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Comparison of Electrified Mats and Cattle Guards to Control White-Tailed Deer (*Odocoileus virginianus*) Access through Fences

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ABSTRACT: White-tailed deer pose economic and safety concerns for agricultural and transportation industries that may be addressed by reducing their access to areas of concern. Here, we review research findings relative to the efficacy of an electric mat and cattle guard as means to reduce deer access to protected areas. Intrusions of deer across a prototype electronic mat were reduced an average of 95% from pretreatment levels. Deer intrusions across a simulated cattle guard were reduced by at least 88% from pretreatment levels. Comparisons of other cattle guard studies show that when flat material is used instead of rounded for cross members, deer cross the guard. Initial expense for electric mats is lower than for cattle guards, but electric mats will require higher maintenance input than guards. When used as part of an integrated deer control program, properly constructed and maintained electric mats or cattle guards can reduce deer intrusions into areas of concern.

KEY WORDS: cattle guard, deer, deer guard, electric mat, exclusion techniques, *Odocoileus virginianus*, white-tailed deer, wildlife damage management

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INTRODUCTION

White-tailed deer (*Odocoileus virginianus*) populations within the United States have increased from an estimated low of 350,000 to a conservative estimate of 17 million individuals (McCabe and McCabe 1984, 1997). With the increase in numbers of white-tailed deer has come more frequent conflicts with humans due their adaptability to human activities, and fragmentation of habitat (Conover et al. 1995, Hussein et al. 2007). Deer pose direct hazards to people when they move in the way of vehicles, whether automobiles or aircraft (Bashore and Bellis 1982; Conover et al. 1995; Wright 1996; Wright et al. 1998; Dolbeer et al. 2000). In 1993 the estimated costs of deer-automobile collisions in the United States were $1.1 billion with an estimated 29,000 human injuries (Conover et al. 1995). Between 1990 and 2006, there were at least 684 civil aircraft collisions in the United States with white-tailed deer. Damage to aircraft occurred in 82% of these collisions with a total reported cost of $25.7 million. Seventeen deer strikes by aircraft resulted in human injuries, with 1 fatality (Cleary et al. 2007).

In addition, white-tailed deer cause extensive damage to orchards, nurseries, ornamental trees, and shrubs (Scott and Townsend 1985, Purdy et al. 1987, Sayre and Decker 1990). High-density deer populations can also adversely affect native plant communities, including reforestation efforts (Craven and Hygnstrom 1994, Waller and Alverson 1997). Deer damage to agricultural and timber productivity in the United States may be $500 million and $750 million annually for agriculture and timber, respectively (Wywialowski 1994, Conover et al. 1995, Conover 1997).

Limiting access of deer to potential areas of conflict is possibly the most efficacious means of reducing deer damage. Fences of various designs are effective at reducing deer intrusions (Brenneman 1983, Palmer et al. 1983, McAninch et al. 1983, Craven and Hygnstrom 1994, Seamans and VerCauteren 2006). However, openings in fences for vehicles provide access points for deer (Leblond et al. 2007). The use of cattle guards (a grid of metal bars or tubes over a shallow pit) and electronic mats provide a potential means of reducing intrusions (Belant et al. 1998a, Peterson et al. 2003, Seamans and Helon 2008). Frightening devices at openings would not be effective for extended periods of time because deer habituate to the devices (Bomford and O'Brien 1990; Craven and Hygnstrom 1994; Curtis et al. 1995; Belant et al. 1998b,c; Beringer et al. 2003). Clearly, effective and economical deer barriers at gates are needed to exclude deer from airfields, busy roadways, and crop-producing areas. We review recent research to compare both electrified and mechanical at-grade crossing products for fence openings and examine the advantages and disadvantages of each.

EXPERIMENTS

Unless otherwise noted, we refer to work by Belant et al. (1998a) and Seamans and Helon (2008). The aforementioned authors conducted their research within the 2,200-ha NASA Plum Brook Station (PBS), Erie County, Ohio (41° 27' N, 82° 42' W). A 2.4-m-high chain-link fence with barbed-wire outriggers enclosed the facility. Habitat within PBS differed from the surrounding agricultural and urban area and consisted of canopy-dogwood (*Cornus* spp.) (39%), grass-forb fields (31%), open woodlands (15%), mixed hardwood forests (11%), and roads and buildings (4%) (Rose and Harder 1985). The estimated minimum deer density was 91 and 54/km^2 in 1994 and 2004, respectively (E. Cleary and J. D. Cepek, USDA, unpubl. data), reflecting a high deer density when compared to common winter densities in the Midwestern and Great Lakes regions of the United States of 6-13 deer/km^2 (Gladfelter 1984, Menzel 1984).

