

**Translocation as a Management and Restoration Technique
for the Threatened Florida Scrub-jay
(*Aphelocoma coerulescens*)**

**Ronald L. Mumme¹
Theodore H. Below²**

¹Department of Biology
Allegheny College
Meadville, Pennsylvania 16355

²National Audubon Society
3697 North Road
Naples, Florida 33942

Submitted as Final Report for
Project E-1 III-1-5
Report submitted May 1998

June 2000

This report is the result of a project supported by the Florida Fish and Wildlife Conservation Commission's Nongame Wildlife Trust Fund and Federal Section 6 Funds. Although the report fulfilled the project's contractual obligations, it has not been reviewed for clarity, style, or typographical errors, and has not been peer reviewed. Any opinions or recommendations in this report are those of the author and do not represent policy of the Commission.

Suggested citation:

Mumme, R. L., and T. H. Below. 2000. Translocation as a management and restoration technique for the threatened Florida scrub-jay (*Aphelocoma coerulescens*). Fla. Fish and Wildl. Conserv. Comm. Final Rep., E-1 III-1-5. Tallahassee. 23 pp. + v.

TRANSLOCATION AS A MANAGEMENT AND RESTORATION TECHNIQUE FOR THE THREATENED FLORIDA SCRUB-JAY (*APHELOCOMA COERULESCENS*)

RONALD L. MUMME

Department of Biology, Allegheny College, Meadville, Pennsylvania 16335

and

THEODORE H. BELOW

National Audubon Society, 3697 North Road, Naples, Florida 33942

Date of Final Report: 23 May 1998

Project Number: III-1-5.

Abstract: The Florida scrub-jay (*Aphelocoma coerulescens*) is restricted to the oak scrub of peninsular Florida. Although loss of habitat is the major problem facing this threatened species, habitat protection alone is unlikely to ensure its continued survival. Because Florida scrub-jays are extremely sedentary and are often found in isolated fragments of suitable habitat, many existing populations are too small to be viable indefinitely. For these reasons, a successful management plan for the species should incorporate both habitat protection and the translocation of jays from healthy populations to isolated areas of suitable habitat where jays either are absent or have been recently extirpated. Prime candidates for such translocations are the "surplus" nonbreeding helpers that comprise roughly a third of the adult population of jays. Although physiologically capable of breeding, nonbreeding helpers are unable to do so because all suitable oak scrub habitat within a local population is usually occupied and defended by other jays.

The purpose of this project was to evaluate translocation as a management technique for the Florida scrub-jay. Between 1987 and 1995, 20 Florida scrub-jays (14 nonbreeding helpers plus 3 breeding pairs) were removed from a color-banded population of jays at Archbold Biological Station in Highlands County and translocated to suitable but unoccupied habitat at Rookery Bay National Estuarine Research Reserve in Collier County. Although 9 (45%) of the translocated birds emigrated from Rookery Bay or died in the first 8 weeks following translocation, 11 remained and eventually settled at Rookery Bay. Successful nesting first occurred in 1989, and from 1991 through 1997 the population remained relatively stable with 6-10 individuals and 1-3 breeding pairs. Measures of nesting success, juvenile survival, and adult survival at Rookery Bay were all comparable to those from Archbold Biological Station. However, because of high rates of mortality or emigration by females fledged at Rookery Bay, from 1991 through 1997 the population sex ratio was strongly biased toward males.

Our results indicate that translocation of Florida scrub-jays is a viable technique for management and restoration of this threatened species. However, because of the scarcity of suitable translocation sites, the high rates at which jays emigrate or die following translocations, and the potential negative impacts on source populations, translocation should be pursued only under unusual circumstances. It should not be considered an acceptable substitute for the protection of existing populations and should be viewed only as a technique for the restoration of jays to unoccupied portions of their historic range.

ACKNOWLEDGEMENTS

The authors express their sincere gratitude to the scientific and support personnel of Archbold Biological Station, the National Audubon Society, Rookery Bay National Estuarine Research Reserve, and Briggs Nature Center. Our research would not have been possible without their assistance and cooperation. Bob Curry, Frank Dunstan, John Fitzpatrick, Jim McGinnity, Sandy Sprunt, Kris Thoemke, Gary Lytton, and Glen Woolfenden deserve special thanks. Glen Woolfenden generously provided data used in Fig. 6, and Virginia Below, David Dunning, Jim McGinnity, Steve Schoech, and Ximena Valderrama provided capable assistance at Archbold and Rookery Bay. An early draft of the report was thoroughly and constructively reviewed by Mark Kopeny. Financial support for our research was provided by awards NG88-043 and III-1-5 from the Nongame Wildlife Program of the Florida Game and Fresh Water Fish Commission.

TABLE OF CONTENTS

Abstract	iii
Acknowledgments	iv
Table of Contents	v
Introduction	1
Methods	3
Study Sites	3
1989 Translocations	3
1990 Translocations	4
1995 Translocations	5
Post-Translocation Monitoring	5
Results	6
1989 Translocations	6
1990 Translocations	7
1995 Translocations	7
Population Dynamics at Rookery Bay	7
Site Persistence of Translocated Birds	8
Nesting Success at Rookery Bay	8
Site Persistence of Young Fledged at Rookery Bay	9
Effects of Translocation on Source Population	9
Discussion	10
Translocation as a Management Technique	10
Timing of Translocation	12
Selection of Birds for Translocation	12
Length of the Pre-Release Period	13
Management Implications	14
Literature Cited	15
Tables	17
Figures	18



INTRODUCTION

The Florida scrub-jay (*Aphelocoma coerulescens*) is restricted to the unique oak scrub of peninsular Florida. Because oak scrub grows only on sandy, well-drained soils that are also ideal for citrus cultivation and residential or commercial development, tracts of oak scrub habitat, along with the jays they support, are disappearing at a rapid rate. As a result, in 1987 the Florida scrub-jay was designated by the U. S. Fish and Wildlife Service as a "Threatened" species (Fitzpatrick et al. 1991, Stith et al. 1996, Woolfenden and Fitzpatrick 1996).

A successful conservation plan for the Florida scrub jay will clearly require preservation of large areas of suitable habitat. However, areas of scrub that are protected from fire become too densely vegetated to support populations of jays (Woolfenden and Fitzpatrick 1984, 1991, 1996). Thus, a conservation plan for the species must incorporate both habitat protection and judicious fire management of that habitat (Fitzpatrick et al. 1991).

Nonetheless, even concerted efforts to protect and manage remnants of oak scrub habitat may prove to be inadequate. The Florida scrub-jay currently exists in a number of small, isolated populations inhabiting restricted patches of suitable habitat (Woolfenden and Fitzpatrick 1991, Stith et al. 1996). Because of the isolated nature of these habitat patches and the extremely limited dispersal shown by Florida Scrub Jays (individuals rarely disperse more than a few kilometers from their birthplace; Woolfenden and Fitzpatrick 1986; Stith et al. 1996), many areas of apparently suitable habitat lack jays. This fact has been noted by many field workers (e.g., Westcott 1970, Woolfenden and Fitzpatrick 1984, Cox 1987).

Furthermore, the long-term survival of small populations can be seriously threatened not only by deterministic factors such as habitat destruction, but also by stochastic factors that can have unpredictable effects on the dynamics of small, fragmented populations. A series of inopportune chance events that would have relatively little effect on large populations could have potentially disastrous consequences for small populations, greatly increasing the risk of local (or global) extinction (Shaffer 1981, Soule 1987). Thus, small populations of Florida scrub-jays, even those inhabiting scrub that is protected from development and properly fire-managed, are nonetheless vulnerable to local extinction simply because of "bad luck." Local extinctions will in many cases prove to be permanent because of the isolated nature of habitat patches and the sedentary nature of jays (Fitzpatrick et al. 1991, Woolfenden and Fitzpatrick 1991).

