Development of a Deer-guard Prototype for Florida Key Deer

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Abstract: Due to increased deer/vehicle collisions involving endangered Florida Key deer *(Odocoileus virginianus clavium)*, the Florida Department of Transportation (FDOT) planned to fence a stretch of U.S. Highway 1 that crosses Big Pine Key, Florida. Public access roads, which would allow deer to enter the fenced portion of the highway, posed public and wildlife-related hazards. Currently there are no structures (deer guards) that are effective in preventing deer from entering access roads. Our purpose was to design, construct, and test a deer guard that would allow normal passage of vehicles while preventing Key deer from crossing. Between September 1998 and December 1999, we constructed and tested deer-guard prototypes within a deer-holding facility at the Welder Wildlife Foundation Refuge near Sinton, Texas. Wild-trapped Texas white-tailed deer *(O. v. texanus)* were used as test animals. Deer-guard prototypes were subjected to 4 tests: (1) no incentive to cross; (2) extra food and water incentive to cross; (3) fawn separated from mother; and, (4) estrous doe separated from mature buck. Three deer-guard designs included: (1) a guard installed at ground level, (2) a guard raised (0.6 m) off the ground, and (3) a raised guard with sloped ends. Deer guards were tested at two lengths (either 3.6 m or 5.5 m) and had 1.9 cm cross-member spacing. We monitored effectiveness of each test visually and with infrared-triggered cameras for one week except for the fawn-separated-from-doe tests (2 hours). Deer jumped 3.6-m guards and walked through guards placed on the ground. No deer crossed a raised 5.5-m guard during any of the tests. With slight modifications, the design should be useful with other ungulates, including Key deer, and for use in urban environments.

Key words: deer guard, Florida, Key deer, *Odocoileus virginianus clavium*

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Reducing highway mortality on endangered Florida Key deer *(Odocoileus virginianus clavium)* has been a major aspect of Key deer management in recent years.

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An increase in deer/vehicle collisions on Big Pine Key, Florida, has created concern among wildlife biologists, area residents, and conservation groups. Highway mortality has been the most common cause of death of Key deer (Klimstra et al. 1982). An increase in deer populations (Lopez 2001) and urbanization has facilitated this deadly interaction. From 1989–1995, there were approximately 45 Key deer killed annually on roadways. During 1996–1999, average Key deer highway mortalities increased 73% annually (Fig. 1). A record high of 88 Key deer were killed on roadways in 1998 and an additional 78 animals were killed in 1999 (Lopez 2001).

The Florida Department of Transportation (FDOT) has recognized an undeveloped stretch of U.S. Highway 1 (US-1) that traverses through Big Pine Key, Florida, as a problem area for deer/vehicle collisions. This stretch of highway accounts for about half of the road-kills on Big Pine Key. The FDOT developed a plan to reduce the number of deer/vehicle collisions along this section of US-1 by placing high fences on each side, and parallel to, the roadway. In conjunction with high fences, plans included wildlife crossing or underpasses to allow deer travel between habitats surrounding US-1. A potential disadvantage with this plan was that public roads intersecting US-1 could funnel deer into fenced portions of the highway which would trap deer between the fences and lead to increased mortalities. Residents of nearby neighborhoods and fishing camps and tourists use these access roads. Access could be facilitated by using a structure that would allow normal passage of vehicular traffic, while preventing deer from crossing (e.g., deer guards). Currently there are no deer guard designs that are effective at preventing deer access; however, Belant et al. (1998) noted cattle guards reduced deer crossing through fence openings.

High fencing of roadways, in conjunction with wildlife crossings, has been used to help reduce highway-related deer deaths. However, management of deer access onto fenced roadways has been an unresolved issue with no viable control available. Little work has been published concerning effective deer guards. Reed et al. (1974) noted that cattle guards were ineffective. Reed et al. (1979) reported on five prototypes of deer guards and found none were effective for mule deer *(O. hemionus)* in Colorado. They installed two guards (3.0-m wide) constructed of flat mill steel 1.3 x 10.2 x 304.8-cm (width, height, and length, respectively) with rails running perpendicular to direction of travel. Rails were placed 10.2-cm apart. Three different lengths of guards were tested (3.7, 5.5, and 7.3 m). Lengths were measured parallel to the direction of travel. To test the effect of guard length on whether deer would cross, mule deer were released from crates into a pen with a deer guard as their only means of exit. Sixteen of the 18 deer used in this test made it across the guard regardless of length. Deer walked across the guards by placing the tips of their hooves on one rail and their dewclaws on the preceding rail. Some deer fell through but were able to regain their footing by rolling on their sides and standing up. Effectiveness of the deer guards was tested in the field by observing tracks leading up to the structure, and scuff marks made by hooves on the guard rails. Observations at the two test sites indicated that collectively 15 deer crossed and 11 did not. None of the animals jumped completely across any of the guards.

