

# **Mitigating Wildlife Mortality and Habitat Fragmentation Due to Transportation Infrastructure**

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## 1. EXECUTIVE SUMMARY

In 2002, the Western Transportation Institute (WTI) and Dr. Anthony Clevenger identified a shared interest in the topic of wildlife crossing structures on rural highways. WTI elected to partner with Dr. Clevenger to support the continuation of his 5-year landmark Banff-Bow Valley research monitoring program in Banff National Park. In return, Dr. Clevenger agreed to bring his expertise and research and publication record to bolster WTI in the pursuit to become a national leader in the wildlife-transportation research focus area. Dr. Clevenger also offered guidance on other wildlife projects such as the study to evaluate the effectiveness of wildlife crossing structures and fencing that will be incorporated into reconstruction of a section of U.S. 93 in Montana.

### *Extension of Banff Research and Evaluation*

Through the initial five-year study, researchers monitored wildlife movements and mortality in Banff from fall 1996 through spring 2002. This project allowed for additional monitoring from June 2002 through March 2003. During that period, nearly 6000 individual wildlife passes were detected at the 23 crossing structures; 125 wildlife mortalities from vehicle collisions were documented; and the crossing activity of six species was monitored through snowtracks. The additional data has contributed to the success of the principal outcomes of the six-year wildlife monitoring and mitigation program, including development and implementation of mitigation options, recommendations for prioritization of projects, and development of measures of success.

### *U.S. 93 Research Assistance and Integration*

Dr. Clevenger served on the U.S. 93 research oversight committee that helped set the direction of the evaluation project. The committee was instrumental in refining the scope and defining the two response variables of interest: animal-vehicle collisions and wildlife movements across U.S. 93. He also provided the U.S. 93 Principal Investigators with other technical assistance, including: sharing of wildlife crossing literature; database development guidance; data collection methodologies (including a pin flag system pioneered in BNP), tracking bed guidance, and report review.

### *Partnership and Outreach Development*

The collaboration between WTI and Dr. Clevenger resulted in substantial development of the Transportation Wildlife Interactions research focus group within the Western Transportation Institute. Specifically, this project enhanced the institutional research resources of WTI, facilitated new partnerships with leading national and international interests, and expanded the organization's visibility in leading research publications and forums.

As a direct result of this project and Dr. Clevenger's efforts, WTI secured a follow-up project funded by the Woodcock Foundation. "DNA Profiling to Identify Individuals Using Wildlife Crossings" is a pilot study to test techniques and develop a protocol for systematically sampling and genotyping of hairs "captured" from passing animals at wildlife crossings.

As a result of both the tangible and intangible benefits achieved by this project, WTI offered Dr. Clevenger a permanent position on the research staff.

## 2. INTRODUCTION

Multi-year research projects and programs in major research institutions typically have the greatest sustained impact and are mainly funded by state or federal governments. However, today such programs are extremely rare. An intensive 5-year research program was initiated in Banff National Park, Alberta, in November 1996 by Dr. Anthony Clevenger. This study focused on the Trans-Canada Highway, its permeability for wildlife and effects in terms of wildlife mortality, movements, and habitat connectivity in the Bow River Valley, where Banff NP resides. Means of mitigating road effects on wildlife were evaluated and recommendations made for future transportation planning schemes in the mountain parks.

Today the Banff-Bow Valley is the only location in the world where the abundance and variety of wildlife crossing structure designs, in addition to national park-supported wildlife research, provides an unrivalled environment for research on the efficacy of wildlife crossing structures and reducing wildlife-vehicle collisions. Banff mitigation research can boast of having the world's longest, year-round monitoring program and largest dataset on passage use by wildlife. This alone has allowed Banff to be on the cutting edge of investigations regarding the effectiveness of highway mitigation passages in maintaining landscape connectivity.

Concurrently, the Western Transportation Institute (WTI) has been expanding its research into similar issues regarding the inter-relationship of roads and the wildlife that lives in the surrounding habitat. The impact of roads on the environment is well-documented and gaining attention worldwide. With the reauthorization of TEA-21, the following two potential research programs could provide opportunities for funding projects in the newly established Wildlife and Transportation Interactions focus research area at WTI: the Surface Transportation Environmental Cooperative Research Program (\$150 Million), which recommends a broad research agenda to address ever-growing needs for mobility and environmental protection; and the new Strategic Highway Research Program (\$450 Million), which focuses on applied research. These programs and numerous others will be targeted to jump-start this new and emerging research area at WTI.

WTI and Dr. Clevenger identified a shared interest in the topic of wildlife crossing structures on rural highways. WTI elected to partner with Dr. Clevenger to support the continuation of the landmark Banff-Bow Valley research. In return, Dr. Clevenger agreed to bring his expertise and research and publication record to bolster WTI in the pursuit to become a national leader in the wildlife-transportation research focus area. Dr. Clevenger also offered guidance on other wildlife projects such as the study to evaluate the effectiveness of wildlife crossing structures and fencing that will be incorporated into reconstruction of a section of U.S. 93 in Montana. In addition, it was anticipated that this collaboration would bring in new research projects to the Wildlife and Transportation Interactions focus area.

This report summarizes the outcomes of this collaborative project.

### **3. SCOPE AND RESEARCH TASKS**

WTI and Dr. Clevenger outlined a one-year collaboration that consisted of three principal research tasks:

#### **3.1. Task 1: Extension of Banff Research and Evaluation**

The partnership would enable Dr. Clevenger to continue his research in Banff beyond the original five-year program. This extension would facilitate:

- Additional monitoring. Adding another year of monitoring wildlife crossings would provide additional data for evaluating the long term effectiveness of the crossing structures.
- Funding opportunities. The extension would allow additional time for securing long-term funding sources and research partners

#### **3.2. Task 2: US 93 Research Assistance and Integration**

Dr. Clevenger would provide guidance and technical assistance to a WTI project to evaluate the effectiveness of crossing structures on installed as part of the reconstruction of U.S. 93 in Montana. He would provide the U.S. 93 oversight committee with assistance on preconstruction study design and monitoring.

