Management and Conservation Article

Evaluation of the Efficacy of Florida Key Deer Translocations

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ABSTRACT The endangered Florida Key deer (*Odocoileus virginianus clavium*) is endemic to the Lower Florida Keys. In recent years, habitat fragmentation and restricted dispersal have resulted in small, isolated herds on some islands. Recovery biologists proposed translocations to increase the island herds that had declined or remained low; however, efficacy of Key deer translocations had yet to be evaluated. Our objective was to evaluate survival, ranges, reproduction, and dispersal of translocated deer. During 2003–2005, we translocated 39 adult or yearling deer to Sugarloaf (approx. 19 km from trap site; 10 M, 14 F) and Cudjoe (approx. 15 km from trap site; 6 M, 9 F) keys. We kept deer in large, high-fenced holding pens (Sugarloaf = 7.7 ha, Cudjoe = 10.7 ha) on the destination islands for 3–6 months (i.e., soft release). We observed low mortality ($n = 6$ mortalities) of translocated deer with average annual survival (S) of 0.796 for both sexes. We found translocated deer had larger seasonal ranges than did resident deer (i.e., those located on Big Pine and No Name keys). In evaluating effects of acclimation period on ranges and dispersal, we found no difference in 95% ranges or 50% core areas ≤4 month postrelease versus 4–8 months postrelease. We found, however, postrelease dispersal distances were dependent on time kept in pen. Only 2 of 39 (5%) translocated deer left the destination islands by the end of the study. With high survival and low dispersal indicating success, we credit soft release translocation in establishing deer herds on Sugarloaf and Cudjoe keys. Our data support translocations as an effective strategy for creating sustainable outer-island Key deer herds. (JOURNAL OF WILDLIFE MANAGEMENT 72(5):1069–1075; 2008)

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The endangered Florida Key deer (*Odocoileus virginianus clavium*) is the smallest subspecies of white-tailed deer in North America and is endemic to the Lower Florida Keys (Hardin et al. 1984). The historic range of Key deer once extended from Key Vaca to Key West (U.S. Fish and Wildlife Service [USFWS] 1999). In recent years, long dispersal distances (15–19 km) and increasing urban development have resulted in an approximately 65% decrease in distribution of Key deer to the current range extending from West Summerland to Sugarloaf keys (Fig. 1). Outer islands with good habitat but low deer density likely had difficulty in herd establishment due to inconsistent immigration from the core habitat blamed on long dispersal distances and variable intervening habitat quality. Additionally, previous studies have hypothesized that large subdivisions (e.g., Ramrod and Summerland keys) serve as effective barriers to deer dispersal (Harveson et al. 2004; Fig. 1). Currently, the Key deer population is estimated at 600–700 deer on 20–25 islands (Lopez et al. 2003); however, approximately 75% of the total population is located on only 2 adjacent islands—Big Pine (2,522 ha) and No Name (459 ha) keys. These islands are currently experiencing locally abundant deer numbers (i.e., near or at carrying capacity; Nettles et al. 2002, Lopez et al. 2004*a*, Roberts 2005), whereas other islands have small or declining herds. This situation presents unique management challenges and will require a 2-prong approach to the Key deer's recovery. First, islands with high deer density will require the reduction of herd numbers to maintain the integrity of vegetative communities that support local Key deer herds (Barrett 2004). Reduction of Key deer density in these areas would reduce semidomestication (Peterson et al. 2005), disease transmission (Nettles et al. 2002, Quist et al. 2002), and impacts to native vegetation (Barrett 2004). Second, islands with low deer density will require increasing deer numbers following traditional approaches used in the recovery of endangered species (i.e., land acquisition, habitat improvement, and translocations; Lopez et al. 2003, 2004*b*).

