J. Field Ornithol., 66(1):140–151

RED-COCKADED WOODPECKER POPULATION TRENDS AND MANAGEMENT ON TEXAS NATIONAL FORESTS

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Abstract.—Red-cockaded Woodpecker (*Picoides borealis*) population trends and concurrent management on four national forests in eastern Texas were evaluated from 1983 through 1993. Following years of decline, populations stabilized and began to increase after intensive management efforts were initiated. Management activities included control of hardwood midstory and understory, thinning pines within woodpecker cavity-tree cluster areas, use of cavity restrictors and artificial cavities, translocation of first-year woodpeckers to replace lost breeders, and reintroductions of male and female first-year woodpeckers to form totally new breeding pairs. Most newly formed woodpecker groups were associated with midstory removal (30) and installation of artificial cavities (22). Reversal of severe declines on the three small populations in eastern Texas suggests that recovery of other small populations throughout the south is an achievable goal if management is committed to recovery of the species.

TENDENCIAS POBLACIONALES DE *PICOIDES BOREALIS* Y SU MANEJO EN LOS BOSQUES NACIONALES DE TEXAS

Sinopsis.—Entre 1983 y 1993 se evaluaron las tendencias poblacionales de *Picoides borealis* y su manejo actual en cuatro bosques nacionales en el este de Texas. Después de años de reducción numérica, las poblaciones se estabilizaron y comenzaron a aumentar tras iniciar esfuerzos intensivos para su manejo. Actividades para manejar la especie incluyeron el control del sotobosque medio y bajo en bosques de maderas duras, limpiar pinos dentro de áreas donde los pájaros carpinteros construían muchos nidos, usar restrictores a las cavidades y usar cavidades artificiales, trasladar individuos de un año para reponer aves reproductoras perdidas y reintroducir individuos de un año de ambos sexos para formar parejas completamente nuevas. La mayoría de los grupos nuevos de pájaros carpinteros que se formaron fueron asociados a la remoción del sotobosque (30) y a la instalación de cavidades artificiales (22). El revertir el descenso numérico en las tres poblaciones pequeñas del este de Texas sugiere que la recuperación de otras poblaciones pequeñas a través del sur de los E.E.U.U.A. es una meta alcanzable si el manejo de los bosques está comprometido con la recuperación de la especie.

The Red-cockaded Woodpecker (*Picoides borealis*) is an endangered species that has continued to decline throughout its range during the 1980s (Baker 1982, 1983; Carter et al. 1983; Conner and Rudolph 1989; Costa and Escano 1989; Eddleman and Clawson 1987; Jackson 1980; Masters et al. 1989; Ortego and Lay 1988) despite two decades of protection under the Endangered Species Act and two recovery plans. Of the 26

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Red-cockaded Woodpecker populations on national forests, 11 were still declining between 1990 and 1992 and 15 appeared to be stable (U.S. Department of Agriculture 1993). South-wide, only in one instance has an increase occurred in a population without the aid of artificial cavities and woodpecker translocations (Hooper et al. 1991). This increase occurred in a large population estimated to contain 427 woodpecker groups on the Francis Marion National Forest in South Carolina prior to Hurricane Hugo. It is thought that the large population and observed increase were due primarily to the history of prescribed burning and the relative abundance of potential cavity trees (Hooper et al. 1991). Furthermore, the largest remaining woodpecker population (nearly 700 woodpecker groups on the Apalachicola National Forest in Florida) has recently exhibited signs of population declines, particularly within the smaller subpopulations on the eastern portion of the forest (James 1991).

