Evaluation of deer-exclusion grates in urban areas

M. Nils Peterson, Roel R. Lopez, Nova J. Silvy, Catherine B. Owen, Philip A. Frank, and Anthony W. Braden

Abstract The extensive and growing road network in the United States has substantial ecological, economic, and social impacts. Under- and overpasses in combination with fencing can reduce ecological impacts of the expanding road network. In urban areas, however, wildlife can trap themselves inside fenced roadways by entering via access roads. Wildlife-exclusion guards can ameliorate this problem but must be safe for pedestrians and cyclists. For the endangered Florida Key deer (*Odocoileus virginianus clavium*), nearly 50% of mortality is attributed to deer–vehicle collisions. An underpass, fencing, and exclusion-grate system was chosen by the Florida Department of Transportation (FDOT) to address this problem. Traditional exclusion guards were deemed unsafe for pedestrians and cyclists, so we evaluated 3 types of bridge grating for deer-exclusion efficiency. All grates were 6.1 m × 6.1 m; only the openings differed: 1) 10.1 × 12.7-cm rectangular opening, diagonal cross member, 2) 7.6 × 10.1-cm rectangular opening, no diagonal cross member, 3) 10.1 × 7.6-cm rectangular opening, no diagonal cross member. Grate 1 was 99.5% efficient for Key deer exclusion, while grates 2 and 3 were 75% efficient. Grate 1 also may be the safest for pedestrians and cyclists since it has the smallest opening size. It should be an effective tool for reducing economic and social costs associated with deer–vehicle collisions on urban highways.

Key words corridors, deer guard, Florida, highway mortality, Key deer, *Odocoileus virginianus clavium*, urban deer

In the contiguous United States, roads and roadsides cover approximately 1% of the surface area and impact 22% of it ecologically (Forman 2000). For species that readily cross roads, wildlife–vehicle collisions can have serious costs in several forms. Each year in the United States, deer (*Odocoileus* spp.)–vehicle collisions cost $1.1 billion in property damage or losses and cause an estimated 29,000 human injuries and 211 human fatalities (Conover et al. 1995). Since many of the estimated 1 million annual deer–vehicle collisions do not result in immediate death of the deer (Allen and McCullough 1976, Conover et al. 1995), deer–vehicle collisions are an inhumane form of mortality (Lopez et al. 2003). Continued urban sprawl and suburban development are likely to increase costs associated with deer–vehicle collisions.

Florida Key deer (*O. virginianus clavium*) are the smallest subspecies of white-tailed deer (*O. virginianus*) in the United States (Hardin et al. 1984), occupying 20–25 islands in the Lower Florida Keys (Figure 1, Lopez 2001). Approximately 65% of the overall population is found on Big Pine Key. Since the early 1990s, United States Fish and Wildlife Service (USFWS), Florida Department of Transportation (FDOT), and local residents have been trying

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to address deer-vehicle collisions on Big Pine Key, which account for nearly half the total deer mortality (Lopez et al. 2003). Over half the deer-vehicle collisions occur on United States Highway 1 (US 1), the only highway linking the Keys to the mainland (Figure 1, Lopez et al. 2003).

In 1994 the Key Deer-Motorist Conflict Study was initiated by FDOT to evaluate alternatives for reducing deer-vehicle collisions along the US 1 corridor (Calvo 1996). Final study recommendations included construction of barriers (fences) with 2 wildlife crossings (underpasses) to prevent Key deer access onto US 1 (Figure 1, Calvo 1996). Underpasses in combination with fencing have been used successfully to reduce wildlife (Foster and Humphrey 1995, Clevenger and Waltho 2000)- and deer (Bellis and Graves 1971, Reed et al. 1975, Falk et al. 1978, Ford 1980, Reed et al. 1982)-vehicle collisions in many parts of the country. However, access management is a critical factor in the success of fence and underpass-type wildlife crossings. For example, along the US 1 corridor are a number of access points (e.g., side roads, driveways) that make continuous fencing impossible. Previous studies (Reed et al. 1974, Reed et al. 1979, Sebesta 2000) evaluated modified cattle guards or "deer guards" (we define deer guards as cattle guards adapted for deer) that allow unrestricted vehicle access while excluding deer. Traditional deer guards, however, posed a hazard to pedestrians and cyclists, would reduce driver comfort, were unproven in supporting heavy vehicular loads, and their required length would create a skid hazard (Rick Crooks, EAC Consulting, Project Engineer, personal communication). This required the development and testing of effective and safe deer grates (we define deer grates as rectangular bridge grating material used to prevent deer from crossing) for wildlife crossing systems along urban highways. We evaluated 3 types of bridge grating material for Key deer-exclusion efficiency that were deemed safe for pedestrians, cyclists, and motorists by FDOT engineers.

