AVIAN RESTORATION IN EVERGLADES NATIONAL PARK (1997-2001): TRANSLOCATION METHODOLOGY, POPULATION DEMOGRAPHY, AND EVALUATING SUCCESS

Final Report

Submitted by:

Gary L. Slater
Ecostudies Institute
P.O. Box 703
Mount Vernon, WA 98273

18 December 2001

TABLE OF CONTENTS

CHAPTER ONE

INTRODUCTION

During the mid-1900's, four pine-forest cavity-nesting bird species: Brown-headed Nuthatch (*Sitta pussila*), Eastern Bluebird (*Sialia sialis*), Red-cockaded Woodpecker (*Picoides borealis*), and Southeastern American Kestrel (*Falco sparverius paulus*), and two pine-forest associates: Wild Turkey (*Meleagris gallopavo*) and Summer Tanager (*Piranga rubra*) disappeared from southeastern Florida and Everglades National Park (ENP) (Robertson and Kushlan 1974). Another cavity-nester, the Hairy Woodpecker (*Picoides villosus*), has seen its populations decline and may also be extirpated (Robertson and Kushlan 1974, Slater 2000).

Even though these declines and extirpations have been documented, specific causes have never been studied. However, habitat destruction has undoubtedly played a major role. In southern Florida, slash pine (*Pinus elliotti* var. *densa*) forests, termed "pine rocklands" because of their association with limestone outcroppings, have been severely reduced in area due to residential and agricultural development (Snyder et al. 1990). The most dramatic losses have occurred along the Atlantic coastal ridge. These pinelands, which covered approximately 75,000 ha in 1900, have been reduced in area by more than 90% (Figure 1, 2; Doren et al.1993, Snyder et al. 1990). The largest remaining tract lies in the Long Pine Key region of ENP and contains 4600 ha of pine forest (Snyder et al. 1990). Over 85% of this forest was logged during the late 1930's and early 1940's, prior to the establishment of ENP in 1948 (Olmstead et al. 1983). All four extirpated cavity-nesters disappeared from ENP by the mid 1960's.

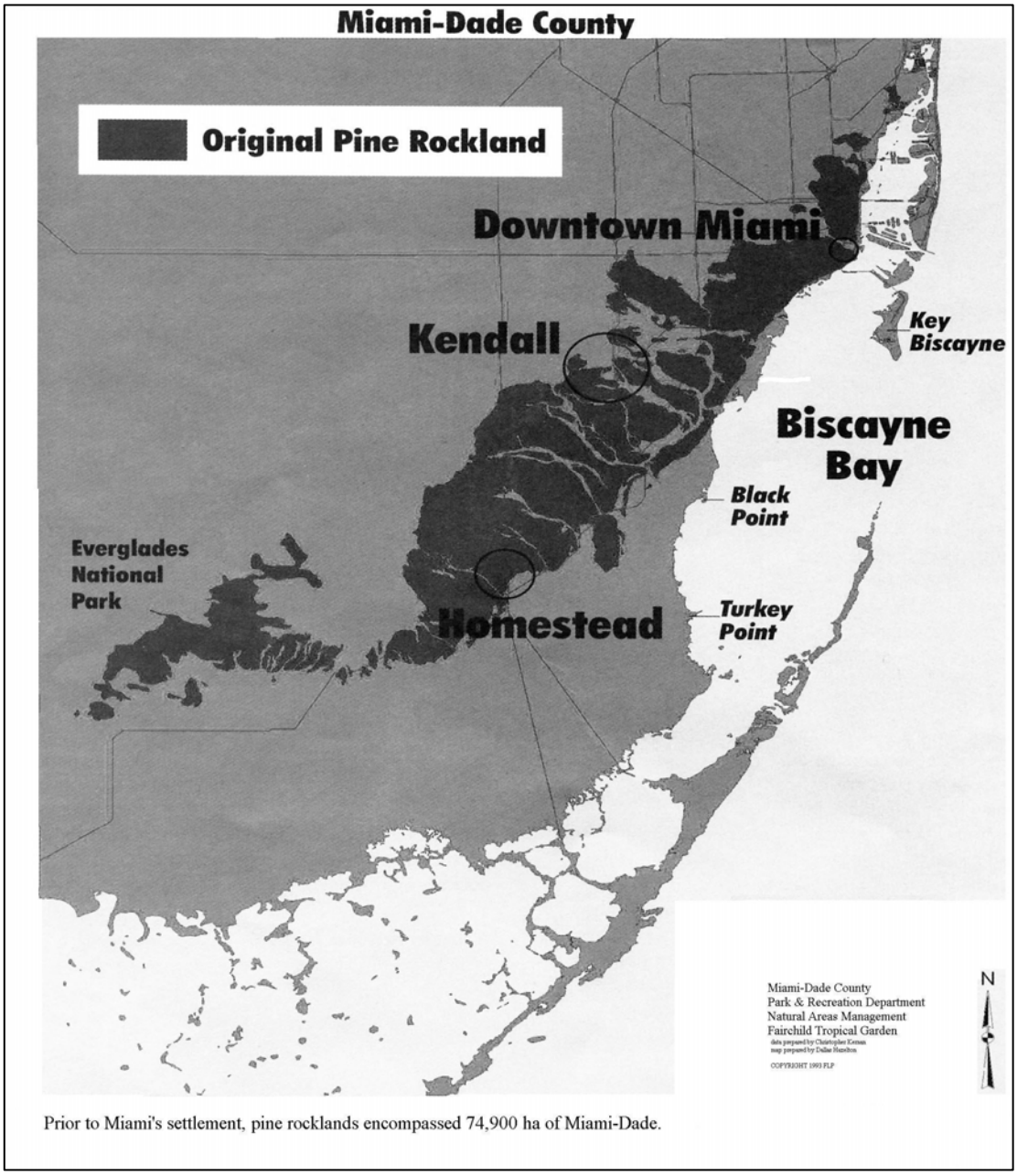
Besides habitat loss, other contributing factors to these species extirpations probably include altered fire and hydrological regimes, effects associated with isolated small populations, and the influence of a warming climate at the southernmost extent of these species' ranges (Robertson and Kushlan 1974, Snyder et al. 1990). Recolonization by extirpated species is unlikely considering the distance between remaining isolated habitat islands and source populations.

By the mid 1990's there was considerable interest in restoring extirpated species back to ENP, particularly nuthatches and bluebirds. Habitat in the Long Pine Key region appeared

suitable to support viable populations of each species - the forest had matured to approximately 60 years of age, a fire management program was established, and abundant snags were present due to Hurricane Andrew (Slater 1997). Research to examine reintroductions as a means to restore biotic losses in upland communities was identified as a critical information need and necessary step in the restoration of the Greater Everglades ecosystem (Orians et al. 1996, Science Subgroup 1996). Finally, the restoration of extirpated upland species would serve as one test of the progress made in restoring the rare pineland ecosystem (e.g. restoration of natural fire regimes, and protection and recovery of the area from logging) represented by Long Pine Key.

In 1997, an experimental reintroduction program was initiated to develop and implement translocation techniques aimed at restoring viable populations of Brown-headed Nuthatches and Eastern Bluebirds. Although species reintroductions by translocation have become an increasingly important conservation technique, most reintroduction projects with birds have focused on raptors and upland game species; few attempts have been successful with passerines (Griffith et al. 1989). The project was unique because the species were passerines and because a plan to monitor the donor population was included to insure its integrity and as a means to evaluate the reintroduced population.

This paper reports on the four-year reintroduction program for Brown-headed and Eastern Bluebirds. Specific research topics are addressed in the following, individual chapters: Chapter Two discusses translocation methodologies and factors related to success; Chapter Three discusses the population demographics of the two reintroduced species during establishment and evaluates the success of the project; and Chapter Four investigates the response and resiliency of Brown-headed Nuthatch and Eastern Bluebird donor populations in BCNP during removals. In an appendix, I report on: 1) the long-term point-count monitoring program for nuthatches and bluebirds, and other pineland bird species in Long Pine Key.



Prior to Miami's settlement, pine rocklands encompassed 74,900 ha of Miami-Dade.

Figure 1. Distribution of Slash Pine forests in southeastern Florida prior to 1900.

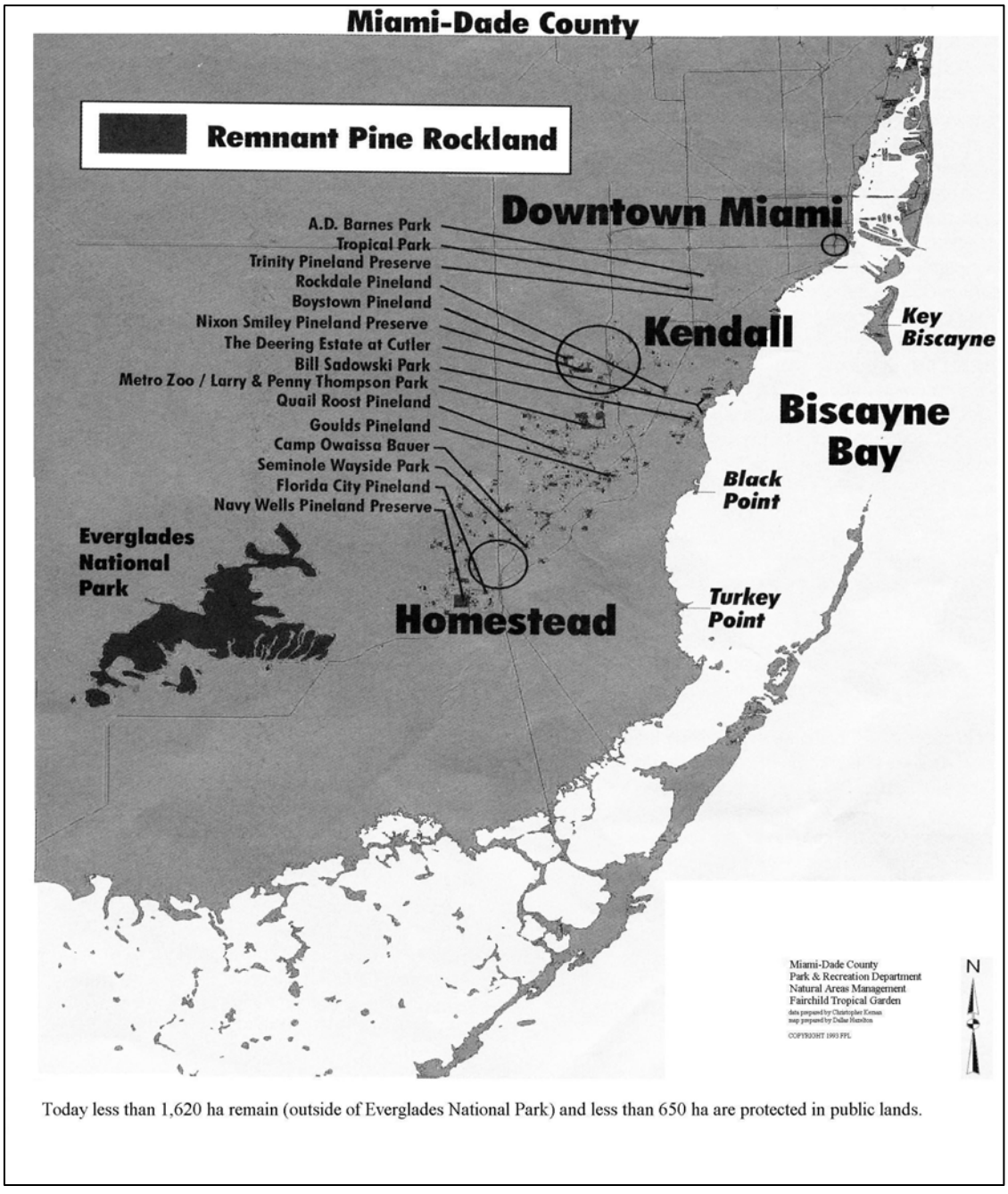


Figure 2. Distribution of Slash Pine forests in southeastern Florida in 1993.

CHAPTER TWO

BROWN-HEADED NUTHATCH AND EASTERN BLUEBIRD TRANSLOCATIONS: METHODOLOGY AND FACTORS ASSOCIATED WITH SUCCESS

INTRODUCTION

With the rapid loss of biodiversity throughout the world, species reintroductions by translocation have become an increasingly important conservation technique. However, most reintroductions have involved threatened and endangered species that are large-bodied and long-lived (Sarrazin and Legendre 2000). For birds, that means most reintroduction projects have focused on raptors and upland game species.