#### **3.3. Task 3: Partnership and Outreach Development**

Dr. Clevenger would help WTI to develop and expand the Transportation Wildlife Interactions research focus area at WTI. His activities would include:

- Lead efforts to initiate additional research partnerships between WTI and other agencies in both the United States and Canada.
- Provide materials from his 900+ citation bibliography on road ecology to WTI's research database
- Assist with the development of conferences, curriculum and other technology transfer activities

## 4. WILDLIFE CROSSING STRUCTURE MONITORING

Through the initial five-year study, researchers monitored wildlife movements and mortality in Banff from fall 1996 through spring 2002. This project allowed for additional monitoring from June 2002 through March 2003. This section summarizes the data collected during this period. Monitoring data tables are included in the Appendix.

### 4.1. Crossing Structure Monitoring

#### 4.1.1. Overview of Crossing Structures in BNP

The Banff-Bow Valley is home to the largest number and greatest variety of wildlife crossing structures designed to reduce wildlife-vehicle collisions along the Trans-Canada Highway (TCH). The transportation corridor also contains the Canadian Pacific Railway mainline, access roads to Banff town site, a primary two-lane highway (Highway 93) and a secondary road. The first 45 km of the TCH from the eastern park boundary (phase 1, 2, and 3A) is four lanes and bordered on both sides by a 2.4 m high large-mammal wildlife-exclusion fence. The remaining 30 km to the western park boundary (Alberta – British Columbia border, phase 3B) is two lanes and unfenced. Upgrading of phase 3B to four lanes with mitigation will be carried out between 2005 and 2007. Twenty-two wildlife underpasses and two wildlife overpasses were constructed between 1980 and 1998 to permit wildlife movement across the four-lane section of TCH.

#### 4.1.2. Monitoring Conducted during Project Year

There have been a total of 3738 through-passes by wildlife at the 10 phase 1 & 2 underpasses since the beginning of the contract on 6 June 2002 (Appendix: Table 1A). Deer were the most frequently detected species at the crossing structures, followed by elk, wolves, sheep and coyotes. Among large carnivores, wolves used the structures 355 times, black bears 50 times, cougars 34 times, and grizzly bears 7 times. Compared to the wildlife passage frequencies, human passage was high; ranking third overall with 934 passes recorded.

There have been 2254 passages by wildlife at the 13 phase 3A crossing structures since 6 June 2002 (Appendix: Table 1B). Among large carnivores, wolves used the structures 74 times, grizzly bears 22 times, cougars 22 times and black bears 12 times.

In the five months of monitoring, 5992 individual wildlife passes have been detected at the 23 crossing structures. Deer were detected using the structures most (3043 times), followed by elk (1536), coyotes (575), wolves (356), cougars (56), black bears (62) and grizzly bears (29).

#### 4.1.3. Total Monitoring Period (1996-2003)

There have been a total of 37,507 through-passes by wildlife at the 10, phase 1 & 2 underpasses since November 1996 (Appendix: Table 2A). Elk were the most frequently detected species at the crossing structures, followed by deer, wolves, sheep and coyotes. Among large carnivores, wolves used the structures 2986 times, cougars 587 times, black bears 526 times, and grizzly bears 36 times.

There have been 11,175 passages by wildlife at the 13 phase 3A crossing structures since November 1997 (Appendix: Table 2B). Among large carnivores, wolves used the structures 254 times, cougars 197 times, black bears 166 times and grizzly bears 50 times.

In the 71 months of monitoring 48,682 individual wildlife passes have been detected at the 23 crossing structures. Among ungulates, elk were detected using the structures most (23,673 times), followed by deer (14,630), sheep (2315) and moose (18). Of the carnivores, coyotes used the structures most often (3244 times) followed by wolves (3240), cougars (784), black bears (692) and grizzly bears (86).

## **4.2. Mortality Monitoring (Wildlife roadkills)**

Since June 2002, a total of 125 animals were reportedly killed from collisions with vehicles on highways in Banff, Yoho and Kootenay national parks and Kananskis Country, Alberta. Of these, 99 (79%) were ungulates and 26 (21%) were carnivores (Appendix: Table 3). Carnivore mortalities consisted of coyotes (n = 19), black bears (n = 4), wolves (n = 2) and lynx (n = 1). We list the mortalities by species and highway in Table 3.

On the national park section of the Trans-Canada Highway (Banff and Yoho) there were 30 road-kills consisting of 21 (70%) ungulates [13 deer, 6 elk, 2 moose] and 9 (30%) carnivores [7 coyotes, 2 wolf].

On Highway 93 North (Banff National Park) there were 8 road-kills consisting of 6 (76%) ungulates [4 deer, 1 elk, 1 mountain goat] and 2 (24%) carnivores [2 black bears].

On Highway 93 South (Banff and Kootenay National Parks) there were 21 road-kills consisting of 16 (79%) ungulates [11 deer, 4 moose, 3 elk, 1 sheep] and 5 (21%) carnivores [1 black bear, 1 lynx, 3 coyotes].

On the Trans-Canada Highway in Alberta province there were 52 road-kills consisting of 43 (83%) ungulates [26 deer, 15 elk, 2 moose] and 9 (17%) carnivores [8 coyotes, 1 black bear].