For these reasons, successful long-term management of Florida scrub-jays may have to include translocation of jays from healthy populations to isolated areas of suitable, protected, and properly managed habitat where jays are either absent or have been recently extirpated. Translocations of wild-caught or captive-reared animals are playing an increasingly important role in conservation of rare and endangered species, and are frequently used to establish new populations, to reintroduce a species to unoccupied portions of its historic range, or to augment populations that are critically small and in danger of imminent extinction (Griffith et al. 1989, Kleiman 1989, Butler and Merton 1992, Cade and Temple 1994, Sarrazin and Barbault 1996, Wolf et al. 1996).

The unusual cooperative social system of the Florida scrub-jay makes the species a good candidate for the use of translocation as a management technique. Florida scrub-jays are permanently monogamous and defend year-round territories that average 9 ha in size. Although at least some jays are capable of breeding at age 1 yr, most young delay breeding for 1-4 years and remain on their natal territories as nonbreeders, primarily because all suitable breeding habitat within a population is occupied and defended by other jays. While living on their natal territories, nonbreeders usually act as "helpers" and assist the resident breeders (usually their parents) in defending the territory against intruders, defending the nest against potential nest predators, and feeding nestlings and fledglings. Prolonged experience as a helper, however, is not a prerequisite for successful breeding in the future. About half of all Florida scrub-jay pairs are assisted by one or more helpers, and approximately one third of the adult population consists of nonbreeding helpers (Woelfenden and Fitzpatrick 1984, 1990, 1996).

These "surplus" nonbreeding helpers are ideal candidates for translocation to other areas capable of supporting jays. Provided with unoccupied but suitable breeding habitat, they should be able to establish territories and nest. At the same time, the removal of nonbreeding helpers should have less effect on the source population than would comparable removal of established breeding pairs.

Here we present the results of a pilot study designed to evaluate translocation as a management technique for the Florida scrub-jay. From 1989-95, 20 Florida scrub-jays, including both nonbreeders and established breeding pairs, were captured at Archbold Biological Station in Highlands County, Florida and translocated to suitable but unoccupied habitat at Rookery Bay National Estuarine Research Reserve in Collier County. The study included detailed post-

translocation monitoring (Scott and Carpenter 1987) of both the reintroduced population at Rookery Bay and the source population at Archbold Biological Station.

METHODS

Study Sites

The Florida scrub-jays used in the translocations were obtained from Archbold Biological Station, a 2000-ha research station in Highlands County. A color-banded population of Florida scrub-jays (the demography tract population) has been under continuous study at Archbold since 1969 (Woolfenden and Fitzpatrick 1984, 1990, 1996). Beginning in 1987, however, additional research on Florida scrub-jays has been conducted on a second population of jays (the experimental tract population) adjacent to the demography tract population (e.g., Schoech et al. 1991, Mumme 1992). All the jays used in our translocation experiments originated from the experimental tract, which served as the source population.

Translocated jays were released at Rookery Bay National Estuarine Research Reserve in Collier County. Rookery Bay is a 3,600-ha reserve managed by the Florida Department of Environmental Protection and situated on the Gulf of Mexico between Naples and Marco Island. It is protected from development and includes approximately 50 ha of coastal oak scrub (Fig. 1). A 50-ha tract of oak scrub should be capable of supporting a population of Florida scrub-jays comprising 4-6 territories and 12-20 birds (Woolfenden and Fitzpatrick 1984, 1991, 1996; Fitzpatrick et al. 1991, Breininger et al. 1996a). In addition, the Rookery Bay management plan includes provisions for periodic prescribed burning. Although Florida scrub-jays formerly occurred in the Naples-Marco Island area, they were last reported from the region in the 1930s (Cox 1987). The closest extant population is approximately 60 km from Rookery Bay and well outside the species' normal range of dispersal (Stith et al. 1996).

1989 Translocations

The source population of Florida scrub-jays at Archbold Biological Station was censused in early March 1989. The population at that time comprised 140 jays in 45 family groups. We then selected 10 nonbreeders from 10 different groups for translocation (Table 1). An equal number of males and females were selected from as diverse a genetic background as possible. In an effort to reduce the possible impact on the source population, 9 of the 10 birds came from

groups containing 2 or more nonbreeders; these groups thus still contained at least 1 potential helper after 1 was removed. Previous work has shown that although pairs assisted by helpers have significantly higher reproductive success than unassisted pairs (Mumme 1992), the reproductive success of pairs with 2 or more helpers is not higher than that of pairs with only a single helper (Woolfenden and Fitzpatrick 1984, 1990). The determination of sex followed behavioral methods outlined by Woolfenden and Fitzpatrick (1984) and Schoech et al. (1991).

The nonbreeders were captured in baited traps 8-9 March, measured, weighed, and given a fresh set of color bands. From 8-11 March the captives were housed at Archbold in 0.46 x 0.61 x 0.91 m holding cages constructed of 1.3-cm galvanized hardware cloth and fed high-protein dog food, peanuts, mealworms, and water. To facilitate the establishment of pair bonds, the 10 captives were caged together in 5 arbitrarily assigned male-female pairs. On 11 March each of the 5 cages was covered with a light cloth, placed in the back of a well-ventilated van, and transported to Rookery Bay. There, we transferred the captives to 5 larger, previously constructed pre-release cages erected in the oak scrub at Rookery Bay. These predator-proof cages (0.91 x 0.91 x 0.91 m) were also constructed of 1.3-cm hardware cloth, and each was placed on a 1.2 m high platform constructed out of 2.5-cm PVC pipe. Thus, the top of each cage was about 2.1 m above ground level, enabling the jays to see much of their surroundings. The 5 pre-release cages were all placed within 10 m of each other in a loose circle, allowing the jays to maintain visual and vocal contact with birds in other cages (Fig. 1).

To orient the captives to their release site and establish site attachment, the 10 birds were maintained in the pre-release cages for 6 days, until 17 March. The cage doors were opened at 1500 hrs on 17 March, and all birds left the cages by 1515 hrs.

Just prior to release, 5 plywood feeding platforms attached to 1.2 m PVC pipes were established at various locations within the scrub. High-protein dog food and peanuts were provided for the first few weeks after release, after which time supplemental feeding was gradually phased out.

1990 Translocations

The methods used in the 1990 translocations differed from those employed during 1989 in two important respects. First, in the hope of improving on the success-rate of the 1989 translocations, we translocated breeding pairs in addition to nonbreeding helpers. Second,

instead of placing the pre-release cages together as in 1989, we scattered them in undefended portions of the Rookery Bay scrub (Fig. 1). Otherwise, procedures used in 1990 closely followed those used in the preceding year.

We censused the Archbold study population in early March 1990. At that time it comprised 109 jays in 39 family groups. Eight Florida scrub-jays (4 males and 4 females) were then selected for translocation (Table 1). These birds included 2 established breeding pairs (pairs who had produced at least 1 nest together in previous breeding seasons), 1 novice breeding pair, and 2 nonbreeding helpers. The 2 nonbreeders were each removed from family groups containing 2 potential helpers.

The 8 jays were captured 9-10 March and housed at Archbold as pairs in the same cages used in 1989. The captives were transferred to 4 pre-release cages at Rookery Bay on 11 March and held there until 1600 hrs on 15 March. Just prior to release, we established 3 feeders near the cages and supplied them with high-protein dog food and peanuts. As in 1989, feeding was continued for the first few weeks post-release and then gradually phased out.

1995 Translocations

To correct a male-biased sex ratio that had developed in the reintroduced population of Florida scrub-jays at Rookery Bay, 2 nonbreeding females from groups containing at least 1 other potential helper were translocated from the Archbold source population in February 1995 (Table 1). The 2 females were captured 12-13 February, housed temporarily at Archbold, and transported to Rookery Bay on 14 February. At Rookery Bay the females were housed individually in 2 adjacent pre-release cages placed in an area frequented by the resident jays. The 2 females were thus able to see their surroundings and interact socially with the resident jays and each other prior to their release. We released the birds at 1500 hrs on 18 February.

