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FACTORS THAT INFLUENCE TRANSLOCATION SUCCESS IN THE RED-COCKADED WOODPECKER

KATHLEEN E. FRANZREB[1]

ABSTRACT-To restore a population that had declined to 4 individuals by late 1985, 54 Red-cockaded Woodpeckers (*Picoides borealis*) were translocated at the Savannah River Site in South Carolina between 1986 and 1995. Translocation success was evaluated by sex, age, and distance between the capture and release site. For moves involving females, the presence of a resident male and the status of the male (breeder, inexperienced, or helper) also was assessed. Of the factors I evaluated, only the distance of the move was statistically significant with increasing success associated with increasing distance. The presence of a resident male at the female's release site led to no more success than releasing the female concurrently with a male; nor did the male's status appear to play a significant role in female translocation success. Overall, 31 of 49 (excluding nestlings) translocated birds remained at or near the release site for at least 30 days, resulting in a success rate of 63.2%. Of the birds that were successfully translocated, 51.0% had reproduced by July 1996. ***Received 2 March 1998, accepted 15 Oct. 1998.***

Endemic to the open pine woodlands of the South, Red-cockaded Woodpeckers (*Picoides borealis*) are cooperative breeders whose groups usually consist of a breeding pair and often one or more helpers, usually male offspring (U.S. Fish and Wildlife Service 1985). A series of cavity trees occupied by such a group is referred to as a cluster. These cavities are used year round for night roosting and as nest sites during the breeding season (Steirly 1957). Since 1970 the species has been considered Federally endangered primarily because of widespread habitat loss, which has fragmented the original population into many subunits, some quite small and/or isolated (U.S. Fish and Wildlife Service 1985). One such small population occupies the Savannah River Site in South Carolina.

By late 1985 the number of Red-cockaded Woodpeckers had dwindled to one breeding pair and two single males (DeFazio et al. 1987), and the Forest Service began intensive management to prevent extirpation on the site (Gaines et al. 1995). With the nearest known Red-cockaded Woodpecker population 32 km away, natural recruitment of and colonization by new individuals was considered unlikely. Because Red-cockaded Woodpeckers prefer older, live pine trees for constructing their cavities (Steirly 1957, Jackson et al. 1979, Conner and O'Halloran 1987, Rudolph and Conner 1991) and few trees of sufficient age and diameter were available, Forest Service personnel installed 305 artificial cavities (see Allen 1991 for details on artificial cavity construction and installation). Other management activities have included: (1) restricting cavity access by other larger woodpecker species with metal "restrictor" plates (Carter et al. 1989), (2) removing southern flying squirrels (*Glaucomys volans*) encountered while monitoring cavities and squirrel nest boxes, and (3) improving habitat quality by controlling the hardwood midstory vegetation that causes woodpeckers to abandon their cavities (Conner and Rudolph 1989, Costa and Escano 1989, Hooper et al. 1991, Loeb et al. 1992).

In an effort to stabilize and eventually increase the population at the site, the Forest Service began a program of translocating woodpeckers from populations outside of and within the site. The objectives were to increase the number of breeding pairs, bolster the overall population size, and minimize potential adverse genetic consequences arising from small population size (Allen et al. 1993, Gaines et al. 1995). Here I assess the results of 10 years of Red-cockaded Woodpecker translocations at the Savannah River Site to determine the variables most likely to contribute to successful translocations, an important strategy in the recovery of small, isolated populations.

