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INFLUENCE OF CAVITY AVAILABILITY ON RED-COCKADED WOODPECKER GROUP SIZE

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ABSTRACT.—The availability of cavities can determine whether territories are occupied by Red-cockaded Woodpeckers (*Picoides borealis*). However, there is no information on whether the number of cavities can influence group size and population stability. We compared group size between 1993 and 1995 in 33 occupied cluster sites that were provisioned with artificial cavities. The number of groups with breeding pairs increased from 22 (67.7%) in 1993 to 28 (93.3%) in 1995. Most breeding males remained in the natural cavities that they had excavated and occupied prior to cavity provisioning in the cluster while breeding females and helpers used artificial cavities extensively. Active cluster sites provisioned with artificial cavities had larger social groups in 1995 ($\bar{x}$ = 2.70, SD = 1.42) than in 1993 ($\bar{x}$ = 2.00, SD = 0.94; Z = −2.97, P = 0.003). The number of suitable cavities per cluster was positively correlated with the number of birds per cluster (r_s = 0.42, P = 0.016). The number of inserts per cluster was positively correlated with the change in group size between 1993 and 1995 (r_s = 0.49, P = 0.004). Our observations indicate that three or four suitable cavities should be maintained per cluster to stabilize and/or increase Red-cockaded Woodpecker populations. *Received 3 March 1997, accepted 27 Oct. 1997.*

The Red-cockaded Woodpecker (*Picoides borealis*) is an endangered species endemic to the pine forests of the southeastern United States (Jackson 1971). Red-cockaded Woodpeckers are unique among woodpeckers in the use of living pines for cavity excavation (Ligon 1970). The abundance and distribution of suitable cavities and residual pines for cavity excavation play a critical role in Red-cockaded Woodpecker population dynamics (Walters et al. 1992). Red-cockaded Woodpeckers are cooperative breeders, occuring in groups comprised of a breeding pair and 0–3 helpers (Lennartz et al. 1987, Walters et al. 1988). Each group inhabits and defends an aggregate of cavity trees, known as a cluster site, and associated foraging habitat (Hooper 1980, 1982). Group size may be an important factor influencing reproductive success (Lennartz et al. 1987) and population stability (Walters et al. 1988). Management practices which would stabilize and/or increase group size would promote recovery of the species. Artificial cavity techniques developed by Copeyon (1990) and Allen (1991) have provided managers with short-term management tools to offset the limitations of young, second-growth pine forests which typically lack adequate numbers of old-growth trees for cavity excavation. Artificial cavities have been used extensively to supplement Red-cockaded Woodpecker cluster sites having insufficient numbers of suitable natural cavities and to rehabilitate abandoned cluster sites. Such cavity provisioning has been used to stabilize and/or increase populations (Copeyon et al. 1991, Conner et al. 1995, Walters et al. 1992, Gaines et al. 1995, Richardson and Stockie 1995, Watson et al. 1995). Copeyon and coworkers (1991) demonstrated that the availability of cavities can determine whether or not territories are occupied. However, no published information has demonstrated whether the number of cavities can influence group size or population stability.

During surveys conducted between 1987 and 1992, biologists documented the limited availability of suitable cavities in occupied cluster sites on Fort Polk, Louisiana. Red-cockaded Woodpeckers excavate cavities in pines with decayed heartwood (Hooper et al. 1991a). The frequency of such decay is a function of tree age (Hooper et al. 1991a, Conner et al. 1994). Forests on the fort are relatively young (<80 years) and lack large numbers of old trees for cavity excavation. An intensive program was begun in 1993 to install artificial cavity inserts in all active cluster sites on the installation. Here, we describe the effect of cavity provisioning on group size.

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STUDY AREA AND METHODS

The study area was the Fort Polk military installation in Vernon Parish, Louisiana. The installation is currently used for training light infantry and simulating low to mid-intensity conflicts. The population in 1993 contained 33 active Red-cockaded Woodpecker clusters and has since been increasing. It is considered a subpopulation of the adjacent population on the Vernon Ranger District managed by the U.S. Forest Service. Vegetation consists primarily of a longleaf pine (*Pinus palustris*) overstory and an understory of bluestem grasses (*Andropogon* spp. and *Schizachrium* spp.). The area is managed for timber production on an 120-year rotation and prescribed burning is conducted on a 3-year rotation.