Post-Translocation Monitoring at Rookery Bay and Archbold Biological Station

We monitored the activities of translocated jays on an essentially daily basis during the first two weeks following their release, about 3-4 times per week during the breeding season (March-June), and 1-3 times per month at all other times, from March 1989 to July 1997. Data were collected primarily through regular surveys of the Rookery Bay scrub and adjacent areas, during which time the identities, locations, activities, and habitat usages of translocated jays

were recorded. Special attention was given to signs of pairing and territoriality (e.g., courtship feeding, territorial pair-flights, etc.). Nests were found during building or incubation and checked 2-3 times per week until fledging or nest failure. Young were color-banded as either nestlings or dependent fledglings.

Following the 1989 and 1990 translocations, we monitored the source population at Archbold Biological Station using the general methods outlined by Woolfenden and Fitzpatrick (1984). We censused the population on an approximately monthly basis December-July in both 1989 and 1990. During the nesting season, we located and determined the fate of all nests so that reproductive success could be measured for both unmanipulated control families and experimental families where birds had been removed and translocated. We did not, however, conduct extensive post-translocation monitoring of the Archbold source population following the modest supplemental translocation of 2 females in February 1995.

RESULTS

1989 Translocations

Although the 10 jays released at Rookery Bay in March 1989 wandered widely at first, by 21 March (4 days post-release) all 10 birds were resident in the oak scrub within 500 m of the release site (Fig. 1). Four of these birds (2 3-year olds and 2 2-year olds) paired and established 2 territories adjacent to the release site. The remaining 6 birds (3 2-year olds and 3 1-year olds) never paired or attempted to establish territories. During late March and April, these unpaired jays were seen most consistently within 500 meters of the release site, inside the territories of the 2 newly established pairs, where they were tolerated but subject to frequent aggression from the residents. These unpaired "floaters" did not make use of areas of seemingly suitable scrub northwest and south of the release site (Fig. 1). They did, however, make occasional exploratory forays, during which they were absent from the Rookery Bay scrub for hours or days, and were seen in mangroves, along roadsides, and in other unsuitable habitats within 2 km of the release site. Regardless, all 6 of these unpaired jays were present in the Rookery Bay scrub on 19 April.

During the last week of April and the first two weeks of May, however, these 6 unpaired birds apparently left Rookery Bay. Despite intensive searches, we failed to locate them. Three birds were last seen on 27 April. A fourth jay, absent from Rookery Bay between 27 April and

6 May, briefly reappeared on 6 May before disappearing permanently. A fifth jay was last seen at Rookery Bay on 10 May. The sixth (a 1-yr old) was last observed at Rookery Bay on 5 May. However, this bird was seen on 22 June at a backyard bird feeder 30 km NE of Rookery Bay. The resident also reported two color-banded jays (including the bird he had seen in June) at his feeder again for a few days in early August. These reports, which we consider reliable, suggest that most or all of the six birds that disappeared from Rookery Bay during April and May did not die but emigrated from the release site.

1990 Translocations

Eight Florida scrub-jays were released at Rookery Bay on 15 March 1990. One male was not seen after 23 March, and a female that had appeared ill for several days disappeared after 1 April. Two of the remaining 6 birds, a pair that had nested unsuccessfully at Archbold in 1989, gradually established a territory near their release site at the northern end of the Rookery Bay scrub (Fig. 1). Two other translocated birds were missing from Rookery Bay between 6 April and 3 May, but they eventually returned, paired, and established a territory near the pre-release cage in which the female (but not the male) had been housed.

The final 2 birds were seen sporadically during March and April before disappearing in late April. One of these birds, however, a female that was last seen at Rookery Bay on 27 April, returned to Rookery Bay on 26 August 1990.

1995 Translocations

Within an hour of her release, 1 of the 2 females translocated to Rookery Bay in 1995 paired with the oldest resident unpaired male. This female and her mate established a territory within 200 m of the pre-release cage (Fig. 1) and nested in late March. The nest, however, was unsuccessful and the female disappeared and presumably died in late June. The second female was courted and fed by at least 4 different unpaired males (regularly by 2) throughout February and March, but did not clearly pair, establish a territory, and nest until 1996. She was still present at Rookery Bay at the termination of the study in July 1997 (Table 1).

Population Dynamics at Rookery Bay

Following the 1989-90 translocations, the population of Florida scrub-jays at Rookery

Bay reached a maximum at 15 birds and 4 breeding pairs in mid-1990 (Fig. 2). From 1991 to 1997, however, the population stabilized at 6-11 birds and 1-3 breeding pairs. The number of jays hatched at Rookery Bay varied from a low of 1 in late 1989 to 8 in 1996 (Fig. 2).

Site Persistence of Translocated Birds at Rookery Bay

We used standard techniques of survival analysis (Abacus Concepts 1994) to estimate duration of residency (site persistence) of translocated jays at Rookery Bay. (We prefer "duration of residency" and "site persistence" to "survival" because, as described above, at least some of the jays that disappeared from Rookery Bay emigrated rather than died.) The mean $\pm$ SE duration of residency at Rookery Bay was 2.04 ± 0.59 yr for the 20 translocated birds, and was virtually identical for males (2.08 ± 0.93 yr, $n = 9$) and females (2.01 ± 0.81 yr, $n = 11$). Site persistence of birds who had been breeders at Archbold was lower than that of nonbreeders (1.14 ± 0.48 yr [$n = 6$] vs. 2.40 ± 0.82 yr [$n = 14$], respectively), but this difference was not statistically significant (Breslow-Gehan-Wilcoxon $\chi^2 = 0.11$, $df = 1$, $P = 0.74$).

Persistence time was positively related to age at the time of translocation. Assuming that birds of unknown age were the minimum age listed in Table 1, mean $\pm$ SE persistence times at Rookery Bay were 0.63 ± 0.51 yr for 1-yr olds, 2.13 ± 0.99 yr for 2-yr olds, and 2.71 ± 1.10 for birds who were 3 yr or older when translocated (Fig. 3). These differences, although suggestive, were not statistically significant (Breslow-Gehan-Wilcoxon $\chi^2 = 3.05$, $df = 2$, $P = 0.22$).

Nine of the 20 jays translocated to Rookery Bay emigrated or died within two months of their release (Table 1). For the 11 jays that remained at Rookery Bay for at least two months, the annual rate of disappearance was 23.8% (10 disappearances in 42 bird-years). This is not significantly different from the long-term average annual mortality rate of 22% reported by Woolfenden and Fitzpatrick (1996) for breeding Florida scrub-jays at Archbold Biological Station ($\chi^2 = 0.80$, $df = 1$, $P = 0.77$).

Nesting Success at Rookery Bay

During 1989-97, Florida scrub-jays at Rookery Bay produced a total of 22 nests that received eggs. Nine (40.9%) were successful, fledging a total of 23 young. This success rate is slightly lower than the long-term average nest success rate of 49% reported by Woolfenden and

Fitzpatrick (1996) for jays at Archbold Biological Station, but not significantly so ($\chi^2 = 0.58$, $df = 1$, $P = 0.45$).

Site Persistence of Young Fledged at Rookery Bay

Of 23 fledglings produced at Rookery Bay 1989-97, 11 (47.8%) were still present at Rookery Bay at age-1 yr. This is slightly higher than the long-term average of 33% first-year survival for jays at Archbold Biological Station (Woolfenden and Fitzpatrick 1996), but not significantly so ($\chi^2 = 2.29$, $df = 1$, $P = 0.13$).

Among birds fledged at Rookery Bay, site persistence was considerably lower in females than in males. Ten young survived long enough so that sex could be determined. Of these, 8 were males and 2 were females. Furthermore, duration of residency of the 2 known females was just 1.08 ± 0.40 yr compared to 3.65 ± 0.86 yr for the 8 known males, a difference that was statistically significant (Breslow-Gehan-Wilcoxon $\chi^2 = 10.67$, $df = 1$, $P = 0.001$). Neither of the 2 females survived long enough to breed at Rookery Bay. In contrast, males hatched at Rookery Bay nested there from 1994-1997. The higher rate of mortality (or emigration) experienced by females led to a male-biased sex ratio in the population from 1992-1997, a bias that continued even after the supplemental translocation of 2 females to Rookery Bay in February 1995 (Fig. 4).

