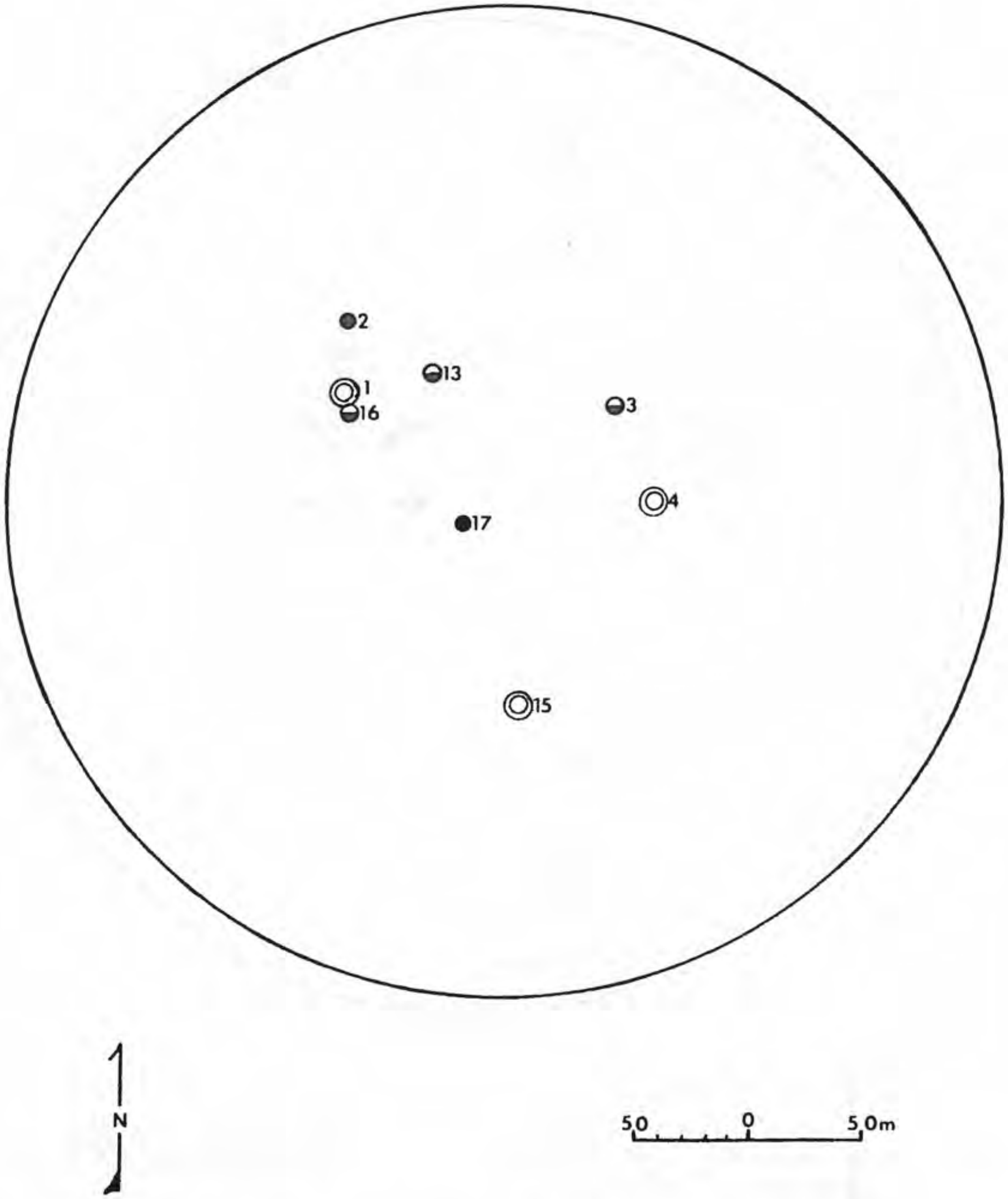

Figure 60. Spatial arrangement of cavity trees in the LPN colony. Numbers indicate tree number. The large circle represents an area of 15 ha.

⊖ Tree containing start holes only.

● Tree containing one or more completed cavities.

◎ Roost cavity tree.

◉ Nest cavity tree.

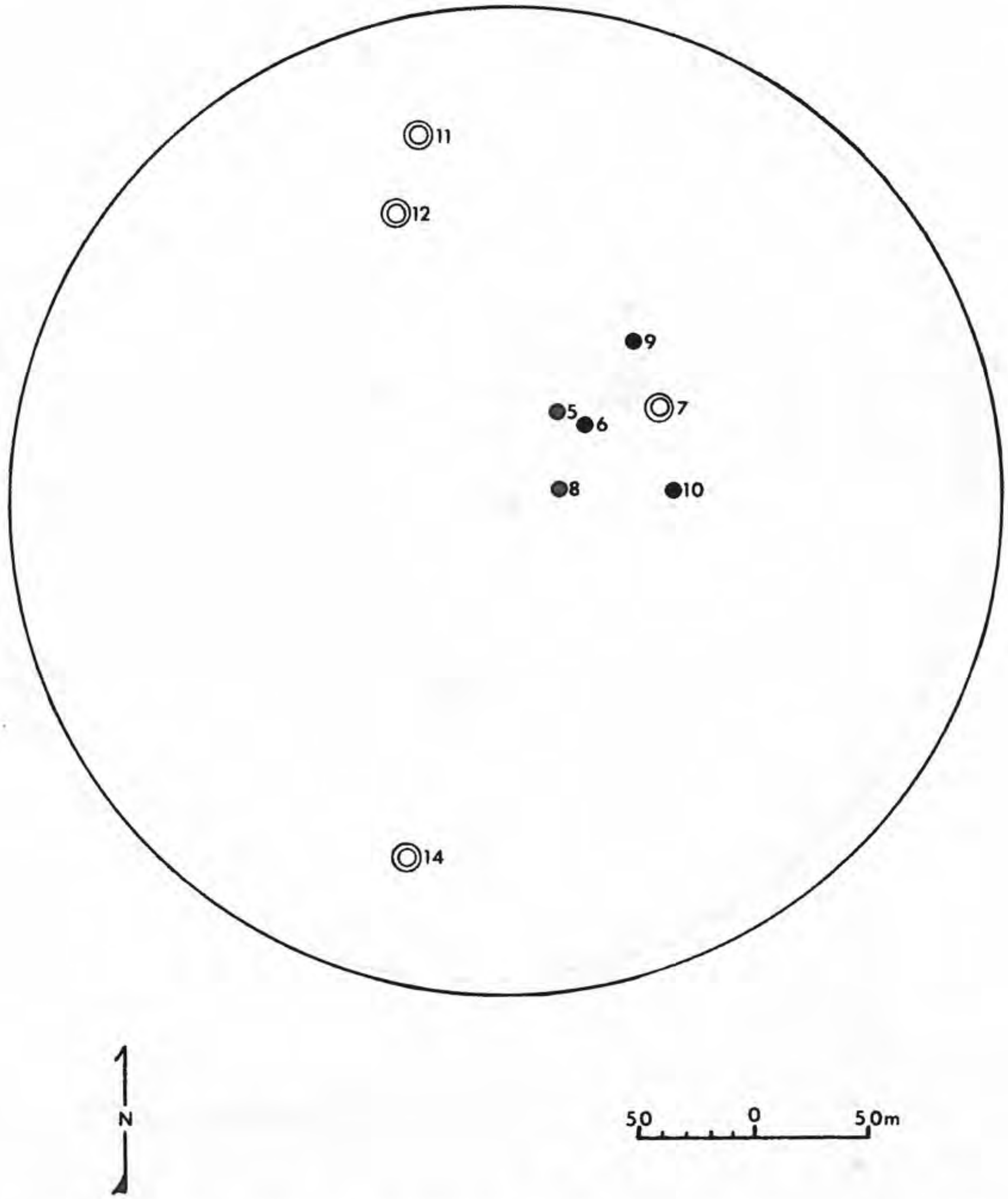

Figure 61. Spatial arrangement of cavity trees in the LPS colony. Numbers indicate tree number. The large circle represents an area of 15 ha.

- Tree containing start holes only.
- Tree containing one or more completed cavities.
- Roost cavity tree.
- Nest cavity tree.

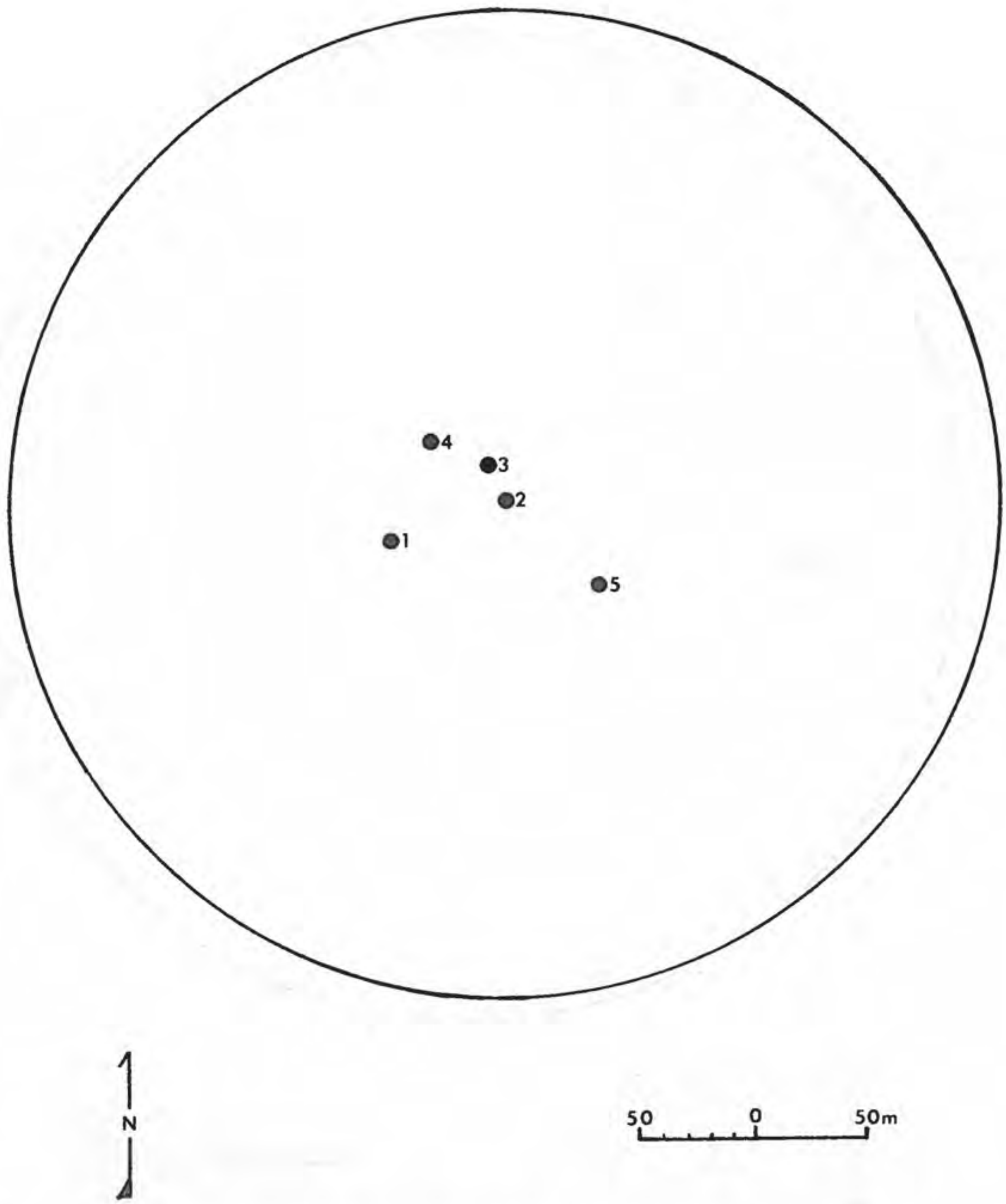

Figure 62. Spatial arrangement of cavity trees in the JR colony. Numbers indicate tree number. The large circle represents an area of 15 ha.

