HABITAT PREFERENCES OF FORAGING RED-COCKADED WOODPECKERS AT THE SAVANNAH RIVER SITE, SOUTH CAROLINA

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Abstract: I conducted a foraging study to examine habitat use of red-cockaded woodpeckers at the Savannah River Site, South Carolina. Because much of the land had been harvested in the late 1940s and early 1950s prior to being sold to the Department of Energy, the available habitat largely consisted of younger trees (e.g., less than 40 years old). From 1992 to 1995, I examined the foraging behavior and reproductive success of 7 groups of red-cockaded woodpeckers. Availability of pines of various age classes (<20, 20-29, 30-39, and ≥40 years old) and size classes (<20.3, 20.3-25.4, ≥25.4 cm dbh; <8, 8-10, ≥10 in, respectively) was estimated from extensive vegetation sampling (n = 14,713 trees) within 800 m (2,640 ft) of the nest trees of each of the 7 groups. I compared habitat availability to actual foraging use of the trees. A total of 6,284 foraging observations was taken during all seasons of the year and at all times of day. Birds in all 7 groups foraged selectively with respect to tree age. Birds in each group preferred to forage in trees that were ≥30 years in age and displayed even stronger preferences for trees ≥40 years in age. On the basis of availability, it was predicted that 24.5% of the foraging observations of all groups combined would occur in trees with the largest size class (dbh ≥25.4 cm). However, that size class contained 66.9% of the total foraging observations. Birds in all 7 groups foraged selectively with respect to tree size, and selected the medium (20.3-25.4 cm dbh) and largest (≥25.4 cm dbh) size classes. Reproductive success tended to increase with an increase in number of pine stems ≥25.4 cm dbh within 800 m of the nest cavity.

Key words: age class, availability, diameter at breast height, foraging, habitat preferences, habitat use, Savannah River Site, South Carolina.

Sufficient foraging habitat is essential for reproduction and persistence of endangered red-cockaded woodpeckers (*Picoides borealis*). Provision of such habitat requires an understanding of how the birds forage, what habitat characteristics influence habitat selection, and whether they have consistent foraging patterns throughout their range.

Living pines were used almost exclusively for foraging by red-cockaded woodpeckers in Florida (Ligon 1968,1970; Nesbitt et al. 1978; DeLotelle et al. 1983; Porter and Labisky 1986), Louisiana (Morse 1972), South Carolina (Skorupa and McFarlane 1976, Skorupa 1979, Hooper and Lennartz 1981), Mississippi (Ramey 1980), Oklahoma (Wood 1977), Virginia (Miller 1978), and North Carolina (Repasky 1984). In a foraging and home range study conducted in a longleaf (*Pinus palustris*)-slash (*P. elliottii*) pine forest in Florida, red-cockaded woodpeckers used longleaf pine in excess of its availability in the home range and slash pine in proportion to its presence (Porter and Labisky 1986). Porter and Labisky (1986) suggested that differing foraging requirements in different habitats necessitate habitat specific forest management guidelines.

In most foraging studies, red-cockaded woodpeckers have been observed feeding on hardwoods, but hardwood use is very limited. For example, in a North Carolina Sandhills study, 2% of observations were in hardwoods and primarily occurred in fall and early winter (Repasky 1984). Hardwood use was reported as 15% by Wood (1977), 4% (Miller 1978), 1% in summer and 3% in winter by males only (Skorupa 1979), 10% in winter (Skorupa and McFarlane 1976), and 22% by males and 6% by females (Ramey 1980). At least one researcher noted that red-cockaded woodpeckers did not forage below the height of the understory (Crosby 1971*b*) and another study (Skorupa 1979) revealed only 1 case of foraging below the height of the understory. Skorupa (1979) speculated that portions of the pine trunks found below the top of the understory vegetation may be disregarded by red-cockaded woodpeckers as foraging substrate. This may reduce the amount of prey available as the bark in the lower 0 to 5 m (16.5 ft) of the trunk has the deepest furrows and, therefore, is likely to have a rich, dense array of potential prey items. Further, although birds did not avoid stands with a high proportion of hardwoods in a South Carolina study, they usually foraged in scattered pines in such situations (Hooper and Lennartz 1981). In a study on the Francis Marion National Forest in South Carolina, red-cockaded woodpeckers selected live pines far in excess of their availability (96% use vs. 71% availability) and avoided hardwoods (1% use vs. 25% availability)

(Hooper and Lennartz 1981). Birds also used recently dead or dying pines, most of which had been struck by lightning.

A preference for large diameter trees for foraging has been noted for many woodpecker species, including the three-toed (*P. tridactylus*) (Dement'ev et al. 1951, Hogstad 1977), white-headed (*P. albovaratus*) (Hilkevitch 1974), pileated *(Dryocopus pileatus)* (Bull and Meslow 1977), and ivory-billed (*Campephilus principalis*) (Tanner 1942) woodpeckers. The 18 groups of red-cockaded woodpeckers on the Francis Marion National Forest that were examined used stands relative to their availability with respect to density and size of pines (Hooper and Harlow 1986). Stand selection was variable and birds used stands in a great variety of conditions. Thus, Hooper and Harlow (1986) suggested that red-cockaded woodpeckers are not strongly selective in their foraging requirements, at least in terms of stand conditions. Yet the authors also stated that stand selection was significantly higher as density of pines ≥24 cm (9.5 in) diameter at breast height (dbh) increased and as basal area of hardwoods ≥12 cm (4.7 in) dbh declined. Although these differences were statistically significant, the relationship was weak.

The vast majority of the Savannah River Site was harvested for timber in the late 1940s and early 1950s as part of the sale of this land by private landowners to the federal government. When this study began in 1992, most of the land on the site had been regenerated using several pine species. The resulting forest stands generally were less than 40 years in age. Earlier foraging and habitat use studies dealt primarily with areas that contained a fairly large proportion of older trees in comparison to the tree distribution by age and size at the Savannah River Site. Such older, larger diameter trees are sparse at the Savannah River Site. One of the purposes of this study was to examine how red-cockaded woodpeckers responded from a foraging perspective to a habitat which largely consisted of younger trees that were small to medium-sized.