To date, there are no published studies of passerine reintroductions, however, several have been attempted. A captive breeding program with the Puaiohi (*Myadestes palmeri*), an endangered Hawaiian thrush, has released fourteen birds from a large aviary into an unoccupied drainage. After release, 64% (9 of 14) were located on nesting territories, with several of the birds nesting in adjacent drainages with wild birds. A second reintroduction project, also in Hawaii, with Palila (*Loxioides bailleui*) has not been successful after several years of reintroduction efforts, mainly because birds return to their capture population (E. Tweed, J. Foster, pers. comm).

Even though translocations and reintroductions are numerous, few studies have examined the consequences of various release strategies (Sarrazin and Legendre 2000, Sarrazin and Barbault 1996). Detailed monitoring of reintroductions and the founding populations are important to assess the effectiveness of reintroduction techniques and success of the reintroduction program (Sarrazin and Legendre 2000). Moreover, detailed results will provide criteria to evaluate future translocation programs.

In 1997, a reintroduction program for two passerines, the Brown-headed Nuthatch (*Sitta pusilla*) and the Eastern Bluebird (*Sialia sialis*), was initiated in the Long Pine Key region of Everglades National Park (ENP). Nuthatches and bluebirds disappeared from this area in the early 1940s and 1950s as a result of habitat destruction. The goal of this chapter is to report on

the translocation methodology for this program and to identify factors associated with the successful release of individuals and their establishment in the reintroduction area.

METHODS

STUDY AREAS

Capture sites-The primary donor site for Brown-headed Nuthatches and Eastern Bluebirds was located in Big Cypress National Preserve (BCNP) in an area known as Raccoon Point. Raccoon Point contains approximately 9,000 ha of old-growth slash pine (*Pinus ellioti* var. *densa*) interspersed in a cypress (*Taxodium distichum*) matrix and lies on the northwestern edge of the rockland pine ecosystem (BCNP General Management Plan, Snyder et al. 1990)(see Chap. 4 for additional vegetation details). The area contains approximately 500 breeding territories of each species (Slater 1997). Nuthatches and bluebirds were removed from a wide area with capture locations separated by up to 10 km (see Chapter 4 for additional details of capture locations). Access into Raccoon Point is along 11-mile road, which was constructed for oil extraction activities and is approximately a two-hour drive from the release site.

In the fourth year of translocations, two nuthatch groups were captured from the Addition Land, which lies in BCNP, 30 km north of Raccoon Point. Also, five pairs of bluebirds and five nestlings were removed from golf courses in Naples, Florida (Slater 2001).

Release site-The 8,100 ha area known as Long Pine Key in ENP is the release site for the Brown-headed Nuthatch and Eastern Bluebird translocations. The area contains 4,600 ha of pine forest and is the largest, intact remnant of the Atlantic coastal ridge pine forest (Snyder et al. 1990). Within mostly continuous pine forest are "transverse" or "finger" glades of *Muhlenbergia* prairie, and occasional hardwood hammocks and cypress forest (Olmstead et al. 1983, Snyder et al. 1990). The forest is mostly even-aged second-growth, however, snags are abundant due to Hurricane Andrew, which passed over in 1992 (Doren et al 1993). The diverse shrub and herbaceous layers are mostly derived of West Indian origin and their distribution and abundance are maintained by fire (Snyder et al 1990). In areas where fire has been suppressed, the understory is characterized by a dense, and, in places, impenetrable layer of shrubby plants and

vines. However, the implementation of a prescribed fire program that mimics the natural frequency and season of fires in uplands has been implemented and many areas have or are returning to a more natural herbaceous understory with small patches of shrubby hardwoods.

CAPTURE AND TRANSPORT

In the first three years of this project, translocations were performed only when a breeding pair was captured. This was done with the hope that pairs would establish a territory and breed more quickly than individuals. This criterion was relaxed in the final year, when it appeared more important to move individuals than breeding pairs. Still, only three nuthatches translocations may not have included an entire breeding unit. Bluebirds were always moved as pairs, except in the third year when a single female was captured and used as a lure bird, before being released.

Brown-headed Nuthatch groups were typically captured an hour before sunrise from cavity roosts using the plastic bag attached to the top of a telescoping pole method (Slater 2000). Several captures were conducted at night about one hour after sunset with this method, and several captures were conducted using mist nets and playbacks. Translocations were conducted between November and the start of the breeding season.

Bluebird translocations were initiated in mid-February, when pairs began to establish breeding bonds. Bluebirds were captured with mist-nets and playbacks in locations where breeding behavior was observed; a live lure bird improved trapping success. Some bluebird pairs were translocated with their nestlings. In those cases, pairs were captured with mist-nets at nests while feeding nestlings (> 12 days old) and nestlings were removed from the cavity.

All captured individuals were banded with an aluminum U.S. Fish and Wildlife Service band and an unique array of color-bands. Birds were transported in either hand-made or pet-store variety bird cages approximately 1 x 1 x 1-m in size. Pine branches were placed inside for perches and cover, along with mealworms and water. During transport, the cage was covered with a lightweight cloth to allow air circulation, but reduce the amount of light into the cage.

AVIARIES

At the release site, birds were placed in one of two sizes of aviaries: 1 x 1 x 2-m (small), or 2 x 2 x 2-m (large). Aviaries were constructed with 1 x 2-m panels of wood and hardware cloth and then bolted together. Both aviary types provided open views of the surrounding area and protection from the sun, rain and wind. Aviaries were relatively mobile, and could be set up or taken down in about two hours. To deter small rodents and snakes from entering between the aviary and ground, a one-meter skirt of hardware cloth was placed on the ground along the outside of the aviary. One edge was stapled to the base of the aviary and the remaining width covered with large rocks and logs. Except for one year, nuthatches were always placed in small aviaries. Bluebird pairs were always placed in large aviaries.

In the aviary, different-sized branches were placed at various heights and positions to provide multiple perch choices, and a nestbox was placed inside for roosting and/or nesting. If nestlings were translocated, they were placed in an artificial nest in the nestbox. Nuthatch food platforms were adjacent to the wall 1 m above the ground with branches that led to it. Bluebird food bowls and water were placed on the ground.

Before birds were placed in the aviary, mealworms were placed in the food bowl and drizzled over all branches to facilitate feeding. Crickets were found to attract bluebirds' attention more quickly than mealworms and were used in later years to encourage them to use the food bowl. Both species were monitored hourly the first day to make sure they were eating and active. If birds refused to eat and appeared in poor condition during the day, they were either released or removed to be hand-fed until they could be released or returned to an aviary. After the first day, birds were checked and fed daily until released.

RELEASE SITE

During the first year, the nuthatch release site was located in the eastern area of Long Pine Key (Block J). This area contained larger trees and snags than other areas, and had been recently burned. In following years, releases were located adjacent to existing territories so that translocated birds would be aware that other individuals were in the area. Initial bluebird release

sites were located south of the campground in an area where a bluebird had been observed the previous year (Block F2). The area was relatively open and had been recently burned. In following years, releases sites were located adjacent to existing territories or in open areas that had been recently burned.

HOLDING TIME

Holding times varied during the study as adjustments were made in response to observed behavior and in an attempt to determine if holding time had an effect on success. In the first year, nuthatches were held for one night and released the next day. In following years, holding period varied between 1-10 days. Bluebird pairs were typically held for 1-3 weeks. If bluebirds were translocated with nestlings they were held until the juveniles were flying well, usually about 7 days after fledging.

RELEASE

During the first two years, attempts were made to follow birds after release, however, birds were usually lost within 30 min. Thereafter, most searches for released birds began the following day in the release area and continued for at least one week or until the birds were located and had established a territory. Systematic searches were conducted regularly in accessible areas of Long Pine Key to locate individuals not found after release.

In the second year, bluebirds were radio-tagged to help locate individuals after release. Radios weighed 1.0 g, or about 3% of the adults body weight, and had a life expectancy of 40-50 days (American Wildlife, Tallahassee). Radios were attached to the back with epoxy, which allowed the bird to fly normally and insured that the radio dropped off when the bird molted in the fall.

FACTORS ASSOCIATED WITH TRANSLOCATION SUCCESS

Translocation success and the methods associated with it were evaluated at two levels. The first level of success was whether individuals were released in good condition. The second level of success was the establishment of a territory by an individual released in good condition.

All adult bluebirds were released in good condition, so the first-level analysis was only performed with nuthatches. Brown-headed Nuthatches were placed in two groups: those released in good condition (i.e., successful), and those that died or were released in poor condition (i.e., unsuccessful). I compared date captured (measured as the days from mean incubation date), weight, capture method (roost vs. mist-net), and aviary type (small vs. large) between the two groups to identify factors associated with being released in good condition.

Factors associated with individuals that established a territory after being released in good condition was evaluated for both species. Again, individuals were placed into two groups: those that established a territory (i.e., successful) and those that did not (i.e., unsuccessful). For nuthatches, I compared date captured, weight, capture method, aviary type, and holding period (> 1day vs. $\leq$ 1day) between the two groups. For all adult bluebirds, I compared weight, radio-tagged (yes vs. no), sex, and if it was translocated with juveniles (yes vs. no) between the two groups. I compared date captured, and holding period (> 7 days vs. $\leq$ 7days) between the two groups for adult bluebirds not translocated with juveniles or that did not breed in the aviary.

Statistical analysis- SPSS (SPSS 8.0) was used to perform all statistical analyses and to test critical assumptions associated with each statistical test. Continuous variable were tested for normality using a K-S test with Lilliefors significance correction. Variables normally distributed were compared between groups using two-sample *t*-tests, other continuous variable were compared using Mann-Whitney *U*-tests. Chi-square analysis was used to compare categorical data.

RESULTS

BROWN-HEADED NUTHATCHES

During the four-year project, 22 capture events resulted in 53 nuthatches being removed from donor sites and taken to Long Pine Key (Table 1). Except for five individuals taken from the Addition Land, all nuthatches were removed from Raccoon Point. Forty-two of 53 (79%) nuthatches were released in good condition, 5 (9%) died during transport or in the aviary, and 6 (11%) were released in poor condition (Table 2).

Nuthatch deaths occurred in Year 2 and 4 of the translocations. Year 2 was the only year that large aviaries were used for nuthatches and three individuals died in separate translocation events. One nuthatch became lethargic and died by mid-afternoon its first day in the aviary, while a second was found on the ground the morning after it was placed in the aviary barely alive and it died shortly thereafter. Both nuthatches appeared to eat the day they were placed inside the aviary. The third nuthatch died four days after being placed in a large aviary. This bird scalped its forehead the first day in the aviary. The area around the base of his bill to his forehead became inflamed and caused swelling around the eyes. The bird was captured from the aviary and taken to a veterinarian, who recommended immediate release. By the time it was returned to the release site its condition had deteriorated and it was too weak to fly. After hand-feeding for a day the bird died. In Year 4, two nuthatches died at one translocation event. One individual died during transport, while the second nuthatch, which was observed eating during the afternoon in the aviary, was found dead the following morning, after a night that was unseasonably cold.

Six individuals from three translocation events in Year 3 and 4, had to be released during their first day in the aviary because they were in poor condition. In all cases, at least one individual in the aviary had been found on the ground and lethargic. At one event, the pair was hand-fed several mealworms before release. A single nuthatch released in poor condition was observed for several hours. It tried to forage, but was unsuccessful. As time passed it became more lethargic and eventually stayed in one location for several hours. When checked later in the day, it had disappeared, and was assumed to have died. In all other cases, released birds in poor condition flew away from the site and were not observed again.

Twenty-five of 42 (60%) nuthatches released in good condition established a territory. Nuthatch releases in Year 1 had the lowest percentage of birds located on a territory; however, none of the birds were found until October, five months after the breeding season. The percentage of released birds found on a territory increased in following years to approximately 70%. Several nuthatches were observed for short periods of time after release, but were never found on a territory.