⊖ Tree containing start holes only.

● Tree containing one or more completed cavities.

◎ Roost cavity tree.

◉ Nest cavity tree.

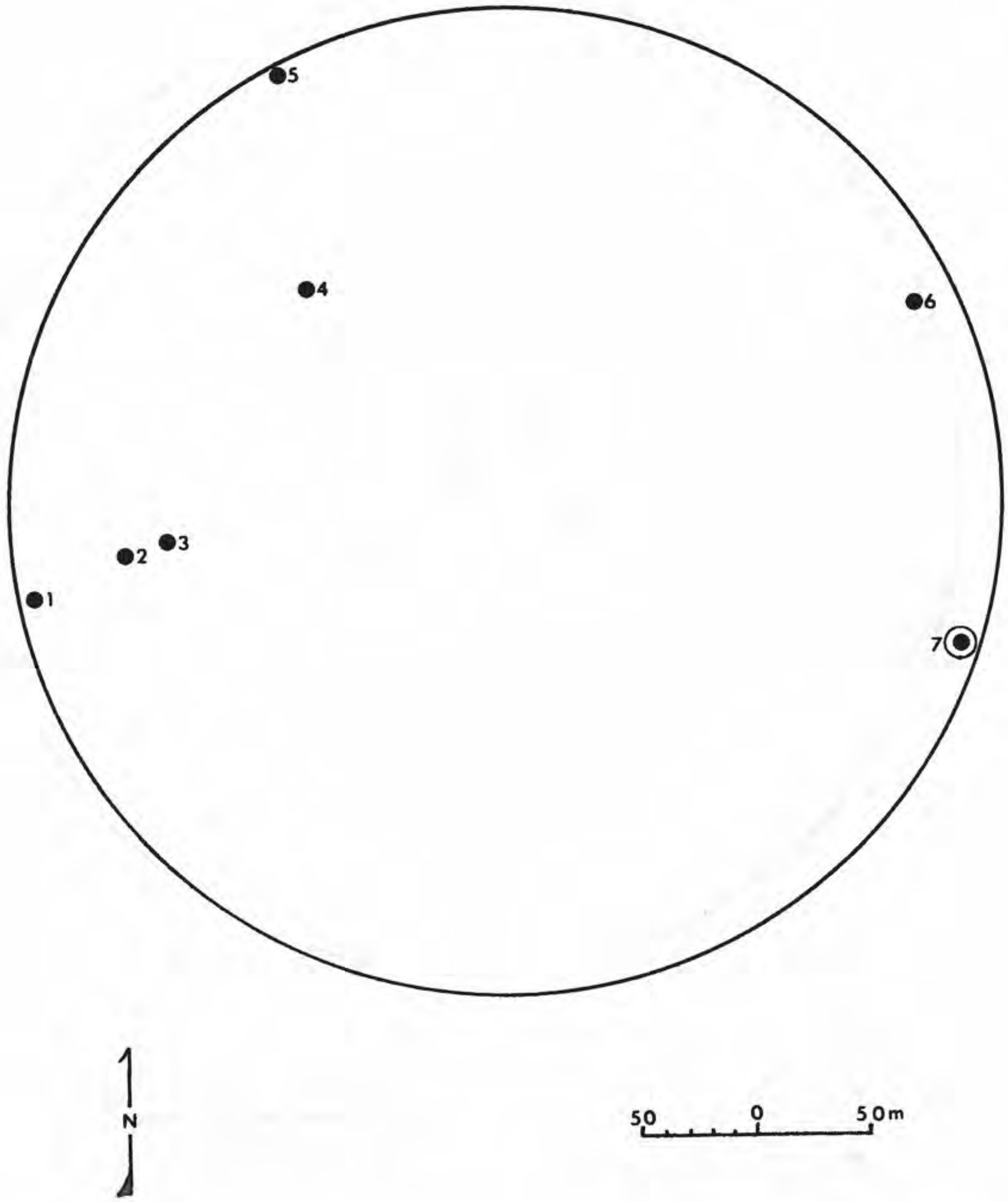

Figure 63. Spatial arrangement of cavity trees in the SMN colony. Numbers indicate tree number. The large circle represents an area of 15 ha.

- Tree containing start holes only.
- Tree containing one or more completed cavities.
- Roost cavity tree.
- Nest cavity tree.

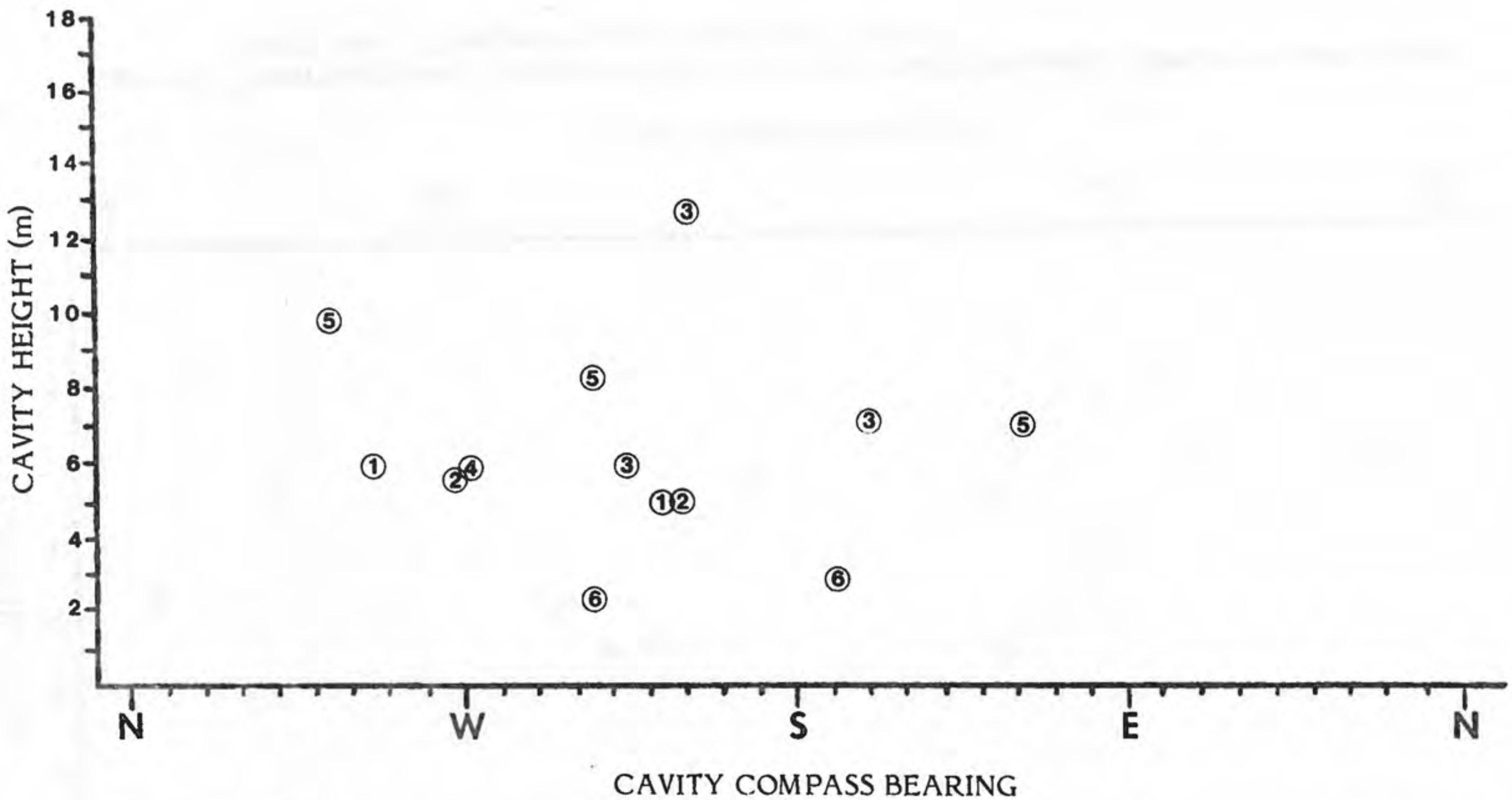

Figure 64. Type, height and compass bearing of cavities in the CC colony. Circled numbers indicate cavity type. Those underlined are enlarged (Type 7).

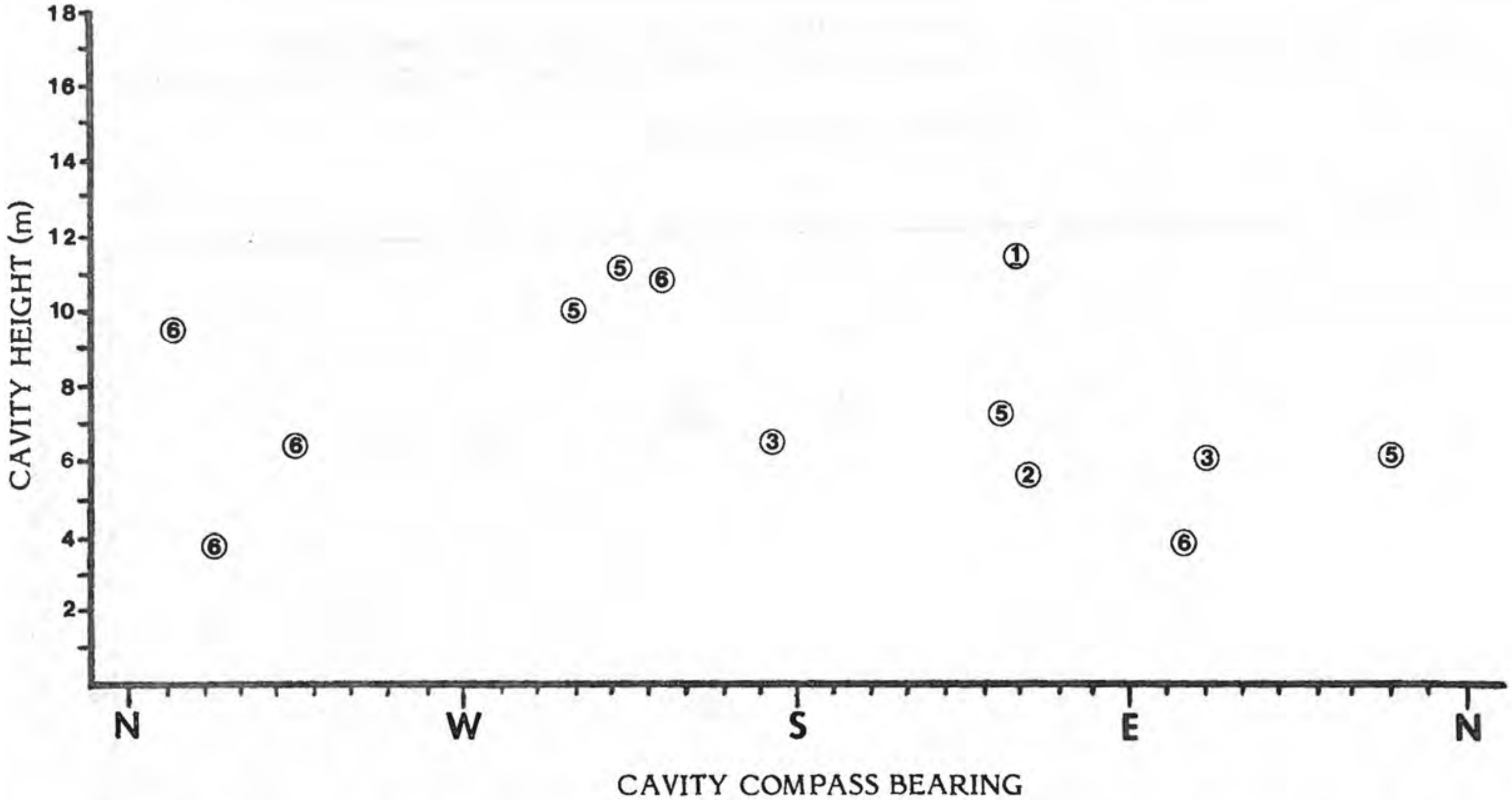

Figure 65. Type, height and compass bearing of cavities in the CCA colony. Circled numbers indicate cavity type. Those underlined are enlarged (Type 7).