At the time of this study, the U.S. Forest Service (Region 8) standards and guidelines for the red-cockaded woodpecker specified maintaining 50 ha (about 125 ac) of foraging habitat per group (see U.S. Fish and Wildlife Service 1985). However, the 50-ha figure was not universally accepted and, in fact, was challenged (Ligon et al. 1986, Jackson 1986, Reed et al. 1988). Concerns arose because: (1) birds have been observed in some instances to use more than the 50 ha, (2) this acreage does not consider habitat quality, and (3) in arriving at this value, extra-territorial areas were not incorporated even though such areas may be used by the birds. In concert with the Red-cockaded Woodpecker Recovery Team, the U.S. Fish and Wildlife Service is in the process of revising the foraging guidelines for this species. It is not known at this time how the revised recovery plan will differ from that approved in 1985. In addition, the U.S. Fish and Wildlife Service Section 7 guidelines specified that 6,350 pine stems ≥25.4 cm dbh be available within 800 m of each cluster.

The null hypothesis I tested was that birds select trees for foraging on a random basis (e.g., regardless of tree age or size) in proportion to the availability of such trees. The objectives of this study were to: (1) determine red-cockaded woodpecker foraging preferences in relation to tree size and age; (2) assess whether there was a relationship between the number of stems ≥25.4 cm dbh within the 800 m of the nest tree in the cluster and reproductive success; and (3) evaluate if possible modifications in foraging guidelines and management of the Savannah River Site may be warranted and, if so, whether Section 7 guidelines should be developed that are specific for the Savannah River Site.

STUDY AREA

The Savannah River Site lies within the Upper Coastal Plain physiographic region in Aiken, Allendale, and Barnwell counties in South Carolina. The land now designated as the Savannah River Site was purchased by the Department of Energy (DOE) in the early 1950s to serve as a nuclear production facility. At that time most of the site was in agricultural use or had been harvested for timber. Under an interagency agreement, the U.S. Department of Agriculture Forest Service has managed the natural resources of the site for DOE since 1952. The Savannah River Site is a National Environmental Research Park. The area managed for woodpeckers contains 31,970 ha (78,966 ac) of pine forest consisting of longleaf (37.7% of the pine area), loblolly (45.4%), slash (13.4%), and other pines (0.2%), in addition to pine-hardwoods (3.3%) (G.Gaines, U.S. Forest Service, unpublished data). The majority of pine stands now present are the result of replanting efforts undertaken in the 1950s, although there are some residual older pine trees.

METHODS

Each bird on the site was banded with a unique set of colored plastic leg bands for field identification and also with a numbered aluminum leg band provided by the U.S. Geological Survey. I obtained the necessary endangered species permits and banding permits from the U.S. Fish and Wildlife Service, U.S. Geological Survey, and State of South Carolina.

I selected 7 groups of red-cockaded woodpeckers for intensive observation of their foraging behavior. These groups were selected because they had a history of successfully breeding, thus increasing the likelihood that the group would remain intact for the entire length of the study.

During the nesting season, each active red-cockaded woodpecker cavity was checked to determine laying and hatching dates for eggs. Using a Swedish climbing ladder and safety rigging, a field crew member climbed to the nest entrance and used a lighted mirror to check the nest. Cavities also were checked for the presence of southern flying squirrels. Any squirrels that were found were humanely destroyed or removed from the area. After being removed from the nest using a noose (Jackson 1982), nestlings were weighed and banded as described. Fledging rates were determined for each group by observing the cluster location closely at the time the nestlings were anticipated to fledge and shortly thereafter. Reproductive rate was defined as the number of fledglings produced per successful nest. Mean reproductive rates were obtained for the groups from 1992 to 1996 as part of a long term monitoring effort for this species at the site.

Foraging observations were obtained from 1992 to 1995. For each foraging observation, the following data were collected: individual (band colors), date, time, tree species, tree height (m), tree condition (alive or dead), dbh (cm), tree age, foraging method, foraging substrate (trunk, limb), foraging site (crown, mid trunk, lower trunk), timber stand location (compartment and stand number), and weather conditions (percent cloud cover, wind conditions, precipitation). Location of each observation was more precisely defined using a global positioning system (GPS). Observations were obtained for all members of the red-cockaded woodpecker groups. Data were collected during all seasons of the year and all times during the day. When a bird was detected, it was followed until it made a foraging "strike" at which time the first observation was taken. A strike is defined as an actual attempt to collect prey. Sequential observations were at least 15 minutes apart to minimize interdependence of subsequent observations (Hejl et al. 1990). Porter et al. (1985) reported that a 15-minute interval between sequential observations of the same red-cockaded woodpecker was sufficient to consider the observations independent. Birds were observed from the time of leaving the roost cavity in the morning and, if possible, until they returned to the cavity at night. It is important to record foraging data throughout the day as there is some evidence that foraging may differ as the day progresses. For example, Nesbitt et al. (1978) and Repasky (1984) found red-cockaded woodpeckers foraging on dying and recently dead trees more frequently in the afternoon.