Translocation is the transport and release of free-ranging animals into areas where the species presently occurs or once occurred (Nielson 1988). Translocations offer recovery biologists the opportunity to increase a population's range and reproductive potential (Beringer et al. 2002). In the case of the Key deer, translocations would allow managers to establish viable and sustainable Key deer herds on outer islands (Nielson 1988, Komers and Curman 2000). According to the South Florida Multi-Species Recovery Plan, Key deer are required to increase in both range and numbers before any consideration of downlisting can occur

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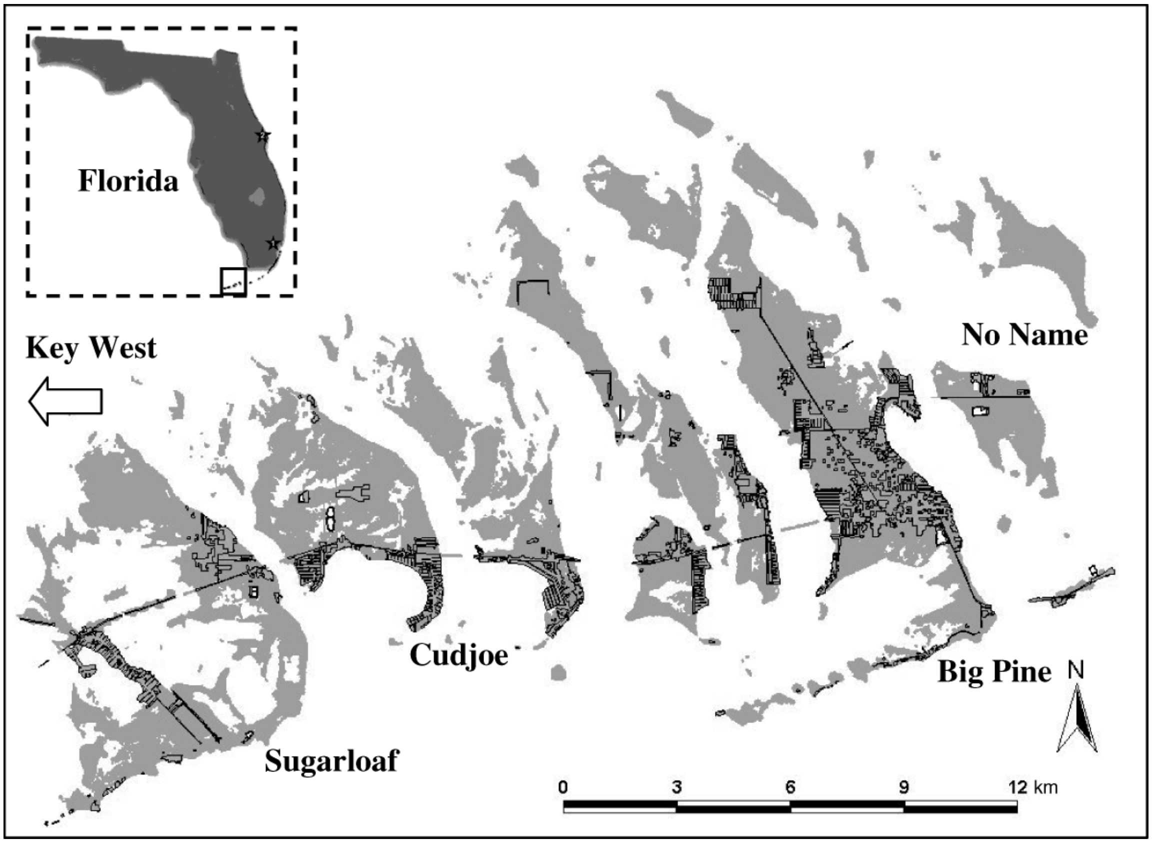

Figure 1. Current Key deer range in the Lower Florida Keys, USA, 2005. Outlined sections represent areas of dense urban development, which can serve as barriers to deer dispersal.

(USFWS 1999). Previous recovery attempts made in the early 1980s and 2000s consisted of hard release translocations of Key deer to Sugarloaf and Little Pine keys, respectively. These efforts met with little success (S. B. Klett, R. R. Lopez, USFWS, unpublished data). Hard release is defined as the transport of animals from capture to release areas followed by immediate and unassisted release into the new environment (Bright and Morris 1994). However, several studies (Bright and Morris 1994, Biggins et al. 1998, Wanless et al. 2002) have reported that soft releases can increase animal survival and fidelity to release sites by allowing translocated wildlife to acclimatize to their new environment. Soft release refers to the release of translocated animals after an acclimation period in a holding facility for a variable length of time (Nielson 1988). Some purported benefits of soft releases include increased site fidelity and animal survival (Nielson 1988); however, the importance and effectiveness of soft releases in translocation of Key deer have not been evaluated.

