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**The Strategic Integration of Wildlife  
Mitigation into Transportation Procedures:  
Practices, Partnerships, and Next Steps**

**March 2022**

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The Wildlife Vehicle Collision (WVC) Reduction and Habitat Connectivity  
Transportation Pooled Fund Project TPF 5(358)

## **The Strategic Integration of Wildlife Mitigation into Transportation Procedures: Practices, Partnerships, and Next Steps**

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Photo Credit: George Andrejko AZGFD

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Final Report of the Nevada Department of Transportation and Federal  
Highway Administration Pooled Fund Study:  
The Wildlife Vehicle Collision (WVC) Reduction and Habitat Connectivity  
Transportation Pooled Fund Project TPF 5(358)

## **The Strategic Integration of Wildlife Mitigation into Transportation Procedures: Practices, Partnerships, and Next Steps**

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## Key Terms and Abbreviations

Acronym	Definition
AASHTO	American Association of State Highway Transportation Officials
ADOT	Arizona Department of Transportation
AVC	Animal-vehicle collisions. Crashes with wild and domestic animals or because of animals. They may or may not be reported crashes. The term is more of a phenomenon than a specific type of crash or carcass. Evolving to the term animal-vehicle conflict, which explains the effects of transportation on wildlife and animals, and not just collisions.
BCMOTI	British Columbia Ministry of Transportation
BCWMA	Blackfoot Clearwater Wildlife Management Area in Montana
BFC	Blackfoot Challenge, a Montana organization
CDOT	Colorado Department of Transportation
C.F.R.	Code of Federal Regulations
CPW	Colorado Parks and Wildlife
CS&KT	Confederated Salish and Kootenai Tribes
DOT	Department of Transportation, for individual states in the U.S.
DGR	New Mexico Division of Government Research
DTD	Division of Transportation Development – a division described here in the Colorado DOT
FHWA	The U.S. Federal Highway Administration
HSIP	Highway Safety Improvement Program – a source of funding from the U.S. federal government for highway safety projects
ICOET	International Conference on Ecology and Transportation
ITRD	International Transport Research Documentation ( <a href="https://www.itf-oecd.org/international-transport-research-documentation-public">https://www.itf-oecd.org/international-transport-research-documentation-public</a> )
KABCO	Crash types: Fatality of human involved (K), Type A injury – suspected serious injury, Type B Injury – suspected minor injury, Type C injury – possible injury, and Property Damage Only (O).
L RTP	Long Range Transportation Plan
MDT	Montana Department of Transportation
MFWP	Montana Fish Wildlife and Parks
MOA	Memorandum of Agreement

<b>Acronym</b>	<b>Definition</b>
MoT	Ministry of Transportation for each province in Canada
MoTI	Ministry of Transportation and Infrastructure in Canada
MPO	Metropolitan Planning Organization – a U.S. federally designated organization representing localities in all urbanized areas with human populations of 50,000 or more. The board is to carry out the metropolitan transportation planning process. See: URL: <a href="https://www.transit.dot.gov/regulations-and-guidance/transportation-planning/metropolitan-planning-organization-mpo">https://www.transit.dot.gov/regulations-and-guidance/transportation-planning/metropolitan-planning-organization-mpo</a>
MTP	Metropolitan Transportation Plans – developed by MPOs
NMDOT	New Mexico Department of Transportation
NEPA	National Environmental Protection Act
PAS	Passage Assessment System, created by Kintsch and Cramer (2011) for Washington DOT to assess existing infrastructure for wildlife permeability of various types of species
PDO	Property Damage Only accidents
PFS	Pooled Fund Study
ROW	Road right of way, area owned by the transportation agency, stretching from the ROW fence to the ROW fence on each side of a road
RTA	Regional Transportation Authority of Pima County, Arizona
STIP	U.S. State Transportation Improvement Plan. A 5-year planning document created by every U.S. DOT that include upcoming projects across the state.
TAC	Technical Advisory Committee – the members of the supporting organizations that advise the project. See Acknowledgement section for key members.
TIP	Transportation improvement programs – short range plans for upcoming transportation projects.
TON	Tohono O’odham Nation
TRB	Transportation Research Board of the U.S National Academies ( <a href="https://www.nationalacademies.org/trb/transportation-research-board">https://www.nationalacademies.org/trb/transportation-research-board</a> )
TRID	An integrated database that combines the records from TRB’s Transportation Research Information Services, (TRIS) and the Joint Transport Research Centre’s International Research Documentation (ITRD) Database. URL: <a href="https://trid.trb.org/">https://trid.trb.org/</a> .
TRIS	Transportation Information Services ( <a href="http://www.trb.org/InformationServices/InformationServices.aspx">http://www.trb.org/InformationServices/InformationServices.aspx</a> )

Acronym	Definition
TxDOT	Texas Department of Transportation
USDOT	U.S. Department of Transportation, the federal level DOT
VTrans	Vermont Agency of Transportation
VZS	Vision Zero Suite – a benefit-cost approach to looking at crashes
WARS	British Columbia Ministry of Transportation and Infrastructure Wildlife Accident Reporting System
WSWPS	Colorado’s Western Slope Wildlife Prioritization Study
WVC	Wildlife-vehicle collisions. The phenomenon of wildlife involved in crashes on the highway, whether reported or un-reported. It is evolving to represent wildlife-vehicle conflict, which includes crashes and the effects of transportation on wildlife such as reduced connectivity

# Executive Summary of the Strategic Integration of Wildlife Mitigation into Transportation Procedures

## Introduction

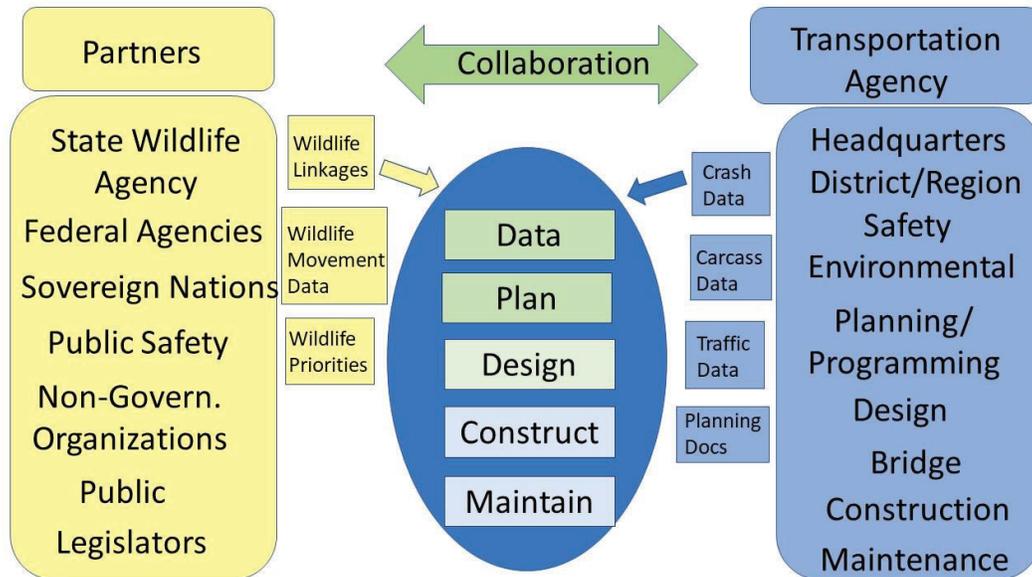
This study was part of the Wildlife Vehicle Collision (WVC) Reduction and Habitat Connectivity Pooled Fund Study of 2018-2022. This pooled fund study (PFS) seeks to identify cost-effective solutions that integrate highway safety and mobility with wildlife conservation and habitat connectivity. This was a collaborative project through the U.S. Federal Highway Administration Transportation Pooled Fund Program. The goal of this greater project was to reduce wildlife-vehicle collisions (WVC) for the safety of motorists and wildlife, and to promote and restore wildlife connectivity. Contributing partners include the Departments of Transportation (DOTs) of Alaska, Arizona, California, Iowa, Michigan, Minnesota, New Mexico, Oregon, Washington, and Nevada. The Nevada DOT administers this project. Canadian partners include the Ontario Ministry of Transportation (MoT), and Parks Canada. The non-profit, ARC Solutions, Incorporated was also a partner. Representatives from these organizations serve on the Technical Advisory Committee (TAC) for this study.

This executive summary summarizes the research on the second task of the larger PFS, “The Strategic Integration of Wildlife Mitigation into Transportation Procedures.” The team for this PFS second task was completely independent of the team working on the first task. There were three sub-tasks to the reported research under this PFS Task 2: 1) Investigate transportation procedures; 2) Develop a manual to integrate wildlife mitigation in transportation planning; and 3) Develop a communication plan. The researchers also met annually with the TAC. This executive summary is for the Final Report for Task 1- Investigate Transportation Procedures.

This Executive Summary is organized by subtask, with each subtask presented as an individual chapter of the report: Chapter 2 - Literature Review and Survey; Chapter 3 - Partnerships; Chapter 4 - Data Requirements; and Chapter 5 - Pros, Cons, Gaps, and Recommendations for Change.

## Guiding Flow Diagram

Figure 1 presents a high-level overview of all of the divisions within a transportation agency and their external partners involved in wildlife mitigation project planning, design, and construction, and how each of these entities contribute data and information that feed into these processes. Each of these entities and data sources are integral in the development of effective wildlife mitigation projects.



**FIGURE 1. THE TRANSPORTATION PROCESS, DATA NEEDED, TRANSPORTATION AGENCY DIVISIONS, AND OUTSIDE PARTNERS IMPORTANT TO THE CREATION OF WILDLIFE MITIGATION.**

## Results

### Chapter 2 Literature Review and Survey

The researchers used multiple public and academic databases to search for articles and publications related to wildlife and transportation. Eight search terms were used to search various academic, transportation, and personal databases. The 265 references were organized into eight sub-headings:

- Guidance resources for planning for wildlife in transportation
- Mapping wildlife-vehicle conflicts
- Applications and websites for reporting wildlife carcasses
- Identifying and prioritizing wildlife-vehicle conflict areas
- Benefit-cost assessments in transportation
- Animal detection systems, driver warning systems, and other wildlife-vehicle collision reduction techniques
- Wildlife and habitat connectivity, and
- Transportation planning and wildlife mitigation.

There was a plethora of information on how well wildlife crossing structures work for large wild animals in the U.S. and Canada, and a need for additional research and guidance related to the eight sub-headings above, as well as research and practices for connectivity for smaller animals.

The research team conducted an online survey sent to 237 professionals in all U.S. state Departments of Transportation (DOTs) and Canadian Ministries of Transportation (MoTs). Simultaneously, a similar online survey was sent to 230 Metropolitan Planning Organization (MPO) personnel. The objectives of the surveys were to learn of activities and opinions concerning agency inclusion of wildlife consideration in transportation processes. The completed surveys represented 57 respondents in 31 U.S. state DOTs, and six Canadian MoTs, 39 respondents in 27 MPOs in 21 states, and eight anonymous responses.

Respondents consistently identified the information sources most important for integrating wildlife needs into transportation planning as: 1) wildlife-vehicle collision crash data; and 2) hotspot analyses of the crash data. Survey participants indicated the most important part of planning processes were: 1) collaboration with wildlife agencies; and 2) inclusion of wildlife mitigation plans in the long range transportation plans. The top four most common needs identified among the 47 written responses were:

- Dedicated funding
- Legislation support to incentivize or compel transportation agencies to consider wildlife movement needs into transportation processes
- Collaboration with wildlife agencies was considered important to respondents in both surveys
- Instilling environmental stewardship and awareness of wildlife into the transportation or MPO agency/corporate culture from the top down.

