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Forest Stands Selected by Foraging Red-Cockaded Woodpeckers

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ABSTRACT

Selection of forest stands by 18 clans of foraging red-cockaded woodpeckers (Picoides borealis) was studied in their year-round home ranges on the Francis Marion National Forest in South Carolina. The foraging use of 276 stands relative to their availability within the home ranges was compared to several stand characteristics. Selection among stands with similar characteristics was highly variable and red-cockaded woodpeckers foraged in stands with a great variety of conditions, suggesting the birds were not very selective. Although stand selection increased significantly as the density of pines ⩾24 cm d.b.h. increased and as the basal area of hardwoods ⩾12 cm d.b.h. decreased, these relationships were weak. Beyond 30 years, stand age was not found to be a significant factor in stand selection.

Keywords: Endangered species, foraging habitat, habitat selection, loblolly pine, longleaf pine, Picoides borealis.

Foraging red-cockaded woodpeckers clearly prefer pines over other trees and tend to select trees that are larger than the average available ones (DeLotelle and others 1983; Hooper and Lennartz 1981; Porter and Labisky 1986; Skorupa 1979). Pines grow in a variety of conditions from stands of nearly pure pines to those with a few pines scattered among hardwoods. Even stands that are dominated by pines differ in the amount of hardwood understory and midstory, and they vary in the density, size, and age of the pines. Year-round home ranges of red-cockaded woodpeckers are large and are typically composed of a mosaic of forest stands that differ in these various ways (Hooper and others 1982). Within the limits set by soil and other natural site factors, conditions of forest stands used by red-cockaded woodpeckers are determined to a great extent by forest management. A knowledge of stand conditions selected by the bird for foraging enhances assessment of management options for this endangered species. This study compared selection of forest stands by foraging red-cockaded woodpeckers to stand age, density and size of pine stems, and basal area of hardwoods.

Methods

The study was conducted on the Francis Marion National Forest in South Carolina. With more than 400 clans, the area has one of the largest populations of red-cockaded woodpeckers (Lennartz and others 1983). The size and apparent stability of the population suggest relatively good habitat conditions for the species on the study area.

Stands of loblolly (Pinus taeda) and longleaf (P. palustris) pines occur on the higher and better drained sites, interspersed with hardwood and cypress (Taxodium spp.) stands in drainages and low areas. The most common hardwoods are tupelo (Nyssa spp.), oaks (Quercus spp.), red maple (Acer rubrum), sweetgum (Liquidambar styraciflua), redbay (Persea borbonia), magnolias (Magnolia spp.), and hollies (Ilex spp.). Stands are second growth and essentially even-aged; however, some have scattered older

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[1] Now retired.

trees in the overstory or an understory of younger trees. Since 1944, pine stands have been prescribed burned on 1- to 4-year intervals. Even-age timber management has been practiced on the National Forest since 1950.

Eighteen different clans (six/year) of color-banded red-cockaded woodpeckers were studied between May 1976 and April 1979. Clans were family groups of two to nine birds consisting of the breeding pair, juveniles, and adult male helpers. Clans were followed 2 to 14 hours/day on 454 days for a total of 2,350 hours. Birds were out of their cavities from 9 to 14 hours, depending on time of year, and the average time spent following a clan was 5.2 hours/day. Thus, sampling was skewed toward the morning hours, and about 80 percent of the observations were collected in the first 5 hours after the birds left their roosts.

At 5-minute intervals, the coordinates of each clan were determined from 1:24,000 scale aerial photographs gridded to a scale of 15.2 m with each 10th line shown on the photographs. Major grid points (152 x 152 m) were marked in the forest when sufficient natural features for determining location of the clans were lacking. After delineation of the home ranges (Hooper and others 1982), maps showing forest stands were prepared for each home range. Stands were defined as areas with aggregations of trees and other vegetation of sufficient uniformity in composition, age, and density to be distinguished from the vegetation and conditions of adjoining stands. Coordinates for the foraging locations of clans were matched with stand coordinates to determine the use of each stand.

Although red-cockaded woodpeckers are territorial, we were unable to delineate entire territorial boundaries (Hooper and others 1982); however, most clans did share some mutual boundary with adjacent clans. If an adjacent clan was not apparently aware of it, a clan would sometimes violate the boundary and travel into the adjacent territory. Although foraging occurred on these extraterritorial trips, areas across territorial boundaries were not considered available foraging habitat.