Small Red-cockaded Woodpecker populations (<50 woodpecker groups) appear to be highly vulnerable to cluster isolation, habitat fragmentation and demographic problems, and thus, are more likely to suffer population declines than larger populations (Conner and Rudolph 1989, 1991a; Costa and Escano 1989; Hooper and Lennartz 1995; Rudolph and Conner 1994). Populations composed of <10 clans with large distances between clusters are in critical danger of extirpation (Conner and Rudolph 1989, 1991a). Stabilizations and increases of critically small Red-cockaded Woodpecker populations are urgently needed throughout the south (Costa and Escano 1989). Populations in Texas declined during the 1960s (Lay 1969, Lay and Russell 1970), 1970s (Jackson et al. 1978), and 1980s (Conner and Rudolph 1989, Ortego and Lay 1988, Rudolph and Conner 1994).

We examined population trends of Red-cockaded Woodpeckers on the four national forests in eastern Texas over the past decade. These four populations include three that are relatively small (8–40 woodpecker groups) on the Angelina, Davy Crockett and Sabine National Forests and one of moderate size (>100 woodpecker groups) on the Sam Houston National Forest, all of which declined during the 1980s. We evaluated court-ordered management and other intensive management activities that included removal of hardwood vegetation from cluster areas and pine thinning (Conner and Rudolph 1991b), installation of cavity restrictors (Carter et al. 1989), an aggressive artificial cavity program (Allen 1991, Copeyon 1990) to offset significant cavity tree mortality (Conner et al. 1991), woodpecker translocation (DeFazio et al. 1987, Allen et al. 1993), and reintroduction of new woodpecker groups (Rudolph et al. 1992). Concurrent with evaluation of management activities, we monitored woodpecker population responses to these special recovery efforts.

STUDY AREAS

The Angelina (31°15′N, 94°15′W), Davy Crockett (31°21′N, 95°07′W), Sabine (31°30′N, 93°45′W) and Sam Houston (30°30′N, 95°22′W) National Forests are located in central to south-central eastern Texas. The

Davy Crockett (65,359 ha) and Sam Houston (65,218 ha) National Forests are composed predominantly of loblolly (*Pinus taeda*)-shortleaf (*P. echinata*) pine, whereas only the northern portions of the Angelina (62,423 ha) and Sabine (63,923 ha) National Forests are covered by these pines. Longleaf pine (*P. palustris*) is the dominant tree species on the southern portions of the Angelina and Sabine National Forests in the areas where Red-cockaded Woodpeckers are found (Conner and Rudolph 1989, Rudolph and Conner 1994).

The loblolly-shortleaf pine habitat occurs mainly on mesic, shrink-swell clays (Woodtel and LaCerda soil types), which readily support growth of hardwood vegetation. Longleaf pine habitat occurs primarily on deep loamy sands (Tehran and Letney soil types) containing materials of volcanic origin. These soils contain very little organic material resulting in a low water-holding capacity. High soil temperatures during summer and limited water in these soils limit the growth of hardwoods on these sites. Thus, efforts to control hardwood vegetation within cluster areas is more difficult in loblolly-shortleaf pine habitat than in the longleaf pine type.

Woodpecker populations on each of the four Texas national forests were composed of aggregations of smaller, relatively isolated subpopulations (Conner and Rudolph 1989, Rudolph and Conner 1994). In 1990, three small subpopulations (each having only 1–4 breeding pairs) were well isolated from each other (>25 km apart) on the Sabine National Forest. The Angelina National Forest also contained three widely separated subpopulations with woodpeckers on the northern side (six active clusters) of the forests 34 km distant (plus the 4–6-km wide Sam Rayburn Reservoir) from about 14 active clusters in the combined two southern subpopulations. Two subpopulations were present on the Davy Crockett National Forest; the larger northern subpopulation (about 20 active clusters) was 25 km distant from small aggregation of three breeding pairs on the southeastern portion of the forest. Three subpopulations were present on the Sam Houston National Forest. The largest (>100 pairs) on the western portion of the forest, about 10 clusters on the Four Notch area to the north, and about 24 active clusters on the San Jacinto Ranger District on the southeastern portion of the forest.