STUDY AREA AND METHODS

Study area.-The Savannah River Site lies within the Upper Coastal Plain physiographic region in Aiken, Allendale, and Barnwell counties in South Caro-

[1] Southern Research Station-USDA Forest Service, Dept. of Forest Resources, Clemson Univ., Clemson, SC 29634–1003; E-mail: KFRANZR@clemson.edu

lina. By the early 1950s, most of the site was in agricultural use or had been harvested for timber. In 195 1, the Department of Energy (DOE) acquired 80,269 ha of contiguous land to develop the area as a nuclear production facility. Under an interagency agreement, the Savannah River Natural Resource Management and Research Institute (U.S. Department of Agriculture, Forest Service) has managed the natural resources on the site for DOE since 1952. Today approximately 69,000 ha on the site are in pine stands (Workman and McLeod 1990). most of which are less than 50 years old although there are some residual older pine trees. The area managed for the woodpecker contains 3 1,970 ha of pine forest consisting of longleaf (*Pinus palustris;* 37.7% of the pine acreage), loblolly (*P. taeda;* 45.4%), slash (*P. elliotti;* 13.4%), and other (0.2%) pines in addition to pine-hardwoods (3.3%; G. Gaines, unpubl. data).

Field methods.-Beginning in 1980, Red-cockaded Woodpeckers at the Savannah River Site were banded with a U.S. Fish and Wildlife Service aluminum leg band and with a unique color plastic leg band combination for field identification. Birds were banded as nestlings on the site, when first captured as adults, or just prior to release if they were from an offsite population.

Blood samples were taken from adults at the Savannah River Site to determine the relatedness of individuals of unknown heritage and level of genetic heterozygosity (Stangel et al. 1992, Haig et al. 1993). The results helped to provide the genealogical pedigree and verification of parentage needed to determine which individuals should be matched for mating.

Individual translocations either provided a mate for an established breeding bird (e.g., to replace a lost mate) or established a new pair in unoccupied territory. If a translocated bird remained in the vicinity of the release site for at least 30 days, I regarded the release as successful. Preference was given to abandoned clusters that were more than 1 km from other active clusters to minimize interference by other Red-cockaded Woodpeckers.

Translocated individuals and pairs were introduced into groups with an unpaired, resident bird or into abandoned clusters. Trapping, transportation, and release followed the methods described by DeFazio and coworkers (1987) and Allen and coworkers (1993). The age, group, sex, status (such as helper or breeding female), previous breeding experience, distance from the capture to release site, and location of capture site were recorded for each bird translocated. Translocations involved moving an independent subadult (one year or less in age) or adult female to a bachelor male, moving an unpaired female and/or male to unoccupied habitat, moving a family unit (mated pair and nestlings) to unoccupied habitat, and cross-fostering nestlings.

Observations of translocated birds lasted approximately 8-30 hrs per bird the week immediately following release and were repeated at least once per week during the breeding season and once per month during the non-breeding season to monitor each bird's status. If a translocated bird could not be relocated, a thorough search was made in clusters within approximately 0.8 km. For birds captured on the site, the search included previous roost trees even if they were beyond 0.8 km of the release site.

Analytical methods.-How a bird responded to translocation (e.g., stayed at release site, returned home, disappeared), whether or not it eventually reproduced in the vicinity of the release site, and the number of fledglings produced was recorded for each bird. Because the distance between the capture and release site was found to influence the results, the data were examined separately for moves of various distances ($\leq$ 7 km, 19-23 km, 182-483 km).

To evaluate if sex of the translocated bird affected the outcome of a move, translocation success was compared for all males to all females, adult males to adult females, and subadult males to subadult females. To determine if there was a period of time shortly after fledging when younger subadult females were more likely to remain at the release site, the translocation success of subadult females 5-7 months of age was compared to those 7-12 months old.

Distance between the capture and release site was evaluated by examining translocation success for short ($\leq$ 7 km), moderate (19-23 km), and long (182-483 km) distance moves. There are two subpopulations of Red-cockaded Woodpeckers at the Savannah River Site. Moves within either subpopulation were no more than 7 km. The two subpopulations are separated by about 19 km. Hence, translocations onsite between the two subpopulations involved distances of 19-23 km. All offsite populations were at least 182 km from the Savannah River Site. Moves from offsite were done for 7 of 10 years between 1986 and 1995. Capture sites on the Savannah River Site were monitored to determine if released birds returned home. Similar monitoring was not undertaken at offsite populations because they were too far from the Savannah River Site to check routinely.