This theme of instilling environmental stewardship arose multiple times in the survey results, and led to an identified need for a change in agency culture to improve consideration of wildlife connectivity into transportation processes. The respondents' ranked legislative action, and direction from agency headquarters and local offices as the two most important means to accomplish this.

Respondents from three states, Washington, Minnesota, and Massachusetts mentioned that their state transportation agency can no longer keep track of specific dedicated wildlife crossing structures because incorporating wildlife concerns have become standard operating procedures. Respondents from these three states mentioned that they did not have specific target species for the wildlife mitigation, but rather, in the words of Peter Leete of Minnesota "Our structures have not specifically targeted any species. The intent is to maintain (or reconnect) ecological connectivity along our streams and rivers." This was a sign that some states were succeeding at incorporation of wildlife concerns into every day and long range planning activities. However, this is also indicative of a state with average annual precipitation of 18 to 32 inches each year depending on the location, making it a modestly moist state. In turn, some of the species the state agencies are trying to provide for connectivity occur in association with

wetlands, thus providing for aquatic and semi-aquatic connectivity along with nearby terrestrial passage, which may vary in more arid climates.

Another sign of the progress that has been made in agencies across the U.S. and Canada, is that respondents from 28 states and provinces indicated their agency had upsized replacement structures and made enhancements on structures to specifically promote wildlife passage. These actions have become increasingly more common and demonstrate that the consideration of wildlife movement has become more common since 2006 when a similar survey was completed Bissonette and Cramer (2008).

### Chapter 3 Partnerships

The research team's experience and knowledge were instrumental in identifying and presenting several successful approaches that transportation and MPO agencies embraced to help increase the consideration of wildlife in transportation. Chapter 3 presents twelve case studies of DOT's, MPO's, and Federal Agencies' approaches that include the reduction of WVC and the inclusion of wildlife connectivity needs in transportation processes.

The case studies focused on:

- A wildlife program's success within a transportation agency
- Working partnerships
- Gaining support with outside partners for wildlife crossing structures
- Consideration of construction project ecological impacts
- A method for benefit-cost analysis of wildlife-vehicle collision crash data
- Recommendations for changes to DOT manuals
- Potential legal changes on how MPOs plan for environmental concerns
- A wildlife and ecological education program in a department of transportation
- A state's legislative actions to plan for and mitigate for wildlife movement
- Partnerships to advance wildlife-highway mitigation
- Funding opportunities at the county-regional level, and
- A federal agency civil engineer perspective.

These case studies informed and were referred to in the following tasks and chapters in the research.

### Chapter 4 Data Requirements

In this chapter the transportation and ecological data requirements necessary for considering multiple species' needs for connectivity across transportation are presented, described, and referenced to websites, reports, and papers. Table 1 summarizes the data.

**TABLE 1. DATA REQUIREMENTS FOR INTEGRATION OF WILDLIFE MITIGATION INTO TRANSPORTATION PROCEDURES.**

<b>Type of Data</b>	<b>Specific Types of Data to Explore and Gather</b>
<b>Transportation Data</b>	
	Identify the Scope, Extent and Cost of WVC Crashes
	Carcass Data, Mapping, and Analysis
	Traffic Volume Data
	Culvert and Bridge Inventory Listings and Maintenance
	Transportation Planning Documents
	Costs of Recent Wildlife Mitigation Infrastructure
	Funding Sources
<b>Ecological Data</b>	
	Wildlife Habitat Maps
	Wildlife Linkages and Corridor Maps
	Wildlife Locational Data
	Wildlife Movement Abilities and Needs
	Pre-Construction and Other Wildlife Mitigation Monitoring
	State Wildlife Action Plan <u>and Species Recovery Plan</u>
	Needs Assessment from Wildlife Agency
	Land Ownership and Use
	Identify Permanent and Perennial Water Sources
	Topography
	Climate Change

### Chapter 5 Pros, Cons, Gaps, and Recommendations for Change

This chapter presents a succinct view of what was learned in the research conducted for this report, and what could be improved upon concerning the strategic integration of wildlife concerns in transportation procedures.

### *List and Compare Methods Presented in This Report*

Various approaches used to assist in the inclusion of wildlife into transportation processes were presented, compared and contrasted, with specific recommendations for the best methods highlighted. These included:

- Data
  - Crash data
  - Carcass data
  - Map hotspots
  - Recent mitigation costs
  - Wildlife habitat maps
  - Wildlife linkage maps
  - Wildlife locational data
  - Climate change
  - Climate change mapping
- Plan – Integration of Wildlife Movement Needs into Planning
  - Legislation for wildlife connectivity
  - Transportation agency and partners' alliance
  - Memorandum of Understanding between agencies
  - Wildlife agency comment on the STIP
  - Wildlife monitoring and mapping
  - Linkage and corridor mapping
  - Standardize wildlife concerns in manuals
  - Create checklist for wildlife needs in planning process
  - Design for ecological connectivity
  - Slopes under bridges designed for wildlife
  - Offset secondary culverts
  - Retrofit existing structures in project
  - Design manuals
- Construct Wildlife Infrastructure
  - Mitigation banking for construction
  - Construction manual recommendations
  - Fence construction guidelines
- Maintain – Partnering to Research and Adaptively Manage
  - Transportation agency provides funding for monitoring and then adaptively manages infrastructure from results
  - Performance Measures

### *Pros and Cons of Efforts and Recommendations for Change*

There were many efforts that have addressed wildlife connectivity and the reduction of wildlife-vehicle collisions, however, there were several consistent systemic approaches that continue to both promote these considerations and have their challenges. In Table 2 below, we present consistent themes of transportation agency efforts that have both pros and cons to them and offer opportunities for improvement.

**TABLE 2. EFFORTS TO ADDRESS WILDLIFE CONNECTIVITY AND WILDLIFE-VEHICLE COLLISIONS, PROS, CONS, AND IMPROVEMENTS.**

<b>Effort</b>	<b>Pros</b>	<b>Cons</b>	<b>Opportunities for Improvement</b>
The number one way to get wildlife crossing structures is to include them in existing projects	Mitigation gets done in a timely manner and at a lower cost because it is spread over a larger project	May not be where efforts are most urgently needed. May not be top crash or wildlife connectivity area.	Funding for standalone wildlife crossing structure projects is needed at a national level, and may occur with the 2021 Transportation Act passage. Additional funding sources within Federal Highways that can be applied to wildlife crossing infrastructure would help provide additional funding opportunities.
Use the State Transportation Improvement Plan (STIP) and bridge and culvert replacement projects to identify potential projects that could incorporate wildlife concerns	For modest to no cost increases, a project could include wildlife crossing structures that were created by upgrading the size of already planned culverts and bridges, or other infrastructure.	Areas in greatest need of wildlife mitigation most typically are not addressed in STIP plans. The STIP areas may expend capital cooperation among agencies that could have been better spent on areas in greatest need.	The state wildlife agency should be reviewing the STIP in US States, annually, and have annual meetings with the transportation agency to discuss where wildlife need infrastructure to reduce wildlife-vehicle collisions and move safely. The environmental and traffic safety staff within a transportation agency put forth STIP projects that are meant to reduce wildlife-vehicle collisions and promote wildlife connectivity. This could help future STIP projects to be created specifically for wildlife.
Wildlife Crossing structure projects can be politically influenced	Some projects important to the public are completed through this process	These projects may not be the most urgent, or where wildlife most need to move	Scientific prioritization of statewide / province wide projects helps to eliminate biases in delivery. However, the legislative process is still a good place to formulate funding opportunities for these projects.
The most ambitious wildlife crossing projects come with large	These allow for multiple wildlife crossing structures, improve chances of	When these projects are completed, the momentum for more structures and	Transportation agencies need to institutionalize consideration of wildlife and continue to build these considerations into all project development. For example, in Minnesota,

Effort	Pros	Cons	Opportunities for Improvement
highway improvement and new highway construction	success, and bring attention to wildlife needs. These projects can also jump start a state or provinces' wildlife crossing program.	to adaptively manage the new structures can potentially become greatly reduced.	designing for the maintenance and restoration of natural processes through culverts and under bridges for all projects helps to maintain ecological and thus wildlife connectivity.
Institutionalize climate change resiliency in agencies and the transportation network	The transportation infrastructure survives with climate changes, and increasing opportunities for wildlife movement and ecological connectivity are delivered	Many professionals don't have enough ecological understanding to support these efforts, and this has not been done enough wide-scale to know best methods	State and provinces need to accept and admit climate change and human effects on ecosystems, and plan for those changes by ensuring ecological and climatic processes are provided for in the entire transportation process and infrastructure. Opportunities must be part of agency agendas to provide for wildlife, fish, and plants to adapt to a changing world. See <i>The Dasgupta Review on the Economics of Biodiversity</i> , to better understand nature's services and their contribution to society's well-being. See: <a href="https://www.nature.org/en-us/newsroom/jennifer-morris-statement-dasgupta-review/">https://www.nature.org/en-us/newsroom/jennifer-morris-statement-dasgupta-review/</a>

**Research Needs**

A list of top research needs was presented. They were:

1. Research on species little studied in North America
2. Standardized methods for monitoring and researching wildlife-vehicle conflict and mitigation
3. Long term studies of the effects of wildlife mitigation
4. Different types of infrastructure and evolving technology need research
5. Regularly updated Best Management Practice Manuals
6. Additional research and management actions dealing with climate change.

### *A Summary of How Administrators, Environmental Staff, Engineers, and Planners, and Others Can Be Brought into the Practice of Integrating Wildlife into Transportation Planning and Daily Operations*

In the on-line survey of transportation professionals conducted in this study in 2019, the two themes that emerged were:

- 1) The need for the incorporation of wildlife awareness into the agency/corporate culture from the top down at the headquarters and local levels; and
- 2) Instilling a sense of environmental stewardship among personnel within transportation agencies.

The summary of these two themes was at the root of this entire study – bringing transportation agency professionals’ awareness to a level that they choose to bring concerns for wildlife into their everyday duties and long term plans. In another survey question, 98 percent of respondents said that agency headquarters’ support was very important or moderately important in the integration of wildlife accommodation into transportation planning and project development. Thus, actions from the top down are critical. How do these individuals and others learn enough about wildlife, ecosystems, and climate change to affect their thinking and decisions? There are several ways to affect this change. These include: education from within the agency; information and partners outside the agency; and carrots and sticks.

**Education from Within** - As was demonstrated in the case study from Vermont, with its Highways and Habitats educational program (Chapter 3), an in-agency program of continuous learning of ecosystems and wildlife is necessary to affect change that works at the heads and hearts level. Also important is local champions within the agency, at headquarters and especially at district levels. These long term strategies within agencies are successful for small changes, incremental change, and systemic changes that help garner actions that support wildlife movement and minimize wildlife conflict.

**Information and Partners Outside the Agency** - In the on-line survey of transportation professionals in this study, survey participants indicated the most important part of planning processes for including wildlife concerns were:

- 1) Collaboration with wildlife agencies; and
- 2) Inclusion of wildlife mitigation plans in the long range transportation plans.

The role of wildlife professionals outside a transportation agency is highly important and cannot be overstated. The wildlife agency can provide data, expertise, persuasion, and political support to transportation agencies interested in addressing the needs of wildlife.

**Carrots and Sticks** - Rewards and mandates to build wildlife mitigation into transportation both work, but from different angles. This research’s on-line survey participants indicated that the top two intra-agency barriers to wildlife mitigation inclusion in transportation plans, projects, and every day operations were lack of funding and agency culture. This is the root of creating actions to make change for

wildlife. Agencies need a funding source, and motivation to change their culture of how things may have been carried out in the past.

