MULE DEER-HIGHWAY MORTALITY IN NORTHEASTERN UTAH: CAUSES, PATTERNS, AND A NEW MITIGATIVE TECHNIQUE

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Introduction

Collisions between deer (*Odocoileus* spp.) and vehicles have resulted in considerable human, economic, and environmental losses. Romin and Bissonette (1996a) estimated that at least 538,000 deer were killed along highways nationwide during 1991. Deer-vehicle encounters are likely to increase as roads are upgraded and expanded through areas of active deer use. This paper reports on the increased levels of deer-vehicle accidents that resulted from highway realignments associated with the construction of a municipal reservoir in northeastern Utah. The study began in October 1991; we present results obtained through November 1995. In particular, we focus on the spatial distribution of deer-vehicle accidents with respect to vegetative and topographic features adjacent to the highways. The observed kill patterns were used to determine placement of newly-designed highway crosswalks. The effectiveness of the crosswalks at reducing deer-vehicle accidents and maintaining migratory movements of the local mule deer (*O. hemionus*) population is discussed. We provide design modifications that may increase the utility of the crosswalk system. In preparing this manuscript, we have drawn heavily from data found in Romin and Bissonette (1996b) and Lehnert (1996). We refer the reader to those sources for a more in-depth analysis of our methodology and results.

We thank the Bureau of Reclamation, the Utah Department of Transportation, the Utah Division of Wildlife Resources (UDWR), and the United States Fish and Wildlife Service for funding and support throughout the study. Special thanks go to L. B. Dalton (UDWR) for initiating funding and coordinating interagency activities.

Study Area

We conducted the study in Summit and Wasatch counties of northeastern Utah. The Jordanelle Reservoir, located approximately 6 km southeast of Park City, was at the center of the study area. Portions of three new highways surrounding the reservoir were used in our investigation: state route (SR) 248 from milepost (MP) 3.3 east to MP 13.5, SR 32 from MP 0.0 east to MP 9.6, and US 40 from MP 4.0 south to MP 13.1. State routes 248 and 32 were two-lane highways with occasional passing lanes. Highway US 40 was a divided four-lane highway. Area vegetation was dominated by oakbrush (*Quercus gambelii*) clones and sagebrush (*Artemisia* spp.)-grass communities. Mule deer inhabited the area throughout the year. Heavy winters, however, forced most deer onto adjacent winter ranges.

Causes of Increased Highway Mortality

Prior to construction of the Jordanelle Reservoir, two roads totalling 42 km traversed the valley floor and provided access to the surrounding communities of Kamas, Francis, and Heber. Highway mortality along those roadways was estimated at 12 deer per year. To accommodate the reservoir, portions of the two roads were closed and subsequently inundated. Three new highways (US 40, SR 248, SR 32) totalling 59 km were constructed at higher elevation to circumvent the reservoir and service the local communities. The new highways traversed areas of more active deer use and bisected seasonal migration corridors. Deer-vehicle collisions were expected to increase to 22 per year (Bureau of Reclamation 1979).

During the first year of new road operation, 174 deer were reported killed by vehicles in the study area, prompting an in-depth analysis to accurately quantify the extent of roadway losses and to identify areas of concentrated deer kill.

Spatial Distribution of Highway Mortality Relative to Roadside Characteristics

We investigated the spatial distribution of deer-highway mortality along study areas roads for three years (1991-1994) prior to mitigative efforts. The first two years were used to identify road-kill patterns. We documented the location of 397 deer mortalities along study area roads during that time. Data from year three (103 deer-vehicle accident locations) confirmed those findings. High kill areas were demarcated, examined for common features, and used in recommending placement of mitigative structures. Installation of the newly-designed crosswalks at these sites helped maintain the daily and seasonal movement patterns of the local mule deer population. Road-kill locations, spotlight counts, and habitat analyses provided the data for these comparisons.

