EFFECTS OF TRANSLOCATION AND DEER-VEHICLE COLLISION MITIGATION ON FLORIDA KEY DEER

A Thesis

by

ISRAEL DAVID PARKER

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

August 2006

Major Subject: Wildlife and Fisheries Sciences

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Approved by:

Chair of Committee,	Roel R. Lopez
Committee Members,	Nova J. Silvy
	Donald S. Davis
Interim Head of Department,	Delbert M. Gatlin, III

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ABSTRACT

Effects of Translocation and Deer-Vehicle Collision Mitigation on Florida Key Deer.

(August 2006)

Israel David Parker, B.S., New Mexico State University

Chair of Advisory Committee: Dr. Roel R. Lopez

Urban development and habitat fragmentation threaten recovery and management of the endangered Florida Key deer (*Odocoileus virginianus clavium*). Urban development has reduced deer dispersal from their core habitat resulting in deer "overabundance" and has increased deer-human interactions (mostly deer-vehicle collisions [DVCs]). Conversely, deer populations on outer islands have declined in recent years due to limited deer dispersal from source populations. In order to expand the Key deer's range and reduce DVCs within their core habitat, wildlife managers determined translocations and DVC mitigation were needed. Thus, the objectives of my thesis were to determine (1) effects of translocation on the establishment of outer-island local populations, and (2) effects of United States 1 Highway (US 1) improvements (i.e., exclusion fencing, underpasses, deer guards, and extra lane creation) on DVCs and deer movements.

I evaluated the efficacy of translocations by comparing annual survival and seasonal ranges between resident and translocated deer and by analyzing reproduction of translocated deer. Translocated females (yearlings and adults) had lower annual survival than resident deer. Conversely, males (yearlings and adults) demonstrated higher annual survival than resident males. Due to low sample sizes and large variation, these numbers are potentially less important than the high overall survival (only 4 of 38 died). Seasonal ranges were generally smaller for resident deer than translocated deer. I attribute differences in ranges to differences in habitat quality between the core habitat and destination islands and to use of soft releases. Presence of fawns and yearlings indicated successful reproduction of translocated deer. Overall, the project was successful in establishing populations on the destination islands.

The US 1 Highway improvements reduced DVCs along the fenced section of US 1 (2003, $n = 2$; 2004, $n = 1$; 2005, $n = 0$); however, overall DVCs increased on Big Pine Key (1996–2000, $\bar{x} = 79$; 2003, $n = 91$; 2004, $n = 84$; 2005, $n = 100$). Data suggest DVCs shifted to the unfenced segment of US 1. However, monthly deer surveys also suggested an increase in deer numbers that may explain overall DVC increases observed in my study.

DEDICATION

For my mother and family

ACKNOWLEDGEMENTS

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CHAPTER I

INTRODUCTION

BACKGROUND

The endangered Florida Key deer (*Odocoileus virginianus clavium*) is the smallest sub-species of white-tailed deer in North America and is endemic to the Lower Florida Keys (Hardin et al. 1984). Key deer, on average, stand 65–69 cm at the shoulder and weigh 28–36 kg for females and males, respectively (United States Fish and Wildlife Service [USFWS] 1999). They are characterized by shorter legs, stockier build, and wider, shorter skulls than other white-tailed deer (Hunt 1977). Their historic range, thought to have extended from Key Vaca to Key West, dwindled to a 30-km stretch from West Summerland in the north to Sugarloaf Key to the southwest (Folk 1991, USFWS 1999).

Key deer population numbers are thought to have always been low but only in the early and mid-parts of the twentieth century was a threat to survival recognized (USFWS 1999). Intense and uncontrolled hunting caused a decline in population numbers to 25–80 animals by the 1940's (Dickson 1955, Folk 1991). The deer population began to recover as illegal hunting was curtailed and its habitat protected with the establishment of the National Key Deer Refuge in 1957 (Lopez et al. 2004*a*). Currently, the Key deer population is estimated at 600–700 deer which occupy 20–25 islands (Lopez et al. 2003*b*, Fig. 1.1). Though the current population estimates are similar to mean historic numbers, approximately 75% of the population is located on

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The format and style of this thesis follow The Journal of Wildlife Management.

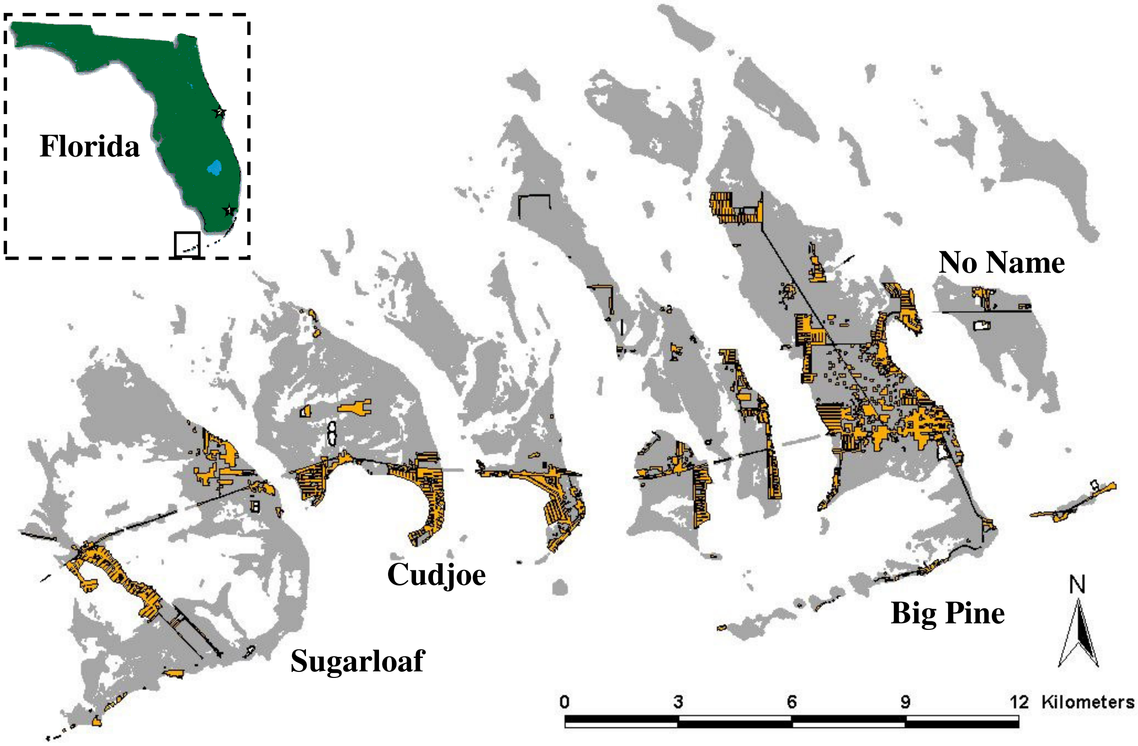


Figure 1.1. Range of the Florida Key deer in the Lower Florida Keys, 2005. Outlined areas indicate development.

only 2 adjacent islands: Big Pine (BPK; 2,522 ha) and No Name (NNK; 459 ha) keys (Seal and Lacy 1990, Lopez et al. 2003*b*). These 2 islands form the core of the population due their relatively large size, year-round abundant freshwater, and substantial preferred habitat (pineland and hammock; Folk 1991). Dispersal from this core population to smaller satellite populations is believed to be limited due to urban development and habitat fragmentation (Harveson et al. 2004). An observed increase in abomasal parasite counts is an indication the deer population has reached or is near carrying capacity in the core area (Nettles et al. 2002). However, some studies indicate other islands such as Sugarloaf (1,399 ha) and Cudjoe (1,319 ha) keys have experienced a population decline below hypothesized carrying capacity (both islands ≤6 deer, Harveson et al. 2006). The decline of these deer populations can be attributed to a combination of factors including skewed sex ratios, limited dispersal due to habitat fragmentation, and decreased habitat quality (e.g., lack of prescribed fire, maintenance of water holes).

CONSERVATION INITIATIVES

While the deer population numbers have rebounded from lows reached in the first half of the twentieth century, threats to recovery still exist. The historically low human population in the Keys soared beginning in the 1950s and increased nearly 10-fold between 1968 and 1998 (Monroe County Growth Management 1992, Peterson et al. 2002). This human population growth and the environmental disturbances associated with it (i.e., urban development, habitat fragmentation, and human-wildlife interactions) have caused concerns for various Florida Keys' species including the Key deer (Folk 1991, Folk and Klimstra 1991*b*, Lopez et al. 2003*c*). Habitat fragmentation has diminished or prevented dispersal from the core population, thereby unnaturally sequestering the population. Escalating human presence also has increased vehicle-related collisions (Hardin 1974, Folk 1991, Lopez et al. 2003*b*, Fig. 1.2). United States Highway 1 (US 1) is the only roadway connecting the Florida Keys to the mainland and is the major vehicular thoroughfare through the Key deer core habitat. Annually, deer-vehicle collisions (DVCs) account for the vast majority of Key deer mortalities (82–100 DVCs per year in 2003–2005) and nearly half of all DVCs (36–44 DVCs per year in 2003–2005) occur on the 5.6-km section of US 1 on BPK. A few of the strategies designed to protect both deer and people from these and other adverse impacts include translocating animals from the core population to outlying local populations, and fencing the western-most section of US 1 on BPK and creating underpasses to prevent deer intrusion onto the highway (US 1 Project, Braden 2005) . Evaluation of the efficacy of these strategies requires comprehensive analysis of translocation success on outer islands and deer movements and mortality on BPK.

RESEARCH OBJECTIVES

The objectives of my thesis are to (1) determine the utility and effectiveness of Key deer translocations in creating a more viable population, and (2) determine the effects of the US 1 Project on DVCs. My thesis is divided into 3 primary chapters, with each chapter designed as an individual publication so some repetition between chapters may occur. The chapters are as follows:

1. Efficacy of Key deer translocations (Chapter II).

Figure 1.2. Vehicle-caused mortality of Key deer fawn on Big Pine Key, Florida, 2004.

2. Monitoring of the US 1 Project (Chapter III).
3. Conclusion and management implications (Chapter IV).

As a point of departure, an overview of the study area will be presented, including vegetation types commonly found in the Lower Florida Keys.

