Outreach and Technology Transfer on the Effectiveness of Wildlife Fences and Wildlife Crossing Structures in a Multifunctional Landscape

Marcel P. Huijser, Ph.D.
Western Transportation Institute (WTI)
Montana State University
P.O. Box 174250
Bozeman, MT 59717-4250

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Prepared by: Marcel P. Huijser, Ph.D.

Center for Environmentally Sustainable Transportation in Cold Climates
Duckering Building Room 245
P.O. Box 755900

Fairbanks, AK 99775
U.S. Department of Transportation
1200 New Jersey Avenue, SE
Washington, DC 20590

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## Authors
Marcel P. Huijser, Ph.D.  
Western Transportation Institute (WTI)  
Montana State University  
P.O. Box 174250  
Bozeman, MT 59717-4250

## Performing Organization Name(S) and Address(es)
Center for Environmentally Sustainable Transportation in Cold Climates  
University of Alaska Fairbanks, Duckering Building, Room 245  
P.O. Box 755900  
Fairbanks, AK 99775-5900

## Abstract
This project undertook outreach and technology transfer tasks on the effectiveness of wildlife fences and wildlife crossing structures in a multifunctional landscape. The tasks accomplished included (1) publication of an article in an international peer-reviewed journal on the effectiveness of wildlife mitigation measures along U.S. Highway 93 North; (2) submitting an abstract to, presenting at, and attending the 2017 International Conference on Ecology and Transportation in Salt Lake City, Utah; and (3) updating the website and outreach material of the People’s Way Partnership (http://www.peopleswaywildlifecrossings.org/).

## Keywords
Animals, Article, Connectivity, Corridors, Crossing structures, Deer, Ecology, Effectiveness, Habitat, Highways, Large mammals, Mammals, Mitigation, Movement, Native American, Outreach, Peer-reviewed, Publication, Science, Transportation, Tribes, Ungulates, Underpasses, Wildlife
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| **AREA** | | | | **AREA** | | | |
| in² | square inches | 645.2 | mm² | mm² | millimeters squared | 0.0016 | square inches | in² |
| ft² | square feet | 0.0929 | m² | m² | meters squared | 10.764 | square feet | ft² |
| yd² | square yards | 0.836 | m² | m² | meters squared | 39.30 | square yards | yd² |
| mi² | square miles | 2.59 | km² | km² | kilometers squared | 2.471 | acres | ac |
| ac | acres | 0.4046 | hectares | ha | | | |

| **MASS** (weight) | | | | **MASS** (weight) | | | |
| oz | Ounces (avdp) | 28.35 | grams | g | g | grams | 0.0353 | Ounces (avdp) | oz |
| lb | Pounds (avdp) | 0.454 | kilograms | kg | kg | kilograms | 2.205 | Pounds (avdp) | lb |
| T | Short tons (2000 lb) | 0.907 | megagrams | mg | megagrams (1000 kg) | 1.103 | short tons | T |

| **VOLUME** | | | | **VOLUME** | | | |
| fl oz | fluid ounces (US) | 29.57 | milliliters | mL | mL | milliliters | 0.034 | fluid ounces (US) | fl oz |
| gal | Gallons (liq) | 3.785 | liters | L | liters | 0.264 | Gallons (liq) | gal |
| ft³ | cubic feet | 0.0283 | meters cubed | m³ | m³ | meters cubed | 35.315 | cubic feet | ft³ |
| yd³ | cubic yards | 0.765 | meters cubed | m³ | m³ | meters cubed | 1.308 | cubic yards | yd³ |

**Note:** Volumes greater than 1000 L shall be shown in m³

| **TEMPERATURE** | | | | **TEMPERATURE** | | | |
| °F | Fahrenheit | 5/9 (°F-32) | Celsius | °C | °C | Celsius temperature | 9/5 °C+32 | Fahrenheit | °F |

| **ILLUMINATION** | | | | **ILLUMINATION** | | | |
| fc | Foot-candies | 10.76 | lux | lx | lx | lux | 0.0929 | foot-candies | fc |
| fl | foot-lamberts | 3.426 | candela/m² | cd/cm² | cd/cm² | candela/m² | 0.2919 | foot-lamberts | fl |

**FORCE and PRESSURE or STRESS**

| lbf | pound-force | 4.45 | newtons | N | N | newtons | 0.225 | pound-force | lbf |
| psi | pound-force per square inch | 6.89 | kilopascals | kPa | kPa | kilopascals | 0.145 | pound-force per square inch | psi |

