RANGE-WIDE SUCCESS OF RED-COCKADED WOODPECKER TRANSLOCATIONS

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Abstract: Red-cockaded woodpeckers (*Picoides borealis*) have declined range-wide during the past century, suffering from habitat loss and the effects of fire exclusion in older southern pine forests. Red-cockaded woodpecker translocations are a potentially important tool in conservation efforts to reestablish red-cockaded woodpeckers in areas from which they have been extirpated. Currently, translocations are critical in ongoing efforts to save and restore the many existing small populations. We examined the effects of demographic and environmental factors on the range-wide success of translocations between 1989 and 1995. In translocations of adult and subadult females to clusters containing solitary males, success of adult females (45%) and subadult females (39%) was similar. Translocations of females to clusters containing solitary males were significantly more successful than translocation of potential pairs. Age in months, translocation time, distance between donor and recipient populations, physiographic province, season, forest type, and pre-translocation and post-translocation temperatures did not differ between successful and unsuccessful translocations. Because our measure of success (bred at recipient cluster) was more conservative than that used in other studies, translocation success reported here is lower than previously reported. It is important to compare differences in how success was defined and measured among studies, however, because past success serves as the basis for developing translocation protocol.

Key words: at-risk populations, red-cockaded woodpecker, translocation success.

The red-cockaded woodpecker is a federally endangered species endemic to pine (*Pinus* spp.) forests of the southeastern United States (Jackson 1971). Populations of red-cockaded woodpecker have declined range-wide during the past century, suffering from habitat loss and effects of fire exclusion in older southern pine forests (Jackson 1995). Until very recently, numerous populations continued to decline (James 1995) and many remained at risk (Ligon et al. 1986, Escano 1995) because of small size (<30 potential breeding groups) and habitat degradation (Conner and Rudolph 1989, Krusac et al. 1995). Small size and genetic isolation continue to threaten small populations with imminent extirpation through habitat loss, chance demographic events, and reduced fitness resulting from inbreeding (Shaffer 1981, 1987; Ralls et al. 1988).

The Red-cockaded Woodpecker (*Picoides borealis*) Recovery Plan: Second Revision (U.S. Fish and Wildlife Service 2003) emphasizes restoration of populations within recovery units throughout the range of the species to provide for region-wide, long-term survival. Restoration efforts include reestablishment of red-cockaded woodpeckers in areas from which they have been extirpated (Hagan and Costa 2001) and ongoing augmentation of existing small populations (Hess and Costa 1995). Habitat enhancement includes provisioning suitable forested stands with artificial cavities (Copeyon 1990, Allen 1991) to create recruitment clusters. In today's relatively young forests, habitat availability and suitability are limiting factors for red-cockaded woodpecker populations. Recruitment clusters are an effective management tool to induce formation of new groups where artificial cavities are present (Copeyon et al. 1991, Heppell et al. 1994). Although installation of artificial cavities may be sufficient to increase the number of groups in relatively large populations (Copeyon et al. 1991), for the numerous small, remnant, or extirpated populations, translocating red-cockaded woodpeckers after habitat enhancement and artificial cavity construction may be one of the few options to reduce demographic and genetic effects of small population size (Allen et al. 1993).

Range-wide red-cockaded woodpecker translocation success varies by sex and age class and is dependent on how success was defined (Costa and Kennedy 1994). Translocations of females to clusters containing solitary males are generally more successful than translocating potential pairs of unrelated subadults or solitary males to recruitment clusters (Allen et al. 1993, Costa and Kennedy 1994; but see Carrie et al. 1999 and Franzreb 1999). Success also is higher when translocating subadult male and female red-cockaded woodpeckers compared to translocations of adult birds

(Costa and Kennedy 1994). Although current recommendations are based on past success and include some genetic considerations (Haig et al. 1993, 1994), the effects of environmental and demographic factors on range-wide translocation success have not been examined.

Consequently, our objective was to examine the effects of demographic and environmental factors on success of past red-cockaded woodpecker translocations. Moreover, we wanted to evaluate current translocation guidelines (U.S. Fish and Wildlife Service 2000) on the basis of our findings.

METHODS

We obtained summary information on all red-cockaded woodpecker translocations conducted throughout the southeast between 1989 and 1995 (U.S. Forest Service red-cockaded woodpecker translocation database; D. Krusac, U.S. Forest Service, personal communication). Data were limited to translocations conducted on federal properties, which included national forests, military reservations, and a Department of Energy site. Information available on each translocation included: date, sex, age, and U.S. Geological Survey band identification number, donor population, recipient population, and outcome of translocation (e.g., bird not seen, paired and reproduced). To obtain additional information on distance between donor and recipient populations, physiographic province of donor and recipient populations, time of translocation, forest type of donor and recipient cluster, and translocation success, we sent a questionnaire to all participants identified in the red-cockaded woodpecker translocation database.