Stands ranged in size from 0.5 to 35.9 ha. By chance alone, larger stands would be expected to receive more foraging use than smaller stands. Thus, to compare foraging use among stands, stand size was taken into account by calculation of a use/availability ratio (UAR) for each stand:

$$UAR_{ai} = \frac{O_{ai} \div \sum_{i=1}^{n_a} O_{ai}}{A_{ai} \div \sum_{i=1}^{n_a} A_{ai}}$$

where:

UAR_{ai} = the UAR for stand i in home range a

O_{ai} = the number of foraging observations in stand i of home range a

A_{ai} = the area of stand i in home range a

Because on most days we did not follow clans all day, results could be biased in favor of forest stands close to the roost trees and against stands near the home range boundary. To test for bias, we compared the length of daily observation period to the proportion of observations recorded in stands various distances from the colony. In 10 home ranges we followed clans all day on 48 days. These observations were free of bias that could have resulted from following birds for only part of a day. Thus, the proportion of observations in a stand, based on the sum of observations for whole-day monitoring within a home range, was considered an unbiased estimate for the comparison. Whole days were divided into 1-hour periods, and the number of observations for each of the stands was summed within hourly periods. Beginning each time with the first hourly period, these sums were accumulated across hourly periods to create partial-day observation periods of 1 hour, 2 hours, 3 hours, and so on. Next, the proportion of observations in each stand for the observation periods was determined. The deviation of the estimate for the partial-day observation from the whole-day estimate for each stand was determined by subtracting the whole-day value from each partial-day estimate. Thus, for each of 140 stands in these 10 home ranges, a deviation from the unbiased whole-day estimate was obtained for each length of observation. The mean of the distances from the breeding male's roost tree to the proximal and distal boundary of each stand was determined. The deviations for individual stands were plotted by mean stand distance for each of the created partial-day observation periods. Figure 1 shows results for periods ending in odd-numbered hours.

Consistently higher or lower estimates by partial-day observation periods when compared with whole-day estimates would suggest that partial-day estimates are biased. Such appeared to be the case if birds were followed for only 1 hour (fig. 1). Stands within 200 m of