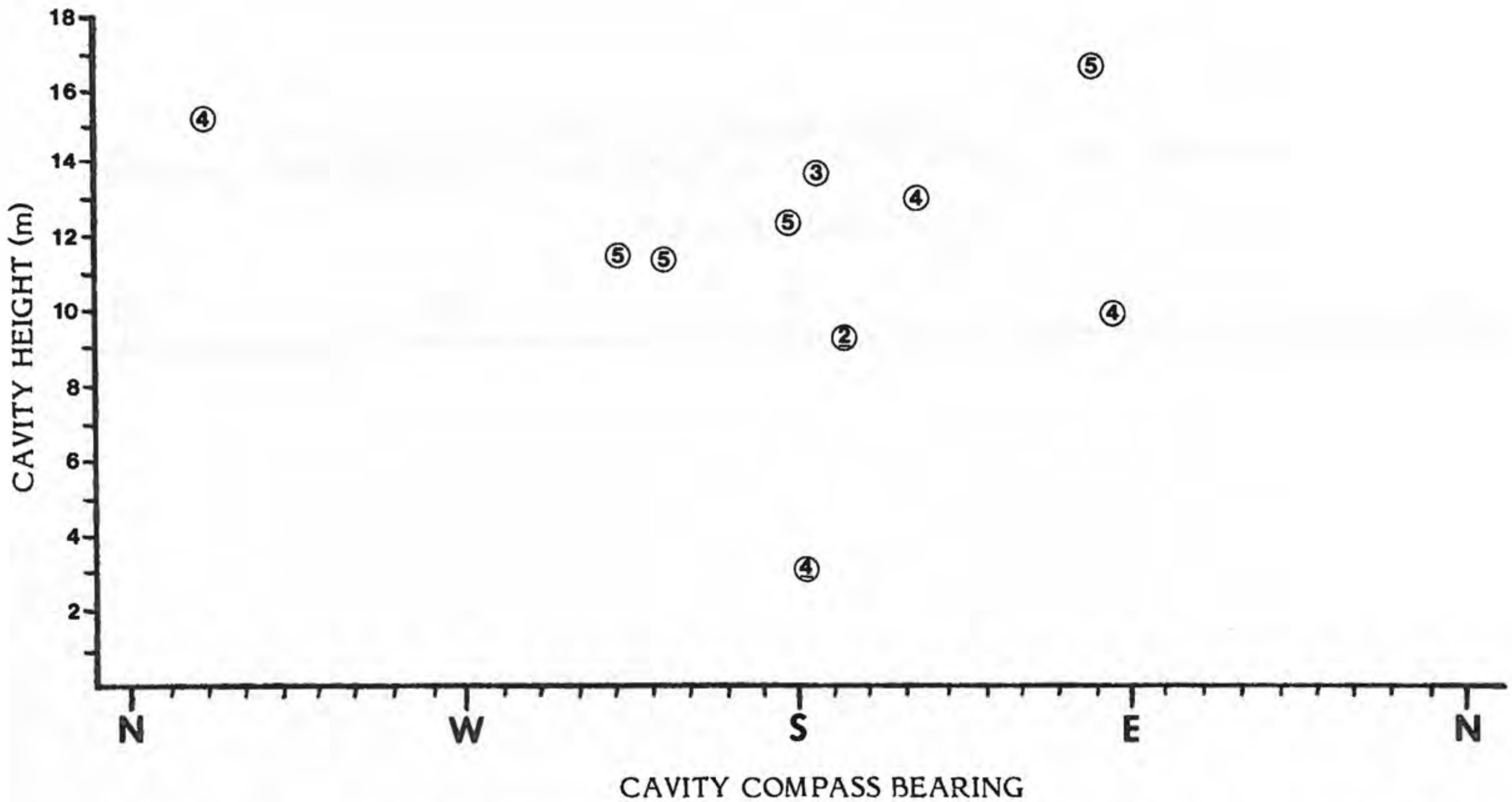

Figure 66. Type, height and compass bearing of cavities in the Rh colony. Circled numbers indicate cavity type. Those underlined are enlarged (Type 7).

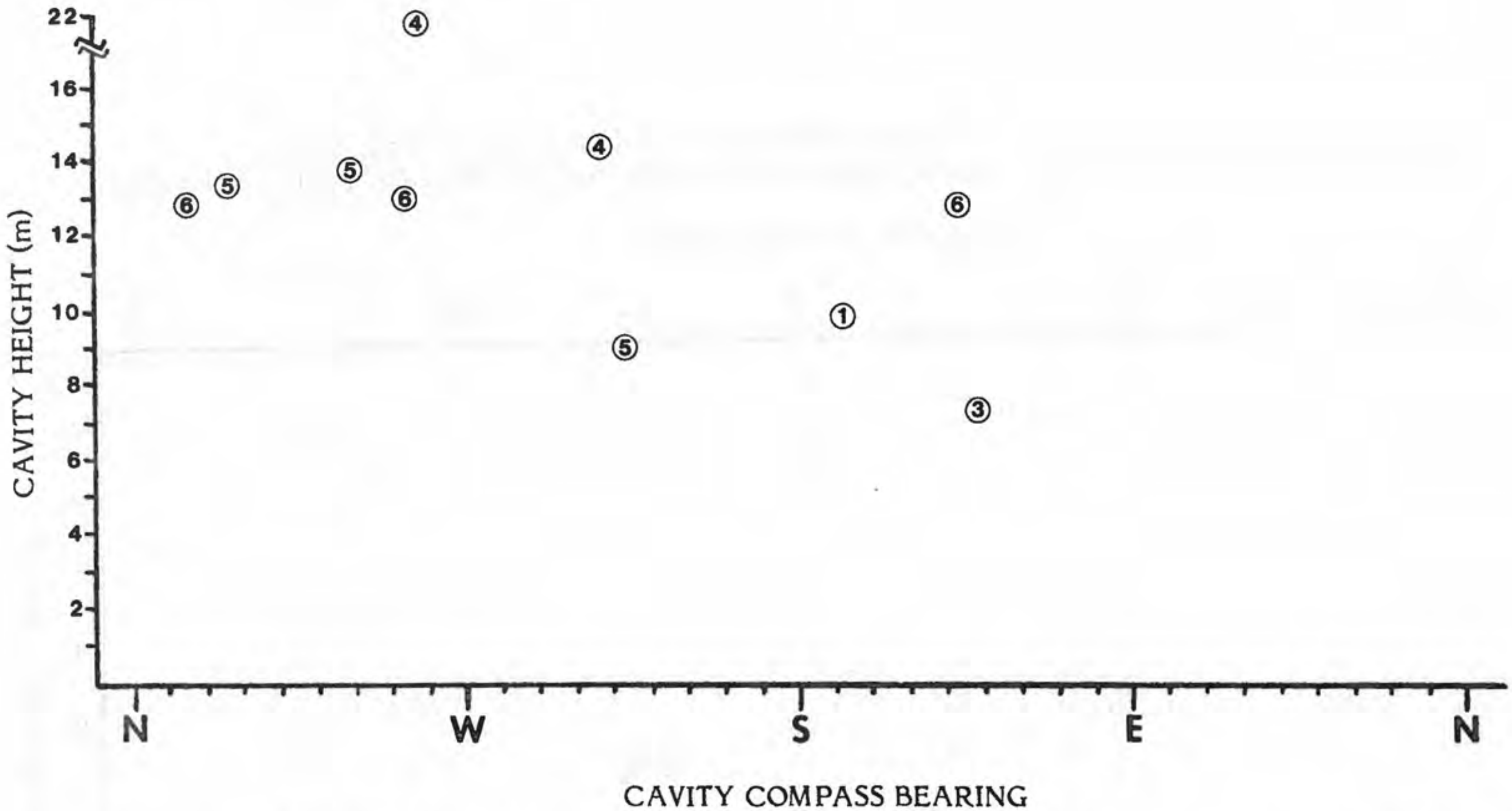

Figure 67. Type, height and compass bearing of cavities in the RhA colony. Circled numbers indicate cavity type. Those underlined are enlarged (Type 7).

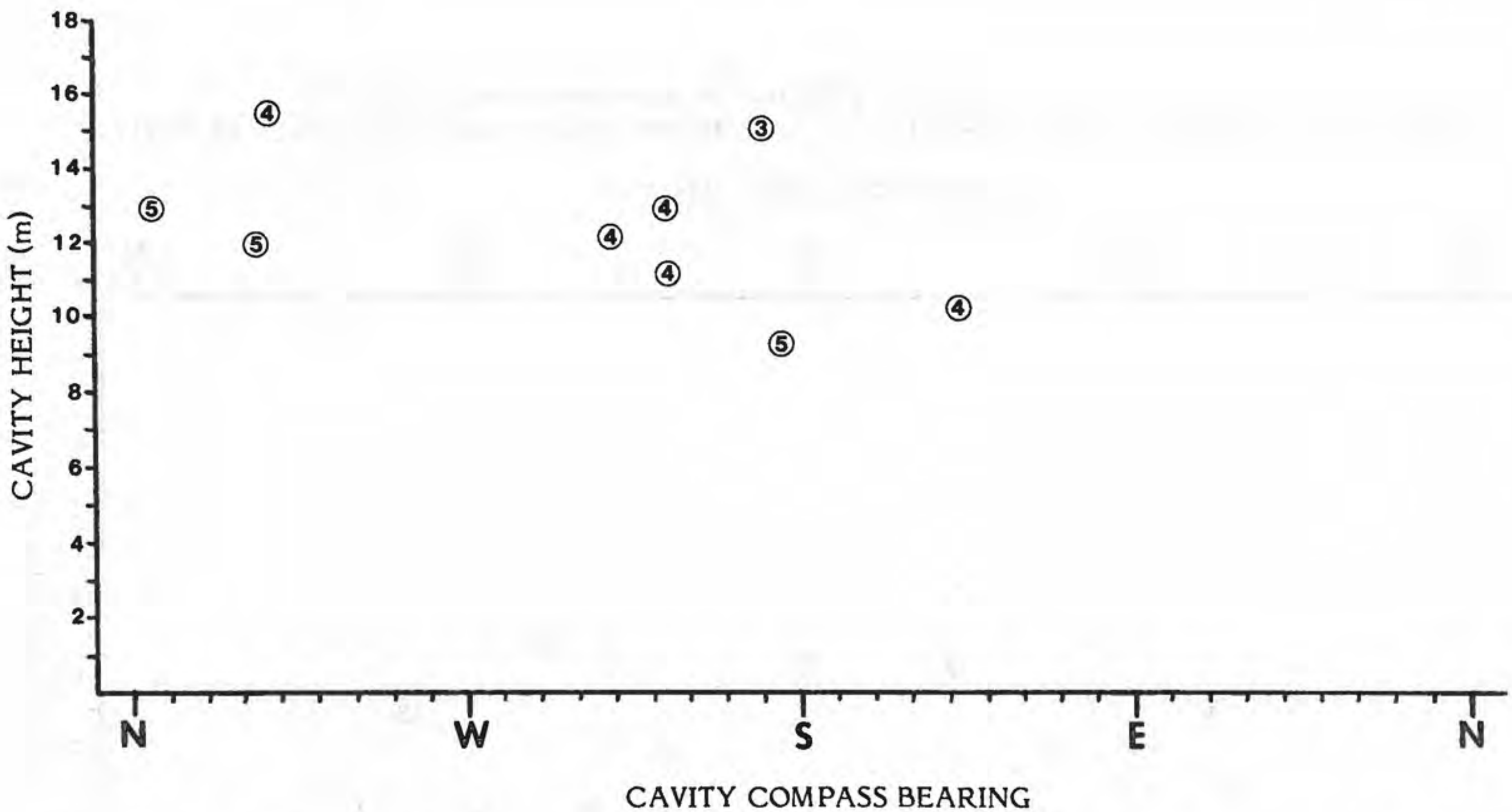

Figure 68. Type, height and compass bearing of cavities in the RhB colony. Circled numbers indicate cavity type. Those underlined are enlarged (Type 7).