The Continuous Inventory of Stand Conditions (CISC) database provided information on stands that included the dominant tree vegetation, stand age, and stand condition on the Savannah River Site (U.S. Forest Service, unpublished data). In addition, vegetation was sampled in all stands within 800 m of the nest tree of each of the red-cockaded woodpecker groups that was studied. In each stand, 0.04-ha (0.1-ac) fixed radius plots were sampled at a rate of 1 plot per 2 ha (4.9 ac) of stand size following the procedures outlined in James and Shugart (1970). A random point was selected in each stand to serve as the beginning of a transect. Sample stations were 50 m (165 ft) apart along the transects. Transects were no closer than 50 m from each other. In each plot, the following variables were measured for each tree: tree species, tree height (m), tree condition (alive or dead), dbh, length of longest branch (m), age (increment bore reading), location (compartment/stand/red-cockaded woodpecker group number), and specific plot location. Data were grouped by age class (<20 years, 20-29 years, 30-39 years, and ≥40 years). Trees were classified by dbh as <20.3 cm, ≥20.3-25.4 cm, and ≥25.4 cm. During the early phase of the vegetation sampling, increment bore readings were taken for each tree; however, time constraints caused a modification in this process. In pine stands that appeared to be even-aged (and where the initial increment bore readings confirmed this observation), few pines were actually bored. Also, because of the difficulty involved in boring and reading hardwoods, as well as the fact that red-cockaded woodpeckers forage almost exclusively on pines, hardwoods were rarely bored in the later phases of vegetation sampling.

Canopy cover was estimated using the ocular tube method (James and Shugart 1970), including saplings as well as canopy trees. Stems ≥7.6 cm (3 in)

dbh were included. Groundcover was estimated also using the ocular tube method. Shrub density was assessed by making 2 transects at right angles to one another across the 0.04-ha circle and counting the number of woody stems within 1 m on either side of the transect. From the 0.04-ha plot information, I estimated how many pine and hardwood trees of specific ages and dbh class intervals were available within each of these stands. I then calculated how much of the stand fell within the 800 m radius circle. An estimate of the number of pine stems ≥25.4 cm dbh within the 800 m radius circle of the cavity tree was made based on the vegetation data and the proportion of the 800 m radius circle that the particular stand comprised. ArcInfo coverages were used to aid in this analysis.

Observations of all pine trees regardless of species were combined and classified by dbh and tree age. The percent use by each red-cockaded woodpecker group of pine trees in 4 age classes and 3 size classes was compared to availability within the 800 m radius circle to determine preference patterns. Estimates were derived for each of the groups and for a mean value for all groups. Actual use versus availability based on tree age and dbh for trees within 800 m of the clusters was compared for each of group and for all groups combined using a *G*-test (Sokal and Rohlf 1995), with a significance level of $P < 0.05$. Birds were monitored, nestlings were banded, and reproductive rate was estimated for each group on an annual basis as described in Franzreb (1997*a*). The reproductive rate (number of fledglings/breeding pair) for each of the 7 groups was compared over 5 years (1992 to 1996) to the availability of stems ≥ 25.4 cm dbh within the 800 m radius circle surrounding the nest cavity using analysis of variance (Sokal and Rohlf 1995).

RESULTS

There were a total of 6,284 foraging observations of all 7 groups ranging from a low/group of 754 to a high/group of 1005 (X = 897.71 + 29.55 SE). All but a very small proportion of the observations were in pine trees (K. Franzreb, U.S. Forest Service, unpublished data).

Within the groups, on average, approximately 69% of the pines available to the birds within the 800 m radius circles were less than 30 years in age. The proportion of available young pines (<20 years in age) varied from 3.3% for Group 7 to 44.1% for Group 5. The proportion of pines ≥40 years in age within the 800 m radius of the nest tree for each group varied from a low of 5.0% for Group 3 to a high of 32.5% for Group 4 (Table 1). Relict pine trees were present, though not numerous. The mean proportion of pine trees available for all groups in the <20, 20-29, 30-39, and ≥40 year age classes, was 26.1%, 42.4%, 18.2%, and 13.3%, respectively (Table 1). Groups 1, 2, 4, 5, and 7 did not use trees less than 20 years in age and Groups 1, 2, 3, 4, and 7 did

Table 1. Number and percent (in parentheses) of pine trees sampled by age class within 800 m of the nest tree of 7 groups of red-cockaded woodpeckers at the Savannah River Site, South Carolina (1992 to 1995).

	Number of Trees (%)				
Group No.	< 20 yrs	20 - 29 yrs	30 - 39 yrs	≥ 40 yrs	*N*
1	309 (38.4)	307 (38.1)	85 (10.6)	104 (12.9)	805
2	436 (27.0)	884 (54.8)	169 (10.5)	124 (7.6)	1613
3	228 (28.5)	317 (39.6)	216 (27.0)	40 (5.0)	801
4	99 (19.6)	136 (26.9)	106 (21.0)	164 (32.5)	505
5	598 (44.1)	441 (32.5)	271 (20.0)	45 (3.3)	1355
6	88 (21.6)	170 (41.8)	80 (19.7)	69 (17.0)	407
7	22 (3.3)	426 (63.3)	124 (18.4)	101 (15.0)	673
Mean	254 (26.1)	383 (42.4)	150 (18.2)	92 (13.3)	880
Total Sampled	1780 (28.9)	2681 (43.5)	1051 (17.1)	647 (10.5)	6159 (100.0)

Table 2. Number and percent (in parentheses) of pine trees sampled by size class within 800 m of the nest tree of 7 groups of red-cockaded woodpeckers at the Savannah River Site, South Carolina (1992 to 1995).