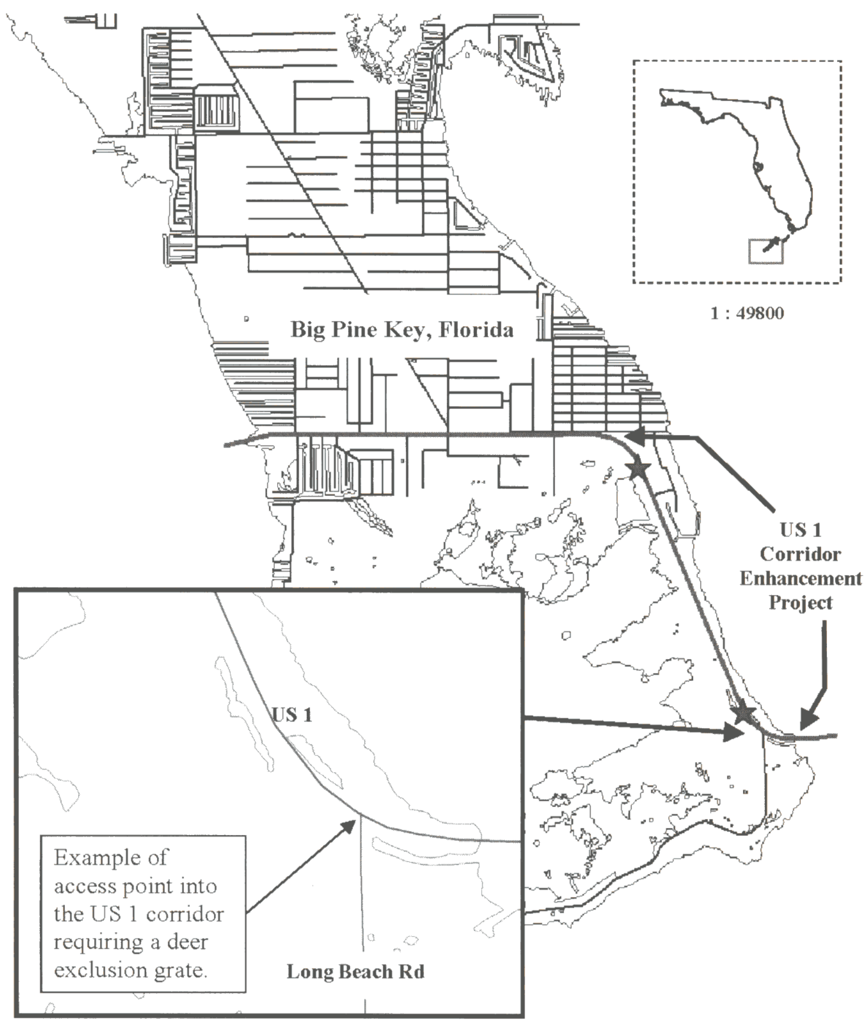

Figure 1. United States Highway 1 corridor enhancement project, Big Pine Key, Florida. Arrows represent beginning and end points of fencing; stars represent wildlife underpasses.

Methods

Study area

The Florida Keys are a chain of small islands approximately 200 km long extending southwest from peninsular Florida, USA. Big Pine Key (2,548 ha), within the National Key Deer Refuge (NKDR) and Monroe County (Figure 1), supported the majority (≈ 65%) of the Key deer population (Lopez 2001). We installed and tested deer-grate prototypes on the northern half of Big Pine Key where deer densities were the highest (Lopez 2001).