Analysis of designated kill zones compared to non-kill zones on each highway helped identify distinguishing features that aided placement of the crossing structures. Percent vegetative cover was higher for designated kill zones (40%) compared to non-kill zones (29%). High percent cover beyond the right-of-way (ROW) encouraged deer to approach the ROW for preferred foraging. Agricultural areas provided abundant forage away from the ROW and were associated with lower deer-vehicle collision levels. During spotlight censuses, a higher proportion of deer were observed along the

ROW adjacent to dense mountain brush habitat than nearby agricultural areas. Drainages appeared to facilitate initial deer movements toward the highway; 79% of the designated kill zones were associated with major drainages. Only 37% of the non-kill areas were located near drainage features. As evidenced by low correlations between spotlight count data and kill locations, deer did not immediately cross roads where they entered the ROW. Deer moved parallel to the road while foraging within the ROW; snow track analysis supported this conclusion.

Given the unpredictability of deer movements within the ROW, placement of the mitigative structures was primarily based on the location of designated kill zones and the intersection of major drainage features with the road surface. Roadway characteristics at selected locations (i.e., alignment and sight-distance) were used to modify placement of the structures at a smaller scale.

Highway Crosswalk System Installed to Reduce Deer-Vehicle Collisions

Crosswalk System Description.--The crosswalk system restricted deer-crossings to specific, well marked areas along the highways where motorists could anticipate them. Right-of-ways were fenced off with deer-proof fencing to direct the animals to the designated crossing areas. At these locations, deer jumped a 1.0 m high fence to enter the crosswalk funnel constructed of additional deer-proof fencing (Fig. 1a). Once in the funnel the animal could choose to forage on desired ROW vegetation, or continue to approach the road. Federal highway regulations specified that funnel fencing could not extend closer than 9.1 m from the highway surface. Fields of rounded river cobbles were used to demarcate a path for the deer to follow as it continued to approach the road. Painted cattle-guard lines on the road surface were used to delineate crosswalk boundaries for oncoming motorists, and may have served as a visual cue to guide deer directly across the highway. Once across the road, the animal encountered another 9.1 m long dirt path bordered by cobbles, and a narrow fence opening allowing entry to the crosswalk funnel and distant habitat.

Vegetation in and along cobble paths was eliminated to discourage deer from remaining near the highway. A series of three warning signs was installed at each crosswalk to advise motorists that they were entering a crossing zone. Four one-way gates were installed in the vicinity of each crosswalk to enable deer that became trapped along the highway corridor to escape the ROW.

Crosswalk System Effectiveness.--Five crosswalks and associated fencing were installed along SR 248. Four crosswalks and fencing were constructed along the northern half of US 40 (Fig. 1b). State route 32 and the remaining portion of US 40 were left untouched to serve as the corresponding control roads. We monitored highway mortality patterns along the three roads for an additional 15 months following crosswalk installation. To determine the effectiveness of the system, we (1) compared highway mortality levels in treatment and control areas before and after crosswalk installation, (2) used spotlight censuses to document deer use of the highway ROW and indirectly assess whether the crosswalk system impeded seasonal deer migrations, (3) used night-vision equipment to document deer behavior and movement patterns in