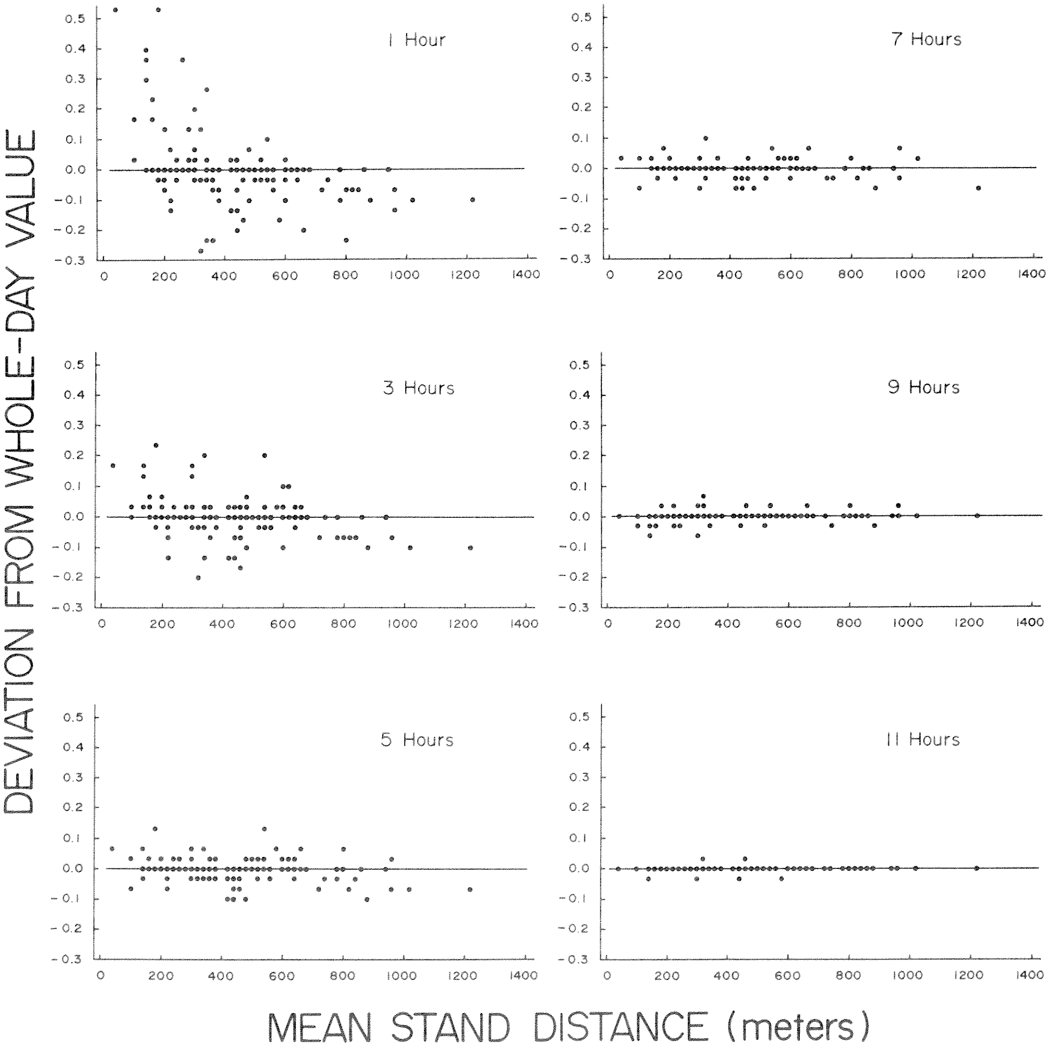

Figure 1.--Deviation of partial-day from whole-day estimates of the proportion of foraging time spent by red-cockaded woodpeckers in 140 forest stands at various distances from the breeding males' roost cavities. A positive deviation indicates an inflated partial-day estimate, and a negative deviation indicates an underestimate. Data were calculated from 48 whole days of observation in 10 home ranges on the Francis Marion National Forest in South Carolina.

the breeding male's roost tree appeared to have inflated estimates of foraging time, whereas stands at more than a 600-m distance appeared to have underestimated values. If birds were followed 5 hours, this trend was no longer apparent. Following birds longer than 5 hours reduced the variation in observed values, but we used 5-hour days as the minimum to include in the analysis. By using 5-hour and longer days, the sampling intensity was twice that of 7-hour and longer days: 283 days and 1,910 hours vs. 109 days and 971 hours, respectively. Data collected on 171 days (442 hours) were not used in the analysis because they were collected on days when we followed clans less than 5 hours.

Characteristics of the vegetation were measured in the 276 stands contained within the home ranges of the 18 clans. Depending on stand size, 3 to 20 sampling points were located systematically from a random starting point. Each sample point served as the center of a 1-m^2/ha factor wedge prism plot and a fixed radius plot of 0.02 ha. The prism plot sampled trees >12.0 cm d.b.h. and the 0.02-ha radius plot sampled stems 3.0 to 11.9 cm d.b.h. All stems were recorded by species and d.b.h. to allow calculation of basal area and density of stems for hardwood, pines, and cypress. Stand age was determined by increment boring a dominant tree on each plot and averaging plot values for each stand.

For analysis, forest stands were the observational unit and UAR was the dependent variable. Regressions were run by using various measures of stand conditions (table 1) as independent variables.

Results

The density, size, and age of pines and the basal area of hardwoods varied greatly among forest stands, providing red-cockaded woodpeckers a wide choice of conditions from which to select foraging areas (table 1). Given the range of conditions available to the birds, perhaps the most notable result of the study was the variability in the selection of stands with similar conditions (figs. 2,3,4,). These results suggest that the red-cockaded woodpeckers were not very selective of forest stands in which they foraged. Despite the variation in stand selection, statistically significant relationships were found between stand selection and the major stand characteristics that we measured.