Deer-grate construction

Florida Department of Transportation road crews installed 3 types of bridge grates in summer 2001 (deer grate 1) and summer 2002 (deer grates 2 and 3; Figures 2 and 3). Each grate consisted of 6.1 × 6.1-m bridge grating material (L. B. Foster, Pittsburgh, Pa.), each with a different grate pattern: deer grate 1 had 10.1 × 12.7-cm openings with a diagonal cross member; deer grate 2 had 10.1 × 7.6-cm openings with no diagonal; deer grate 3 had 7.6 × 10.1-cm openings with no diagonal (Figure 2). We placed an automatic deer feeder (Moultrie Feeders, Alabaster, Ala.) within a 9.1 × 9.1-m fenced area adjacent to the deer grate (Figure 2) and released shelled corn 4 times a day at 6-hour intervals as an incentive for deer to cross the grate (Figure 2). We enclosed the feeding area with a 2.4-m-high chain-link fence since that was the type of fencing proposed to enclose US 1 (Rick Crooks, EAC Consulting, Project Engineer, personal communication; Figure 3).

Deer-grate trials

We covered all deer grates with 1.2 × 2.4-m sheets of plywood for a 1–2 week-acclimation period prior to each trial. This acclimation period was used to familiarize Key deer to grates and surroundings in addition to allowing deer to find the feed. Following acclimation, we conducted 3 trials for each grate type to evaluate its effectiveness in preventing Key deer access. Each trial consisted of one week with the grate covered, followed by one week with the grate uncovered or exposed.

We used 3 Trailmaster® (TM 1500) active infrared monitor and camera (Goodson and Associates, Lenexa, Kans.) pairs housed in 30-caliber ammunition boxes (United States Army, 28 × 10 × 18 cm, Lopez and Silvy 1999) to monitor deer activities for each trial (Figure 2). We positioned cameras to detect movement: at the edge of the grate directly opposite the enclosed feeding area (camera 1), in the center of the grate (camera 2), and at the edge of the grate adjacent to the feeding area (camera 3, Figure 2). We set trail monitor sensitivity at 7 with a photographic interval of 10 minutes. We checked cameras and feeders daily and replaced batteries or film and added feed when necessary. We positioned a Trailmaster® (TM 700v) active infrared monitor and Sony Handycam® camcorder (Goodson and Associates, Lenexa, Kans.) pair to detect movement in the feeding area during trials for grate 1 (Figure 2).

We entered camera number, date, sex and age of deer, and activity (entering or leaving) into a Microsoft Access (Version 97) database. Due to difficulty in identifying individual deer, deer pictures served as a crude index to Key deer crossings and

