J. Field Ornithol. 73(2): 125-129, 2002

Does the availability of artificial cavities affect cavity excavation rates in Red-cockaded Woodpeckers?

Richard N. Conner,[1] Daniel Saenz, D. Craig Rudolph, and Richard R Schaefer

Wildlife **Habitat and** *Silviculture* **Laboratory, Southern Research Station, U.S. D.A. Forest Service,** *Nacogdoches,* Texas 75762 *USA*

Received 10 January 2001; accepted 17 April 2001

ABSTRACT. Rates of cavity excavation by Red-cockaded Woodpeckers (*Picoides* **borealis)** **were examined** from 1983 to 1999 on the Angelina National Forest in east Texas. We compared the rate of natural cavity excavation between 1983 and 1990 (before artificial cavities were available) with the rate of cavity excavation between 1992 and 1993, a period when artificial cavities were regularly installed within active woodpecker cavity-tree clusters. Our comparison was restricted to cavity-tree clusters in longleaf pine (*Pinus palustris*) and lohlolly (*P. taeda*)-shortleaf (*P. echinata*) pine habitats where woodpecker groups were present for the entire period between 1983 and 1399. Excavation rate of new cavities was significantly higher in longleaf pine habitat when artificial cavities were nor available than during the subsequent period when artificial cavities were provided in all active cavity-tree clusters. In loblolly-shortleaf pine habitat, we did nor detect a significant difference in the rate of new cavity excavation between rhe periods before and after the use of artificial cavities. Wc attribute the difference in results **between** habitats to a relative scarcity of cavities in loblolly-shortleaf pine sites due co a higher hark beetle-induced cavity tree mortality.

SINOPSIS. **¿Afecta la disponibilidad de cavidades artificiales las tasas de excavación de** ***Picoides borealis*** **?**

Se examinaron las tasasde excavación de cavidades por individuos de *Picoides* **borealis** en el Bosque Nacional de Angelina al este de Texas. Se comparó *la* tasa de excavaciones de cavidadcs naturales entre 1983 y 1990 (previo a hacer disponihles las cavidsdes arrificiales) con la tasa de excavación de estas entre 1992 y cl 1993, cuando se instalaron regularmente cavidadcs nrtificiales dcntro de grupos árboles con cavidades activas (con nidos) de Piciformes para aumentar la disponibilidad dc cavidades apropiadas para estos. Nuestra comparación se restringe a grupos de árboles con cavidades en habitats de *Pinus palustris* y de *P. taeda-P. echinata*, donde estuvieron presentes grupos de Piciformes por todo el período entre 1983 y 1999. Las tasas nuevas cavidades fué significativamente mayor en hábitats de *P. palustris* durante los primeros 8 años cuando las cavidades artificiales no estahan disponihles al compararsc con los 8 años posteriores (0.125 nuevas cavidades excavadas/grupo/año), cuando se colocaron cavidades artificiales en todos los grupos de árboles con cavidades activas. En hábitats de *P. taeda-P. echinata,* no detectamos una diferencia significativa en la tasa de nuevas excavaciones de cavidades entre los períodos de 8 años anteriores y posteriores al uso de cavidades arrificiales. Atribuímos esta diferencia en resultados entre habitats a una escasez relativa en cavidades en áreas de *P. taeda-P. echinata* debido a una mayor mortalidad de árboles producida por cavidades inducidas por coleópteros barrenadores.

Key **words:** cavity excavation, cavity-tree cluster, lohlolly pine, longleaf pine, management, *Picoides* **borealis**

The Red-cockaded Woodpecker (*Picoides borealis*) is a cooperative breeder that excavates cavities in live pines for nesting and roosting (Ligon 1370; Waiters et al. 1988). A single tree, or aggregation of cavity trees, termed the **cluster**, is inhabited by a group of woodpeckers that includes a single breeding pair (Walters 1990). New cavities are excavated regularly by the woodpeckers with cavities in loblolly and shortleaf pines averaging less time to excavate than those in longleaf pines, about two versus six years, respectively (Conner and Rudolph 1995a). In general, cavities are a rare resource because they rake a long time to excavate and pines suitable for excavation are often **in** short supply (Conner and Rudolph 1995a; Harding 1997).

In 1990 new technology became available (Copeyon 1990; Allen 199 I), and artificial cavities were installed in woodpecker **cluster** areas to augment the number of suitable cavities available (generally four per cluster) for woodpecker groups to use (Conner et al. 1995). Here, we ask whether the addition of artificial cavities influences cavity excavation behavior in Red-cockaded Woodpeckers. We explore this possibility by examining cavity excavation rates

[1] Corresponding author. Email: <c_connerrn@titan.sfasu.edu>

on the Angelina National Forest in Texas during an eight-yr period prior to the use of artificial cavities with an eight-yr period when artificial cavities were provided in all active woodpecker clusters.