Table 1.--Summary of characteristics of 276 forest stands used by 18 clans of red-cockaded woodpeckers as year-round home ranges on Francis Marion National Forest, South Carolina

Variable	Mean	Range	SD
Stand age (years)	55.5	4-144	22.3
Number pine trees/ha (by d.b.h. in cm)			
3.0-11.9	152.4	0-3863	327.0
12.0-23.9	118.0	0-840	141.2
24.0-35.9	63.8	0-260	58.0
36.0-47.9	24.3	0-130	25.7
>48.0	5.3	0-105	10.9
>3.0	363.7	0-4016	388.6
>12.0	211.4	0-1036	173.5
>24.0	93.4	0-307	72.1
>36.0	29.6	0-150	30.5
Basal area pines (m^2/ha)			
>12.0 cm d.b.h.	11.5	0-34	7.7
Basal area hardwoods (m^2/ha)			
>12.0 cm d.b.h.	5.6	0-45	9.4

Several weak but statistically significant trends were found between stand selection and the density and size of pines. Regressions that used the density of pines ≥24 cm, ≥36 cm, and ≥48 cm d.b.h. were significant, but the percentage of the variation in stand selection that was accounted for was very small (fig. 2). Regressions that included pines <24 cm d.b.h. were not significant ($P<0.05$).

Although small, the amount of variation in stand selection that was accounted for by the regression models