In 1994, 3 simulated cattle guards were constructed following USDA guidelines and then evaluated in 2 experiments during 1994-1995. An active-infrared trail-monitoring device (TrailMaster®, Goodson and Associates, Inc., Lenexa, KS) was set at each opening and the number of animals crossing through the openings was recorded. Depth of the pits under the cattle guards was increased from 0.5 to 1.0 m to determine if depth played a role in reducing deer crossing.

In 2004, the authors established 10 electric mat test stations ≥1 km apart. At each station they erected an orange snow fence around 3.5 sides of a feed trough that contained about 25 kg of corn. The trough was located about 3 m from the back of the opening of the 6.1- × 6.1-m enclosure. An active-infrared trail-monitoring device (TrailMaster®) was placed at the opening of the site to count deer visits to the trough. The device was installed 60 cm above ground at each opening to continually monitor the number of deer intrusions and avoid recording non-target species (e.g., raccoon, *Procyon lotor*; fox squirrel, *Sciurus niger*).

Ten electric mats (5 control and 5 with power) were installed in 4 days. Each mat was constructed out of five 24-cm-wide (including tongue-and-groove flange) × 4-cm-thick × 3-m-long recycled plastic boards (U.S. Plastic Lumber, Chicago, IL) that were either yellow or black. Electricity was supplied to 5 mats via a Viper™ 5000 solar-powered energizer (Tru-Test Inc., San Antonio, TX) which had a maximum pulse output of 5.0 Joules and was powered by a 12-volt deep-cycle battery. For more detailed information see Seamans and Helon (2008).

EXPERIMENTAL FINDINGS

In each cattle guard experiment, the authors reported that the mean daily number of deer crossings after installation of the guards was reduced by ≥88% when compared to pretreatment crossings. The depth of the excavation under the cattle guard did not alter their results.

Deer intrusions across electrified mats decreased an average of 95% when compared to pretreatment levels. Deer intrusions across non-electrified mats decreased by 60% during the initial phase of the experiment but gradually increased throughout the rest of the experiment to within 10% of pretreatment levels.

Corn consumption at electrified mat sites was initially less than pretreatment amounts but did increase significantly throughout the treatment period. Corn consumption at non-electrified mat sites was initially lower than pretreatment but increased towards pretreatment levels throughout the experimental period. In both electrified and non-electrified sites, the authors report that deer routinely tore down, went through, or jumped over the snow fence surrounding the site.

DISCUSSION

Seamans and Helon (2008) found that white-tailed deer intrusions across an electrified mat were reduced when the mat was operational. However, when power loss to mats, as well as to electric fences, has occurred, deer crossed into protected areas (Seamans and VerCauteren 2006, Seamans and Helon 2008). In addition, within the context of the experiment by Seamans and Helon (2008), deer could jump over the electric mat. However, the authors report little evidence of this occurring either on camera or based on tracks in the snow or mud. Reed et al. (1974) saw similar behavior with mule deer and deer guards. Belant et al. (1998a) found that deer jumped into the middle of simulated guards, but that it was a rare event.

Also, Seamans and Helon (2008) suggest that the pain caused by the shock is enough to prevent deer from returning to the mat with the intention of jumping the protected space. Similar behavior was observed during testing of an electric fence over which deer could easily have jumped over but did not (Seamans and VerCauteren 2006). In both the electric mat and electric fence studies, deer were observed to come within 1 m of an electrified area and then back away before turning to leave. Currently, however, there is no research reporting whether deer can sense electric fields associated with mats or fences.

Notably, Seamans and Helon (2008) report that deer did circumvent the electric mat by tearing down or going over the surrounding snow fence. However, the test occurred in an area with high deer densities (54/km^2) during an energetically stressful period and in the presence of a desirable food source (whole-kernel corn; Wywialowski 1996). Important to the implications of this experiment was that deer entrance into protected areas by means other than crossing the mat provided additional evidence that the mat was perceived as a barrier. Further, the authors note that the destruction of the snow fence to access a resource is a deviation in general behavior (Saur 1984) and a deviation from behavior observed in previous tests (Belant et al. 1997, 1998c; Seamans et al. 2002).