These factors conform to the requirement of FHWA Order 5190.1A *SI is the symbol for the International System of Measurements

![Temperature Scale](https://via.placeholder.com/150)
ACKNOWLEDGMENTS

The authors of this report would like to thank the Center for Environmentally Sustainable Transportation in Cold Climates for funding this project. The authors thank the Montana Department of Transportation for permission to conduct research related to the crossing structures and other mitigation measures in the right of way, and they thank the Confederated Salish & Kootenai Tribes for advocating for the wildlife crossing structures and associated mitigation measures, providing input throughout the planning and implementation process, and granting us permission to conduct research on tribal lands.
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EXECUTIVE SUMMARY

This project undertook outreach and technology transfer tasks on the effectiveness of wildlife fences and wildlife crossing structures in a multifunctional landscape. The following tasks were accomplished:

1. An article in an international peer-reviewed journal on the effectiveness of wildlife mitigation measures along U.S. Highway 93 North.

We measured movements of large mammal species at 15 elliptical arch-style wildlife underpasses and adjacent habitat along a 56-mile (90 km) stretch of U.S. Highway 93 North on the Flathead Indian Reservation in western Montana between April and November 2015. We investigated whether movements of large mammals through the underpasses were similar to the movements of large mammals in adjacent habitat. We found that across all structures, large mammals (all species combined) were more likely to move through the structures than pass at a random location in the surrounding habitat.


We investigated the effectiveness of wildlife fences and wildlife crossing structures in reducing vehicle collisions with large mammals and of providing habitat connectivity for deer and black bear along a U.S. Highway 93 North reconstruction project on the Flathead Indian Reservation in Montana. Vehicle collisions with large mammals were reduced by 71% (carcass removal data) and 80% (wildlife crash data). For the unmitigated road sections, vehicle collisions with large mammals did not remain the same before and after highway reconstruction; they increased by 232% (carcasses) and 91% (crashes). This finding suggests that historic wildlife-vehicle collision data are not a good predictor of collisions after highway reconstruction. We also
investigated habitat connectivity for deer and black bear before and after highway reconstruction and the associated implementation of mitigation measures. Highway crossings by deer remained similar or increased after highway reconstruction. Highway crossings by black bear remained similar after highway reconstruction. We conclude that highway reconstruction and the associated mitigation measures did not reduce habitat connectivity for deer or black bear.

3. An updated website and outreach material for the People’s Way Partnership.

The website of the People’s Way Partnership was updated through restructuring of the web pages. The text on the website was improved by making it more concise and understandable for a general audience, including information from the final report of the U.S. Highway 93 North research project. We included still images of wildlife using the structures, a link to a YouTube video with animals using the structures, a link to the Facebook feed of the People’s Way Partnership, information about the student drawing contest on wildlife crossing structures, and downloadable outreach materials.
CHAPTER 1.0
INTRODUCTION

1.1 Background

In the United States, the total number of deer-vehicle collisions has been estimated at 1–2 million per year, and that number is increasing (Conover et al. 1995, Huijser et al. 2008). These collisions lead to substantial property damage, cause human fatalities and injuries and animal deaths with the loss of associated economic values, and negatively affect the population level of certain species (Romin and Bissonette 1996, Huijser and Bergers 2000, Huijser et al. 2009a). Over 40 different mitigation measures have been implemented or described to reduce animal-vehicle collisions (Huijser et al. 2008). However, only wildlife fencing in combination with safe crossing opportunities for wildlife (e.g., Clevenger and Huijser 2011) and animal detection systems (Huijser et al. 2006, 2009b) have been shown to substantially reduce collisions with large mammals.

The U.S. Highway 93 North (US 93 North) reconstruction project on the Flathead Indian Reservation in Montana represents one of the most extensive wildlife-sensitive highway design efforts to date in North America. The reconstruction of the 56-mile (90 km) road section included the installation of wildlife crossing structures at 39 locations and wildlife exclusion fences along approximately 8.71 miles (14.01 km) on both sides of the road. The mitigation measures are aimed at improving safety for the traveling public by reducing wildlife-vehicle collisions while simultaneously allowing wildlife to continue to move across the road. The wildlife mitigation measures along US 93 North are an integral part of the reconstruction of this highway because the Confederated Salish and Kootenai Tribes (CSKT) required the reconstruction efforts to be respectful of the land, the people and their culture, and the wildlife.
The federal, state, and tribal governments agreed to reconstruct US 93 North based on the idea that “the road is a visitor and that it should respond to and be respectful of the land and the 'Spirit of the Place.’” The “guiding philosophy” for the reconstruction of the highway was to “protect cultural, aesthetic, recreational, and natural resources located along the highway corridor and to communicate the respect and value that is commonly held for these resources pursuant to traditional ways of the Tribes.”