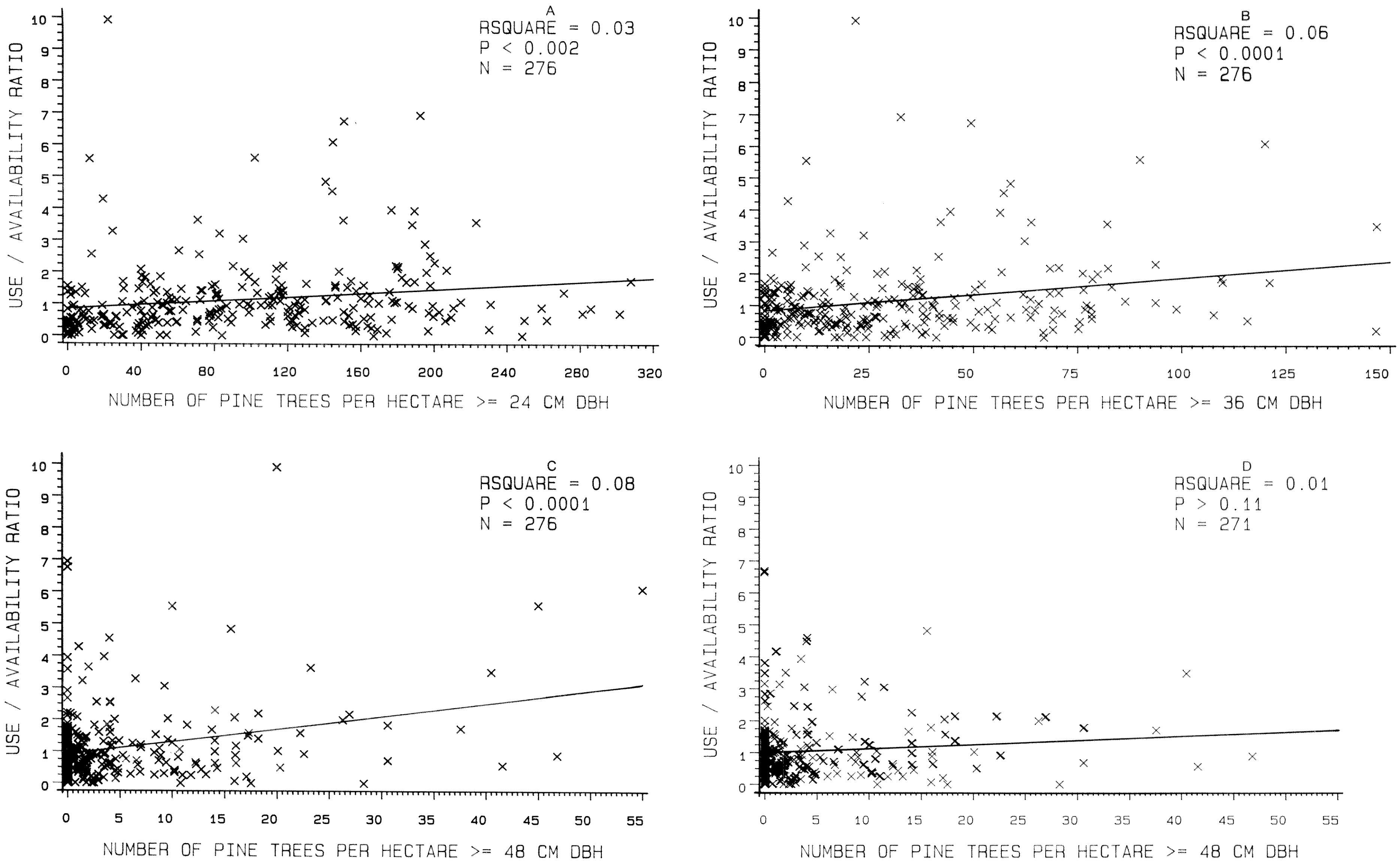

Figure 2.--Use/availability ratio compared to the density of live pines in forest stands selected by 18 clans of foraging red-cockaded woodpeckers: A, Pines ⩾24 cm d.b.h.; B, pines ⩾36 cm d.b.h.; C, pines ⩾48 cm d.b.h.; D, pines ⩾48 cm d.b.h. but with the area and associated foraging observations within 60 m of the cavity trees omitted from the comparison. Data are from year-round home ranges on the Francis Marion National Forest in South Carolina.

increased as the minimum d.b.h. of pines used in the independant variable became larger (fig. 2). Specifically, the density of pines ≥36 cm d.b.h. had a stronger relationship to stand selection than pines ≥24 cm d.b.h., and pines ≥48 cm d.b.h. had a stronger relationship to stand selection than pines ≥36 cm d.b.h. These results appear to suggest that stands with pines ≥48 cm d.b.h. were preferred over those with smaller trees. Other results, however, do not support such a conclusion. We found no significant difference in selection of stands with and without pines ≥48 cm d.b.h. (mean UAR=1.3 and 1.2, n=141 and 93, respectively, $\underline{P}>0.81$ based on $\underline{t}$-test; all stands used in this comparison had ≥10 pines/ha that were ≥24 cm d.b.h.). In addition, when the area and associated foraging observation within 60 m of cavity trees were removed from the analysis, the relationship of stand selection to density of pines ≥48 cm d.b.h. was not significant (fig. 2,D). In contrast, without the effect of cavity trees the relationship between stand selection and the density of pines ≥24 cm d.b.h. was somewhat stronger than when all observations were used ($R^2=0.07$, $\underline{P}<0.0001$, n=271 and $R^2=0.03$, $\underline{P}<0.002$, n=276, respectively). The relationship between stand selection and the density of pines ≥37 cm d.b.h. was the same whether or not the area around cavity trees was included. Removing the 60-m area and observations around cavity trees from the analysis made little change in the availability of stands with pines ≥48 cm d.b.h. Only 5 of the 28 stands with cavity trees were dropped from the analysis, leaving 145 stands with pines ≥48 cm d.b.h. In total, the 775 ha of stands with pines ≥48 cm d.b.h. was reduced by only 7 percent. Thus, any apparent preference for stands with pines ≥48 cm d.b.h. seems to be due primarily to the attraction of cavity trees.

Preference for foraging in stands tended to decrease as the basal area of hardwoods ≥12 cm d.b.h. increased (fig. 3). Although statistically significant,