Since 1998, researchers have recorded a cumulative total of more than 600 high-accuracy road-kill locations in the Mountain Parks.

## **4.3. Snowtrack Road Transects**

In the 2002-2003 winter season, snow conditions allowed for the phase 3B snow tracking survey to be completed seven times. A total of six different species (cougar or lynx, wolf, coyote, deer, elk, and moose) were identified and their behavior and activity around the road was noted, i.e. approach the highway, cross the highway or traverse parallel to the highway. Table 4 in the Appendix summarizes the date, locations (UTMs), direction, activity, and numbers of detections for each species.

### **4.3.1. Carnivores**

Coyotes were detected along the highway 35 times but only crossed on 13 of these occasions. Cougar or lynx approached and crossed the highway two times. Wolves crossed the highway eight times.

### **4.3.2. Ungulates**

Deer were detected 57 times and crossed the highway 38 times. Elk were detected 32 times and crossed 24 times. Moose approached and crossed the highway twice. Unidentified ungulates were detected six times and crossed the highway twice.



#### 4.4. Summary/Outcomes

This project made it possible for researchers to conduct an additional year of monitoring at the wildlife crossing structures throughout Banff National Park. This effort provided additional data that allowed researchers to address the following management research questions:

##### *Mitigations evaluation research*

- What are the wildlife crossing structure attributes that facilitate passage? Researchers have identified key factors influencing wildlife passage at the crossing structures and how to manage people and habitats so that wildlife use at the structures is optimized.
- What is the relative importance of large, open-span viaducts (eg, 5-Mile bridge) vs. smaller, bridge-span wildlife underpasses to large carnivore movement? (i.e. will the existing underpass designs suffice or do carnivores need large extensions of raised highways?).
- Can drainage culverts serve as effective habitat linkages?
- How effective is BNP mitigation at reducing road mortality?
- What fence designs (buried, unburied) effectively impede wildlife intrusions onto the TCH?

##### *Mortality and crossing research*

- What are the patterns of wildlife-vehicle collisions with respect to population parameters?
- What are the patterns and factors influencing small vertebrate fauna road-kills?
- What are the relationships between grizzly bears, highways and habitat in the Bow Valley?
- What are some of the factors influencing successful and unsuccessful road-crossings by wildlife?
- Are successful and unsuccessful road-crossing locations by wildlife the same (are they spatially correlated)?

In addition, the data has contributed to the success of the principal outcomes of the six-year wildlife monitoring and mitigation program, including:

- Development and implementation of mitigation options to reduce mortality and barrier effects on the Trans-Canada Highway
- Recommendations for prioritization of Trans-Canada Highway mitigation projects and funds (including retrofitting)
- Development of measures of success for mitigation

Data from the BNP wildlife mitigation program will be of significant interest to both environmental interests and transportation agencies. The Banff crossing structures and fencing are notable because of their success in facilitating safe passage for wildlife across the freeway

and significantly reducing the amount of roadkill. Since November of 1996, the Parks Service has recorded more than 37,000 crossings by eleven large mammal species including deer, elk, moose, bear, wolves and coyotes. Vehicle collisions with elk, previously the most frequent victim involved in animal-vehicle collisions on the Trans-Canada Highway in Banff National Park, have decreased by 95 percent.

## **5. U.S. 93 RESEARCH ASSISTANCE AND INTEGRATION**

### **5.1. U.S. 93 Project Background**

The Montana Department of Transportation (MDT) is planning a major reconstruction of more than 50 miles of U.S. 93 in Montana. The segment runs from Evaro to Polson, through the Flathead Reservation. MDT, in cooperation with FHWA and the Confederated Salish and Kootenai Tribes (CSKT), have developed a wildlife mitigation plan that consists of 42 fish and wildlife crossing structures and 14.7 miles (23.66 km) of wildlife-proof fencing. WTI is leading the evaluation component of the mitigation project. Specifically, WTI researchers are quantifying the effects that wildlife crossings and fencing may have on the following two parameters: 1) animal-vehicle collisions and 2) wildlife movements across US 93, with a focus on deer species and black bear.

As was the case in Banff National Park, the magnitude of the U.S. 93 mitigation offers an excellent opportunity to evaluate the effectiveness of wildlife crossing structures to help guide similar mitigation measures in the future. Dr. Clevenger's recent experience leading the monitoring and evaluation of wildlife crossing structures in BNP had the potential to serve as an invaluable resource to the U.S. 93 project at WTI.

Dr. Clevenger served on the U.S. 93 research oversight committee that helped set the direction of the evaluation project. The committee was instrumental in refining the scope and defining the two response variables of interest: animal-vehicle collisions and wildlife movements across U.S. 93.

### **5.2. Summary/Outcomes**

Dr. Clevenger provided the U.S. 93 Principal Investigators with research data, lessons learned, and other technical assistance based on his experiences in Banff, including:

- **Literature.** Dr. Clevenger shared extensive wildlife crossing literature gathered for BNP with researchers at WTI.
- **Database Development.** Dr. Clevenger provided guidance for developing a database to evaluate Animal Vehicle Collision data, which facilitated analysis and database integration.
- **Data Collection Methodologies.** WTI was able to use methodologies for a pin flag system pioneered in BNP, which provides more spatially accurate AVC data.
- **Tracking Bed Guidance.** Dr. Clevenger reviewed and made recommendations on plans to use tracking beds as a monitoring technique.
- **Report Review.** The U.S. 93 Principal Investigators had access to in-house technical review of draft literature reviews and reports.