STUDY AREA

Geology and Soils

The Florida Keys are a chain of islands stretching southwest from the southern coast of Florida. As sea level rose with the retreat of the Wisconsin Glacier 4,000 years ago, the solid landmass at the extreme southern tip of Florida fragmented into a 200-km chain of small islands effectively isolating the resident white-tailed deer (Maffei et al. 1988, Folk and Klimstra 1991*a*). Key deer have since adapted to this isolated, island environment.

The Florida Keys together form a low-lying archipelago, with the majority of the land rising only 1–2 m above mean sea level (Hoffmeister 1974). The soil of the Keys is entirely limestone and can be divided into 2 types: Key Largo limestone in the Upper Keys and Miami limestone making up the Lower Keys (Hardin et al. 1984, Folk 1991). The Upper Keys extend from Key Largo in the north to West Summerland in the south and the Lower Keys range from BPK to Key West. The Lower Keys likely began as an oolitic mound that slowly grew in size as ooids (calcareous sand spheres) were added and covered the existing corals. This limestone is often covered by soil ranging from blue-grey marl to black peat (Dickson 1955).

Vegetation

Vegetation of West Indian origin dominates the Lower Keys and habitat quality varies between islands (Dickson 1955). Vegetation type changes according to elevation with red (*Rhizophora mangle*), black (*Avicennia germinans*), and white (*Laguncularia racemosa*) mangrove forests occurring near sea level. This gives way to transitional buttonwood (*Conocarpus erectus*) areas as elevation increases. At the highest elevations the buttonwood areas transition into hammock (e.g., Jamaican dogwood [*Piscidia piscipula*] and poisonwood [*Metopium toxiferum*]) and pineland (e.g., slash pine [*Pinus elliottii*] and pineland croton [*Croton linearis*]) upland forests intolerant of salt-water. Freshwater marshes (e.g., saw grass [*Cladium jamaicense*] and golden leather fern [*Acrostichum aureum*]) inhabit lowland areas surrounded by upland forests or lie between upland areas and transition zones. All study islands support wide-ranging pine rocklands (preferred deer habitat) and have the most extensive year-round freshwater in the Keys (USFWS 1999).

Water

The Lower Florida Keys has a unique freshwater system. The location and availability of water greatly influences the distribution and movement of Key deer (USFWS 1999). Water is widely available during the wet season (May to October) but becomes scarce during the dry season (Folk 1991). While an oversimplification, for the sake of brevity, it can be stated that during the wet season the rain recharges an underground water lens that sits on top of denser salt water (Meadows et al. 2004). This lens is available to wildlife through openings in the porous limestone and scattered waterholes. This lens shrinks during the dry season however, drying up in some areas and becoming saline in others. While some evidence implies that deer can consume brackish water up to 15 ppt salt (Jacobson 1974), the waterholes in many places far exceed this and deer may not be able to survive for long periods without freshwater (<5 ppt; USFWS 1999).

CHAPTER II

EVALUATION OF THE EFFICACY OF KEY DEER TRANSLOCATIONS

SYNOPSIS

The endangered Florida Key deer (*Odocoileus virginianus clavium*) are endemic to the Lower Florida Keys. In recent years, habitat fragmentation and restricted dispersal have resulted in small, isolated local populations on some islands. Translocations of Key deer can potentially increase population numbers that have declined or remain low, and aid in the species recovery; however, the efficacy of Key deer translocations has yet to be evaluated. The objective of my study was to evaluate survival, ranges, reproduction, and dispersal of translocated deer. Between 2003–2005, I translocated 39 adult/yearling deer to Sugarloaf (≈19 km from trap site; 10 M, 14 F) and Cudjoe (≈15 km from trap site; 6 M, 9 F) keys. Deer were kept 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"). Overall, I observed high Key deer survival ($n = 4$ mortalities, $S = 0.89$) for translocated deer. Translocated females had lower ($P < 0.05$) annual survival than resident deer; whereas, translocated male annual survival was higher ($P < 0.05$) than for resident males. I found translocated deer had larger ($P = 0.05$) seasonal 95% ranges than resident deer. In evaluating the effects of acclimation period on ranges and dispersal, I found no difference in 95% ranges ($P = 0.063$) or 50% core areas ($P = 0.052$) ≤4 month post-release versus 4–8 month post-release. However, first-week post-release dispersal distances were significantly ($P < 0.01$) dependent on time kept in pen. Only 2 translocated deer (5%, 2/39) left the destination islands by the end

of the study. I credit the use of soft releases for the success in establishing deer on Sugarloaf and Cudjoe keys.

INTRODUCTION

The endangered Florida Key deer 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 (United States Fish and Wildlife Service [USFWS] 1999). In recent years, urban development has resulted in a decrease in distribution of Key deer (≈65% decline) to the current distribution from West Summerland to Sugarloaf keys (Fig. 2.1). It has been hypothesized that large subdivisions (e.g., Ramrod and Summerland keys) may serve as effective barriers to deer dispersal (Harveson et al. 2004, Fig 2.1). Currently, the Key deer population is estimated at 600–700 deer on approximately 20–25 islands (Lopez et al. 2003*b*); however, approximately 75% of the total population is located only on 2 islands – Big Pine (2,522 ha) and No Name (459 ha) keys. Big Pine and No Name keys are experiencing locally abundant deer numbers (Nettles et al. 2002, Lopez et al. 2004*a*, Roberts 2005). The unique management challenges with the Key deer population increasing or at carrying-capacity on some islands versus decreasing deer numbers on other islands will require a 2-prong approach to the Key deer's recovery. First, islands with high deer density will require the reduction of population numbers to maintain the integrity of vegetative communities that support local Key deer populations (Barrett 2004). Reduction of Key deer density in these areas would reduce the affects of "semi-domestication" (Peterson et al. 2005), disease transmission (Nettles et al. 2002,

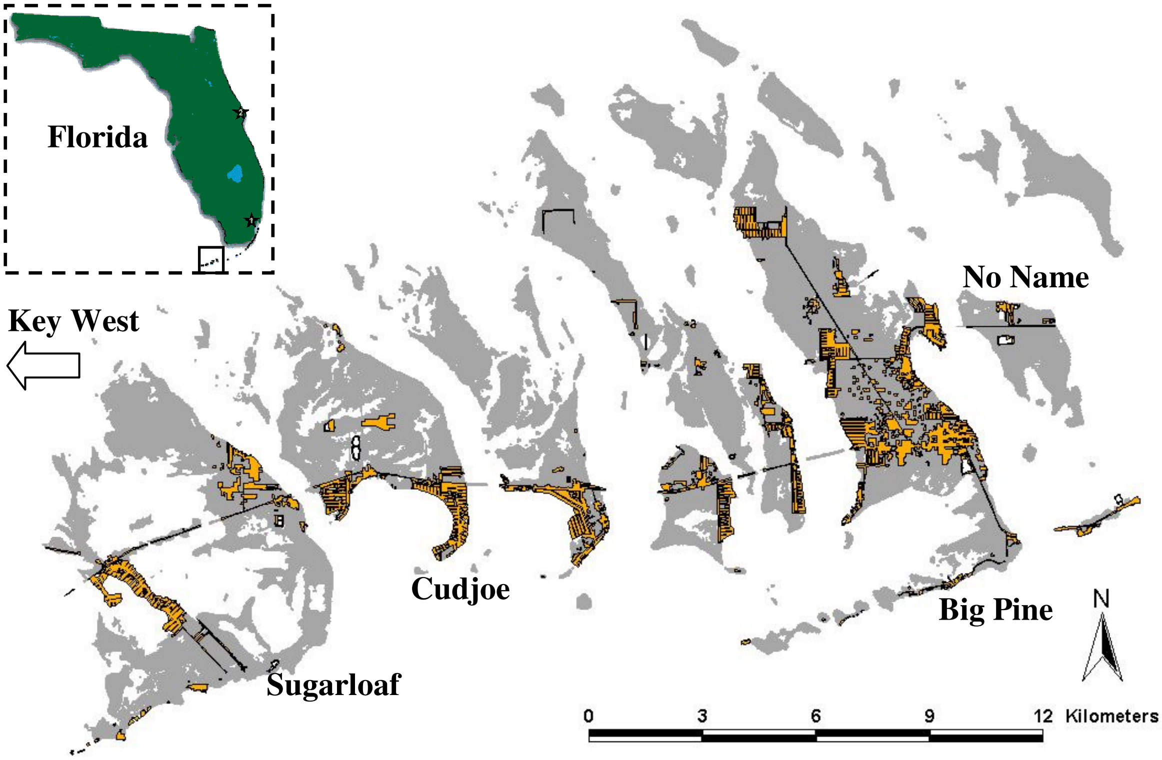


Figure 2.1. Current Key deer range in the Lower Florida Keys, 2005. Outlined sections represent areas of dense urban development, which can serve as barriers to deer dispersal.

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. Such strategies may include land acquisition, habitat improvement, and translocations (Lopez et al. 2003*b*, 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/or reproductive potential for translocated individuals (Beringer et al. 2002). In the case of the Key deer, translocations would allow managers to establish viable and sustainable Key deer populations 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 (USFWS 1999). In the early 1980's and 1990's, "hard release" translocations of Key deer were attempted on Sugarloaf and Little Pine keys, respectively, with little success (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). Previous 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 of the purported benefits of soft releases include increased site fidelity and animal survival (Nielson 1988); however, the importance and effectiveness of soft releases in the translocation of Key deer have not been evaluated.

My study objective was to evaluate the effectiveness and utility of Key deer translocations, particularly soft release translocations, to demographics of resident deer. Specifically, I compared (1) annual survival between resident and translocated deer, (2) seasonal 95% kernel ranges and 50% core areas between resident and translocated deer, and (3) 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. 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 and 15 km, respectively, from the core population. 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 (≈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*). Cudjoe and Sugarloaf keys were selected as translocation sites because they both have an abundance of preferred habitat (i.e., pineland and hammock [Cudjoe Key = 198 ha, Sugarloaf Key = 294 ha; Lopez et al. 2004*b*]), contain substantial freshwater, and sustained historic deer herds. Additionally, ≤6 deer occupied either Cudjoe or Sugarloaf keys immediately prior to the translocation project (Harveson et al. 2006). The destination islands also have considerably less development than the core habitat (Big Pine Key = 577 ha, No Name Key = 23 ha, Cudjoe = 206 ha, Sugarloaf = 91 ha).