To determine if the presence of a resident male affected the translocation success of a female, I compared responses of females who were moved to clusters with a resident male (regardless of his reproductive experience) versus a "co-move" in which a male (captured in a separate cluster) was translocated simultaneously with a female to a new site. To evaluate the possible influence of distance from the capture to release site, the translocation success for females moved to resident males and those moved with a male were compared with respect to distance.

The possible effect of male status (breeder, helper, or inexperienced) on female relocation success was examined for females: (1) moved to a resident male, (2) moved simultaneously with a male, and (3) for both situations combined. An "inexperienced" male had no known experience as a breeder or helper. Female translocation success with respect to male status was segregated further by distance moved.

All statistical comparisons were made using Fisher's

Exact Test (Sokal and Rohlf 1995) with the level of significance defined as $P \leq 0.05$ and executed with SAS (version 6.12, Windows 95, IBM-compatible: SAS Institute 1990). Fisher's Exact Test for contingency tables was used because in most cases cell frequencies were too small to support standard χ^2 tests. Unless otherwise noted, the results for the five translocated nestlings are excluded from these comparisons.

RESULTS

From 1986 to 1995, 54 Red-cockaded Woodpeckers were translocated, at first from populations off the site, but later from onsite as their numbers increased. Beginning in 1986, 21 birds were taken from offsite populations: 7 females, 1 male, and 5 nestlings from the Francis Marion National Forest in South Carolina (about 192 km away): 5 females from the Apalachicola National Forest in Florida (483 km away); 1 female from Fort Bragg in North Carolina (266 km away); and 2 females from the Carolina Sandhills National Wildlife Refuge in South Carolina (182 km away). Offsite locations were selected because they contained relatively large numbers of Red-cockaded Woodpeckers. Thirty-three birds were translocated within the site beginning in 1987.

Of the 24 subadult females, 6 remained at the release site and bred, 1 died after remaining more than 30 days, 6 moved to clusters near the release site and bred with nearby males, 1 returned to the capture site, and 10 disappeared. Of the 10, 4 remained at the release site for more than 30 days, 1 was chased away by other Red-cockaded Woodpeckers, and another reappeared five months later approximately 20 km away and became the breeding female in that cluster. Of 9 adult females, 2 remained at the release site and bred, 5 moved to nearby clusters and bred, 1 returned to her original cluster, and 1 remained at the release site but did not breed.

Of 10 subadult males, 2 stayed at the release site and bred, 2 moved to a nearby cluster and bred, 1 remained at the release site for four months then disappeared, 4 disappeared soon after release, and 1 returned home after 30 days. Two adult males remained where released or close by and bred, 1 disappeared in less than two days, and 3 returned home immediately.

Five nestlings were relocated. The first three nestlings were moved with their parents to the Savannah River Site from the Francis Marion National Forest in 1988 and later died from parental neglect (Allen et al. 1993). The other two nestlings were fostered in 1987; both successfully fledged after being placed in a Red-cockaded Woodpecker nest. The female disappeared after five months, and the male became a breeder in a nearby cluster and eventually produced two fledglings.

Ten of the 49 birds (excluding the 5 nestlings) that were moved consisted of pairs of subadult females and subadult males moved concurrently. Overall, 31 of 49 (63.2%) adults and subadults remained at or near the release site for at least 30 days after release and 25 (51.0%) eventually reproduced (Table 1). The number of birds represented in the various combinations of moves segregated by age and cluster status are shown in Table 1.

Translocation was successful for 61.8% of subadults (21 of 34) and 66.7% of adults (10 of 15; Table 2). There were no significant differences in success measured either by the number that stayed or by the number that reproduced for adult males compared to adult females for short, moderate, or long distance moves (Table 2; Fisher's Exact Tests: all $P > 0.05$). Nor was there a difference in success of subadult males compared to subadult females for any of the distance classes (Fisher's Exact Tests: all $P > 0.05$).