METHODS

We monitored cavity-tree cluster status (active vs. inactive) of Red-cockaded Woodpecker populations on the Angelina (1983–1993), Davy Crockett (1987–1993), Sabine (1987–1993) and Sam Houston (1988–1993) National Forests (Conner and Rudolph 1989, Rudolph and Conner 1994, National Forests and Grasslands in Texas Ranger District records). Active and inactive cavity-tree clusters on all forests were visited at least annually, primarily during the spring. Cluster areas were judged active when bark bordering resin wells of cavity trees was red, indicating recent pecking (Jackson 1978), and clear, fresh pine resin was flowing from the wounds. Other factors used to evaluate cluster-area status included presence and activity of Red-cockaded Woodpeckers and fresh scaling of bark on pines

within the cluster area (Jackson 1977, 1978). We searched active cluster areas regularly and noted new cavity trees. National Forest records from the Ranger Districts on the Davy Crockett National Forest were used to determine the number of active clusters on that forest in 1983. Forests were regularly searched by ranger district biologists, timber markers and research personnel for newly formed and previously undiscovered active clusters. The number of cavity trees, size of plate around the cavity entrance and number of cavities within cavity trees were used to determine whether a newly discovered cluster was recently formed or had been in existence for some time. During the study we monitored the numbers of woodpecker groups on each national forest by determining the number of active cavity-tree clusters. We did not monitor the number of woodpeckers within all groups, however, group size in some cavity-tree clusters was determined on the Angelina and Davy Crockett National Forests from 1987 to 1993 by dawn and dusk surveys of roosting woodpeckers.

During 1988, management activities were intensified in response to woodpecker population declines (Conner and Rudolph 1989) and a court-ordered management plan (Bigony 1991, McFarlane 1992). Management activities, recorded annually from 1989 through 1993 included: area of midstory removal, number of artificial cavities installed (Allen 1991, Copeyon 1990), number of metal cavity restrictors (Carter et al. 1989), and attempts to augment woodpecker groups with translocated birds (DeFazio et al. 1987). We also determined the amount of prescribed burning and thinning completed within active and inactive cavity-tree clusters and in the area around active clusters.

We examined the trend in woodpecker group numbers on individual forests by comparing each to both linear and quadratic models using regression analyses (SAS Institute 1988). High similarity to a linear model would suggest that a population was increasing, decreasing or stable throughout the course of the study. High similarity to a quadratic model would suggest that population trends initially decreased and then increased, or increased and then decreased. We used the Durban-Watson d statistic to evaluate autocorrelation of error terms in the regression analyses as it frequently occurs with time-series data. As significant autocorrelations were not detected, results of regression analyses were considered valid.

RESULTS

Populations of Red-cockaded Woodpeckers declined on the Angelina and Davy Crockett National Forest between 1983 and 1988, appeared to stabilize between 1988 and 1991, and increased in 1992 and 1993 (Fig. 1). Populations on the Sabine National Forest decreased between 1987 and 1990, but increased in 1992 and 1993 (Fig. 1). Woodpecker populations on the Sam Houston National Forest decreased between 1989 and 1992, but showed an increase in 1993 (Fig. 1). Thus, the trends in numbers of groups of woodpeckers on all four forests showed an apparent pattern of decrease during the early years and an increase in later years.