## Summary

This report presented a breadth and depth of knowledge that can help the U.S. and Canada continue to improve considerations of wildlife in transportation processes. From this research, a companion manual on how to emulate lessons learned will be developed and completed in 2021-2021.

## Chapter 1 Introduction, Background, and Approach

This study is part of the Wildlife Vehicle Collision (WVC) Reduction and Habitat Connectivity Pooled Fund Study of 2018-2022. This pooled fund study (PFS) seeks to identify cost-effective solutions that integrate highway safety and mobility with wildlife conservation and habitat connectivity. This is a collaborative project through the U.S. Federal Highway Administration Transportation Pooled Fund Program. The goal of this greater project is to reduce wildlife-vehicle collisions (WVC) for the safety of motorists and wildlife, and to promote and restore wildlife connectivity. Contributing partners include the Departments of Transportation (DOTs) of Alaska, Arizona, California, Iowa, Michigan, Minnesota, New Mexico, Oregon, Washington, and Nevada. The Nevada DOT administers this project. Canadian partners include the Ontario Ministry of Transportation (MoT), and Parks Canada. The non-profit, ARC Solutions, Incorporated is also a partner. Representatives from these organizations serve on the Technical Advisory Committee (TAC) for this study.

This report summarizes the research on the second task of the larger PFS, “The Strategic Integration of Wildlife Mitigation into Transportation Procedures.” The team for this PFS second task is completely independent of the team working on the first task. There are three sub-tasks to the reported research under this PFS Task 2: 1) Investigate transportation procedures; 2) Develop a manual to integrate wildlife mitigation in transportation planning; and 3) Develop a communication plan. The researchers also meet annually with the TAC. This report is the final report for our team’s Task 1- Investigate Transportation Procedures.

### Background

State, provincial, and smaller transportation agencies need standardized proven methods to integrate wildlife concerns into transportation processes. The science and practice of transportation ecology have grown exponentially in the past 20 years. It is time national level proven standards and guidance are created to assist these and other agencies. Bissonette and Cramer (2008) found that the states and provinces with the largest number of wildlife crossing structures (dozens) had just three to five people within the transportation agency who promoted wildlife connectivity. Today there may be more individuals involved in wildlife mitigation, but administrators, engineers and planners struggle to understand what types of structures and fences work, and how they can incorporate concerns for wildlife in regular transportation practice. The experiences of states and other entities who have created standards and wildlife mitigation can be used as examples and templates for a two-nation manual to help guide professionals in the consideration of wildlife in the course of transportation processes.

Progress in the field of transportation ecology began to in earnest in the mid to late 2000's. Since then several guidance documents and manuals have been published, Bissonette and Cramer (2008), Huijser et al. (2008), and Shilling et al. (2011). Additionally, Washington DOT (WSDOT) created a Passage Assessment System (PAS) to evaluate retrofit potentials (Kintsch and Cramer 2011). WSDOT developed a method for integrating wildlife concerns over time (K. McAllister, personal communication), and Arizona created a draft document to begin such measures (N. Dodd personal communication). Texas DOT (TxDOT) included wildlife concerns into TxDOT manuals as an approach to incorporate wildlife concerns into everyday activities as well as planning (Loftus-Otway et al. 2019).

Idaho was the first state to create a standardized process for prioritizing road segments for wildlife mitigation (Cramer et al. 2014). This was followed by Nevada's prioritization process for addressing wildlife-vehicle conflicts (Cramer and McGinty 2018), and Colorado's Western Slope Wildlife Prioritization Study (Kintsch et al. 2019). Utah recently completed a standardization study for incorporating wildlife crash hotspots into transportation planning (Cramer et al. 2019). In 2021 New Mexico developed its Wildlife Corridors Action Plan to address top priority areas for wildlife-connectivity mitigation (P. Cramer et al. 2021).

These efforts are also growing across regions. Now is a critical time to synthesize the results of these and other studies. This research reviews progress made across the U.S. and Canada, and will provide guidance to the U.S. and Canadian transportation agencies for approaches to including wildlife concerns in transportation procedures.

## Research Approach

This research project has three main tasks: Task 1 – Investigate Transportation Procedures, and Task 2 – Develop a Manual to Integrate Wildlife Mitigation into Transportation Planning, and Task 3 – Develop a Communication Plan. This report is the final report for Task 1 – Investigate Transportation Procedures. The technical objective of Task 1 is to identify and describe how transportation agencies integrate wildlife mitigation into transportation procedures such as planning, project development, infrastructure design, construction, monitoring, and related processes. The research in Task 1 is organized into subtasks which are presented in the individual chapters of this report: Chapter 2 - Literature Review and Survey; Chapter 3 - Partnerships; Chapter 4 - Data Requirements; and Chapter 5 - Pros, Cons, Gaps, and Recommendations for Change.

### Sub-Task 1. Literature Review and Survey – Chapter 2

This sub-task addresses the challenge of the lack of knowledge of what has worked and what has not for the integration of wildlife needs into transportation by conducting a literature review, and on-line survey of transportation professionals.

### *Literature Search*

Our team searched the Transportation Research Board's (TRB) Transportation Research Information Services (TRID) database, the International Conference on Ecology and Transportation (ICOET) proceedings, scientific literature, engineering reports and ecological reports of how states, provinces and other countries have included wildlife needs in transportation to complete this sub-task. The literature review results are presented in Appendix A.

### *U.S. and Canadian Electronic Survey of Transportation Professionals*

Our team conducted an on-line electronic survey of U.S. and Canada personnel in departments and ministries of transportation. We also surveyed personnel from several Metropolitan Planning Organizations (MPOs) across the U.S.; MPOs are responsible for developing long-range transportation plans in more populated areas of the U.S. and have a role in regional transportation decision-making. Two separate surveys were developed for the transportation agencies and MPOs. The survey results are presented in Chapter 2, with additional information in Appendix B.

### *Sub-Task 2. Partnerships – Chapter 3*

Our team identified and described some of the partnerships that have made transportation agencies successful in incorporating wildlife mitigation into their transportation procedures. These results are presented in Chapter 3. Our team authored 12 case studies that represent states' and provinces' transportation and MPOs perspectives on including wildlife in transportation processes. Each case study represents a specific concept that the research team and survey respondents indicated they thought was important to changing the way transportation agencies have traditionally conducted business.

### *Sub-Task 3. Data Requirements Chapter 4*

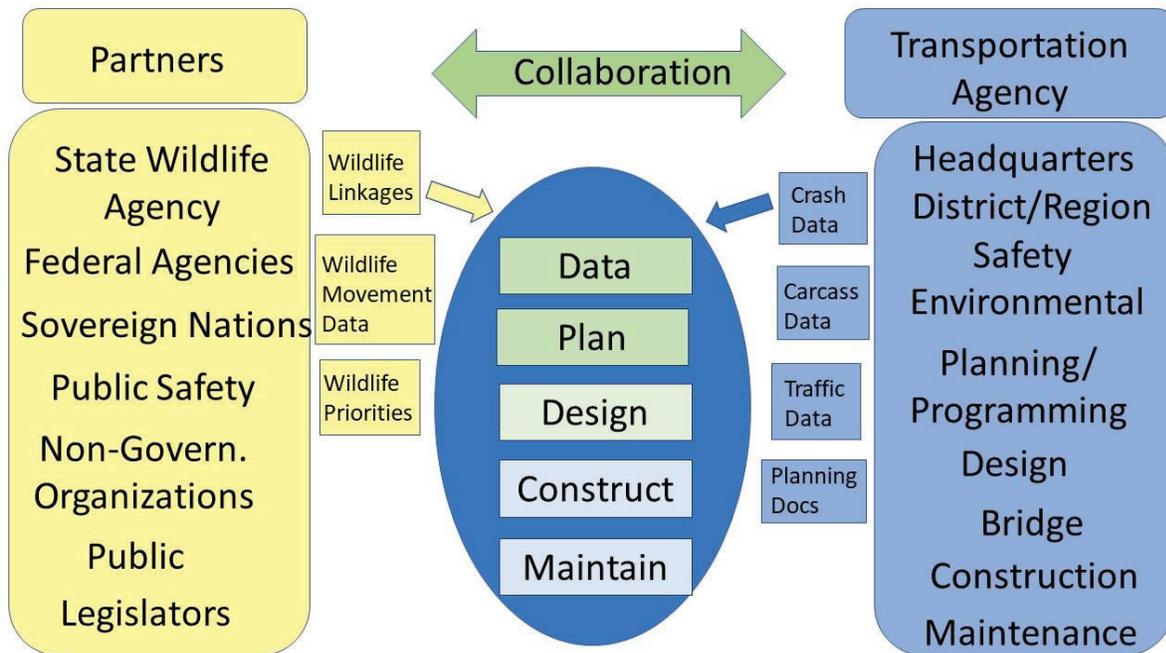
Our team identified and described the data and map requirements needed for the successful integration of wildlife passage mitigation into transportation procedures, including project prioritization, planning, and implementation. The TAC provided additional insight and information to round out this chapter. In Chapter 4 we present the initial analysis of the costs of reported wildlife-vehicle collision crashes.

### *Sub-Task 4: Pros, Cons, Gaps and Recommendations for Change Chapter 5*

This chapter presents a succinct view of what was learned in the research conducted for this report, and what could be improved upon concerning the strategic integration of wildlife concerns in transportation procedures.

## Guiding Flow Diagram

Figure 2 presents a high-level overview of all of the divisions within a transportation agency and their external partners involved in wildlife mitigation project planning, design, and construction, and how each of these entities contribute data and information that feed into these processes. Each of these entities and data sources are integral in the development of effective wildlife mitigation projects.



**FIGURE 2. THE TRANSPORTATION PROCESS, DATA NEEDED, TRANSPORTATION AGENCY DIVISIONS, AND OUTSIDE PARTNERS IMPORTANT TO THE CREATION OF WILDLIFE MITIGATION.**

## Chapter 2. Literature Review and Comparisons

Patricia Cramer, PhD

Julia Kintsch, MS

Lisa Loftus-Otway, JD

Kimberly Andrews, PhD

Task 1 was composed of two subtasks, the literature review and the U.S.-Canadian survey of transportation professionals. These sub-tasks are completed, but the information in this chapter will be treated like a living document and be updated over the course of the study.

### Literature Review

#### Summary

The researchers used multiple public and academic databases to search for articles and publications related to wildlife and transportation. Eight search terms were used to search various academic, transportation, and personal databases. The 265 references were organized into eight sub-headings.

#### Methods

References included in this literature review were compiled through existing databases and through online literature searches. Specifically, citations were gathered using public sources (Google Scholar) and libraries at the University of Georgia (Web of Science; Wildlife and Ecology Studies Worldwide). Notably, searches conducted via Google Search also accessed databases for the ICOET and TRB's TRID, and Transportation Information Services ([TRIS](#)) and the International Transport Research Documentation ([ITRD](#)). Where free access is available, the URL links to the articles are included (all checked as of 16 August 2019). Our primary focus was to search for articles that featured work in North America; yet, we included reference to international materials that have application to the topics of focus. Within the search terms listed below, we queried both biology and engineering publication platforms. Specifically, our goal was to query resources that focused on *planning* tools or research findings that directly contribute to planning, rather than to enumerate articles focused on specific mitigation designs and their efficacy. However, articles featuring key species of interests for this project were included.

Reference to unpublished literature, active research projects, and informational websites is not included in this literature review. Upon request, we can provide further

information from these unpublished and current sources. The literature review will be an ongoing process and updated throughout the project.