METHODS

Translocations

Key deer were captured using either portable drive nets (Silvy et al. 1975), drop nets (Lopez et al. 1998), or hand capture (Silvy 1975). Key deer were restrained with rope (legs bound) and a hood was placed over each deer's head prior to transportation. Average handling time was 20–35 minutes (no drugs used). For each translocated deer, I recorded sex, age, body condition, capture location, and weight (Lopez et al. 2003*b*). Each deer was fitted with a battery-powered mortality-sensitive transmitter (radio-collar [115 g] or antler transmitter [15 g]; 150–152 MHz, Advanced Telemetry Systems, Inc., Isanti, Minnesota; Lopez et al. 2003*b*). Transmitters for males were attached with either polyvinyl breakaway collars with integrated elastic (allowed for seasonal neck expansion) or leather antler assemblies (Lopez 2001). Females received non-expandable polyvinyl collars with attached transmitters. Finally, each animal received an ear tattoo as a permanent marker (Silvy 1975).

Once at the destination island, Key deer were soft released into a holding pen and supplementally fed (e.g., whole corn, cracked corn, sweet feed). Placement of 757 l rain-catchment guzzlers (1 on each destination island; Wildlife Water Guzzlers, Buffalo Trail Canyon, Texas) and excavation of waterholes provided 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 the deer to their new environment. Translocation project guidelines mandated translocated deer be held 3–6 months in release-site pens prior to release. Upon completion of holding time in pens, gates were opened and supplemental feeding ceased.

Radiotelemetry

Post-release translocated Key deer were monitored 3–4 times/week via homing (White and Garrott 1990, Lopez et al. 2003*b*). Deer locations were recorded on geo-referenced maps then inputted into a Geographical Information System (GIS) using ArcView (Version 3.3, Lopez et al. 2003*b*). Mortality signals were immediately investigated and cause of death determined by necropsy if possible (Nettles 1981). Deer that died of unknown causes were sent to the Southeastern Cooperative Wildlife Disease Study for further analysis. During the fawning (1 April–31 June) and post-fawning (1 July–30 September) season, female deer were visually located via walk-ins (i.e., tracking with telemetry equipment until sighted) and infrared-triggered remote digital cameras (Non Typical, Inc., Park Falls, Wisconsin) to gather information on reproductive status (i.e., visibly pregnant, full udder; Cutler and Swann 1999, Claridge et al. 2004). Remote cameras were moved to various locations on the destination islands to aid in collecting visual observations of adult female deer with fawns.

Data Analysis

I determined annual survival (*S*) estimates as a proportion of translocated deer and compared these to resident deer survival estimates reported in the literature (Lopez et al. 2003*b*). Seasonal (≈32 locations/3 months) ranges (95%) and core areas (50%) were calculated using a fixed-kernel home range estimator (Worton 1989, Seaman et al. 1998, 1999) using methods identical to Lopez et al. (2005). Seasons for analysis were defined as winter (post-breeding, January–March), spring (fawning, April–June), summer (post-fawning, July–September), and fall (breeding, October–December; Lopez 2001). In comparing seasonal ranges for translocated deer, I calculated a seasonal range estimate for the season in which a deer was released. In other words, breeding range estimates for deer released during the breeding season were compared to resident breeding range estimates. This allowed me to minimize seasonal effects and instead evaluate translocation effects. I compared calculated range estimates to those published in the literature (Lopez et al. 2005). Finally, I evaluated post-release acclimation period by comparing the first 4-month post-release 95% range and 50% core area to the subsequent 4-month range and core area estimates using a Mann-Whitney U test (Dytham 2003). I compared holding time to maximum post-release dispersal distances to determine the effect of holding time on site fidelity. I defined dispersal distance as the maximum distance traveled in the first 10 days post-release.

RESULTS

From 2003–2005, I translocated 23 females (yearling, n = 8; adult, n = 15) and 16 males (yearling, n = 2; adult, n = 14) from Big Pine and No Name keys to holding pens on Sugarloaf and Cudjoe keys. Key deer were translocated in the fall, winter, and spring when does were pregnant or likely bred. In 2003, I translocated 5 deer to Sugarloaf (2 adults [1 M, 1 F], 3 yearlings [1 M, 2 F]). In 2004, I moved an additional 12 deer to Sugarloaf (11 adults [4 M, 7 F], 1 yearling [1 M]) and began Cudjoe translocations with 8 initial deer (7 adults [3 M, 4 F], 1 yearling [1 F]). In 2005, I translocated 7 deer to Sugarloaf (4 adults [3 M, 1 F], 3 yearlings [3 F]) and 7 deer to Cudjoe (5 adults [3 M, 2 F], 2 yearlings [2 F]), which completed our translocation efforts for both islands. Only 2 deer (Sugarloaf = 1 M, Cudjoe = 1 M) of the total of 39 deer translocated during the study left the destination islands. For range and core area analysis, I observed high deer censorship for males due to collar loss (i.e., breakaway collars, 14 M); thus, range and core area analysis were not performed for males. In my survival analysis, I censored 1 adult male due to capture myopathy.

Survival

Overall, translocated deer demonstrated high survival, with only 11% observed mortality (4/38 deer; 2 deer-vehicle collisions [DVCs], 2 unknowns). One adult male was omitted from the study due to capture myopathy less than 7 days after initial translocation. Translocated adult ($n = 15$) and yearling ($n = 8$) females exhibited lower ($P < 0.05$) annual survival than resident females (Table 2.1). Conversely, adult ($n = 13$) and yearling male ($n = 2$) annual survival was higher ($P < 0.05$) than resident deer (Table 2.1).

Deer Movements

As expected, mean (± SE) seasonal 95% ranges for observed deer ($n = 18$, females) were highest during the fall/breeding season (139 ± 127 ha) compared to other seasons (winter/post-breeding, 120 ± 55 ha, spring/fawning, 86 ± 60 ha). Translocated females had significantly ($P < 0.05$) larger seasonal 95% ranges (113 ± 22 ha) and 50% core areas (15 ± 4 ha) than resident female deer (Table 2.2, Fig. 2.2). I found no significant decrease in 95% ranges ($P = 0.063$) or 50% core areas ($P = 0.052$) from the first 4 months post-release (≈50 locations) to the second 4-month period though 95% ranges and 50% core areas were smaller in the second 4-month period for 7 out of 10 deer (70%).

Table 2.1. Estimated annual survival of translocated deer ($n = 38$) compared to annual survival of resident deer ($n = 233$), Lower Florida Keys, 1968–1972, 1998–2000, and 2003–2005.

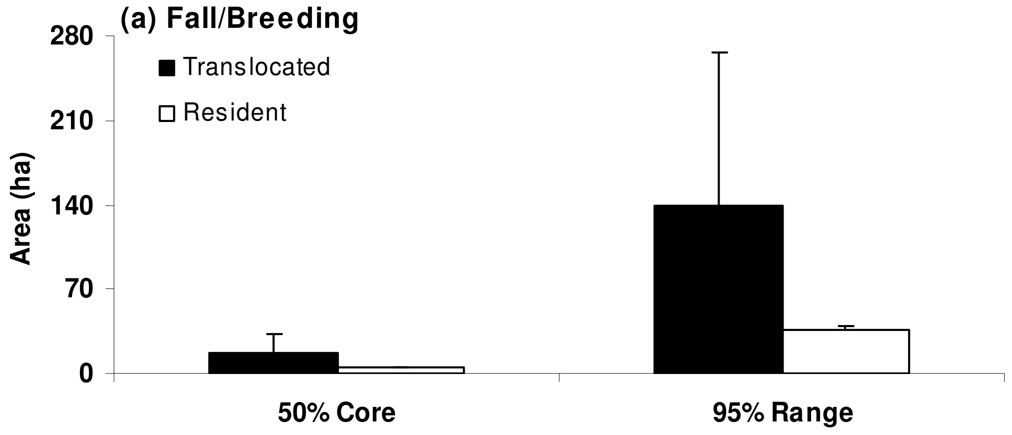
		Translocated		Resident[a]			
Sex	Age	*n*	*S*	*n*	*S*	95% LCI	95% UCI
Female	Yearling	8	0.695	30	0.848	0.770	0.902
Female	Adult	15	0.574	96	0.848	0.770	0.901
Male	Yearling	2	1.000	38	0.583	0.457	0.690
Male	Adult	13	0.709	69	0.583	0.458	0.690

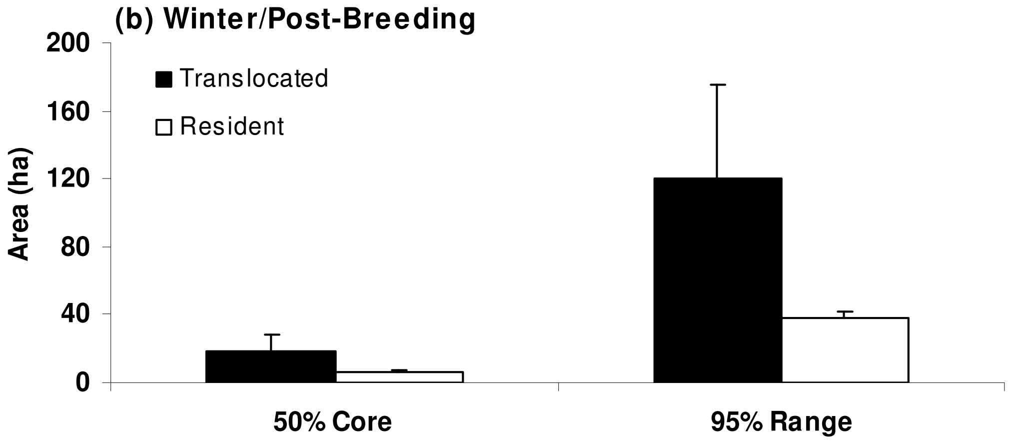
[a] Source of resident survival estimates, Lopez et al. (2003*a*)

Table 2.2. 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*	*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


(a) Fall/Breeding


(b) Winter/Post-Breeding

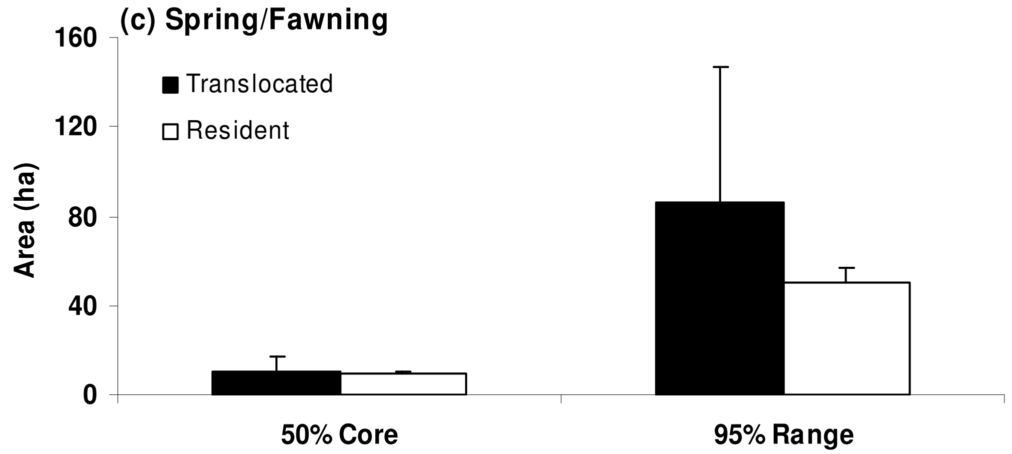

(c) Spring/Fawning

Figure 2.2. Seasonal ranges and core areas (mean, 1 SE) of translocated and resident Florida Key deer, Big Pine, No Name, Sugarloaf and Cudjoe keys, Florida, 1998–2000, 2003–2005.