On the basis of this information we determined the following attributes for each translocation: sex and age of birds in months; season (fall = September to December; spring = January to April); distance translocated; physiographic province of donor and recipient populations (Flatwoods Coastal Plain, Piedmont, Blue Ridge, Cumberland Plateau, Hilly Coastal Plain, Middle Coastal Plain, Alluvial Floodplain and Terraces, Ouachita Mountains, Ozark Plateau); translocation time (day or night); forest type of donor and recipient clusters [longleaf pine (*Pinus palustris*), loblolly pine (*P. taeda*), shortleaf pine (*P. echinata*), slash pine (*P. elliotti*), Virginia pine (*P. virginiana*), pine/hardwood]; translocation type: subadult (<8 months) male to a recruitment cluster, adult (≥8 months) male to a recruitment cluster, subadult (<8 months) female to a cluster containing a solitary male, adult (≥8 months) female to a cluster containing a solitary male, unrelated subadult potential pair simultaneously moved to the same recruitment cluster; average temperature at donor population during the 5 days prior to translocation; and average temperature at recipient population during 10 days following release. We assigned red-cockaded woodpecker populations a physiographic province according to Miller and Robinson (1995). Average temperatures for each translocation were calculated from nearest weather station data (National Oceanic and Atmospheric Administration 1989, 1990, 1991, 1992, 1993, 1994, 1995). We defined translocation success as an individual remaining at the release cluster, followed by pairing and nesting. Success was determined independently for individuals of potential pair translocations. Although other measures of success have been employed (Costa and Kennedy 1994, Carrie et al. 1999, Franzreb 1999), our more conservative measure was necessary to allow for inferences regarding recipient cluster characteristics and translocation protocol.

Because our data did not meet assumptions of normality, we used the nonparametric Mann-Whitney-U test (α = 0.05) to examine differences between successful and unsuccessful translocations. We used χ^2 analyses (α = 0.05) to compare categorical variables. Power analysis (α = 0.05) followed Zar (1996).

RESULTS

We obtained information on 178 translocations, of which 48 (27%) were successful by our criteria. We recorded only 13 (7%) translocations of males to recruitment clusters or to clusters containing solitary females, of which 2 (15%) were successful. Because of this small sample size, we deleted male translocations, except those involving potential pairs, from further analysis.

In translocations of adult and subadult females to clusters containing solitary males, success rates for translocations of adult (45%, 18 of 40) and subadult (39%, 18 of 46) were similar (χ^2 = 0.11, 1 df, P = 0.740), and were therefore combined as translocations of females (42% success, 36 of 86). Individuals of potential pairs were successfully translocated in only 10 of 79 (13%) attempts (males 5 of 40; females 5 of 39). Success rates for translocations of females to clusters containing solitary males were significantly greater than those for translocations of potential pairs (Table 1). Moreover, translocation success was not related to age

Table 1. Relations between successful and unsuccessful red-cockaded woodpecker translocations in the southeast, U.S. 1989 to 1995.

	Number of Individuals			
	Successful	Unsuccessful	$\chi^{2\,a}$	P
Season				
Fall	25	55		
Spring	21	64	0.58	0.445
Physiographic Province				
Same	21	49		
Different	23	70	0.33	0.567
Translocation Time				
Day	11	27		
Night	37	58	1.11	0.292
Forest Type				
Same	29	58		
Different	14	52	2.16	0.141
Translocation Type				
Female to Male	36	50		
Unrelated Pair	10	69	16.04	0.001

[a] Continuity-adjusted Chi-square.

in months, translocation time, and distance between donor and recipient populations (Tables 1 and 2). Environmental factors, physiographic province, season, forest type, and pre-translocation and post-translocation temperatures were not related to translocation success (Tables 1 and 2). Because our measure of success was more conservative than used in other studies (but see Hess and Costa 1995), translocation success reported here is lower than previously reported (Table 3).