## 6. PARTNERSHIP AND OUTREACH DEVELOPMENT

The collaboration between WTI and Dr. Clevenger resulted in substantial development of the Transportation Wildlife Interactions research focus group within the Western Transportation Institute. Specifically, this project enhanced the institutional research resources of WTI, facilitated new partnerships with leading national and international interests, and expanded the organization's visibility in leading research publications and forums.

### 6.1. Partnership Development

#### 6.1.1. Internal Resource Development

Dr. Clevenger became a valuable addition to the staff of professional researchers at WTI, strengthening our in-house technical expertise in the field of road ecology. This, in turn, allowed WTI to attract and conduct more research in this area.

In addition, Dr. Clevenger has provided materials from his 900+ citation bibliography on road ecology to WTI's research database. His extensive body of work strengthens and facilitates literature reviews and synthesis research projects.

#### 6.1.2. External Partnership Development

Dr. Clevenger led efforts to extend the reach of WTI's road ecology research to the international environmental community. In particular, he has facilitated ongoing research relationships with leading Canadian agencies including:

- Canadian Heritage, Parks Canada Agency, Banff, Alberta, Canada
- Alberta Natural Resources, Canmore, Alberta, Canada
- University of Calgary, Faculty of Env. Design, Calgary, Alberta, Canada
- Geomar Consulting Ltd., Grand Forks, British Columbia, Canada
- Alberta Transportation, Edmonton, Alberta

He has also initiated new partnerships between WTI and private environmental foundations, including:

- Woodcock Foundation
- Wilburforce Foundation

For example, as a direct result of this project and Dr. Clevenger's efforts, WTI secured a follow-up project funded by the Woodcock Foundation. "DNA Profiling to Identify Individuals Using Wildlife Crossings" is a pilot study to test techniques and develop a protocol for systematically sampling and genotyping of hairs "captured" from passing animals at wildlife crossings. The aim is to acquire a simple, non-invasive, cost-effective method to identify and quantify animals using wildlife crossing structures. If successful, the technique will enable demographic and movement data to be collected that are requisite for accurately assessing the conservation value of wildlife crossings. The development of this technique will significantly advance understanding of wildlife crossings as conservation tools to enhance population viability.

## **6.2. Outreach**

Through his activities on behalf of WTI, Dr. Clevenger has significantly expanded the outreach and technology transfer activities of the wildlife research focus area.

### **6.2.1. Technology Transfer Events**

#### **6.2.1.1. Wildlife Crossing Structure Field Course**

In September 2002, WTI sponsored the “Wildlife Crossing Structure Field Course” in cooperation with the Federal Highway Administration (FHWA), the Center for Transportation and Environment (CTE) at North Carolina State University, and the US Forest Service (NFS). The goal of the course was to give engineers, administrators and resource management professionals examples of the Context-Sensitive Design (CSD) approach to transportation projects that cross through important habitat for wildlife. With the assistance of Dr. Clevenger, WTI was able to select Banff National Park as the setting for the field course, making it possible for participants to learn from Canada’s experience with mitigating wildlife-transportation conflicts on the high traffic volume Trans-Canada Highway. Dr. Clevenger also served as one of the primary speakers and field trip leaders during the course.

#### **6.2.1.2. ICOET Conference**

In 2003, the International Conference on Ecology and Transportation (ICOET) was held in Lake Placid, New York. WTI’s Wildlife researchers took an active role in the conference, and arranged for WTI to sponsor publication of the proceedings. Dr. Clevenger helped WTI achieve high visibility at the conference by presenting three research papers.

#### **6.2.1.3. Academic Mentorship**

Dr. Clevenger supervised a graduate thesis project, based on the BNP monitoring research (Caryl, F.M. 2003. Ungulate mortality on a forested highway. MSc thesis, University of East Anglia, Norwich, UK, 42 pp.).

### **6.2.2. Presentations**

During the project period, Dr. Clevenger presented his research at numerous national and international venues, to audiences consisting of both transportation professionals and environmental specialists. Major presentations are listed here:

"Performance and Benefits of Highway Fencing and Wildlife Crossing Structures: Considerations for Future Applications"; Transportation Association of Canada Annual Meeting; St John’s, Newfoundland, Canada; September 2003.

"Long-term, year-round monitoring of wildlife crossing structures and the importance of temporal and spatial variability in performance studies"; International Conference on Ecology and Transportation; Lake Placid, New York, USA; August 2003.

"Large animal-vehicle collisions in the Central Canadian Rocky Mountains: patterns and characteristics"; International Conference on Ecology and Transportation; Lake Placid, New York, USA; August 2003 [presented by K. Gunson].

"Review of methods used to determine the location and performance of wildlife passages"; International Conference on Ecology and Transportation; Lake Placid, New York, USA; August 2003 [presented by A. Hardy].

"From afterthought to planning principle: Mapping the route towards connectivity in Banff National Park"; Yellowstone-to-Yukon Conservation Initiative – "Making science, making change in Y2Y: Four years of research and collaboration on ecological connectivity"; Calgary, Alberta, Canada; May 2003.

"Roads and wildlife in the Canadian Rocky Mountains: Mortality, movements and mitigation"; Road Ecology Workshop, UC Davis, Institute of Transportation Studies; Davis, California, USA; May 2003.

"Relationships among grizzly bears, highways and habitat in the Banff-Bow Valley"; U.S. Association of Landscape Ecology meeting; Banff, Alberta, Canada; March 2003.

"Mitigation for road impacts on wildlife"; Urban Development Institute of Canmore, Alberta & G8 Environmental Legacy Project – Building Sustainable Communities: Living with Wildlife; Canmore, Alberta, Canada; March 2003.

"Living with highways: sharing the road with wildlife"; Sandy Cross Conservation Foundation, Conservation Education Lecture Series; Calgary, AB, Canada; February 2003.