Factors associated with successful release.- Mean weight at capture (± S.E.) was higher for individuals that died or were released in poor condition (9.82 ± 0.40 g, $n = 9$) than those released in good condition (9.03 ± 0.09 g, $n = 42$), but did not differ significantly (Mann-Whitney U-test, $U = 128.00$, $P = 0.130$). Nuthatches that died or were released in poor condition were captured significantly closer to the mean incubation date (± S.E.) (21 ± 10 days, $n = 11$) than individuals released in good condition (56 ± 6 days, $n = 42$; Mann-Whitney $U = 72.50$, $P < 0.001$). The probability of a nuthatch being released in good condition did not differ whether it was captured at a roost (34 of 41; 83%) or by a mist-net (8 of 12; 67%; chi-square = 1.49, df = 1, $P = 0.24$). The probability of a nuthatch being released in a good condition did not differ whether it was placed in a large aviary (5 of 8; 63%) or a small aviary (37 of 44; 84%; chi-square = 2.03, df = 1, $P = 0.33$).

Factors associated with successful territory establishment.-Mean weight at capture (± S.E.) of Brown-headed Nuthatches released in good condition did not differ between those that established a territory (9.01 ± 0.12 g, $n = 25$) and those that did not (9.06 ± 0.13 g, $n = 17$; Mann-Whitney $U = 164.00$, $P = 0.21$). Date captured (± S.E.), in relation to mean incubation date, did not differ between individuals that established a territory (57 ± 8 days, $n = 25$) and those that did not (55 ± 10 days, $n = 17$; Mann-Whitney $U = 204.50$, $P = 0.84$). The probability of a nuthatch released in good condition establishing a territory did not differ whether it was captured at a roost (20 of 34; 59%) or with a mist-net (5 of 8; 63%; chi-square = 0.36, df = 1, $P = 0.85$). The probability of a nuthatch released in a good condition establishing a territory did not differ whether it was placed in a large aviary (3 of 5; 60%) or a small aviary (22 of 37; 59%; chi-square = 0.001, df = 1, $P = 0.98$). The probability of a nuthatch released in a good condition occupying a territory did not differ whether it was held for 1 day or less (11 of 22; 50%) or for more than one day (14 of 20; 70%; chi-square = 1.74, df = 1, $P = 0.19$).

EASTERN BLUEBIRDS

During 1998 - 2001, 24 capture events resulted in the translocation of 47 adult and 18 nestling bluebirds to Long Pine Key (Table 3). Except for 10 adults and 5 nestlings removed from five golf courses in Naples, FL in 2001, all birds were captured in Raccoon Point. One

female was translocated twice (in 1998 and 2000) after she returned to her original capture territory in Raccoon Point.

In most cases, bluebirds readily accepted captivity. Two pairs of bluebirds, one in 1998 and 1999, nested in the aviary. Bluebird pairs translocated with nestlings quickly began feeding their young as long as the top of the nestbox was removed. The top of the nestbox could be replaced once the adults began feeding. At three translocations involving a pair, the female became lethargic and appeared to eat sparingly. In one case the pair was released after spending several hours in the aviary. Both individuals flew off and appeared in good condition. The other two females were removed from their aviary the day after being translocated and placed in a small cage where they were hand-fed for 1-3 days. One female was then released with the male she was captured with, while the second female was placed in a small aviary, and released two days later. Overall, all adult bluebirds were released in good condition.

In the first two years, nestlings had difficulty fledging in the aviary. The two pair that bred in their aviary and the one pair translocated with nestlings each successfully fledged one individual. However, two nestlings fledged to the ground and were injured, while the remains of two others were found either inside or just outside the aviary. In following years, aviaries were checked multiple times during the day nestlings were expected to fledge. If nestlings fledged to the ground they were removed and hand-fed until capable of sustained flight. In some cases nestlings were removed before they fledged and hand-fed until capable of sustained flight. All remaining nestlings fledged from the nest without incident. However, in two aviaries, three fledglings capable of flight were depredated by Rat Snakes (*Elaphe obsoleta*).

Twenty-five bluebirds were radio-tagged before release and this improved our ability to track released bluebirds. In many cases, however, the radio's life span ended before the bird had established a territory. Observations of radio-tagged birds showed that during the first several days most birds made long distance movements of up to 11 km.

Twenty-seven of 47 (57%) bluebird adults established a territory, although some were not found until the year after their release and some did not appear to breed (Table 4). The percentage of relocated bluebirds did not vary much between years. One pair in 1998 bred in the aviary and again after release, but none of the birds were relocated the following year. The female from this translocation was relocated back in Raccoon Point on her original territory in 2000. None of the twelve fledglings that were released from aviaries in the first three years were found on a breeding territory. In 2000, three released juveniles were hit by cars.

Factors associated with successful territory establishment.-Mean weight at capture (± S.E.) of adult Eastern Bluebirds was lower for individuals that established a territory (27.51 ± 0.31 g, $n = 25$) than for individuals that did not (28.60 ± 0.48 g, $n = 18$), and was very close to being significant ($t = 1.91$, df = 41, $P = 0.05$). The probability of an adult bluebird establishing a territory did not differ whether it was radio-tagged (16 of 25; 64%) or not (11 of 22; 50%; chi-square = 0.94, df = 1, $P = 0.33$). Males had a higher probability of establishing a territory (16 of 23; 69%) than females, but did not differ significantly (11 of 24 (46%); chi-square = 2.71, df = 1, $P = 0.10$). Adults translocated with nestlings did not have a higher probability of establishing a territory (8 of 12, 67%) than adults translocated without nestlings (19 of 35 (54%); chi-square = 0.56, df = 1, $P = 0.45$). Adult bluebirds (those not translocated with nestlings or that did not bred in aviary) that did not establish a territory were captured closer to the mean incubation date (± S.E.) (35 ± 8 days, $n = 16$) than bluebirds that did (43 ± 3 days, $n = 19$), however, the difference only approached significance (Mann-Whitney $U = 95.50$, $P = 0.06$). The probability of a bluebird (not translocated with juveniles or that bred in aviary) establishing a territory did not differ whether it was held for 7 days or less (6 of 10; 60%) or for more than 7 days (11 of 21; 52%; chi-square = 0.16, df = 1, $P = 0.69$).

DISCUSSION

BROWN-HEADED NUTHATCHES

Translocated Brown-headed Nuthatches were more likely to die or be released in poor condition the closer their capture was to the mean incubation date, suggesting that breeding condition had an effect on translocation success. Another indicator of breeding condition, weight, indicated that nuthatches that died or were released in poor condition weighed approximately 10% more than those released in good condition. As the breeding season approaches, nuthatches acquire substantial fat reserves, and some individuals weight approached 11 grams. The only year that all nuthatches were released in good condition was in the winter 1997-1998, when the southern El Nino oscillation weather pattern was in southern Florida. That year the average weight of individuals was about 15% (1g) less than birds caught during the winter of 1998-99 and only 29% of nuthatch territories in the donor population attempted nesting

(Slater et al. 1999). None of the translocated birds in that year appeared to be in breeding condition.

There is no clear explanation why nuthatches in breeding condition have greater difficulty in aviary conditions than nuthatches that are not in breeding condition. In general, many of the birds that died or were released in poor condition appeared to be more agitated and fed less than birds released in good condition. Nuthatches with high fat reserves initially have more energy to spend looking to escape from an aviary and may become more agitated than individuals in nonbreeding condition, who immediately begin looking for food. A nuthatch's physical condition can deteriorate rapidly because of their small size, and they are probably at a higher risk of stress-induced mortality than larger-bodied birds. These factors may cause individuals who are extremely agitated to deplete their fat reserves at such a quick rate that it is difficult for them to recover. Most individuals in this study that died or were released in poor condition were observed to be in poor condition within 24 hours of being placed in the aviary. Attempts to hand-feed nuthatches were never successful. For small birds like nuthatches, we suggest that it is critical to determine quickly whether birds are feeding. If not, they should be released immediately to give them the best opportunity for survival.

No factor related to the translocation methodology was correlated with an individual establishing a territory. The percentage of individuals that established a territory increased substantially from 38% the first year to approximately 70% by the third year. Two possible explanations for this trend exist. The first explanation is that during the first year environmental conditions were poor, a result of the southern El Nino oscillation event. The high water levels during that winter may have reduced insect and pine-cone seed abundance, the primary foods of nuthatches, resulting in nuthatches being translocated in poor condition or having difficulty surviving in a new environment.

A second factor that may have influenced relocation rate between years is that nuthatches released in the first year were released into completely vacant areas, whereas in subsequent years translocated birds were released adjacent to existing groups. Several studies suggest that some migratory bird species select areas where conspecifics are present and avoid unoccupied areas, perhaps, because it indicates that habitat is poor. Moreover, as the population increases released birds are more likely to encounter an unpaired nuthatch searching for a mate or discovering a

territory that has a breeding occupancy. It seems likely that at some population size, translocation effectiveness should become constant and this may have occurred in the last two years when success approached 70%.

EASTERN BLUEBIRDS

Most bluebird adults appeared to have little difficulty adjusting to the aviaries. The only exceptions were a female that didn't appear to be eating and was released after only a couple hours in the aviary and two females that became lethargic after a day in the aviary. The latter two birds were removed from their aviary and hand-fed until they became active. All three females appeared to be in good condition when released.

In the first two years, nestlings had difficulty fledging in their aviary, which resulted in serious injuries or predation to many of the birds. Nestlings attempting to fledge in the aviary had difficulty maneuvering in such a small area and often ended up landing on the ground or injuring themselves. Once on the ground they were unable to get up to a perch and became susceptible to predation. In our cases, it appears American Crows (*Corvus brachyrhynchos*), which often landed on the aviaries and harassed birds, are able to pick at fledglings on the ground through the hardware cloth. This issue was resolved by making multiple checks during the day nestlings were scheduled to fledge to remove nestlings that fledged to the ground and hand-feeding them until they were capable of sustained flight.

A second problem in the aviary for young birds was that several fledglings were depredated by Rat Snakes inside the aviary. Because of the lack of soil in the pine rocklands, aviaries are place on limestone rock. Even though wide skirts of hardware cloth were placed along the outside, it is impossible to fully secure the aviary from predators, particularly snakes that can get into very small cracks and crevices. One solution would be to place solid floors in the aviaries.

Bluebirds translocated with nestlings were not more likely to establish a breeding territory than bluebirds without nestlings and none of the nestlings were ever found on a breeding territory in subsequent years. These results suggest it may be a better strategy to move bluebirds before nesting. Then they have a chance to breed naturally and improve their offsprings ability to survive to breeding age.

Date captured and mean weight were the two factors most associated with bluebirds occupying a territory. Bluebirds that were heavier and translocated closer to the mean incubation date were less likely to occupy a territory, suggesting that breeding condition may have an effect on translocation success. Bluebirds did not have problems surviving in the aviary like nuthatches, which suggests a different mechanism makes bluebirds in breeding condition less likely to establish a territory. One explanation may be that bluebirds closer to breeding condition have invested enough time and energy in acquiring a territory at the donor site, that after release they make a significant attempt to relocate the area. Moreover, they may have the additional fat reserves to put into such an effort. The return of a translocated bluebird to her original territory indicates they have the ability to return to their capture site. On the other hand, bluebirds that have not invested the time and energy into a territory before they were captured may be content being translocated to a new area with good habitat and little competition.

The probability of an adult bluebird establishing a territory was relatively similar between years, staying around the 60% mark. Even though a pair in 1998 nested successfully in the area, the first bluebirds didn't overwinter in the area and breed the following year until 1999-2000, the year after 8 adult bluebirds were translocated. Bluebirds, unlike nuthatches, do not maintain breeding territories in the winter. Rather, they disperse, join other bluebirds, and forage with mixed-species flocks. Non-breeding season social interactions may be important to bluebirds to remain in an area, which may explain why bluebirds didn't remain during the non-breeding season until a larger numbers of birds were translocated.

SYNTHESIS

Breeding condition appears to be the most important factor associated with the success of both species translocations. Birds translocated closer to the breeding season are less likely to be successful, whether in the translocation process or in establishing a territory. Results suggest that other translocation programs may want to consider timing of translocations when developing translocation methods. Moving birds at least one month before incubation begins may improve success. Another alternative may be to move birds after the breeding season, which was not examined in this study.

Only a couple pairs of either species maintained pair bonds when breeding groups were translocated, suggesting that this factor is not important to the success of a reintroduction program. For monomorphic species, like nuthatches, translocating breeding units may be important to insure that both sexes are equally translocated. However, it may be more important to move large numbers of individuals, at least initially, to insure that some individuals become established. Results from this study suggest that translocations may be more successful once individuals are established in the reintroduction area.