Starting in March 1993, artificial cavities were installed in 32 of 33 active cluster sites with fewer than four suitable cavities. Installation was completed by March 1995. Cavities were installed using the insert technique (Allen 1991) at heights of 4.0 m or 7.5 m, depending on the diameter of the trees available in the site. Provisioned cluster sites received up to four inserts depending on the number of usuable excavated cavities that were available in a site. Management of active sites was consistent for all sites during the period that sites were provisioned with inserts. Provisioning was considered a treatment while other variables that may influence population numbers were considered constant during the project. No sites were considered to have significant midstory development and none required midstory removal. All sites selected had adequate foraging according to guidelines of the U.S. Fish and Wildlife Service (1989). However, U.S. Army management guidelines required all suitable sites be provisioned with inserts. The resulting lack of control sites for comparison limits interpretation of our results.

Cavity trees were routinely monitored for activity (Jackson 1978a). All birds were captured on Fort Polk during the fall and winter of 1993 and 1995 as part of a monitoring program initiated in 1993. Birds were banded with unique combinations of colored leg bands and a U.S. Fish and Wildlife Service band. Nestlings have also been banded in the same manner since 1993. Banding birds enabled us to follow individuals as they moved between sites and to monitor changes in group size between years.

Total numbers and mean numbers per cluster of natural and artificial cavities was computed for 1993 and 1995 to assess cavity availability. Unenlarged natural cavities with entrance tunnels approximately 7 cm in diameter were considered useable (Rudolph et al. 1990) and were included in the analysis. Mean group size and mean numbers of helpers were compared between 1993 and 1995 in occupied clusters provisioned with inserts using a Wilcoxon pair-wise test. To assess the relationship between cavity availability and group size, adult group size was compared to the number of available cavities in 1995 and changes in adult group size were compared to the number of inserts installed per site using Spearman rank correlations. A χ^2-test was used to assess differences in the numbers of birds by social status using artificial and natural cavities during 1995. Numbers of birds using artificial and natural cavities during 1995 were used as observed values for the test. Analyses were performed with SPSS Version 6.0 (Norusis and SPSS Inc. 1993).

RESULTS

Thirty of the 33 clusters that were active in 1993 and which were provisioned with inserts were still active in 1995. Almost all (96 of 105) the birds recaptured in 1995 had been banded on the fort in 1993. Of the 105 birds captured in 1995, four birds originated from the population on the Vernon Ranger District. The origin of 5 unbanded birds was unknown. The small number of birds from the Veron population suggests that increases in group size on the fort were primarily the result of internal population changes rather than immigration from the Vernon population. The lack of population data prior to 1993 required our comparison of group size to use data from 1993 when 55 inserts had already been installed. The number of groups with breeding pairs increased from 22 (67.7%) in 1993 to 28 (93.3%) in 1995. By 1995, the number of available cavities had been increased by 139.4% in active clusters as a result of insert provisioning. The total number of inserts available and number of active inserts in 1995 exceeded the total number of natural cavities available and number of active natural cavities, respectively in a site (Table 1). In 1995, inserts comprised 57.9% of all active cavities with 55.6% of inserts being active and natural cavities made up 42.1% of all active cavities with 56.3% of natural cavities being active. The number of natural cavities remained almost constant between 1993 and 1995; only one new natural cavity was constructed during this time. No natural or artificial cavities were lost between 1993 and 1995. Most breeding males remained in the natural cavities which they had excavated and occupied prior to the insert program while breeding females and helpers used inserts extensively (Table 2).

Active cluster sites provisioned with artificial cavities had larger social groups in 1995 ($\bar{x}$ = 2.70, SD = 1.42) than in 1993 ($\bar{x}$ = 2.00, SD = 0.94; $Z = -2.97$, $P = 0.003$). The number of groups with helpers increased from 9 (27.3%) in 1993 to 15 (50.0%) in 1995. Provisioned sites had more helpers in 1995 ($\bar{x}$ =

TABLE 1. Total numbers and mean numbers (± SD) per cluster of natural and artificial cavities available in 1993 and 1995 on Ft. Polk.

	1993		1995	
	Total	No. active	Total	No. active
Total natural cavities	70	54	71	40
Total inserts	55	24	99	55
Mean cavities/cluster	3.79 (1.63)	2.36 (1.11)	5.09 (1.26)	2.76 (1.48)
Mean natural cavities/cluster	2.12 (1.14)	1.64 (0.82)	2.15 (1.12)	1.21 (0.99)
Mean inserts/cluster	1.67 (1.45)	0.73 (0.80)	3.00 (1.25)	1.67 (1.22)

0.70, SD = 0.88) than in 1993 ($\bar{x}$ = 0.33, SD = 0.60; $Z = -1.96$, $P = 0.05$). The number of suitable cavities per cluster was positively correlated with the number of birds per cluster ($r_s = 0.42$, $P = 0.016$; Fig. 1). The number of inserts per cluster was positively correlated with the change in group size between 1993 and 1995 ($r_s = 0.49$, $P = 0.004$; Fig. 2).