	Number of Trees (%)			
Group No.	< 20. 3 cm	≥ 20.3 - 25.4 cm	≥ 25.4 cm	*N*
1	756 (73.9)	95 (9.3)	172 (16.8)	1023
2	1423 (72.0)	266 (13.5)	288 (14.6)	1977
3	745 (60.0)	121 (9.7)	376 (30.3)	1242
4	424 (61.3)	68 (9.8)	200 (28.9)	692
5	1098 (62.2)	126 (7.1)	542 (30.7)	1766
6	304 (53.1)	38 (6.6)	230 (40.2)	572
7	270 (70.9)	45 (11.8)	66 (17.3)	381
Mean	717.1	108.4	267.7	1093.3
Total Pines Sampled (%)	5020 (65.6)	759 (9.9)	1874 (24.5)	7653 (100.0)

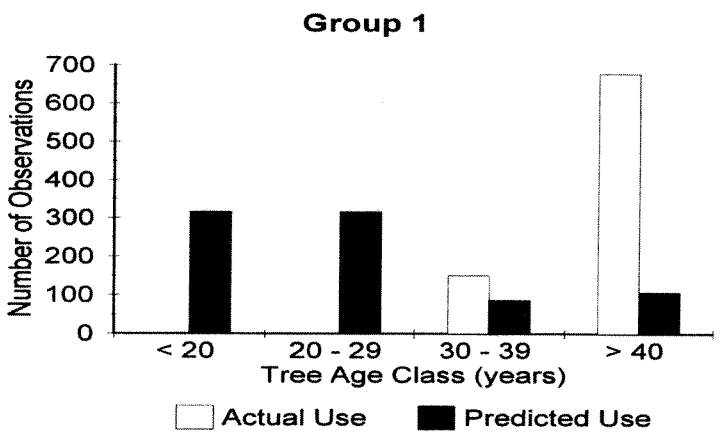

Figure 1. Foraging of red-cockaded woodpeckers in Group 1 versus availability of pine trees by tree age class within 800 m of group nest tree at the Savannah River Site, South Carolina (1992 to 1995).

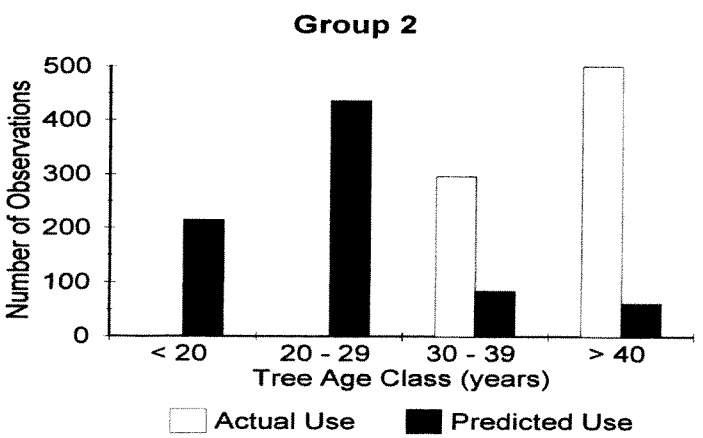

Figure 2. Foraging of red-cockaded woodpeckers in Group 2 versus availability of pine trees by tree age class within 800 m of group nest tree at the Savannah River Site, South Carolina (1992 to 1995).

not forage in trees 20-29 years in age (Figures 1-7). Each group showed a significant departure from random use of trees by age class (G values for all groups ≥ 378.90, df = 3, $P < 0.001$) (Figures 1-7). Thus, use of trees 30 years or less in age was significantly less than predicted based on availability ($G = 383.71$, df = 3, $P < 0.001$ for age class <20 years; $G = 282.80$, df = 3, $P < 0.001$ for age class 20-29.9 years). Trees 30-39 years in age were used more than expected by Groups 1, 2, 5, and 7, and in approximately the proportion they were available in Groups 3, 4, and 6. Each group displayed a strong preference for foraging in trees ≥40 years in age. Mean use of pines in the 30-39 and ≥ 40 year-old age classes were more than expected based on availability ($G = 311.25$, $P < 0.001$, $G = 178.13$, $P < 0.001$, respectively) (Figure 8).

Use of pines of different size classes was significantly different from random availability for all groups (Figures 9-15, all G values ≥ 323.29, df = 2, $P < 0.001$). The majority of pine trees available in the habitat were small (less than 20.3 cm dbh) (Table 2) and these trees were avoided by red-cockaded woodpeckers (Figures 9-15). Each group used medium-sized trees (size class ≥20.3-25.4 cm dbh) either in approximately equal or larger proportions than those available (Figures 9-15). Mean use by size class based on consolidated data for all groups showed a clear preference for trees in the middle size class ($G = 40.72$, df = 6, $P < 0.001$) and in the largest size class ($G = 90.96$, df = 6, $P < 0.001$) (Figure 16). On the basis of availability, it was predicted

that only 24.5% of the foraging observations of all groups combined would occur in trees with a dbh ≥25.4 cm. However, that size class contained 66.9% of the total foraging observations.

Reproductive success tended to increase with an increase in the number of pine stems ≥25.4 cm dbh within 800 m of the nest cavity (Figure 17). However, the group that inhabited the area with the highest number of pine stems ≥25.4 cm dbh (>25,000 pine stems) had a mean reproductive success rate of 2.4, which was only the fourth highest of the 7 groups. Higher reproductive rates (2.8 - 3.4) were observed in situations with at least 10,000 pine stems ≥25.4 cm dbh. Only 1 group, with a mean reproductive rate of 1.4, fell below the U.S. Fish and Wildlife Service requirements, having 5,691 stems ≥ 25.4 cm dbh within the 800 m radius circle. Reproductive rate was significantly related to the number of pine stems ≥25.4 cm dbh ($F_{6,28}$ = 5.75, P = 0.0005, MSE = 0.79).

DISCUSSION

The results of this study indicate that red-cockaded woodpeckers at the Savannah River Site prefer to forage in older, larger living pine trees, but will use trees ≥30 years in age. These preferences are similar to what has been observed in other parts of the range and are of particular interest because the Savannah River Site contains a generally younger forest structure than what is available in much of the remaining range.

During a 5 month study in 1976-1977, foraging behavior of the red-cockaded woodpecker at the Savannah River Site was compared to that of other sympatric woodpeckers: pileated woodpecker, red-bellied woodpecker (*Melanerpes carolinus*), hairy woodpecker (*D. villosus*), and downy woodpecker (*D. pubescens*) (Skorupa 1979). The red-cockaded woodpecker was the most specialized and stereotyped in its foraging behavior (Skorupa 1979).