In general there appeared to be little advantage to holding birds, particularly the smaller nuthatch. This is similar to the result found by Griffith et al (1989) who found that successful reintroductions were not associated with soft- or hard-releases. It obviously is in the best interests of the reintroduction plan to minimize time in the aviary to reduce the risk of injury, or other negative effect during the translocation.

Overall, passerine reintroductions appear to have the opportunity to be as successful as other, longer-lived and large-bodied bird taxa, such as raptors and game birds. To date, however, few translocation studies with passerines have been reported. This study should contribute to our current knowledge of passerine translocation methodology.

Table 1. List of Brown-headed Nuthatches translocated to Long Pine Key, ENP.

Capture event	Date	Left leg	Right leg	Weight (g)	Age	Sex	Capture method	Days to mean	Days held	Aviary size	Release condition	Breeding territory
YEAR ONE; 1997-1998												
1	12/17/97	Y/Al[a]	CC	8.6	U	F	Roost - AM	131	1	Small	Good	FT
1	12/17/97	Al/Y	BB	8.3	U	U	Roost - AM	131	1	Small	Good	
1	12/17/97	GG	AL/Y	9.0	U	U	Roost - AM	131	1	Small	Good	GT
1	12/17/97	RR	AL/Y	8.9	U	U	Roost - AM	131	1	Small	Good	
1	12/17/97	YY	AL/Y	9.4	U	U	Roost - AM	131	1	Small	Good	
1	12/17/97	Y/Al	WW	9.6	U	U	Roost - AM	131	1	Small	Good	GT
2	2/9/98	Al/W	C/B	8.8	AHY	M	Roost - AM	68	1	Small	Good	FT
2	2/9/98	G/Y	Al/W	8.7	AHY	F	Roost - AM	68	1	Small	Good	GT
2	2/9/98	CC	Al/W	8.0	AHY	U	Roost - AM	68	1	Small	Good	
2	2/9/98	YY	Al/W	9.1	AHY	U	Roost - AM	68	1	Small	Good	
3	3/3/98	C/Al	YY	8.0	AHY	U	Roost - AM	47	1	Small	Good	
3	3/3/98	W/Al	YY	9.3	AHY	U	Roost - AM	47	1	Small	Good	
3	3/3/98	BB	C/Al	9.5	AHY	U	Roost - AM	47	1	Small	Good	
YEAR TWO; 1998-1999												
4	11/16/98	Al/R	YY	8.5	U	M	Roost - AM	121	8	Large	Good	HC
4	11/16/98	BB	Al/R	8.5	U	F	Roost - AM	121	8	Large	Good	HC
5	11/18/98	B/Al	RR	8.6	U	M	Roost - AM	119		Large	Dead	
5	11/18/98	GG	B/Al	9.0	U	F	Roost - AM	119	10	Large	Good	FT
6	2/10/99	Al/L	OO	9.5	AHY	U	Roost - AM	35	6	Large	Good	
6	2/10/99	LL	Al	10.5	AHY	U	Roost - AM	35		Large	Dead	
7	2/19/99	R/Al	WR	9.0	AHY	M	Mist-net	26	7	Large	Good	
7	2/19/99	LL	Al/R	11.1	AHY	F	Mist-net	26		Large	Dead	
8	3/1/99	L/Y	Al/O	11.5	AHY	F	Roost - AM	16	1	Small	Good	GT
8	3/1/99	Al/O	OO	9.5	AHY	M	Roost - AM	16	1	Small	Good	
YEAR THREE; 1999-2000												
9	1/17/00	Al/C	LL	9.0	AHY	F	Roost - AM	56	0	Small	Good	FT
9	1/17/00	GG	Al/C	8.9	AHY	M	Roost - AM	56	0	Small	Good	FT
10	2/2/00	WW	Al/Y	9.1	AHY	U	Roost - AM	40	3	Small	Good	
10	2/2/00	Al/Y	RR	9.8	AHY	U	Roost - AM	40	3	Small	Good	
11	2/4/00	Al	LY	8.8	AHY	M	Roost - AM	38	7	Small	Good	EI
11	2/4/00	BR	Al/G	8.6	AHY	F	Roost - AM	38	7	Small	Good	HT
12	2/8/00	RL	Al/R	8.5	AHY	F	Roost - AM	34	3	Small	Good	LF
12	2/8/00	CL	G/Al	9.3	AHY	M	Roost - AM	34	3	Small	Good	GT
13	2/28/00	GY	Al/B	8.8	AHY	U	Roost - PM	14	0	Small	Poor	
13	2/28/00	Al/B	OL	11.7	AHY	U	Roost - PM	14	0	Small	Poor	
14	3/1/00	L/Al	YG	8.8	AHY	F	Roost - PM	12	7	Small	Good	
14	3/1/00	RR	L/Al	9.3	AHY	M	Roost - PM	12	7	Small	Good	HT
15	3/10/00	RY	O/Al	8.5	AHY	M	Roost - AM	2	3	Small	Good	LF
15	3/10/00	O/Al	GR	9.0	AHY	F	Roost - AM	2	3	Small	Good	HT

Capture event	Date	Left leg	Right leg	Weight (g)	Age	Sex	Capture method	Days to mean	Days held	Aviary size	Release condition	Breeding territory
YEAR FOUR; 2001												
16	2/2/01	Al/C	YY	9.2	ASY	F	Roost - PM	45	3	Small	Good	SJ
16	2/2/01	AL/C	WB	8.9	ASY	M	Roost - PM	45	3	Small	Good	
16	2/2/01	RY	AL/C	9.0	AHY	F	Roost - PM	45	3	Small	Good	EJ
17	2/13/01	LL	AL/L	9.2	AHY	U	Mist-net	34	2	Small	Good	WR
17	2/13/01	RG	AL/L	9.3	AHY	U	Mist-net	34	2	Small	Good	WR
18	2/14/01	WO	Y/Al	9.0	AHY	M	Mist-net	33	1	Small	Good	SJ
18	2/14/01	Y/AL	GL	8.5	AHY	M	Mist-net	33	1	Small	Good	EJ
18	2/14/01	AL/G	OY	9.0	AHY	F	Mist-net	33	1	Small	Good	NE
19	2/22/01	AL/G	YB	9.7	AHY	U	Mist-net	25	1	Small	Good	
19	2/22/01	GG	AL/G	9.2	AHY	U	Mist-net	25	1	Small	Good	
20	3/8/01	WW	B/AL	9.1	AHY	U	Roost - PM	11	0	Small	Poor	
20	3/8/01	B/AL	OO	10.8	AHY	U	Roost - PM	11	0	Small	Poor	
20	3/8/01	YL	B/AL	9.8	AHY	U	Roost - PM	11	0	Small	Poor	
21	3/21/01	O/Al	RC	NA	AHY	U	Mist-net	-3		Small	Dead	
21	3/21/01	OL	O/AL	NA	AHY	U	Mist-net	-3		Small	Dead	
22	3/27/01	W/AL	OG	8.5	AHY	U	Mist-net	-3	0	Small	Poor	

[a] Color-band colors; Al = aluminum, W = white, Y = yellow, O = orange, R = red, C = light blue, G = green, L = dark blue, B = black.

Table 2. Results of Brown-headed Nuthatch translocations to Long Pine Key, ENP.

Year	Nuthatches translocated	Died	Released in poor condition	Released in good condition	Observed on territory
1997-1998	13	0	0	13	5 (38%)
1998-1999	10	3	0	7	4 (57%)
2000	14	0	2	12	9 (75%)
2001	16	2	4	10	7 (70%)
Totals	53	5	6	42	25 (60%)

Table 3. List of Eastern Bluebirds translocated to Long Pine Key, ENP.

Capture event	Date	Left leg	Right leg	Weight (g)	Age	Sex	Days to mean Incubation	Days held	Radio-tagged	Breeding territory-Year
YEAR ONE; 1998										
1	3/30/98	Al/C[a]	WW	30.3	AHY	M	33	65		F1-1998
1	3/30/98	Al/C	BB	31.0	AHY	F	33	65		F1-1998
2	4/13/98	Al/Y	CC	27.7	AHY	F	19	0		
2	4/13/98	Al/Y	RR	32.0	AHY	M	19	0		
YEAR TWO; 1999										
3	2/19/99	Al/O	OO	27.1	AHY	M	41	25	151.184	BD-1999
3	2/19/99	WW	Al/O	26.4	AHY	F	41	25		
4	2/23/99	Al/G	GG	28.6	AHY	F	37	4		BD-1999
4	2/23/99	RR	Al/G	29.6	AHY	M	37	4		
5	3/5/99	Al/Y	CC	29.1	AHY	F	27	69		
5	3/5/99	LW	Al/Y	27.6	AHY	M	27	69	151.096	GT-1999
6	5/3/99	L/Al	GG	26.2	AHY	M	-32	7	151.136	GB-1999
6	5/3/99	RR	L/Al	24.5	AHY	F	-32	7		GB-1999
6	5/3/99	L/Al	WW	25.4	Nestling	M	Depredated in aviary			
6	5/3/99	YB	L/Al	26.7	Nestling	F		7		
6	5/3/99	L/Al	RW	24.7	Nestling	F	Injured and euthanized			
YEAR THREE; 2000										
7	2/17/00	Al/R	WG	28.3	AHY	M	43	0		WA-2001
7	2/17/00	YY	R/Al	27.7	AHY	F	43	0		
8	2/17/00	Al/L	OO	25.8	AHY	F	43	39		AA-2001
9	2/25/00	Al/Y	00	28.5	AHY	M	35	14	151.274	WB-2001
9	2/25/00	LL	Al/Y	25.4	AHY	F	35	14		
10	2/25/00	CC	W/Al	26.2	AHY	M	35	7	150.133	CG-2000
10	2/25/00	W/Al	WR	27.2	AHY	F	35	7		GT-2000
11	2/26/00	B/Al	BY	27.4	AHY	M	34	7	150.113	AA-2001
11	2/26/00	OC	B/Al	27.5	AHY	F	34	7	150.090	
12	3/2/00	Al/W	YC	27.9	AHY	M	29	14	150.076	
12	3/2/00	OG	Al/W	31.8	AHY	F	29	14	150.056	CG-2000
13	3/10/00	OR	G/Al	26.2	AHY	F	21	17		BD-2000
13	3/10/00	G/Al	YC	26.9	AHY	M	21	17	150.022	BD-2000
13	3/10/00	B/Al	YO	29.4	Nestling	F		17		
13	3/10/00	WC	B/Al	28.5	Nestling	F		17		
13	3/10/00	GL	BA/l	27.1	Nestling	M		17		
13	3/10/00	B/Al	CY	31.0	Nestling	F		17		
14	4/5/00	LL	O/Al	27.1	AHY	M	-5	11	150.005	WR-2001
14	4/5/00	Al/C	BB	26.4	AHY	F	-5	11		

14	4/5/00	O/Al	WW		Nestling	F		11	Killed by car	
14	4/5/00	YY	O/Al		Nestling	M		11		
14	4/5/00	O/Al	RR		Nestling	M		11	Killed by car	
15	5/23/00	R/AL	CC	26.7	AHY	M	-33	14	150.955	BS-2001
15	5/23/00	RY	Y/AL	24.8	AHY	F	-33	14	151.226	
15	5/23/00	BO	L/AL	27.5	Nestling	M		14		
15	5/23/00	W/L	AL/L	30.6	Nestling	M		14		
15	5/23/00				Nestling				Depredated by snake	
2001 Translocation										
16	2/20/01	LO	C/AL	28.4	AHY	M	65	21	151.045	PI-2001
16	2/20/01	C/AL	RY	28.5	AHY	F	65	21		IB-2001
17	2/27/01	AL/R	LL	27.2	AHY	M	58	17	150.997	FT-2001
17	2/27/01	WW	AL/R	25.6	AHY	F	58	17	150.038	PI-2001
18	3/5/01	AL/B	RR	28.5	AHY	M	52	18	151.161	GO-2001
18	3/5/01	OB	AL/B	26.1	AHY	F	52	18		GO-2001
19	3/5/01	AL/C	GY	29.3	AHY	M	52	17	151.025	IB-2001
19	3/5/01	LY	AL/C	30.8	AHY	F	52	17		
20	3/14/01	CC	R/AL	29.5	AHY	M	43	15		
20	3/14/01	R/AL	OO	28.2	AHY	F	43	15		
21	3/26/01	LO	O/AL	29.4	AHY	M	31	15	151.140	
21	3/26/01	O/AL	WR	31.2	AHY	F	31	15	151.121	
22	3/26/01	AL/L	OW	29.7	AHY	M	31	14	151.089	
22	3/26/01	YG	AL/L	28.2	AHY	F	31	14	151.007	
23	4/17/01	LL	AL/W		AHY	M	9	20	151.073	
23	4/17/01	AL/W	GG		AHY	F	9	20	151.058	
23	4/17/01				Nestling				Depredated by snake	
23	4/17/01				Nestling				Depredated by snake	
24	4/17/01	Y/AL	RW		AHY	M	9	21	151.196	Observed
24	4/17/01	YY	T/AL		AHY	F	9	21		Observed
24	4/17/01	Y/AL	LL	30.3	Nestling	F		21		Observed
24	4/17/01	Y/AL	GW	26.7	Nestling	F		21		
24	4/17/01	OO	Y/AL	27.1	Nestling	M		21		

[a] Color-band colors; Al = aluminum, W = white, Y = yellow, O = orange, R = red, C = light blue, G = green, L = dark blue, B = black.