Specific search terms (and variations thereof) that were used for each of the database inquiries:

- Wildlife planning transportation
- Wildlife planning road
- Wildlife transportation engineering
- Wildlife road engineering
- Wildlife transportation crossing design
- Wildlife road crossing design
- Wildlife mitigation.

## Results

The 265 references presented are organized according to the following headings:

- Guidance resources for planning for wildlife in transportation
- Mapping wildlife-vehicle conflicts
- Applications and websites for reporting wildlife carcasses
- Identifying and prioritizing wildlife-vehicle conflict areas
- Benefit-cost assessments in transportation
- Animal detection systems, driver warning systems, and other wildlife-vehicle collision reduction techniques
- Wildlife and habitat connectivity.

This sub-task revealed that the field of transportation ecology and publications on how transportation-related infrastructure impacts wildlife has grown dramatically in recent years. However, there is still a disparity in how such information is shared, including how research findings are implemented, and the degree of exchange among states and provinces. In summary, there is a need to establish protocols and strategic and economic planning tools that are more broadly transmitted among governmental transportation agencies (federal, state, provincial, and MPOs), engineers, and biologists.

The Literature Search results are presented in [Appendix A](#).

## The U.S. & Canadian Survey on the Inclusion of Wildlife Consideration in Transportation Processes Survey Results

### Summary

The research team conducted an online survey sent to 237 professionals in all U.S. state DOTs and Canadian MoTs. Simultaneously, a similar online survey was sent to 230 MPO personnel. The objectives of the surveys were to learn of activities and opinions concerning agency inclusion of wildlife consideration in transportation processes. The completed surveys represented 57 respondents in 31 U.S. state DOTs, and six Canadian MoTs, 39 respondents in 27 MPOs in 21 states, and eight anonymous responses.

Respondents consistently identified the information sources most important for integrating wildlife needs into transportation planning were: 1) wildlife-vehicle collision crash data; and 2) hotspot analyses of the crash data. Survey participants indicated the most important part of planning processes were: 1) collaboration with wildlife agencies; and 2) inclusion of wildlife mitigation plans in the long range transportation plans. The top four most common themes among the 47 written responses were:

- A need for dedicated funding;
- Legislation support to incentivize or compel transportation agencies to consider wildlife movement needs into transportation processes;
- Collaboration with wildlife agencies was considered important to respondents in both surveys;
- A need to instill environmental stewardship and awareness of wildlife into the agency/corporate culture from the top down.

This theme of instilling environmental stewardship was a consistent theme in the survey results. It led to specific ideas that there is a need for a change in agency culture to improve consideration of wildlife connectivity into transportation processes. The respondents' ranked legislative action, and direction from the headquarters and local offices of the agencies were the two most important means to accomplish this. Respondents from three states, Washington, Minnesota, and Massachusetts mentioned that their state transportation agency can no longer keep track of specific dedicated wildlife crossing structures because incorporating wildlife concerns have become standard operating procedures. Respondents from these three states mentioned that they did not have specific target species for the wildlife mitigation, but rather, in the words of Peter Leete of Minnesota "Our structures have not specifically targeted any species. The intent is to maintain (or reconnect) ecological connectivity along our streams and rivers." This was a sign that some states are succeeding at incorporation of wildlife concerns into every day and long range planning activities.

Another sign of the progress that has been made in agencies across the two countries, is that respondents from 28 states and provinces indicated their agency had upsized replacement structures and made enhancements on structures to promote wildlife passage. These increasingly more common activities demonstrate that the consideration of wildlife movement has become more common than when a similar survey was conducted in 2004-2006 (Bissonette and Cramer 2008), or if one only considers the number of wildlife crossing structures in a jurisdiction as the sole measure of progress.

## Introduction

For this research project to best provide recommendations to transportation agencies to better consider wildlife movement needs in transportation processes, two tasks needed to be accomplished during this sub-task of the research:

- 1) It is necessary to assess where various agencies are on the continuum of incorporating wildlife crossing structures into their programs;
- 2) It is necessary to understand how the prevailing attitudes in those agencies can support or hinder a shift in traditional processes toward accommodating wildlife.

Our approach to this survey was to reach out to the American Association of State Highway Officials (AASHTO) Committee on Environment and Sustainability member representatives for each state, and equivalent members in Canadian Provincial MoTs to ask for their knowledge and opinions on the topic. It was assumed that the environmental staff within these agencies would have the best understanding of how their agency considers wildlife movement needs and wildlife-vehicle collisions (WVC). It was also assumed these individuals would be best positioned to identify what potential changes that may be needed to better address wildlife connectivity within their transportation planning processes.

We also reached out to representative U.S. MPO's. All U.S. state DOTs include transportation plans from city, county, and regional level MPOs in the overall state transportation improvement program (STIP), a four to five-year list of planned transportation projects. These federally mandated MPOs are planning agencies for cities and regions with 50,000 or more residents. MPOs have rarely considered wildlife movement needs or the reduction of wildlife-vehicle collisions as a priority in their regional transportation plans. A key part of our team's survey was to examine MPO participants' understanding of opportunities for increasing their agency's planning for wildlife connectivity and potential collisions with vehicles.

The objectives of the surveys were to learn of 1) current efforts to include wildlife consideration in transportation planning and processes, and 2) what efforts the respondents thought would best enhance those efforts, and 3) what were the most important barriers to those efforts. This survey was part of Task 1.A.i of the Pooled Fund Project: to identify and describe how transportation agencies integrate wildlife

mitigation into transportation procedures such as planning, project development, infrastructure design, construction, monitoring, and related processes.

## Methods

### *Survey Development*

The questions used in the on-line survey were developed from May through August of 2019 by the project researchers in conjunction with the TAC. Two separate surveys were created, one targeting state and provincial transportation agencies, and the second directed to MPOs that represent counties and cities. Surveys were administered using the Qualtrics platform, which allows subscribers to create single-question web pages with various opportunities to install check off boxes, and typed answers. Once the survey is closed, the results are summarized with spreadsheets.

### *Survey Question-Answer Format*

The research team employed four different formats to present survey questions:

- 1) Questions with multiple choice answers with the opportunity to select more than one answer;
- 2) Questions with multiple choice answers with only one selectable answer;
- 3) Questions using the Likert scale, with five distinct rating choices: Not at all important; Slightly important; Moderately important; Very important; and Not applicable;
- 4) Open ended questions to which participants could opt to provide a written response.

### *Overview of Survey Question Topics*

The DOT/MoT survey presented 10 questions on the following seven topics:

- 1) Wildlife mitigation implemented by the DODT/MoT since 2014;
- 2) Primary factors supporting the agency's integration of wildlife accommodations;
- 3) Greatest internal and external to the agency barriers to incorporating wildlife mitigation into transportation processes;
- 4) Rating the importance of six information sources for wildlife considerations;
- 5) Rating the importance of five planning tools and processes needed to support the inclusion of wildlife considerations;
- 6) Rating the importance of entities inside and outside of the agency; and
- 7) Provide written recommendations on how transportation agencies can improve their practices to include considerations for wildlife connectivity and wildlife-vehicle conflict in long-term planning and everyday practices.

The MPO survey presented seven questions on the following six topics:

- 1) How important addressing wildlife-vehicle conflict is to the agency;
- 2) Wildlife mitigation implemented by the MPO since 2014;
- 3) Information sources needed to incorporate wildlife considerations;
- 4) Rating the importance of collaboration with various outside entities;

- 5) The internal and external barriers to the inclusion of wildlife accommodations into plans, projects and everyday operations; and
- 6) The primary elements that could assist the MPO in improving their ability to consider wildlife connectivity and WVC in transportation planning.

#### *Invitation to Participate to Departments and Ministries of Transportation*

The invitation to partake in the on-line survey was sent via email to 237 professionals in U.S. state DOTs and Canadian MoTs. The U.S. state DOT professionals' contact information was obtained from members of the AASHTO Committee on Environment and Sustainability, the Environmental Process Sub-committee and the Natural Resources Sub-committee. In states not represented on those committees, internet searches of the state DOTs and the phrases "environmental branch" and "environment division" were the only phrases used and revealed the potential points of contact to disseminate the survey.

The Canadian transportation professionals' contact information were obtained for each Canadian provincial or territorial ministry of transportation with internet searches of each agency combined with the phrases used in the U.S. survey. Through these methods, personnel from the environmental departments or divisions were contacted in every U.S. state, and Canadian province and territory. Survey recipients were asked to share the survey with up to three colleagues whom were the most knowledgeable about wildlife crossings and transportation in their jurisdiction.

#### *Invitation to Participate to Metropolitan Planning Organizations*

The Federal Highway Administration (FHWA) master list of 404 MPOs was subsampled for representative MPOs. The large number of contacts on the list, the small size of some MPOs, and out of date contact information for some personnel necessitated a sampling from the list to create the contact list of potential survey participants. This sampling provided geographic representation throughout the U.S, and MPOs of various size populations of small, medium and large, based on the 2010 US Census data.

The sampling of the MPOs for potential participants also included other criteria. MPOs bordering Canada or Mexico were also targeted where relevant. In addition, specific MPOs that were known to have integrated wildlife accommodations in their master plans were also selected. Finally, the research team also selected MPOs that were close to forest areas/preserves/national or state parks and mountains where wildlife would be expected to be present in large numbers, or would migrate through or around the MPOs jurisdiction. It should be noted, that in some states MPOs were not geographically distributed across the state: the research team sought to gain spatial coverage, without nullifying selection methodology.

The research team reviewed MPO website contact pages to gather current names and emails for staff who (1) held management positions or (2) were principal/lead staff in a position of managing the development of federally mandated long-and short-range plans and programming of transportation projects. In some of the larger MPOs, staff that had titles indicating they conducted environmental analysis were points of contact. Emails to participate in the survey were sent to 230 personnel in MPOs throughout the U.S.

### *Survey Invitations, Posting, and Reminder Emails*

The two surveys were administered using the Qualtrics online survey platform. This platform allowed for separate pages for each question, response buttons, and other features for both ease of use and of analysis of responses. Two days prior to the survey, a pre-survey email was sent to inform recipients of the upcoming invitation to partake in the survey. Email invitations to participate in the survey included the subject line “Survey on the Inclusion of Wildlife Considerations in Transportation Processes” were sent out on to state and provincial transportation agencies on August 26, 2019. The survey to MPOs was sent on August 29, 2019.

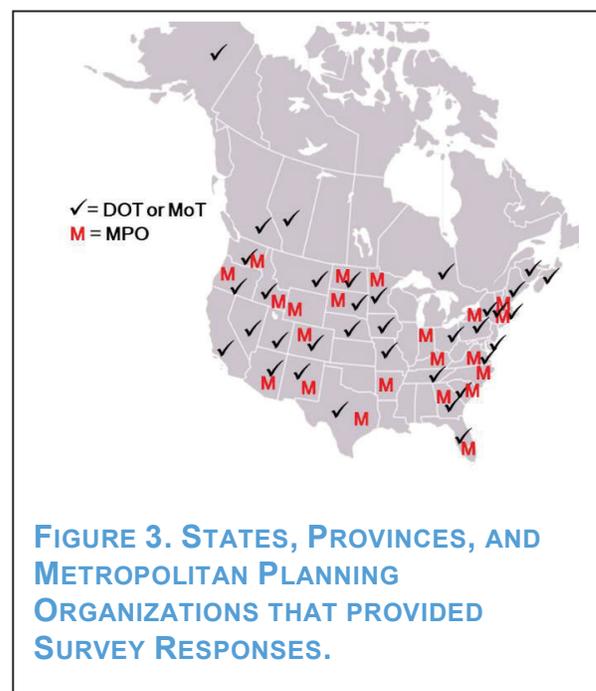
The survey was open through September 30. On September 21, the researchers sent reminder emails to all contacts in agencies who had not yet submitted a survey response. Several respondents requested the survey be extended an additional week, so the survey was officially closed on October 4, 2019.