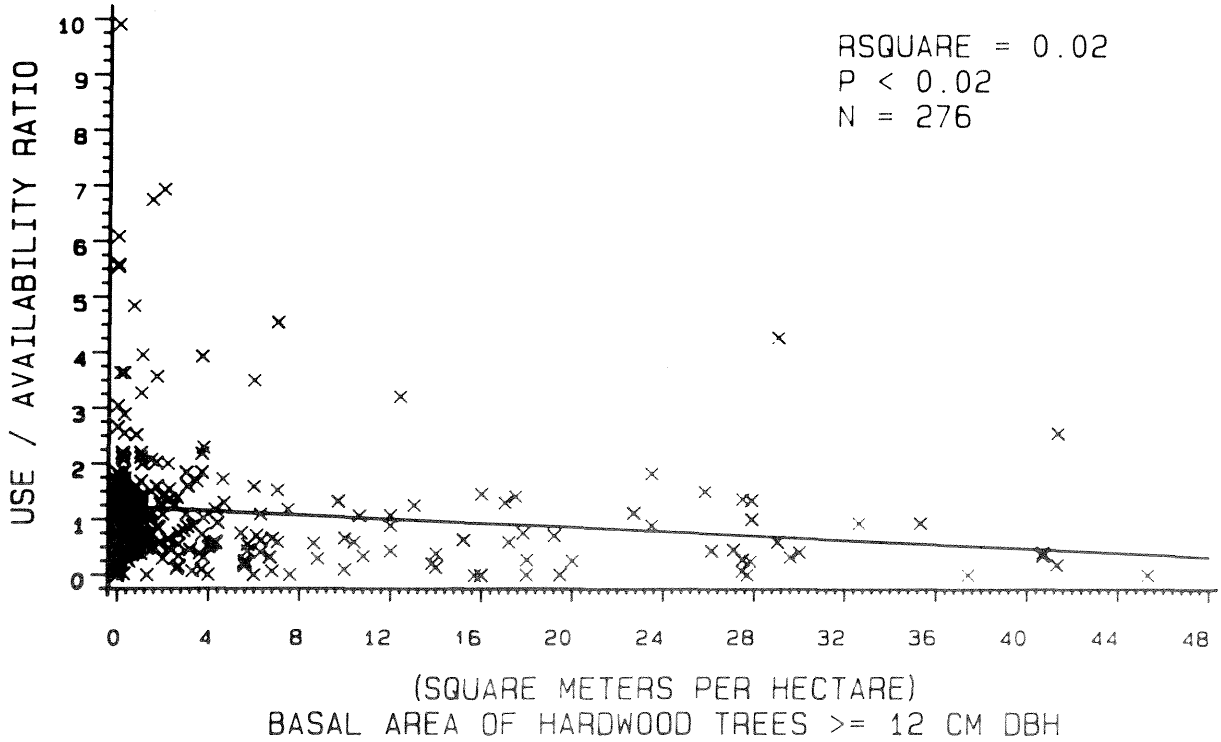

Figure 3.--Use/availability ratio compared to the basal area of hardwood trees ≥12 cm d.b.h. in forest stands selected by 18 clans of foraging red-cockaded woodpeckers. Data are from year-round home ranges on the Francis Marion National Forest in South Carolina.

the regression accounted for virtually none of the variation in stand selection, suggesting that the density of hardwoods was not an important factor in stand selection. Excluding the area and foraging observations around cavity trees did not change the regression of stand selection and hardwood basal area ($R^2=0.02$, $P<0.02$, $n=271$).

Stand selection was significantly related to stand age, but the amount of variation accounted for by the regression was very small (fig. 4,A). Two factors appeared to be responsible for the relationship between stand selection and stand age. The first factor was that the selection for stands <30 years old was radically different from selection for older stands in that all the UAR values were low (fig. 4,A). The second factor was that most cavity trees occurred in older stands and the attraction of cavity trees tended to inflate the UAR values. When stands <30 years old and the area and foraging observation within 60 m of cavities trees were removed from the analysis, the regression was no longer significant (fig. 4,B). Using 30 years as the point to delete young stands was arbitrary, but the same result occurred when stands <25 years old or <20 years old were used ($R^2=0.003$, $P>0.35$, $n=256$; and $R^2=0.005$, $P>0.25$, $n=259$, respectively). Discounting the area around cavity trees had little effect on the availability of stands ≥80 years old. Of the 133 ha in stands ≥80 years old, only 23 ha were excluded.

Discussion

Red-cockaded woodpeckers on the Francis Marion National Forest had a wide range of tree densities, tree sizes, hardwood basal area, and stand ages from which to select stands for foraging. The results suggested that all these measures of stand conditions had some bearing on stand selection. However, the birds were highly variable in their selection, and the observed relationships between stand conditions and stand selection were consequently weak. Several reasons for the variation in stand selection can be suggested. It was possible that clans in some, but not all, home ranges had more foraging resources than they needed (Hooper and others 1982; Wood and others 1985). If true, this might explain why some stands of apparently preferred foraging conditions received little or no use during the study. On the other hand, some home ranges may have been deficient in preferred foraging stands. If so, birds could have quickly exhausted stands with preferred conditions and have been forced to use less desirable stands at a higher rate than the more desirable ones. Another possible source of variation was related to stand size. For small stands, a few foraging observations could result in a stand having a high use/availability ratio (UAR). Also large stands could receive a considerable amount of use and still have a relatively low UAR. The UAR accounted for the inequities of stand size to a large extent, as evidenced by the correlation between stand size and use ($r=0.62$) and between stand size and use/availability ($r=0.07$). Nonetheless, stand size possibly contributed to the large variation in UAR's for stands of similar conditions.