DISCUSSION

The ultimate measure of translocation success is the recovery or establishment of a viable wild population (Scott and Carpenter 1987, Griffith et al. 1989). Such efforts may include multiple translocations of 1 or more individuals over a period of time. Success of translocations also may be measured by the contribution of translocated individuals to the recovery of the population. For an individual to contribute to recovery it must assume a breeding role. In this capacity, it can potentially contribute to increasing population size and genetic diversity, and to reducing inbreeding depression in small populations (Scott and Carpenter 1987). If a translocated individual dies or leaves the population prior to producing offspring, it has contributed little to the recovery of the population.

Success of translocations has been measured and evaluated in a number of ways (Costa and Kennedy 1994, Hess and Costa 1995, Carrie et al. 1999, Franzreb 1999). Criteria used to measure success has ranged from "interacted well" to "fledged young," but generally included some assessment of reproduction or site fidelity (Costa and Kennedy 1994). Understandably, the more liberal the success criteria are, the higher the reported success is. We employed the most conservative measure of success used to date: the bird had to remain at the release cluster, pair, and successfully breed. We chose the "remained and bred at release cluster" success criterion because it allowed us to compare attributes between donor and recipient clusters. Other success criteria, such as "remained in the population and bred" (Carrie et al. 1999) or "remained at or near the release site for ≥30 days" (Franzreb 1999), would not allow for this comparison. Our more conservative criterion, however, resulted in lower levels of success for translocated females and potential pairs when compared to previous studies (Table 3; Costa and Kennedy 1994,

Table 2. Age of individual, distance moved, and environmental conditions associated with red-cockaded woodpecker translocations in the southeast, U.S. 1989 to 1995.

	Successful			Unsuccessful			
	$\bar{x}$	SE	n	$\bar{x}$	SE	n	P^a
Age in Months	7.8	0.3	46	8.0	0.3	114	0.884
Distance Moved (km)	219.1	27.0	42	253.3	17.6	117	0.384
Pre-trans. Temperature (°C)	11.6	0.8	46	12.8	0.4	115	0.146
Post-trans. Temperature (°C)	11.9	0.7	41	11.1	0.3	112	0.179

[a] Mann-Whitney U-test with continuity correction.

Franzreb 1999). It is important to compare differences in how success was defined and measured among studies because past success serves as the basis for developing translocation protocol.

Generally, our findings offer only limited support for the current translocation guidelines for red-cockaded woodpeckers adopted by the U.S. Fish and Wildlife Service (2003), which include (1) moving subadult (<12 months) males and females; (2) conducting translocations from 15 September to 1 January; and (3) restricting translocations between donor and recipient populations to within recovery units whenever possible. The U.S. Fish and Wildlife Service does not issue permits for translocations of adult breeder and helper males because of their tendency to return to their original territory (Odom 1983, Reinman 1984, Allen et al. 1993, Carrie et al. 1996), and possible adverse impacts to donor populations. Genetic variability among populations serves as the basis for habitat and geographic proximity recommendations (Stangel et al. 1992; Haig et al. 1993, 1994, 1996).

Our findings support mate provisioning as a valuable conservation tool. We found 42% of females translocated to clusters containing solitary males remained at the recipient cluster to become breeders. Successful mate provisioning (female to male) results in the immediate change from a territory occupied by a non-breeding, solitary male to a territory occupied by a potential breeding group. In contrast to other studies (Allen et al. 1993, Franzreb 1999), we found no difference between translocation success of adult and subadult females. Translocating subadult females from a donor group/population is likely to have minimal impact on the group and population, given their reported dispersal (31%) and mortality (68%) rates (Walters et al. 1988*a*). Moreover, we found no significant difference in the success of translocated subadults on the basis of age (5 to 8 months), which is consistent with Franzreb (1999). Because of the increasing difficulty of locating subadults to translocate as the bird's first potential breeding season approaches, we suggest considering individuals for translocation anytime between age 5 and 10 months, generally from October through March.

We found no direct evidence to support a translocation protocol to maintain similar physiographic provinces, which approximate recovery units in most instances. Although success was slightly higher in translocations to similar than disparate physiographic provinces (30% vs. 28%) and forest types (33% vs. 21%), differences were not statistically significant (power = 0.89 and 0.63, respectively; $\alpha = 0.05$). However, because geographically distant populations generally share less genetic material (Stangel et al. 1992) and show some clinal variation (Mengel and Jackson 1977, Pizzoni-Ardemani 1990), it is recommended that individuals selected for translocation come from adjacent or nearby populations (Haig et al. 1993) or from the same physiographic province (Haig et al.

Table 3. Red-cockaded woodpecker translocation success reported in the southeast, U. S. 1994 to 1999.