The context-sensitive design of US 93 North includes wildlife fencing and wildlife crossing structures along selected road sections and research to evaluate the effectiveness of the fencing and crossing structures. The function of the wildlife fences is to keep wildlife from accessing the highway and to help guide wildlife towards safe crossing opportunities. The wildlife crossing structures allow wildlife to cross the highway without being exposed to potential collisions with vehicles. Wildlife crossing structures also help reduce intrusions of wildlife into the fenced road corridor, as wildlife may choose to use the crossing structures rather than breach the wildlife fences to access the other side of the highway. While similar mitigation measures have been implemented along a number of road sections in North America, the project on the Flathead Indian Reservation is relatively unique because it is situated in a multifunctional landscape. The presence of agriculture, small villages, and dispersed houses resulted in mitigation measures implemented along short road lengths, which affected the preferred design characteristics and the effectiveness of the mitigation measures.

The cross-disciplinary research focus on the effectiveness of the mitigation measures on human safety and habitat connectivity for wildlife spanned pre-construction and post-construction periods. A final report was published in December 2016 (Huijser et al. 2016). The research resulted in important new findings with regard to the effectiveness of the mitigation
measures in reducing collisions with wild large mammals and providing safe crossing opportunities for wildlife. The funds provided by the Center for Environmental Sustainability in Cold Climates (CESTiCC) helped with outreach and technology transfer through a publication in an international peer-reviewed journal, participation in a conference, and support of a website that contains information aimed at the general public. Better access to the project's findings for researchers, policy and decision makers, practitioners, and the general public is expected to result in a more sustainable approach to highway construction practices, in terms of improved human safety and habitat connectivity for wildlife.

1.2 Tasks

This project had the following outreach and technology transfer tasks:

1. Submission of an article to an international peer-reviewed journal on the effectiveness of the wildlife mitigation measures along U.S. Highway 93 North.

2. Submission of an abstract to and our attendance at the 2017 International Conference on Ecology and Transportation in Salt Lake City, Utah.

3. Updating of the existing website and outreach material of the People’s Way Partnership (http://www.peopleswaywildlifecrossings.org/). The People’s Way Partnership is a collaboration of the Confederated Salish & Kootenai Tribes, the Western Transportation Institute at Montana State University, Defenders of Wildlife, and the Montana Department of Transportation. The mission of the partnership is to effectively communicate to the general public the human safety and conservation values that led to installation of wildlife crossing structures along U.S. Highway 93 North on the Flathead Indian Reservation.

We report on these three tasks in the following chapters.
CHAPTER 2.0
ARTICLE FOR AN INTERNATIONAL PEER-REVIEWED JOURNAL

Based on existing data (Huijser et al. 2016), we conducted analyses and wrote a paper on the effectiveness of wildlife underpasses along highways.

To summarize, we found that in recent decades an increasing number of highway construction and reconstruction projects have included mitigation measures aimed at reducing wildlife-vehicle collisions and maintaining habitat connectivity for wildlife. The most effective and robust measures include wildlife fences combined with wildlife underpasses and overpasses. The installation of 39 wildlife crossing structures included along a 56-mile (90 km) stretch of U.S. Highway 93 North on the Flathead Indian Reservation in western Montana represents one of the most extensive of such projects.

We measured movements of large mammal species at 15 elliptical arch-style wildlife underpasses and adjacent habitat between April and November 2015. We investigated whether the movements of large mammals through the underpasses were similar to large mammal movements in the adjacent habitat. Across all structures, large mammals (all species combined) were more likely to move through the structures than to pass at a random location in the surrounding habitat. At the species level, white-tailed deer (Odocoileus virginianus) and mule deer (O. hemionus) used the underpasses significantly more than would be expected based on their movement through the surrounding habitat. However, carnivorous species such as black bear (Ursus americanus) and coyote (Canis latrans) moved through the underpasses in similar numbers compared with their movement through the surrounding habitat.