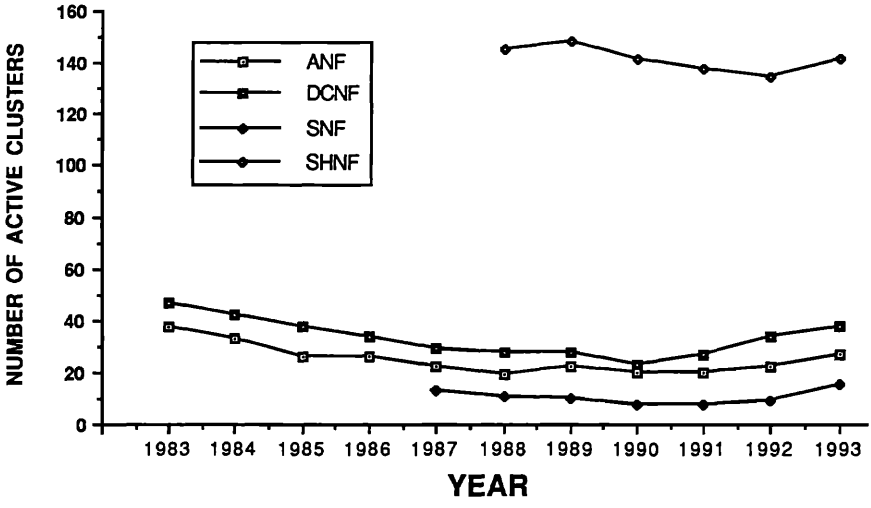

FIGURE 1. Number of active Red-cockaded Woodpecker cavity-tree clusters on the Angelina (ANF) and Davy Crockett (DCNF) (1983–1993), Sabine (SNF) (1987–1993) and Sam Houston (SHNF) National Forests (1988–1993).

The number of active cavity trees also decreased during the early years of the study and increased on the forests between 1991 and 1993, indicating that the number of woodpeckers within each group was also increasing. This was consistent with our direct counts of woodpecker group sizes in selected cavity-tree clusters on the Angelina and Davy Crockett National Forests.

Our attempt to fit the population data from each National Forest to a linear model was generally unsuccessful (Davy Crockett: $F = 1.2$, $P = 0.32$; Sabine: $F = 0.2$, $P = 0.64$; Sam Houston: $F = 2.8$, $P = 0.19$), although the Angelina National Forest population did fit a linear model ($F = 7.9$, $P = 0.02$). Population trends on all four forests were highly similar to a quadratic model, however, accounting for high percentages of statistical variation (Angelina: $r^2 = 0.96$, $F = 85.5$, $P = 0.0001$; Davy Crockett: $r^2 = 0.93$, $F = 31.9$, $P = 0.0014$; Sabine: $r^2 = 0.89$, $F = 15.7$, $P = 0.0127$; Sam Houston: $r^2 = 0.95$, $F = 20.9$, $P = 0.0457$). The close fit of these population trends to the quadratic model strongly suggests that populations decreased initially and subsequently increased in a biologically meaningful fashion.

During the early- and mid-1980s, Conner and Rudolph (1989) identified hardwood midstory encroachment in clusters as a major probable cause of population declines in Texas. Midstory vegetation was removed from cavity-tree cluster areas during the 5-yr period following implementation of a court-ordered management plan in 1988 (Table 1). Prior to the court order, midstory had primarily been controlled only within 16 m of cavity trees to prevent hardwood foliage from blocking cavity en-

TABLE 1. Amount of midstory removal completed, number of artificial cavities installed and number of cavity restrictors installed within Red-cockaded Woodpecker clusters on National Forests in Texas between 1988 and 1993.

	Year of management activity				
	1988–1989	1989–1990	1990–1991	1991–1992	1992–1993
Midstory removal (ha)					
Angelina N.F.	0	127	170	102	75
Davy Crockett N. F.	273	163	90	153	101
Sabine N. F.	186	58	161	210	52
Sam Houston N. F.	139	174	1023	331	86
Total	598	522	1444	796	314
Artificial cavities (#)					
Angelina N. F.	0	31	27	50	22
Davy Crockett N. F.	0	33	16	56	37
Sabine N. F.	0	0	0	7	20
Sam Houston N. F.	0	2	17	356	42
Total	0	66	60	469	121
Cavity restrictors (#)					
Angelina N. F.	4	1	31	16	16
Davy Crockett N. F.	22	20	29	52	30
Sabine N. F.	0	15	20	12	8
Sam Houston N. F.	106	68	17	114	53
Total	132	104	97	194	107

trances. Midstory removal over entire cluster areas after 1988 was achieved by a large drum-mulching machine, chainsaws, and mechanical hydroaxes (Conner and Rudolph 1991b).