The importance of the density of pines as a factor in stand selection was corroborated to some extent by other studies, but direct comparison of results are confounded. In one home range, Wood (1983) found the most intensively foraged area had the highest tree density, the moderately foraged area had an intermediate density, and the area of limited use had the least density of trees. In central Florida, DeLotelle (pers. commun.) found a positive relationship between density of pines ≥6 cm d.b.h. and stand selection. That relationship of smaller pines to stand selection might be explained by the lack of pines ≥30 cm d.b.h. (DeLotelle and others 1983). Foraging areas in one home range in North Carolina had fewer pine trees/ha than the home range as a whole, whereas the foraging areas in one other home range had a higher density than that home range as a whole (Repasky 1984). Repasky included pines ≥2.5 cm

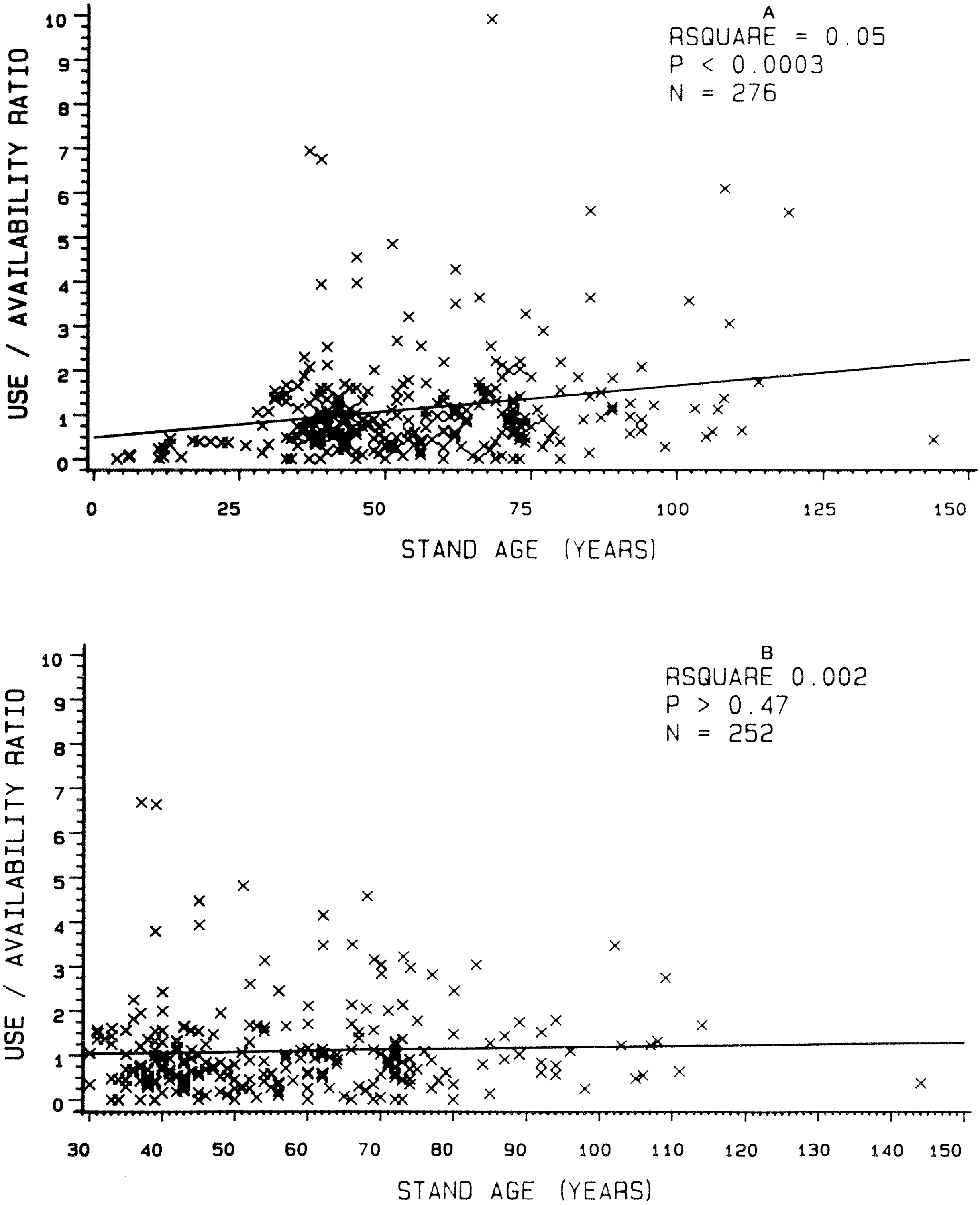

Figure 4.--A, Use/availability ratio compared to the age of forest stands selected by 18 clans of foraging red-cockaded woodpeckers; B, the same comparison except the area and associated foraging observations within 60 m of cavity trees in stands <30 years old have been omitted. Data are from year-round home ranges on the Francis Marion National Forest in South Carolina.