"A highway runs through it: highway mitigation in Banff National Park"; Banff National Park Science Workshop; Banff, Alberta, Canada; January 2003.

### 6.2.3. Publications

During the project period, Dr. Clevenger's findings were published in a wide range of journal articles, reports, and books.

#### 6.2.3.1. Published Articles and Books

Chruszcz, B., Clevenger, A.P., Gunson, K. & Gibeau, M.L. "Relationships among grizzly bears, highways and habitat in the Banff-Bow Valley, Alberta." *Canadian Journal of Zoology* 81:1378-1391.

Clevenger, A.P., B. Chruszcz, & K. Gunson 2003. "Spatial patterns and factors influencing small vertebrate fauna road-kill aggregations." *Biological Conservation* 109:15-26.

Forman, R.T.T., Sperling, D., Bissonette, J., Clevenger, A., Cutshall, C., Dale, V., Fahrig, L., France, R., Goldman, C., Heanue, K., Jones, J., Swanson, F., Turrentine, T. & Winter, T. 2002. *Road ecology: Science and solutions*. Island Press, Washington, DC.

Little, S.J., Harcourt, R.G. & Clevenger, A.P. 2002. "Do wildlife passages act as prey-traps?" *Biological Conservation* 107:135-145.

Clevenger, A.P., Wierzchowski, J., Chruszcz, B., & Gunson, K. 2002. "GIS-generated expert based models for identifying wildlife habitat linkages and mitigation passage planning." *Conservation Biology* 16:503-514.

Gibeau, M.L., Clevenger, A.P., Herrero, S & Wierzchowski, J. 2002. "Grizzly bear response to human development and activities in the Bow River watershed, Alberta." *Biological Conservation* 103:227-236.

Clevenger, A.P., Wierzchowski, J., & Waltho, N. 2002. "Planning and performance of wildlife crossing structures in a major transportation corridor." Pages 267-276, in: Environmental Concerns in Rights-of-Way Management: Seventh International Symposium.

#### **6.2.3.2. Technical Reports~**

Clevenger, A.P. 2003. Highway research, monitoring and adaptive mitigation study – Banff, Yoho and Kootenay national parks. Final Report (March 2003). Report prepared for Parks Canada, Radium Hot Springs, British Columbia. 33 pp.

Clevenger, A.P., Chruszcz, B., Gunson, K., and Wierzchowski, J. 2002. Roads and wildlife in the Canadian Rocky Mountain Parks - Movements, mortality and mitigation. Final Report (October 2002). Report prepared for Parks Canada, Banff, Alta.

#### **6.2.3.3. Non-technical Reports**

Clevenger, A.P. 2003. Movements, mortality and mitigation: an overview of the Final Report on Roads and Wildlife in the Canadian Rocky Mountains. Research Links 11:2, 16-20 (Summer/Autumn).

### **6.3. Summary/Outcomes**

The sections above listed specific examples of new funding and technology transfer activities initiated or facilitated by this project. In a more general, long-term sense, the project has resulted in numerous positive outcomes for the Wildlife Transportation Interaction Research Group at WTI:

- Expanded in-house research capabilities and technical expertise
- Increased visibility and representation at national and international research forums
- Enhanced reputation of WTI as leading-edge research institute in the field of wildlife-transportation interactions

As a result of both the tangible and intangible benefits achieved by this project, WTI offered Dr. Clevenger a permanent position on the research staff.

## **7. RECOMMENDATIONS AND NEXT STEPS**

### **7.1. Need for Additional Monitoring and Research at Banff National Park**

To mitigate the effects of roads, passage structures for wildlife are now being designed and incorporated into some road construction projects. Wildlife passages are in essence site-specific movement corridors strategically placed over a deadly matrix habitat of pavement and high-speed vehicles. Yet the impact of transportation systems on wildlife ecology and remedial actions to counter these effects is an emerging science. Currently there is limited knowledge of effective and affordable passage designs for most wildlife species.

Research at Banff National Park has provided a valuable foundation of data, and continues to provide an unrivalled environment for further study. Additional monitoring and research would allow for investigation into refined topics, such as:

- Factors contributing to wildlife-vehicle collisions - coarse- and site-level analyses
- Grizzly bear movement in relation to the TCH - pre- and post-highway improvement
- Time series analysis of wildlife crossing structure function and efficacy
- Modeling of highway mortality vs. barrier effects on population persistence.
- Development of cost-effective and innovative wildlife passage designs.
- Assessment of methodologies for habitat linkage modeling across highways.
- Effect of habitat fragmentation by highways on the genetic subdivision of fauna populations.
- Population-level assessment of highway impacts and mitigation efficacy

### **7.2. Next Steps**

The follow-up project funded by the Woodcock Foundation ("DNA Profiling to Identify Individuals Using Wildlife Crossings") will allow WTI and Dr. Clevenger to continue research on the effectiveness of wildlife crossing structures. WTI and Dr. Clevenger will pursue additional opportunities to conduct research in Banff National Parks, as well as to study new topics related to wildlife transportation interactions.

As a member of WTI's permanent staff, Dr. Clevenger can also continue his activities on behalf of the U.S. 93 project in Montana, as well as efforts to expand and enhance technology transfer activities.



## **8. APPENDIX**

### **Wildlife Monitoring Data Tables**

Table 1A. Summary of wildlife crossing structure use in Banff National Park, Alberta, June – November 2002.

