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Authors

Braden, Anthony W.

Lopez, Roel R.

Roberts, Clay W.

et al.

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EVALUATION OF A HIGHWAY IMPROVEMENT PROJECT ON FLORIDA KEY DEER

Anthony W. Braden (Email: anthonybraden@hotmail.com), **Roel R. Lopez** (Phone: 979-845-5777, Email: roel@tamu.edu), **Clay W. Roberts**, and **Nova J. Silvy**, Department of Wildlife and Fisheries Sciences, Texas A&M University, College Station, TX 77843

Catherine B. Owen (Phone: 305-470-5399, Email: catherine.owen@dot.state.fl.us), Florida Department of Transportation, Environmental Management Office, Miami, FL 33172

Philip A. Frank, U.S. Fish and Wildlife Service, National Key Deer Refuge, Big Pine Key, FL 33043

Donald S. Davis, Department of Veterinary Pathobiology, Texas A&M University, College Station, TX 77843

Abstract: Deer-vehicle collisions (DVCs) are a concern in the recovery of the endangered Florida Key deer (*Odocoileus virginianus clavium*) on Big Pine Key, Florida. Since the 1960s, nearly half of the total deer mortality has been attributed to DVCs; the majority of these mortalities occurring along the United States Highway 1 (US 1) corridor. In 2002, the Florida Department of Transportation completed modifications to a 2.6-km segment of the US 1 corridor that included fencing, experimental deer guards, and underpasses designed to prevent deer entry into the roadway and minimize DVCs. We evaluated the effectiveness of highway modifications in reducing Key deer-vehicle collisions pre- and post-project using long-term mortality data. Overall US 1 DVCs remained unchanged due to DVC increases along the unfenced section of US 1 on Big Pine Key; even though highway modifications (i.e., deer guards, fencing, and underpasses) reduced Key deer-vehicle collisions by 83–95 percent both post-project years. Experimental deer guards minimized deer crossings to six deer crossings the first post-project year and three crossings the second year. As a result, we recommend experimental deer guards in combination with fencing (and underpasses when applicable) can benefit wildlife in urban/suburban settings while maintaining human safety.

Introduction

Deer-vehicle collisions (DVCs) have increased in the United States, Canada, and Europe in recent years (Groot Bruinderink and Hazebroek 1996, Romin and Bissonette 1996, Putman 1997, Forman et al. 2003). In addition to human dangers associated with DVCs (Conover et al. 1995, Forman et al. 2003), local deer populations can be significantly impacted (e.g., Florida Key deer [*Odocoileus, virginianus clavium*], Lopez et al. 2003b). Since it is unlikely deer populations will decrease in the near future, methods to reduce DVCs will become increasingly important with continued suburban sprawl (McShea et al. 1997, DeNicola et al. 2000), increasing roadways, and higher traffic coinciding with wildlife activity (Foreman et al. 2003).

Florida Key deer are the smallest subspecies of white-tailed deer in the United States (Hardin et al. 1984), occupying 20–25 islands in the Lower Florida Keys (Lopez 2001). Approximately 65 percent of the overall population is found on Big Pine Key (BPK, Lopez et al. 2004). Since the 1960s, DVCs have been the single largest Key deer mortality factor accounting for >50 percent of annual losses (Silvy 1975, Lopez et al. 2003b). Because of this, United States Fish and Wildlife Service (USFWS) and Florida Department of Transportation (FDOT) biologists have attempted to address DVCs on United States Highway 1 (US 1) which bisects BPK (fig. 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 on BPK (i.e., ability to evacuate residents during a hurricane) was found to be inadequate (Lopez et al. 2003a). The two objectives of the Key Deer-Motorist Conflict Study were to evaluate methods to (1) decrease DVCs and (2) improve US 1 traffic flow. Final study recommendations included (1) construction of barriers (fences) with two wildlife crossings (underpasses) along an undeveloped segment of US 1 on BPK, and (2) an extra northbound lane through the developed segment of US 1 (hereafter US 1 corridor project; Calvo 1996). The developed “business” segment 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. 2003a).