Effects of Translocation on Source Population

The reproductive success of the 12 Florida scrub-jay families from which nonbreeding helpers were removed during 1989-90 was virtually identical to that of 18 control families where nonbreeding helpers were not removed (Fig. 5). Breeder survival during the 3-month nesting season was slightly higher in control families than in experimental families (94.4% [$n = 36$] vs. 83.3% [$n = 24$]). The difference, however, was not statistically significant (Fisher exact test $P = 0.21$). Thus, the removal and translocation of nonbreeding helpers performed during this study had no detectable short-term impact on the survival and reproductive success of the breeders in their former groups.

Six of the 8 birds translocated to Rookery Bay in 1990 comprised three territorial pairs. The removal of these birds produced no net change in the density of territorial pairs at Archbold; by the end of the 1990 nesting season, all 3 pairs had been replaced by new pairs

made up of formerly nonbreeding helpers from neighboring territories. However, none of the 3 newly established replacement pairs built nests or laid eggs during the 1990 nesting season, a pattern typical for newly formed pairs (Woolfenden and Fitzpatrick 1996).

During 1989-90, the source population of Florida Scrub-Jays at Archbold declined by 20.3%, from 148 jays in July 1988 to 132 jays in July 1989 and 118 birds in July 1990 (Fig. 6). However, during the same 2-year period, the adjacent but unmanipulated population monitored by Woolfenden and Fitzpatrick (1984, 1990) underwent an even more extreme decline of 34.0% (Fig. 6), largely because of an intense fire that burned a significant portion of the study area in May 1989 (G. E. Woolfenden, per. commun.). This complicates any attempt to estimate the effects of removal of jays from the source population. Nonetheless, it is likely that the translocation of 10 birds in March 1989 (7.1% of the source population) and 8 additional jays in March 1990 (7.3% of the population) contributed to the population decline observed in the source population during 1989-90 (Fig. 6).

DISCUSSION

Translocation as a Management Technique

Our results suggest that the translocation of Florida scrub-jays from healthy populations to areas of suitable but unoccupied habitat is a potentially useful technique for the management and restoration of this threatened species. Successful nesting by birds translocated to Rookery Bay occurred in the first year of the study (1989), and successful nesting by birds hatched at Rookery Bay first occurred 5 years later (1994). Nesting success, juvenile survival, and adult survival of jays in the reintroduced population at Rookery Bay were all comparable to those of jays living at Archbold Biological Station.

Consequently, the reintroduction of Florida scrub-jays to Rookery Bay can be viewed as a modest management success, with two important qualifications. First, almost half (9 of 20; 45%) of the birds translocated to Rookery Bay disappeared within the first 8 weeks of translocation. Although our observations indicate that many if not most of these birds emigrated rather than died, future translocation programs should anticipate an initially high rate of emigration or mortality of translocated birds. Second, the reintroduced population at Rookery Bay did not grow to be as large as expected. Based on the amount of oak scrub available, we anticipated that Rookery Bay could support a population of 4-6 territories and

12-20 birds. Instead, the population stabilized at only about half that number (Fig. 2).

Why did the Rookery Bay population not reach its expected maximum size? Two factors are probably responsible. First, although the Rookery Bay management plan calls for periodic burning of oak scrub, fire management was not aggressively pursued. Although about a third of the oak scrub at Rookery Bay was burned in 1988, one year before the initial translocation, no additional prescribed burning was performed during the duration of our study (1989-1997). By 1997, much of the habitat at Rookery Bay was considerably overgrown and of poor quality. Although all of the oak scrub at Rookery Bay was occupied and defended when the population was at its peak of 4 pairs and 15 birds in 1990, between 1990 and 1993 most of the scrub not burned in 1988 was abandoned.

A second and perhaps related factor underlying the overall poor growth of the Rookery Bay population was the very low rate of production, survival and persistence of females hatched at Rookery Bay. This led to a strongly male-biased sex ratio in the reintroduced population and an extreme shortage of potential mates for males, thereby limiting reproduction and local recruitment into the population. The reasons for the poor performance of females hatched at Rookery Bay are not clear, especially considering that survival and persistence of females translocated to Rookery Bay was virtually identical to that of translocated males. However, at Archbold Biological Station nonbreeding females are more likely to engage in temporary dispersal forays than are nonbreeding males, leading to a higher rate of mortality for females and a nonbreeder sex ratio that is male biased (Woolfenden and Fitzpatrick 1984). The same process could be responsible for both the relatively poor survival and persistence of females hatched at Rookery Bay and the resulting male-biased sex ratio. Male-biased nonbreeder sex ratios have been observed in other populations of Florida scrub-jays as well (e.g., Breininger et al. 1996b).

Despite these caveats, our results suggest that translocation has considerable potential as a technique for restoring the Florida scrub-jay to unoccupied portions of its historic range. However, even after a suitable translocation site and a healthy host population have been identified, a number of methodological issues must be considered before any translocation program is implemented.

Timing of Translocation

Translocations of Florida scrub-jays would probably have the highest chances for success at two times of the year: (1) early spring (late February or early March) and (2) late summer (August). Because of the Florida scrub-jay's dependence on stored acorns during the winter months (DeGange et al. 1989), translocating birds after the onset of the fall acorn harvest is inadvisable. By late February and early March, however, insect populations in the oak scrub begin to increase and dependence on stored acorns declines (DeGange et al. 1989). Thus, translocations done at this time should have a reasonable chance of success. Translocations conducted during late winter or early spring also minimize the amount of time translocated jays are subject to sources of mortality before the onset of the breeding season.

Translocations during mid-summer are also inadvisable; Florida scrub-jays experience heavy mortality during June and July (Woolfenden and Fitzpatrick 1984), a time when the birds are molting heavily (Bancroft and Woolfenden 1982). However, by mid-August molt is largely complete, and translocations at this time would allow birds to harvest and cache ripening acorns at the translocation site.

Selection of Birds for Translocation

Our results indicate that the best candidates for translocation are 2- and 3-year-old nonbreeding helpers from families with at least 1 other potential helper. Survival and long-term persistence at Rookery Bay was higher for nonbreeders than for breeders, and higher for 2- and 3-year olds than for 1-year olds (Fig. 3). Although 1-year-old Florida scrub-jays are capable of establishing territories and breeding in at least some circumstances (Woolfenden and Fitzpatrick 1984, 1996), three of the four 1-year olds translocated to Rookery Bay disappeared within two months of their release (Table 1). In contrast, 7 (63.6%) of the 11 older nonbreeders paired and established territories. The success rate for breeding pairs was about the same; of the six established or novice breeders translocated in 1990, three (50%) became paired territory holders, although a fourth remained at Rookery Bay as an unpaired nonbreeder.

Translocating nonbreeding helpers instead of breeders would also be preferred if it can reduce impact on the source population. Reduced impact is especially likely if nonbreeders can be selected from large families where additional potential helpers are present. In our study, removal of 1 nonbreeder from groups with at least 2 potential helpers had no significant impact

on either reproductive success (Fig. 5) or survival of breeders. In contrast, removal of all nonbreeders from a group can significantly reduce reproductive success of Florida scrub-jays (Mumme 1992).

Length of the Pre-Release Period

Our primary objective in housing birds 4-6 days in pre-release cages was to establish a measure of site attachment between the jays and Rookery Bay scrub, thereby lessening the probability that a disoriented, just-released jay would wander away from the release site and disappear. This procedure appears to have been reasonably effective; none of the 20 translocated jays disappeared immediately after their release, and all remained at Rookery Bay for at least eight days. Even those jays that disappeared within the first few months of their release usually did so in such a way (e.g., following prolonged forays away from and back to the Rookery Bay scrub) to suggest that their disappearances were a result of voluntary emigration rather than disorientation or death. Longer pre-release periods could increase the probability that translocated birds would remain on the release site, but this possibility would have to be weighed against the potential stress imposed on wild birds by caging them for a prolonged period of time.

