EXECUTIVE SUMMARY

Animal-vehicle collisions (AVCs) are a growing concern as vehicle miles traveled and human encroachment into wildlife habitat continues to increase throughout the United States. Measures to prevent AVCs such as wildlife exclusion fencing and wildlife passages can impose significant investments for transportation agencies. One potentially less expensive approach is to use intelligent transportation systems (ITS) to modify driver behavior to reduce these collisions. This study investigated the effectiveness of ITS to disseminate seasonal animal movement advisories as a speed reduction tool on interstate highways in the field and replicated in a virtual environment. The project consisted of the following components:

- A literature review to document previous research related to the subject;
- A field study in the Bozeman Pass region of Interstate 90 in Montana, to investigate the effectiveness of wildlife advisories posted on Dynamic Message Signs;
- A simulator study to investigate the relative impact of various types of message signs on driver behavior;
- Field monitoring of wildlife-vehicle collisions and movements on Bozeman Pass; and
- A survey of Montana Department of Transportation (MDT) division maintenance chiefs to document the impacts of AVCs on their operations.

Literature Review

The literature review focused on studies addressing the relationship between speed and animal-vehicle collisions, and driver responses to signs in the field as well as in a simulated environment. Researchers consulted an internal literature database of approximately 2,600 articles related to wildlife and transportation, the Proceedings from Transportation Research Board Annual Meetings, Transportation Research Information Services (TRIS) On-line, and other on-line literature search engines in the transportation engineering and wildlife ecology sectors. Principal findings included:

- Driver speed likely contributes to AVCs;
- Enhanced signs, with additional, unique features to catch the attention of drivers, have greater potential of impacting driver behaviors;
- Enhanced static animal advisory warning signs have been studied in a limited number of field studies with varying results; and
- Simulator studies indicate that dynamic warning messages have a short-term impact on driver speed, but that drivers often increase speeds later, resulting in ambiguous safety results.

In summary, the literature reveals significant variation in driver responses to enhanced signs. The potential to reduce speeds and AVCs using enhanced signs is likely to be affected by interactions between the sign's characteristics (size, design, location), its message, the surrounding context (environment, time of day or season), the driver's

ability to see and understand the message, and the driver's familiarity with the local conditions and potential risks in the area.

Field Study

In the field study, Dynamic Message Signs (DMSs) were used to post messages advising motorists to watch for wildlife moving across Interstate 90 in the Bozeman Pass region of southwestern Montana. One control and three treatment messages were displayed on two permanent and one portable DMS, and individual speeds were recorded to measure drivers' responses to these messages. The control message was comprised of a blank message and three treatment messages, which included a general transportation advisory message and two wildlife advisory messages. Field study results suggest the following:

- The wildlife advisory messages posted on DMS reduced average motorist speeds;
- Speed reductions associated with the wildlife advisory messages were greatest during "dark" conditions;
- A greater speed reduction was observed after drivers passed animal advisory messages on the portable DMS compared to the permanent DMS; and
- Responses to animal advisory messages on DMS waned over time and distance traveled past the signs.

Another component of the field study was a local public outreach campaign, in which press releases and radio public service announcements were disseminated regarding wildlife movements in the Bozeman Pass area. The driver survey conducted for the field study included questions regarding the public outreach effort, and provided qualitative feedback indicating that the publicity did reach drivers.

Driving Simulator Study

The driving simulator study examined driver responses to enhanced wildlife advisories as a potential means of reducing wildlife-vehicle collisions. The study was conducted in the WTI Driver Simulator Laboratory, in a scenario that replicated the Bozeman Pass environment used in the field study. Eighty-one participants were divided by age and gender into four groups. Each group was exposed to a different wildlife advisory sign treatment consisting of the following: (1) a standard sign with the text "Next 20 Miles", (2) a standard sign with flashing beacon with the text "Next 20 Miles", (3) a Dynamic Message Sign (DMS) with the text "Animal Crossing Next 20 Miles Be Alert"; and (4) a combination of a DMS with the text "Animal Crossing Next 20 Miles Be Alert" and a standard sign with a flashing beacon with the text "Next 20 Miles" located approximately 6 miles beyond the DMS sign. Results indicated the following:

- All enhanced signage treatments resulted in decreased speeds and an increased onset of braking distance (i.e. faster reaction time);
- The standard sign with flashing beacon demonstrated a statistically significant reduction in speed over the standard sign; and
- The combination treatment of the standard sign with flashing beacon and the DMS sign was "positively identified" most often, resulted in the least number of

collisions with deer (in the simulated scenario), and provided the greatest statistically significant onset of braking distance.