DISCUSSION

In 1993, most groups on Fort Polk appeared to be either single males or breeding pairs lacking helpers. The increase in group sizes observed in 1995 resulted from unpaired males acquiring mates and groups retaining males as helpers. The increase in reproduction resulting from additional breeding units should increase the number of subadult birds in the population. Most subadult females disperse and fill breeding vacancies while subadult males may remain as helpers in their natal cluster or disperse (Walters et al. 1988).

Helpers may enhance reproduction within clusters (Lennartz et al. 1987, Walters 1990, Heppell et al. 1994). The critical-resource model proposed by Walters (1990) suggests that cavities are the critical determinant of habitat quality. The addition of cavities to a site with few suitable cavities may enhance the quality of the site by providing additional roosting opportunities and encourage subadult males to remain and potentially inherit the territory. Subadult males which remain in their natal clusters may help stabilize populations by buffering against clusters going inactive as a result of the death of the breeding male. In addition, many solitary males occupying sites in 1993 that we provisioned had secured mates by 1995, suggesting that dispersing females may also prefer sites with many roosting alternatives.

TABLE 2. Numbers of Red-cockaded Woodpeckers by social status using natural and artificial cavities during 1995.

	Number of birds by cavity type			
Status	Natural	Artificial	χ^2	P
Breeding male	23	7	8.53	0.004
Breeding female	8	20	5.14	0.023
Helper	8	15	2.13	0.144

Females, and to a lesser extent helpers, appear to benefit when additional cavities are provided. Females are typically the most subordinate member of Red-cockaded Woodpecker social groups (Walters et al. 1988) and as a result may not always be able to secure an adequate roost cavity. Hooper and Lennartz (1983) observed breeding males, breeding females and helpers roosting in the open or in surplus cavities in adjacent territories when cavities were unavailable in their own site. Individuals roosting in the open may be more vulnerable to predation and/or extreme weather conditions, although no information is available on how much such factors contribute to mortality. A combination of these factors may have contributed to the lower numbers of breeding units and helpers observed in 1993 relative to 1995.

An increase in group size was observed only when at least 3 inserts were installed in a site. Sites with less than 3 inserts had at least 2 inactive, but suitable, natural cavities. The stable or decreasing group sizes in clusters with less than 3 inserts suggests that the remaining inactive natural cavities may not have been suitable for occupation. In addition, most excess natural cavities we considered suitable were not used between 1993 and 1995. Such cavities may have been occupied on a regular

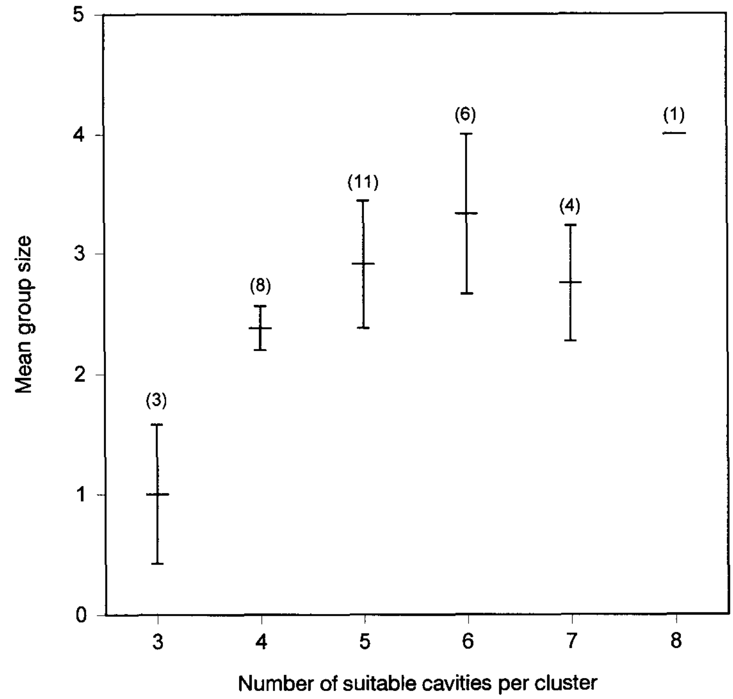

FIG. 1. Relationship between mean group size and number of suitable cavities per cluster in 1995 (bars indicate standard errors; number of clusters in parenthesis).

basis by southern flying squirrels (*Glaucomys volans*), particularly since flying squirrels prefer unenlarged cavities (Rudolph et al. 1990). There is little information on the other factors that may influence the ability of a cavity to remain suitable for Red-cockaded Woodpeckers over time. Birds have abandoned cavities in which the interior chamber had decayed and become too enlarged and deep to remain functional as roost sites (R. Conner, pers. comm.). Cavities we observed with large amounts of dead wood in the plate region surrounding the entrance were seldom used. Dead wood does not produce resin in the area of the plate and may deter use by woodpeckers which normally maintain extensive resin wells around the edges of the plate. The potentially subtle nature of factors influencing cavity suitability requires that the condition and number of surplus natural cavities should be examined closely when determining the number of artificial cavities necessary to supplement or rehabilitate a site.