Development of a structure (deer guard) that prevents Key deer access to fenced roadways while allowing vehicular traffic would be a valuable tool in reducing oc-

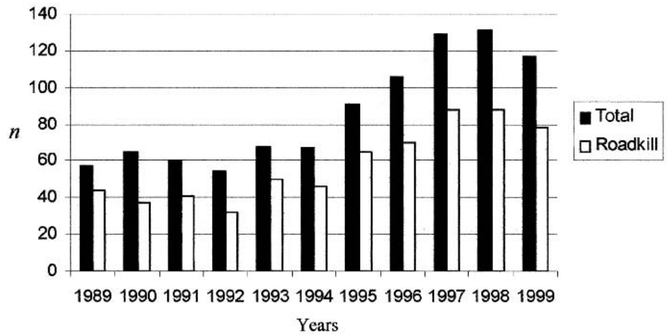

Figure 1. Comparison of total mortality and road mortality *(n)* of Florida Key deer on Big Pine Key, Florida from 1989–1999.

currences of deer/vehicle collisions, The purpose of this study was to design and test the effectiveness of deer guards for use on Florida Key deer. Texas deer were used for the study because of the endangered status of Key deer and because Texas deer were of similar size and physical characteristics.

Methods

Study Site

Research was conducted at the Welder Wildlife Foundation Refuge in San Patricio County, near Sinton, Texas. A previously constructed deer facility, under a scientific research permit (SPR-0290-004) held by the Welder Wildlife Foundation and issued by Texas Parks and Wildlife, was available at the Refuge. The deer facility consisted of eight holding pens; two rows (A and B) each with four individual pens separated by cross fencing (Fig. 2). Exterior and interior cross fences were covered with black nylon material to prevent deer from seeing objects beyond the fences and to minimize outside distractions or disturbances. The two rows of pens were separated by a 5.5-m wide walkway. Individual pens could be accessed via the walkway through 0.9-m wide gates. The walkway allowed researchers to move from pen to pen without disturbing deer. Individual holding pens were approximately 24 x 24 m and had gates (0.9 m) between individual pens within rows that allowed deer to move among pens. Exterior fences were 2.7 m in height and interior cross fences were 2.5 m in height. All fences were constructed of 12.7-cm square-mesh galvanized fencing material supported by 5-cm pipe and creosote-treated telephone poles.

Test Animals

Twenty wild-caught, Texas white-tailed does, trapped in May 1998, were housed in the holding pens. Deer were held under a scientific research permit issued by Texas Parks and Wildlife Department to the Welder Wildlife Foundation. Our research was conducted under Texas A&M University's approved Animal Use Protocol 9-105.

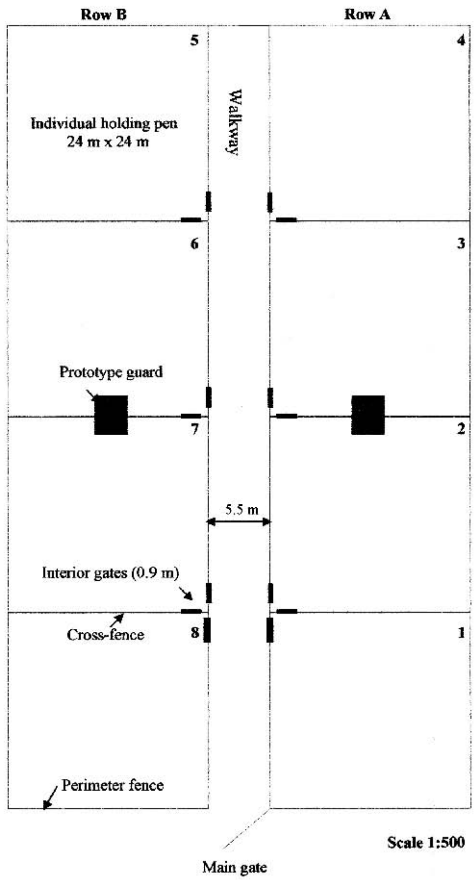

Figure 2. Aerial diagram of deer pens with location of deer guards installed at Welder Wildlife Foundation Refuge, Sinton, Texas.