Our secondary objective in housing the jays temporarily in pre-release cages was to facilitate the establishment of pair bonds in previously unpaired jays. However, none of the six arbitrarily created "pairs" remained together after their release.

MANAGEMENT IMPLICATIONS

We have shown that translocation of nonbreeding helpers is a viable technique for restoring the Florida scrub-jay to unoccupied portions of its historic range. Because populations of this threatened species are often small and prone to local extinction (Fitzpatrick et al. 1991, Woolfenden and Fitzpatrick 1991, Stith et al. 1996), reintroductions will probably play an increasingly important role in future management plans. Translocations, however, should be pursued only under unusual circumstances. First, a potential translocation site must have an adequate area of oak scrub habitat that is suitable for Florida scrub-jays, protected from development, and properly managed. Areas satisfying all these requirements are scarce. Second, our results suggest that a reintroduction program should anticipate initially high rates

of mortality and emigration in translocated birds; thus, translocations of very small numbers of birds are unlikely to be successful. Finally, because translocations of large numbers of birds will have substantial impact on source populations, reintroductions should be pursued only when the potential benefit of establishing a new population is likely to outweigh the probable costs to the source population.

Translocation is therefore no panacea for the problems that threaten the Florida scrub-jay with extinction, and it should not be viewed as an acceptable substitute for the protection of existing populations. Translocation of Florida scrub-jays should be viewed only as a technique for restoring this species to unoccupied portions of its historic range, not as a technique for mitigating the effects of habitat destruction.

LITERATURE CITED

- Abacus Concepts. 1994. Survival tools for StatView. Abacus Concepts, Inc., Berkeley, Cal. 125pp.
- Bancroft, G. T., and G. E. Woolfenden. 1982. The molt of scrub jays and blue jays in Florida. Ornithol. Monogr. 29. 51pp.
- Breining, D. R., V. L. Larson, B. W. Duncan, R. B. Smith, D. M. Oddy, and M. F. Goodchild. 1996a. Landscape patterns of Florida scrub jay habitat use and demographic success. Conserv. Biol. 9:1442-1453.
- _____, D. M. Oddy, _____, and M. J. Barkaszi. 1996b. Florida scrub-jay demography in different landscapes. Auk 113:617-625.
- Butler, D., and D. Merton. 1992. The black robin: saving the worlds' most endangered bird. Oxford Univ. Press, Oxford, U. K. 294pp.
- Cade, T. J., and S. A. Temple. 1994. Management of threatened bird species: evaluation of the hands-on approach. Ibis 137:S161-S172.
- Cox, J. A. 1987. Status and distribution of the Florida scrub jay. Florida Ornithol. Soc. Spec. Publ. 3. 110 pp.
- DeGange, A. R., J. W. Fitzpatrick, J. N. Layne, and G. E. Woolfenden. 1989. Acorn harvesting by Florida scrub jays. Ecology 70:348-356.
- Griffith, B., J. M. Scott, J. W. Carpenter, and C. Reed. 1989. Translocation as a species conservation tool: status and strategy. Science 245:477-480.
- Kleiman, D. G. 1989. Reintroduction of captive mammals for conservation. BioScience 39:152-161.
- Fitzpatrick, J. W., G. E. Woolfenden, and M. T. Kopeny. 1991. Ecology and development-related habitat preservation for the Florida scrub jay (*Aphelocoma coerulescens coerulescens*). Florida Nongame Wildlife Prog. Tech. Rept. No. 8. Florida Game and Fresh Water Fish Comm., Tallahassee. 49pp.
- Mumme, R. L. 1992. Do helpers increase reproductive success? An experimental analysis in the Florida scrub jay. Behav. Ecol. Sociobiol. 31:319-328.
- Sarrazin, F., and R. Barbault. 1996. Reintroductions: challenges and lessons for basic ecology. Trends Ecol. Evol. 11:474-478.
- Scott, J. M., and J. W. Carpenter. 1987. Release of captive-reared or translocated endangered birds: what do we need to know? Auk 104:544-545.
- Schoech, S. J., R. L. Mumme, and M. C. Moore. 1991. Reproductive endocrinology and mechanisms of breeding inhibition in cooperatively breeding Florida scrub jays (*Aphelocoma c. coerulescens*). Condor 93:354-364.
- Shaffer, M. L. 1981. Minimum population sizes for species conservation. BioScience 31:131-134.

- Soule, M. E., editor. 1987. Viable populations for conservation. Cambridge Univ. Press, Cambridge, U. K. 189pp.
- Stith, B. M., J. W. Fitzpatrick, G. E. Woolfenden, and B. Pranty. 1996. Classification and conservation of metapopulations: a case study of the Florida scrub jay. Pages 187-215 in D. R. McCullough, ed. Metapopulations and wildlife conservation. Island Press, Washington, D.C.
- Westcott, P. W. 1970. Ecology and behavior of the Florida scrub jay. Ph.D. Thesis, Univ. Florida, Gainesville. 82pp.
- Wolf, C. M., B. Griffith, C. Reed, and S. A. Temple. 1996. Avian and mammalian translocations: update and reanalysis of 1987 survey data. *Conserv. Biol.* 10:1142-1154.
- Woolfenden, G. E., and J. W. Fitzpatrick. 1984. The Florida scrub jay: demography of a cooperative-breeding bird. Princeton Univ. Press, Princeton, N. J.
- _____, and _____. 1986. Sexual asymmetries in the life history of the Florida scrub jay. Pages 87-107 in D. I. Rubenstein and R. W. Wrangham, eds. Ecological aspects of social evolution. Princeton Univ. Press, Princeton, N. J.
- _____, and _____. 1990. Florida scrub jays: a synopsis after 18 years of study. Pages 240-266 in P. B. Stacey and W. D. Koenig, eds. Cooperative breeding in birds: long-term studies of ecology and behavior. Cambridge Univ. Press, Cambridge, U. K.
- _____, and _____. 1991. Florida scrub jay ecology and conservation. Pages 542-565 in C. M. Perrins, J. D. Lebreton, and G. J. M. Hirons, eds. Bird population studies: relevance to conservation and management. Oxford Univ. Press, Oxford, U. K.
- _____, and _____. 1996. Florida scrub-jay (*Aphelocoma coerulescens*). Pages 1-28 in A. Poole and F. Gill, eds. The birds of North America, no. 228. Acad. Nat. Sci., Philadelphia, and Amer. Ornithol. Union, Washington, D.C.

Table 1. Characteristics of Florida scrub-jays translocated from Archbold Biological Station to Rookery Bay National Estuarine Research Reserve.

Bird	Sex	Date	Reproductive status	Age (years)	Date disappeared
		translocated	when translocated	when translocated ^a	from Rookery Bay
-WSA	F	March 1989	Nonbreeder	3	April 1996
-LSG	M	March 1989	Nonbreeder	3	September 1993
A-SA	F	March 1989	Nonbreeder	2+	November 1993
SWF-	M	March 1989	Nonbreeder	2	April 1997
SRF-	F	March 1989	Nonbreeder	2	April 1989
SRO-	F	March 1989	Nonbreeder	2	May 1989
SPA-	M	March 1989	Nonbreeder	2	May 1989
-SRY	F	March 1989	Nonbreeder	1	April 1989
-SLY	M	March 1989	Nonbreeder	1	April 1989
-SGG	M	March 1989	Nonbreeder	1	May 1989
-LSL	F	March 1990	Established breeder	4	May 1991
P-SA	M	March 1990	Established breeder	6+	February 1993
Y-SF	F	March 1990	Established breeder	3+	August 1990
P-SG	M	March 1990	Established breeder	4+	May 1990
YR-S	F	March 1990	Novice breeder	1	May 1992
A-SB	M	March 1990	Novice breeder	2+	March 1990
-SWR	F	March 1990	Nonbreeder	2	April 1990
Y-SB	M	March 1990	Nonbreeder	2+	October 1992
S-YB	F	February 1995	Nonbreeder	2	June 1995
S-GL	F	February 1995	Nonbreeder	2	— ^b

^a Minimum age shown for birds of unknown age.