STUDY AREA AND METHODS

Our study was conducted at the Angelina National Forest (31°15′N, 94°15′W) in east Texas from 1983-1999. A co-occurring mixture of loblolly (*Pinus taeda*) and shortleaf (*P. echinata*) pines dominate the northern portion of this forest, whereas longleaf pine (*P. palustris*) is dominant in the southern portion (Conner and Rudolph 1989). Longleaf pines are infrequent on the northern Angelina National Forest, and young slash pines (I? *elliottii*), an introduced species in this region, are not sufficiently old for cavity excavation where they occur near active woodpecker clusters.

We regularly visited all active and inactive Red-cockaded Woodpecker cavity-tree clusters each year from March through June, as well as occasionally at other times through the year, and examined them closely for use by woodpeckers. Existing cavity trees and other pines in the cluster areas were examined for new-cavity starts and new cavities. We noted the year in which new cavities were completed and used by Red-cockaded Woodpeckers. Although we had exact measures of group size during later years of the study, we used the number of active cavity trees within each cavity-tree cluster as an estimate of group size in order to have an equivalent estimate throughout the study. Active cavities had clear, fresh resin flowing from reddish resin wells (recently pecked), and the boles of active cavity trees were reddish because of bark scaling by Red-cockaded Woodpeckers (see Jackson 1977, 1978). During annual visits to cluster areas, we determined the number of naturally excavated cavities and cavity inserts available for woodpeckers to use and the numbers used within each cluster. See Conner and Rudolph (I 995a) for details on our methods.

Our comparisons of cavity excavation rates were restricted to cavity-tree clusters in longleaf pine ($N = 9$) and loblolly-shortleaf pine ($N = 5$) habitats where woodpecker groups were present for the entire period from 1983-1999. We used a chi-square analysis to compare the number of new, naturally excavated cavities from 1983-I 990 (pre-artificial cavity period) with the number excavated from 1992-I 999. We excluded new naturally excavated cavities completed in 193 1 from the analysis because it was a transitional year during which cavity inserts were still being installed in some clusters. We felt that chi-square analysis did not violate the assumption of independence because, at best, cavity excavation rate was about 0.5 cavity per year, group membership was two to four birds per group, and membership changed throughout the 17-yr study as birds died or changed group membership. In view of the possibility that excavation of individual cavities was not independent across years, we also used a binomial test to compare overall excavation rates of the two time periods (before and after cavity inserts), as well as a t-test to compare cavity excavation rates per group per year during the two time periods.

In late 1990 and 1991, all active cavity-tree clusters began to receive artificial insert cavities, precluding a comparison of excavation rates of groups with and without artificial cavity inserts during the same time period. Although we were unable to have a true experimental control, we suggest that the eight-yr span for both periods of time should reduce the likelihood that annual variation biased our results. We used a *t*-test to compare the rate of cavity insert installation between forest cover types to make sure that augmented cavity availability did not differ among habitat types. We used t-tests to compare the number of active cavity trees within cavity-tree clusters as an estimate of woodpecker group sizes to determine if group size varied between treatment periods within and among forest cover types.

RESULTS

Red-cockaded Woodpeckers excavated fewer cavities after the installation of cavity inserts than they did in the period before inserts were present. Twenty-two new cavities were completed between 1983 and 1990 in longleaf pines; nine were completed between 1992 and 1939. We did not detect a difference in loblolly and shortleaf pines where the sample size was only five woodpecker groups; 22 new cavities were completed prior to the use of inserts; 15 were completed when inserts were available (Table 1). Of the nine groups of woodpeckers

Table 1. Red-cockaded Woodpecker cavity excavation rates in longleaf and loblolly-shortleaf pine habitats before (I 983-l 990) and after (1992-I 999) the use of artificial insert cavities at the Angelina National Forest in east Texas.