Of 189 fledglings produced from 1986-1996, 104 (55.0%) had at least one parent that had been translocated. The number of fledglings excludes the young produced by birds that were translocated but did not remain in the vicinity of the release site to breed (Table 2).

Translocation success of younger subadult females (5-7 months of age) did not differ significantly from those that were older (7-12 months of age; Fisher's Exact Test: $P > 0.05$ for all comparisons). There were no short distance moves involving younger subadult females.

Because sex and age did not appear to influence success (Table 2), I pooled the data and tested for a distance effect. Translocated birds were more likely to stay with increasing distance from their capture site: 25.0% success for translocations less than 7 km, 71.4% for 19-23 km, and 81.3% for 182-483 km moves. The distance a bird was moved had a

TABLE 1. Success of translocated Red-cockaded Woodpeckers by age and type of move at the Savannah River Site (19861995).

	Number of birds		
	Translocated	Stayed > 30 days	Reproduced
Translocated to resident male:			
Adult female	5	5	5
Subadult **female**	17	13	9
Translocated to unoccupied cluster:			
Adult breeding male	1	0	0
Subadult **male**	5	3	2
Adult female	1	1	1
Adult male/adult female[a]	4	2	2
Adult male/subadult female[b]	4	2	2
Subadult male/subadult female[c]	10	4	4
Adult male/adult female/nestings[d] **(family unit)**	5	1	0
Fostered nestlings	2	2	1
Total adults and subadults	49	31 (63.2%)	25 (51.0%)
Total including nestlings	54	33 (61.1%)	26 (48.1%)

[a] In one move, the male remained: in the other, only the female remained.
[b] In one move, neither bird remained: in the other, both remained.
[c] In three cases, neither the male nor female remained; in two cases, only the male remained; in three cases, only the female remained; in two cases, both birds remained.
[d] Only the female remained.

highly significant effect on whether the bird remained more than 30 days (Fisher's Exact Test: $P = 0.01$), but was not significant for birds that eventually reproduced (Fisher's Exact Test: $P = 0.12$; Table 3). Birds moved a short distance were more likely to return home [41.7% (n = 12) for short versus 4.8% (n = 21) for moderate distance moves; Fisher's Exact Test: $P = 0.021$. There was no significant difference in the success rate of a bird moved a moderate versus a long distance (Fisher's Exact Test: $P > 0.05$ stay, $P > 0.05$ reproduce, n = 21 and 16, respectively). Nor was there a significant difference in rate of return for males versus females moved a short (Fisher's Exact Test: $P > 0.05$) or moderate distance (Fisher's Exact Test: $P > 0.05$).

Eighteen of 22 females (81.8%) that were moved to resident males were successful (stayed), whereas 5 of 10 females (50.0%) succeeded that were moved concurrently with a male. Of the 10 co-moves, 3 females remained after the male left and 2 males stayed even though the female departed. In two cases, both male and female remained. In one of the three instances when both members of the co-move left, the female left first and in the other two cases it could not be determined which of the birds was the first to leave. Of the six cases in which the male left, the female remained behind in three of them. Although moving a female to a site where a male already was established was thought to be advantageous, the success rate was not significantly different from situations in which the female was moved simultaneously with a male for either moderate (Fisher's Exact Test: $P > 0.05$ for stay, $P > 0.05$ for reproduce, n = 14) or long distance moves (Fisher's Exact Test: $P > 0.05$ for stay, $P > 0.05$ for reproduce, n = 14). Nor was there a significant difference in success of females moved either to a resident male or with a male when translocations of moderate and long distances were combined (Fisher's Exact Test: $P > 0.05$ stay, $P > 0.05$ reproduce, n = 28). No short distance moves of a female to a resident male were undertaken.