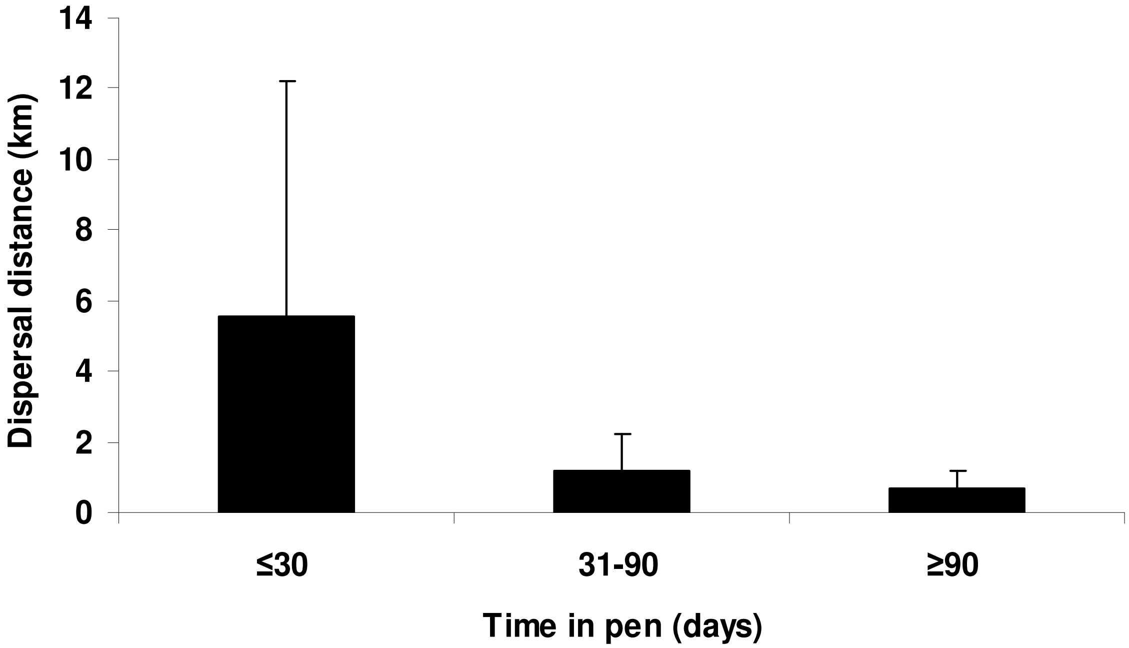


Figure 2.3. Average maximum dispersal distance of translocated Key deer for the first 10 days post-release, Sugarloaf and Cudjoe keys, Florida, 2003–2005.

Nine deer were censored from dispersal analysis due to insufficient data. A total of 30 deer (22 adults [8 M, 14 F], 8 yearlings [8 F]) was analyzed to determine the effects of time in pen on dispersal distance. 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. 2.3).

Reproduction

From visual observations/walk-ins (*n* = 106) and camera data (*n* = 731 pictures, 251 video clips [22–30 seconds each]), I observed 3 marked does with fawns from 1 July to 30 September 2005 (23%, 3/13 translocated does). In addition, 5 translocated does showed obvious signs of lactation (38%, 5/13). Eleven different, unaccompanied weaned fawns were identified as well as 1 unmarked yearling. Nearly 62% of observed does (*n* = 8) had confirmed fawns or obvious signs of lactation.

DISCUSSION

Survival

Overall, I found annual survival for translocated deer was high with only 11% observed mortality (4/38 deer). I found that overall survival for translocated Key deer was higher than other translocation studies that involved longer holding times, animal sedation, and/or use of hard releases (Jones and Witham 1990, Bryant and Ishmael 1991, Jones et al. 1997). My results suggest that observed increased survival is likely attributable to use of soft releases. Annual survival for translocated females was slightly lower compared to resident deer; however, translocated male annual survival was actually higher than resident deer. I hypothesize the observed differential survival in translocated deer may be due to behavioral differences between sexes. For example, females generally have smaller ranges (Nelson and Mech 1992, DeNicola et al. 2000, Lopez et al. 2005) and do not readily disperse (Mattfeld et al. 1977, Lopez et al. 2005) compared to males. Thus, the translocation of females into new areas may make them more susceptible to mortality factors such as DVCs due to unfamiliarity with their new environment. Conversely, male white-tailed deer typically have larger ranges and readily disperse into "new" areas (Mattfeld et al. 1977, Nelson and Mech 1992). Thus, males may fare better in new environments compared to females.

Deer Movements

Seasonal ranges for translocated deer were highest during the fall/breeding season. This was expected as ranges typically increase as breeding activity begins (Kammermeyer and Marchinton 1976, Mattfeld et al. 1977). I 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 likely inflated observed range sizes (Beringer et al. 2002). Though not statistically significant, I did observe a decrease in range size over time, suggesting some level of acclimation may have occurred. Another factor that may have contributed to increased ranges observed was deer density on the destination islands. Previous studies (Lopez et al. 2005) have reported deer ranges decrease with increasing population densities.

Overall, I observed the majority (93%) of 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 (e.g., Hawkins and Montgomery 1969, Jones and Witham 1990). I attribute the success of Key deer releases to habitat suitablity of destintation islands and use of soft releases versus hard releases. Jones and Witham (1990) argued that suitable habitat at release sites improved the the success of translocations. In my study translocated Key deer had access to relatively large tracts (>322 ha, Sugarloaf, >197 ha Cudjoe) of preferred habitat (i.e., hammocks, pineland, freshwater marsh, Lopez et al. 2004*b*). This combined with a low deer population density may have resulted in little incentive for deer to disperse far from the release sites or off the islands (Hawkins and Montgomery 1969). DVCs account for the majority (>50%) of Key deer mortality (Lopez et al. 2003*b*). In comparing release sites to source islands, Cudjoe and Sugarloaf have lower road densities (Cudjoe = 0.04 km/ha, Sugarloaf = 0.03 km/ha) than Big Pine and No Name keys (Big Pine Key = 0.05 km/ha, No Name Key = 0.02 km/ha), suggesting the risk of DVCs is lower. Collectively, increased habitat suitability (i.e., large, intact uplands, lower roadway densities) is likely responsible for observed site fidelity and high survival.

Use of soft releases 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 (USFWS, unpublished data). Three adult female deer were trapped from No Name Key and moved to Little Pine Key (approximately 1 km away). 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 the effects of soft release confinement time on translocation success or dispersal distance (Franzeb 2004). However, I found a relationship between holding time and mean dispersal distances. My results indicate that soft releases are an important factor in Key deer translocations, and a minimum of 30 days holding is recommended for the effects of the soft release to be effective.

Reproduction

I observed reproduction in translocated Key deer. In selecting females to translocate, I targeted pregnant or likely bred animals to maximize reproductive potential and increase site fidelity. Previous studies (Bartush and Lewis 1979, Bertrand et al. 1996) have reported that females close to parturition constrict ranges, increase site fidelity, and decrease daily movements. Upon parturition, females generally continue these behaviors as 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

My results suggest that translocations are a viable alternative for bolstering Key deer populations on outer islands where few resident deer are found. Assuming suitable habitat is available (Lopez et al. 2004*b*), I recommend the integration of soft releases versus hard releases in future Key deer translocations. Though hard releases are more cost- and time-efficient (Bryant and Ishmael 1991, Beringer et al. 2002), study results suggest soft releases increase site fidelity to release sites which ultimately will determine the success of translocation programs. For Key deer, I recommend a minimum of 30 days in holding pens prior to release.

CHAPTER III

POST-PROJECT EFFECTS OF REDUCING FLORIDA KEY DEER MORTALITY ALONG US 1

SYNOPSIS

Deer-vehicle collisions on a 5.6-km segment of United States Highway 1 (US 1) on Big Pine Key (BPK), Florida, are responsible for approximately 26% of annual mortality of the endangered Florida Key deer (*Odocoileus virginianus clavium*). The Florida Department of Transportation (FDOT) has attempted to address deer-vehicle collisions (DVCs) along this road segment by excluding deer from the highway. In 2002, a 2.6-km system of 2.4-m fencing, 2 underpasses, and 4 experimental deer guards were completed on approximately 46% of US 1 on BPK. Key deer used underpasses all 3 post-project years (2003–2005); however, higher ($P < 0.05$) underpass use was observed in 2004 and 2005 compared to 2003. Fencing reduced deer crossings within the project area with ≤12 deer crossings observed annually (2003, $n = 7$ deer; 2004, $n = 4$; 2005, $n = 12$). With a reduction of deer incursions onto this section of US 1, DVCs naturally decreased in the fenced area by 73–100%; however, US 1 DVCs within the unfenced sections of US 1 increased (40%). In controlling for effects of deer density and traffic volume, study results suggest that highway improvements have decreased the net risk of DVCs along US 1. The US 1 Project successfully reduced DVCs within the fenced section of US 1, and prevented an overall increase of DVCs despite an increase in deer population density on BPK.