	Before inserts	After inserts	Tesr	P
Longleaf"				
No. new cavities excavated	22	9	χ^2_1 = 5.45	0.02
No. groups excavating more cavities	8	1	Binomial test	0.02
New cavities excavated/group/yr	0.31 (0.21)	0.12 (0.20)	t = 2.16	0.04
Cavities available for use/group/yr	8.3 (0.8)	13.3 (1.6)	t = 7.94	<0.0001
Cavity inserts installed/group/yr	0.0	0.78 (0.54)		
Loblolly-shortleaf[b]				
No. new cavities excavated	22	15	χ^2_1 = 1.32	0.25
No. groups excavating more cavities'	3		Binomial test	0.50
New cavities excavated/group/yr	0.55 (0.11)	A.28 (0.29)	t = 1.99	0.08
Cavities available for use/group/yr	7.2 (0.7)	11.1 (1.1)	t = 8.71	<0.0001
Cavity inserts installed/group/yr	0.0	1.05 (1.08)		

[a] Nine Red-cockaded Woodpecker groups.
[b] Five Red-cockaded Woodpecker groups.
[c] One group excavated the same number of new cavities during both time periods.

in longleaf pine habitat, eight groups excavated fewer new cavities, and one group excavated more new cavities after inserts were installed than prior to the availability of cavity inserts (χ^2_1 = 5.44, P = 0.02). Of the five woodpecker groups in loblolly and shortleaf pine habitat, three groups excavated fewer new cavities, one group excavated more new cavities, and one group excavated the same number of new cavities when inserts were available than before inserts were available (χ^2_1 = 1.00, P = 0.32). More cavities were available for use by Red-cockaded Woodpeckers after the installation of cavity inserts than before inserts were present in both longleaf and loblolly and shortleaf pine habitats (Table I). When cavity inserts were available, more cavities were available in longleaf pine habitat than in loblolly and shortleaf pine habitat (t = 3.13, P = 0.007).

The rate that cavity inserts were installed within forest types did not differ. From 1992–1999, an average of 1.05 inserts were installed per woodpecker group per year in loblolly and shortleaf pine habitat, whereas an average of 0.78 inserts per group per year were installed in longleaf pine habitat (t_{12} = 1.2, P = 0.26). An average of 4.4 active cavity trees were killed by bark beetles *(Dendroctonus frontalis* and *Ips* spp.), and 1.4 died from wind damage, per group in loblolly and shortleaf pine habitat from 1992-1999, whereas only 0.4 active cavity trees were killed by bark beetles and 0.1 died from wind damage per group in longleaf pine habitat over the same period. Previous studies suggest that active naturally excavated cavity trees and active insert cavity trees are infested and killed by bark beetles at similar rates (Conner et al. 1998b).

Comparisons of woodpecker group sizes (estimated by the number of active cavity trees within cavity-tree clusters) before and after cavity inserts became available failed to detect temporal differences in group size in either longleaf or loblolly-shortleaf pine habitats (t = 0.86, P = 0.42; t = 0.41, P = 0.70, respectively). Similarly, no group-size differences were detected between longleaf and loblolly-shortleaf pine habitat types either before or after the availability of artificial cavities (t = 0.17, P = 0.87; t = 1 .06, P = 0.31, respectively).

During the breeding season in 1999 the proportion of woodpeckers roosting in naturally excavated cavities versus insert cavities was greater in loblolly-shortleaf pine habitat than in longleaf pine (χ^2_1 = 4.21, P = 0.04). During this period, Red-cockaded Woodpeckers used 12 naturally excavated cavities for roosting and six insert cavities in the loblolly-shortleaf habitat, and 18 naturally excavated cavities and 29 insert cavities in the longleaf habitat.

During 1999 in loblolly-shortleaf pine habitat, Red-cockaded Woodpeckers nested in 12 of 33 available naturally excavated cavities and 6 of 26 available insert cavities (χ^2_1 = 1.21, P

= 0.27). In longleaf pine, the woodpeckers nested in 18 of 83 available naturally excavated cavities and 29 of 52 available insert cavities (χ^2_1 = 16.36, $P < 0.0001$), suggesting that in the latter habitat cavity inserts were used more often for nesting than would be expected based on their availability.

DISCUSSION

The presence of a surplus of suitable cavities within cluster areas provisioned with cavity inserts may have reduced the stimulus for Red-cockaded Woodpeckers to complete existing cavity starts and begin new cavity excavation. Also, when woodpeckers use new insert trees, they invest substantial work to excavate resin wells and remove loose bark from the bole of the pine, likely decreasing time available for new cavity excavation. We did not observe a significant decrease in new cavity excavation in loblolly-shortleaf pine habitat. However, the mortality rate of active cavity trees in loblolly-shortleaf pine habitat was more than five times the rate in longleaf pines before inserts were available (Conner et al. 1991) and about 10 times the rate of active longleaf pine cavity trees during the period when artificial cavities were available. Thus, a surplus of suitable cavities in loblolly-shortleaf pine likely never occurred because many cavity-insert trees and naturally excavated cavity trees were infested and killed by southern pine beetles (Conner and Rudolph 1995b; Conner et al. 1998b).