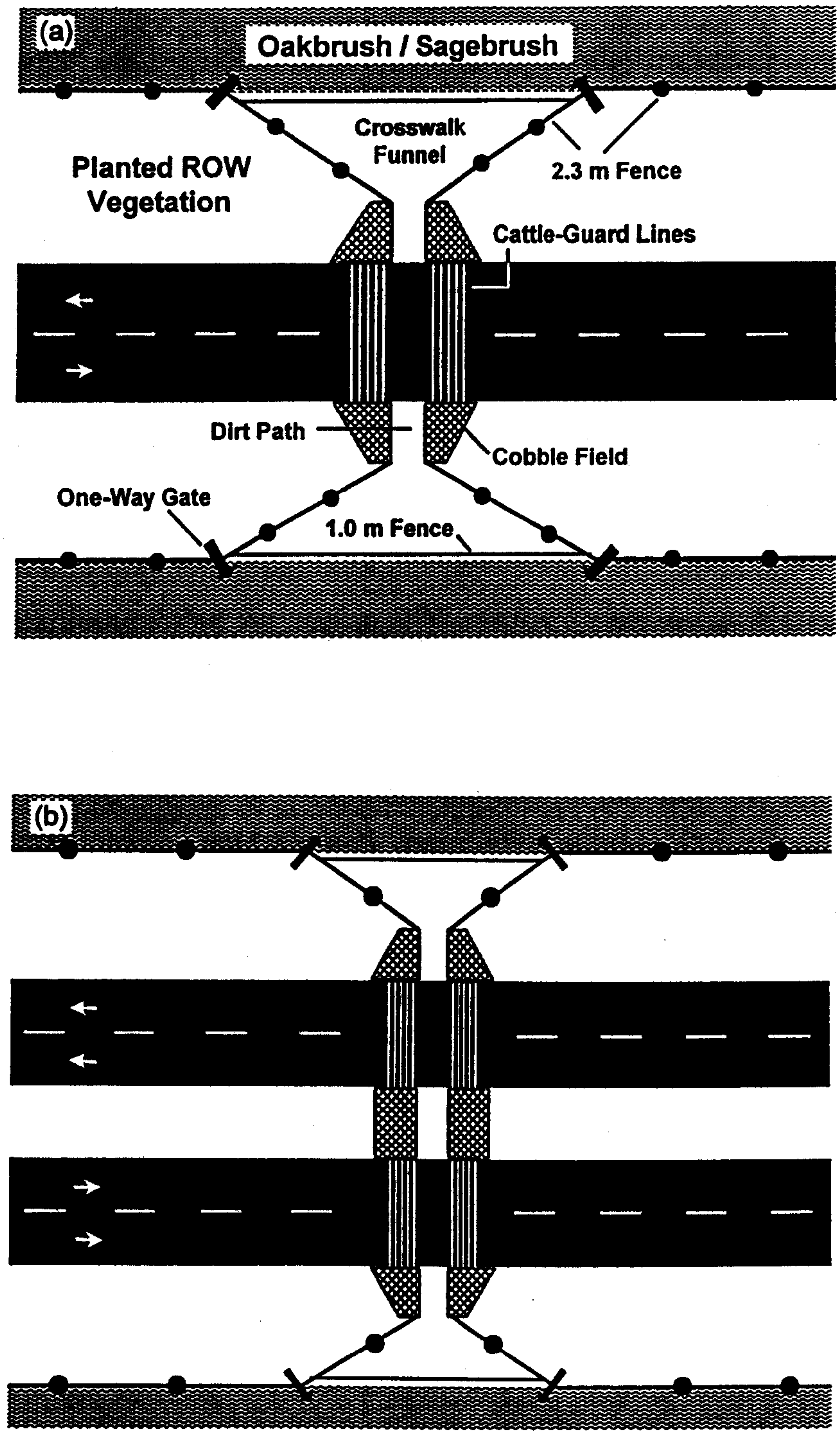

Fig 1. (a) Major features associated with the crosswalk system on a two-lane highway. Crosswalk features were the same on a (b) four-lane, divided highway, except the animal was required to negotiate four-lanes of traffic and a median during its crossing attempt. The median path was demarcated by additional river cobbles. White arrows on the road surface indicate the direction vehicles were travelling.

the crosswalk zones, (4) conducted speed assessments to evaluate motorist response to crosswalk warning signs, and (5) constructed earthen track beds to monitor use of the one-way ROW escape gates.

Based on expected kill levels, we documented a 40% reduction in deer-vehicle collisions subsequent to crosswalk installation. We were unable to statistically demonstrate that mortality reductions were a direct result of mitigative efforts, primarily because high costs precluded the spatial replication required by most statistical tests. Nevertheless, some aspects of the crosswalk system worked as intended and contributed to reduced mortality. Building upon the successes and redesigning aspects of the system that failed may improve the utility of this approach.