On 1 September 1998, all deer—except eight does of which four had fawns—were released from the facility. Of the 12 does and fawns kept at the facility, six (four does and two fawns) were placed in each row of individual pens. Pelleted food (20% protein) and water (ad libitum) were provided. In October 1998, an adult male entered the walkway of the facility by coming through the walkway door that had been left open. This male was placed into a separate pen within the facility. During his first night in the facility, he jumped over an interior fence and bred at least one doe (which gave birth to twin fawns in summer 1999), and the next day, he jumped the exterior fence and escaped the facility. In September 1999, an adult male was enticed to enter the pens through an open walkway door. He was isolated from the other deer and later used during guard testing. In December 1999, all deer were released from the facility.

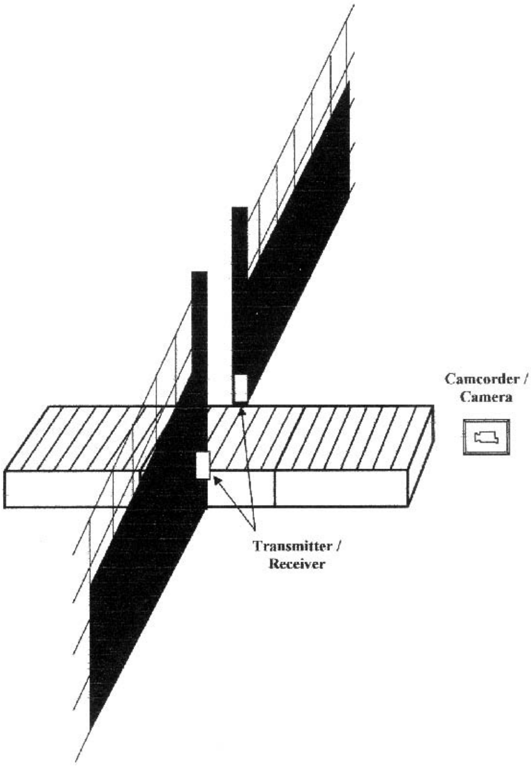

Figure 3. Aerial diagram of 5.5-m guard (three sections) installed in cross fence, at ground level with location of infrared sensors and cameras.

Deer Guard Prototype Construction

We based our original design on the Reed et al. (1974) mule deer guard. Initially (September 1998) two deer guards of a single prototype were constructed for simultaneous testing. Guards were 3.7-m long, measured parallel to potential flow of traffic, and 1.5-m wide, measured perpendicular to the flow of traffic. Cross-member spacing was set at 10.2 cm. The guard frame was constructed of weather resistant treated 5 x 30-cm lumber, and cross-members were made of untreated 2.5 x 10.2-cm lumber. Treated 5 x 30-cm frames built in 1.8-m sections and placed end to end completed the 3.7-m deer guard. Cross-members were attached to the frame by a series of tongue and groove joints that were cut in the interior side of each side frame. This allowed the 2.5 x 10.2-cm cross members to be oriented in a manner so that the 2.5-cm edge was facing upward.

Deer Guard Prototype Installation

On 15 October 1998, the 3.7-m prototypes were installed by cutting out sections of cross fences and placing guards at ground level (Fig. 3). Since the frame of the guard measured 30.5 cm in height, this placed cross-members approximately the same distance above ground level. This type of installation was chosen initially to allow deer to become familiar with the guards. This installation allowed deer to reach the ground, thereby preventing injury, if they attempted to cross the guard.

Galvanized, welded cattle panels were attached to the sides of guards perpendicular to cross-fences. Metal t-posts (1.8 m) supported the panels. The purpose of these panels was to prevent deer from jumping diagonally across the guards, thereby forcing deer to attempt crossing the entire length of the structure. Fresh soil was placed at each end of the 2 replicated deer guards as well as underneath the guard to allow researchers to identify tracks in order to document crossings or attempted crossings. Two weeks following installation (1 November 1998) deer were observed to jump the guards; therefore, an additional 1.8-m section was added to the length of both guards. This third section increased the guard length to 5.5 m.