In conjunction with the speed study recommendations regarding seasonal use and placement of enhanced signs, it appears that the use of multiple enhanced animal advisory signs, on a seasonal and site-specific basis, has greater potential to increase driver awareness and potentially decrease speeds in hopes of reducing animal-vehicle collisions compared to the use of the standard, static wildlife warning signs. Further driver simulator studies would be useful in exploring what types, combinations of, and appropriate distances between enhanced signs maximize driver awareness and speed reductions.

Wildlife Monitoring

Due to the short-term nature of this project, the ultimate variable of interest, animal-vehicle collision rates, could not be evaluated in terms of the effect of the DMS messages in a statistically sound manner. However, this project allowed the continuation of wildlife traffic mortality and movement monitoring that was initiated to assess the effect of wildlife fencing that is being installed and landscape modifications that have been incorporated into the reconstruction of the Montana Rail Link underpass near the Bear Canyon interchange on I-90. The monitoring efforts consisted of:

- Road-kill data collection and analysis. From 2001-2005, researchers conducted more than 500 road kill surveys and documented more than 1300 AVCs. Most AVCs occurred in June, July, September, October and November during those years. Two regions with higher than average numbers of AVCs across the study area were identified; and
- Monitoring of wildlife behaviors and movements in the Montana Rail Link (MRL) overpass area of I-90. Using tracking beds, researchers were able to establish crossing rates under I-90 for deer. Remote motion- and heat-sensing cameras verified the presence of numerous other species in the overpass area.

Maintenance Operations Impacts

To better understand how and to what degree the Montana Department of Transportation's (MDT) Maintenance Operations are impacted by AVCs, researchers developed and delivered a survey to Maintenance Chiefs in all maintenance divisions in the state in August 2005. Survey questions sought to qualitatively characterize the approaches, issues, expenses, and challenges related to road killed carcass removal in the various divisions. Twelve surveys were completed by 14 individuals and returned by October 2005. Results are summarized, below:

- Maintenance operations opportunistically remove, dispose of and report animal carcasses from the roadways in their divisions as part of routine road inspection duties;
- Reporting appears to vary somewhat from division to division; e.g., some divisions report all animal carcasses observed, while others may not report domestic animal carcasses or carcasses that were moved but not removed and disposed of outside of the right-of-way, or there were a few divisions that reported

carcass locations to the nearest mile marker while most divisions reported locations to the nearest tenth of a mile;

- Effort and expenses associated with these duties is challenging to quantify because this task is lumped with other "debris removal" activities associated with routine road inspections; however some divisions estimated that these duties may comprise 1-3% of their division's annual budget; and
- Signs are currently the main mitigation measure used in most if not all divisions, but several efforts (e.g., wildlife fencing and crossing structures, animal-detection/driver-warning system) are newly installed or planned in some divisions.

At this time, it is not clear how much effort is required to maintain other mitigation techniques such as wildlife fencing and crossings or animal-detection systems, nor is it apparent how well the mitigation may perform. Hence, assessment of the trade-offs of proactive investments in mitigation versus the time and expense for removing and disposing carcasses may be premature given the relatively new or planned mitigation installations.