Prescribed burning efforts for hardwood control and maintenance were intensified between 1988 and 1993. By 1993 98% of active cluster areas, 58% of inactive clusters, and 79% of the areas designated as recruitment/replacement stands had been prescribe burned during winter at least once. During 1992 and 1993 initial efforts were made on some ranger districts to conduct growing-season burns which tend to be more effective in removing hardwood vegetation.

Thinning of pine stands within and around cavity-tree cluster areas also intensified between 1989 and 1993. Basal area of pines in all active clusters was reduced to about 14 m^2/ha between 1989 and 1993. Similar basal area thinning was completed in more than 50% of the inactive cavity-tree clusters and in about 60% of the pine forest within 1200 m of active clusters.

Installation of artificial cavities began in late 1989 (Table 1). Most of the 716 artificial cavities were created using the insert technique (Allen 1991); less than 20 were made using the drilling method (Copeyon 1990). A large number of cavity inserts (356) were installed on the San Jacinto Ranger District of the Sam Houston National Forest during fiscal year 1992 under a challenge cost-share agreement negotiated by district personnel with the Exxon Corporation. Cavity restrictors were installed by

TABLE 2. Translocations of male and female Red-cockaded Woodpeckers on National Forests in Texas from 1989 through 1992.

Forest	Date augmented	Sex of bird moved	Success of translocation
Davy Crockett	Nov. 89	Female	Yes
	Nov. 89	Female	Yes
	Feb. 90	Female	No
	Feb. 90	Female	No
Sam Houston	Jan. 90	Female	No
Davy Crockett	Feb. 91	Female + Male	Yes
	Feb. 91	Female	Yes
Sam Houston	Oct. 90	Male	Yes
	Nov. 90	Female	Yes
Angelina	Nov. 90	Female	No
	Dec. 90	Female	Yes
	Jan. 91	Female	Yes
	Feb. 91	Male	No
Sabine	Feb. 92	Female	Yes
	Feb. 92	Female	Yes
	Feb. 92	Female + Male	Yes
Davy Crockett	Feb. 92	Female	Yes
	Dec. 91	Male	No
Sam Houston	Oct. 91	Male	Yes
	Oct. 91	Male	Yes

District personnel between 1989 and 1993 as a means to rehabilitate cavities that had been enlarged by other woodpeckers and to prevent enlargement of cavities in areas where Pileated Woodpeckers (*Dryocopus pileatus*) were common (Table 1).

During the 3-yr period between 1989 and 1992, 14 female and five male first-year Red-cockaded Woodpeckers were translocated to cavity-tree clusters containing a single woodpecker of the opposite sex (Table 2). Eight (57%) of the 14 female translocations and three (60%) of the five male translocations resulted in successful pair formation. Unsuccessful attempts to translocate woodpeckers to induce pair formation were not necessarily a total loss. Translocated woodpeckers from failed attempts occasionally paired successfully with other woodpeckers at different clusters within the population. In 1991 and 1992, reintroductions of both first-year male and female Red-cockaded Woodpeckers were made on the Davy Crockett and Sabine National Forests (Rudolph et al. 1992) (Table 2).

During the period between 1990 and 1993, 50 new cavity-tree clusters were found on the four National Forests in Texas (Table 3). Eleven of these 50 new active clusters (all on the Raven Ranger District of the Sam Houston National Forest) were determined to have been in existence for some time as evidenced by multiple cavities within trees, more than one cavity tree in the cluster area, and the formation of large, barkless "plates" around cavity entrances. Thirty-nine newly formed active clusters were found collectively on the seven ranger districts of the National For-

TABLE 3. Factors associated with new Red-cockaded Woodpecker cavity-tree clusters on National Forests in Texas from 1990 through 1993.