### Results

There were 57 respondents to the DOT/MoT survey from 31 U.S. state DOTs, and six Canadian MoTs. The Ontario Ministry of Transportation sent in responses electronically via email after the survey had closed. Missouri was included in the results of Question 4, the only question the respondent from that state answered. There were three anonymous respondents.

For the MPO survey, there were 39 respondents from 27 MPOs, representing 21 states (see Figure 3). Like the DOT/MoT survey, there were respondents who chose to remain anonymous (n=5).

Each of the survey questions and the available answer choices for both surveys are presented below. For certain survey questions, a discussion of the results is presented to provide context for interpretation.



## *Transportation Agency Survey Questions and Responses*

### *Wildlife Mitigation Since 2014*

#### **1. Since 2014, has your agency implemented any of the following mitigation measures for large or small wildlife? Check all that apply.**

- New dedicated wildlife crossing structures **with** wildlife exclusion fencing. Please note how many have been constructed since 2014: \_\_\_\_\_
- New dedicated wildlife crossing structures **without** wildlife exclusion fencing. Please note how many have been constructed since 2014: \_\_\_\_\_
- Wildlife exclusion fencing **without** crossing structures
- Replaced existing culverts or bridges with upsized structures to promote wildlife passage
- Enhanced or improved existing culverts or bridges to promote wildlife passage (e.g., add fence, add cover elements, remove sediment, create pathways, etc.)
- Animal detection systems or crosswalks

Please include a written response if you would like to describe your answer in greater detail [Optional]

#### **Wildlife Crossing Structures**

Respondents from all 31 states and provinces and two anonymous respondents indicated their agency had implemented at least one of the above mitigation measures. Twenty-four states and provinces reported building wildlife crossing structures with or without fences since 2014. The number of wildlife crossing structures built in a given state or province ranged from one per state or province, to a high of 26 structures in Ontario. In total, the respondents reported over 188 new wildlife crossing structures built since 2014 (Table 3). These results can be considered estimates. In general, states and provinces may have different definitions of what constitutes a wildlife crossing structure (e.g., only purpose-built wildlife crossings versus bridges or culverts that may provide some wildlife passage function). In addition, some respondents noted a lack of formal counts of the number of wildlife crossing structures, and when structures were created for smaller animals such as reptiles, the exact number created was generally not known.

There was a geographic range of states and provinces with dedicated wildlife crossing structures, including 13 states and provinces from the western parts of the U.S. and Canada; three mid-western states; nine eastern states and one eastern Canadian province.

**TABLE 3. THE NUMBER OF WILDLIFE CROSSING STRUCTURES REPORTED BY EACH STATE OR PROVINCE CREATED SINCE 2014\*.**

State/ Province	Number of Wildlife Crossing Structures with Fence	Number of Wildlife Crossing Structures without Fence	State/ Province	Number of Wildlife Crossing Structures with Fence	Number of Wildlife Crossing Structures without Fence
Arizona	4	0	Nevada	11+	0
California	15	20	New York	3	10
Colorado	15	0	North Dakota	1	0
Delaware	1	0	Ohio	5+	1
Florida	~3	0	Ontario	26	1
Idaho	1	0	Oregon	1	0
Georgia	0	1	Texas	8	0
Iowa	3	1	Virginia	2	0
Maine	1	5	Washington	10	0
Maryland	1	0	Anonymous1	18	0
Massachusetts	2	1	Anonymous2	12	0
Montana	5	1	<b>Total reported</b>	<b>147+</b>	<b>41</b>
<b>States/ Provinces that did not report numbers</b>					
Utah					
Wyoming					
British Columbia					
Alberta					
			<b>Overall Total</b>		<b>188+</b>

\* Utah, Wyoming, British Columbia, and Alberta participants responded ‘yes’ to this question, but did not report specific numbers.

### **Wildlife Exclusion Fence, Enhanced and Retrofit Structures, and Animal Detection Systems**

Survey participants’ responses on agencies’ use of these three types of mitigation are listed in Table 4, below. Upsizing existing structures and the enhancement of existing structures were combined for reporting purposes. These were the most commonly implemented mitigation measures for most agencies since 2014.

**TABLE 4. U.S. STATE AND CANADIAN PROVINCES REPORTING ON USE OF THE THREE TYPES OF MITIGATION FOR WILDLIFE: FENCES ALONE, THE ENHANCEMENT OR RETROFIT OF STRUCTURES, AND ANIMAL DETECTION SYSTEMS AND/OR CROSSWALKS SINCE 2014.**

State / Province	Wildlife Exclusion Fence	Enhanced and Retrofit Structures	Animal Detection Systems and / or Crosswalks
Alberta	✓	✓	
Alaska	✓	✓	
Arizona	✓	✓	✓
British Columbia	✓	✓	✓
California		✓	
Colorado	✓	✓	✓
Delaware	✓	✓	
Florida	✓	✓	
Georgia	✓	✓	
Idaho		✓	
Iowa	✓		✓
Maine	✓	✓	
Maryland	✓	✓	
Massachusetts	✓	✓	
Minnesota	✓	✓	✓
Montana		✓	
Nevada	✓	✓	
New Brunswick	✓	✓	
New Mexico	✓	✓	✓
New York	✓	✓	
North Dakota	✓	✓	
Ohio		✓	
Ontario			
Oregon	✓	✓	✓
Pennsylvania		✓	
Tennessee			✓
Texas	✓	✓	
Utah		✓	✓
Virginia	✓	✓	✓
Washington			
Wyoming			

### Discussion on Wildlife Mitigation Questions and Responses

The respondents’ optional written responses were informative for providing details beyond the limits of the survey’s multiple choice answers. These responses spanned a range of ideas including wildlife crossing structures that were in the planning stages, fish passage, the placement of wildlife crossing structures in conjunction with water flow, and animal detection systems. Several respondents described practices that have

supported the inclusion of wildlife considerations in transportation projects. In Washington, Minnesota, and Massachusetts, it has become common practice to include wildlife accommodations as part of bridge or culvert replacement projects or in new larger projects wherever it is relevant. In these cases, it can be difficult to specify that these structures were upsized or retrofit specifically for wildlife. The creation of terrestrial pathways beneath bridges within the field of rock rip rap (which is very difficult for any wildlife to negotiate) is also becoming more common. In Minnesota, there is a new bridge and rip rap design aimed at assisting wildlife. The riprap does not have a bench pathway, but rather the entire slope is backfilled to fill the voids among the rocks, and make the surface walkable for a range of wildlife. Another common practice mentioned in several states was the installation of wildlife exclusion fence to existing bridges and culverts.

Overall the survey revealed the now common practices for upsizing replacement structures and retrofitting existing structures for wildlife. These practices may have been overlooked in previous studies. The important findings of this survey demonstrate that states and provinces across the two countries: install fence parallel to roadways to direct wildlife to existing structures to guide wildlife toward culverts and bridges for use; upsize new culverts and bridges to better accommodate wildlife passage; and retrofit structures, rip rap, pathways, and remove debris in structures to improve wildlife passage. These actions may be most affordable and most feasible mitigation strategies across all states and provinces. Complete written responses are presented in [Appendix B](#).

Question 1 was meant to also determine each respondent's agency's recent (previous five years) experience constructing wildlife crossing structures. The researchers could then correlate responses on specific opinion questions with the respondent's agency's recent past actions. If respondents did not report wildlife crossing structures or wildlife mitigation had been implemented by their agency in the previous five years, it was assumed the respondents may not have had recent experience in negotiating the process of implementing wildlife crossing structures. The goal of determining a difference among respondents was to see if the opinions of those working in an agency that was actively creating wildlife crossing structures were different than those whose agency had not created such structures in the past five years.

### *Target Species*

**1b. If your agency has constructed dedicated wildlife crossing structures since 2014, for which target species were these structures constructed? Check all that apply.**

- Federally protected species - please specify taxonomic group(s):
- State or provincially protected species - please specify taxonomic group(s):
- Large ungulates (such as deer, elk, moose, bighorn sheep, pronghorn)
- Large carnivores (such as bear, mountain lion)

- Medium to small sized mammals (such as bobcat, fox, raccoon, rabbit, mouse)
  - Reptiles
  - Amphibians
  - Invertebrates
- Other: please specify \_\_\_\_\_

There were several trends in the responses for question 1b, results are presented in Table 5. Key findings from the answers include the following:

Eighteen out of 33 (55 percent) of the states/provinces reported creating structures for large ungulates such as deer.

Thirteen states (39 percent, including three states that were associated with anonymous respondents) reported having created structures for federally or state/provincial protected species. The species listed were (in order of how often the species was mentioned): turtles, desert tortoise, lynx, grizzly bear, indigo snake, ocelot, and a number of species Washington included as targets species of their projects: wolverine, Cascades red fox, fisher, hoary marmot, American pika, Cascades golden-mantled ground squirrel, yellow pine chipmunk, and Douglas squirrel.

Thirteen of the states reported building structures for small to medium sized animals that were not listed as federal or state/provincial protected species.

Eleven states (33 percent) reported building structures for reptiles, the majority reported were turtles and tortoises, many of which are listed as federal or state/provincial threatened or endangered species, and were the target specie for improving passage on those transportation projects.

Ten states reported amphibians were the target species for building wildlife passage structures.

Large carnivores were the lowest represented taxa in the list, with seven states and provinces (21 percent) indicating there were structures built for them.

There were two written answers. Delaware replied they built structures for fish.

Washington respondents indicated that target species for transportation projects in the Central Cascade mountains included: "All invertebrates that occur in the central Cascades," lichens and fungus.

Minnesota and North Dakota mentioned that "restoring ecological function" was the target species.

Geographic locations of respondents spanned the U.S. and Canada. There were 12 states/provinces from the western half of the continent, nine states from the eastern

region, and three states from the Midwest. There were also three anonymous respondents whose locations were not known.

**TABLE 5. RESPONDENTS' IDENTIFICATION OF TYPES OF TARGET SPECIES WILDLIFE CROSSING STRUCTURES WERE CONSTRUCTED TO ACCOMMODATE SINCE 2014.**

State/ Province	Target Species						
	Federally protected species	State or provincial protected species	Large ungulates	Large carnivores	Medium to small sized mammals	Reptiles	Amphibians
AB			X	X			X
AZ	X	X	X		X	X	
			Bighorn sheep			Desert tortoise	
CA	X	X			X	X	X
CO			X	X	X		
DE			X				
DE							Fish
FL	X	X		X	X		
GA	X					X	
	Eastern Indigo snake, Gopher tortoise						
MA	X	X	X		X	X	X
		Reptiles Amphibians				Turtles	
IA		X				X	
ID			X				
ME	X	X			X	X	
	Lynx				Lynx	Turtles	
MD			X				

State/ Province	Target Species						
	Federally protected species	State or provincial protected species	Large ungulates	Large carnivores	Medium to small sized mammals	Reptiles	Amphibians
MT	X						
	Grizzly bear		X	X	X		
ND	X		X		X		X
NM			X	X			
NV	X						
	Desert tortoise		X			X	
NY					X	X	X
OH			X		X	X	X
OR			X		X		
PA			X	X			
TX	X				X		X
	Ocelot				Ocelot		
UT			X				
VA			X				X
WA	X	X					X
	Wolf, Grizzly bear, Canada lynx	Wolverine, Cascades red fox, Fisher, Hoary marmot, American pika, Cascades golden-mantled Ground squirrel, Yellow pine chipmunk, Douglas squirrel, etc.	X	X	X	X	All invertebrates that occur in the central Cascades AND lichens and fungus

State/ Province	Target Species						
	Federally protected species	State or provincial protected species	Large ungulates	Large carnivores	Medium to small sized mammals	Reptiles	Amphibians
Anonymous	X						
	Mammals Amphibians				X		X
Anonymous	X						
	Amphibians		X			X	
Anonymous	X						
	Mohave desert tortoise						

## Discussion of Target Species

The results of this survey are very similar to a survey conducted between 2004 and 2006 (Bissonette and Cramer 2008). Both surveys found the primary reasons transportation agencies build wildlife crossing structures are for large ungulates, and for federally and state/provincially protected species. There are many exceptions, but the trend continues to be that the construction of wildlife crossing structures is based mainly on safety factors (the ungulates' threat to motorists), and from regulatory input from wildlife agencies, such as the U.S. Fish and Wildlife Service. These two factors align with the following question concerning the primary factors for integrating wildlife accommodations into transportation projects.