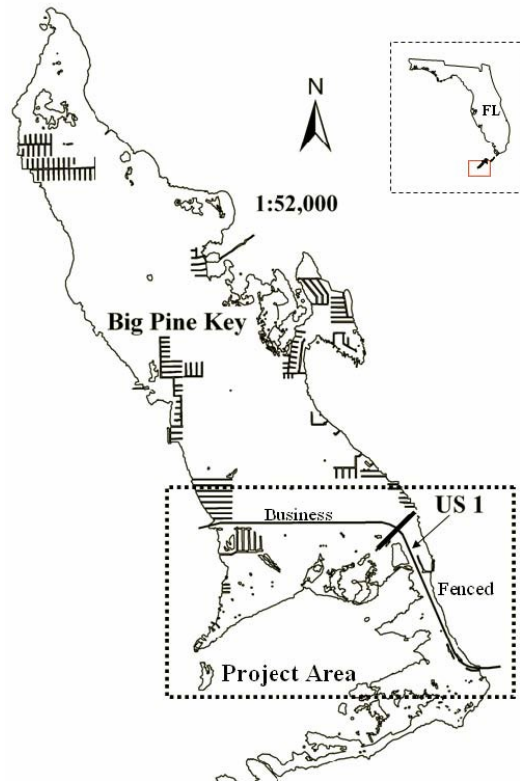


Figure 1. The study site (dashed line) including United States Highway 1 (US 1, 5.6 km) divided into business (3.1-km) and fenced segments (2.6-km) on southern end of Big Pine Key, Monroe County, Florida.

Fencing in combination with wildlife crossings has proven to successfully reduce DVCs in many parts of the country (Bellis and Graves 1971, Reed et al. 1975, Falk et al. 1978, Ford 1980); however, for exclusion fencing to be effective, access management (e.g., fence ends, side roads) is a critical factor (Peterson et al. 2003). Traditionally, modified cattle guards or “deer guards” that allow unrestricted vehicle access are used to exclude deer at fence ends (Reed et al. 1974, Reed et al. 1979, Woods 1990, Sebesta 2000). Traditional deer guards, however, posed a hazard to pedestrians and cyclists in the US 1 corridor project, and were unproven in supporting heavy vehicular loads (Peterson et al. 2003). Peterson et al. (2003) recommended a standard bridge grating material which was reported to be 98 percent efficient at excluding Key deer access during baited pen trials (fig. 2).

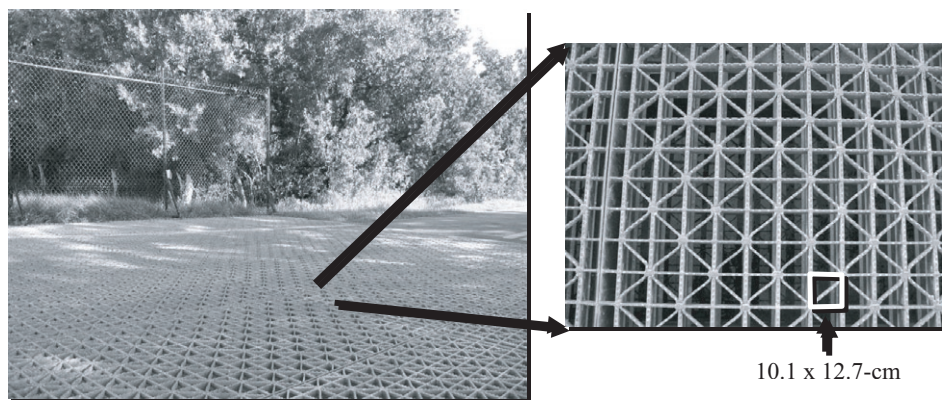


Figure 2. Experimental deer guard ($n=4$) and close up of standard bridge grating material used in US 1 improvement project.

In 2002, construction of the 2.6-km fenced segment, two underpasses (2.9 x 7.6 x 14.2-m), four experimental deer guards (7.8-m wide; Peterson et al. 2003), and extra 1.4-km traffic lane were completed (fig. 3). With the US 1 corridor project completed, the objective of our study was to evaluate the effectiveness of fencing and experimental deer guards in reducing Key deer-vehicle collisions. Specifically, our study objectives were to compare (1) pre- and post-project fence US 1 DVCs and (2) deer access into the fenced segment of project area.