Studies conducted at various locations have demonstrated that red-cockaded woodpeckers have preferences for foraging on larger trees (Skorupa 1979, Hooper and Lennartz 1981, DeLotelle et al. 1983). Engstrom and Sanders (1997) found that birds foraging in uncut, old-growth longleaf pine forest preferred the largest of the large trees (>50 cm dbh) even though that size class constituted only 15% of the trees. Zwicker and Walters (1999) found that birds responded to tree age, independent of tree size, although they also responded to size. For example, in their study, old-growth trees

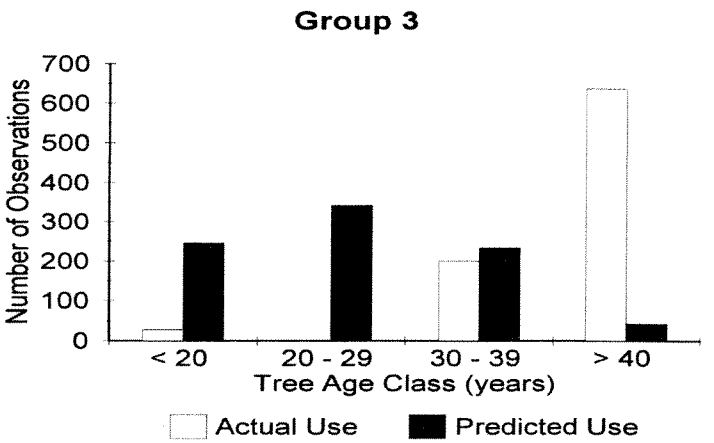

Figure 3. Foraging of red-cockaded woodpeckers in Group 3 versus availability of pine trees by tree age class within 800 m of group nest tree at the Savannah River Site, South Carolina (1992 to 1995).

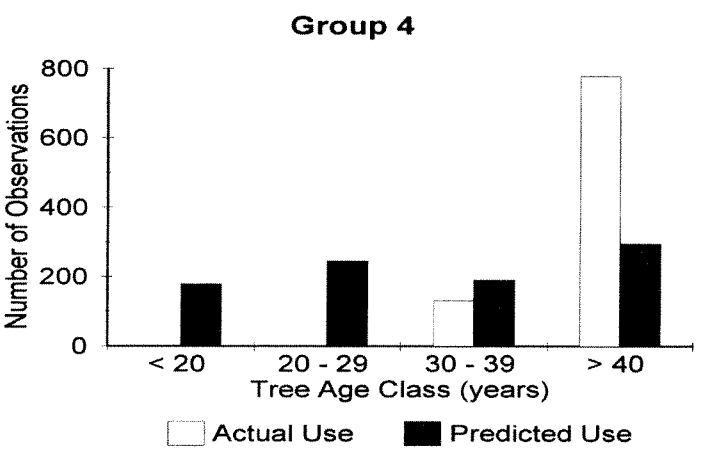

Figure 4. Foraging of red-cockaded woodpeckers in Group 4 versus availability of pine trees by tree age class within 800 m of group nest tree at the Savannah River Site, South Carolina (1992 to 1995).

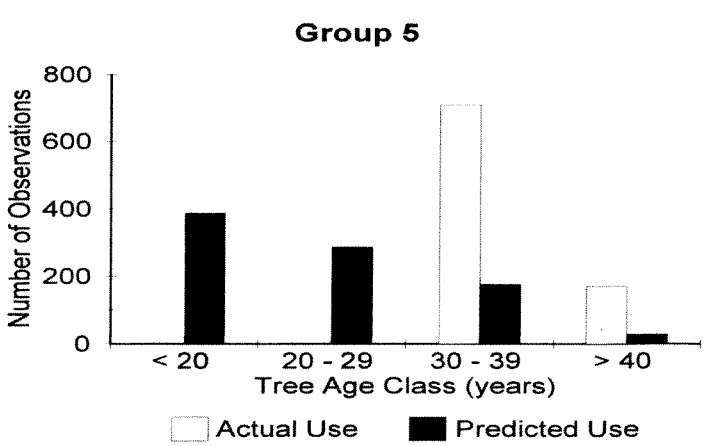

Figure 5. Foraging of red-cockaded woodpeckers in Group 5 versus availability of pine trees by tree age class within 800 m of group nest tree at the Savannah River Site, South Carolina (1992 to 1995).

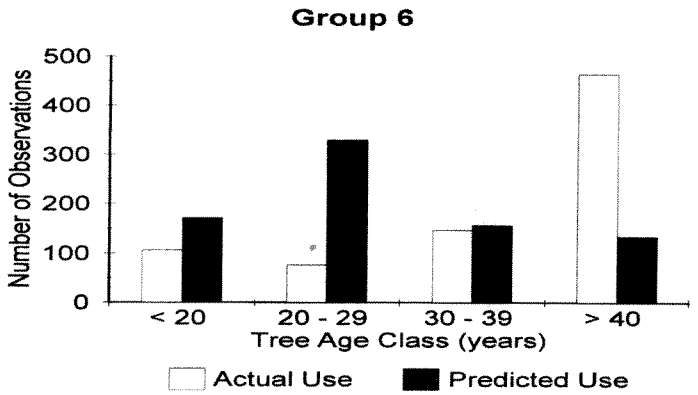

Figure 6. Foraging of red-cockaded woodpeckers in Group 6 versus availability of pine trees by tree age class within 800 m of group nest tree at the Savannah River Site, South Carolina (1992 to 1995).