An interesting trend that did not appear in the 2004-2007 survey is that three states (MN, ND, and MA) mentioned that they did not have a specific target species for creating the mitigation, but rather, in the words of Peter Leete of Minnesota "Our structures have not specifically targeted any species. The intent is to maintain (or reconnect) ecological connectivity along our streams and rivers." This is an important point along the evolution of transportation ecology; progression in wildlife mitigation trends from a focus on species that pose a danger to motorists or that are protected by legislation, to preserving or restoring ecological connectivity across the landscape. This more holistic approach may be considered ecologically sound and easier to strive for than following specific data or regulatory requirements.

Several comments are reported in [Appendix B](#).

### *Primary Factors for Integrating Wildlife Mitigation*

Respondents were then asked to identify various factors that have compelled their agency to integrate wildlife accommodations into projects. Ten respondents from agencies that had not created mitigation for wildlife since 2014 also answered this question. Thirty-eight respondents from states and provinces that created wildlife crossing structures since 2014 answered this question. Respondents could select multiple responses. This question did not limit responses from respondents whose agencies constructed mitigation since 2014.

## **2. If your agency has implemented wildlife mitigation, what were the primary factors that compelled your agency to integrate wildlife accommodations/mitigation into projects? Check all that apply.**

- Demonstrated safety hazard
- Legislative requirement (e.g., federal or state/provincial listed species mandates mitigation, or other legislative mandate)
- Action recommended by wildlife agency
- Research demonstrating an area is critical for wildlife movement
- Private entities such as citizens and non-profits are promoting mitigation

- Wildlife mitigation identified at the district or regional level of the transportation agency
- Wildlife mitigation identified at the headquarters level of the transportation agency
- Political support outside of the agency (e.g., state/provincial representatives or governor)

Please include a written response if you would like to describe your answer in greater detail [Optional]

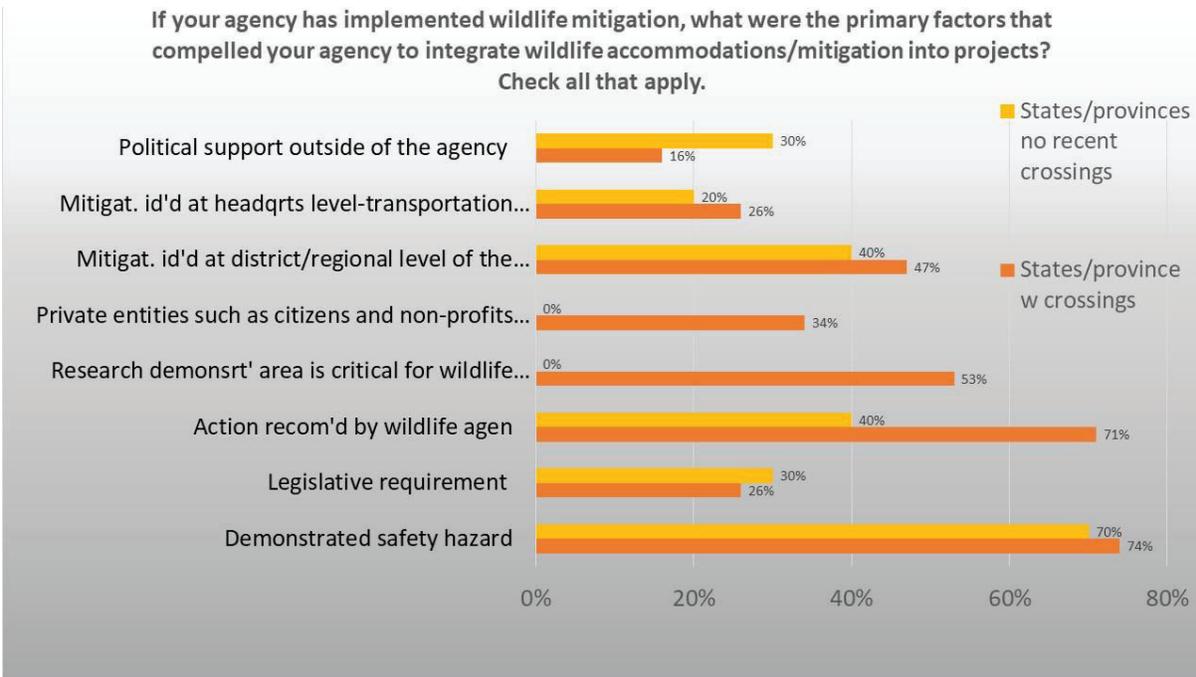
Responses were divided between those from agency personnel who indicated their agency had created wildlife crossing structures since 2014, and those that did not. The goal was to determine if the personnel whose agencies had recent (in the past five years) experience implementing wildlife crossing structures provided different answers and thus perspectives than those whose agencies had not recently created wildlife crossing structures. In Figure 4 below, the deep orange bars represent responses from personnel in agencies with experience creating wildlife crossing structures since 2014 (state/provinces with crossings), while the light mustard-yellow bars represent agency personnel responses from agencies that did not have recent (since 2014) experience creating wildlife crossing structures (state/province no recent crossings). Respondents could select all answers that applied.

The most commonly identified factors identified by respondents from agencies with recent crossing structures were, presented as percent of the 38 respondents who answered the question:

- 1) A demonstrated safety hazard (77 percent);
- 2) Mitigation action recommended by wildlife agency (71 percent); and
- 3) Research demonstrating that an area is critical for wildlife movement (53 percent).

For 10 agency personnel from agencies with no recent crossings, who responded, the top factors identified are presented as percentages of those respondents who chose the factor:

- 1) Demonstrated safety hazard (70 percent);
- 2) Mitigation action recommended by wildlife agency (40 percent); and
- 3) Mitigation identified at district/regional level of the transportation agency (40 percent).



**FIGURE 4. RESPONSES FROM SURVEY PARTICIPANTS IN STATES AND PROVINCES THAT CREATED WILDLIFE CROSSINGS STRUCTURES SINCE 2014 (DARK ORANGE BARS), AND RESPONDENTS WHOSE AGENCIES HAVE NOT CREATED CROSSING STRUCTURES SINCE 2014 (YELLOW BARS). RESULTS REPORTED IN PERCENTAGE OF THOSE IN EACH CLASS OF AGENCY THAT SELECTED EACH FACTOR.**

### Discussion of Important Factors

There was no clear distinction between the two groups of agency personnel who answered Question 2: those in agencies with experience in implementing crossing structures in the past five years, and those who had not. Both groups ranked a need for a project to have a demonstrated safety hazard as the top factor, and recommendation by wildlife agency to create mitigation as a second factor as the main drivers for constructing wildlife crossing structures. Agencies that had not recently created wildlife crossing structures also identified the importance of mitigation identified at district/regional level of the transportation agency as another second place factor. Overall, these results help inform this research as to what all agency personnel view top factors that compel agencies to develop projects with wildlife crossing structures.

[Appendix B](#) presents the participants' comments.

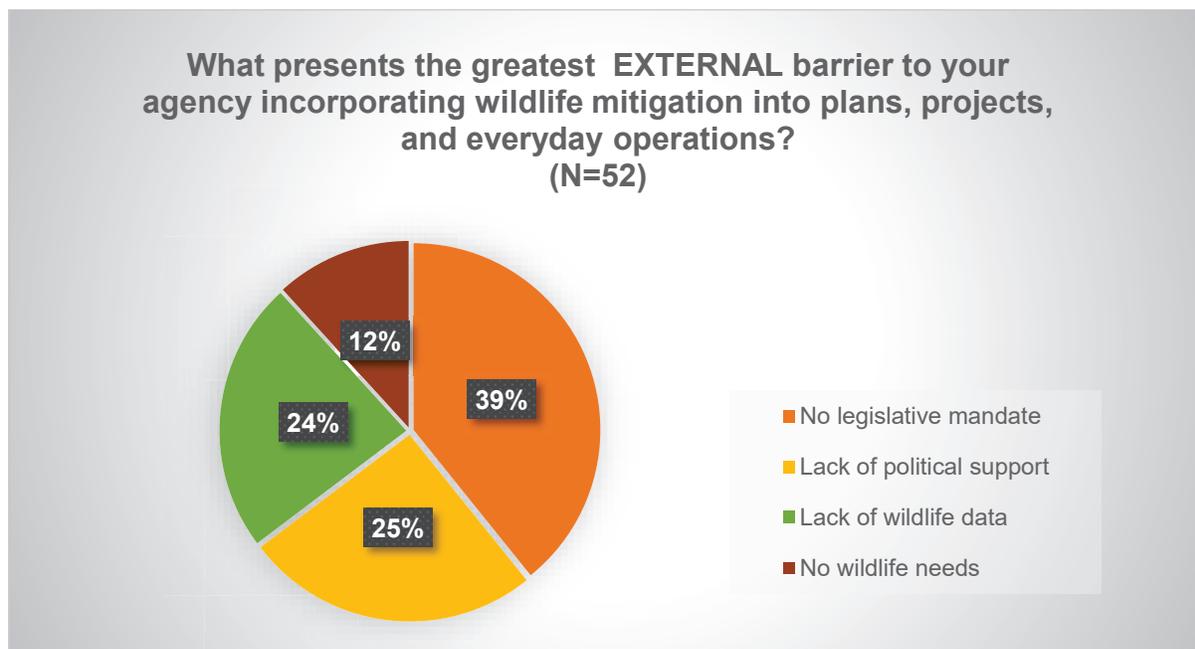
### *Barriers to Incorporation of Wildlife Mitigation*

Question 3 asked participants about external barriers to agency incorporation of wildlife mitigation, while Question 4 asked about barriers internal to their agency. The answers are displayed in Figures 5 and 6.

**3. Of the following items, which presents the greatest barrier to your agency incorporating wildlife mitigation into plans, projects, and everyday operations? Select one.**

- No need to incorporate wildlife mitigation into transportation planning
- Lack of wildlife movement data
- No legislative mandate to construct wildlife crossings or mitigation
- Political climate, i.e., lack of high-level political support outside of the agency.