^b Still present at Rookery Bay July 1997.

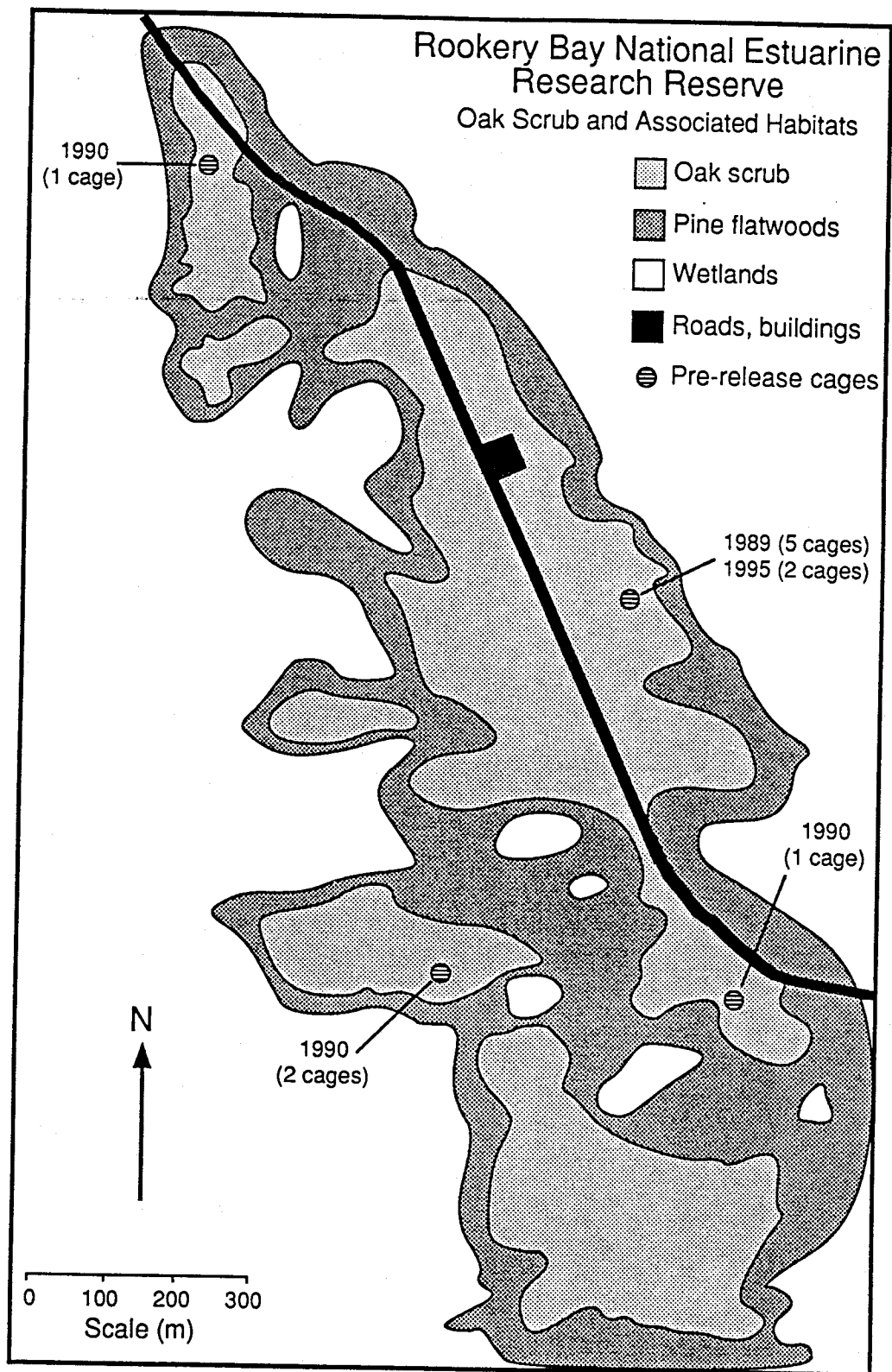


Fig. 1. Oak scrub and associated habitat at Rookery Bay National Estuarine Research Reserve, Collier County, Florida. Surrounding habitats are coastal wetlands, including mangrove swamps and marshes. Location of pre-release cages used to house translocated jays temporarily in 1989, 1990, and 1995 are shown.

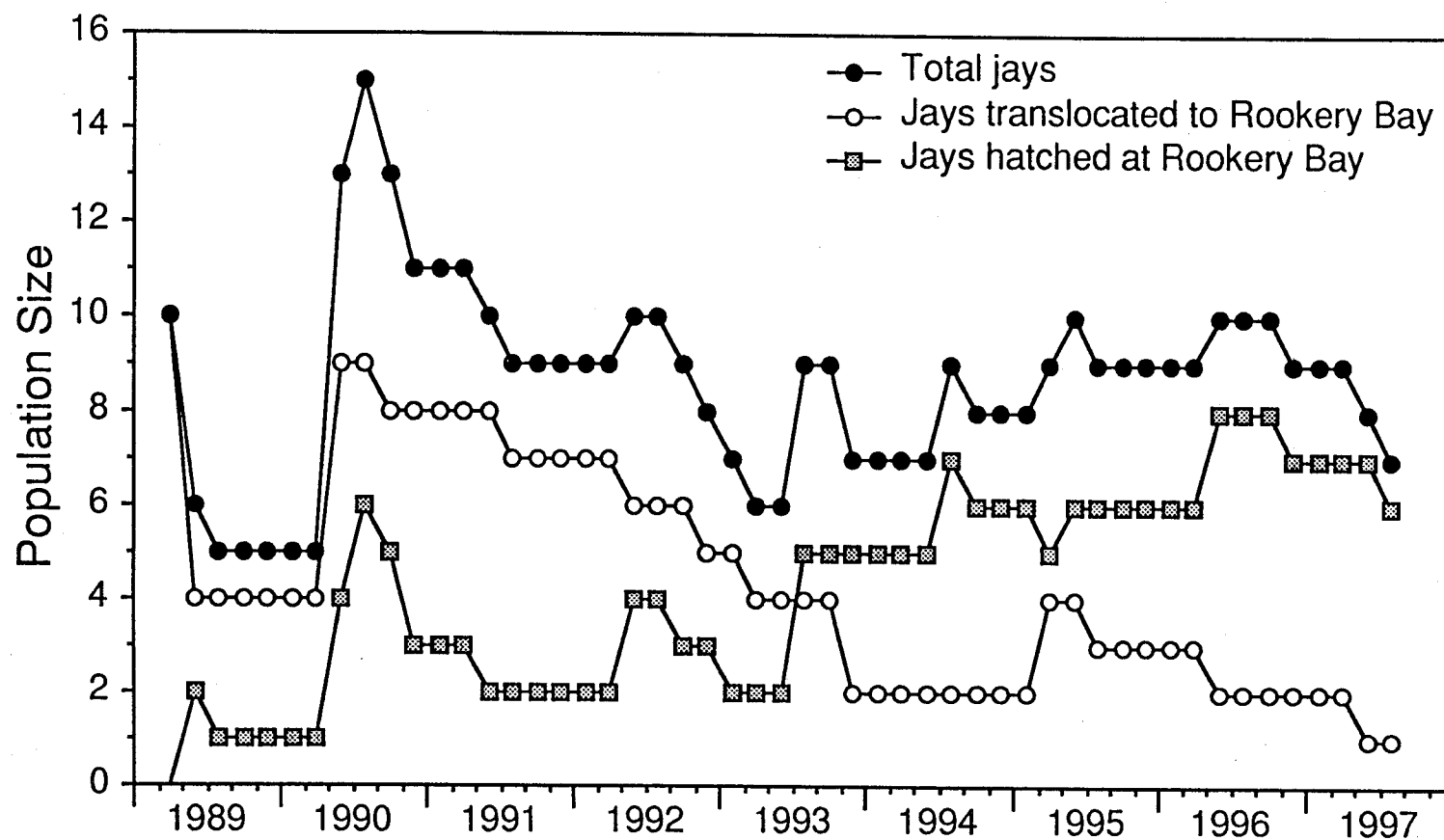


Fig. 2. Changes in the size of the re-established population of Florida scrub-jays at Rookery Bay National Estuarine Research Reserve, 1989-1997.