Table 4. Results of Eastern Bluebird translocations to Long Pine Key, ENP.

Year	Adult Bluebirds translocated	Adults Observed on territory (or area)	Nestling Bluebirds translocated	# Nestlings or fledglings that died	# Nestlings found on breeding territory
1998	4	2 (50%)	0	0	0
1999	8	5 (63%)	3	2	0
2000	17	11 (65%)	10	1	0
2001	18	9 (50%)	5	2	1
Totals	47	27 (57%)	18	5	1

CHAPTER THREE
POPULATION DEMOGRAPHICS OF TWO REINTRODUCED SPECIES: BROWN-HEADED NUTHATCHES AND EASTERN BLUEBIRDS DURING ESTABLISHMENT

INTRODUCTION

In 1997, a reintroduction program for two passerines, Brown-headed Nuthatches (*Sitta pusilla*) and Eastern Bluebirds (*Sialia sialis*) was initiated in the Long Pine Key region in Everglades National Park (ENP). Nuthatches and bluebirds disappeared from Long Pine Key between the early 1940s and 1950s. Evaluating success of reintroduction efforts is one of the most challenging aspects in conservation. Undoubtedly, the primary goal of a reintroduction project is to establish a self-sustaining population in the release area. However, the term self-sustaining is ambiguous without a defined temporal framework and without taking into account various dynamic scenarios, including unexpected catastrophic events. Moreover, data needed to determine sustainability includes demographic and reproductive parameters and genetic data, which are difficult to collect and typically require several years worth of work and large sample sizes to determine accurate estimates. Thus, it is not surprising that detailed studies of reintroduced populations are rare and efforts to define criteria for success are lacking (Cade and Temple 1995, Sarrazin and Legendre 2000). One suggested approach to evaluation is to identify short- and long-term criteria to assess success of the reintroduction methods(Sarrazin and Barbault 1996).

This study presents demographic data collected during a 4-year period when translocation efforts were taking place and evaluates the success of the program based on short- and long-term criteria.

METHODS

STUDY AREA

The 8,100 ha area known as Long Pine Key in ENP is the release site for the Brown-headed Nuthatch and Eastern Bluebird translocations. The area contains 4,600 ha of pine forest and is the largest, intact remnant of the Atlantic coastal ridge pine forest (Snyder et al. 1990).

Within mostly continuous pine forest are "transverse" or "finger" glades of *Muhlenbergia* prairie, and occasional hardwood hammocks and cypress forest (for detailed description, see Chapter 2) (Olmstead et al. 1983, Snyder et al. 1990).

Raccoon Point is a large old-growth forest, approximately 9,000 ha, located in Big Cypress National Preserve (BCNP) (for detailed description, see Chapter 4), and serves as a high-quality reference site to Long Pine Key. This area contains a large population of nuthatches and bluebirds and was the primary donor source for the reintroduction program. Reproduction data was collected between 2000-2001 on two plots (one removal and one control) that each contained approximately 10 territories (for details, see Chapter 4) and some adjacent territories. Color-banded birds were monitored in the area from 1998-2001. Three or 4 removals of each species were conducted on the removal site each year.

STUDY SPECIES

The Brown-headed Nuthatch inhabits the open pine forests of the southeast ranging from eastern Texas to the Atlantic coast, as far north as Delaware and south to Florida and the Bahamas (Bent 1948). This small, gregarious species excavates its own nest cavity and frequently breeds in social groups composed of a breeding pair and helpers, which are typically male offspring from the previous year (Norris 1958). Nuthatches maintain year-round territories and feed on insects gleaned from the trunk and branches of pines and on pine seeds (Bent 1948, Nesbitt and Hetrick 1976).

Population trends from Breeding Bird Survey data show the Brown-headed Nuthatch declining throughout its range (Sauer et al. 2000). This decline is especially apparent in Florida, where nuthatches have declined precipitously since 1969 (Cox 1987, Stevenson and Anderson 1994, Sauer et al. 2000). Explanations for declining nuthatch populations in Florida include: a warming climate (i.e., range contraction due to unfavorable climate) (Robertson and Kushlan 1974), the decreasing availability of nest sites due to habitat changes (Cox 1987), and the loss of old-growth pine forest (Stevenson and Anderson 1994). In southern Florida, nuthatches are thought to have disappeared from the Long Pine Key region in Everglades National Park (ENP)

in the early 1940's (B. Robertson, pers. comm), shortly after extensive clear-cutting in that region.

The Eastern Bluebird has been relatively well-studied, mainly because of its acceptance of nest boxes and its striking color. Still, few nesting studies have been performed at sites without nestboxes. This non-excavating cavity-nester declined sharply in North America, beginning around the mid-1940's, due to: habitat loss, land management practices that removed snags, the increased use of insecticides, and competition for nest sites with the exotic House Sparrow (*Passer domesticus*) and the European Starling (*Sturnus vulgaris*) (Peakall 1970, Zeleny 1976). Breeding Bird Survey results indicate bluebird populations have generally increased over most of their range since 1966 (Sauer et al. 2000), a likely result of the strong public support for the species, changes in land management practices, and organized nest box programs.

However, in Florida, bluebird populations have continued to decline strongly (Cox 1987, Sauer et al. 2000). Influential factors are similar to those for nuthatches and include habitat loss, competition for nest sites, and a warming climate (Robertson and Kushlan 1974, Cox 1987, Stevenson and Anderson 1994). Bluebirds require open habitats with an abundance of dead trees and limbs that are used for nest sites and foraging perches, and a sparse understory for optimal foraging conditions (Pinkowski 1976, Pinkowski 1977). Increased frequency of fire has been correlated with high bluebird densities (Ahlgren and Ahlgren 1960, Pinkowski 1976) and is likely a strong factor in maintaining suitable habitat in southern Florida as fire deters succession and reduces ground cover.

BREEDING BIOLOGY AND SURVIVAL

In Long Pine Key, Brown-headed Nuthatch and Eastern Bluebird breeding territories were located by walking systematic transects through areas where individuals were released, in existing territories, and in other accessible areas of Long Pine Key. Because Brown-headed Nuthatches maintain year-round territories, observations during the winter were helpful in identifying breeding territories. In Raccoon Point, systematic transects within plots were conducted until territories were identified.

Brown-headed Nuthatches exhibit breeding behavior earlier than Eastern Bluebirds, which allowed us, for the most part, to conduct nest searches independently for each species. Nest searches for nuthatches were initiated in mid-February when they typically begin excavating cavities (Slater 1997). Bluebird nest searches began in mid-March.

Once excavation and nest-building behaviors were noted, nest sites were checked regularly until egg-laying began. Upon incubation (clutch complete) a nest site was classified as a nesting attempt. Nests were typically checked every 3-5 days until nestlings fledged or the nest failed. When possible, clutch size was determined with a Tree Top Peeper^{TM} System (Sandpiper Technologies, Inc., Manteca, CA). A nest was successful if it fledged at least one nestling and overall productivity was calculated as the number of young fledged per territory. If a nest failed, we followed the group in following weeks to see if they renested.

All individuals released to Long Pine Key were uniquely color banded. For a nuthatch or bluebird released to Long Pine Key, its survival was calculated from the time it was first observed on a breeding territory. Some bluebirds translocated late in the breeding season did not set up a breeding territory, but were observed regularly. The survival of those individuals was also calculated beginning in that breeding season. Ongoing efforts to color band adults and offspring were conducted whenever possible in both study areas, and at several accessible nests nestlings were banded. Adult annual survivorship (annual return rate) was calculated as the proportion of adults resighted from the total number of adults present the previous breeding season. For both species we categorized the breeding season as the period between 15 February until 15 July. Annual juvenile survivorship was not calculated because of small sample sizes.

POPULATION SIZE

Population size was estimated for Brown-headed Nuthatches and Eastern Bluebirds in Long Pine Key at the end of each breeding season. Adults that disappeared during the breeding season were assumed to have died and not dispersed. Unless it was known that a juvenile had died (i.e., it disappeared before it was capable of independence), we assumed that all juvenile were alive at the end of the breeding season.

EVALUATING SUCCESS

The reintroduction program was evaluated using short- and long-term criteria of success. The short-term criteria of success was simply whether translocated individuals established territories and breed successfully and that in each successive year the reintroduced populations increased. The long-term criteria was to determine if reproduction and survival differed between the reintroduced populations and populations in the high quality reference site.

Comparisons between reintroduced and control populations were made for years when sample sizes in the reintroduced populations were high enough for valid tests. For Brown-headed Nuthatches, reproductive parameters were compared between populations in 2000-2001; data were pooled among years by population. Eastern Bluebird reproduction was compared between populations only in 2001. Most nuthatch nesting attempts were detected before egg-laying, while bluebirds were usually detected during the incubation stage. Undoubtedly, some attempts failed early and escaped observation, however, we believe these incidents are low, and no evidence suggests those incidents occurred more often in one population. Thus, we used a Chi-square analysis, instead of Mayfield estimates to compare the probability of nesting success by nuthatches and bluebirds between the reintroduced and control populations. This also allowed us to make comparisons on a territorial basis, which is more important to overall population dynamics. Overall productivity was compared using a Mann-Whitney *U*-test. Adult annual survivorship was calculated for the entire reintroduction program period (1998-2001) in both the reintroduced and control populations. Statistical tests to compare sites were not performed.

RESULTS

BROWN-HEADED NUTHATCHES

The first established Brown-headed Nuthatch territories in Long Pine Key were found in October 1998, seven months after they were translocated. Five banded individuals and an

unbanded bird were located on two territories. The unbanded nuthatch was assumed to be an offspring indicating that at least one successful breeding event occurred in 1998. In each year of the reintroduction program the number of territories increased and successful breeding occurred; by 2001, the population had increased to fifteen territories (Table 1). In 2000, the first breeding pair comprised of offspring of translocated birds bred successfully. In general, nesting success declined between 1999 and 2001 as the number of territories increased (Table 1). Overall, 16 of 24 (66%) territories nested successfully, mean incubation date (first attempts) was 20 March $\pm$ 4 days and overall productivity was 2.33 $\pm$ 0.39 young/territory (Table 1). Two territories, one in 2000 and one in 2001 contained a helper. Overall adult survival was 63% and was similar between years (Table 2). At the end of the 2001 breeding season the population size was estimated at 32 adults and 23 juveniles. Population size increased substantially during the reintroduction period and the proportion of the adult population composed of resident vs. translocated nuthatches increased substantially (Figure 1, 2).

Evaluation.-In each year of the reintroduction program, translocated nuthatches established territories and bred successfully and populations size increased in each successive year, indicating that we achieved the annual short-term criteria of success.

Between 2000-2001, Brown-headed Nuthatches nesting success in Long Pine Key (13 of 21 territories, 62%) , did not differ from that in Raccoon Point (22 of 43, 55%, chi-square = 0.24, df = 1, $P = 0.62$). Overall productivity (fledglings/territory) was higher in Long Pine Key than Raccoon Point, but did not differ significantly (Table 3). Nineteen of 30 (63%) adults that bred in Long Pine Key returned the following breeding season, while in Raccoon Point 20 of 41(49%) breeding adults returned in the following breeding season (Table 3).