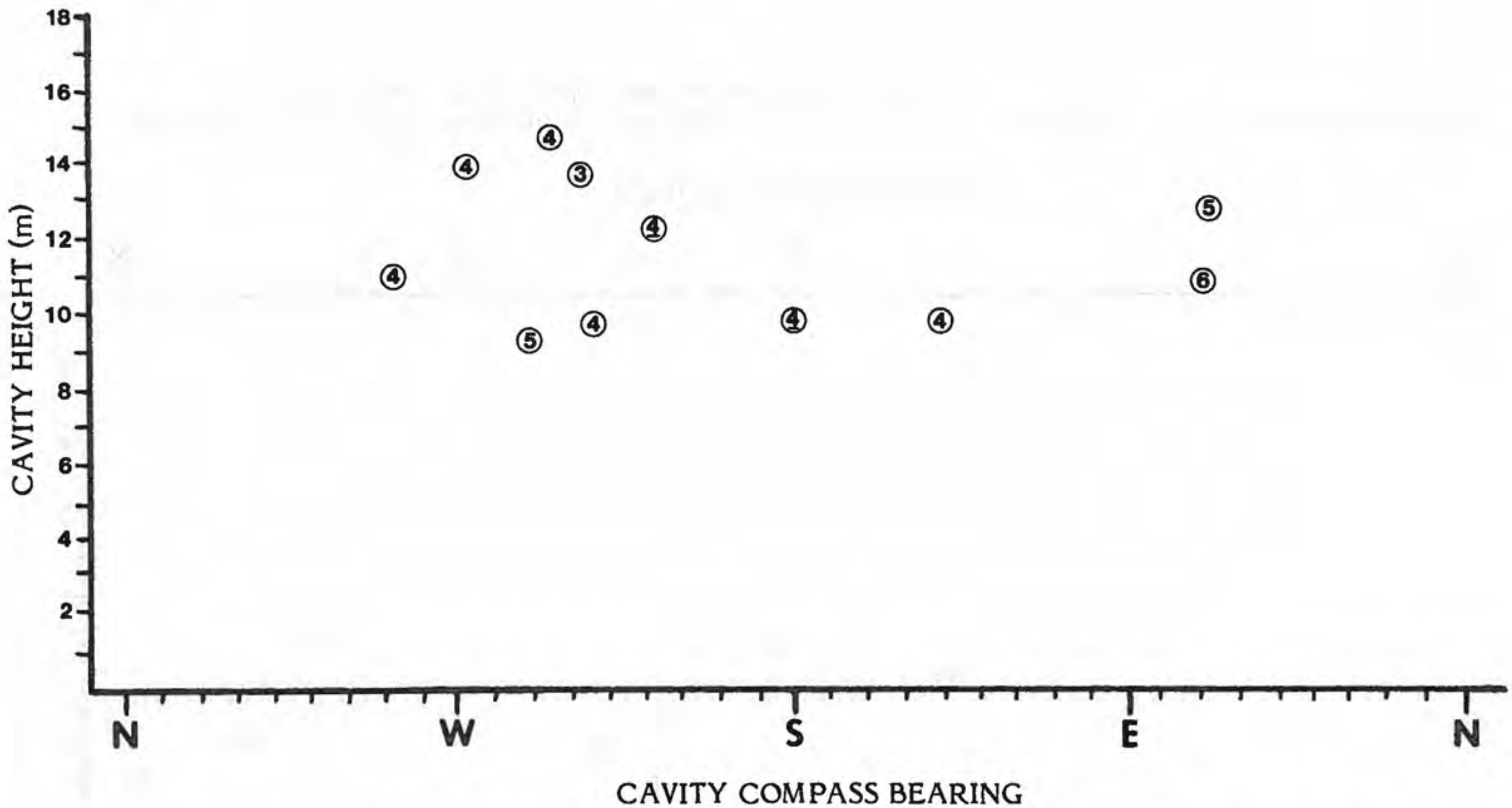

Figure 69. Type, height and compass bearing of cavities in the Oa colony. Circled numbers indicate cavity type. Those underlined are enlarged (Type 7).

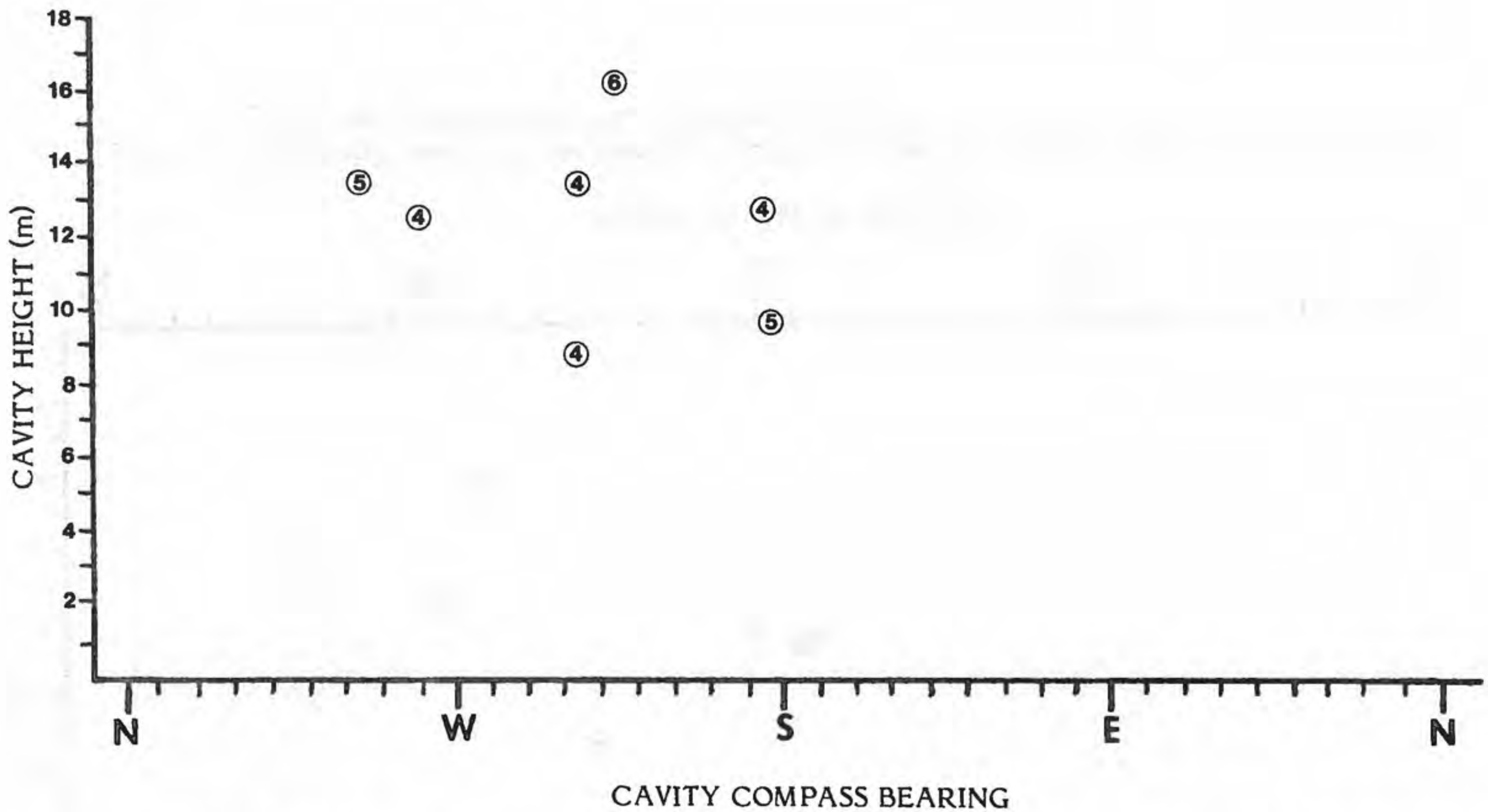

Figure 70. Type, height and compass bearing of cavities in the OaA colony. Circled numbers indicate cavity type. Those underlined are enlarged (Type 7).

