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Landscape factors that contribute to animal–vehicle collisions in two northern Utah canyons

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ABSTRACT

Animal–vehicle collisions (AVCs) are a serious problem that can result in property damage and human and animal injury and death. This study investigated the role that elevation, slope, and vegetation may have in AVC locations (mule deer *Odocoileus hemionus* and elk *Cervus canadensis*) in several canyon corridors in north central Utah. This was done by comparing these characteristics around known AVCs with those around control points where AVCs did not occur. The study found that elevation was significantly lower around AVC points, slope was significantly greater, and there was no difference in overall vegetation when measured with NDVI, but there was a difference in percentage of Sage brush (*Artemisia tridentata* Nutt) steppe around the points. AVCs may occur in these areas because mule deer tend to be more active in the lower elevations and use steeper slope for cover. Also, in areas with greater slope, the road will probably be curvier and provide less driver visibility than in areas with less steep slope. These results may help guide where to place deer warning signs and other AVC mitigation strategies.

Introduction

Animal–vehicle collisions (AVCs)

Human–environment interactions occur when humans encroach on wild land or when humans convert wild land into usable land. Often times, roads are built through the middle of previously wildlands where they act as corridors for vehicles. These roads may intersect wildlife migration or movement patterns. Animal–vehicle collisions (AVCs) represent one of the most common and dramatic types of human–environment interactions, and AVCs are a significant problem in many areas of the United States and throughout North America (Conover, Pitt, Kessler, DuBose, & Sanborn, 1995; McKee & Cochran, 2012). For example, in 2002 there were over 1.5 million AVCs resulting in over 1 billion dollars in damages, 150 human fatalities, and approximately 1.5 million white-tailed deer deaths (Curtis & Hedlund, 2005). In total, there are roughly 4100 AVCs per day in the United States resulting in daily damage of over 2.7 million dollars. The average insurance claim for an AVC is $3050 (Gkritza, Baird, & Hans, 2010). Unfortunately, the number of AVCs is increasing in North America (Ng, Nielsen, & St. Clair, 2008). This increase has been linked to rising human and animal populations (Found & Boyce, 2011).

AVCs have been studied in a large variety of contexts and with different kinds of data. For example, Gonser, Jensen, and Wolf (2009) examined the spatial distribution of AVCs and habitat type in a western Indiana county. They found that the location of AVCs does not occur due to random chance and that habitat type probably plays an important role in the AVC locations. As almost all AVCs occur at night (80–90%), Mastro, Conover, and Frey (2010) examined factors that influence how motorists see deer at night using deer decoys. The authors found that deer are better detected when there are no reflective highway signs and the car's high-beams are on. Motorists were able to detect deer equally whether they were moving or stationary. Finder, Roseberry, and Woolfa (1999) examined the role of topographic features, highway construction variables, and landscape metrics around areas with high numbers of deer–vehicle collision in Illinois. The authors discovered that greater distances to forest cover resulted in fewer collisions. Found and Boyce (2011) discovered that deer–vehicle collisions occur more in urban areas where the vegetation along the road was both dense and diverse, and that collisions are more likely to occur along roads with small-width groomed rights-of-way. Farrell and Tappe

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(2007) found that DVCs were related to urban environments with high road and human population densities with average daily traffic.

Various techniques have been used to mitigate AVCs (Gkritza et al., 2010). These techniques can be grouped into three categories: 1) driver measures – driver education, animal warning signs, reduced speed limits; 2) animal measures – herd reduction, fencing, vegetation management, underpasses; and 3) driver/animal measures – special lighting and long-term road management (Gkritza et al., 2010). However, in many areas, little or no collision strategies are implemented. For example, in a survey of 22 transportation agencies across the United States and Canada, it was found that 68% rarely or never consider AVC avoidance solutions, and 77% rarely or never employ AVC avoidance solutions (Kociolek & Clevenger, 2007).

Mule deer and elk biology

Rocky Mountain Mule deer (*Odocoileus hemionus*) are members of the deer (or cervid) family – along with moose, elk, and caribou. Mule deer inhabit much of the western third of North America. Mule deer get their name from their large mule-like ears. Where white-tailed deer are common throughout much of the eastern and central parts of North America, mule deer are dominant in the west. However, white-tailed deer have made inroads into several western states including Montana and Colorado.

Similar to their eastern cousins, mule deer forage most actively at dusk and dawn and typically bed down in protected areas during the day. Their beds are generally located close to both water and forage. During the summer and early fall, bucks tend to remain at higher elevations while does and fawn stay in lower elevations. By late fall, bucks join the does at lower elevation to mate and spend the winter. The rut is the breeding period for mule deer. In Utah, the rut usually occurs in mid-November. Does usually give birth to two fawns in late spring at intermediate elevations. The average birth date for fawns in Utah is June 20 (Robinette, Hancock, & Jones, 1977).