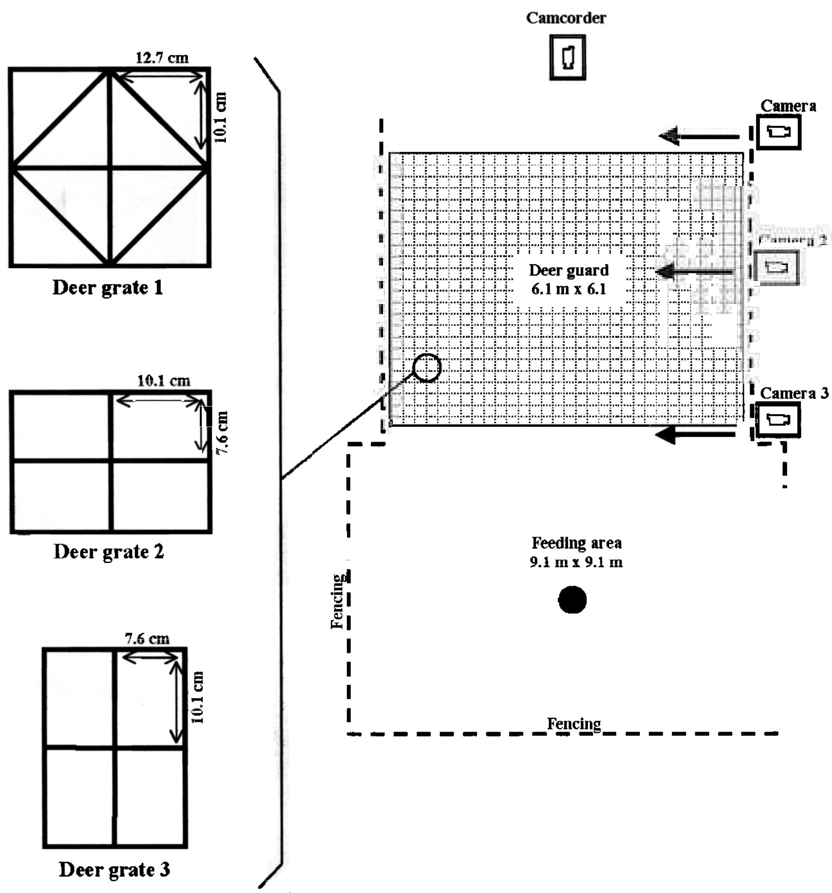

Figure 2. Deer-grate patterns and study-site layout for testing Key deer-exclusion grates, Big Pine Key, Florida, 2001–2002.

attempts. We defined attempts as the number of pictures taken by camera 1. We determined deer crossings using photos from camera 2 because cameras 1 and 3 recorded successful and unsuccessful attempts (Figure 2). We assumed deer crossings to equal one-half the number of pictures since each deer had to pass camera 2 when entering and leaving the feeding area. The photographic interval would require deer to stand on the grate between cameras 2 and 3 for 10 minutes prior to turning around and exiting for a crossing to be recorded without the deer actually entering the feeding area.