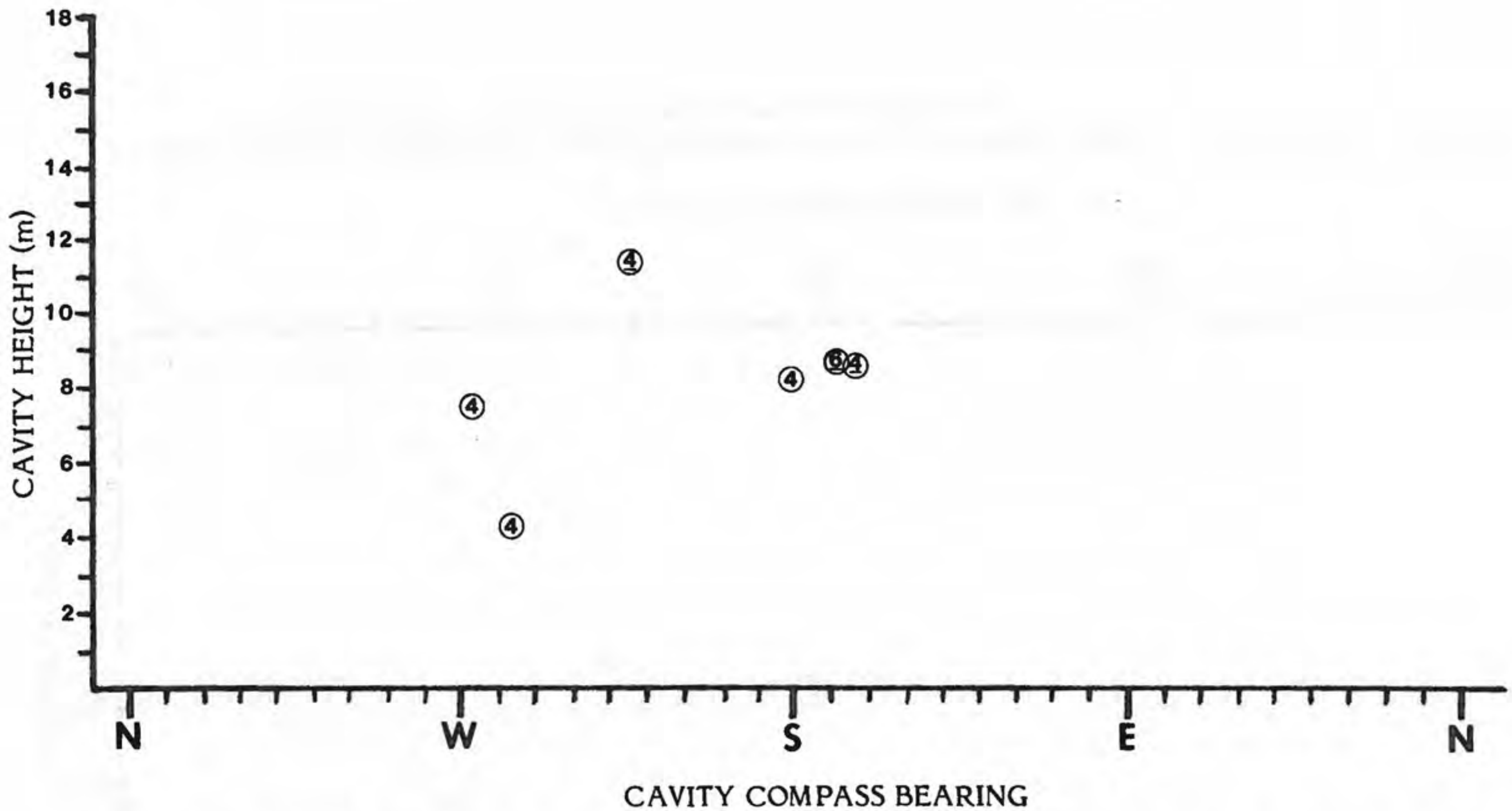

Figure 71. Type, height and compass bearing of cavities in the OaB colony. Circled numbers indicate cavity type. Those underlined are enlarged (Type 7).

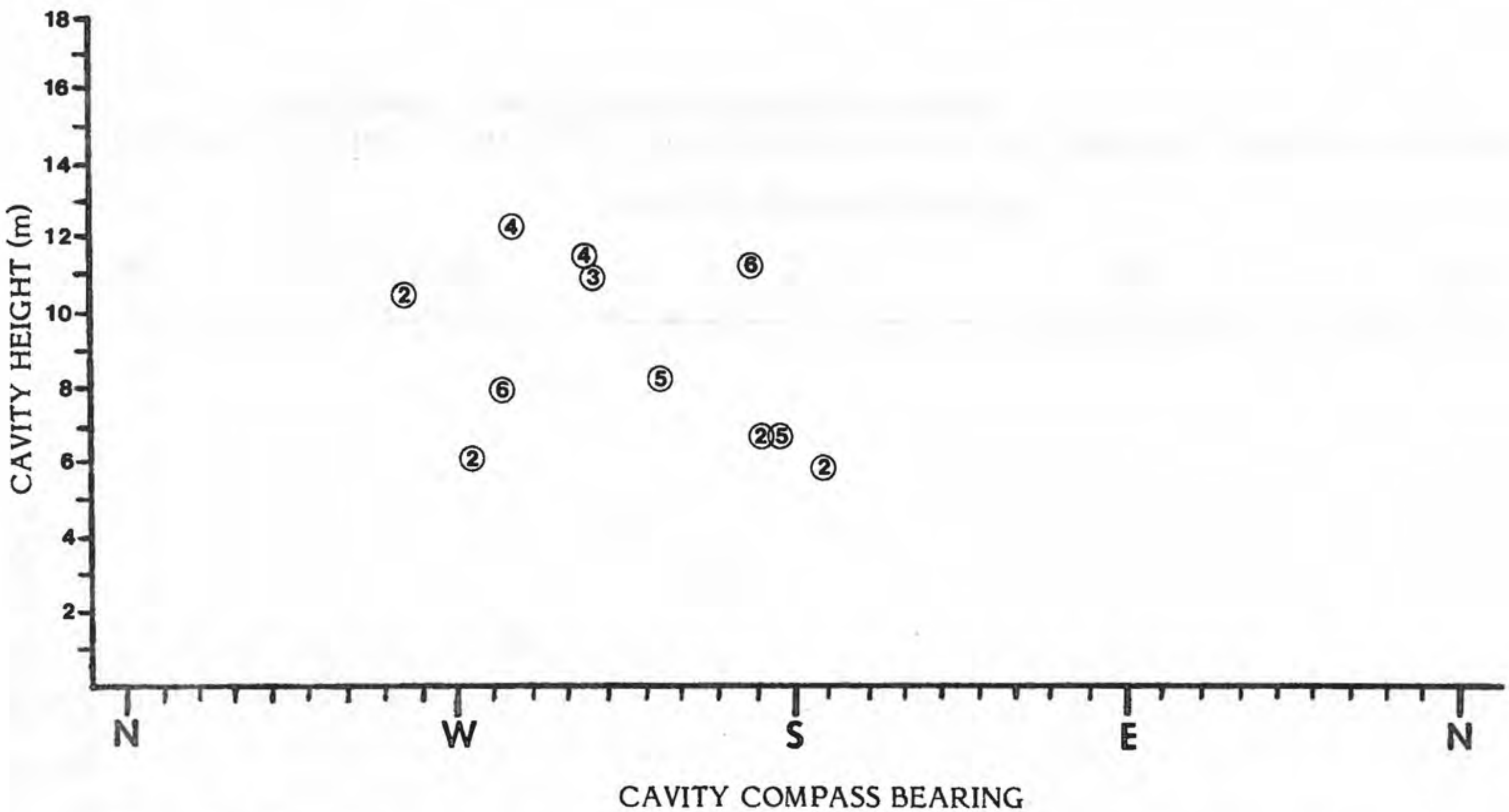

Figure 72. Type, height and compass bearing of cavities in the EM colony. Circled numbers indicate cavity type. Those underlined are enlarged (Type 7).

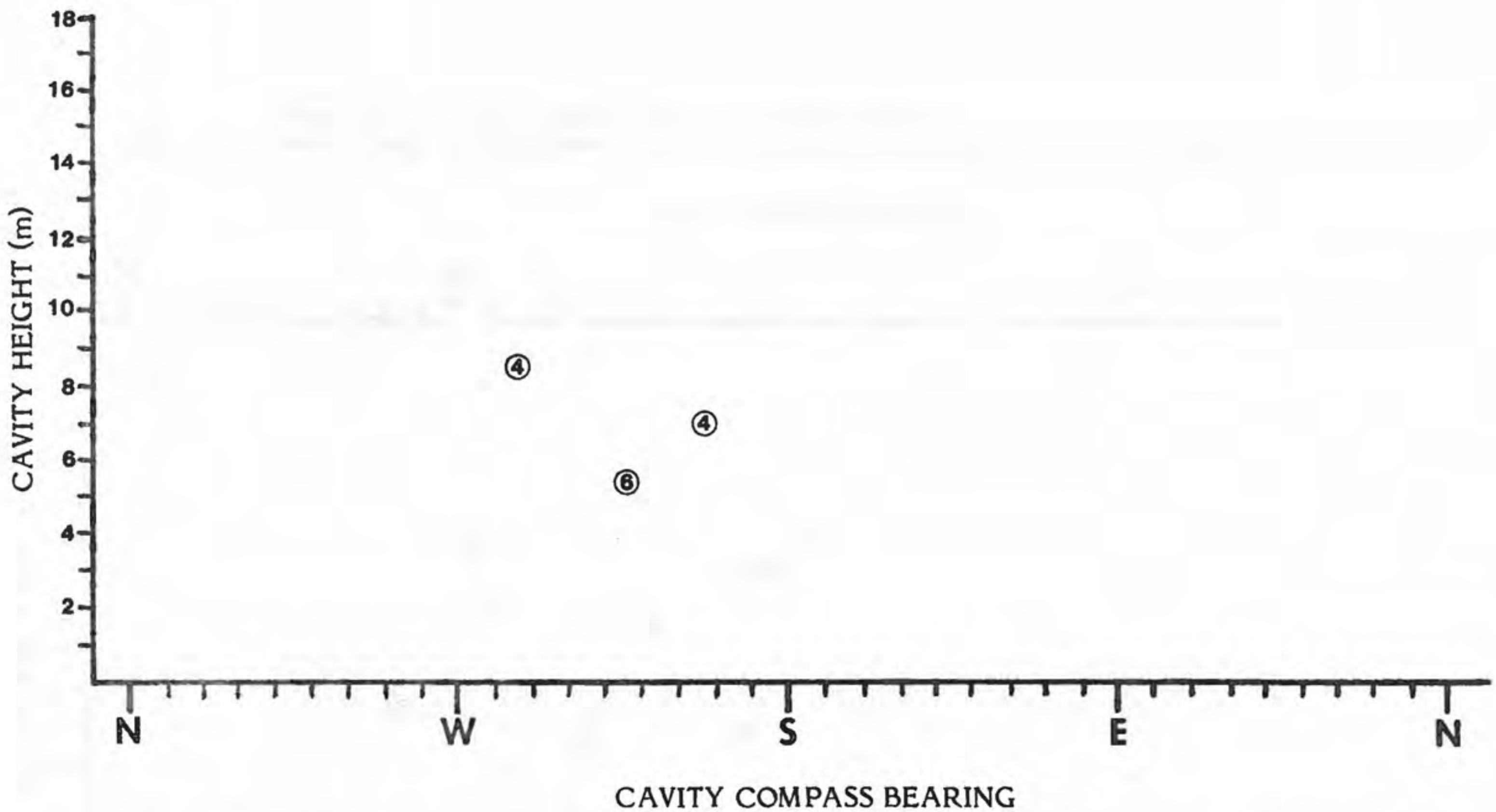

Figure 73. Type, height and compass bearing of cavities in the EMA colony. Circled numbers indicate cavity type. Those underlined are enlarged (Type 7).