INTRODUCTION

Deer-vehicle collisions (DVCs) have increased in the United States, Canada, and Europe in the last several years (Groot Bruinderink and Hazebroek 1996; Romin and Bissonette 1996; Putman 1997; Forman et al. 2003). In the United States, 720,000–1.5 million estimated DVCs occur each year, resulting in approximately 29,000 human injuries and 211 human fatalities (Conover et al. 1995; Forman et al. 2003). In addition to the obvious human dangers associated with DVCs, approximately 92% result in deer mortality (Allen and McCullough 1976), which can have a significant impact on white-tailed deer (*Odocoileus virginianus*) populations including the endangered Florida Key deer (Lopez et al. 2003*b*).

Florida Key deer are the smallest subspecies of white-tailed deer in the United States (Hardin et al. 1984). Key deer occupy 20–25 islands in the Lower Florida Keys, with approximately 65% (453–517 deer in 2000) of the overall population found on BPK (2,548 ha; Lopez et al. 2004*a*). Since the 1960s, DVCs have been the single largest Key deer mortality factor, accounting for >50% of annual losses (Silvy 1975; Lopez et al. 2003*b*). United States Fish and Wildlife Service (USFWS) and FDOT biologists have attempted to address DVCs on United States Highway 1 (US 1), which bisects BPK (Fig. 3.1). In 1994, the Key Deer-Motorist Conflict Study was initiated by FDOT to evaluate alternatives for reducing DVCs along the US 1 corridor (Calvo 1996). Furthermore, in 1995, the level of service (i.e., ability to evacuate residents during a hurricane) was found to be inadequate on BPK and No Name Key (NNK, Lopez et al.

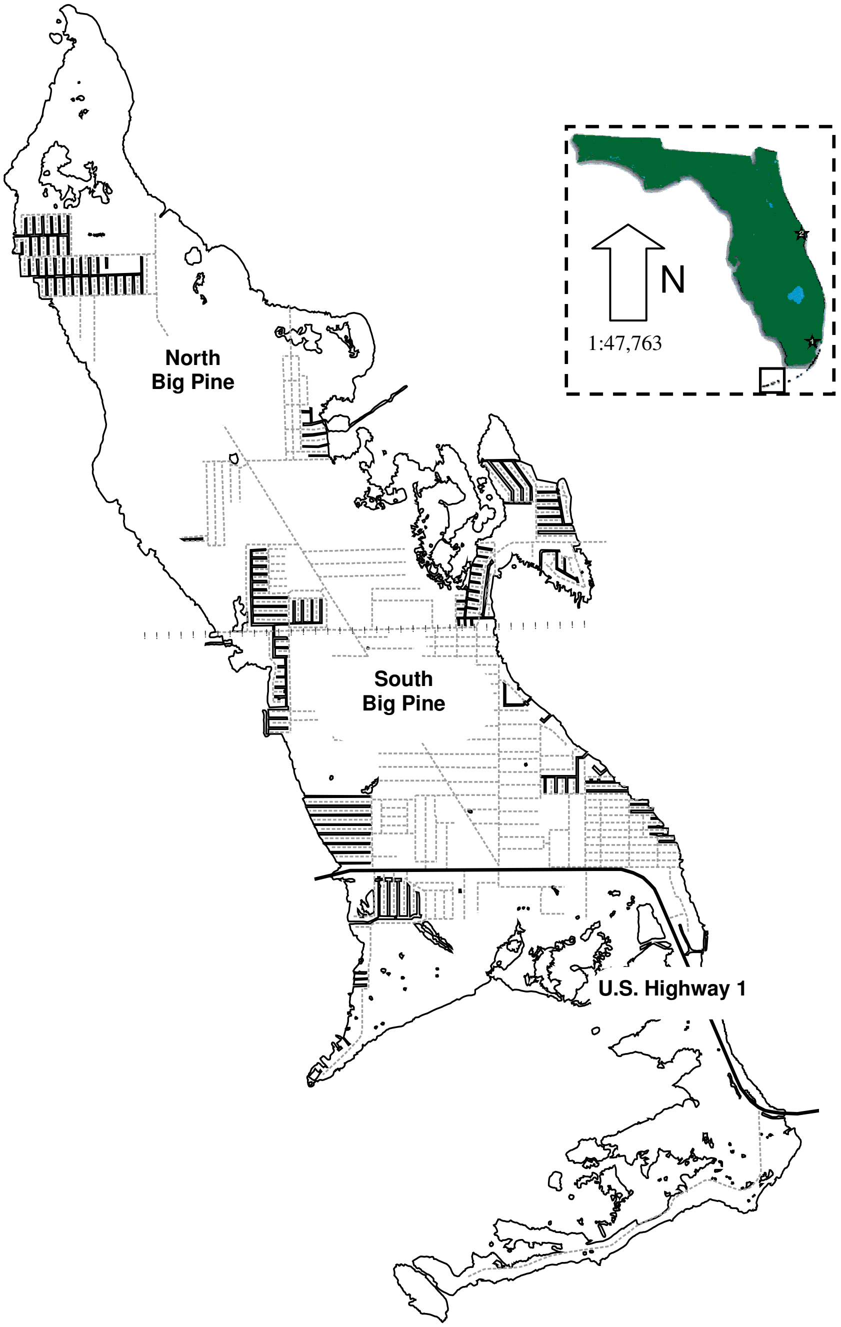


Figure 3.1. Roadways (US 1 [solid line], other roads [dashed gray lines]), and project area on Big Pine Key (north and south, separated by dotted line), Monroe County, Florida, 2004.

2003*d*). In an effort to decrease DVCs and increase US 1 traffic flow, the Key Deer-Motorist Conflict Study recommended (1) a combination of fences, 2 underpasses, and 4 deer guards along the 2.6-km undeveloped section of US 1 on BPK, and (2) an extra northbound lane through part of the 3-km developed segment of US 1 on BPK (hereafter US 1 Project; Calvo 1996, Harveson et al. 2004; Fig. 3.2). A portion of US 1, the developed "business" segment that includes the extra traffic lane, was not fenced due to potential economic losses (i.e., restricted business access in an area with a tourist-based economy, Calvo 1996; Lopez et al. 2003*a*).

In 2002, construction of the 2.6-km fenced segment, 2 underpasses (14 x 8 x 3 m), 4 experimental deer guards (Peterson et al. 2003), and the extra 1.4-km traffic lane were completed. The objective of my study was to evaluate the long-term effectiveness of fencing, underpasses, and experimental deer guards in reducing Key deer mortality by (1) comparing DVCs on US 1 on BPK pre- and post-project, (2) analyzing deer population trends, and (3) comparing long-term use of underpasses and deer crossing within the project area. Previous studies (Braden et al. 2006) monitored deer movements and underpass use 1 year post-project. Here, I evaluate the long-term effectiveness of the roadway project (3 years post-project) in addition to changes in DVCs outside of the project area.

STUDY AREA

The Florida Keys are a chain of islands 200 km in length stretching southwest from the southern coast of Florida. Two adjacent islands, BPK (2,522 ha) and NNK (459 ha), form the core habitat for Florida Key deer (Lopez et al. 2005). My study

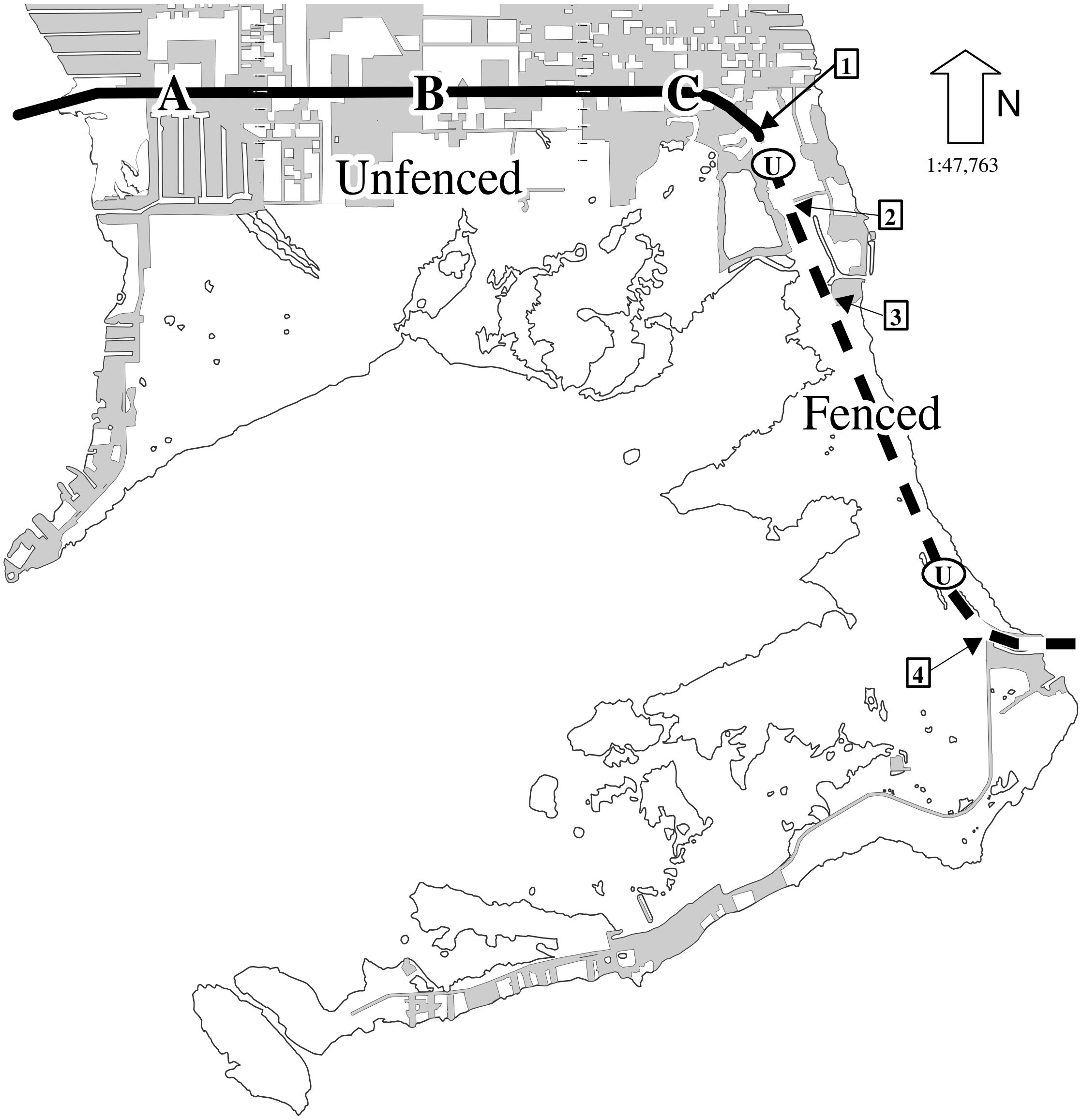


Figure 3.2. Project area for U.S. Highway 1 (US 1, 5.6-km) corridor project on Big Pine]) Key, Florida, 2002. US 1 is divided into unfenced (3.1-km, solid line [A + B + C and fenced (2.6-km, dashed line) segments. The unfenced road section consists of a west (0.8-km [A]), extra lane (1.4-km [B]), and east (0.8-km [C]) segment. The fenced section includes 2 underpasses (denoted by U) and 4 experimental deer guards (indicated by arrows and numbered). Gray areas denote developed areas.