Please include a written response if you would like to describe your answers in greater detail [Optional]

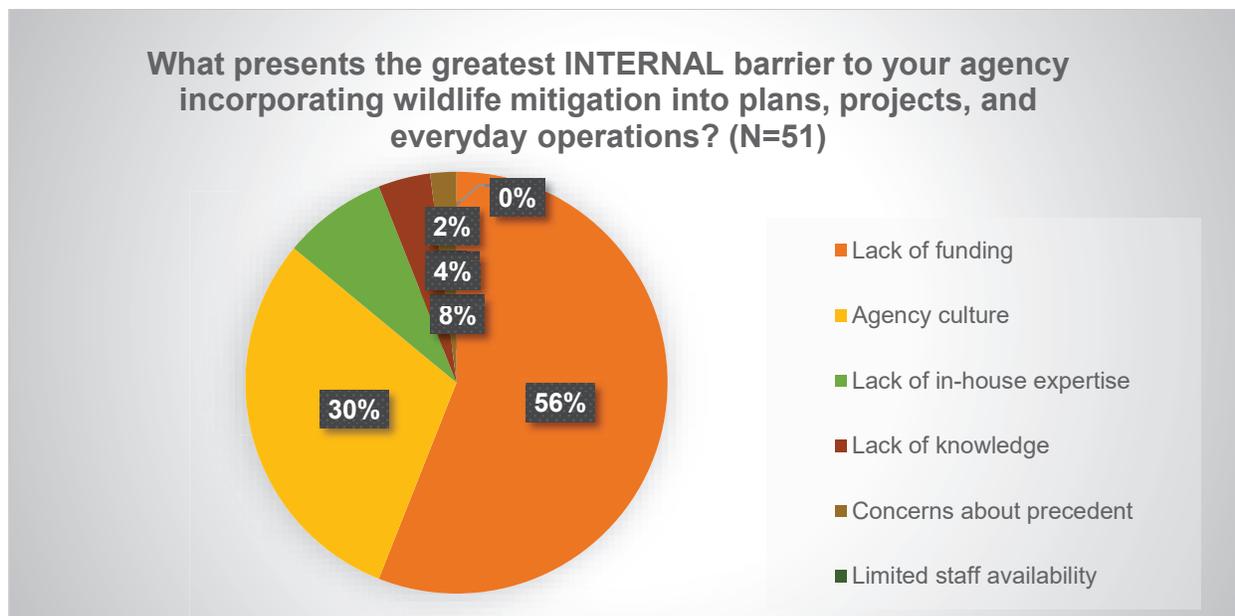


**FIGURE 5. IMPORTANCE OF DIFFERENT BARRIERS EXTERNAL TO THE AGENCY, AS SELECTED BY RESPONDENTS. PERCENTAGES REPRESENT THE PERCENTAGE OF RESPONDENTS THAT SELECTED THE BARRIER.**

**4. Of the following items, which presents the greatest barrier to your agency incorporating wildlife mitigation into plans, projects, and everyday operations? Select one.**

- Lack of knowledge about wildlife mitigation strategies
- Lack of in-house guidance or expertise
- Limited staff availability
- Lack of funding for mitigation
- Concerns about setting a precedent for future commitments
- Agency culture, i.e., lack of internal support for wildlife mitigation

Please include a written response if you would like to describe your answers in greater detail [Optional]



**FIGURE 6. IMPORTANCE OF DIFFERENT BARRIERS INTERNAL TO THE AGENCY, AS SELECTED BY RESPONDENTS. PERCENTAGES REPRESENT THE PERCENTAGE OF RESPONDENTS THAT SELECTED THE BARRIER.**

### Discussion of Barriers

The responses most frequently mentioned were no legislative mandate for barriers outside the agency, and lack of funding to do so as the barrier within the agency. The second most important set of barriers were lack of political support external to the agency, and agency culture.

The 20 comments from respondents were instructive in specific pros and cons of various agency practices. See [Appendix B](#).

### *Importance of Information Sources*

Respondents were asked to use a Likert scale to rate how important various information sources were to incorporating considerations of wildlife connectivity and wildlife-vehicle conflict into transportation planning, projects and everyday operations.

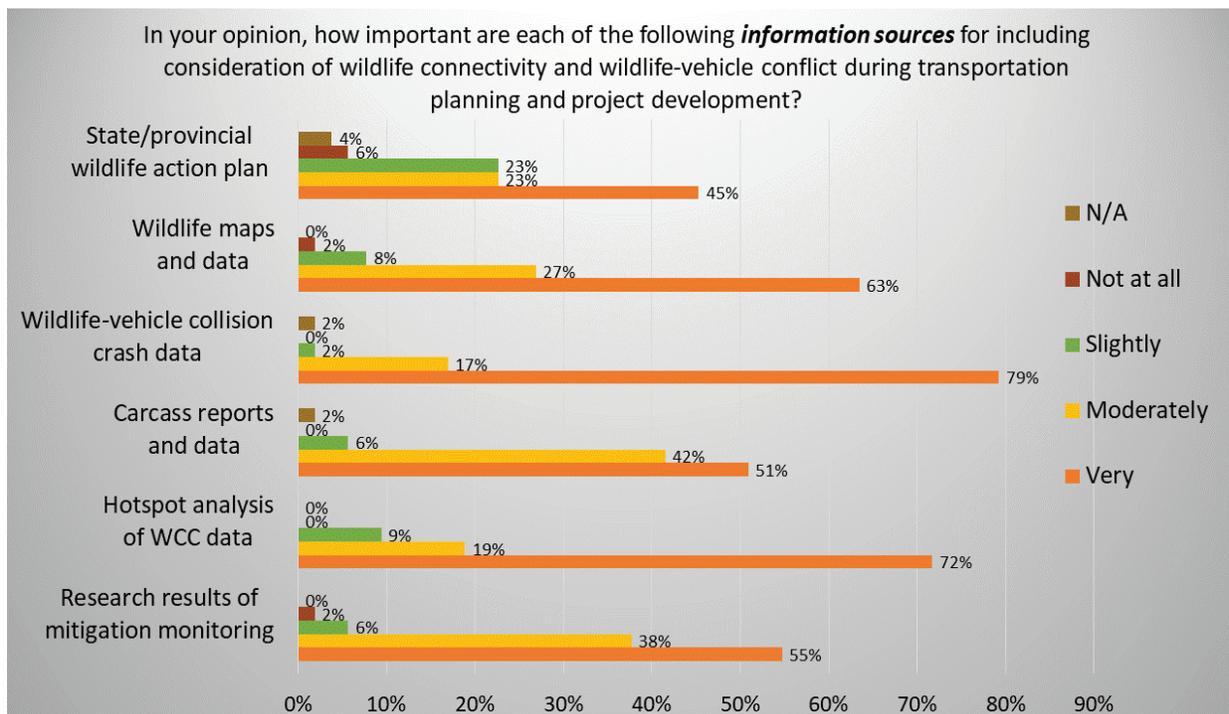
### **5. In your opinion, how important are each of the following *information sources* for including consideration of wildlife connectivity and wildlife-vehicle conflict during transportation planning and project development?**

- State/provincial wildlife action plan
- Wildlife maps and data
- Wildlife-vehicle collision crash data
- Carcass reports
- Hotspot analysis of wildlife-vehicle collision data
- Research results of mitigation monitoring

The following percentage of respondents rating each of these information sources as ‘Very Important’ or ‘Moderately Important’ was:

- 1) Wildlife-vehicle collision data (96%);
- 2) Research results from mitigation monitoring (93%);
- 3) Carcass data (93%);
- 4) Hotspot analyses of wildlife-vehicle collision data (91%);
- 5) Wildlife maps and data (90%);
- 6) State/provincial wildlife action plans (68%).

The full range of responses for each question are presented below (Figure 7).



**FIGURE 7. RATINGS OF IMPORTANCE OF VARIOUS INFORMATION SOURCES.**

### *Importance of Planning Tools*

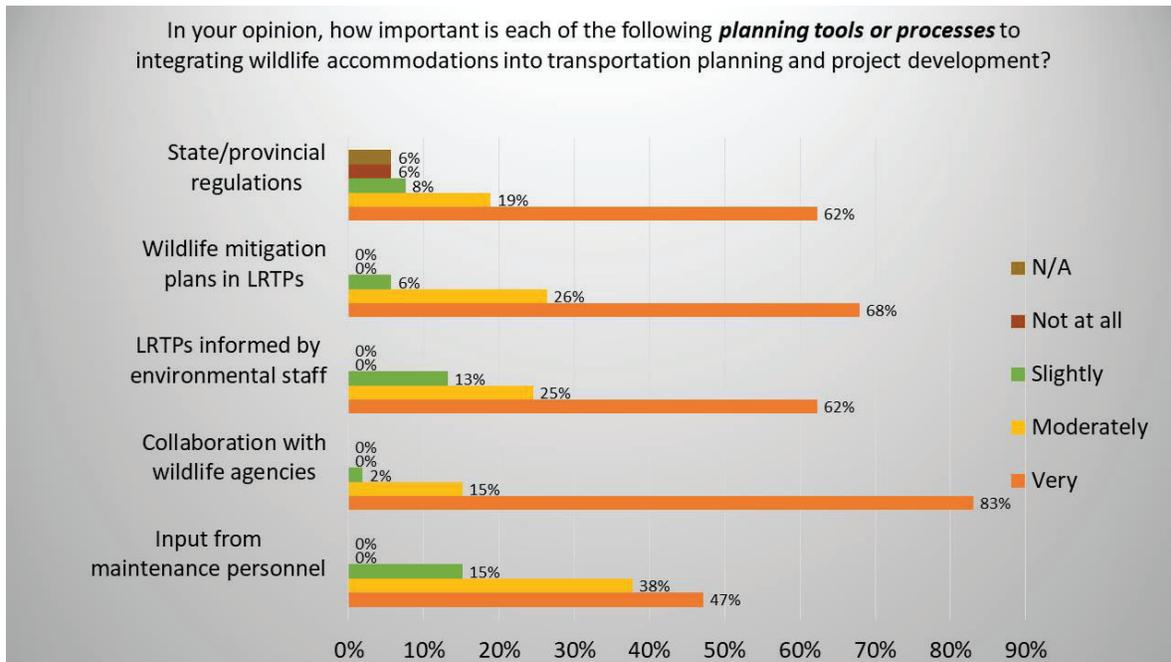
Participants were asked to rate on a Likert scale, how important five planning tools and processes were for integrating wildlife connectivity and collision concerns into transportation planning and project development. The results are presented with the five different tools and processes ranked in Figure 8.

### **6. In your opinion, how important is each of the following *planning tools or processes* to integrating wildlife accommodations into transportation planning and project development?**

The percentage of respondents rating each of these planning tools and processes as ‘Very Important’ or ‘Moderately Important’ was:

- 1) Collaboration with wildlife agencies (98%);

- 2) Inclusion of wildlife mitigation plans in the long range transportation plans (94%);
- 3) Long range transportation plans (LRTP) informed by environmental staff (87%);
- 4) Input from maintenance personnel (85%); and
- 5) State/Provincial regulations (81%).