We note that the electrified mat design tested by Seamans and Helon (2008) has been used successfully to keep elk (*Cervus elaphus*) from red willow (*Salix laevigata*) in Arizona. Additionally, when the mat concept has been used in conjunction with electric fence, deer and elk have been funneled across roadways. The fence leads the animals to specific crossing points, and an electric mat embedded in the road inhibits the animals from walking out of the designated crosswalk area (pers. commun., R. Lampman, ElectroBraid Fence Ltd.).

From the perspective of human health and safety, it is possible for a person to be shocked by an electrified mat. For the shock to be felt, contact would have to be made with one of the rods while the person was also in contact with the ground. Although this shock would not be any more severe than could be expected from an electric fence, harmful effects to a person with a heart condition could occur (Fowler and Miles 2002). As with an electric fence, signs should be posted to alert people to the potential hazard presented by the mat.

Material costs for the 3.0 × 1.2-m electric mats described in Seamans and Helon (2008) were about $550; however, the authors report additional costs associated with inclusion of a solar panel and deep-cycle battery. Maintenance costs for electric mats would likely be greater than for cattle guards, as the mats must have electric power maintained to them at all times. A power monitoring system would allow notification of personnel when there was a drop in power. Additionally, electric mats would have to be kept clear of snow and ice so that deer are exposed to electric fields. There would also be a variable cost for electricity to maintain the efficacy of electric mats.

Similar to behavior observed in response to the electric mat, Belant et al. (1998a) reported that deer did not readily cross simulated cattle guards. Peterson et al. (2003) also found that Florida Key deer (*O. virginianus clavium*) were reluctant to cross grates over shallow pits in front of corn feeders. Ward (1982) reported mule deer (*O. hemionus*) crossing over cattle guards but did not include information on the specifications of the cattle guards. Mule deer readily crossed 3-m-wide × 3.7-m-long deer guards made with 1.3-cm-wide, 305-cm-long, 10-cm-apart flat mill steel (Reed et al. 1974). White-tails can also learn to walk across cattle guards when flat stock is used for cattle guard cross pieces instead of rounded stock (C. Lovell, USDA, pers. commun.).

Cattle guards using rounded pipes provide a rough surface for vehicles to cross. Grates, as used by Peterson et al. (2003), avoid creating as rough a crossing as cattle guards, but the authors caution that hoof size must be considered in grate design, as larger deer may be able to cross a grate that smaller deer cannot cross. Guards using flat steel would be smoother for vehicles to cross than guards with rounded stock, but deer also can cross guards using flat steel stock (Reed et al. 1974). Electric mats imbedded in roadways do not create rough areas for motorists to cross. As with grates, the spacing of electric bars must account for the size of the animal that is to be excluded.

Standard cattle guards cost about $1,000 for a 3.6 × 1.8-m guard (American Fence and Supply Co., Georgetown, TX), while guards built for special circumstances may cost up to $40,000 (C. Lovell, USDA, pers. commun.). Peterson et al. (2003) reported that decking alone varied from $40-130/m^2. Importantly, the area under cattle guards will have to be cleaned out and the base structure maintained, but this work should require a minimal annual investment. Cattle guards that use rounded stock should remain effective as long as the pit below is not filled with dirt or hard-packed snow.

MANAGEMENT IMPLICATIONS

Under proper circumstances, both cattle guards and electric mats can successfully prevent deer from crossing into areas where they could present a hazard. Any design will have to account for size and behavior of the animals in that specific area, as deer have shown the ability to circumvent both guards and mats. When deer have gotten past protected openings, and it has been possible to discern why, this would allow for modifications to be made to the system in order to prevent deer from crossing. Electric mats initially may cost less to install but have higher maintenance costs than cattle guards. Cattle guards, when constructed with flat stock to create a smooth vehicle crossing, have been defeated by deer. However, electric mats or cattle guards, when properly constructed, maintained and used in conjunction with fencing, harassment, habitat management, and lethal control (Cleary and Dolbeer 2005), can provide an opportunity to reduce the number of deer crossing through fence openings. This reduction of deer in areas subject to vehicle traffic will reduce the threat deer pose both to themselves and the health and safety of the traveling public.

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