was conducted on the southern half of BPK. US 1 is a 2-lane highway that links the Keys to the mainland with an estimated annual average daily traffic volume of approximately 18,000 vehicles/day (FDOT, Monroe County, 2006). Maximum speed limits are 72 km/hr during the day and 56 km/hr at night. Vegetation near sea level and in tidal areas on BPK is comprised of black mangrove (*Avicennia germinans*), red mangrove (*Rhizophora mangle*), white mangrove (*Laguncularia racemosa*), and buttonwood (*Conocarpus erectus*) forests. With increasing elevation, maritime zones transition into hardwood (e.g., gumbo limbo [*Bursera simaruba*], Jamaican dogwood [*Piscidia piscipula*] and pineland (e.g., slash pine [*Pinus elliottii*], saw palmetto [*Serenoa repens*]) upland forests with vegetation intolerant of salt water (Dickson 1955; Folk 1991; Lopez et al. 2004*b*).

METHODS

Underpass Use

TrailMaster 1500 Active Infrared Trail Monitors (ITC, TrailMaster, Goodson and Associates, Inc., Lenexa, Kansas, USA) consisting of a transmitter, receiver, and 35mm camera (Jacobson et al. 1997) were placed in the center of each underpass (north underpass, south underpass) to monitor deer movements (Braden et al. 2006, Fig. 3.2). Camera stations collected data for 3 years post-project and were set to take pictures throughout the day (0001–2400 hours) with a camera delay of 2 minutes (Jacobson et al. 1997). A camera delay of 2 minutes was sufficient to avoid double-counting (Braden et al. 2006). The number, sex, age, and location of deer were recorded and entered into Microsoft Access (Version 2000).

Deer-Vehicle Collisions

Since 1966, USFWS biologists have recorded Key deer mortality (hereafter USFWS mortality data) on all roads on BPK via direct sightings, citizen and law enforcement reports, and observation of turkey vultures (*Cathartes aura*, Lopez et al. 2003*b*). Age, sex, and body mass were recorded for each dead animal, and all road-related deer mortality locations were entered into a Geographical Information System (GIS) using ArcView (Version 3.2) and Microsoft Access (Version 2000). In addition to Key deer mortality data, I also obtained USFWS annual deer survey data (1996–2005, Lopez et al. 2004*a*).

Deer Incidents

The number, sex, age, and point of entry of all deer entering the fenced roadway (hereafter deer incidents) were recorded based on USFWS biologist sightings or law enforcement reports. Deer unable to egress on their own were removed using exit gates along the fence.

Data Analysis

Underpass Use.-- I compared average monthly underpass use post-project completion (2003–2005) for each underpass using an ANOVA (Ott 1993). Differences were separated using Tukey's HSD procedure where appropriate (Fowler et al. 1998; SPSS, Version 11.5).

Deer-Vehicle Collisions.-- USFWS mortality data were sorted by DVC mortalities by road segments pre- (1996–2000) and post-project (2003–2005) years (Fig. 3.2). Road segments analyzed include US 1 unfenced (west, extra lane, and east) and fenced segments, and all roads on BPK (Fig. 3.2). Mortality data were not analyzed between 2001–2002 due to project construction (Braden et al. 2006). I compared annual US 1 DVCs pre- and post-project by sex, age, and area (road segments). Previous research reported DVCs are a function of population size (Lopez et al. 2005); thus, I accounted for population size by dividing DVCs by USFWS population indices (i.e., average number of deer seen annually along standardized route, Lopez et al. 2004*a*).

RESULTS

Underpass Use

Underpass use by Key deer increased in 2003 ($n = 871$ exposures) and 2004 ($n = 1{,}857$ exposures) but stabilized the third year (2005, $n = 1{,}629$ exposures, Fig. 3.3). Key deer use of the south underpass was greater ($P = 0.008$) than the north underpass use for all 3 years of the study (Fig. 3.3). In comparing underpass camera exposures between years, I found underpass use significantly increased from the first year post-construction to years 2 and 3 post-construction for the north ($P < 0.013$) and south ($P < 0.012$) underpasses. In combining data for both underpasses, underpass use in the initial post-construction study year (2003) was lower ($P < 0.004$) than the subsequent 2 study years (2004–2005). I found the 2004 and 2005 study years to be similar ($P > 0.05$).

Deer-Vehicle Collisions

DVCs decreased (2003, $n = 3$; 2004, $n = 1$; 2005, $n = 0$) within the fenced section of US 1 immediately following construction. These data represent an approximately 73–100% decrease (from range of 11–20 DVCs per year, 1996–2000). In contrast, new “hotspots” sprang up west of the fenced area as DVCs increased

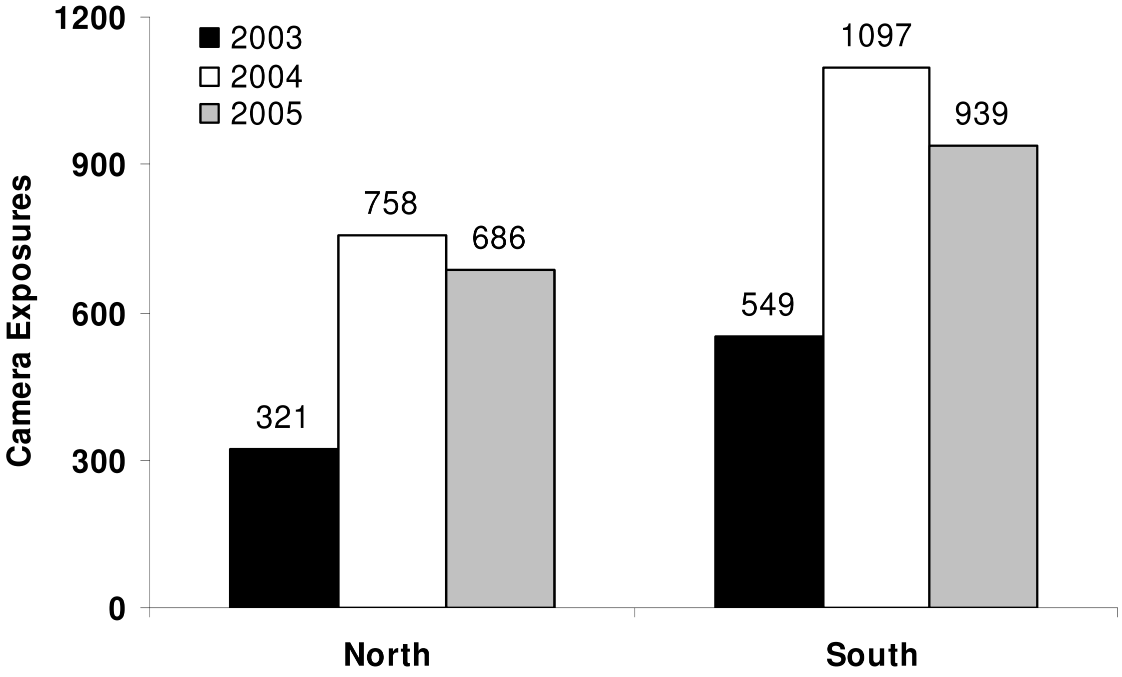


Figure 3.3. Average monthly camera exposures of Key deer underpass use along the US 1 corridor, Big Pine Key, Florida, 2003–2005.

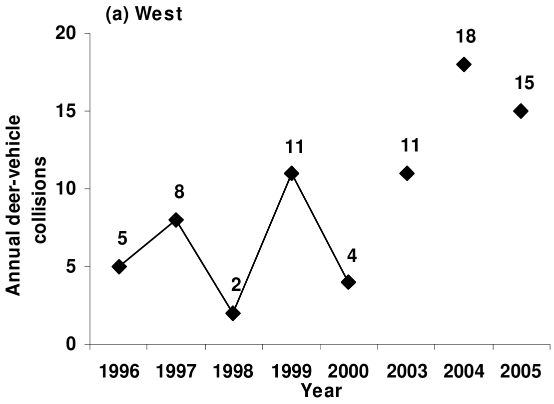
approximately 26–50% (Table 3.1) within the unfenced section of US 1. DVCs generally increased in all unfenced segments of US 1 (Table 3.1, Fig. 3.4). In addition, total DVCs reached a record level of 100 animals in 2005. Overall, there was no difference in the mean (± SD) number of DVCs on US 1 pre-construction ($\bar{x} = 40 \pm 6$, 1996–2000) and post-construction ($\bar{x} = 41 \pm 4$, 2003–2005; Table 3.1, Fig. 3.4). The extra lane segment (pre-construction, $\bar{x} = 10 \pm 3$; post-construction, $\bar{x} = 15 \pm 6$) and east segment (pre-construction, $\bar{x} = 8 \pm 2$; post-construction, $\bar{x} = 10 \pm 4$) showed small increases in DVCs from pre- to post-fence; however, the highest increase in DVCs for the undeveloped section was the west segment (pre-construction, $\bar{x} = 6 \pm 4$; post-construction, $\bar{x} = 15 \pm 4$ [Table 3.1, Fig. 3.4]). Observed increases for the undeveloped section of US 1 were 25% (east), 50% (extra lane), and 150% (west) (Table 3.1, Fig. 3.4).