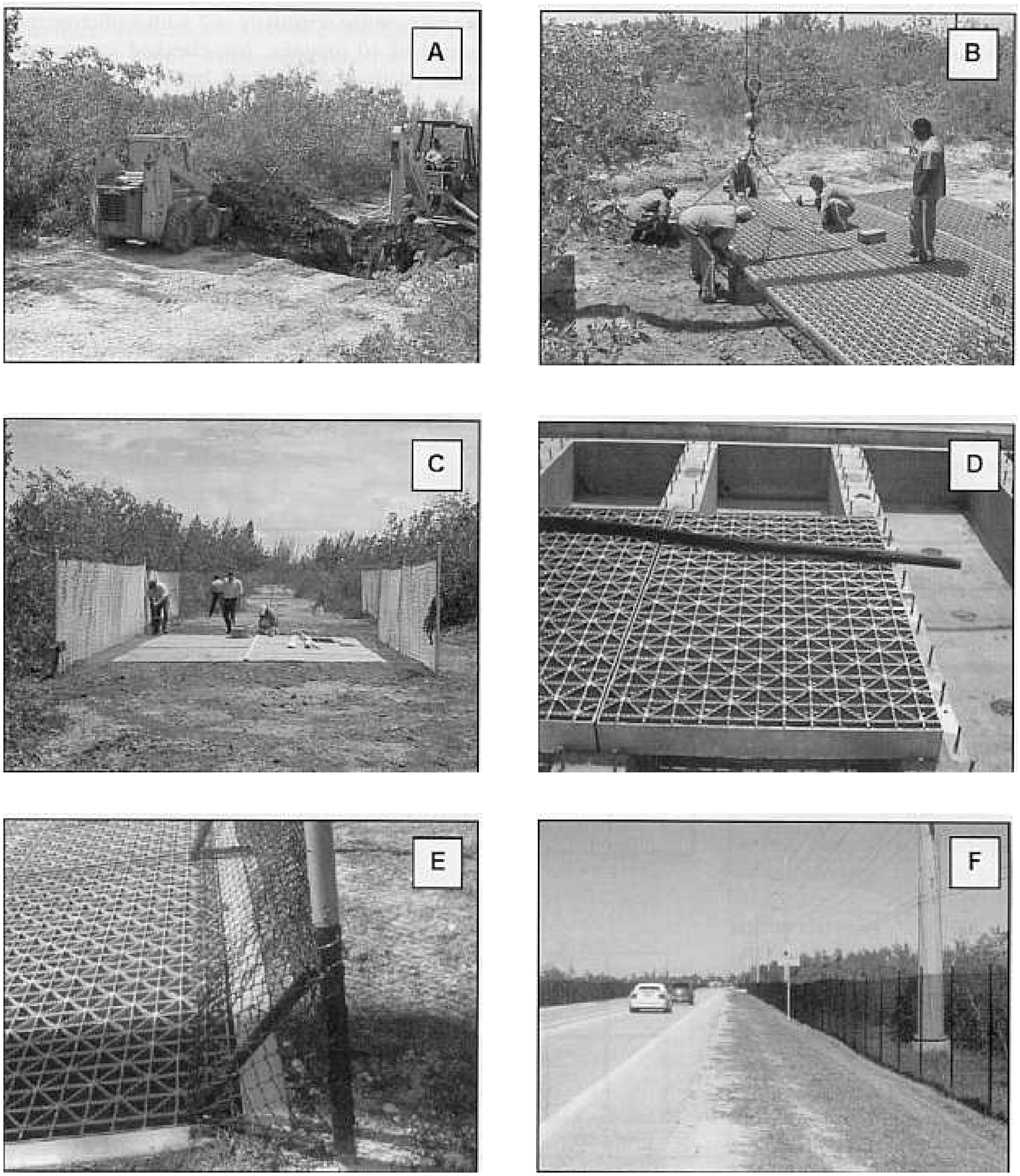

Figure 3. Construction of deer-grate prototypes (A–C) and actual deer grates (D and E), which allow vehicular access to US 1 (F).

Results

We completed 3 trials for deer grates 1 and 2, but only 1 trial for deer grate 3. Grates 2 and 3 differed only in direction of the grate openings (10.1 × 7.6 cm versus 7.6 × 10.1 cm, Figure 2). Trial 1 for deer grate 3 suggested similar levels of effectiveness for grates 2 and 3 (grate 2=75% effective, grate 3=79% effective). Because of similar results and a limited budget, we terminated trials for grate 3. For the remainder of the paper, we present results for deer grates 1 and 2, assuming that results from grate 3 would have been similar to those for grate 2.

Key deer did not jump the fence in our observations of escape attempts or during infrared video surveillance of trials for grate 1. Overall, we found that grates effectively reduced Key deer access to the feeding area (Figure 4). In comparing deer grates 1 and 2, however, we found grate 1 to be more effective. During covered trials for grate 1, deer crossings were 59, 134.5, and 112, respectively. During uncovered trials, deer crossings were 0, 0, and 1, respectively. Of 611 photos taken (303 males, 253 females, 55 unknowns) by camera 2 for deer grate 1, only 2 deer were documented during uncovered trials. One adult female crossed once in the final week, and one adult male made an unsuccessful attempt, reaching camera 2 before turning back (Figure 4). Including both events as crossings, grate 1 was 99.5% efficient in excluding Key deer.

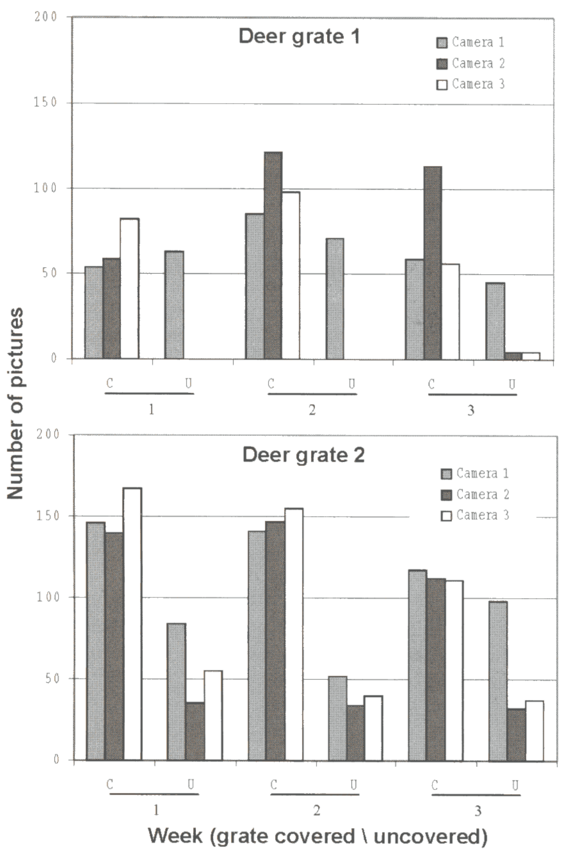

Figure 4. Number of pictures taken by camera location and week (deer-grate status, covered = C, uncovered = U) in testing Key deer grates, Big Pine Key, Florida, 2001–2002.