Our study objective was to evaluate the effectiveness and utility of Key deer translocations, particularly soft release translocations, in increasing or stabilizing outer island deer herds. Specifically, we 1) compared annual survival between resident (i.e., those located on Big Pine and No Name keys) and translocated deer, 2) analyzed sex- and age-based survival differences among translocated deer, 3) compared seasonal 95% kernel ranges and 50% core areas between resident and translocated deer, and 4) analyzed reproduction and site fidelity of translocated deer. Such information is imperative for the recovery of Key deer and in drafting guidelines for recovery biologists managing endangered deer populations.

STUDY AREA

The Florida Keys are a chain of islands stretching southwest from the southern coast of Florida, USA. Key deer from Big Pine and No Name keys were translocated to Sugarloaf (1,399 ha) and Cudjoe (1,319 ha) keys, a distance of approximately 19 km and 15 km, respectively, from the core habitat. Big Pine Key is the largest island in the Key deer range and, along with the adjacent No Name Key, forms the core Key deer habitat (approx. 75% of total deer population; Lopez et al. 2004*b*). All capture locations and translocation destinations were within the boundaries of the National Key Deer Refuge, Monroe County (Lopez et al. 2004*b*). We selected Cudjoe and Sugarloaf keys as translocation sites due to the abundance of preferred Key deer habitat (i.e., pineland and hammock [Cudjoe Key = 198 ha, Sugarloaf Key = 294 ha; Lopez et al. 2004*b*]), presence of substantial freshwater, and history of deer herds. Additionally, $\leq$6 deer occupied either Cudjoe or Sugarloaf keys immediately prior to the translocation project (Harveson et al. 2006). Destination islands also had considerably less development than the core habitat (area developed: Big Pine Key = 577 ha, No Name Key = 23 ha, Cudjoe = 206 ha, Sugarloaf = 91 ha [ArcView 3.3]).

METHODS

We captured Key deer using either portable drive nets (Silvy et al. 1975), drop nets (Lopez et al. 1998), or hand capture (Silvy 1975). We restrained all deer with rope (legs bound) and placed a hood over each animal's head prior to transportation. Our average handling time from trapping to release was 30–45 minutes; we used no drugs. We recorded sex, age, body condition, capture location, and weight for each translocated deer (Lopez et al. 2003). We fitted each deer with a battery-powered mortality-sensitive transmitter (radiocollar [115 g] or antler transmitter [15 g]; 150–152 MHz, Advanced Telemetry Systems, Inc., Isanti, MN; Lopez et al. 2003). We incorporated transmitters for males either into polyvinyl breakaway collars with integrated elastic (seasonal neck expansion) or leather antler assemblies (Lopez 2001). We attached transmitters for females on nonexpandable polyvinyl collars. Finally, we ear tattooed each animal as a permanent marker (Silvy 1975).

Once at the destination island, we soft released Key deer into a holding pen and provided supplemental feed (e.g., whole corn, cracked corn, or sweet feed). We placed 757-l rain-catchment guzzlers (Wildlife Water Guzzlers, Buffalo Trail Canyon, TX) on each destination island and excavated waterholes to provide permanent water sources. The Sugarloaf and Cudjoe high-fenced (2.4 m) pens measured 7.7 ha and 10.9 ha, respectively, and served to acclimatize deer to their new environment. Translocation project guidelines mandated confinement of translocated deer for 3–6 months in release-site pens prior to release. Upon completion of holding time in pens, we opened gates and ceased supplemental feeding.