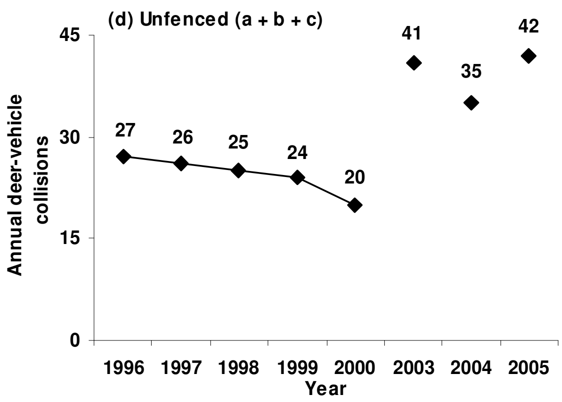
Review of USFWS mortality and road survey data indicates an increase in overall DVCs and the deer population post-construction (2001–2005, Fig. 3.5). The total DVCs on BPK also appears to have increased post-construction, suggesting the observed increase in US 1 DVCs is likely related to increased deer densities (Table 3.1, Fig. 3.5). In reviewing the ratio of US 1 DVC/average deer seen annually, trend data suggests that DVCs on US 1 have declined post-construction (Fig. 3.6) despite increases in population densities on BPK.

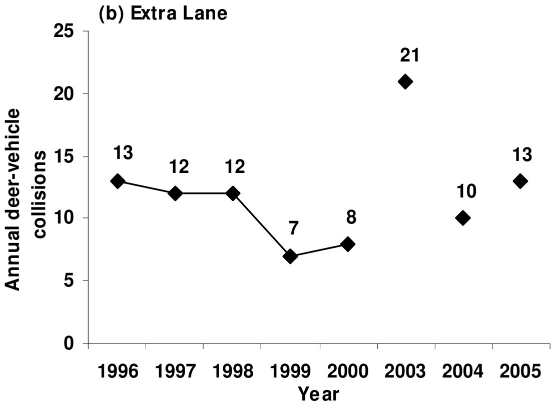
Table 3.1. Annual Key deer-vehicle collisions along US 1 corridor by highway segment[a] on Big Pine Key (BPK), Florida, 1996–2000, 2003–2005.

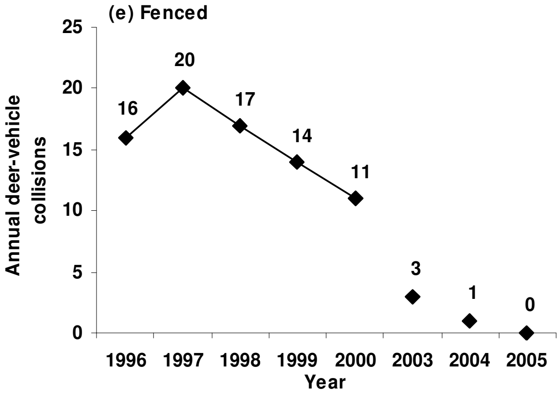
Period Year	West (A)	Extra Lane (B)	East (C)	Fenced	Total US 1	BPK Roads
Pre-project						
1996	5	13	9	16	43	70
1997	8	11	6	20	46	88
1998	2	12	11	17	42	88
1999	11	7	6	14	38	78
2000	4	8	8	11	31	69
Mean	6	10	8	16	40	79
Post-project						
2003	11	21	9	3	44	91
2004	18	10	7	1	36	82
2005	15	13	14	0	42	100
Mean	15	15	10	1	41	91

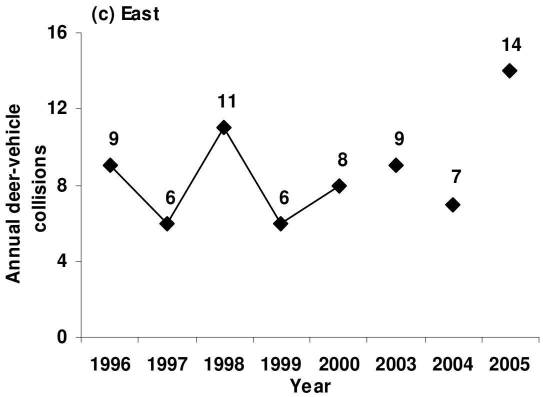
[a] US 1 is divided into unfenced (A + B + C) and fenced segments. The unfenced road section consists of a west (A), extra lane (B), and east (C) segment. For spatial relationships of highway segments, see Fig. 3.2.


(a) West


(d) Unfenced (a + b + c)


(b) Extra Lane


(e) Fenced


(c) East

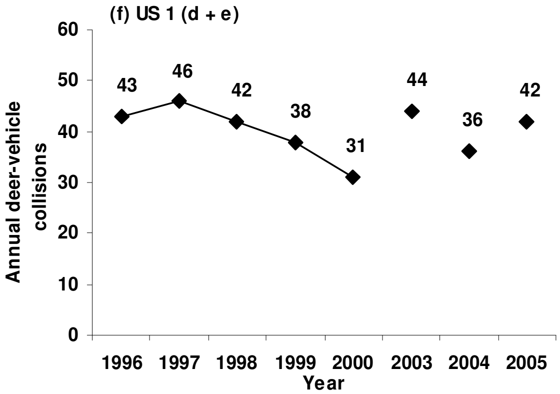

(f) US 1 (d + e)

Figure 3.4. Annual Key deer-vehicle collisions by US 1 road segment (west, extra lane, east, fenced segment) and combined segments (unfenced and US 1) for pre-fence (1996–2000) and post-fence (2003–2005) periods on Big Pine Key, Florida.

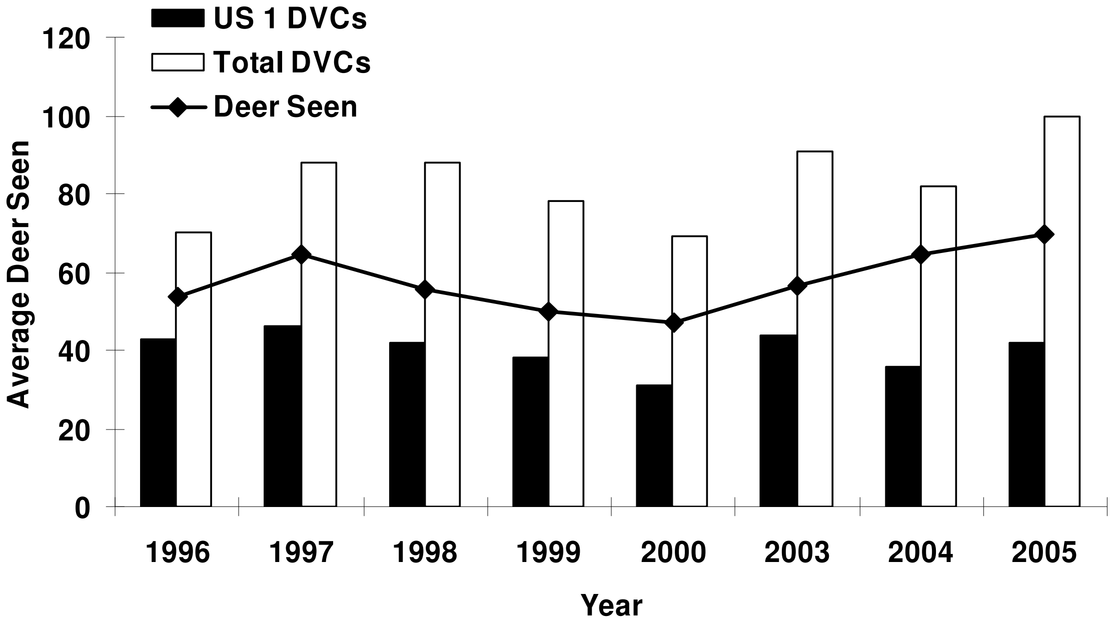


Figure 3.5. Average deer seen annually along standardized route compared to deer-vehicle collisions (DVCs, US 1 and total deer) on Big Pine Key, 1996–2000, 2003–2005.

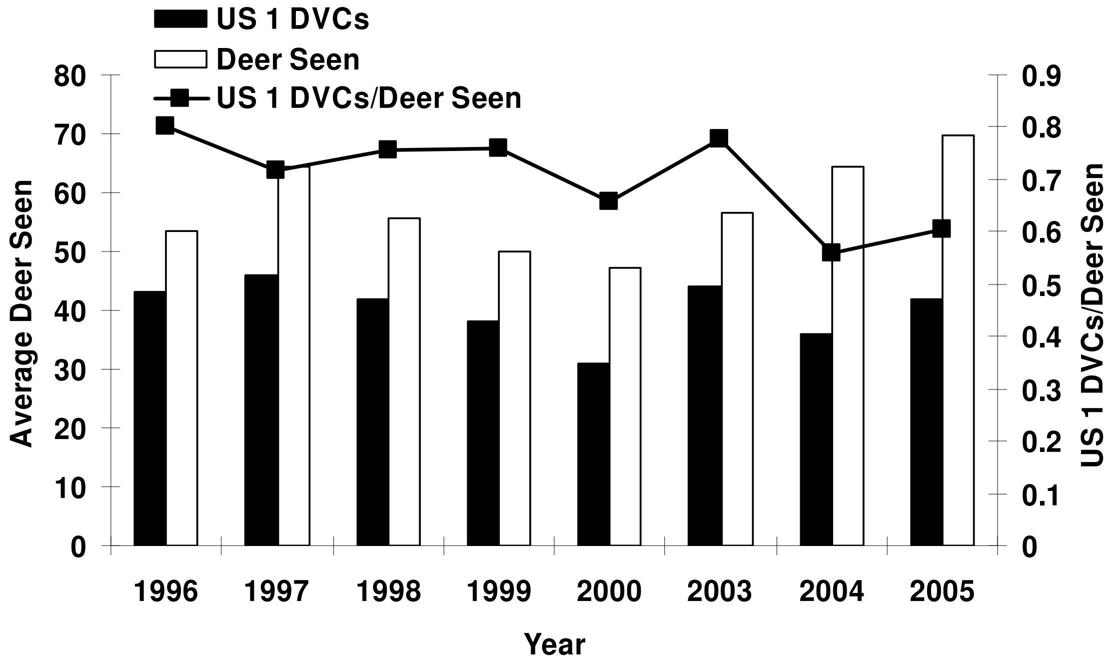


Figure 3.6. Deer-vehicle collisions (DVCs) along US 1, average deer seen annually on Big Pine Key, and ratio of DVCs/deer seen, 1996–2000, 2003–2005.