Though not as effective as grate 1, grate 2 prevented approximately 75% of deer crossing attempts (Figure 4). During 3 covered trials, deer crossings were 69.5, 73.5, and 56, respectively. For uncovered trials, deer crossings were 16.5, 16, and 17.5, respectively. Data indicated that both males (18.5 crossings) and females (13.5 crossings) were successful in crossing this uncovered grate. Males crossed the grate in disproportionately high numbers. Fewer males attempted crossings (of 498 photos taken, 45 were males, 211 were females, 242 were unknowns), but more males actually crossed (n=18.5).

Fawns did not cross any uncovered grate, but one crossing was documented when grate 1 was covered and 4 were documented when grate 2 was covered. Key deer negotiated the grate by walking in all documented crossings, and we observed no deer attempting to jump grates. Although behavior was not quantified, all deer observed crossing the grate exhibited investigative behaviors, including pacing across the grate entrance and making multiple exploratory movements onto the grate surface before crossing.

Discussion

We recommend deer grate 1 for excluding Key deer from fenced roadways along the US 1 corridor. Grate 1 was 99.5% effective, while grates 2 and 3 were only 75% effective. Due to the cross member in grate 1, its openings actually were smaller in area and potentially safer for pedestrians and cyclists than grates 2 and 3. Thus grate 1 was preferred in terms of both human safety and Key deer exclusion.

The difference in exclusion efficiency may be attributed to the effect of more complex grating pattern on foot placement. Animals crossing grates 2 and 3 encountered grating material either perpendicular or parallel to foot placements, while those crossing grate 1 also encountered grating material at a 45° angle to foot placement. Complexity in grate pattern may allow smaller openings that pose less threat to pedestrians and cyclists, but still deter larger ungulates.

Food was a strong incentive for deer to cross grates in our trials; they had no alternative other than crossing the grate to acquire the corn. Roadside forage (Figure 3) may provide incentive for deer to cross grates. However, forage is available on both sides of the road and underpasses provide an alternative to crossing grates. Further, high traffic levels would preclude investigative behaviors exhibited by deer prior to crossings in our trials. We expect that actual crossing rates along the US 1 project will be less than those in our trials.

Hoof size and agility of target species should be considered when choosing wildlife-exclusion grates. Reed et al. (1974) found in field tests that mule deer (*O. hemionus*) and elk (*Cervus elaphus*) walked 3.7-m-long guards (10.2-cm spacing between rails) but would not jump them. Conversely, Sebesta (2000) found in field tests that white-tailed deer would jump 3.7-m-long guards (10.2-cm spacing between rails), but would not walk across them. Size differences between male and female Key deer may have caused the male bias in crossings for grate 2. We observed no documented crossings for fawns for any grates tested. Fawns, females, and males had progressively higher success rates crossing the grate and likely had progressively larger hoof size. Results suggest that target-species hoof size should be considered when choosing opening size for an exclusion grate. Exclusion grates should have larger openings for species with larger hooves and should be longer for more agile species. Thus, if grate 1 was applied to exclude mule deer or elk, it could be shortened but larger openings might be required. Although 2.4-m-high fencing excluded Key deer, larger white-tailed deer subspecies might require slightly higher fencing.

Deer grate 1 presents an effective method to limit Key deer access at points of entry to fenced roadways. Complexity introduced by a cross member may allow smaller grate openings to be more efficient in excluding ungulates. In urban areas where roads have multiple vehicle-access points and pedestrian and bicycle traffic is high, the smaller opening size is particularly valuable. Further, higher economic and social costs associated with higher traffic levels in urban areas make the high cost (Lehnert and Bissonette 1997) of fence, underpass, and grate systems less onerous. Bridge decking costs \$40-\$130/m^2 depending on project size, grate size, and attachments required (Melinda Gaetano, L. B. Foster Company, Inside Sales Representative, personal communication). Actual project costs (\$6.2 million; Richard Kinkead, EAC Consulting, Project Engineer, personal communication) were largely a function of location (Florida Keys), project size, and procedural constraints from environmental regulations. Bridge grates for all 4 access points cost \$104,160. Underpasses in combination with fencing can reduce ecological impacts of constantly expanding road networks, but are problematic unless access points can filter out the wildlife species most vulnerable to collisions with vehicles. Wildlife grates allow vehicles to access and use fenced roadways while reducing the ecological, economic, and social impacts associated with those collisions.

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