Ranger district	# new clusters	Prior existence	Management factors involved			
			None	Reintroduction	Midstory removal	Artificial cavities
Angelina N. F.						
Angelina	5	0	0	0	5	4
Davy Crockett N. F.						
Neches	10	0	4	1	6	6
Trinity	4	0	0	0	4	2
Sabine N. F.						
Tenaha	2	0	0	0	2	2
Yellowpine	4	0	0	1	4	4
Sam Houston N. F.						
Raven	22	11	5	0	6	2
San Jacinto	3	0	0	0	3	2
Totals	50	11	9	2	30	22

ests in Texas. Of these 39, 30 formed in areas where midstory had been removed from either inactive clusters or recruitment-and-replacement stands. Of the 30 areas where midstory had been removed, 22 formed in old inactive cluster areas and recruitment-and-replacement stands where new artificial cavity inserts had also been installed. Two of the previous 22 resulted from reintroductions of a young male and female woodpecker to form a totally new pair in an area that had received both midstory control and cavity inserts. Only nine of the 39 new active clusters (<25%) occurred in areas where recent midstory removal had not been completed and cavity inserts were not installed.

DISCUSSION

Our results suggest that an aggressive management program that includes hardwood midstory control, artificial cavities, woodpecker translocations, cavity restrictors and thinning within cluster areas can stabilize and begin to increase a wide range of Red-cockaded Woodpecker population and subpopulation sizes. Documented, steady declines of relatively small populations on the Angelina, Davy Crockett and Sabine National Forests (Conner and Rudolph 1989) were halted and followed by population increases for at least two successive years.

Increases in small Red-cockaded Woodpecker populations during the past two decades are relatively rare. Hooper et al. (1990) reported an estimated population increase of 10% on the large Frances Marion National Forest population in South Carolina between 1980 and 1988. One year later, Hurricane Hugo destroyed 87% of the cavity trees and killed 63% of the woodpeckers in September 1989 (Hooper et al. 1990). With the aid of artificial cavities, however, the surviving population of 100–125

groups had increased to 320 groups by 1992 (Watson et al. 1995). Following a steady population decline between 1977 and 1986 (Jackson 1990), Red-cockaded Woodpeckers on the Savannah River Nuclear Production Facility increased from four woodpeckers (only one pair) in 1986 to six pairs (27 birds) in 1991 as a result of 16 woodpecker translocations and installation of artificial cavities over a 5-yr period (Allen et al. 1993, Gaines et al. 1995). On the Noxubee National Wildlife Refuge in Mississippi the numbers of active clusters increased from 16 to 26 between 1987 and 1992 as a result of installation of artificial cavities and other management activities (Richardson and Stockie 1995).

With essentially full implementation of the court-ordered comprehensive Red-cockaded Woodpecker management plan, which included hardwood midstory control and thinning of pines (but did not specifically include installation of cavity inserts and woodpecker augmentation), woodpecker populations on the Angelina National Forest began to stabilize between 1988 and 1991, populations on the Sabine National Forest continued to decline between 1988 and 1991, and populations on the Davy Crockett National Forest appeared to decline slightly. Red-cockaded Woodpecker populations on the Sam Houston National Forest declined between 1988 and 1992.

Red-cockaded Woodpecker population increases between 1991 and 1993 on the Angelina, Davy Crockett and Sabine National Forests coincided with aggressive installation of cavity inserts and translocation of woodpeckers. Use of cavity inserts commenced on the Raven Ranger District in 1992; only then was the decline halted and an increase in the Red-cockaded Woodpecker population observed on the Sam Houston National Forest.