During late November 1998, the guards were raised to a level of 0.6 m above the ground by attaching legs cut from 5 x 15-cm treated lumber. Ramps constructed of 1.9-cm treated plywood were placed at each end of the guards to allow deer to easily approach the structure. Ramps were covered with soil in order to disguise them and identify tracks of deer approaching the guards. Ramps were used on all raised deer guards through the remainder of the study (31 December 1999).

After completion of the first replication of test procedures, guards were then modified to test effects of guards having sloped ends. The purpose of this modification was to evaluate possible effects of a sloped end that may act as a visible deterrent to deer approaching a guard, or attempting to cross a guard. To modify the guards in a sloped-end configuration, legs were removed at opposite ends of the guard allowing the frame to rest at ground level (Fig. 4). This design was intended to offer alternative methods of guard installation in order to compare effectiveness of a raised object that offers obstruction of vision, versus an object installed at ground level that offers little obstruction of vision. Test procedures were then repeated with the modified guard design and monitored for effectiveness.

Monitoring

To monitor deer-guard effectiveness, infrared-triggered 35-mm TrailMaster cameras (TM 35-1 cameras with TM 1500 sensors, Goodson and Associates, Inc., Lenexa, Kansas) were installed near each guard. The TM 1500 active systems were mounted to fence posts in the center of the cross fence in order to document any animals that reached the mid-length of the guard (Fig. 3). Remote TM 35-1 cameras were mounted to a 2.4-m pole near the end of each guard in order to get a view of the entire structure (Fig. 3).

Additionally, a TrailMaster passive TM 700v video trail monitor was installed in conjunction with an infrared spotlight and Sony 8mm video camera (CCD-TR940) capable of recording in darkness. The Sony 8mm video camera was housed in a waterproof dry box (MTM Molded Products, Dayton, Ohio). A deep cycle, 12-volt marine battery powered the spotlight and video-light controller. The video equipment was installed to collect behavioral data as deer approached or crossed the deer guards (Fig. 3).

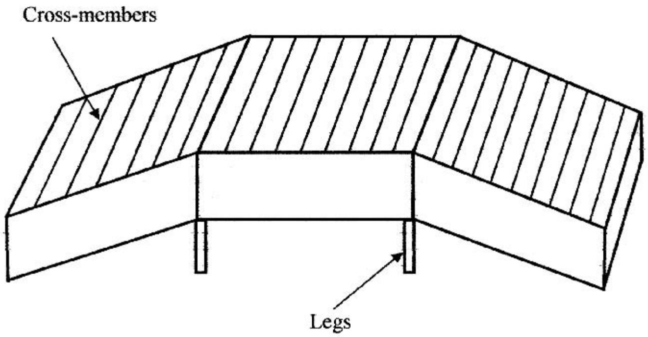

Figure 4. Aerial diagram of modified guard with sloped sides and legs at ends removed.

Events (when sensor beam was broken) were recorded at each guard design, excluding the original 3.7-m prototype, which was not monitored by cameras. Photographs were analyzed and categorized based on type of animal causing the event. If the photograph provided no evidence to what triggered the sensor, it was categorized as unknown.

Test Procedures

Deer Guard Prototype (3.7-m).—The first test was designed to determine the length of guard needed to prevent white-tailed deer from jumping the guard. Reed et al. (1974) noted that mule deer would not jump a 3.7-m guard. From 15–29 October 1998, a 3.7-m guard was installed on the ground between pens 2 and 3 (Row A) and replicated between pens 6 and 8 (Row B; Fig. 2). Water and food were available within all pens (1-8). Six deer (four does and two fawns) were used with each replicate (Row A and Row B).

Deer Guard Prototype (5.5-m) Non-raised.—Guard length was extended to 5.5 m and a second test was conducted from 1–15 November 1998. All other conditions were the same as in the first test.

Deer Guard Prototypes (5.5) with Raised or Sloped Ends.—Once the length of guard needed to prevent white-tailed deer from jumping was determined, 2 (5.5-m) guard prototypes (raised and sloped ends) were constructed to keep deer from walking through the guards. These two prototypes were tested in replicate during 1998 and 1999 using four different test protocols. The four test protocols designed to evaluate the effectiveness of deer guards were: (1) a no-incentive test; (2) additional food and water test; (3) a fawn/doe separation test; and, (4) a rutting buck separated from an estrous doe test (Table 1). The raised prototype was tested in replicate first, followed by replicate tests of the prototype with sloped ends. Each replicate test was conducted for 7 days with each test protocol lasting 14 days (7 days for the duplicate raised-guard tests and 7 days for duplicate sloped-end-guard test).