We monitored postrelease translocated Key deer 3–4 times/week via homing (White and Garrott 1990, Lopez et al. 2003). We recorded deer locations on geo-referenced maps then inputted these data into a Geographic Information System (ArcView [Version 3.3], Lopez et al. 2003). We immediately investigated mortality signals and determined cause of death by necropsy if possible (Nettles 1981). We sent deer that died of unknown causes to the Southeastern Cooperative Wildlife Disease Study for further analysis. We visually located female deer during the fawning (1 Apr–31 Jun) and postfawning (1 Jul–30 Sep) season via walk-ins (i.e., tracking with telemetry equipment until sighted) and we used infrared-triggered remote digital cameras (Non Typical, Inc., Park Falls, WI) to gather information on reproductive status (i.e., fawn presence, visibly pregnant, full udder; Cutler and Swann 1999, Claridge et al. 2004). We moved remote cameras to various locations on the destination islands to aid in collecting visual observations of adult female deer with fawns.

Monitoring of translocated Key deer began immediately upon deer release into pens and ended only upon censoring or end of study. To compare annual survival between translocated and resident deer we converted radiotelemetry data into encounter histories and used Program MARK (White and Burnham 1999) to generate monthly known-fate survival estimates. Encounter histories consisted of the number of deer available at the beginning of each month and the number of fatalities occurring during each month grouped by sex. We censored animals during the last month whose radios failed or disappeared (Pollock et al. 1989). We converted monthly survival estimates into annual survival estimates. We calculated model-averaged 95% confidence intervals for annual survival rates with a logit transformation (Burnham et al. 1987). We used a likelihood ratio (LR) test to determine the influence of sex and age on survival. Additionally, we compared survival estimates to resident deer survival estimates reported in the literature (Lopez et al. 2003).

We calculated seasonal (approx. 32 locations/3 months) ranges (95%) and core areas (50%) using a fixed-kernel home range estimator (Worton 1989; Seaman et al. 1998, 1999) following methods identical to Lopez et al. (2005) to allow direct comparison. We defined seasons for analysis as winter (postbreeding, Jan–Mar), spring (fawning, Apr–Jun), summer (postfawning, Jul–Sep), and fall (breeding, Oct–Dec; Lopez 2001). In comparing seasonal ranges for translocated deer, we calculated a seasonal range estimate for the season in which a deer was released; i.e., we compared breeding range estimates for deer released during the breeding season to resident breeding range estimates, which allowed us to minimize seasonal effects and instead evaluate translocation effects. We used a *t*-test to compare 95% ranges and 50% core areas of translocated deer based on age. We then compared calculated range estimates for translocated deer to those published in the literature (Lopez et al. 2005). Finally, we evaluated postrelease acclimation period by comparing the first 4-month postrelease 95% range and 50% core area to the subsequent 4-month range and core area estimates using a Mann–Whitney *U* test (Dytham 2003). We compared holding time to maximum postrelease dispersal distances to determine the effect of holding time on site fidelity. We used these data as a means of analyzing release-type effects (i.e., soft versus hard) on project outcome. We defined dispersal distance as the maximum distance traveled in the first 10 days postrelease.

RESULTS

From 2003 to 2005, we translocated 23 females (yearling, *n* = 8; ad, *n* = 15) and 16 males (yearling, *n* = 2; ad, *n* = 14) from Big Pine and No Name keys to holding pens on Sugarloaf and Cudjoe keys. We translocated Key deer in fall, winter, and spring when females were pregnant or likely bred. In 2003, we translocated 5 deer to Sugarloaf (2 ad [1 M, 1 F], 3 yearlings [1 M, 2 F]). In 2004, we moved an additional 12 deer to Sugarloaf (11 ad [4 M, 7 F], 1 yearling [1 M]) and began Cudjoe translocations with 8 initial deer (7 ad [3 M, 4 F], 1 yearling [1 F]). We completed translocation efforts for both islands in 2005 by translocating 7 deer to Sugarloaf (4 ad [3 M, 1 F], 3 yearlings [3 F]) and 7 deer to Cudjoe (5 ad [3 M, 2 F], 2 yearlings [2 F]).

Table 1. Seasonal 95% ranges of female resident and translocated Key deer on Big Pine, No Name, Sugarloaf, and Cudjoe keys, 1998–2000, 2003–2005.