Deer Incidents

Deer entered the fenced area of US 1 (presumably over a deer guard) 13 times following the completion of the project: 5 crossings in 2003 (5 adults [4 M, 1 F]), 4 crossings in 2004 (3 adults [2 M, 1 F], 1 yearling [1 M]), and 4 crossings in 2005 (2 yearlings [1 M, 1 F], 1 fawn [unknown sex], 1 unknown deer). An additional 10 deer breached the fencing itself through opened gates, erosion, or damaged fencing: 1 adult female and 1 unknown in 2003, no breaching events in 2004, and 2 adults (1 M, 1 F), 4 yearlings (3 M, 1 unknown sex), and 2 unknown age deer in 2005. The increase in breaching events in 2005 was due to an active hurricane season causing fence damage. A total of 23 deer incidents resulted in 3 Key deer mortalities within the fenced segment of the project area ($n = 2$, vehicle collision; $n = 1$, severe injury during removal attempt, euthanized).

DISCUSSION

Underpass Use

Reed et al. (1975) and Foster and Humphrey (1995) demonstrated that deer and other wildlife will use underpasses as a means to move between areas. The installation of 2 underpasses within the US 1 highway project appears to have improved the permeability of the project area for Key deer. I observed increasing use of underpasses by Key deer 3 years post-construction. Previous studies have reported an acclimation period to underpass structures may be necessary (Reed et al. 1975, Braden et al. 2006). My study results supported predictions by Braden et al. (2006) who monitored underpass use the first year of the US 1 project. As predicted, underpass use continued to increase in 2004 and stabilized in 2005. The observed decrease in 2005 was likely due to the removal of camera stations on 4 separate occasions due to an active hurricane season. Approximately 6 weeks were not monitored in 2005. I also observed differential underpass use for Key deer for the south underpass (higher) compared to the north underpass which is near the fence end. I attribute this differential underpass use to the lack of alternative crossings in the southern region compared to the north where the fencing project ends <200 m from the north underpass (Braden et al. 2006).

Deer-Vehicle Collisions

DVCs along the fenced section of US 1 decreased from pre- to post-construction years, which agrees with other studies (Reed et al. 1982, Ludwig and Bremicker 1983, Woods 1990). As is the case with many deer exclusionary fencing projects, 100% effectiveness (i.e., no deer inside the fence) was not achieved and believed to be an impractical goal (Woods 1990, Putman 1997; Key Deer Habitat Conservation Plan 2005, under review). In comparing DVCs for the unfenced segment of US 1, I observed increases in DVCs following project completion. Possible explanations for increased DVCs along the unfenced sections include (1) natural increases in mortality associated with fence ends (east segment; Ward 1982, Feldhamer et al. 1986), (2) the addition of an extra 1.4-km traffic lane in the unfenced section of US 1, (3) habitat improvement work along US 1 (west and extra lane segments), and (4) an increase in deer population numbers on BPK (Lopez et al. 2004*a*).

The small increase in mortality observed at the fence end (+25%) was expected but likely had a relatively small impact on overall DVCs. It is possible that the increase in mortality in the extra lane (+50%) occurred due to the associated increased traffic flow (higher average speeds, more vehicles/hr), reduced deer visibility, and the additional hazard of deer having to cross 3 lanes of traffic versus 2 (Lopez et al. 2003*a*; Key Deer Habitat Conservation Plan 2005, under review). It is also possible that some deer chose to avoid the extra lane segment and crossed US 1 in the west segment, resulting in additional DVCs in that segment (+150%). Additionally, USFWS undertook a habitat restoration project (i.e., removal of exotic plants, waterhole creation) along the extra lane and west segments of US 1. Carbaugh et al. (1975) and Bashore et al. (1985) found that attractive habitat near roadways in Pennsylvania lead to increased deer presence in this area and/or lower roadside visibility. Research conducted by Hedlund et al. (2004) and Lopez et al. (2005) supports the idea that increased deer density in areas of high traffic volume would lead to increased DVCs. While it is likely that all of these points contributed to the location and quantity of DVCs pre- and post-project, an increase in deer population appears to be the major factor. My analysis supports the conclusion that the major contributor to post-project DVC numbers on US 1 is an increasing deer density in the core habitat.

Deer Incidents

Deer crossed the 4 experimental deer guards proposed by Peterson et al. (2003) 13 times to enter the fenced segment. Although pen trials found the deer guards to be 98% effective, we were unable to determine how many crossing attempts occurred during the pre- or post-fence periods. Factors that may explain some of the deer crossings are a fencing adjustment period and Key deer sociobiology. Previous fencing studies have found that an acclimation period exists with wildlife fencing structures (Reed et al. 1975, Clevenger 1998, Hardy et al. 2003). Additionally, Key deer are known to have strong site and movement pattern fidelity (Lopez 2001). These 2 factors resulted in deer crossings as attempts were made to revert to pre-fence movements and ranges. The number of these “reminiscence” deer crossings should decrease as older deer acclimate to the location of crossings and as younger deer establish ranges with the fencing project in place (Braden 2005). Overall, the Key deer incidents highlight the need for 2 things: (1) easy egress for deer from the fenced area and (2) thorough maintenance of all aspects of the fence. Foster and Humphrey (1995) and Falk et al. (1978) found that exclusion fencing is only effective if it is continuously and thoroughly maintained.

MANAGEMENT IMPLICATIONS

The US 1 Project succeeded in reducing DVC risk locally on US 1. Additionally, the use of deer fencing is applicable in other communities experiencing unacceptable levels of DVCs. The incorporation of specially designed deer guards is a unique facet to my study, allowing safe passage for humans on foot, bicycles, and in vehicles.

CHAPTER IV

CONCLUSION AND MANAGEMENT IMPLICATIONS

TRANSLOCATIONS

Study results suggest that translocations are a viable alternative to bolstering Key deer (*Odocoileus virginianus clavium*) populations on outer islands where few resident deer are found. Assuming suitable habitat is available (Lopez et al. 2004*b*), I recommend the integration of soft releases versus hard releases in future Key deer translocations. Though hard releases are more cost- and time-efficient (Bryant and Ishmael 1991, Beringer et al. 2002), study results suggest soft releases increase site fidelity to release sites which ultimately will determine the success of translocation programs. For Key deer, I recommend a minimum of 30 days in holding pens prior to release. If the results and conclusions of the translocation chapter are taken as accurate portrayals of the current situation then certain actions are required to ensure the continued success of the project. These are as follows:

1. Closely monitor the populations on Cudjoe and Sugarloaf.

While growing, these small groups of deer on outer islands will be more vulnerable to environmental and demographic stochasticity. Monitoring is essential to evaluate the ultimate success of the project. Recovery biologists need information on population size and demographics, population growth, fawn presence and survival, and herd health. These data are imperative in determining the future direction of the translocation project.

2. Translocate more yearling females or pregnant adult females if needed as determined by population monitoring.

If the subpopulations decline or fail to grow significantly, then hard release translocations can be implemented. While my study has proven the superiority of soft releases, hard release translocations can likely be implemented with success. My thesis has demonstrated that females are likely to react favorably to hard release now that a population has been established on the destination islands. This has the extra benefit of adding additional genetic diversity to the subpopulation. However, recovery biologists must accept the higher risks associated with hard releases (e.g., increased dispersal, increased risk of deer-vehicle collisions [DVCs]).

3. Carefully monitor both the habitat and the water resources on the destination islands.

Deer can only exist in areas of adequate habitat. It is incumbent upon USFWS personnel to monitor the local habitat to ensure that loss and damage are minimized. In the wake of hurricanes, prescribed fires, increased deer presence, droughts, etc. recovery biologists should monitor existing habitat carefully. In addition, I have already mentioned the importance of freshwater to Key deer distribution. As the destination islands have large amounts of preferred habitat, the main threat to subpopulation survival is water availability. Without consistent and reliable water the subpopulations on Cudjoe and Sugarloaf will likely stagnate, attenuate, and finally cease to exist. It is not enough to simply monitor waterholes. Extant waterholes should be actively maintained. Recovery biologists should also consider creating additional waterholes in appropriate areas if population monitoring indicates static or declining populations. Prudence also dictates that rain-catchment guzzlers be maintained on the destination islands. As of

2006, 2 guzzlers (1/island) were present and functional. More guzzlers could be added to supplement available water resources.

US 1 HIGHWAY IMPROVEMENTS

The analysis of effects of the US 1 Project on Key deer is an ongoing study. The US 1 Project has succeeded in reducing DVC risk locally on US 1 but this study has applications beyond the Florida Keys. The creation of deer exclusion structures is applicable in communities experiencing unacceptable levels of DVCs. The incorporation of specially designed deer guards is a unique facet to my study. For the first time, communities can incorporate deer-specific guards to fencing projects to allow multiple entrances on a thoroughfare. In this way, deer fencing only restricts deer while allowing safe passage for humans on foot, bicycles, and in vehicles. Additionally, underpasses are expensive but not always necessary if deer crossings are acceptable in unfenced areas (i.e., outside city limits). The US 1 Project is a proof-of-concept study that has demonstrated the ability of well-designed deer-exclusion structures to lower the risks of DVCs not only in the Florida Keys but wherever deer and people coexist.

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VITA

ISRAEL DAVID PARKER

EDUCATION

Master of Science, Wildlife and Fisheries Sciences, Texas A&M University, 2006.

Bachelor of Science, Wildlife Science, New Mexico State University, 2002.

WORK EXPERIENCE

Graduate Student, Florida Key Deer Research (*Odocoileus virginianus clavium*), Texas A&M University, Florida Keys, Florida, 2003–2006.

Field Technician, White-tailed Deer Population Research (*Odocoileus virginianus*), Texas A&M University, Johnson Space Center, September 2003–May 2004.

Field Technician, Black-tailed Prairie Dog Population Research (*Cynomys ludovicianus*), New Mexico State University, Armendariz Ranch, Summer 2003.

Technical Assistant, Savannah Sparrow Site Fidelity Research (*Passerculus sandwichensis*), New Mexico State University, Padre Island National Seashore, January 2003–April 2003.

Internship, Sonoran Pronghorn Recovery Project (*Antilocapra americana sonoriensis*), Arizona Department of Game and Fish, Summer 2002.

Assistantship, Gemsbok Reproductive Research (*Oryx gazella gazella*), New Mexico State University, White Sands Missile Range, 2000–2002.