Phase 1 &amp; 2 Wildlife Crossings from 6 June 2002 to 31 March 2003

CS	CS type	Grbear	Blbear	Wolf	Cougar	Coyote	Moose	Elk	Deer	Sheep	Total	Human Use
East	Open span	0	0	12	1	23	0	108	545	0	689	1
Carrot	Creek bridge	0	2	12	2	12	0	12	70	0	110	8
MCoulee	Culvert-lg	0	7	38	1	11	0	33	149	0	39	1
Duthil	Open span	0	11	176	3	20	0	88	157	0	455	5
Powerhouse	Open span	0	7	10	2	12	0	66	122	6	225	149
Buffalo	Open span	0	0	14	7	19	0	271	125	0	436	372
Vermilion	Open span	0	2	8	8	22	0	156	55	46	297	75
Edith	Open span	3	2	29	5	25	2	72	190	14	342	190
Healy	Open span	4	18	46	5	70	0	152	212	14	521	0
5-mi	Open-span bridge	0	1	10	0	8	0	164	67	174	424	133
Total		7	50	355	34	222	2	1122	1692	254	3738	934

Table 1B. Phase 3A Wildlife Crossings from June 06, 2002 to 31 March 2003 (Castle monitored since November 01, 1996)

CS	CS type	Grbear	Blbear	Wolf	Cougar	Coyote	Moose	Elk	Deer	Sheep	Total	Human Use
WOP	Overpass	15	1	10	2	20	0	35	301	0	384	4
WUP	Culvert-lg	0	0	3	2	15	0	18	27	0	65	1
Bourgeau	Culvert-medium	0	1	0	0	22	0	2	1	0	26	0
WCR	Creek bridge	0	1	7	4	37	0	25	20	0	94	7
Massive	Culvert-lg	0	1	4	3	50	0	30	25	0	113	6
Sawback	Box	0	0	0	0	17	0	18	1	0	36	0
Pilot	Box	1	6	5	2	23	0	22	24	0	83	0
REUP	Box	0	2	0	2	42	0	32	15	0	93	0
REOP	Overpass	6	0	10	1	16	2	92	508	0	635	2
RECR	Creek bridge	0	0	2	3	23	0	22	100	0	150	40
Copper	Culvert-lg	0	0	5	0	42	0	18	235	0	300	8
John	Box	0	0	9	2	29	0	1	6	0	47	0
Castle	Culvert-lg	0	0	23	1	17	0	99	88	0	228	8
Total		22	12	74	22	353	2	414	1351	0	2254	76
Grand Total		29	62	356	56	575	4	1536	3043	254	5992	1010

Table 2A. Summary of wildlife crossing structure use in Banff National Park, Alberta, November 1996 – March 2003.

Phase 1 &amp; 2 Wildlife Crossings from 1 November 1996 to 31 March 2003

CS	CS type	Grbear	Blbear	Wolf	Cougar	Coyote	Moose	Elk	Deer	Sheep	Total	Human Use
East	Open span	0	31	171	71	193	0	1553	2604	1	4624	20
Carrot	Creek bridge	2	39	148	52	88	0	443	234	0	1006	96
MCoulee	Culvert-lg	0	107	217	62	80	0	526	1109	1	2102	43
Duthil	Open span	5	101	1085	85	194	0	2292	747	0	4509	59
Powerhouse	Open span	2	40	273	43	103	0	1822	697	8	2988	1097
Buffalo	Open span	0	1	251	20	223	0	4340	340	0	5175	1926
Vermilion	Open span	2	8	202	74	248	0	3429	508	797	5268	639
Edith	Open span	5	19	162	86	158	0	1605	1470	189	3694	2558
Healy	Open span	18	167	336	65	380	0	1988	1176	23	4153	28
5-mi	Open-span bridge	2	13	141	29	139	0	1827	541	1296	3988	848
Total		36	526	2986	587	1806	0	19825	9426	2315	37507	7314

Table 2B. Phase 3A Wildlife Crossings, November 1997 to March 2003 (Castle monitored since 1 November 1996)

CS	CS type	Grbear	Blbear	Wolf	Cougar	Coyote	Moose	Elk	Deer	Sheep	Total	Human Use
WOP	Overpass	32	19	41	21	81	6	237	1383	0	1820	27
WUP	Culvert-lg	0	6	10	24	53	0	153	148	0	394	14
Bourgeau	Culvert-medium	0	15	0	18	96	0	10	4	0	143	5
WCR	Creek bridge	1	5	14	33	151	0	248	61	0	513	25
Massive	Culvert-lg	1	9	6	11	157	0	264	226	0	674	15
Sawback	Box	0	3	3	2	65	0	103	28	0	204	26
Pilot	Box	2	28	8	12	85	0	129	65	0	329	19
REUP	Box	1	20	14	16	134	0	174	51	0	410	29
REOP	Overpass	8	9	36	2	91	11	891	2039	0	3087	20
RECR	Creek bridge	2	4	16	20	76	0	161	301	0	580	200
Copper	Culvert-lg	0	5	17	17	157	1	254	486	0	937	13
John	Box	0	17	19	20	211	0	28	24	0	319	7
Castle	Culvert-lg	3	26	70	1	81	0	1196	388	0	1765	142
Total		50	166	254	197	1438	18	3848	5204	0	11175	542
Grand Total		86	692	3240	784	3244	18	23673	14630	2315	48682	7856

Table 3. Summary of large mammal mortality, coyote size and larger, on the mountain park highways and provincial highways from 6 June 2002 to 31 March 2003.