Because of the difference in excavation rates we observed between longleaf and loblolly-shortleaf pine habitats before and after the availability of inserts, we suggest that new cavity excavation rates may be linked to cavity availability. We were only able to measure the number of new cavities excavated over the 17-yr study period and not actual excavation effort of all woodpeckers in all groups. We assume the two are correlated. We realize that our sample sizes are small, but cavity excavation is a slow process (Conner and Rudolph 1995a; Harding 1997), and the data used in this study required 17 yr to collect. Alternatively, fewer new cavities per woodpecker group may have been excavated in longleaf pine because old-growth longleaf pines with appropriate characteristics for cavity excavation are a rare and declining resource.

Although more cavity inserts were installed per woodpecker group in loblolly-short-leaf pine habitat in 1999, woodpeckers used cavity inserts at a higher rate in longleaf pine than they did in loblolly-shortleaf pine habitats. The high cavity tree mortality and cavity excavation rates in loblolly-shortleaf habitat may have created a higher occurrence of new naturally excavated cavities relative to insert cavities, compared to the longleaf habitat. Breeding male Red-cockaded Woodpeckers prefer the newest natural cavities in loblolly, shortleaf, and longleaf pines (Conner et al. 1998a). Woodpeckers in the loblolly-shortleaf pine cavity trees apparently often moved from beetle-killed insert-cavity trees to newly excavated cavities, whereas in longleaf pine, insert-cavity trees were acceptable to the woodpeckers and resistant to beetles.

ACKNOWLEDGMENTS

We thank J. Doresky, R. T. Engstrom, S. R. Harding, J. A. Jackson, F. C. James, J. D. Ligon, M. S. LaBranche, B. R. Parresol, and J. R. Walters for constructive comments on an early draft of the manuscript. The U.S. Forest Service's Wildlife Habitat and Silviculture Laboratory is maintained in cooperation with the Arthur Temple College of Forestry, Stephen F. Austin State University.

LITERATURE CITED

ALLEN, D. H. 1931. Constructing artificial Red-cockaded Woodpecker cavities. United States Department of Agriculture, Forest Service General Technical Report SE-73.

CONNER, R. N., AND D. C. RUDOLPH. 1989. Red-cockaded Woodpecker colony status and trends on the Angelina, Davy Crockett and Sabine National Forests. United States Department of Agriculture, Forest Service Research Paper SO-250.

———, and ———. 1995a. Excavation dynamics and use patterns of Red-cockaded Woodpecker cavities: relationships with cooperative breeding. In: Red-cockaded Woodpecker: recovery, ecology and management (D. L. Kulhavy, R. G. Hooper, and R. Costa, eds.), pp. 343-352. College of Forestry, Stephen F. Austin State University, Nacogdoches, TX.

———, and ———. 1995b. Losses of Red-cockaded Woodpecker cavity trees to southern pine beetles. Wilson Bulletin 107: 81–92.

———, ———, D. L. KULHAVY, AND A. E. SNOW. 1991. Causes of mortality of Red-cockaded Woodpecker cavity trees. Journal of Wildlife Management 55: 531–537.

———, ———, and L. H. BONNER. 1995. Red-cockaded Woodpecker population trends and management on Texas National Forests. Journal of Field Ornithology 66: 140–151.

———, D. SAENZ, D. C. RUDOLPH, W. G. ROSS, AND

D. L. KULHAVY. 1998a. Red-cockaded Woodpecker nest-cavity selection: relationships with cavity age and resin production. Auk 115: 447–454.

———, ———, ———, and R. N. COULSON. 1998b. Southern pine beetle-induced mortality of pine with natural and artificial Red-cockaded Woodpecker cavities in Texas. Wilson Bulletin 110: 100–109.

COPEYON, C. K. 1990. A technique for constructing cavities for the Red-cockaded Woodpecker. Wildlife Society Bulletin 18: 303–311.

HARDING, S. R. 1797. The dynamics of cavity excavation and use by the Red-cockaded Woodpecker (*Picoides borealis*). M.Sc. thesis. Virginia Polytechnic Institute and State University, Blacksburg, VA.

JACKSON, J. A. 1977. Determination of the status of Red-cockaded Woodpecker colonies. Journal of Wildlife Management 41: 448-452.

———. 1978. Pine bark redness as an indicator of Red-cockaded Woodpecker activity. Wildlife Society Bulletin 6: 171-172.

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

WALTERS, J. R. 1990. Red-cockaded Woodpeckers: a "primitive" cooperative breeder. In: Cooperative breeding in birds (I? B. Stacey and W. D. Koenig, eds.), pp. 69–101. Cambridge University Press, UK.

———, I? D. DOERR, AND J. H. CARTER, III. 1988. The cooperative breeding system of the Red-cockaded Woodpecker. Ethology 78: 275-305.