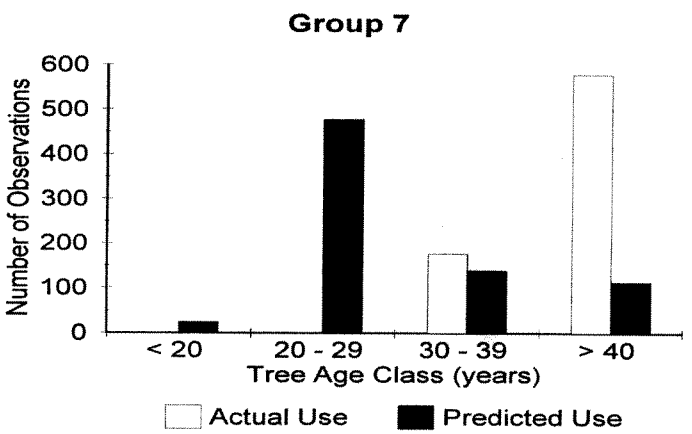

Figure 7. Foraging of red-cockaded woodpeckers in Group 7 versus availability of pine trees by tree age class within 800 m of group nest tree at the Savannah River Site, South Carolina (1992 to 1995).

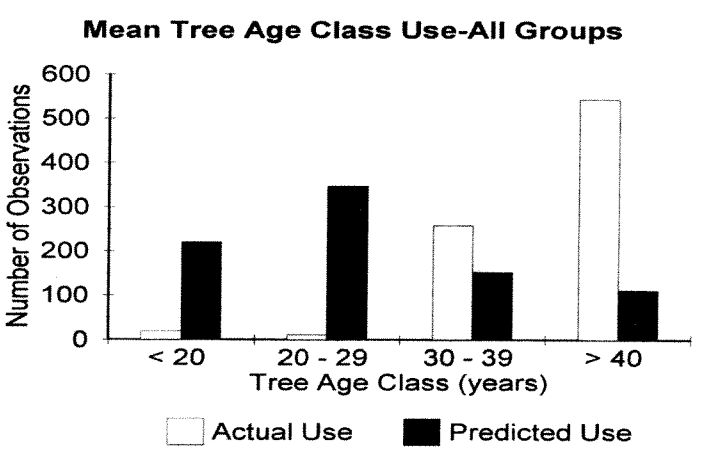

Figure 8. Mean tree use by foraging of red-cockaded woodpeckers, all groups combined, versus mean availability of pine trees by tree age class within 800 m of group nest trees at the Savannah River Site, South Carolina (1992 to 1995).

were strongly favored even though they did not represent the largest trees on the site. As Conner et al. (2001*a*) point out, as yet it is not possible to determine if demonstrated foraging preferences of red-cockaded woodpeckers are the result of tree age alone, tree size alone, or reflect both the age and size of the tree.

Foraging tree selection in relation to tree age has been the subject of a number of foraging studies. Once stands on the Francis Marion National Forest reached 30 years in age, stand age was not a significant factor in determining stand selection for foraging purposes (Hooper and Harlow 1986). Trees less than 50 years old were selected against by red-cockaded woodpeckers foraging in coastal North Carolina (Zwicker and Walters 1999). Red-cockaded woodpeckers foraging at Eglin Air Force Base in Florida preferred old growth trees, thus providing additional evidence of the birds' preference for feeding on the oldest trees available (Hardesty et al. 1997*b*). Both Zwicker and Walters (1999) and Hardesty et al. (1997*b*) demonstrated that trees in longleaf pine forest more than 60 years in age were used in approximately equal proportions to their availability and that use of younger trees was related to the availability of older trees. Hence, if older trees were more readily available, the birds would spend less time foraging on younger (<60 years) pine trees.

In an earlier study conducted on 2 groups of red-cockaded woodpeckers at the Savannah River Site, large diameter trees were preferred (58% utilization vs. 8% availability) (Skorupa 1979). Skorupa (1979) suggested that as volume-age relationships for tree stands display a sigmoidal pattern (when volume vs. age is plotted), it may be that the relationship of surface area to age is also sigmoidal. If so, then foraging habitat quality may be positively correlated with forest age up to a threshold point at which the sigmoidal curve becomes asymptotic. Using forestry yield tables and the fact that pine trunks approximate the shape of a right circular cone (Swank and Schreuder 1974), Skorupa (1979) estimated that the surface area-age curve for longleaf pine would reach an asymptote shortly after 60 years in age. In the case of loblolly pine, the asymptote would occur at about 35 years. This means that if the amount of trunk surface area/ha is of significant importance in determining foraging habitat quality, then the above estimated stand ages would reflect the minimum stand age for acceptable foraging habitat quality. However, in this study it was apparent that red-cockaded woodpeckers were reproducing while using

foraging habitat below these age class thresholds. It should be noted that the Forest Service staff at the Savannah River Site actively manages the red-cockaded woodpeckers there, including conducting an intensive flying squirrel removal program and intensively monitoring the woodpecker population (Franzreb 1997*a*). It is difficult to speculate how successful the red-cockaded woodpeckers would have been at this location without these intensive management activities.

At the time of this study, the U.S. Fish and Wildlife Service guidelines recommended maintaining 6,350 pine stems that were at least 25.4 cm dbh within 800 m of a red-cockaded woodpecker cluster. In my study the 2 groups with the lowest mean reproductive rates also had the lowest number of pine stems ≥25.4 cm dbh, although in only 1 group was the number of stems below that which the U.S. Fish and Wildlife Service recommended. Number of pine stems ≥25.4 cm dbh had a positive influence on reproductive success. Based on the data from these 7 groups, reproductive success at the Savannah River Site would be enhanced by providing more large trees within the 800 m radius of the nest trees. Further analysis will provide additional insights into habitat use, home range characteristics, and foraging ecology of this species on the site.

ACKNOWLEDGMENTS

This research was funded by the Department of Energy, Savannah River Site, and its cooperation is gratefully acknowledged. I am especially grateful to S. Schulze for field support, for generating the data bases to handle a large volume of behavioral and vegetation data, and for assistance with data analysis. I also thank my hard working research field staff whose support has been crucial to the success of the red-cockaded woodpecker research at the site. The Savannah River Site is a National Environmental Research Park. Funding was provided by the Department of Energy-Savannah River Operations Office through the U.S. Forest Service Savannah River under Interagency Agreement DE-IA09-76SR00056. I thank R. T. Engstrom and J. Blake for reviewing the manuscript and B. Parresol for statistical review. The cooperation of the USDA Forest Service Savannah River is gratefully acknowledged (J. Irwin, E. LeMaster, W. Jarvis, G. Gaines, D. Wilson, and various other staff). In particular, I thank Dr. J. Blake, Savannah River Forest Station, for his longstanding support of my research on the site.