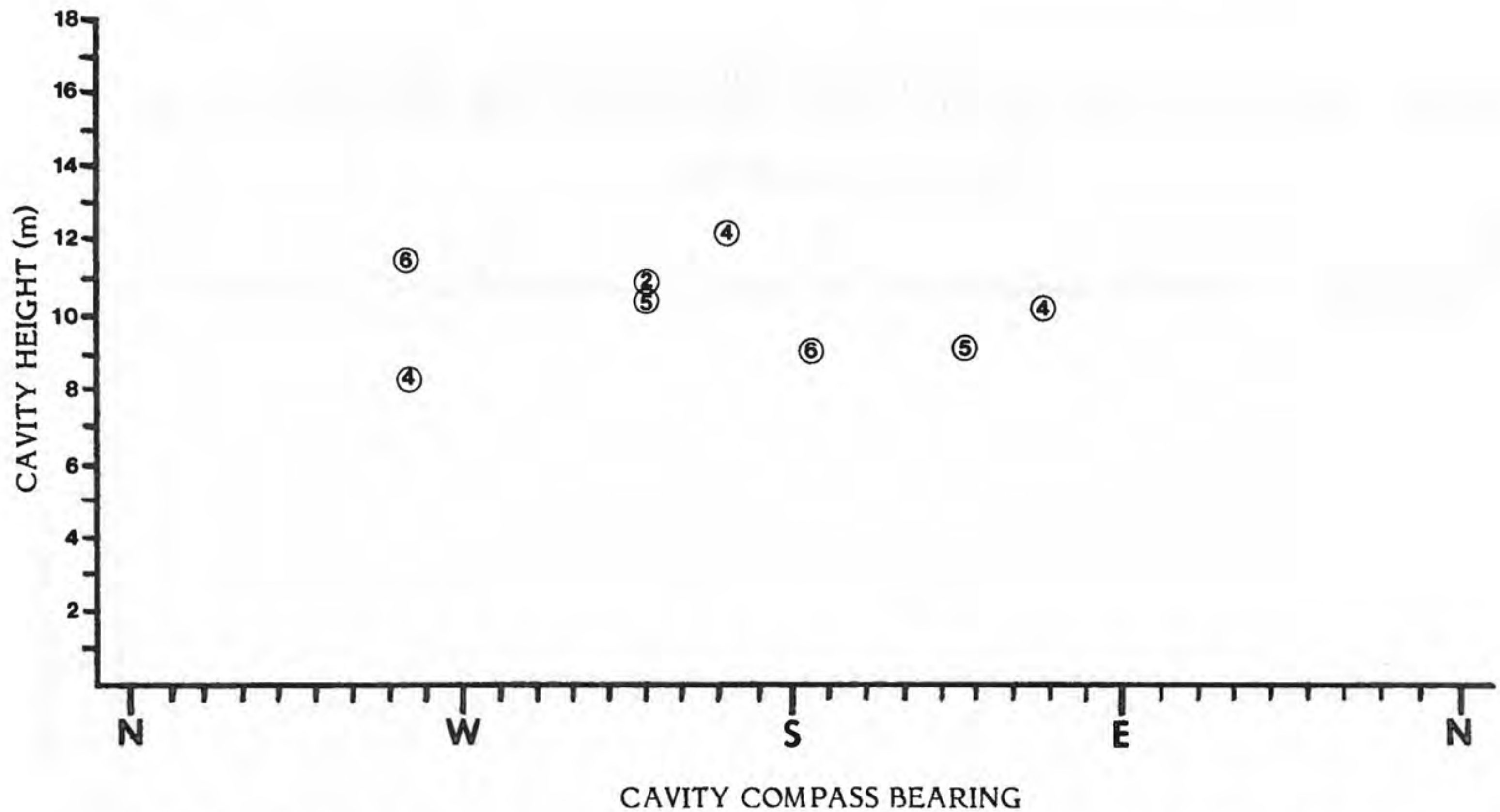

Figure 74. Type, height and compass bearing of cavities in the EMB colony. Circled numbers indicate cavity type. Those underlined are enlarged (Type 7).

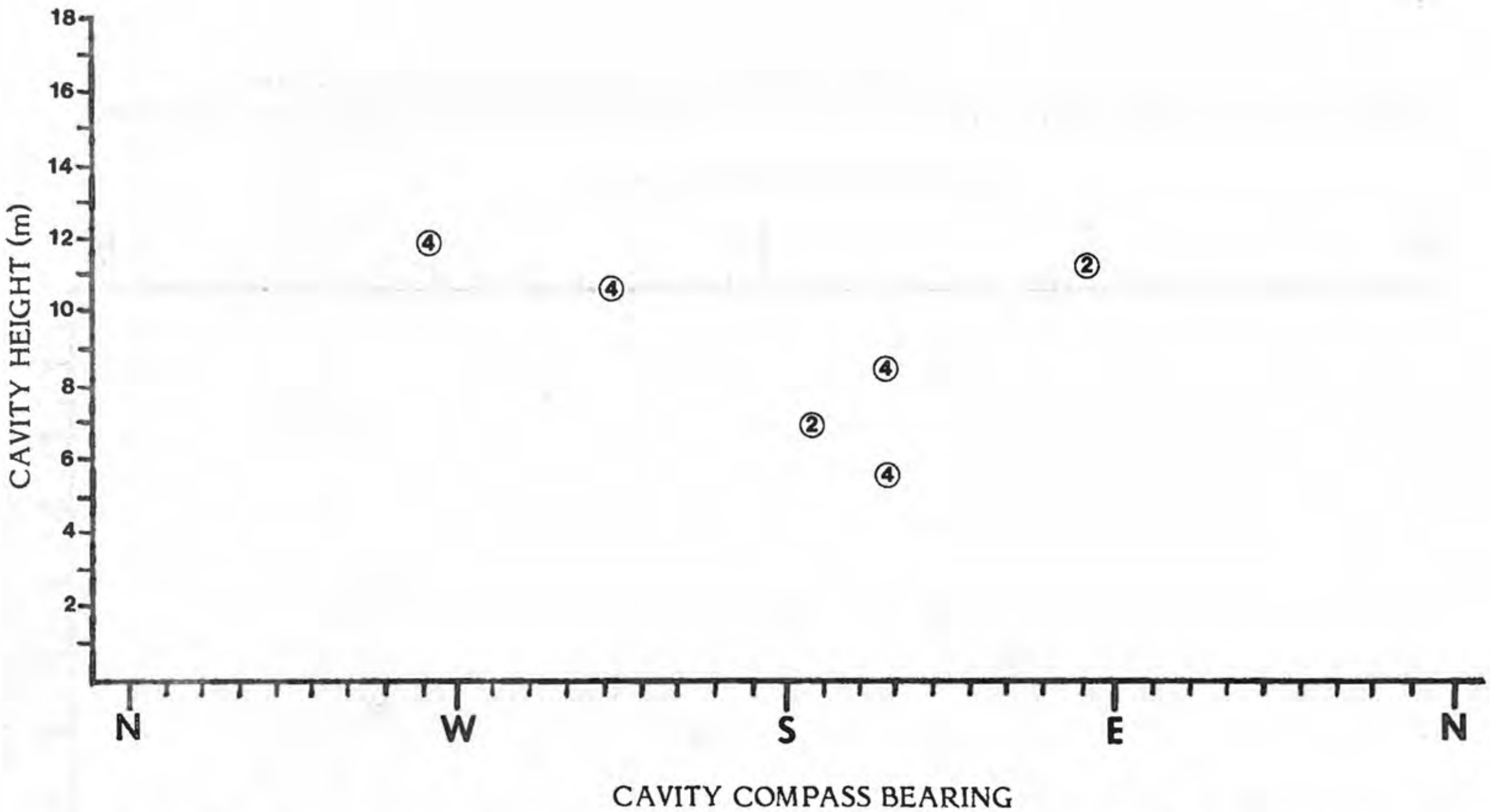

Figure 75. Type, height and compass bearing of cavities in the EMD colony. Circled numbers indicate cavity type. Those underlined are enlarged (Type 7).

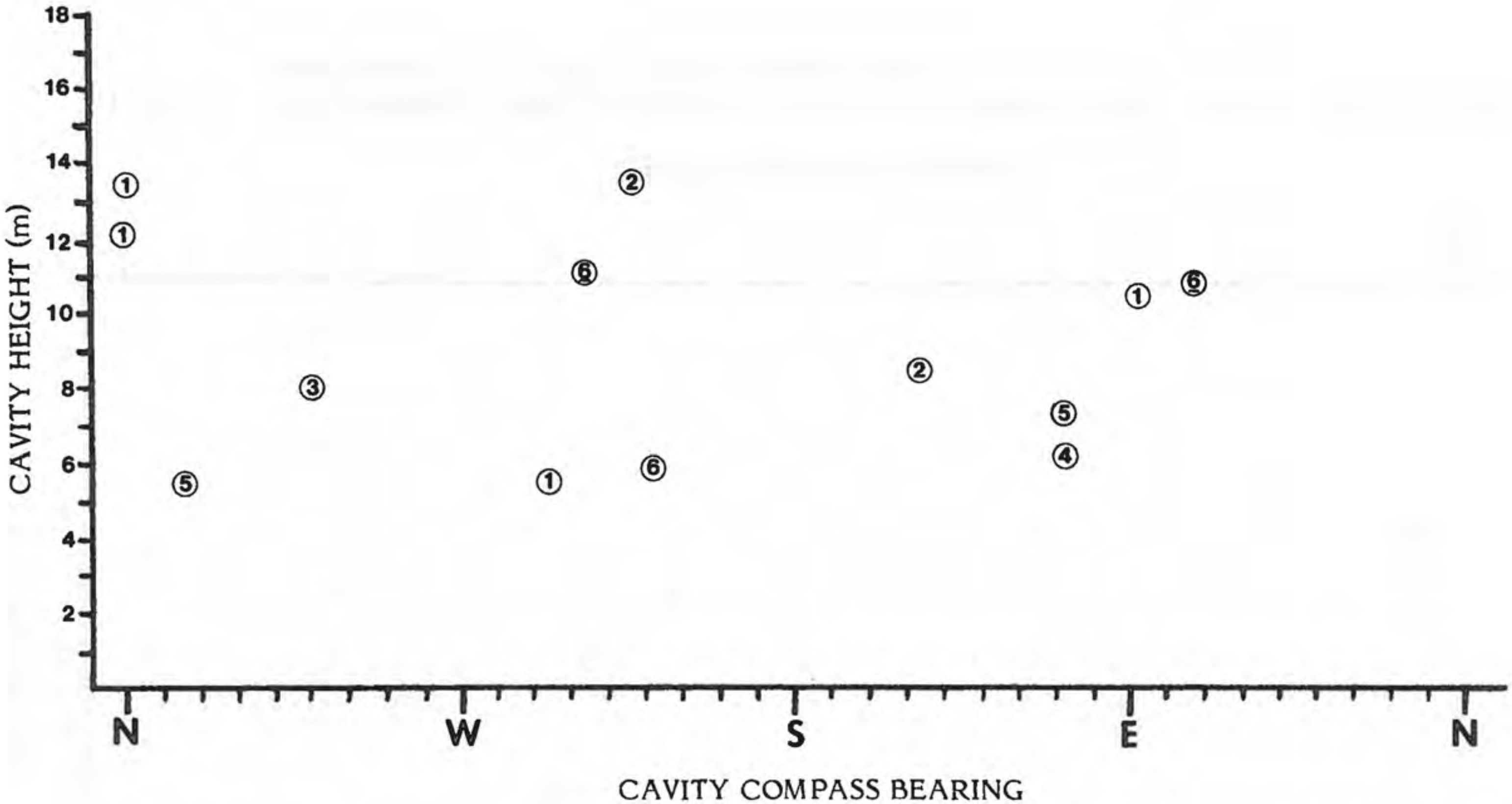

Figure 76. Type, height and compass bearing of cavities in the EMP colony. Circled numbers indicate cavity type. Those underlined are enlarged (Type 7).