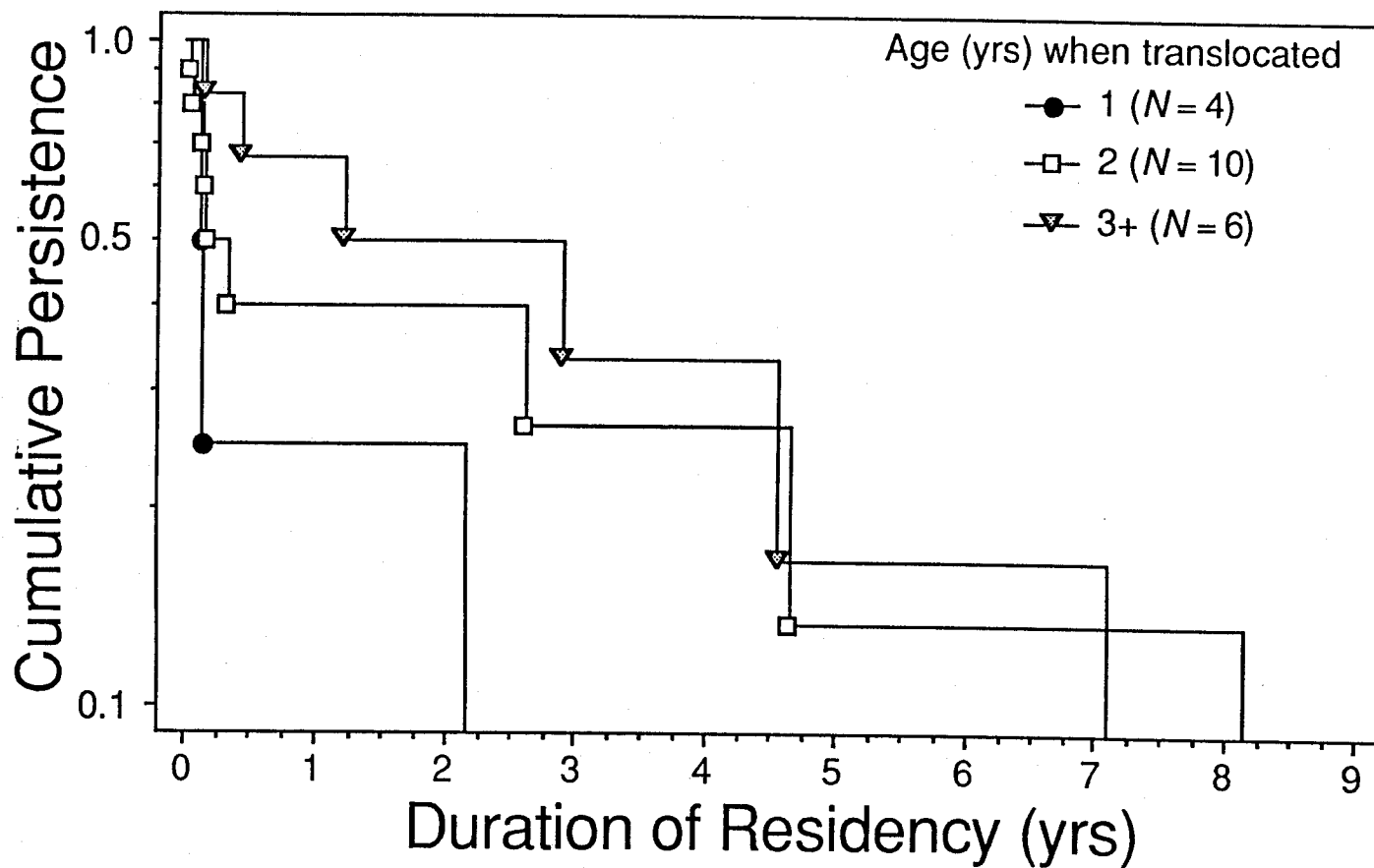


Fig. 3. Kaplan-Meier survival curves showing duration of residency (persistence) by Florida scrub-jays translocated to Rookery Bay at 1, 2, and 3 or more years of age.

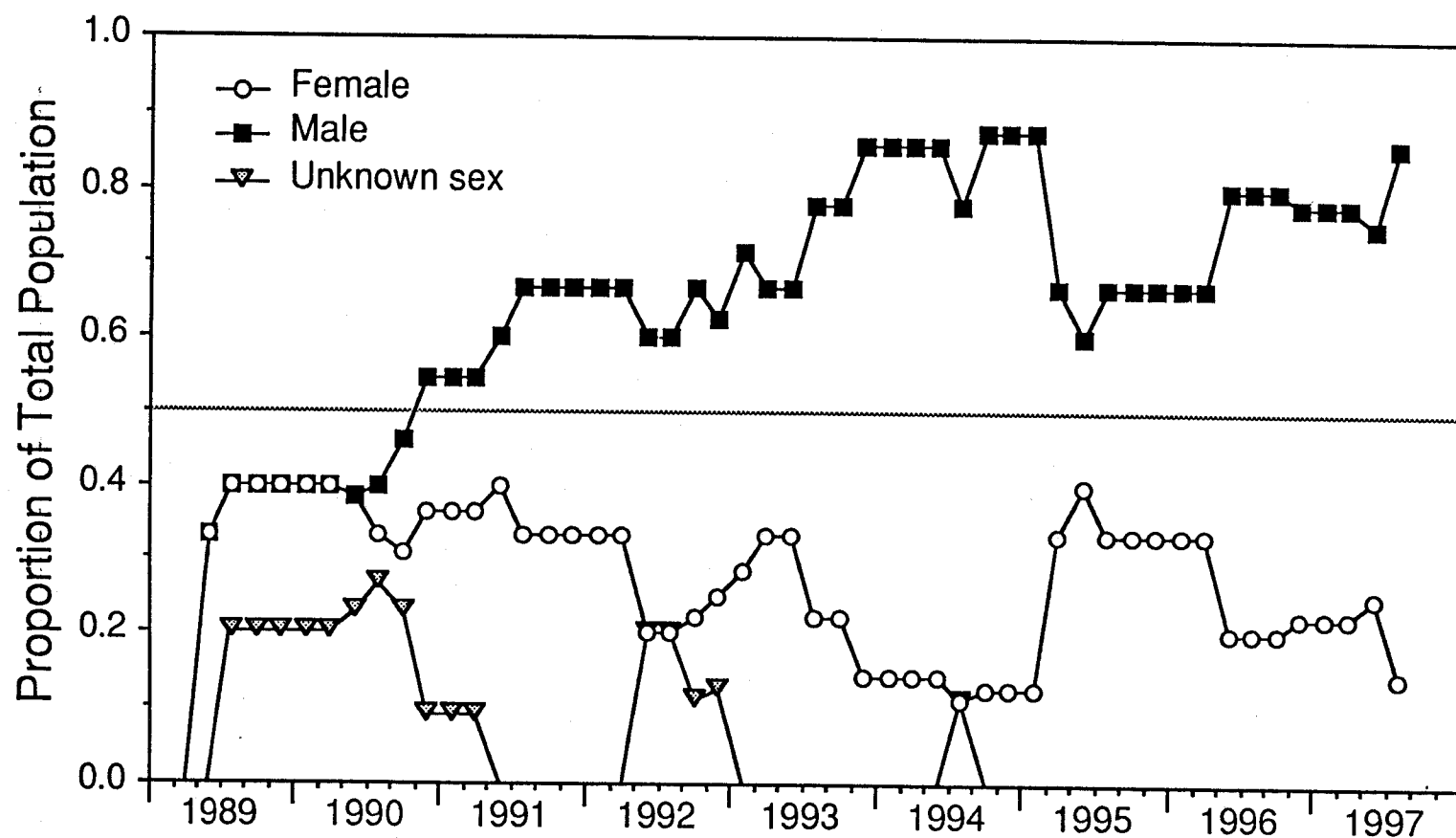


Fig. 4. Changes in the proportion of females, males, and unknown-sex birds in the re-established population of Florida scrub-jays at Rookery Bay. Shaded line reflects the proportion of males and females expected under an even 1:1 sex ratio.