Surplus cavities in a site may also reduce negative interactions between Red-cockaded Woodpeckers and other cavity-dependent species. At least 24 species of birds and mammals have been identified using Red-cockaded Woodpecker cavities as roost and/or nest sites (Jackson 1974, 1978b; Baker 1971; Harlow and Lennartz 1983; Rudolph et al. 1990). Several instances of interspecific aggression involving cavities have also been documented (Ligon 1971, Baker 1971, Jackson 1978b, Harlow and Lennartz 1983). Such interactions may be intense in clusters with few excess cavities, particularly following the breeding season when juvenile birds begin using cavities. Southern flying squirrels have been proposed as an important kleptoparasite of Red-cockaded Woodpecker cavities (Gaines et al. 1995, Richardson and Stockie 1995). Laves (1996) found an increase in Red-cockaded Woodpecker reproduction and in the number of helpers in treatment groups that had flying squirrels removed. However, Conner et al. (1996) observed no relationship between woodpecker reproductive success and flying squirrel use of cavities and no instances of woodpeckers forced to roost in the open be-

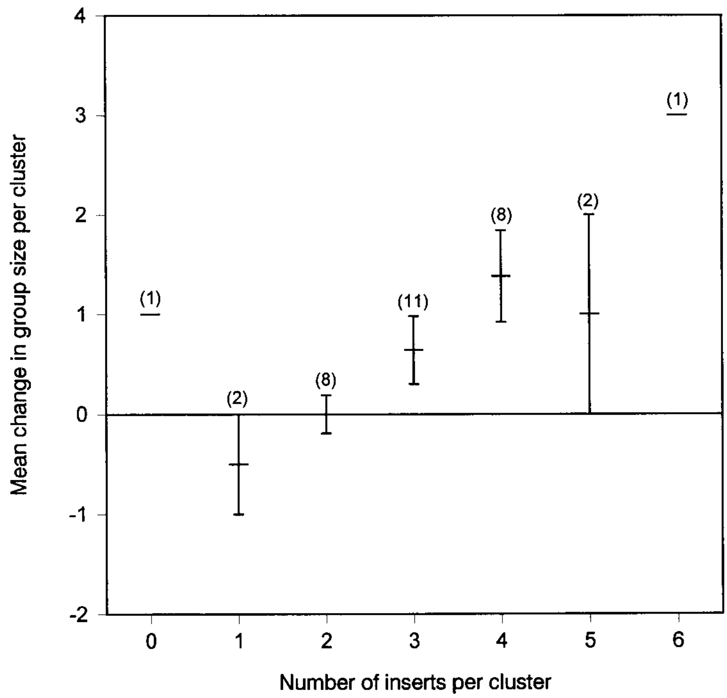

FIG. 2. Relationship between the mean change in group size between 1993 and 1995 and the number of inserts installed per cluster (bars indicate standard errors; number of clusters in parenthesis).

cause of squirrel-caused shortages of unenlarged cavities. Flying squirrels have been frequently found using active Red-cockaded Woodpecker cavities on the fort. Birds that were evicted from their cavities normally roosted in surplus cavities in their cluster or roosted in the open.

Interactions between Red-cockaded Woodpeckers and other cavity-dependent species may be exacerbated in small, declining woodpecker populations that are also stressed by other factors such as isolation and forest fragmentation (Conner and Rudolph 1989, Conner and Rudolph 1991). Negative interactions may be minimized by ensuring that excess cavities are available in each cluster. Because our analysis lacked control sites for comparison, our results may not be definitive and cannot determine an optimum number of suitable cavities. Watson et al. (1995) determined that the population on the Francis Marion National Forest had 3.7 usuable cavities per cluster prior to Hurricane Hugo. At that level, that population was increasing (Hooper et al. 1991b). Our observations and those on the Francis Marion population indicate 3 or 4 suitable cavities should be maintained to stabilize and/or increase Red-cockaded Woodpecker populations.

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