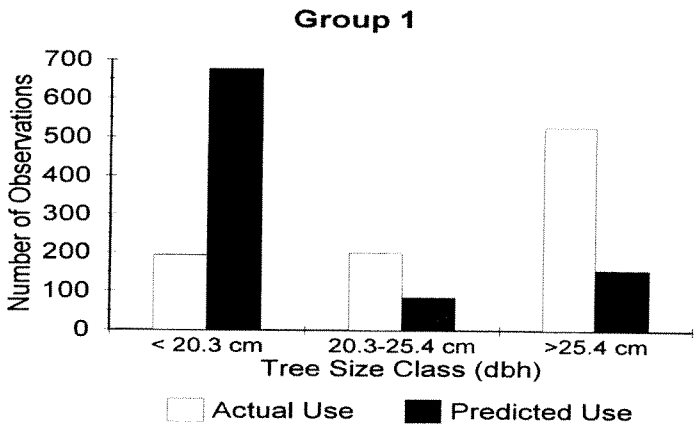

Figure 9. Foraging of red-cockaded woodpeckers in Group 1 versus availability of pine trees by size class within 800 m of group nest tree at the Savannah River Site, South Carolina (1992 to 1995).

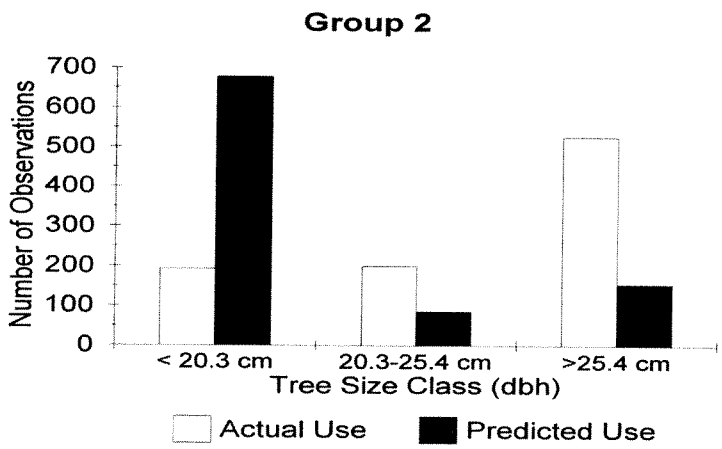

Figure 10. Foraging of red-cockaded woodpeckers in Group 2 versus availability of pine trees by size class within 800 m of group nest tree at the Savannah River Site, South Carolina (1992 to 1995).

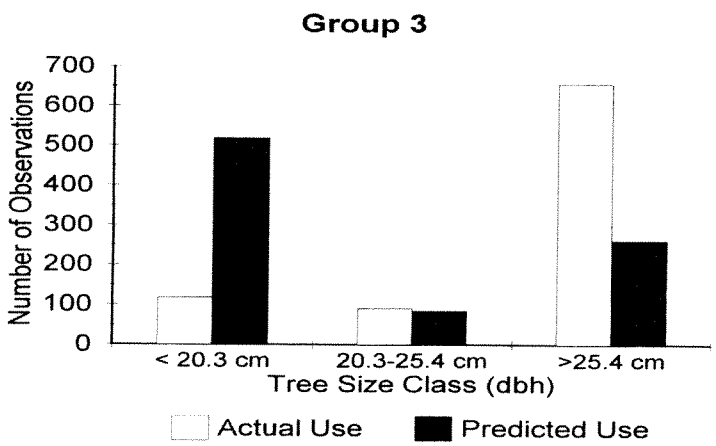

Figure 11. Foraging of red-cockaded woodpeckers in Group 3 versus availability of pine trees by size class within 800 m of group nest tree at the Savannah River Site, South Carolina (1992 to 1995).

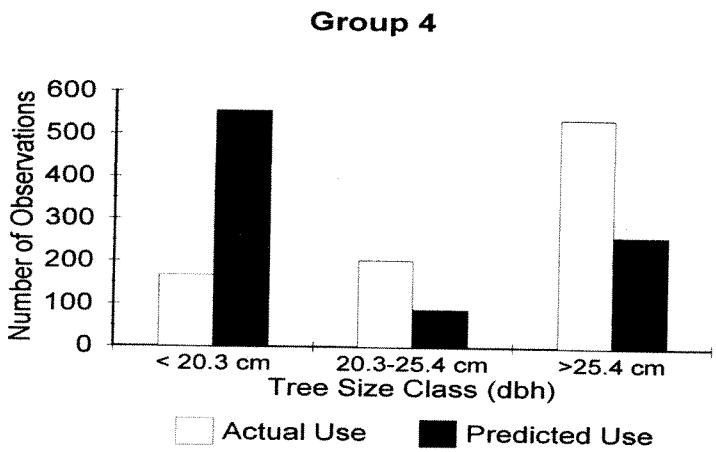

Figure 12. Foraging of red-cockaded woodpeckers in Group 4 versus availability of pine trees by tree size class within 800 m of group nest tree at the Savannah River Site, South Carolina (1992 to 1995).