Study Area

Our study was conducted on the southern half of BPK, Florida (fig. 1). US 1 is a two-lane highway that links the Keys to the mainland with an estimated annual average daily traffic volume of approximately 18,000 vehicles/day (Florida Department of Transportation data, Monroe County, 2004). US 1 bisects BPK on the southern half of the island. Maximum speed limits are 72 km/hr during the day and 56 km/hr at night. The fenced section of US 1 accounts for approximately 46 percent of the US 1 roadway on BPK (fig. 3). The unfenced section included west of extra lane, extra lane, and east of extra lane segments (fig. 3). The west of extra lane, extra lane, and east of extra lane segments account for 14 percent, 23 percent, and 17 percent of the unfenced section, respectively.

Methods

Deer-vehicle collisions

Since 1966, USFWS biologists have recorded all known Key deer mortalities on all roads on BPK via direct sightings, citizen and law enforcement reports, and observation of turkey vultures (*Cathartes aura*, Lopez et al. 2003b). Age, sex, and body mass were recorded for each animal, and all road-related deer mortality locations were entered into a geographic information system (GIS) using ArcView (Version 3.2).

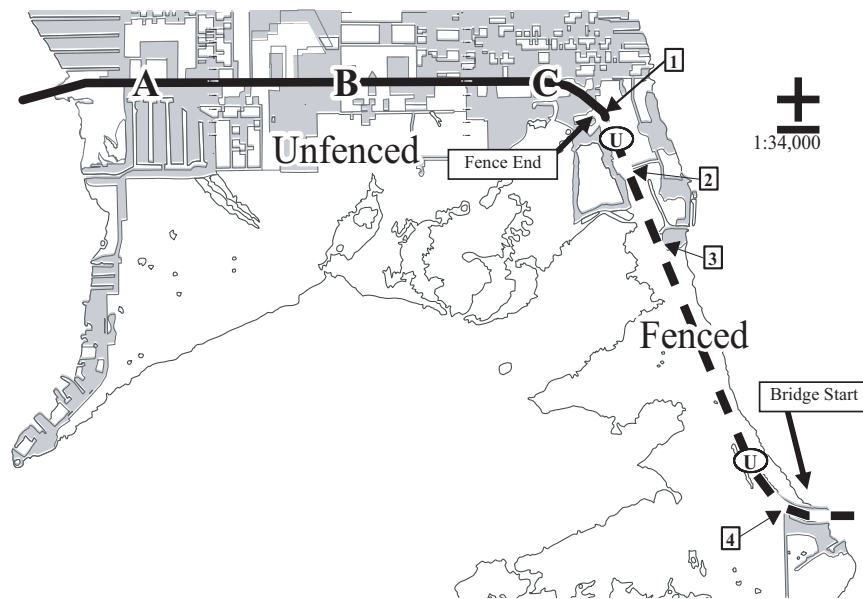


Figure 3. The US 1 corridor project (5.6-km) on Big Pine Key, Florida is divided into unfenced (3.1-km, solid line) and fenced (2.6-km, dashed line) segments. The unfenced road section consists of an extra lane (1.4-km [B]) in between two 0.8-km road sections (A, west) and (C, east). The fenced section includes 2 underpasses (denoted by U) and 4 experimental deer guards (indicated by arrows and numbered). Gray areas denote developed areas.

Using the USFWS Key Deer Refuge mortality data, pre-project (1996–2000) DVCs were compared to post-project (2003–2004) DVCs. US 1 road improvements on BPK included (1) an extra traffic lane in the unfenced section of US 1 that was hypothesized would increase DVCs and (2) a fenced section with associated underpasses and deer guards that was hypothesized would decrease DVCs. We compared US 1 DVCs by individual road segments in addition to overall findings (fig. 3). Key deer mortality data from 2001–2002 were excluded to avoid biases during the construction phase of the project.

Deer crossings

Since the completion of the US 1 corridor project (February 2003), USFWS biologists have recorded the number, age, sex, and point of entry of all known deer inside the fenced segment based on direct sightings and local law enforcement reports. Removal of deer from the fence segment was conducted when necessary using maintenance exit gates ($n = 16$) installed during the project.

Results

Deer-vehicle collisions

We found that annual DVCs within the fenced section decreased 83–91 percent the first post-project year and 91–95 percent the second post-project year (fig. 4). Conversely, we found DVCs in the east of extra lane unfenced segment increased 21–112 percent the first post-project year but returned to pre-project levels the second post-project year (C, fig. 3). DVCs within the extra lane segment also were found to be greater than pre-project levels the first post-project year (21–112% over pre-project levels) and then returned to pre-project levels the second year (B, fig. 3). West of extra lane segment DVCs increased both post-project years with DVC increases of 10–266 percent and 80–500 percent

for the first and second post-project years respectively (A, fig. 3). Overall US 1 post-project DVCs remained similar to pre-project levels during both post-project years.