Highway	Region	Grbear	Blbear	Cougar	Lynx	Wolf	Coyote	Elk	Deer	Moose	Sheep	Mt. Goat	Total
TCH	Province	0	1	0	0	0	8	15	26	2	0	0	52
TCH	BNP	0	0	0	0	0	4	3	6	0	0	0	13
TCH	YNP	0	0	0	0	2	3	3	7	2	0	0	17
1A	Province	0	0	0	0	0	1	0	1	0	1	0	3
40	Kananaskis	0	0	0	0	0	0	1	7	0	0	0	8
93S	BNP	0	0	0	0	0	0	2	1	0	0	0	3
93S	KNP	0	1	0	1	0	3	1	10	4	1	0	21
93N	BNP	0	2	0	0	0	0	1	4	0	0	1	8
TOTAL		0	4	0	1	2	19	26	62	8	2	1	125

Table 4. Wildlife activity along Phase IIIB of the TCH during road surveys, winter 2002-2003.

Species	Date	No.	Civeast	Civnorth	Cross TCH	Direction	Location	Behavior/Comments
<b>COUGAR/ LYNX</b>								
	26-Feb-03	1	562227	5691334	yes	north	2km east of Lake Louise	both sides of highway
	26-Feb-03	1	560395	5693582	yes	south	1.4 km east of Lake Louise	
Total	Cross-Yes	2						Probably one individual
	Cross-No	0						
<b>COYOTE</b>								
	06-Jan-03	1	557239	5698287	yes	south		crossed median
	28-Jan-03	1	550017	5700604	yes	south		good tracks, crossed directly
	05-Feb-03	1	557752	5696261	unk	north		tracks come up to hwy on N side, no tracks on south
	05-Feb-03	1	558145	569622	yes	north		
	05-Feb-03	1	557864	5695986	unk	south		tracks come up to hwy on N side, no tracks on S
	05-Feb-03	1	557611	5696878	yes	north		
	19-Feb-03	1	556932	5698031	yes	south		
	26-Feb-03	1	560148	5693890	no	south		
	26-Feb-03	1	565364	5687719	no	south		
	26-Feb-03	1	565391	5687691	no	south		
	26-Feb-03	1	565796	5687241	n	south		
	26-Feb-03	1	564561	5688586	yes	north		
<b>COYOTE</b>								
	26-Feb-03	1	566407	5685648	yes	south		
	26-Feb-03	1	562085	5691505	yes	south		
	26-Feb-03	1	560884	5692985	no	south		

Species	Date	No.	Civeast	Civnorth	Cross TCH	Direction	Location	Behavior/Comments
	26-Feb-03	1	560745	5093153	yes	north		
	26-Feb-03	1	560529	5093421	no	unk		
	26-Feb-03	1	560426	5693546	no	north		
	26-Feb-03	1	559793	5694228	no	south		
	26-Feb-03	1	559741	5694253	yes	south		
	26-Feb-03	1	564930	5688192	yes	south		
	26-Feb-03	1	568215	5684377	no	south		meandered along highway
	26-Feb-03	1	568792	5683729	no	north		meandered along hwy
	26-Feb-03	1	568833	5683671	no	south		
	26-Feb-03	1	569053	5683431	no	south		
	26-Feb-03	1	567284	5685542	yes	north		
	26-Feb-03	1	569090	5683358	no	north		Probably same coyote?
	26-Feb-03	2	559543	5694335	no	North and south		meandered along highway, never crossing, within 10m
	26-Feb-03	1	569181	5683266	no	west		Same coyote? Just walked west along hwy
	26-Feb-03	1	569208	5683219	no	west		Same coyote? Just walked west along hwy
	26-Feb-03	1	565077	5688033	no	north		
	26-Feb-03	1	557655	5696679	no	west		within 10m, doesn't cross
	26-Feb-03	1	558306	5695406	no	south		approached road
	26-Feb-03	1	558735	5694745	yes	north		
Total	Cross-Yes	13						Probably 6 different individuals
	Cross-No	22						



Species	Date	No.	Civeast	Civnorth	Cross TCH	Direction	Location	Behavior/Comments
DEER								
	18-Nov-02	1	556131	5698383	no	north		approched hwy from S RofW and turned back
	18-Nov-02	1	555795	5699034	unk	south		meandered E-W on N RofW, appr hwy no track S side
	18-Nov-02	1	555367	5699308	yes	north	Just E of 93N OP	
	18-Nov-02	1	555955	5698763	yes	north		crossed 4 lanes with median
	18-Nov-02	1	562954	5690015	yes	north		
	18-Nov-02	2	571421	5681732	no	north		approched hwy from S RofW and turned back
	18-Nov-02	2	571098	5681913	no	south	4.1km West of Castle OP	approched hwy from N RofW and turned back
	18-Nov-02	2	565802	5687326	yes	unk	12.1km West of Castle OP	
	18-Nov-02	1	569999	5682467	yes	north	5.6km West of Castle OP	approched and crossed hwy from N right of way
	18-Nov-02	1	555682	5699123	unk	south		100M west of previous deer same behv (same deer??)
	18-Nov-02	2	570954	5681953	yes	south	4.3km West of Castle OP	approched and crossed hwy from N right of way
	18-Nov-02	2	571188	5681886	no	south	4km West of Castle OP	approched hwy from N RofW and turned back
	06-Jan-03	1	557737	5696312	yes	south		crossed into forest
	06-Jan-03	2	556329	5698287	yes	south	just west of LL	2 lane highway
	06-Jan-03	1	557331	5697801	yes	north		crossed median
	06-Jan-03	1	557471	569579	yes	south		crossed median