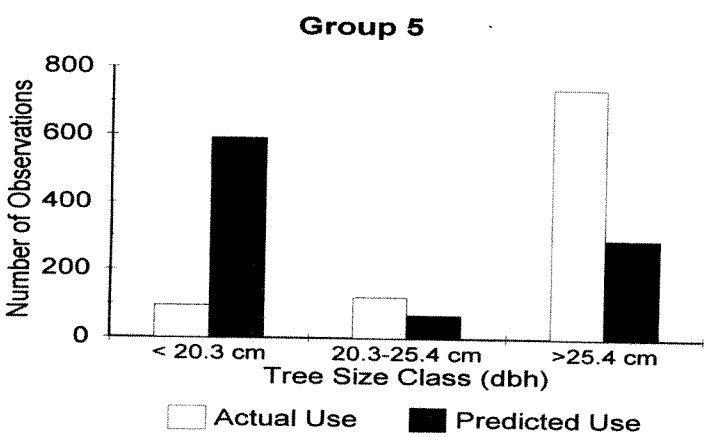

Figure 13. Foraging of red-cockaded woodpeckers in Group 5 versus availability of pine trees by tree size class within 800 m of group nest tree at the Savannah River Site, South Carolina (1992 to 1995).

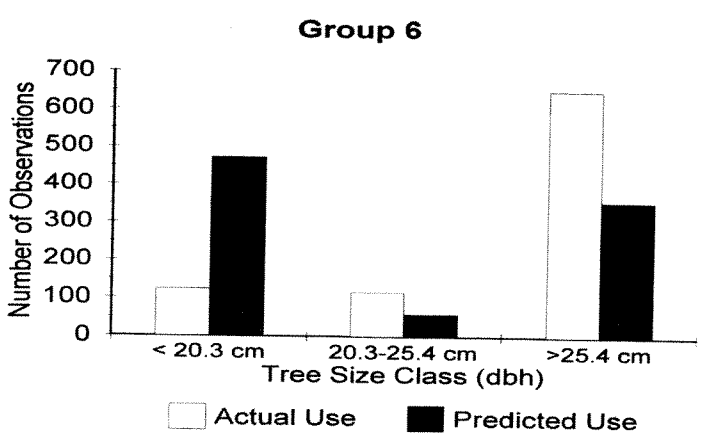

Figure 14. Foraging of red-cockaded woodpeckers in Group 6 versus availability of pine trees by tree size class within 800 m of group nest tree at the Savannah River Site, South Carolina (1992 to 1995).

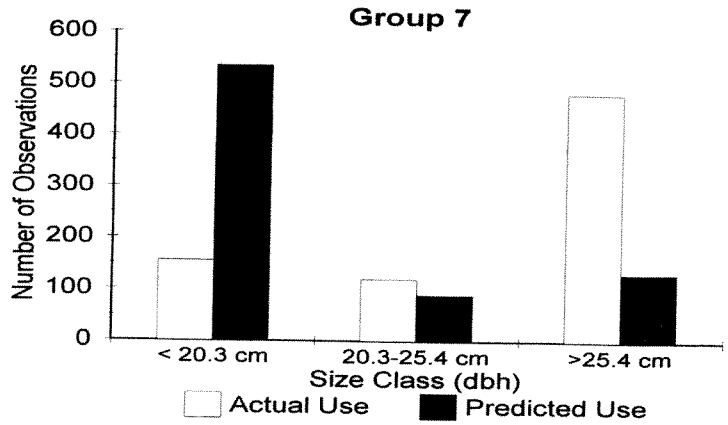

Figure 15. Foraging of red-cockaded woodpeckers in Group 7 versus availability of pine trees by tree size class within 800 m of group nest tree at the Savannah River Site, South Carolina (1992 to 1995).

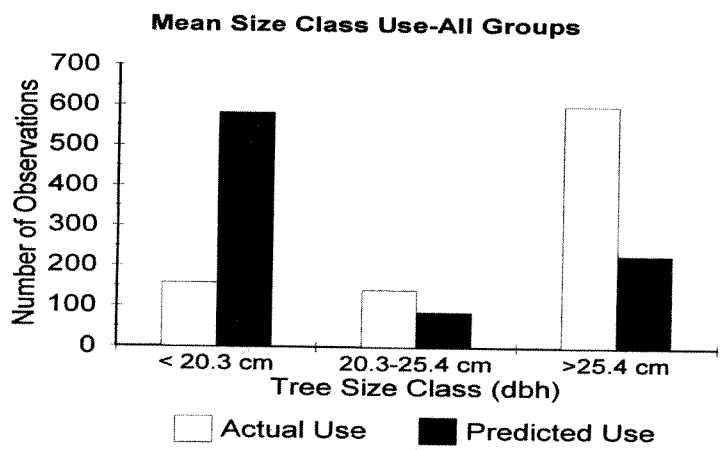

Figure 16. Mean tree use by foraging of red-cockaded woodpeckers, all groups combined, versus mean availability of pine trees by tree size class within 800 m of group nest trees at the Savannah River Site, South Carolina (1992 to 1995).

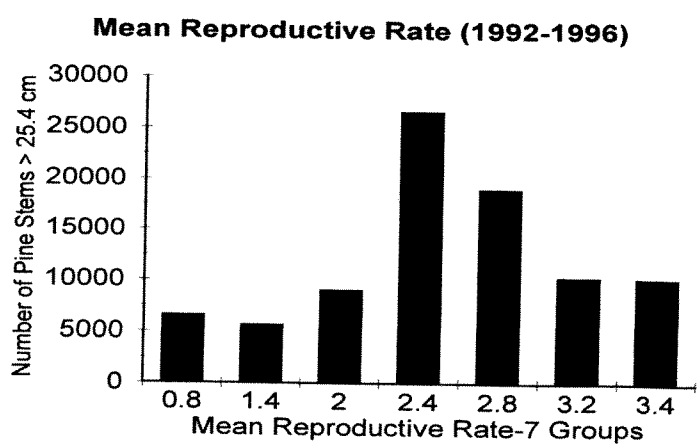

Figure 17. Red-cockaded woodpeckers mean reproductive rate versus number of pine stems greater than 25.4 cm dbh and within 800 m of the nest tree.

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