Type[a]	Season	*n*	$\bar{x}$	SE
Translocated	Fall	9	139	127
Translocated	Spring	5	86	60
Translocated	Winter	3	120	55
Resident	Fall	42	36	4
Resident	Spring	64	50	7
Resident	Winter	55	38	4

[a] Range estimates for resident deer from Lopez et al. (2005).

Only 2 deer (Sugarloaf = 1 M, Cudjoe = 1 M) of the 39 translocated deer during the study left the destination islands. For range and core area analysis, we observed high deer censorship for males due to collar loss (i.e., breakaway collars, 14 M); thus, we did not perform range and core area analyses for males. In our survival analysis, we censored one adult male due to capture myopathy.

We monitored translocated Key deer during 2003–2006. Overall, translocated deer demonstrated high survival, with only 16% observed fatalities (6/38 deer; 4 deer–vehicle collisions [DVCs], 2 unknowns). We omitted one adult male from the study due to capture myopathy <7 days after initial translocation. Estimated annual survival of translocated female deer (0.796, SE = 0.081) was not different from resident deer multi-age class estimates (0.695–0.888, SE = 0.033–0.132) made by Lopez et al. (2003). However, translocated males generally demonstrated higher survival (0.796, SE = 0.081) than did resident male multi-age class estimates (0.412–0.842, SE = 0.060–0.158). We found no difference in survival based on sex ($LR = 1.715_1$, $P = 0.190$) or age ($LR = 0.370_1$, $P = 0.543$) for translocated deer. Moreover, survival (%) of translocated adult and yearling deer was within confidence intervals for resident deer (both yearling and ad = 0.842–0.888, SE = 0.056–0.069; Lopez et al. 2003). There was insufficient data to analyze simultaneous effects of age and sex on survival.

As we expected, mean (±SE) seasonal 95% ranges for observed deer ($n = 18$, F) were highest during the fall–breeding season (139 ± 127 ha) compared to other seasons (winter–postbreeding, 120 ± 55 ha; spring–fawning, 86 ± 60 ha). There was insufficient data to examine male ranges. We found no statistical difference based on age for female 95% ranges (ad = 103 ± 74 ha, yearling = 155 ± 139 ha; $P = 0.299$) or 50% core areas (ad = 14 ± 12 ha, yearling = 19 ± 14 ha; $P = 0.549$); however, the means suggest some level of biological difference. We observed that translocated females had larger seasonal 95% ranges (113 ± 22 ha, $P < 0.05$) and 50% core areas (15 ± 4 ha, $P < 0.05$) than did resident female deer (Table 1; Fig. 2). We found no decrease in 95% ranges ($P = 0.063$) or 50% core areas ($P = 0.052$) from the first 4 months postrelease (approx. 50 locations) to the second 4-month period. However, we found 95% ranges and 50% core areas were smaller in the second 4-month period for 7 out of 10 deer (70%).