EASTERN BLUEBIRD

In 1998, one bluebird pair successfully nested in a natural cavity after successfully nesting in their aviary. Overall, they produced 3 juveniles, however, none of the birds returned to breed in Long Pine Key the following year (the breeding female was found in Raccoon Point on her original territory in 2000). In 1999, two bluebird pairs bred and produced six juveniles. Five adults translocated in 1999, but none of the juveniles, remained in the area to breed in 2000.

In 2001, the population increased dramatically to 16 territories as 18 unbanded birds, assumed to be offspring from 2000, entered the breeding population. With the large number of unbanded birds found in 2001, it appears that several nesting territories were not found in 2000. This is reinforced by the fact that four adults translocated in 2000, were not found until 2001. In 2001, several territories composed of offspring of translocated birds bred successfully.

Annual breeding summaries are presented in Table 4; over the four year period 17 of 23 (74%) territories nested successfully, mean incubation date (first attempts) was 18 April $\pm$ 3 days and overall productivity was 2.70 ($\pm$ 0.51) young/territory. Overall adult survival from 1998 to 2001 was 53%. (Table 5). Population size increased substantially during the reintroduction period and at the end of the 2001 breeding season the adult population size was estimated at 32 adults, of which 50% were translocated, and 39 juveniles (Figure 3, 4).

Evaluation.-In each year of the reintroduction program, translocated bluebirds established territories and bred successfully and populations size increased in each successive year, indicating the project met the annual short-term criteria of success.

For Eastern Bluebirds in 2001, nesting success in Long Pine Key (11 of 16 territories, 69%) did not differ from that in Raccoon Point (16 of 24, 67%, chi-square = 0.019, df = 1, P = 0.89). Overall productivity (fledglings/territory) was higher in Long Pine Key than Raccoon Point, but did not differ significantly (Table 6). Between 1998-2003, 53% of adults in Long Pine Key returned the following breeding season, while in Raccoon Point 9 of 23 (39%) adults returned in the following breeding season.

DISCUSSION

Two significant events worth noting in a translocation program is the first year that a breeder survives over the non-breeding season to breed again, and the first time that individuals produced in the reintroduction site (offspring of translocated birds) go on to breed successfully. These events are significant because they suggest that habitat in the area is suitable and that genetic issues such as inbreeding and outbreeding depressions may not be a concern. These events happened more quickly for nuthatches than bluebirds.

Early in a reintroduction program it is necessary to have simple short-term criteria to evaluate progress because very little information about population viability is available. The reintroduction program for nuthatches and bluebirds met its annual short term-criteria: (1) that individuals establish territories and breed successfully, and (2) populations size increased in successive years. In this study, meeting those criteria during the first two years of translocations were important because it provided incentive to increase the number of translocations in subsequent years in an attempt to establish viable populations more quickly.

In the last two years of the reintroduction program, populations of nuthatches and bluebirds had increased enough to begin to evaluate long-term criteria for success of the program. Reproductive and survival patterns indicate that long-term criteria were met. Nesting success and overall productivity did not differ between the reintroduced and control populations. However, all trends, particularly productivity were higher in the reintroduced population than in the control population. In addition, estimates of annual adult survival were approximately 15% higher for both species in the reintroduced population than the control population. It needs to be noted that the survivorship model used in these analyses are somewhat weak without statistical tests, but they probably represent general trends of each population. One problem is that if color-banded birds move off the plots in Raccoon Point they are not likely to be located, whereas, if birds move in Long Pine Key, they are relocated because most of the area is systematically searched. I hope that as sample sizes grow more robust estimator models and statistical comparison can be used.

Populations of both species have increased dramatically (100-400%) in each year of the reintroduction program. Bluebirds in particular have shown dramatic increases in the last year. Bluebirds may be better adapted to colonize a new area than nuthatches for several reasons. First, they are multi-brooded and under good conditions can nest up to three times per year, unlike nuthatches, which rarely attempt a second brood. Equally important is that bluebirds can disperse to new areas more easily because of their flying ability, whereas nuthatches have been characterized as sedentary, and most dispersal is to adjacent territories (Norris 1958).

Overall, population demographics of both species indicate that the habitat in Long Pine Key has returned to a state that is capable of supporting populations of each species. The forest

is approaching 70 years of age and is slowly recovering from logging in the early 1940's. The establishment of a prescribed fire regime that mimics the natural patterns of fire frequency and season has begun to return understory characteristics to more natural conditions. Moreover, fires have begun to create an uneven-aged forest structure with various snag and tree age-classes that is characteristic of old growth forests. Brown-headed Nuthatches and Eastern Bluebirds in Florida are more abundant in old-growth forests than in other habitats.

SYNTHESIS

With the dramatic increase in size of each population and the increasing proportion of resident vs. translocated individuals that make up the population, additional translocations have been discontinued. Both populations have reached a size where they appear to be sustainable, barring a significant environmental or catastrophic events. We recommend that continued monitoring in the reintroduced population continue for at least two years along with the high quality referee site to further evaluate the population demographics of the reintroduced population without translocations.

Table 1. Breeding biology summary of Brown-headed Nuthatches in Long Pine Key, ENP between 1998-2001.

Year	Territories	Breeding territories	Nests	Mean incubation date	Territories successful	Productivity (young/nest)	Overall productivity
1998	2?						
1999	3	3	4	8 March (± 2)	3 (100%)	2.50 (± 0.87)	3.67 (± 0.87)
2000	8	8	10	19 March (± 5)	6 (75%)	2.20 (± 0.61)	2.75 (± 0.62)
2001	15	13	14	22 March (± 6)	7 (54%)	1.64 (± 0.54)	1.77 (± 0.57)
Overall	26	24	28	20 March (± 4)	16 (66%)	1.96 (± 0.36)	2.33 (± 0.39)

Table 2. Annual survival rates for adult Brown-headed Nuthatches in Long Pine Key, ENP.

Year	Breeding adults	Relocated in following year	Annual recapture
1998	5	3	60%
1999	7	4	57%
2000	18	12	66%
Overall	30	19	63%

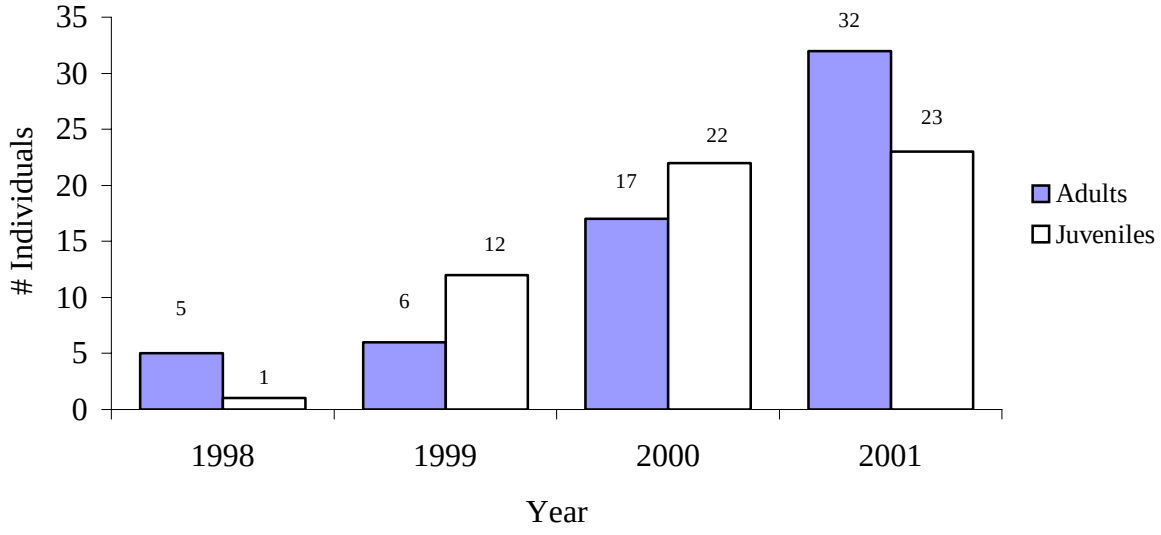


Figure 1. Brown-headed population size in Long Pine Key, ENP between 1998-2001.

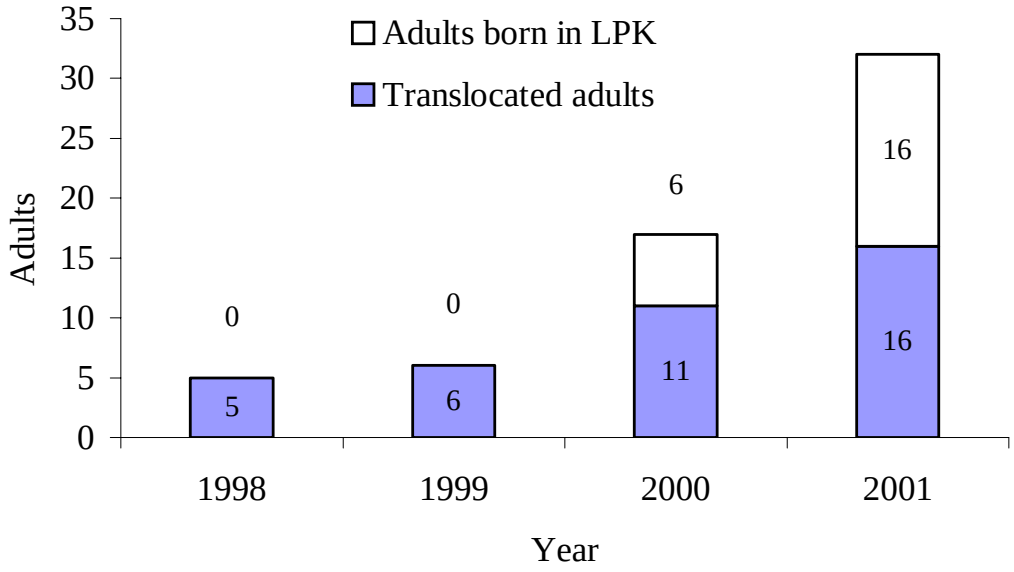


Figure 2. Proportion of translocated vs. resident adult Brown-headed Nuthatches in Long Pine Key, ENP.

Table 3. Comparison of reproduction for Brown-headed Nuthatches in Long Pine Key and Raccoon Point in 2000-2001 (years pooled) and the comparison of annual survival for Brown-headed Nuthatches between 1998-2001.

	Long Pine Key	Raccoon Point	*P*
Breeding territories	21	38	
Successful	13 (62%)	21(55%)	0.62[a]
Overall productivity	2.14 (± 0.43)	1.74 (± 0.27)	0.40[b]
Survivorship	63% (19 of 30)	49% (20 of 41)	

[a] Chi-square test
[b] Two sample *t*-test

Table 4. Breeding biology summary for Eastern Bluebirds in Long Pine Key, ENP between 1998-2001.

Year	Breeding territories	Nests	Mean incubation date	Territories successful	Productivity (young/nest)	Overall productivity
1998	1	1		1	2.00	2.00
1999	2	2		2	3.00	3.00
2000	4	7	6 April (± 6)	3 (75%)	2.29 (± 0.84)	4.00 (± 1.87)
2001	16	27	21 April (± 3)	11 (69%)	1.41 (± 0.30)	2.38 (± 0.57)
Overall	23	37	18 April (± 3)	17 (74%)	1.68 (± 0.28)	2.70 (± 0.51)

Table 5. Annual survival rates for adult Eastern Bluebirds in Long Pine Key, ENP.