No Incentive Test.—Six deer (four does and two fawns) were placed in holding pens 3–4 and replicated with six deer (four does and two fawns) placed in pens 5–6 (Fig. 2). Opened doors (Fig. 2) allowed free movement of deer among pens 3 and 4 and pens 5 and 6, while guards were the only obstructions to movement between the additional holding pens. No food or water was placed in pens 1, 2, 7, and 8; therefore, there was nothing to encourage deer to cross the deer guards. This test was developed to duplicate a naturally occurring scenario where deer may try to enter a fenced roadway.

Food/Water Manipulation Test.—For this test, the same deer as used in the no-incentive test were used, and they were left in the same holding pens as per the no-incentive test. Animals were fed and watered at a normal rate in pens 3 and 6 (Fig. 2), while additional water and food were placed (in view of deer through guard openings) in pens 2 and 7 to encourage deer to cross the guards. A more attractive feed (multi-grain, coated with molasses, horse and mule sweet feed) was used in pens 2 and 7. Deer were attracted to the molasses odor of the feed.

Doe/Fawn Separation Test.—Two adult does were separated from their fawns and the rest of the deer herd. Fawns isolated from their does were placed in pens 2 and 7 (Fig. 2), respectively. The mothers of the 2 fawns were placed in pens 3 and 6, respectively. Deer guards offered the only way for does and fawns to reach one another. Deer not used in this test were isolated from the 2 does and their fawns in pens 4 and 5 (Fig. 2). Due to the stress caused by this test to the animals, a maximum separation time of 2 hours was implemented. During this test, animals were monitored on site by researchers, while deer behavior and guard effectiveness were recorded. All deer had food and water available as in previous tests.

Buck/Doe Separation Test.—For this test, a yearling buck and an adult buck were placed in holding pens 2 and 7 adjacent to female deer in pens 3–4 and 5–6 (Fig. 2), respectively. When the breeding season started (tests were delayed until 15 October 1999 due to timing of breeding season), a deer guard was placed between pen 6 (six females and two fawns) and pen 7 (yearling male) and between pen 3 (six females and two fawns) and pen 2 (adult male). Deer guards offered the only way for the receptive does and the bucks to reach one another. Does will cycle up to four times at 27-day intervals if they do not conceive (Silvy, unpublished data); therefore, some does were receptive during all tests (two seven-day replications of raised and sloped guards) which were run from 15 October–31 December 1999, and guards were monitored continuously during this period.

Results

Prototype Test Results

Deer Guard Prototype (3.7 m) .—The original prototype installed at ground level was unsuccessful at preventing deer crossings. Deer jumped the 3.7-m guard within 3 days of the no-incentive test. This was determined by observation of tracks as deer jumped the guard, as well as the presence of deer in what had been vacant holding pens. Since deer were able to jump the original 3.7-m prototype, these deer guards, which were similar to those designed by Reed (1974), were ineffective at pre-

Table 1. Number of tests, dates, duration of individual test, and test procedures used to test raised (sloped and non-sloped) 5.5-m deer-guard prototypes, November 1998–December 1999.

	Raised *(N)*			
Procedure	Sloped	Non-sloped	Date	Duration (days)
No-incentive	2	2	15–29 Nov 1998	7
	2	2	15–29 Sep 1999	7
Food/water	2	2	1–14 Dec 1998	7
	2	2	1–14 Oct 1999	7
Doe/fawn	2	2	15 Dec 1998	2 h
	2	2	15 Oct 1998	2 h
Buck/doe	2	2	15 Oct–31 Dec 1999	14

venting white-tailed deer from crossing. Because of the jumping problem, no further tests were conducted with this prototype and we extended the guard to 5.5 m.

Deer Guard Prototype (5.5), Non-raised.—No deer tried to jump the 5.5-m non-raised guards. Although extending the original prototype to 5.5 m prevented deer from jumping, it did not prevent them from crossing. With guards installed at ground level, deer were able to step between cross-members and walk the length of the structure. We initially installed guards at ground level to prevent injury to deer that were unfamiliar with the structures. Once deer became comfortable approaching and inspecting the structures they soon learned that by stepping between cross-members they could touch ground and walk over the guards. Because of the crossing problem, no further tests were conducted using this prototype. The decision was then made to raise the guards so that if a deer attempted to step through cross-members the deer would not be able to touch ground.