We submitted an article to *Frontiers in Ecology and Evolution*, which published it in a special issue entitled “Integrating Transport Infrastructures with Living Landscapes.” This is an

The article was published on 26 October 2017. By 18 April 2018, it had been viewed 4,103 times.
CHAPTER 3.0
SUBMIT ABSTRACT TO AND ATTEND THE 2017 INTERNATIONAL CONFERENCE ON ECOLOGY AND TRANSPORTATION IN UTAH

We submitted an abstract entitled “Effectiveness of wildlife fencing and crossing structures in reducing collisions with large mammals and providing habitat connectivity for deer and black bear along US Hwy 93 North, Montana, USA” to the 2017 International Conference on Ecology and Transportation (ICOET) in Salt Lake City, Utah, held May 14–18. The abstract was accepted as a poster presentation. The poster contained the following information:

*Introduction:* The U.S. Highway 93 North reconstruction project on the Flathead Indian Reservation in Montana represents one of the most extensive wildlife-sensitive highway design efforts to date in North America. The reconstruction of the 56.9-mile (90 km) road section included wildlife crossing structures at 39 locations; approximately 17% of the road length included wildlife exclusion fences on both sides of the highway.

We investigated the effectiveness of the fences and crossing structures in reducing vehicle collisions with large mammals and the effectiveness of providing habitat connectivity for deer and black bear in three road sections with relatively long sections of wildlife fencing and crossing structures (Evaro 1.7 mile, Ravalli Curves 3.8 mile, Ravalli Hill 1.2 mile).
Wildlife-Vehicle Collisions: Based on a before-after control-impact (BACI) study design, large mammal-vehicle collisions were reduced by 71% (carcass removal data) and 80% (wildlife crash data) ($P<0.05$). The results of the BACI are partially because large mammal-vehicle collisions increased by 232% (carcasses) and 91% (crashes) in the unmitigated control road sections.
**Habitat Connectivity:** We also investigated connectivity for deer and black bear in the three road sections before and after highway reconstruction and the associated implementation of the mitigation measures. The “before” highway crossings (2003–2005) were measured using 38 randomly located, 100 m long, sand tracking beds situated immediately adjacent to the highway in the three road sections that would later be fenced. The “after” highway crossings (2008–2015) were measured using sand tracking beds and cameras at the crossing structures. We compared the two detection methods (tracking and cameras) for deer (white-tailed and mule deer combined) and black bear. We then applied the associated correction factors to the tracking data to make them comparable to the camera data.

Deer highway crossings remained similar or increased after highway reconstruction \((P=0.065)\). Black bear highway crossings remained similar after highway reconstruction \((P=0.197)\). There was no indication of an increase in deer population size after reconstruction.
compared with pre-construction. However, deer and black bear used the structures more frequently over time after the overpass and underpasses were installed.
**Conclusions:** The wildlife fences and crossing structures along U.S. Highway 93 North on the Flathead Indian Reservation substantially reduced vehicle collisions with large mammals. They also maintained or improved habitat connectivity for deer and black bear. When a rural highway is reconstructed with wider lanes, wider shoulders, longer sight distances, and gentler curves, the design speed of the highway and wildlife-vehicle collisions may increase. This suggests that, in rural areas, wildlife mitigation measures should be an integral part of highway reconstruction projects.

The reference for the poster presentation is as follows:


The ICOET conference was attended by more than 400 participants from over 20 countries and tribal nations. During the conference, there were about 170 oral presentations and 60 poster presentations.
CHAPTER 4.0
UPDATING THE EXISTING WEBSITE AND OUTREACH MATERIAL
OF THE PEOPLE’S WAY PARTNERSHIP

The People’s Way Partnership is a collaboration of the Confederated Salish & Kootenai Tribes, the Western Transportation Institute at Montana State University, Defenders of Wildlife, and the Montana Department of Transportation. The mission of the partnership is to effectively communicate to the general public the human safety and conservation values that led to installation of the wildlife crossing structures along U.S. Highway 93 North on the Flathead Indian Reservation.

The following changes were implemented to the website of the People’s Way Partnership (http://www.peopleswaywildlifecrossings.org/):

1. Restructured the web pages.
2. Improved the website text, making it more concise and understandable.
3. Included information from the final report of the U.S. Highway 93 North research project.
4. Included still images of wildlife using the structures.
5. Included a link to a YouTube video showing animals using the structures.
6. Included a link to the Facebook feed of the People’s Way Partnership.
7. Included information about the student drawing contest on wildlife crossing structures.
8. Included downloadable materials (final report, PowerPoint presentation of the final report, summary report, leaflet, infographics, posters, brochure with images of wildlife using the structures, and information from the roadside panels along U.S. Highway 93 North).
REFERENCES