Because female success was not influenced by whether the male already was on the release site or whether he was moved simultaneously with her, these data were pooled. Females had a success rate of 87.5% (seven successes in eight cases) if the male involved was an experienced breeding male, 40.0% (n = 5) if he was a helper, and 73.7% (n = 19) if the male was inexperienced. Because there were only four short distance moves and none of these involved a breeder male, the effect of male status could not be assessed for females

TABLE 2. Translocation success by sex and age of Red-cockaded Woodpeckers with respect to distance moved at the Savannah River Site (1986–1995).[a]

Sex/age class	Distance moved				No. fledglings produced (No./sex-age class)
	< 7 km	19-23 km	182-483 km	Total	
Adult females:					29 (3.2)
Number translocated	1	3	5	9	
Number stayed (%)	0 (0.0%)	3 (100.0%)	5 (100.0%)	8 (88.9%)	
Number reproduced (%)	0 (0.0%)	3 (100.0%)	4 (80.0%)	7 (77.8%)	
Adult males:					4 (0.7)
Number translocated	4	1	1	6	
Number stayed (%)	2 (50.0%)	0 (0.0%)	0 (0.0%)	2 (33.3%)	
Number reproduced (%)	2 (50.0%)	0 (0.0%)	0 (0.0%)	2 (33.3%)	
Subadult females:					58 (2.4)
Number translocated	3	11	10	24	
Number stayed (%)	1 (33.3%)	7 (63.6%)	8 (80.0%)	16 (66.7%)	
Number reproduced (%)	1 (33.3%)	5 (45.4%)	6 (60.0%)	12 (50.0%)	
Subadult males:					20 (2.0)
Number moved	4	6	0	10	
Number stayed (%)	0 (0.0%)	5 (83.3%)	—[b]	5 (50.0%)	
Number reproduced (%)	0 (0.0%)	4 (66.7%)	—[b]	4 (40.0%)	
All females:					87 (2.6)
Number translocated	4	14	15	33	
Number stayed (%)	1 (25.0%)	10 (71.4%)	13 (86.7%)	24 (72.7%)	
Number reproduced (%)	1 (25.0%)	8 (57.1%)	10 (66.7%)	19 (57.6%)	
All males:					24 (1.5)
Number translocated	8	7	1	16	
Number stayed (%)	2 (25.0%)	5 (71.4%)	0 (0.0%)	7 (43.8%)	
Number reproduced (%)	2 (25.0%)	4 (57.1%)	0 (0.0%)	6 (37.5%)	
Nestlings:					2 (0.4)
Number moved	—[b]	—[b]	5	5	
Number stayed (%)	—[b]	—[b]	2 (40.0%)	2 (40.0%)	
Number reproduced (%)	—[b]	—[b]	1 (20.0%)	1 (20.0%)	
Total includes nestlings				54	104'
Total excludes nestlings				49	102[c]

[a] None of the results from Fisher's Exact Tests was significant at $P < 0.05$.
[b] = not applicable; no tests of this type were made.
[c] Column does not add to 102 or 104 because nine fledglings were produced by parents both of whom had been translocated: total figure includes fledglings produced in 1996.

moved a short distance. For all moves, there was no significant difference in female success when comparing breeder, helper, or inexperienced males (Fisher's Exact Test: all $P > 0.05$).

DISCUSSION

The first reported Red-cockaded Woodpecker translocations involved a 1981 relocation of 12 birds from 5 groups at the Fort Stewart Army Base to St. Catherines Island, both in Georgia (Odum et al. 1982). Five of these birds survived at least eight months and two produced one fledgling in 1981. In 1984 and 1986, two pairs and one single male were moved from private land to the St. Marks National Wildlife Refuge and adjacent Ochlockonee River State Park in Florida in an attempt to enhance the three active groups at the release site (Reinman 1995). One female remained and nested successfully for four consecutive years, one male returned to the capture site, one male died, and the fate of the other birds is unknown. Other translocations have been conducted to establish a group at a site occupied by a single bird (Allen et al. 1993) and to establish new groups (Rudolph et al. 1992, Allen et al. 1993).