d.b.h.; thus his findings were consistent with the lack of relationship we found between density of pines ⩾3 cm d.b.h. and stand selection. But, in four home ranges in north Florida, Porter and Labisky (1986) found an inverse relationship between three levels of selection and the density of trees. Because they apparently included small pines, their results may not be inconsistent with ours, given that we found a lack of relationship between stand selection and pines ⩾3 cm d.b.h.

Over and above the density of pines ⩾24 cm d.b.h., there was no evidence that the density or occurrence of even larger pines enhanced stand selection. Thus, pines 24.0 to 35.6 cm d.b.h. appeared to be equivalent to those ⩾36.0 cm d.b.h. It has been suggested that larger trees could be foraged more efficiently than smaller trees because of presumably more total arthropod biomass and perhaps more biomass per unit area (Hooper and Lennartz 1981; Jackson 1979; Skorupa 1979). Indeed, several studies found that red-cockaded woodpeckers selected individual trees for foraging that were on the average larger in diameter than the mean d.b.h. of available trees (DeLotelle and others 1983; Hooper and Lennartz 1981; Porter and Labisky 1986; Skorupa 1979). However, the results of these studies did not indicate that the rate of selection of individual trees continued to increase with the continued increase in diameter. Specifically, Hooper and Lennartz (1981) found strong selection for pines ⩾24 cm d.b.h., but there was little difference in selection for pines 24.0 to 35.9, 36.0 to 47.9, and ⩾48.0 cm d.b.h. They also found that while the use of pines 12.0 to 23.9 cm d.b.h. only equaled their availability, pines of that size were foraged upon as often as pines ⩾36 cm d.b.h. (27.6 and 26.8 percent, respectively). Porter and Labisky (1986) presented convincing evidence of selection for pines larger than those available on average, but the mean diameter of selected trees converged rapidly with the mean diameter of available trees as the latter increased. DeLotelle and others (1983) found a preference for trees ⩾27 cm d.b.h. for foraging, but smaller trees accounted for 83 percent of trees selected. Skorupa (1979) reported selection for larger than average pines but did not present data that allowed comparison of tree selection by diameter.

Most of the statistical relationship between stand age and stand selection resulted from stands <30 years of age receiving little use as foraging areas and from the attraction of cavity trees in the oldest stands. Whether or not to discount the 60-m area around cavity trees is problematical. There is no doubt woodpeckers met some of their nutritional requirements when foraging in the immediate vicinity of cavity trees. On the other hand, it is questionable if the foraging time around cavity trees was determined primarily by stand conditions. Specifically, the birds began and ended each day at their cavities. They spent additional time in the vicinity of cavity trees engaged in cavity excavation, maintenance, and defense. Although during these times some clan members typically foraged continually and most clan members foraged at least intermittently, the primary attraction appeared to be the proximity of the cavity trees. Other areas of the home range did not have this same attraction to the birds. Most important, discounting the area around cavity trees had little effect on the availability of stands ⩾80 years old. Of the 133 ha in stands ⩾80 years old, only 23 ha were excluded. Thus, the birds had considerable opportunity remaining to select the oldest stands preferentially but did not do so.

The negative effects of hardwoods on stand selection were consistent with the literature. Repasky (1984) found theoretical basis for hardwoods substantially increasing the cost in energy of foraging. Also, Hooper and Lennartz (1981) and Repasky (1984) found that the proportion of hardwoods selected as foraging substrate was much less than that available.

Implications

From a management standpoint, these results imply that any pine or pine-hardwood stand with at least a modest amount of pines $\geqslant 24$ cm d.b.h. will provide highly usable foraging habitat for red-cockaded woodpeckers. Stand age per se does not appear to be of primary importance except that it takes a number of years to grow pines $\geqslant 24$ cm d.b.h. Thinnings, superior stock, fertilization, initial spacing at regeneration, and site index may be as important as age in providing quality foraging habitat.

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