The river cobbles and cattle-guard stripes appeared to be effective at guiding deer movements when they entered the crosswalks to attempt a crossing. Animals that entered the crosswalks to forage, however, typically wandered outside crosswalk boundaries to access abundant vegetation along the open ROW. Once this occurred, deer could wander along the highway corridor and attempt to cross in areas where motorists were not expecting them. This behavior likely led to most treatment area mortalities and was expected to increase overall highway mortality levels; 67% of deer-vehicle collisions occurred outside crosswalk boundaries. In addition, only 16% of the deer that approached the one-way escape gates while on the ROW actually passed through them. The remaining 84% continued to wander along the ROW where they were vulnerable to vehicle traffic. Deer-proof fencing reduced overall deer use of the highway ROW by 42%; possibly compensating for the undesired foraging behavior of individual deer and the ineffectiveness of the escape gates. The crosswalk system did not appear to disrupt seasonal movement patterns to and from adjacent winter ranges. Motorist did not slow down while travelling through the crossing zones.

Recommendations for Improvement.--The major shortcomings in the mitigative system were the lack of motorist response to crosswalk warning signs, the tendency for foraging deer to wander outside crosswalk boundaries in search of roadside vegetation, and the ineffectiveness of the one-way gates at enabling trapped deer to leave the highway ROW.

Even though warning signs explicitly warned of the crosswalk, and indicated the distance to it, many drivers may have mistaken them for typical game-crossing signs to which motorists pay little attention. Flashing lights triggered by deer entering the crossing zones could be attached to the warning signs and may help distinguish them from traditional warning signs. The use of pavement "rumble strips" and cautionary speed limit signs may also help to draw attention to the crosswalk location. Because the success of this mitigative approach is heavily dependent upon motorists reducing vehicle speed in the designated crossing zones, further testing of the crosswalk system should be reserved for relatively low speed, low volume highways that service local residents who would encounter deer in the crosswalks frequently enough to recognize the need to slow down.

The crosswalks were designed so that desired ROW forage would be available to animals in the crosswalk funnel. Animals that proceeded to the road were expected to be those intent on crossing. Resources available in the funnel, however, did not appear adequate given the movement patterns of foraging deer. Strategic placement of deer-proof fencing may reduce the inclination for animals to use the crosswalks as a means of accessing ROW vegetation. Currently, the deer-proof fence is as far as 100 m from the highway surface, and forms a barrier at the interface between the ROW resources deer are attracted to and the oakbrush and sagebrush communities characteristic of the area. If deer-proof fencing could be positioned so it was closer to the highway, while still maintaining the required 9.1 m fence-free zone, then desired ROW vegetation would be available to deer on the non-highway side of the fence. Repositioning the ROW fenceline for a few hundred meters on each side of the crosswalk may be sufficient, but should be tested. Replacing vegetation that remains on the highway side of the fence with a less palatable species may further reduce the tendency for deer to wander outside crosswalk boundaries.

Earthen ramps that lead to the top of a deer-proof fence and enable deer to jump to the safety of the other side are a possible alternative to the one-way escape gates. These structures are being used successfully in Wyoming.

Conclusions

This study represents the initial implementation and testing of the crosswalk system. The crosswalks were used because they could be easily installed along the existing roadways at one-sixth the cost required to excavate tunnels and install underpasses. Studying the spatial distribution of mortalities prior to mitigative efforts enabled us to identify critical areas where the crosswalks were placed. Placing the structures in areas where deer frequently attempted crossings helped maintain daily and seasonal deer movement patterns. Although statistical results precluded statements that observed mortality reductions were a direct result of mitigative efforts, the potential applicability of the crosswalk system should not be dismissed. Observations of deer successfully crossing within crosswalk boundaries, the apparent maintenance of migratory behavior, and reduced deer use of the highway ROW indicate that the system warrants further testing. This study identified problems in the original design so that modifications can be made. The crosswalk system should be tested in multiple settings before the upper limits of success and its applicability for widespread use, or lack thereof, can be defined.

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