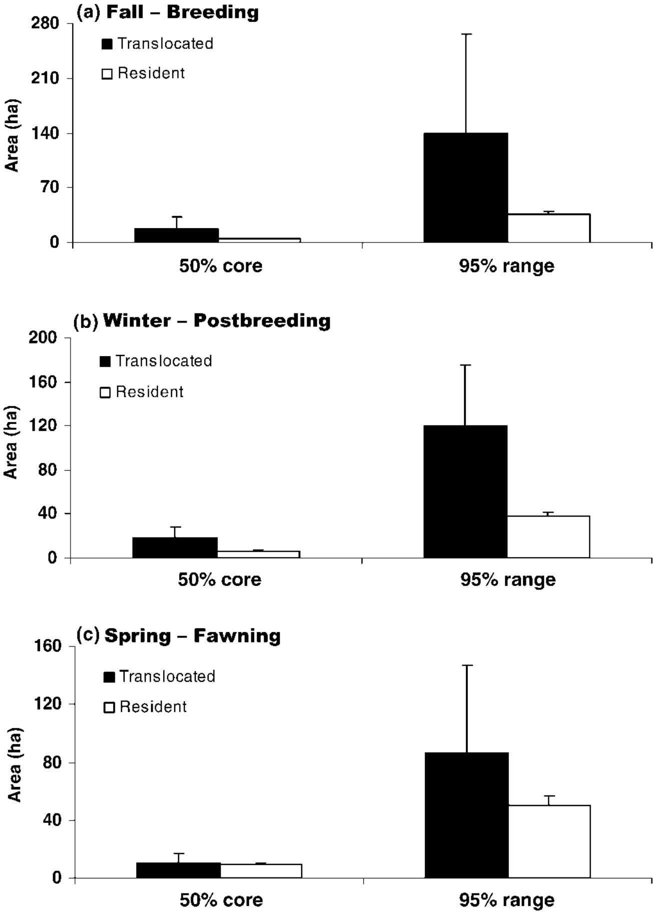

Figure 2. Seasonal ranges and core areas ($\bar{x}$, 1 SE) of translocated and resident Florida Key deer, Big Pine, No Name, Sugarloaf, and Cudjoe keys, Florida, USA, 1998–2000, 2003–2005.

We censored 9 deer from dispersal analysis due to insufficient data. We analyzed 30 deer (22 ad [8 M, 14 F], 8 yearlings [8 F]) to determine effects of time in pen on dispersal distance. We found mean (± SD) dispersal distances indicated an inverse relationship of dispersal distance to pen time (≤30 days = 5.6 ± 6.7 km, 31–90 days = 1.2 ± 1.03 km, ≥91 days = 0.69 ± 0.50 km; Fig. 3).

We observed from visual observations and walk-ins ($n = 106$, 1 Jun 2004–24 Aug 2005) and camera data ($n = 731$ pictures, 251 video clips [22–30 sec each]; 1 Jul–30 Sep 2005), 3 marked females with fawns (23%, 3/13 observed translocated females). In addition, we noted that 5 translocated females showed obvious signs of lactation (38%, 5/13). We also identified 11 different, unaccompanied weaned fawns as well as one unmarked yearling. We observed that nearly 62% of observed females ($n = 8$) had confirmed fawns or obvious signs of lactation.

DISCUSSION

We found that overall survival (0.796) for translocated Key deer was higher than other translocation studies that involved longer holding times, animal sedation, or use of hard releases (Jones and Witham 1990, Bryant and Ishmael 1991, Jones et al. 1997). We also observed that annual survival for translocated females was not significantly

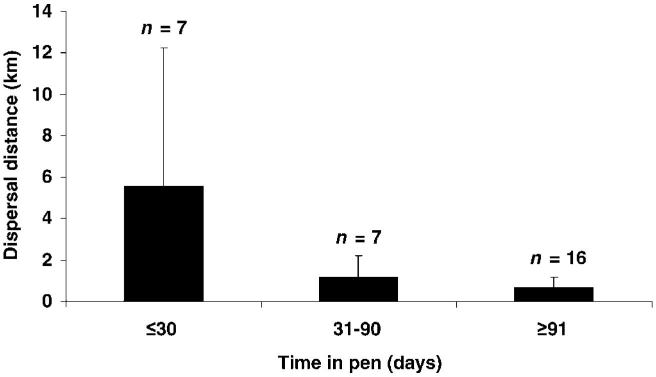

Figure 3. Average maximum dispersal distance of translocated Key deer for the first 10 days postrelease, Sugarloaf and Cudjoe keys, Florida, USA, 2003–2005.

different from resident deer, whereas translocated male annual survival was generally higher than resident deer. Our results suggest that relatively greater survival may be attributable to the use of soft releases, decreased intraspecific competition, lower threat from vehicles due to less development, and abundant resources on the translocation islands. Due to greater natural range sizes, males may particularly benefit from a decreased threat from vehicles.

We observed seasonal ranges for translocated deer to be highest during the fall–breeding season, which we expected, because ranges typically increase as breeding activity begins (Kammermeyer and Marchinton 1976, Mattfeld et al. 1977). We also found that seasonal ranges for translocated Key deer were higher than resident deer ranges. Newly translocated deer likely underwent an exploration phase before they settled, which possibly inflated observed range sizes (Beringer et al. 2002). Though not statistically significant, we did observe a decrease in range size over time, suggesting some level of acclimation may have occurred. Lower deer density on destination islands may also have contributed to the larger observed ranges. Previous studies have reported deer ranges decrease with increasing population densities (Lopez et al. 2005).