Working with data collated from 143 Red-cockaded Woodpecker translocations under a wide range of circumstances, Costa and Kennedy (1994) found various definitions of

TABLE 3. Effect of distance between capture and release site on number of successful translocations of Red-cockaded Woodpeckers at the Savannah River Site (1986-1995).

Number of birds	Distance moved			
	< 7 km	19-23 km	182-483 km	Total
Moved	**12**	**21**	**16**	**49[a]**
Stayed (%)	**3 (25.0%)**	**15 (71.4%)**	**13 (81.3%)**	**31 (63.3%)**
Reproduced (%)	**3 (25.0%)**	**12 (57.1%)**	**10 (62.5%)**	**25 (51.0%)**
Returned home (%)	**5 (41.7%)**	**1 (4.8%)**	—[b]	**6 (7.5%)**

Distance moved	Fisher's exact test: *P value*		
	Stayed	Reproduce	Returned home
All distances	**0.01**	**0.12**	
Short vs moderate distance	**0.01**	**0.15**	
Moderate vs long distance	**0.70**	**1.00**	
Short vs moderate distance			**0.02**

[a] Excludes nestlings.
[b] — = not available.

translocation success ranging from "interacted well" to "fledged young." They noted successful moves 66% of the time for subadult females (n = 44) and 58% of the time for adult females (n = 33). My study showed an overall female success rate of 67% for subadults and 89% for adults. However, Costa's and Kennedy's results are difficult to compare to mine because they contain a variety of criteria for translocation success. Moreover, in my study there was no significant difference in the success rate based on age (subadult versus adult) for either females or males when considering the distance of the move. Some of my comparisons involve small sample sizes and it is possible that a larger data set may have revealed some significant differences. Additional work is needed to explore more fully any possible differences in success rate based on age of the bird.

My study showed a greater tendency for birds being moved a moderate (19-23 km) or long (182-483 km) distance to remain at the release site and reproduce than birds that were moved short distances (< 7 km). Because there were no moves between 7-19 km, it is not known at what distance the success would equal that of moves more than 19 km. Therefore, at the present time, it is recommended that translocations involve distances of at least 7 km (preferably more) between the capture and release sites to discourage homing by the birds.

DeFazio and coworkers (1987), Hess and Costa (1995), and Reinman (1995) suggest that the most successful translocations of females are those in which the release site contains established single males-a finding supported by earlier translocations of 16 females at the Savannah River Site (Allen et al. 1993). The success rate for translocations to areas that contained single established males was 63.2% for Costa and Kennedy (1994) and 81 .O% for my study. However, I found that when the release site contained a resident male, female success was no greater than when a female was moved concurrently with a male for moderate and long distances.

Costa and Kennedy (1994) recommend using a two level standardized definition of success. One level reflects primary evidence of breeding (e.g., copulation, etc.) and the other that the bird has become attached to the site (e.g., roosting in a cluster, etc.). For any translocation effort to succeed, the first major hurdle is for the bird to remain at the release site. In my study, the presence of a translocated bird at the release site after 30 days was considered evidence that the bird had accepted the site and was likely to breed once a suitable mate became available. Because disease and predation may prevent some of these birds from surviving long enough to reproduce, the use of breeding as the criterion of translocation success may be overly conservative. If producing at least one fledgling is used to measure translocation success, then 5 1 .O% of the translocated birds in this study were successful. The success rate was 63.2% if defined

as the number of birds remaining near the release site for at least 30 days.

Translocations at the Savannah River Site have played an instrumental role in restoring the Red-cockaded Woodpecker population from 4 individuals in 1985 to 99 individuals (56 adults and 43 young-of-the-year) and 19 breeding pairs in 1996 (Franzreb 1997). Clearly, the use of translocations as a management tool has been an integral part in the recovery of this nearly extirpated population.

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