Summary of Recommendations

Based on the field speed study's results, the driver simulator study results, and the literature, researchers suggest that enhanced animal advisory signs can affect driver behavior with the potential of reducing animal-vehicle collisions. However, overuse or inappropriate use of such signs may result in drivers becoming complacent to the importance of these signs. A brief summary of recommendations regarding the use of enhanced wildlife advisory signs follow:

- If using DMS to deliver animal advisory messages, follow guidelines on message construction;
- If using enhanced standard signs, use larger-than-typical sizes and fonts and consider including flashing lights, bright flagging, and reflective backing;
- Apply signs as close to specific areas where there is documentation of concentrated animal movements or AVCs, understanding that driver responses will be greatest where they first see the sign;
- Apply or activate signs when animal movements and AVCs peak, typically at night during the fall months;
- Consider the characteristics of the driving population, favoring areas where local motorists may be more aware of AVCs and animal movements. Consider using enhanced signs in conjunction with education outreach and/or public relations campaigns advising drivers of the risks of AVCs;
- Driver simulator studies would be useful in exploring what types, combinations of, and appropriate distances between enhanced signs maximize driver awareness and speed reductions; and
- Driver surveys may also provide useful insight that may allow for adaptive management of the use of these signs.

Regarding the on-going wildlife monitoring efforts to assess the effectiveness of the wildlife fencing and landscaping efforts that will be installed in the fall of 2006 at the Montana Rail Link (MRL) bridge, researchers recommend the following:

- Three to five years of post-fencing monitoring would be an optimal investment of energy in order to make reasonable quantitative comparisons between the pre- and post-fencing AVC data to determine the effect of the fencing. The minimum estimated detectable decline in ungulate-vehicle collisions (UVCs) for three to five years of post-fencing monitoring in the areas to be fenced ranged from 36-27%, while the minimum detectable decline in the area to be fenced plus 0.2 miles adjacent to the fence area ranged from 31-19% given three to five years of post-fencing monitoring.
- Attention must be given to the seasonal differences in UVC and crossing rates by ensuring equal sampling sessions between fall, winter, and summer seasons;
- The UVC and crossing rate data should be assessed annually to determine effectiveness. Effectiveness was defined (by panel consisting of staff from MDT, Montana Fish, Wildlife and Parks, and American Wildlands) as a reduction in UVCs and any degree of wildlife movements under the MRL bridge; and
- Consider adaptive management options if data indicate wildlife fencing does not reduce AVCs or limits wildlife movements.

To better assess the cost-effectiveness of investments in proactive efforts to address AVC issues versus current expenditures and resources dedicated to responding to AVC occurrences, an additional focused assessment of maintenance operations (beyond this study's qualitative survey) is recommended. If the investment of time to post seasonal DMS wildlife advisories is relatively minimal and drivers respond to the messages either by reducing speed, increasing awareness, or both, there may be a "payoff" in terms of fewer collisions with animals, fewer carcasses to remove and report over the years. If divisions have DMS and/or enhanced signs available for seasonal animal advisories, documentation of the effort to deploy these measures and long term monitoring of AVC rates and carcass removals at these sites before and after the deployments could help quantify these trade-offs (i.e., a meta-analysis across all deployment sites in the state to increase statistical power to detect changes in AVC rates and carcass reporting), while proactively increasing the potential for drivers to reduce speeds, increase awareness and ultimately respond faster to avoid a collision with an animal.

In conclusion, efforts to increase driver safety and decrease impacts on wildlife movements in the Bozeman Pass area uniquely address both driver and animal behaviors. The speed study and driving simulator study evaluated methods to modify driver behavior via relatively inexpensive applications of enhanced and targeted signs to deliver wildlife advisory messages at specific times and locations when and where drivers are most likely to encounter animals on the road. The wildlife monitoring efforts provided baseline data on animal-vehicle collisions and wildlife movements in the vicinity of an upcoming installation of wildlife fencing to limit wildlife from crossing the interstate risking colliding with passing vehicles; after fencing is installed, monitoring will continue in order to provide data to evaluate the effectiveness of the fencing in terms of reducing animal-vehicle collisions while providing safe passage under the interstate. The

outcomes from the fencing evaluation will be combined with the results from this project to provide a single, comprehensive assessment that can be used to guide future decisions related to managing wildlife-transportation conflicts in the northern Rocky Mountain region.