Species	Date	No.	Civeast	Civnorth	Cross TCH	Direction	Location	Behavior/Comments
	06-Jan-03	1	557737	5696312	no	east		turned around on S side of highway
	06-Jan-03	1	562923	5690026	yes	south		crossed into forest
	06-Jan-03	1	564873	5688246	yes	south		crossed into forest
	06-Jan-03	1	565149	5687946	no	west		turned around 10 m from the road
	06-Jan-03	1	565218	5687855	yes	south		crossed into forest
	06-Jan-03	1	565520	5687563	yes	north		crossed into forest
	06-Jan-03	2	572270	5681086	yes	north	start of Mannix pit	
	06-Jan-03	1	556229	5698305	yes	north	just west of LL	2 lane highway
	06-Jan-03	1	557502	5697165	yes	south		crossed centre median
	06-Jan-03	1	557471	569579	yes	south		crossed median
	15-Jan-03	2	562114	5691437	yes	south		meandered along s ditch then crossed
	15-Jan-03	1	567141	5685721	yes	south		same deer crossed hwy
	15-Jan-03	1	567597	5685223	yes	unk		poor tracks, slightly snow covered
	15-Jan-03	1	567555	5685277	no			meandered along N ditch
	15-Jan-03	1	567500	5685331	no			same deer approached hwy but no tracks on other side
	15-Jan-03	1	567394	568447	no			same deer walked along road then back towards tree
	15-Jan-03	1	567053	5685817	yes	unk		crossed at some point and meandered along WB ditch
	15-Jan-03	2	566926	5685956	yes	unk		crossed

Species	Date	No.	Civeast	Civnorth	Cross TCH	Direction	Location	Behavior/Comments
	15-Jan-03	1	566857	5686030	no			
	15-Jan-03	1	555904	5698864	no			meandered along N ditch
	15-Jan-03	2	559961	5694082	yes	south		approached road and crossed
	15-Jan-03	1	571765	5691858	no			approached hwy
	15-Jan-03	1	563931	5689090	no			approached road and turned around in S ditch
	15-Jan-03	2	572264	5681093	yes	unk		tracks are slightly snow covered
	15-Jan-03	1	560037	5694002	yes	south		approached road and crossed
	28-Jan-03	1	567284	5685549	yes	unk		snow covered
	28-Jan-03	3	567514	5685311	yes	unk		poor tracks
	28-Jan-03	1	571202	5681878	no			N side deer approach hwy
Total	Cross-Yes	38						Probably 33 different individuals
	Cross-No	19						
<b>ELK</b>								
	18-Nov-02	1	571850	5681404	yes	north	3.1km West of Castle OP	walked across hwy
	06-Jan-03	2	571421	5681748	no	west		elk walking parallel to highway on N side
	06-Jan-03	2	571809	5681445	yes	south		meandered across highway to other side of road
	06-Jan-03	1	570820	5681996	yes	south		crossed highway and river
	06-Jan-03	2	571809	5681445	no	west		walking parallel to highway on N side
	15-Jan-03	3	553921	5699299	no			meandered along N ditch
	15-Jan-03	3	556111	5698466	yes	north		crossed

Species	Date	No.	Civeast	Civnorth	Cross TCH	Direction	Location	Behavior/Comments
	15-Jan-03	1	568357	5684218	yes	north		poor tracks, slightly snow covered
	15-Jan-03	2	556384	5698250	yes	south		approached road and crossed
	28-Jan-03	1	558379	5695290	no			n side turned around, guardrail on s side, steep
	28-Jan-03	1	557354	5697760	yes	unk		gait 5' apart
	28-Jan-03	2	554831	5699316	yes	unk		snow covered tracks, melting snow
	05-Feb-03	2	564691	5688444	yes	north		approach road several times, meandered before cross
	05-Feb-03	2	557796	5696110	yes	unk		
	05-Feb-03	1	558929	5694571	yes	north		
	05-Feb-03	1	559027	5694516	yes	south		
	05-Feb-03	1	559985	5694072	yes	south		crossed road on angle
	26-Feb-03	2	569304	5683013	yes	north		walked directly across hwy, may have been moose
Total	Cross-Yes	24						Probably 23 different individuals
	Cross-No	8						
<b>MOOSE</b>								
	26-Feb-03	1	569090	5683358	yes	north		Very large tracks
	26-Feb-03	1	568084	5684541	yes	south		
Total	Cross-Yes	2						Probably 1 individual
	Cross-No	0						

Species	Date	No.	Civeast	Civnorth	Cross TCH	Direction	Location	Behavior/Comments
UNGULATE								
	15-Jan-03	1	570802	5682010	no			approached road
	15-Jan-03	2	571957	5681332	no			walking parallel to road
	15-Jan-03	2	571810	5681448	yes	south		same ungulates meandered across road
	28-Jan-03	1	571202	5681878	no			unk gait, 5' btw, snow covered
Total	Cross-Yes	2						Probably 2 different individuals
	Cross-No	4						

UNKNOWN SPECIES								
	18-Nov-02	1	564133	5688987	yes	unk	14.6km West of Castle Jct	
	05-Feb-03	1	572459	5688144	no	south		poor tracks, animal approach road turn back
	05-Feb-03	2	559615	5694297	yes	unk		older looking tracks
	05-Feb-03	1	559985	5694072	no	north		approach but no cross
Total		3						Probably 3 different individuals
		2						

Species	Date	No.	Civeast	Civnorth	Cross TCH	Direction	Location	Behavior/Comments
WOLF								
	28-Jan-03	2	572594	5680836	yes	north		crossed hwy from N side, chasing deer
	28-Jan-03	2	572594	5680836	yes	south		crossed highway back to north side, chasing deer
	12-Feb-03	2	558664	5694805	yes	south	East side of the twin bridges	M Percy reported
	12-Feb-03	2	558913	5694543	yes	north	East side of the twin bridges	M Percy reported
Total	Cross-Yes	8						Probably 2 or 4 different individuals
	Cross-No	0						