Study	Translocation type: Female to male	Translocation type: Potential pair[a]	Criteria for success
Costa and Kennedy (1994)	62% (48 of 77)	33% (18 of 54)	ranged from 'interacted well' to 'fledged young'
Hess and Costa (1995)	61% (11 of 18)		remaining at release cluster through subsequent breeding season
Carrie et al. (1999)		65% (11 of 17)[b]	remained in the population and successfully bred
Franzreb (1999)	82% (18 of 22)	40% (4 of 10)	remained in the vicinity of release cluster for ≥30 days
Present study	42% (36 of 86)	13% (10 of 79)	remaining at the release cluster, followed by pairing and nesting

[a] Number in parentheses is the number of individual birds.
[b] Included translocation of 5 potential pairs to inactive clusters and later 6 additional single birds (3M, 2F) to solitary individuals, and 1 solitary male was released to determine whether he would remain at the release site.

1994). It is thought that morphological differences may affect the translocated bird's ability to survive in different environmental conditions (Pizzoni-Ardemani 1990), but this hypothesis has not been tested experimentally. Moreover, we found no difference in success with regard to distance between donor and recipient populations. This is similar to Franzreb (1999) who reported that distance moved had no effect on whether an individual entered the breeding population. Until experimental evidence is available, we support current recommendations to avoid translocations to disparate physiographic provinces and forest types, and from distant populations.

Our examination of the effects of short-term (5-10 days) environmental conditions found no influence of pre- and post-translocation temperatures on success. Perhaps our time periods (5 days pre- and 10 days post-release) were too short to record significant differences in average daily temperatures. Our rational for this metric was that harsh conditions (e.g. cool rains, extreme heat, cold temperatures) prior to, or immediately after, release may impact a bird's energy reserves and reduce its ability to forage, avoid predation, or defend a new territory, and therefore the likelihood that it will pair and breed. Neal et al. (1993*b*) reported a 26% reduction in adult foraging time of adult red-cockaded woodpeckers during a period of abnormally low temperatures and elevated rainfall in Arkansas.

Similar to other studies (Costa and Kennedy 1994, Franzreb 1999), we found that success rates for translocating unrelated subadult potential pairs to establish new potential breeding groups at recruitment clusters were significantly lower than mate provisioning (13% vs. 42%). However, we believe that potential pair translocations remain an important conservation tool in certain situations. Specifically, in critically small (<30 active clusters) populations or subpopulations in danger of extirpation, potential pair moves could be conducted to stabilize and increase populations, thereby improving their viability (Rudolph et al. 1992, Carrie et al. 1999). Improving the demographic viability of small populations can be accomplished by establishing new potential breeding groups in strategic locations to reduce isolation within these populations (Conner and Rudolph 1989). A relatively new technique involves simultaneous, multiple pair (3-5 unrelated pairs) translocations as suggested by Rudolph et al. (1992). Success of this technique is measured as the number of translocated individuals entering the breeding population. Although less conservative than our metric, the biological criteria for such an approach is similar. The initial success of this technique has been encouraging (Carrie et al. 1999). Although Carrie et al. (1999) reported high success (71%; 12 of 17 birds entered the breeding population), it was related to the presence of 9 resident birds, including solitary males and females. Because of the numerous territories occupied by solitary birds prior to and during the 4-month translocation period, multiple and varied demographic opportunities existed for released birds to interact, and eventually pair, with resident birds. Such opportunities will influence translocation success on an individual/population basis. We believe that achieving similar success rates when attempting to reestablish a population (Hagan and Costa 2001), or in populations with few or no solitary bird territories, will require relatively high numbers (≥5 pairs) of birds released over a short period of time, preferably the same day. Further research is needed to determine (1) if multiple pair translocations are more efficient than mate provisioning; (2) how many birds should be translocated and over what time period; and (3) whether birds are moved as potential pairs, or in some ratio other than 1:1 female to male.

Our findings suggest that it is unrealistic to expect translocated red-cockaded woodpeckers to remain at the recipient cluster, particularly members of potential pairs. Although necessary for analyses, our required release cluster fidelity may be too conservative a measure of translocation success relative to the importance of the individual entering the breeding population. When more liberally defined as individuals entering the breeding population, translocation (all types) success was 51% in South Carolina (Franzreb 1999) and 71% in Texas (Carrie et al. 1999). To determine if a translocated individual remains in the population as a breeder requires intensive monitoring of the population. For many of the populations in our database such monitoring was not practical/possible. Therefore, we cannot provide a similar measure of success.

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