Year	Breeding adults	Relocated in following year	Annual recapture
1998	2	0	0
1999	5	3	60%
2000	12	7	58%
Overall	19	10	53%

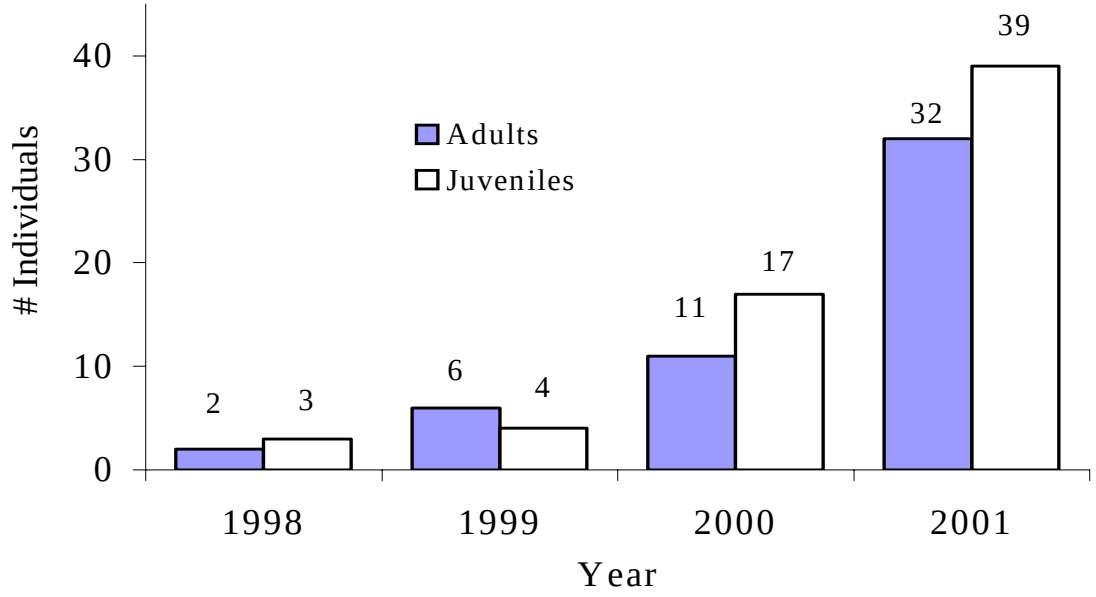


Figure 3. Eastern Bluebird population size in Long Pine Key, ENP between 1998 –2001.

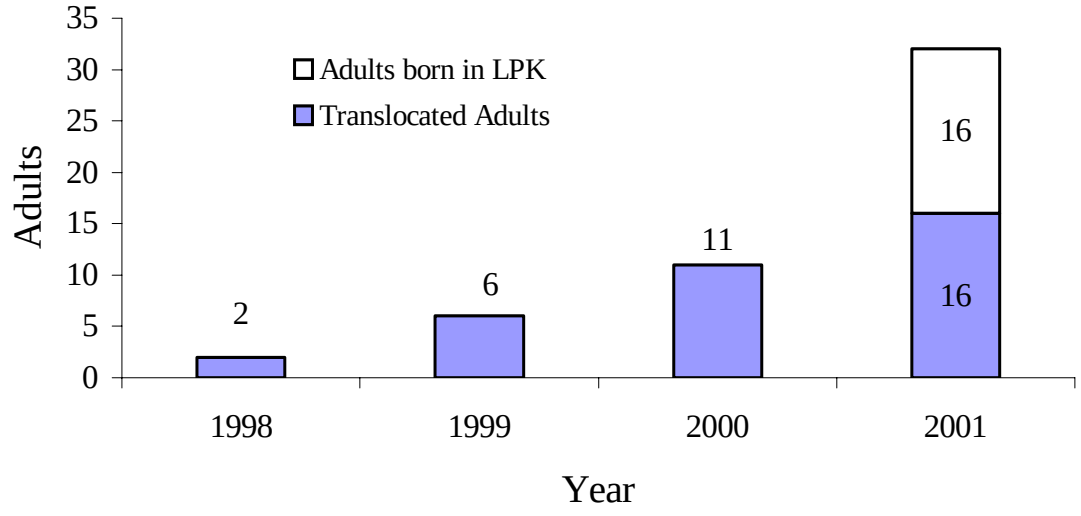


Figure 4. Proportion of translocated vs. resident adult Eastern Bluebirds in Long Pine Key, ENP

Table 6. Comparison of reproduction for Eastern Bluebirds in Long Pine Key and Raccoon Point in 2001 and the comparison of annual survival for Eastern Bluebirds between 1998-2001.

	Long Pine Key	Raccoon Point	*P*
Breeding territories	16	24	
Successful	11 (69%)	16(67%)	0.89[a]
Overall productivity	2.38 (± 0.57)	1.83 (± 0.27)	0.40[b]
Survivorship (1998-2001)	53% (10 of 19)	39% (9 of 23)	

[a] Chi-square test
[b] t-test

CHAPTER FOUR
MONITORING THE DONOR POPULATION OF BROWN-HEADED NUTHATCHES AND EASTERN BLUEBIRDS IN BIG CYPRESS NATIONAL PRESERVE

INTRODUCTION

Big Cypress National Preserve (BCNP), located in southwest Florida, contains an extensive area (approx. 42,000 ha) of both rockland and transitional (between rockland and flatwood) pine forests. The largest and most extensive area of old-growth pinelands is Raccoon Point, a 9,000 ha mosaic of pinelands interspersed in low-elevation cypress (*Taxodium distichum*) forest. Raccoon Point contains the largest populations of nuthatches and bluebirds in southern Florida and both species' nesting biology and habitat associations have been studied (Slater 1997, Slater 2000). In 1994, the density of both nuthatches and bluebirds in Raccoon Point was estimated at 0.055 breeding territories/ha, which translates to approximately 500 breeding territories within Raccoon Point (Slater 1997). The overall population estimate may be higher since floaters and, for nuthatches which are cooperative, helpers are not taken into consideration. Outside of Raccoon Point, nuthatches and bluebirds can be found in the remaining 33,000 ha of forest in BCNP, although probably at a lower density, and movement in and out of Raccoon Point seems likely. Because of the large area of intact pinelands, previous studies on nuthatches and bluebirds, and an access road, Raccoon Point was the most logical choice as a source of birds for the nuthatch and bluebird reintroduction study in Everglades National Park (ENP).

The goal of this study was to monitor nuthatch and bluebird populations between 1998-2001 to determine if removals had an effect on either population. Specific objectives include: 1) to determine if and how quickly territories are reoccupied after removals; 2) to compare reproduction between a control plot where birds were not removed with a plot where individuals were removed.

METHODS

STUDY AREA

Raccoon Point is a slash pine (*Pinus ellioti* var. *densa*)/cypress mosaic that escaped the logging during the 1950s and 1960s that befell most of the preserve. Pine forest is distributed as islands interspersed in a matrix of cypress domes, cypress strands, cypress savannas, and, to a lesser extent, hardwood hammocks. The area is located on the northwest edge of the rockland pine system where extensive areas of limestone outcroppings are found alongside thin, sandy soils. Although the soils drain well, the area floods regularly during the wet season due to its low elevation (Snyder et al. 1990). As is typical for regularly-burned hydric-pinelands, the herbaceous and grass components are well-developed, while the shrub layer contains a sparse to moderate amount of saw palmetto and a variety of hardwoods. Raccoon Point supports a large and diverse avian community and lies at the southernmost extent of the current Brown-headed Nuthatches' and Eastern Bluebirds' range; nuthatches and bluebirds are abundant in Raccoon Point (Slater 2000). Access into Raccoon Point is along 11-mile road, which was constructed for oil extraction activities. Movements inside Raccoon Point were conducted through an extensive network of off-road vehicle trails.

REMOVAL AND CONTROL PLOTS

In the first two years, we attempted to monitor multiple removal and control plots (up to 8), large enough to contain 3-5 territories of Brown-headed Nuthatches and Eastern Bluebirds. As it turned out, monitoring that many plots became exceedingly difficult because of logistics, resulting in changes being made in 2000.

In 2000, monitoring plots were changed to one large removal and control plot to make monitoring more efficient. The two plots were separated by a distance of 2.5 km to minimize influence between sites; each plot contained 10-15 territories. The removal plot is bisected by 11-mile road extending east and west approximately 1 km; the southern edge is marked by Marker A-3, while the northern edge extends approximately 200 m north of Pad 4. The control

plot is located between Marker 20 and Marker 21, and extends west approximately 300m and to the east approximately 2.5 km.

On the removal plot, 3-4 removals of each species were performed. In most cases, the remaining removals were conducted at least 2.5 km from the removal or control plot to eliminate any effect to those sites. However, two bluebird pairs were taken adjacent to the removal plot in 2000; one before the breeding season and one at the end of the breeding season. These areas were monitored to determine if bluebirds reoccupied the area.

MONITORING TERRITORIES

Census before translocation.-Before nuthatch translocations, territories in the removal plot were delineated from behavioral observations. Because bluebirds have not fully established territories by the time of removals, territory delineation before removals was not possible. However, because removed bluebirds are exhibiting breeding behavior, I assumed the removal location was within or adjacent to a potential breeding territory. Reoccupation was dependent on a bluebird pair establishing a territory that included the removal location. Nuthatches and bluebirds were banded when possible. After the removal of birds from a territory, the vacant territories were monitored every 2-4 weeks to observe how quickly territories were reoccupied.

Monitoring during breeding season.-During the breeding season, we tried to locate all nuthatch and bluebird nests in the control and removal plots. Once excavation and nest-building behaviors were noted, nest sites were checked regularly until egg-laying began. Upon incubation (clutch complete) a nest site was classified as a nesting attempt. Nests were typically checked every 3-5 days until nestlings fledged or the nest failed. A nest was successful if it fledged at least one nestling and overall productivity was calculated as the number of young fledged per territory. If a nest failed, we followed the group in following weeks to see if they renested.

Comparisons of nesting success and overall productivity were performed with pooled data from 2000 and 2001. Nesting success was compared between removal and control plots using a Chi-square test. Overall productivity was compared between removal and control plots

using a Mann-Whitney *U*-test. Survivorship was estimated for both plots pooled together because of small sample sizes.

RESULTS

BROWN-HEADED NUTHATCH

Between 1997-2001, 48 Brown-headed Nuthatches were removed from 20 territories in Raccoon Point. Removals from 15 territories were from plots that were monitored after removal; 5 removal territories were not on monitored plots. Ten of 15 (67%) territories were reoccupied by the end of the breeding season in which they were removed, however, all reoccupied territories did not breed (Table 1). All territories that were not occupied by the end of the breeding season in which a removal occurred were occupied by the start of the following breeding season.

Annual breeding summaries by Brown-headed Nuthatches between 1998-2001 are presented in Table 2. In comparisons between removal and control plots the only variable that differed significantly was group size (Table 3). Overall annual survival (1998-2001) of Brown-headed Nuthatches was 20 of 41(49%)(Table 4).

EASTERN BLUEBIRD

Between 1998-2001, 37 Adult Eastern Bluebirds and 13 nestling were removed from 18 territories in Raccoon Point. Removals from 13 territories were from plots that were monitored after removal; 5 removal territories were not on monitored plots. Two of the 13 territories had birds removed at the end of the breeding season and were not monitored after removals. Of the remaining 11 territories, all but one (91%) was reoccupied. All reoccupied territories attempted nesting except one, where a pair had been removed with nestlings in early-April (Table 5).

Annual breeding summaries by Eastern Bluebirds between 1998-2001 are presented in Table 6. Between 2000-2001, Eastern Bluebirds had significantly higher nesting success on the removal plot than the control plot (Table 7). Bluebird territories on the removal plot produced almost one more juvenile that bluebird territories on the control plot, however, this comparison only approached significance (Table 7). Eastern Bluebird territories on the removal plot nested

significantly earlier that bluebirds on the control plot (Table 7). Overall annual survival (1998-2001) of Eastern Bluebirds was 9 of 23 (39%)(Table 8).

DISCUSSION

BROWN-HEADED NUTHATCH

Over 65% of all the territories where Brown-headed Nuthatches were removed had a new group reoccupy the territory by the end of the breeding season. The territories not reoccupied were territories where removals occurred close to the breeding season. Those territories may be less likely to be reoccupied as most potential dispersers (floaters or helpers) have already made the choice to be a helper as opposed to try and locate a mate and attempt breeding. Even though most territories were reoccupied, only the territories removed earlier in the season ended up nesting. Birds that reoccupy territories closer to or during the breeding season may have more difficulty nesting because they must establish pair bonds, find a suitable nesting snag, excavate and build a nest before it's too late in the breeding season. Also, birds that reoccupy territories are probably first-year birds and may have difficulty initiating breeding because they lack experience.

Those territories not reoccupied by the end of the breeding season were always reoccupied by the beginning of the next breeding season. Individuals that establish themselves on these territories are probably helpers or juveniles dispersing from nearby territories.

There were no differences in nesting success and productivity between nuthatches on the removal plot versus those on the control, suggesting that removals did not affect those reproductive parameters. On the removal plot, however, there was no incidence of cooperative breeding in the two years territories were monitored. The removal of nuthatch territories appears to provide breeding opportunities for those helpers or juveniles that otherwise would be forced to remain with their natal territories. In 2001, several territories didn't breed. This may simply be a random event, however, another explanation could be that as territories have been removed over multiple years the individuals reoccupying territories are more likely to be younger birds that have difficulty in initiating breeding.