Overall, we observed that most (93%) translocated Key deer remained at destination islands following release from holding pens. Other translocation studies of white-tailed deer have reported that released animals remained in close proximity to release sites (Hawkins and Montgomery 1969, Jones and Witham 1990). We largely attribute the success of Key deer releases to habitat suitability of destination islands and use of soft releases versus hard releases. Jones and Witham (1990) argued that suitable habitat at release sites improved success of translocations. In our study, translocated Key deer had access to large tracts (>322 ha, Sugarloaf, >197 ha Cudjoe) of preferred habitat (i.e., hammock, pineland, freshwater marsh; Lopez et al. 2004*b*). The combination of plentiful habitat and low deer density may have resulted in little incentive for deer to disperse far from the release sites or off the islands (Hawkins and Montgomery 1969). Deer–vehicle collisions account for most (>50%) Key deer mortality (Lopez et al. 2003). In comparing release sites to source islands, we found Cudjoe and Sugarloaf have lower road densities (Cudjoe = 0.04 km/ha, Sugarloaf = 0.03 km/ha) than did Big Pine Key (0.05 km/ha) but not No Name Key (0.02 km/ha). However, because approximately 65% of the total deer population inhabits Big Pine Key the differential road densities suggest the risk of DVCs is lower for translocated deer. Collectively, increased habitat suitability (i.e., large and intact uplands, lower roadway densities) is likely responsible for observed site fidelity and high survival.

We found soft release also is likely an important factor in establishing permanent ranges on destination islands for translocated Key deer. Previous translocation attempts involving hard releases were conducted in 2000 (R. R. Lopez, unpublished data). Three adult female deer were trapped from No Name Key and moved (approx. 1 km away) to Little Pine Key (Lopez 2001). Within 1 month, 2 of 3 females (67%) swam back to the source island. The remaining adult female had a fawn and established a permanent range on the destination island. Bright and Morris (1994) reported significantly lower dispersal in dormice translocations when they relied on soft releases as opposed to hard releases. Few studies have addressed effects of soft release confinement time on translocation success or dispersal distance (Franzeb 2004). Our data indicate an inverse relationship between pen time and dispersal distance (Fig. 3). Inference from this data supports the conclusion that hard release translocation would result in greater dispersal distance and lower chance of translocation success. Minimally, our results indicate that soft releases are an important factor in Key deer translocations, and $\geq$30 days holding time is recommended for soft release to be effective.

We observed reproduction in translocated Key deer. In selecting females to translocate, we targeted pregnant or likely bred animals to maximize reproductive potential and increase site fidelity. Previous studies have reported that females close to parturition constrict ranges, increase site fidelity, and decrease daily movements (Bartush and Lewis 1979, Bertrand et al. 1996). Upon parturition, females generally continue these behaviors because increased movements would likely prove deleterious to fawn survival. Furthermore, previous studies have reported females may shift normal ranges to birth sites every year (Bartush and Lewis 1979, Bertrand et al. 1996). Collectively, these factors suggest that pregnant females are good candidates for translocation.

MANAGEMENT IMPLICATIONS

Our results suggest that translocations are a viable alternative for bolstering Key deer herds on outer islands where few resident deer are found. Assuming suitable habitat is available (Lopez et al. 2004*b*), we recommend soft releases versus hard releases in future Key deer translocations. Though hard releases are more time-efficient (Bryant and Ishmael 1991, Beringer et al. 2002), our results suggest soft releases increase site fidelity to release sites, which ultimately will determine the success of translocation programs. For

Key deer, we recommend ≥30 days in holding pens prior to release. It is also imperative that recovery biologists continue to monitor translocated herds to ensure successful establishment of viable subpopulations, which will require a holistic posttranslocation monitoring protocol that collects trend data similar to that recorded for deer in the core habitat (i.e., monthly surveys [density and demographics] and mortality data). Such data will allow long-term population analyses needed by the USFWS to effectively monitor and manage translocated herds.

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