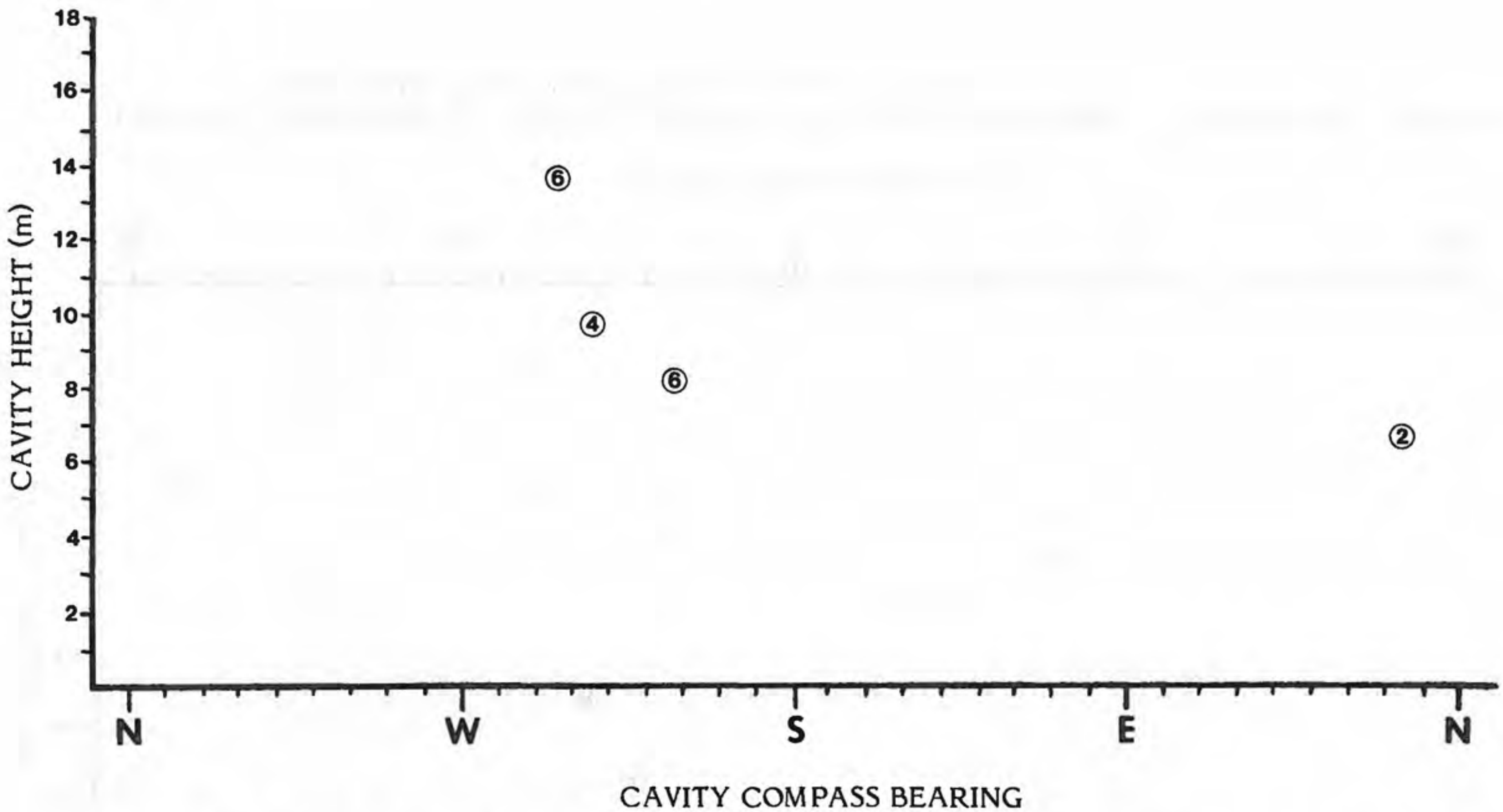

Figure 77. Type, height and compass bearing of cavities in the EMPA colony. Circled numbers indicate cavity type. Those underlined are enlarged (Type 7).

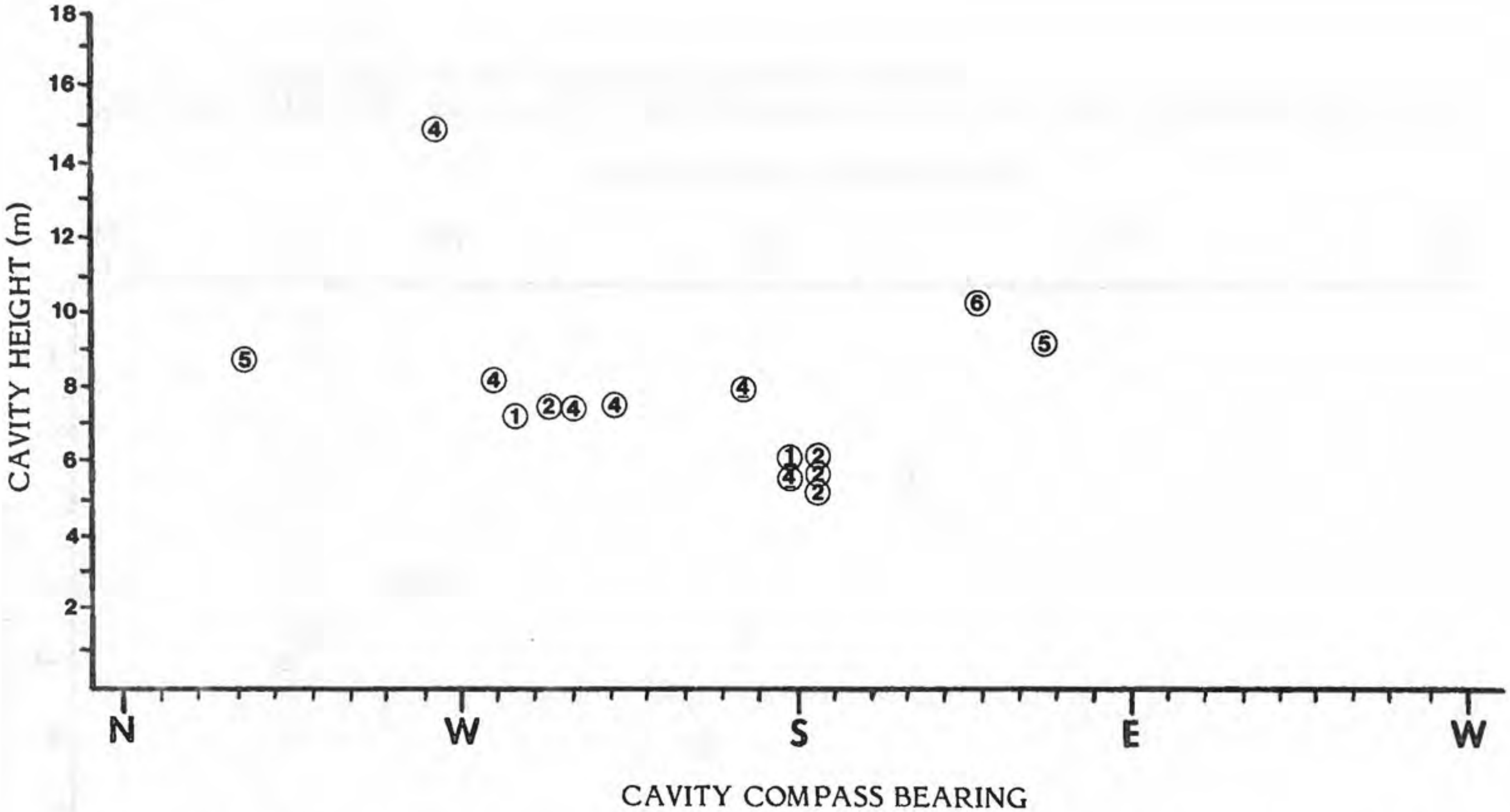

Figure 78. Type, height and compass bearing of cavities in the HaA colony. Circled numbers indicate cavity type. Those underlined are enlarged (Type 7).

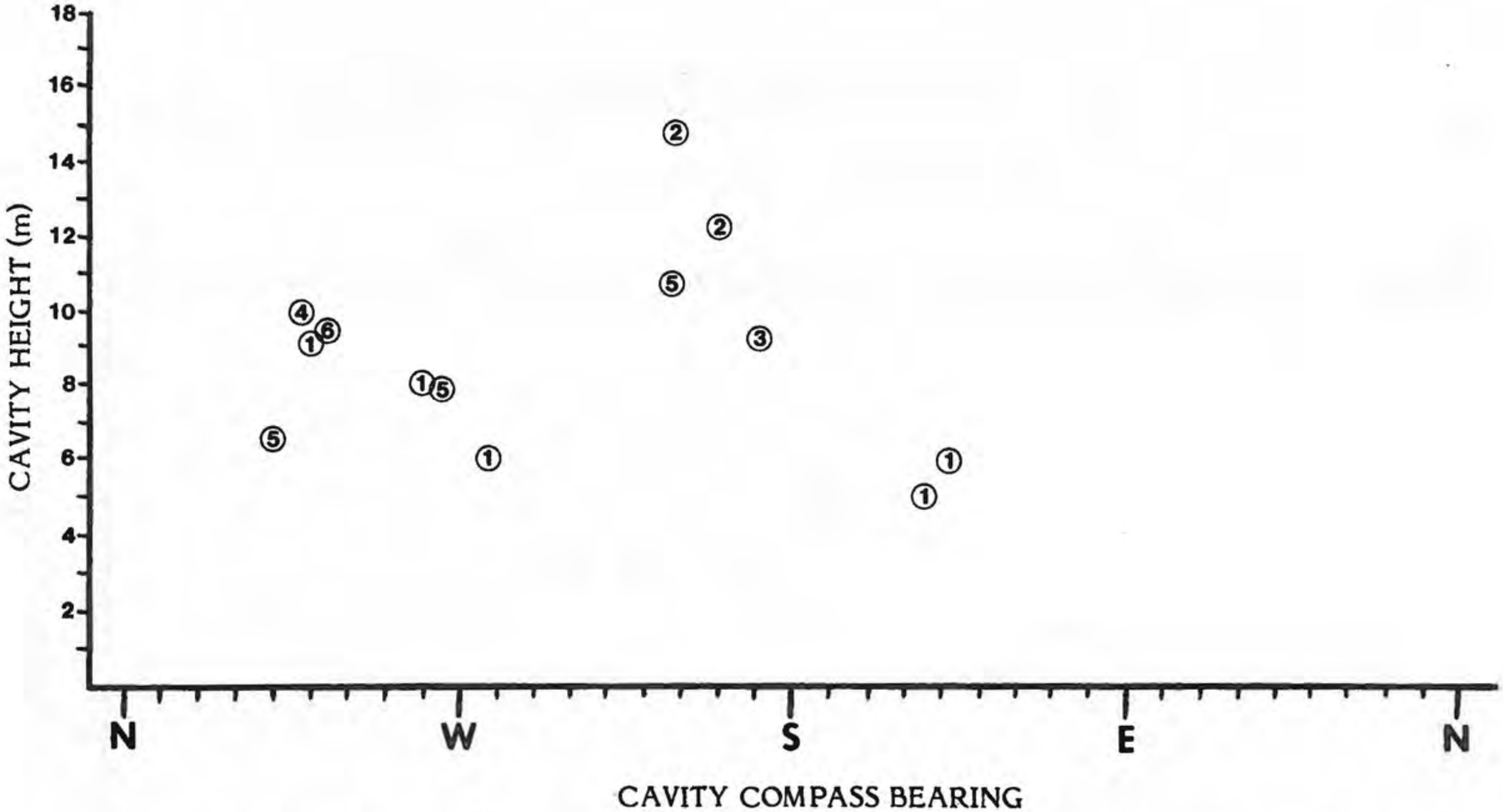

Figure 79. Type, height and compass bearing of cavities in the LPN colony. Circled numbers indicate cavity type. Those underlined are enlarged (Type 7).