Overall, there is no indication that removals had any effect on the Raccoon Point population, which is estimated to approach 500 territories. On a local scale it appears that removals had the effect of reducing group size, however, this did not affect nesting success or productivity.

EASTERN BLUEBIRD

Except for one territory in 2001, bluebirds reoccupied every location where removals occurred, suggesting that a large floater population of bluebirds in Raccoon Point exists. Even in the territory that wasn't reoccupied (PH), the adjacent territory (EP) territory was reoccupied two times after pairs were removed. Except for one territory reoccupied late in the breeding season, all reoccupied territories attempted to breed. Bluebirds may be better at reoccupying and breeding in removal territories than nuthatches for several reasons. Bluebirds don't maintain year-round territories and probably invest little time in establishing pair-bonds. In fact, many bluebirds select a new mate after failing at their first attempt. Also, bluebirds do not need to excavate a cavity. Overall, there is no evidence that bluebird removals have affected the population of bluebirds in Raccoon Point.

Bluebirds on the removal plot were significantly more successful than those on the control plot and produced almost one more fledgling per territory. They also initiated nesting almost 2 weeks earlier than birds on the control plot. One explanation may be prescribed burning. Most of the removal site was burned between January-March 2000. Prescribed burning has been associated with higher bluebird density, but there is no literature that suggests they have higher reproduction. Alternatively, other differences in habitat quality may explain reproductive differences between the removal and control plot. The control plot has a slightly lower elevation than the removal plot, indicated by a more grassy understory and a larger cypress component. This area may stay flooded longer as the breeding season approaches, forcing bluebirds that have territories in the areas to breed later and perhaps be less successful. More analyses looking at environmental factors associated with nesting and reproduction need to be examined to address these differences.

Survival of bluebirds appears low in Raccoon Point. However, sample sizes are low and only in the last two years was a sustained effort made to band individuals. Moreover, bluebirds

may be more likely to move to different territories between years. If so, birds banded on a plot may move off and be considered dead even though they are alive and just off the plot. I anticipate if larger samples can be obtained more appropriate estimator models can be used.

SYNTHESIS

There is little evidence that the removal of Brown-headed Nuthatch and Eastern Bluebirds on the removal plot have had any impact on the Raccoon Point populations. There does appears to be a small local effect on Brown-headed Nuthatch territories expressed as a reduction in group size, however, this had no effect on reproduction. At this time translocations have been discontinued, however, monitoring will continue on the removal and control plots to use as an evaluatory tool for the newly reintroduced population in Everglades National Park.

Table 1. Summary of removal dates for Brown-headed Nuthatch territories in the removal plots and occupation status during the breeding season.

Territory	Date removed	Reoccupied	Comments
NU	12/17/97	Yes	Didn't breed.
CI	2/9/98	No	Not checked in 1999.
CT	3/3/98	Yes	Didn't breed.
LY	11/16/98	Yes	Didn't breed.
WR	11/18/98	Yes	
MA	2/10/99	No	Not checked in 2000.
CA	2/19/99	Yes	
OD	3/1/99	No	occupied in 2000.
WJ	1/17/00	Yes	
AF	2/4/00	Yes	New pair excavating in same cavity as pair removed. New pair removed.
PH	2/18/00	No	Family groups used area at end of breeding season; occupied in 2001.
AF	3/10/00	Yes	New pair nest-building, but didn't nest.
BR	2/2/01	Yes	New pair may have been from adjacent territory; began nest-building, but didn't breed.
EP	2/14/01	No	Family groups used area at end of breeding season.
RC	2/22/01	Yes	Reoccupied, but didn't breed.

Table 2. Annual breeding summary for Brown-headed Nuthatches in Raccoon Point, BCNP in 1998-2001.

	1998	1999	2000		2001	
			Removal plot	Control plot	Removal plot	Control plot
Breeding territories	6	29	9	9	6	8
Territories didn't breed	16	1	1	2	4	0
Mean group size (breeding territories)	2.50 (0.22)	2.14 (0.08)	2.00 (0.00)	2.33 (0.17)	2.00	2.38 (0.18)
Mean incubation date (± S.E.)	27 April (4)	15 March (3)	13 March (4)	14 March (5)	16 March (5)	20 March (6)
No. territories successful (%)	3(50%)	24 (83%)	5 (56%)	5 (56%)	3 (50%)	5 (63%)
Overall productivity (± S.E.)	1.00 (0.52)	2.76 (0.32)	1.78 (0.60)	1.67 (0.18)	1.67 (0.52)	1.63 (0.60)

Table 3. Comparison of reproductive parameters for Brown-headed Nuthatches in Raccoon Point, BCNP between 2000-2001.

	Removal plot	Control plot	*P*
Breeding territories	15	17	
Territories didn't breed	5	2	
Mean group size	2.00 (0.00)	2.35 (0.12)	0.01[a]
Mean incubation date (± S.E.)	15 March (3)	17 March (4)	0.92[a]
No. successful (%)	8 (53%)	10 (59%)	0.76[b]
Overall productivity (± S.E.)	1.73 (0.45)	1.65 (0.39)	0.90[a]

[a] Mann-Whitney U-test
[b] Chi-square test

Table 4. Annual survival rates for color-banded adult Brown-headed Nuthatches in Raccoon Point, BCNP between 1998-2001.

Year	Breeding adults	Relocated in following year	Annual recapture
1998	5	3	60%
1999	10	5	50%
2000	26	12	46%
Overall	41	20	49%

Table 5. Territories and dates of Eastern Bluebird removals on the removal plots and the date reoccupied.

Territory	Date removed	Reoccupied	Comments
BR	3/30/98	Yes	Territory occupied and bred.
MN	4/13/98	Yes	Territory occupied and bred.
VO	2/19/99	Yes	Capture site on boundary of three territories.
PH	2/23/99	Yes	Territory occupied and bred.
MN	5/3/99	N/A	At end of breeding season; not monitored.
PH	2/26/00	Yes	Territory occupied and bred.
AF	3/2/00	Yes	Territory occupied and bred.
BR	4/5/00	Yes	Territory occupied but did not breed.
BF	5/23/00	N/A	Removal at end of breeding season.
PH	2/27/01	No	
EP	3/14/01	Yes	Territory reoccupied and 2nd pair removed on 3/26.
EP	3/26/01	Yes	Territory reoccupied and bred.
RC	3/26/01	Yes	Territory reoccupied and bred.

Table 6. Annual breeding summary for Eastern Bluebirds in Raccoon Point, BCNP in 1998-2001.

	1998	1999	2000		2001	
			Removal plot	Control plot	Removal plot	Control plot
Breeding territories	27	25	9	8	12	12
Nests	27	28	12	10	16	16
Mean incubation date (± S.E.)	3 May (3)	1 April (2)	3 April (9)	15 April (13)	11 April (6)	21April (6)
No. territories successful (%)	13(48%)	13 (52%)	5 (56%)	1 (13%)	9 (75%)	6 (50%)
Overall productivity (± S.E.)	0.96 (0.24)	1.52 (0.35)	1.44 (0.53)	0.75 (0.75)	2.33 (0.53)	1.33 (0.38)

Table 7. Comparison of reproductive parameters for Brown-headed Nuthatches in Raccoon Point, BCNP between 2000-2001.

	Removal plot	Control plot	*P*
Breeding territories	21	20	
Nests	28	26	
Mean incubation date (± S.E.)	13 April (6)	26 April (6)	0.04[a]
No. successful (%)	13 (62%)	6 (30%)	0.04[b]
Overall productivity (± S.E.)	1.95 (0.38)	1.10 (0.37)	0.08[a]

[a] Mann-Whitney U-test
[b] Chi-square test

Table 8. Annual survival rates for color-banded adult Eastern Bluebirds in Raccoon Point, BCNP between 1998-2001.

Year	Breeding adults	Relocated in following year	Annual recapture
1998	2	0	0%
1999	5	2	40%
2000	16	7	44%
Overall	23	9	39%

LITERATURE CITED

Ahlgren, I. F., and C. E. Ahlgren. 1960. Ecological effects of forest fires. Botanical Review 26:483-533.

Bent, A. C. 1948. Life histories of North American nuthatches, wrens, thrashers and their allies. United States Museum Bulletin No. 195.

Cade, T.J. and S.T. Temple. 1995. Management of threatened bird species: An evaluation of the hands-on approach. Ibis 137:161-172.

Cox, J. 1987. The breeding bird survey in Florida: 1969-1983. Florida Field Naturalist 15:29-56.

Doren, R. F., W. J. Platt, and L. D. Whiteaker. 1993. Density and size structure of slash pine stands in the everglades region of south Florida. Forest Ecology and Management 59: 295-311.

Griffith, B., Scott, J.M., J.W. Carpenter, and C. Reed. 1989. Translocation as a Species Conservation Tool: Status and Strategy. Science 245:477-480.

Hutto, R. L., S. M. Pletschet, and P. Hendricks. 1986. A fixed-radius point count method for non-breeding and breeding season use. Auk: 103:593-602.

Lewis, E. A. 1994. Resource use by the woodpeckers of Long Pine Key, Everglades National Park. M.S. Thesis. Florida International University, Miami.

Nesbitt, S. A. and W. M. Hetrick. 1976. Foods of the Pine Warbler and Brown-headed Nuthatch.

Florida Field Naturalist 4:28-34.

Norris, R. A. 1958. Comparative biosystematics and life history of the nuthatches, *Sitta pygmaea*

and *Sitta pussila*. Univ. Calif. Publ. Zool. 56:119-300.

Noss, R.F., E.T. Laroe, and J.M. Scott. 1995. Endangered ecosystems of the United States: A Preliminary assessment of loss and degradation. United States Department of Interior, National Biological Service. Biological Report No. 25.

Olmstead, I., W.B. Robertson Jr, J. Johnson, and O.L.Bass.1983. The vegetation of Long Pine Key, Everglades National Park. S. Fl. Res. Center Rep. SFRC-83/05, National Park Service, Atlanta, GA, 64 pp.

Peakall, D. B. 1970. The Eastern Bluebird: its breeding season, clutch size, and nesting success. Living Bird 9:239-255.

Pinkowski, B. C. 1976. The use of tree cavities by nesting Eastern Bluebirds. Journal of Wildlife Management 40:556-563.

Pinkowski, B. C. 1977. Foraging behavior of the Eastern Bluebird. Wilson Bulletin 89:404-414.

Ralph, C. J., J. R. Sauer, and S. Droege, technical editors. 1995 Monitoring bird populations by point counts. Gen. Tech. Rep. PSW-GTR-149. Pacific Southwest Research Station, Forest Service, USDA, 187pp.

Robertson, W.B., Jr. and J.A. Kushlan. 1974. The southern Florida avifauna. Miami Geological Society. Mem. 2:414-452.

Sauer, J. R., J. E. Hines, I. Thomas, J. Fallon, G. Gough. 2000. The North American Breeding Bird Survey, Results and Analysis 1966-1999. Version 98.1, USGS Patuxent Wildlife Research Center, Laurel, MD.

Sarrazin, F. and R. Barbault. 1996. Reintroduction: Challenges and lessons for basic ecology. Trends in Ecology and Evolution 11:474-478.

Sarrazin, F. and S. Legendre. 2000. Demographic approach to releasing adults versus young in reintroductions. Conservation Biology 14:488-500.

Slater, G. L. 1997. Brown-headed Nuthatches and Eastern Bluebirds in southern Florida Pinelands: Breeding biology, nest-site selection, and the influence of habitat on nesting success. M. S. Thesis. University of Florida, Gainesville.

Slater, G. L. 2000. Annual Report: Avian Restoration in Everglades National Park: Phase II. National Park Service, Homestead, FL.

Slater, G. L. 2001. Golf courses donate bluebirds to reintroduction program in Everglades National Park. Florida Green.

Snyder, J.R., A. Herndon, and W.B. Robertson, Jr. 1990. South Florida Rockland. Pp 230-274 in Ecosystems of Florida, R.L. Meyers and J.J. Ewel (eds.). University of Central Florida Press, Orlando, Fl.

Stevenson, H. M. and B. H. Anderson. 1994. The birdlife in Florida. University of Florida Press,

Gaineseville.

Zeleny, L. 1976. The Bluebird. University of Indiana Press, Bloomington.