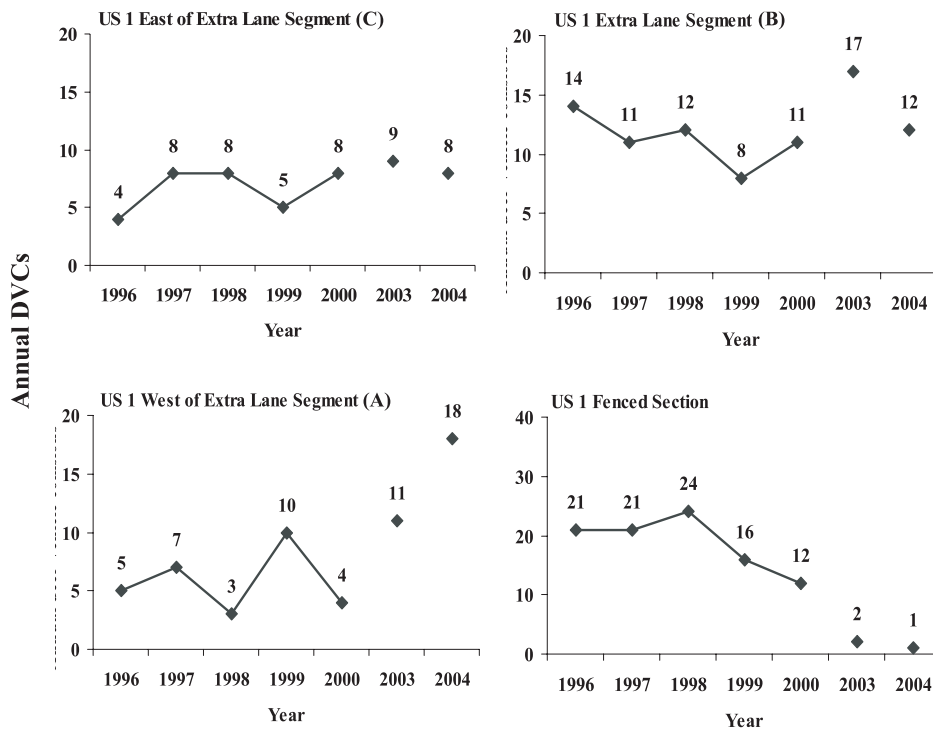


Figure 4. Annual US 1 Key deer-vehicle collisions pre-project (1996–2000) and post-project (2003–2004) by road segments (segments correspond with those in fig. 3).

Deer crossings

The first post-project year, eight deer entries into the fenced segment were recorded (6 deer-guard crossings, 2 side-gate entries). All ($n = 6$) of recorded deer guard crossings involved adult deer (4 males, 2 females). The eight deer incidents resulted in two Key deer mortalities within the fenced segment ($n = 1$, vehicle collision; $n = 1$, severe injury during removal attempt which required euthanasia). The second post-project year, the number of deer reported inside the fenced section decreased to three deer (2 adults, 1 yearling) with one entry event resulting in mortality.

Discussion

Deer-vehicle collisions

Previous studies utilizing fencing and underpasses have proven success in reducing deer mortality 60–95 percent (Reed et al. 1982, Ludwig and Bremicker 1983, Woods 1990). In our study, the post-project decrease in DVCs along the fenced section of 83–91 percent indicates that fencing, underpasses, and deer guards were also successful in reducing Key deer-vehicle collisions. As is the case with many deer exclusionary fencing projects, 100-percent effectiveness (i.e., no deer inside the fence) was not achieved and is likely an impractical goal (Woods 1990, Putman 1997). With the understanding that some deer will cross into the roadway, safe removal of incidental deer from the fenced section becomes essential.