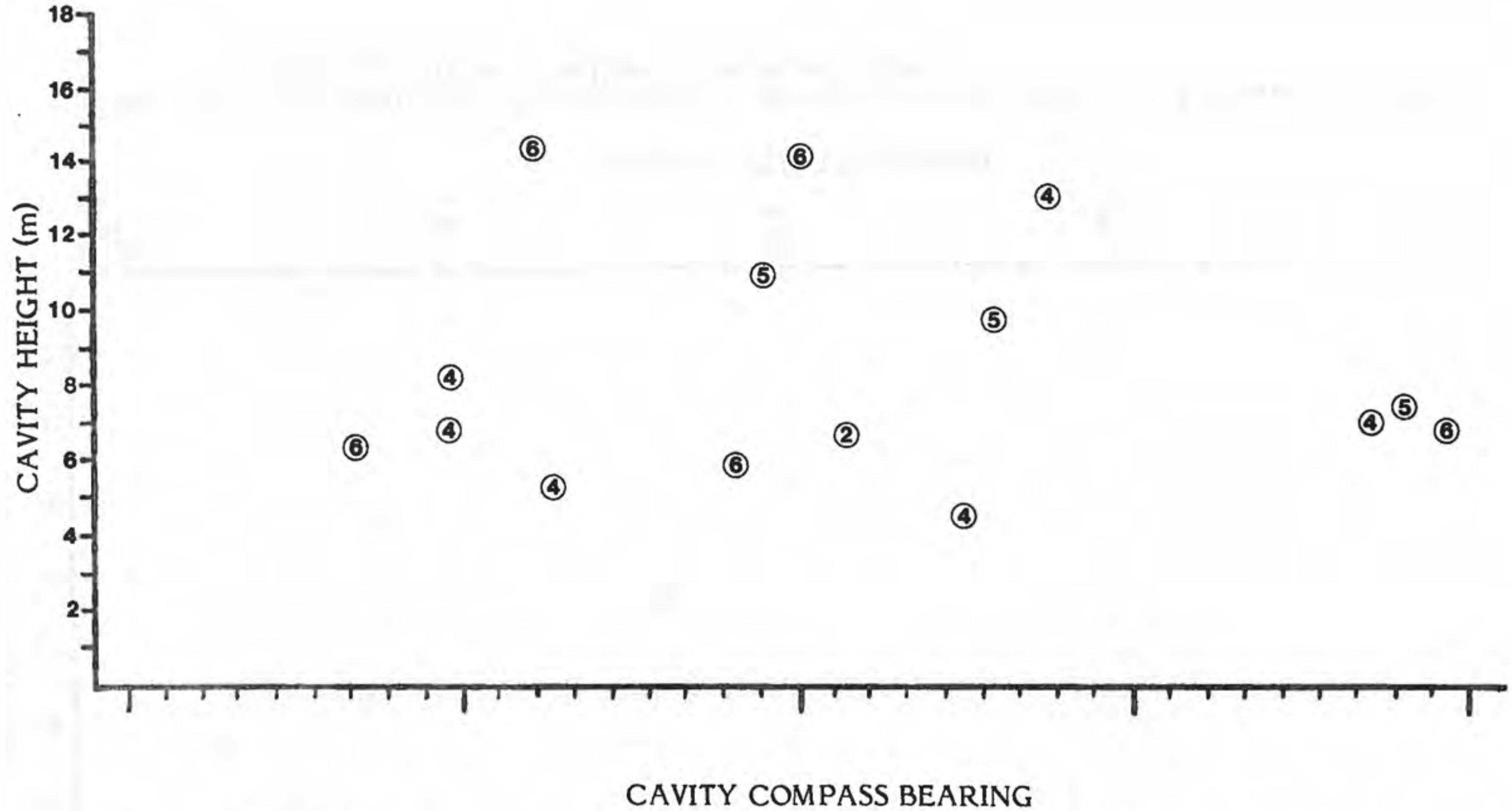

Figure 80. Type, height and compass bearing of cavities in the LPS colony. Circled numbers indicate cavity type. Those underlined are enlarged (Type 7).

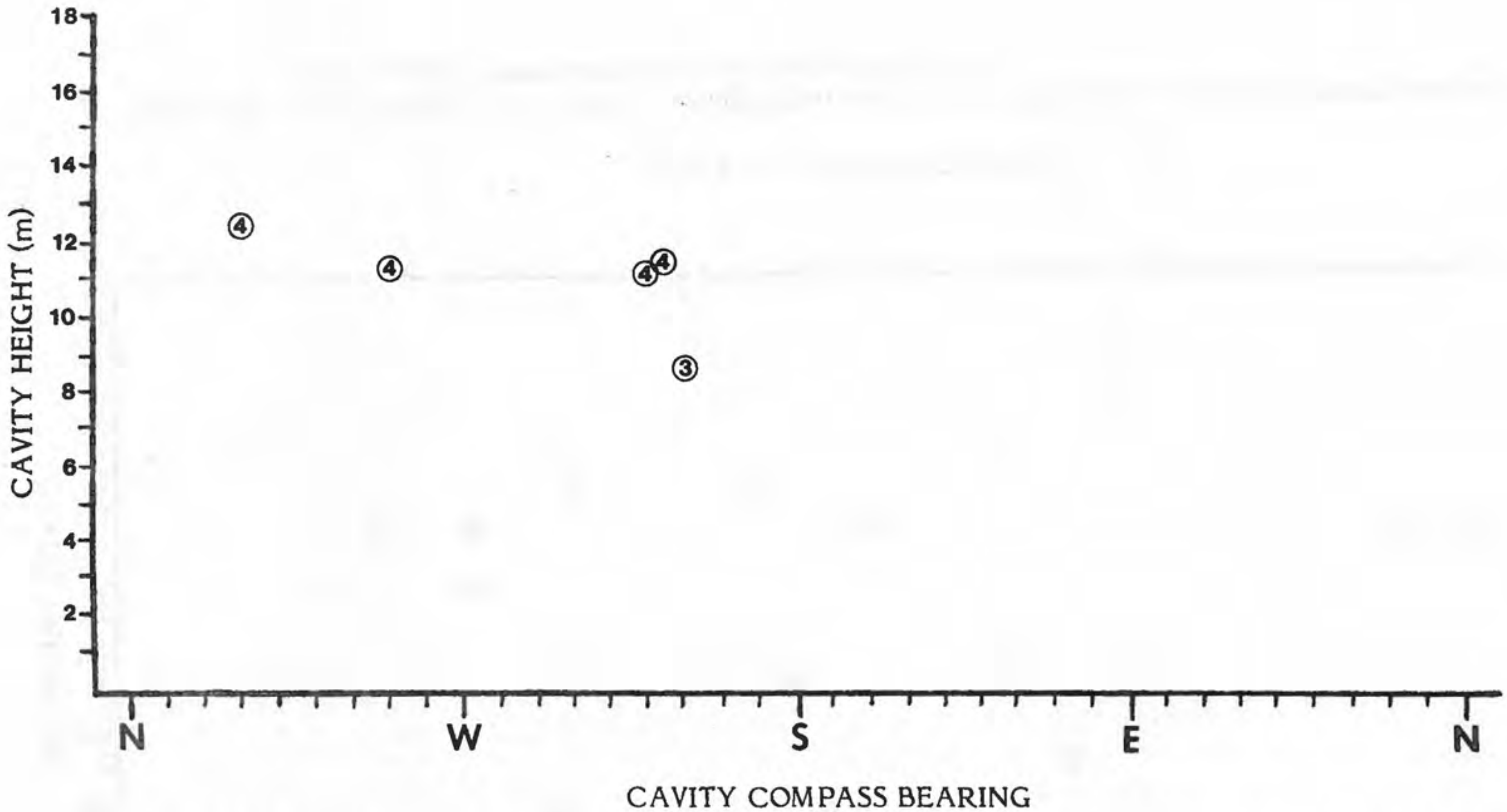

Figure 81. Type, height and compass bearing of cavities in the JR colony. Circled numbers indicate cavity type. Those underlined are enlarged (Type 7).

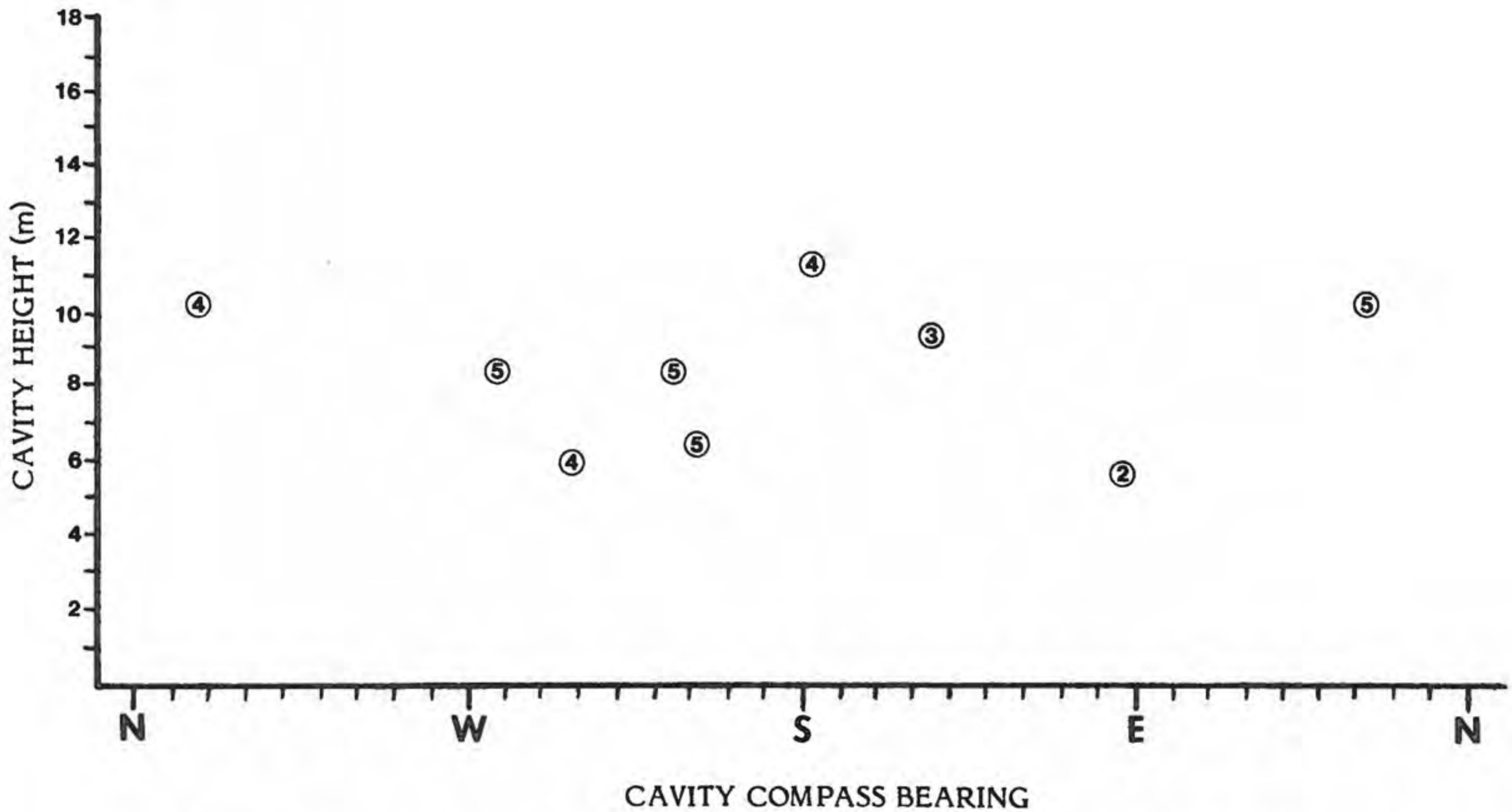

Figure 82. Type, height and compass bearing of cavities in the SMN colony. Circled numbers indicate cavity type. Those underlined are enlarged (Type 7).