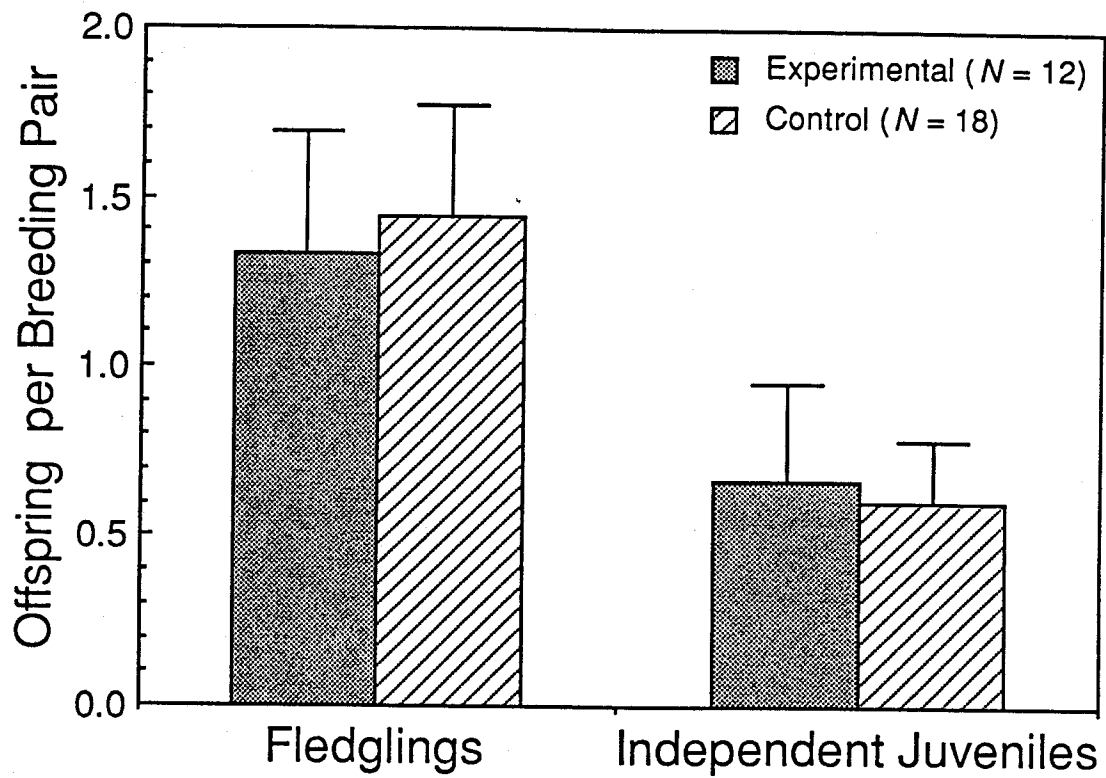


Fig. 5. Effects of removal and translocation of nonbreeders on the production of fledglings and independent juveniles by experimental and unmanipulated control groups at Archbold Biological Station, 1989-90.

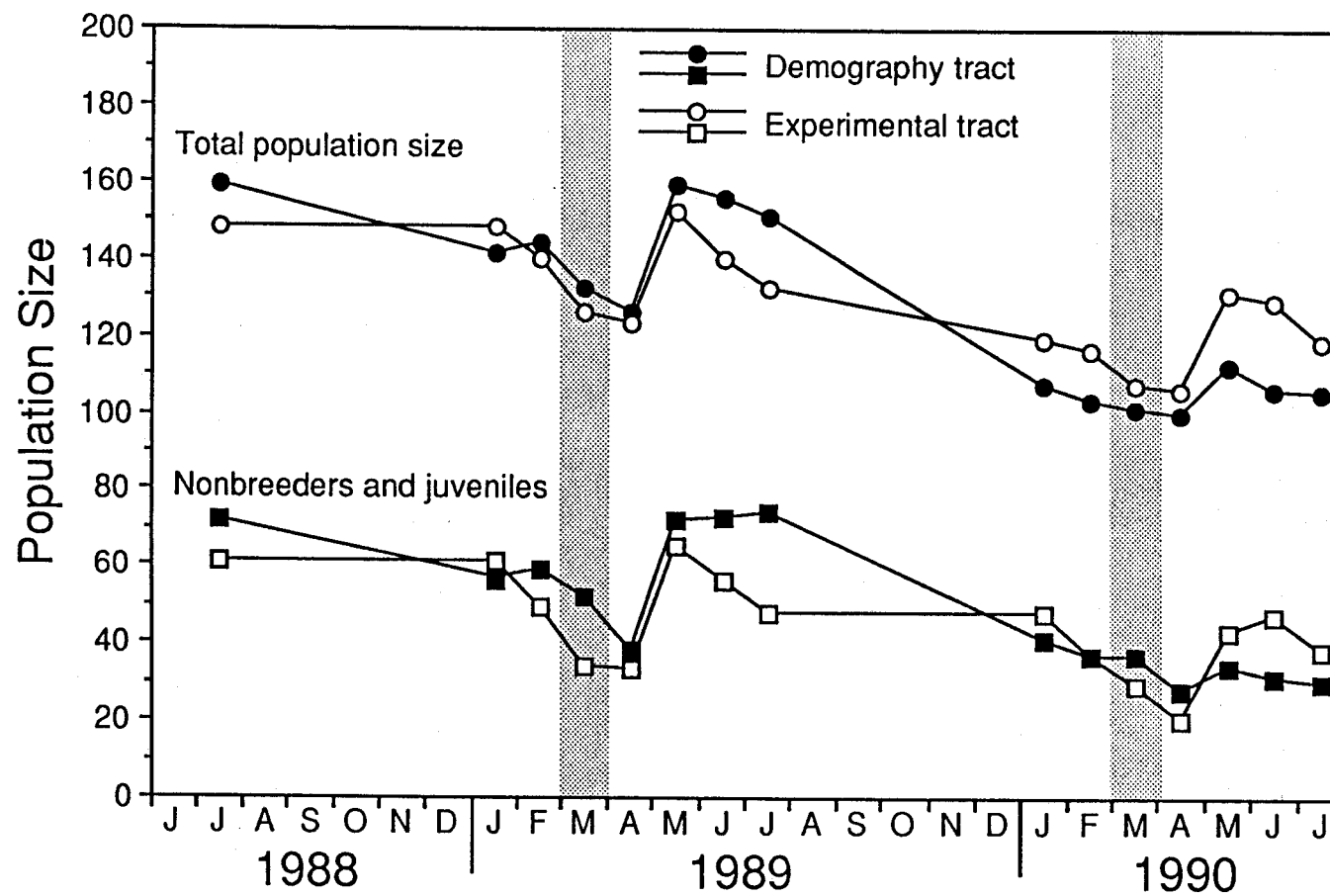


Fig. 6. Changes in the size of the Florida scrub-jay populations in the source (experimental) and control (demography) tract at Archbold Biological Station, 1988-1990.