Deer Guard Prototype (5.5-m), Raised.—No animals crossed the 5.5-m guards once they were raised to 0.6 m during the no-incentive, food/water manipulation, or the doe/fawn separation tests during 1998 and 1999. The buck/doe separation test for 1998 was postponed because the adult male that was to be used in this test jumped out of the deer holding facility prior to the start of this test. No deer crossed the prototype during the buck/doe separation test conducted December 1999.

As no deer tried to cross the raised guard design by jumping or stepping though cross-members, this designed proved effective in preventing deer from crossing the guards. We believe the raised guard prevented crossings because of the visual obstruction value (i.e., deer had difficulty seeing over it), and the fact that deer could no longer touch ground when they stepped through cross-members. Although no deer crossed the 5.5-m raised guard, an alternative sloped-end design also was evaluated because some access roads proposed for guard use on US-1 were sloped. We wanted to determine if deer looking into a guard at an angle and not straight down at a guard would try to cross.

Deer Guard Prototype (5.5 m), Raised with Sloped Ends.—No deer crossed the sloped 5.5-m guards during the no-incentive tests in 1998 and 1999. Two deer in

1999 were photographed jumping diagonally across 1 of the sloped guards during the food/water incentive test. This particular guard was not outfitted with full-length side panels. After both guards were fitted with full-length side panels, there were no crossings during the doe/fawn separation tests in either year. No deer were documented crossing the guard during the buck/doe separation test in 1999.

On two independent occasions a yearling buck was able to get into the adjacent pen with a receptive doe, although no photographs or video images were recorded. This buck was later observed to jump the interior 2.8-m high fence separating him from the doe. The adult buck in the replicate test was never observed to cross into pens holding receptive does.

Discussion

During the study, five deer were recorded crossing a guard. Three of the five deer were able to cross the 5.5-m guard that was installed at ground level. Since the 5 x 30-cm frame held cross-members at approximately 30 cm above ground, deer were able to step through them and walk the length of the guard. This illustrated the importance of having guards installed in such a way that a deer's legs could not reach solid ground below the structure, allowing it to walk across.

Two deer crossed the 5.5-m sloped guard that was not outfitted with full-length side panels. They were photographed jumping diagonally (~ 3 m), instead of having to clear the entire length of the guard (5.5 m). Since no deer crossed guards that were outfitted with full-length side panels, illustrating the importance of having side panels that extended the total length of a guard.

Based on the results of this study, we found the 5.5-m guards that were raised or raised and sloped to be an effective for preventing deer from crossing. Used in conjunction with high fences and wildlife crossings, deer guards could aid in reducing highway mortality of Key deer on Big Pine Key, Florida. We conclude that installation of guards at access points along US-1 could decrease Key deer access. We constructed our guards from wood for ease of construction and handling; however, to be used along US-1, guards would need to be constructed with material that would meet FDOT specifications. In addition, our tests were conducted for only 1 week and, over a longer time period, deer may have been able to "learn" to cross the guards. Also, only 12 does, four fawns, and two bucks were tested during the study. If more deer were tested, there is the possibility that some individuals would be more likely to cross guards than others. Once an individual deer "learns" to cross a guard, additional deer may be more likely to cross. Although the deer-guard design is not perfect and may not prevent all deer from crossing, we anticipate that it will be effective because Key deer will have alternate routs to cross the road and there should be less incentive (food, water, or other deer) to enter the highway at access points.

In addition to the benefits from its intended design, deer guards can be valuable with slight modifications at reducing highway mortality of other species of ungulates. The deer guard designed by Reed et al. (1974) was ineffective at preventing mule deer from walking cross-members, while our similar design was effective at preventing smaller-hoofed white-tailed deer from crossing. Over-population of white-tailed deer herds across the United States has been an emerging issue in recent years (Warren 1997). Fencing in conjunction with our deer-guard design could be useful in keeping deer out of residential areas, thus reducing deer/human conflict. Game-resistant fencing has become a popular method of keeping wildlife in or out of private property, ranches, and hunting preserves (Smith-Rodgers 2001). This deer guard could be valuable to an operation that has high traffic areas or does not want to installs gates that impede traffic. With a slight modification in cross-member spacing, this design should work for different sized ungulates (i.e., larger spaces for larger hooves). In addition, changes in guard dimensions such as length, cross-member spacing, width, slope angle, and/or height of guard could be incorporated in order to match physical and behavioral characteristics of many animals.

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