There are several significant problems that affect small, isolated Red-cockaded Woodpecker populations in Texas and elsewhere in the south. Encroachment of hardwood vegetation is a primary cause of cluster abandonment (Conner and Rudolph 1989, Locke et al. 1983, Van Balen and Doerr 1978). On the Angelina and Davy Crockett National Forests between 1981 and 1987 cavity-tree clusters with abundant hardwood vegetation were abandoned at a significantly higher rate than clusters with little or no hardwood vegetation (Conner and Rudolph 1989). Also, losses of cavity trees to southern pine beetle (*Dendroctonus frontalis*) infestation during autumn resulted in an inadequate and dwindling supply of cavities for nesting and roosting (Conner et al. 1991, Conner and Rudolph 1995). Additionally, low numbers of dispersing woodpeckers, increasing isolation of woodpecker groups and habitat fragmentation in the smaller populations (Conner and Rudolph 1989, 1991a) likely caused insufficient natural dispersal of woodpeckers for replacement of breeders.

Although control of hardwood vegetation within cluster areas and thinning of pines probably helped stabilize Red-cockaded Woodpecker populations, it was insufficient to reverse totally population declines and initiate population increases. Stabilization and subsequent population increases occurred only after intensive management efforts including cav-

ity insert installation (to prevent net loss of cavity trees and induce colonization of new clusters) and woodpecker translocation (to provide sufficient artificial dispersal for mate replacement) were implemented. Clearly, stabilizations and increases of Red-cockaded Woodpecker populations that are currently being observed on the National Forests in Texas are primarily the results of augmentation of single woodpecker "groups" with appropriate mate replacements through translocations, hardwood vegetation control and installation of numerous cavity inserts.

It was not possible to determine the relative contribution of each management activity to population increases. As a result of the court order and urgency to halt population declines, many different habitat treatments were simultaneously applied to cavity-tree clusters on all forests. Thus, statistical controls and experimental designs needed to separate interacting and confounding effects of individual treatments were not possible.

The court-ordered management plan in Texas included cessation of clear-cutting within 1200 m of Red-cockaded Woodpecker cavity-tree clusters in an effort to prevent habitat fragmentation and provide sufficient older growth pines for nesting, roosting and foraging. Beneficial effects of this component of the court order have not had sufficient time to come to fruition. Thus, the court-ordered change in timber harvesting techniques (single tree selection rather than clear-cutting) can not account for the observed favorable Red-cockaded Woodpecker population response.

The intensive management and subsequent favorable population responses observed on national forests in Texas indicate that recovery of the Red-cockaded Woodpecker is possible. If severe declines of extremely small woodpecker populations that have chronic problems of excessive midstory, isolation, fragmentation, southern pine beetle infestation and insufficient numbers of pines suitable for cavity excavation can be stabilized and increased, there is no reason to believe that these methods will not work in other populations that have similar or fewer ecological problems.

Intensive artificial management activities such as installation of restrictors, cavity inserts, mechanically drilled cavities, and translocation of woodpeckers should be viewed as relatively short-term emergency measures to save populations in danger of imminent extirpation. It is not known how long these emergency management activities will be necessary. An aggressive program of prescribed burning is absolutely essential to the recovery and long-term well being of Red-cockaded Woodpecker populations. Provision of adequately aged pines of sufficient abundance for natural-cavity excavation to replace losses to mortality should be a major management goal to achieve woodpecker recovery. Mature forest habitat should be of sufficient continuity to permit adequate dispersal of young woodpeckers for mate replacement and a functional demography. Provision of old-growth pines and an aggressive prescribed burning pro-

gram for Red-cockaded Woodpecker recovery are consistent with an ecosystem approach to management of southern national forests.

ACKNOWLEDGMENTS

We thank Robert G. Hooper, Jerome A. Jackson, Francis C. James and Daniel R. Petit for constructive comments leading to the improvement of an early draft of the manuscript. Debbie Beiber, Steve Best, Dawn Carrie, Ron Mize, Ellen Naegeli and Alfredo Sanchez provided data from national forest ranger districts.

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Received 29 Mar. 1994; accepted 25 Jul. 1994.