Mule deer can have body sizes up to six feet long and four feet high at the shoulder and weigh up to 350 pounds. In winter, mule deer are usually brownish gray with white fur on the stomach, rump, throat, and inside legs. In summer, the general pattern is the same, but the brownish gray color becomes yellowish or reddish brown. Mule deer forage mostly on herbaceous plants and various berries during the summer. During winter, mule deer forage on conifers (e.g., Douglas fir *Pseudotsuga menziesii* and Utah juniper *Juniperus osteosperma*). The antlers on buck mule deer begin to grow as soon as antlers are shed in late winter. Mule deer were common in Utah when Europeans first settled the state, but they are not as prevalent today (Rawley, 1985). Mule deer were not protected in Utah until around 1900. Since then, a closed mule deer season has generally occurred in the fall (State of Utah, 2008).

Rocky Mountain elk (*Cervus canadensis*) is Utah's state animal. Elk typically live in close association with both Mule Deer and Moose (*Alces alces*) throughout Utah. Elk are a generalist ungulate. During the summer, elk forage on grasses and forbs. In winter, they forage on grasses, shrubs, tree bark, and twigs. This kind of diet allows elk to live in a large variety of habitat – all the way from high elevation in Utah's mountains to lower elevation deserts. However, elk seem most comfortable in the high elevation aspen/conifer forests during warmer months. Elk can get up to 700 pounds and stand five feet tall at the shoulder.

Similar to mule deer, elk tend to forage at dawn and dusk and bed down during the day. On hot summer days, elk may wade or lie in streams, rivers, or ponds to seek relief from the heat and biting insects. Elk breed during the fall rut, and bulls aggressively defend their cow harems from other bulls. Sometimes bull elk wage vicious battles for a harem. Elk calves are usually born in late May to early June. Cows, calves, and yearlings live together in loose groups while bulls choose to live in small bachelor groups or alone. In heavy snow, cows, calves, and young bulls tend to migrate to lower elevations.

Both mule deer and elk are popular game animals that are heavily managed by the Utah Department of Natural Resources. The state's most recent mule deer management plan was implemented in 2008. Utah's elk management plan was implemented in 2010. Each management plan attempts to maximize opportunities for sportsmen and sportswomen while addressing concerns from farmers, landowners, and home owners.

Study objectives

Remote sensing and GIS data and techniques can provide insight into the landscape characteristics and distribution of AVCs (e.g., Finder et al., 1999; Found & Boyce, 2011; Gkritza et al., 2010; Gonser et al., 2009). However, land cover datasets that help to describe habitat structure describe only sedentary habitat information, and land cover usually changes because of human disturbance. The purpose of this research is to determine other landscape characteristics that may determine locations of AVCs. It is hoped that this analysis may help to illuminate locations where AVCs may have a higher probability of being located.

Knowledge about factors that influence animal movements around, onto, or across roads and highways is needed to better understand – and then mitigate – AVCs (Finder et al., 1999). Specifically, this study examined the relationship between AVCs and elevation, slope, and vegetation. The study was implemented based the belief that AVCs are probably not occurring at random (e.g., Gonser et al., 2009). To investigate this, we first plotted AVCs throughout several major canyon roads in north central Utah. After this, we noted areas along the roads where AVCs did not occur and plotted these areas as control points. Then, we compared elevation above sea level, slope, and the Normalized Difference Vegetation Index (NDVI) values and percentages of different land cover around both the AVC points and the control points. In summary, the study is based on the working hypothesis that deer–vehicle collisions are determined – at least in part – on the biotic and abiotic characteristics around them and that geospatial technologies can aid our understanding of their locations.

Methods

Study area

This study was conducted in two canyon highways in north central Utah: Provo Canyon, located to the north and east of Provo, Utah (United States Highway 189; 40.32°N, 111.63°W), and Spanish Fork Canyon, located south and east of Spanish Fork, Utah (United States Highway 6). Provo canyon is the main corridor from Utah Valley to Heber City and Park City, Utah and to Interstate 80. Spanish Fork canyon (40.07°N, 11.57°W) supports traffic on United States Highway 6 from Utah Valley to Price, Utah and ultimately traffic from Interstate 15 to Interstate 70. In addition, a highway spur south from Highway 6 (40.00°N, 111.49°W) into the Fairview, Utah area was part of this study (United States Highway 89). As main traffic routes, these roads provide an ideal setting to study AVCs in a relatively large area (Fig. 1). An example of an AVC involving elk is shown in Fig. 2. The location of this AVC is noted with the 'X' (40.03°N, 111.51°W) in Fig. 1.

Both mule deer and elk are common throughout the study area. AVCs involving both animals were included in this analysis. Mule