We found an overall increase in DVCs along the unfenced section of the US 1 corridor project with varied post-project DVC changes within individual unfenced road segments. Previous studies have shown an increase in mortality associated with fence ends (Ward 1982, Feldhammer et al. 1986, Clevenger et al. 2001). The first post-project year east of extra lane segment DVCs increased by 29 percent, which returned to pre-project levels the second-year (fig. 3). We attribute this decrease in DVCs to deer using the underpasses to traverse US 1 instead of crossing at the fence's end (fig.3). The addition of the extra 1.4-km traffic lane in the corresponding segment (fig. 3) may be responsible for the post-project collision increases along the extra lane and west of extra lane segments. Although the increase in mortality in response to the extra lane was predicted to occur due to the associated increased traffic flow (higher average speeds, more vehicles/hr) and reduced visibility (Lopez et al. 2003a), the increase in DVCs along the west of extra lane segment was not expected to occur. The reason for the increase in DVCs in the west of extra lane segment is not fully understood at this time. We will continue to monitor DVCs along the unfenced section west of extra lane segment and all of US 1 to better determine the overall long-term impacts of the extra lane on Key deer-vehicle collisions.

Deer crossings

Deer crossed the experimental deer guards six times during the first post-project year and three times during the second post-project year. Although pen trials found the deer guards to be 98-percent effective, we were unable to determine how many crossing attempts occurred during the post-project period. The finding of almost all deer crossings involving adults supports the theory that larger hoof sizes allow for more successful crossings (Peterson et al. 2003). Other 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). Additionally, Key deer are known to have strong site fidelity (Lopez 2001). These two factors resulted in deer crossings as attempts were made to revert to pre-fence movements and ranges. We believe the number of deer crossings should decrease as older deer acclimate to the location of crossings and as younger deer establish ranges surrounding the fencing project.

Management Implications

Post-project data indicate the US 1 corridor project can reduce DVCs provided that responsible handling of deer incidents is maintained. Although overall US 1 DVCs did not change due to increases in the unfenced section, we believe collisions will decrease as deer movements stabilize. With the Key deer population on BPK believed to be approaching or near carrying capacity (Nettles et al. 2002) and traffic levels increasing, it is likely that DVCs along other BPK roads will become a greater concern for USFWS biologists in the future. Unable to fence all roads on BPK, different strategies to reduce DVCs in these areas will need to be evaluated.

Deer guards proved effective at reducing deer access into the fenced segment of US 1 with no compromise of human safety. As more DVC issues develop in other suburban-type habitats, restricting deer access without interfering with human activities will become more important. The US 1 corridor project demonstrates one design for addressing these issues.

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Biographical Sketches: Anthony W. Braden is a master's student at Texas A&M University. He received his B.S. in wildlife management from Texas Tech University. His master's research focus is on evaluating the effects of US 1 highway improvements on Key deer on Big Pine Key, Florida.

Roel R. Lopez is an assistant professor with the Department of Wildlife and Fisheries Sciences at Texas A&M University. His previous employment was with U.S. Fish and Wildlife Service, National Key Deer Refuge. He received his B.S. in forestry from Stephen F. Austin State University and his M.S. and Ph.D. from Texas A&M University. His research focus is urban wildlife ecology, deer ecology, wildlife population dynamics, and habitat management.

Clay W. Roberts is a biological science technician with U.S. Fish and Wildlife Service, Julia Butler Hansen Refuge for the Columbian White-tailed Deer. He received his B.S. and M.S. in wildlife science from Texas A&M University.

Nova J. Silvy is a Regents Professor with the Department of Wildlife and Fisheries Sciences at Texas A&M University. He received his B.S. and M.S. from Kansas State University and his Ph.D. from Southern Illinois University-Carbondale. Nova served as president of The Wildlife Society in 2000-2001. His research focus is upland gamebird ecology.

Catherine B. Owen is currently the environmental manager for the Florida Department of Transportation's District Environmental Management Office in Miami, where she oversees the analysis and documentation of environmental issues for transportation projects in Miami-Dade and Monroe Counties. She has been involved in various efforts to reduce Key Deer mortality along US 1 for the past 10 years. She received her B.S. and M.S. in marine biology from Florida Atlantic University.

Philip A. Frank is the Florida Keys project leader, U.S. Fish and Wildlife Service. He is responsible for overseeing and implementing recovery actions for threatened and endangered species in the Florida Keys. He received his B.S. in biology from Indiana University, his M.S. in zoology from University of South Florida, and his Ph.D. in wildlife ecology from University of Florida.

Donald S. Davis is an associate professor with the Department of Pathobiology at Texas A&M University. He received his B.S. in biology from the University of Texas and his M.S. and Ph.D. from Texas A&M University. His research focus is infectious and parasitic diseases of native, exotic, and feral wildlife.

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