**FIGURE 8. RATINGS OF IMPORTANCE OF PLANNING TOOLS OR PROCESSES.**

### *Importance of Support from Different Entities*

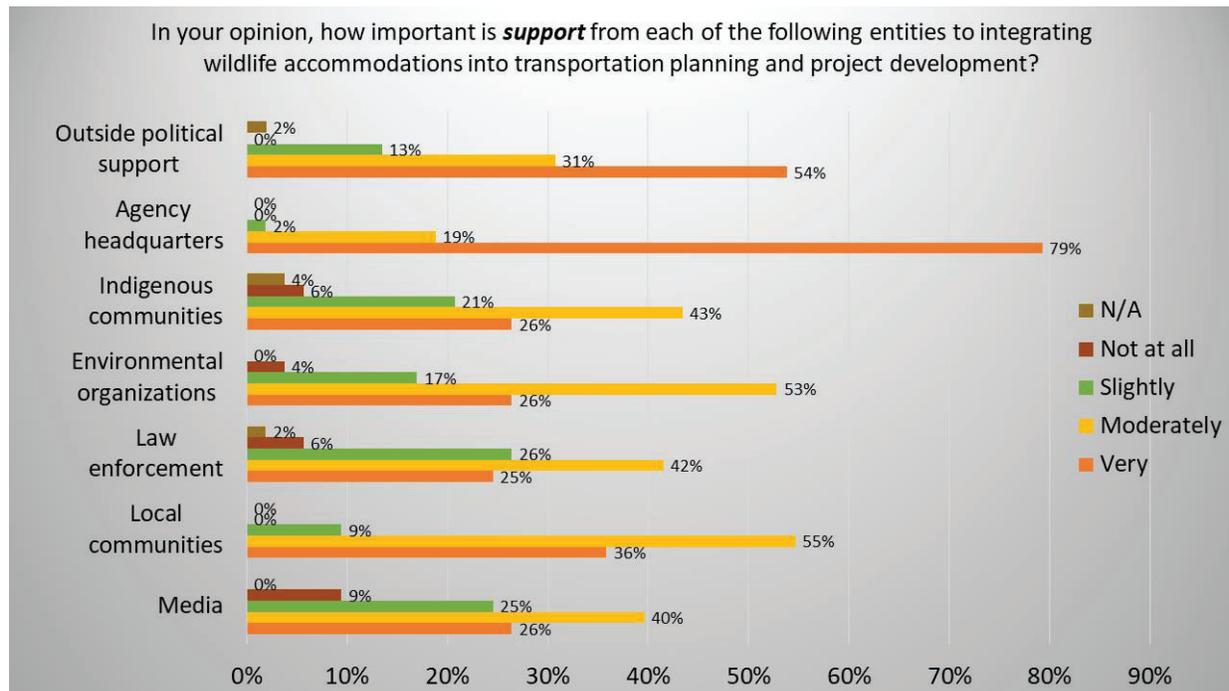
Question 7 of the survey asked respondents about their opinions on the importance of support from various entities within and outside the agency to integrating wildlife accommodations into transportation planning and project development.

### **7. In your opinion, how important is support from each of the following entities to integrating wildlife accommodation into transportation planning and project development?**

The percentage of respondents rating support from each of these entities as 'Very Important' or 'Moderately Important' was:

- 1) Agency headquarters (98%);
- 2) Local communities (91%);
- 3) Outside political support (85%);
- 4) Environmental organizations (79%);
- 5) Indigenous communities (70%);
- 6) Law enforcement (66%), and
- 7) Media (66%).

The full ratings of the importance of each entity are presented below, Figure 9.



**FIGURE 9. RATINGS OF THE IMPORTANCE OF DIFFERENT ENTITIES IN INTEGRATING WILDLIFE INTO TRANSPORTATION PLANNING AND DEVELOPMENT.**

### *Respondents' Recommendations*

The final question asked participants to give recommendations.

**8. Please provide your recommendation(s) for how transportation agencies can improve their practices to include considerations for wildlife connectivity and wildlife-vehicle conflict in long-term planning and everyday practices.**

Common themes among the 47 written responses included:

- 1) A need for dedicated funding;
- 2) Legislation to incorporate wildlife-vehicle collision hotspot analyses into Action Plans;
- 3) Incorporation of wildlife awareness into the agency/corporate culture from the top down, from headquarters to local levels;
- 4) A need to instill environmental stewardship within transportation agencies;
- 5) Agencies should make data available, such as statewide wildlife corridors and action plans;
- 6) States and provinces need additional wildlife movement studies;
- 7) There is a need for federal designation of critical wildlife habitat;
- 8) Agencies should map wildlife-vehicle collision hotspots;
- 9) Maintain provincial/state interagency databases; and
- 10) Establish working groups between transportation and wildlife agencies which in turn can promote important early coordination.

All comments are presented in [Appendix B](#).

### *Metropolitan Planning Organizations Survey Responses*

The types of questions and response choices for MPOs were similar to those described for the transportation agencies survey but tailored toward MPOs.

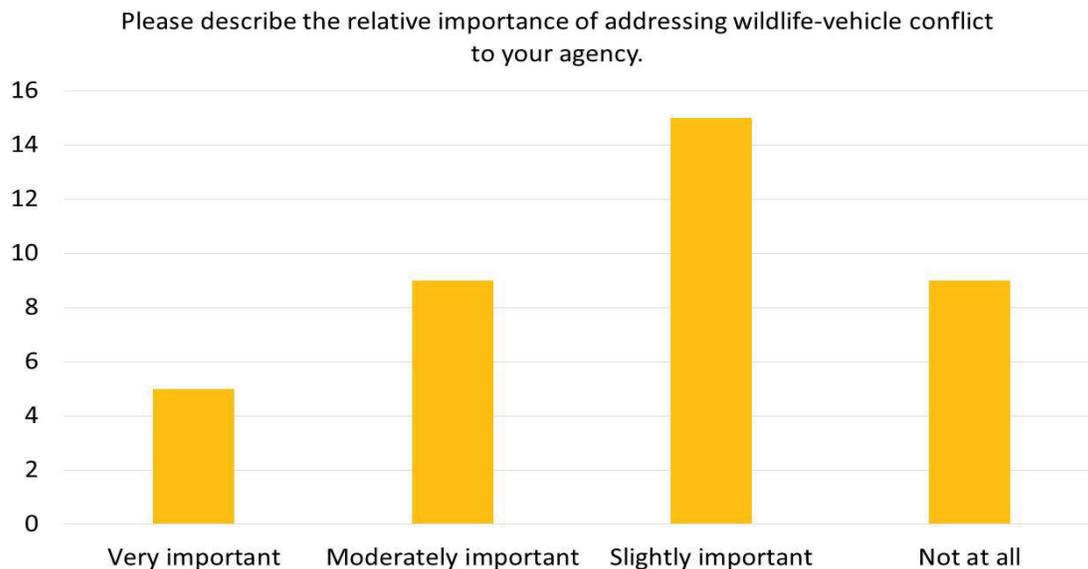
#### *Importance of Addressing Wildlife-Vehicle Conflict in the Agency*

##### **1. Please describe the relative importance of addressing wildlife-vehicle conflict to your agency.**

Thirty-eight respondents characterized the value of addressing wildlife-vehicle conflict in their jurisdiction as follows:

- 1) Very important (5);
- 2) Moderately important (9);
- 3) Slightly important (15); and
- 4) Not at all (9).

Responses are presented in Figure 10.



**FIGURE 10. IMPORTANCE TO AGENCY OF ADDRESSING WVC.**

##### **2. Since 2014, has your agency been involved in planning or constructing mitigation to reduce wildlife-vehicle collisions and/or improve wildlife connectivity?**

- Yes
- No

Seven respondents (18%) replied yes.

The five comments received all focused on planning efforts for wildlife. An Arizona MPO used the wildlife agency wildlife linkage data to identify areas of potential wildlife-vehicle conflict, prioritized those areas, and set project costs. Another MPO was developing a master plan that included wildlife crossing structures. A third agency was working with various agencies to promote safety and security for wildlife.

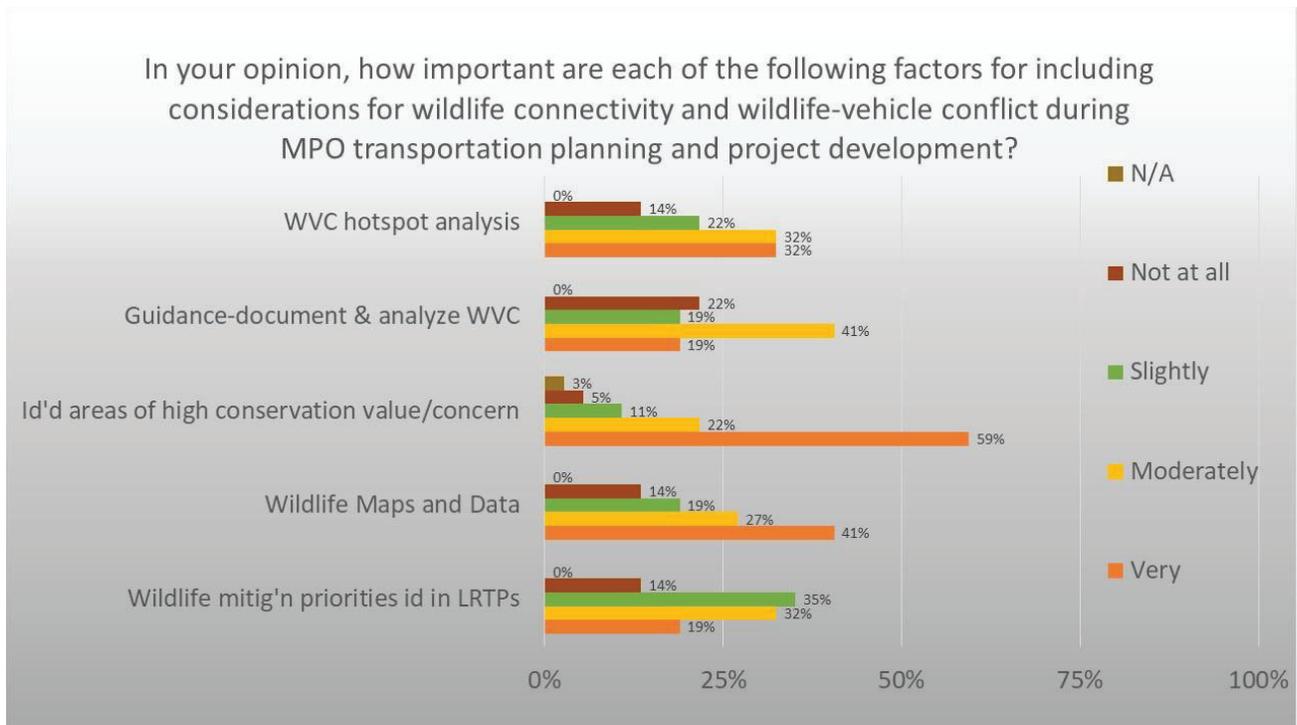
*Importance of Various Factors to Include Consideration of Wildlife*

**3. In your opinion, how important are each of the following factors for including considerations for wildlife connectivity and wildlife-vehicle conflict during MPO transportation planning and project development?**

The percentage of respondents rating each of the following factors as ‘Very Important’ or ‘Moderately Important’ was:

- 1) Areas of high conservation value/concern (81%);
- 2) Wildlife maps and data (68%);
- 3) Wildlife-vehicle collision hotspot analysis (64%);
- 4) Guidance for how to document and analyze wildlife-vehicle conflict (60%); and
- 5) Include wildlife mitigation priorities identified in the long range transportation plan (51%).

Ratings of the factors are presented in greater detail below (Figure 11).



**FIGURE 11. IMPORTANCE OF FACTORS TO INCLUDING CONSIDERATION OF WILDLIFE DURING MPO TRANSPORTATION PLANNING AND PROJECT DEVELOPMENT.**

The major themes that emerged from the 13 detailed responses were:

- 1) Lack of resources and guidance (policy/data) offered for long range plan development at the federal and state level;
- 2) Opportunity challenges – MPO’s do not consider this an urban area issue because:  
(a) limited wildlife in their jurisdictions or species are considered highly adaptable;  
(b) long range plans are high-level and not specific to particular corridor or mitigation options; and (c) corridor studies require specific data/hot spot analysis that are not available for the jurisdiction;
- 3) Priority focus – wildlife-vehicle collisions are not a political priority and other policy/project considerations such as bike/pedestrian projects take a stronger prioritization focus in plan development in urbanized areas.

#### *Importance of Collaboration with Various Entities*

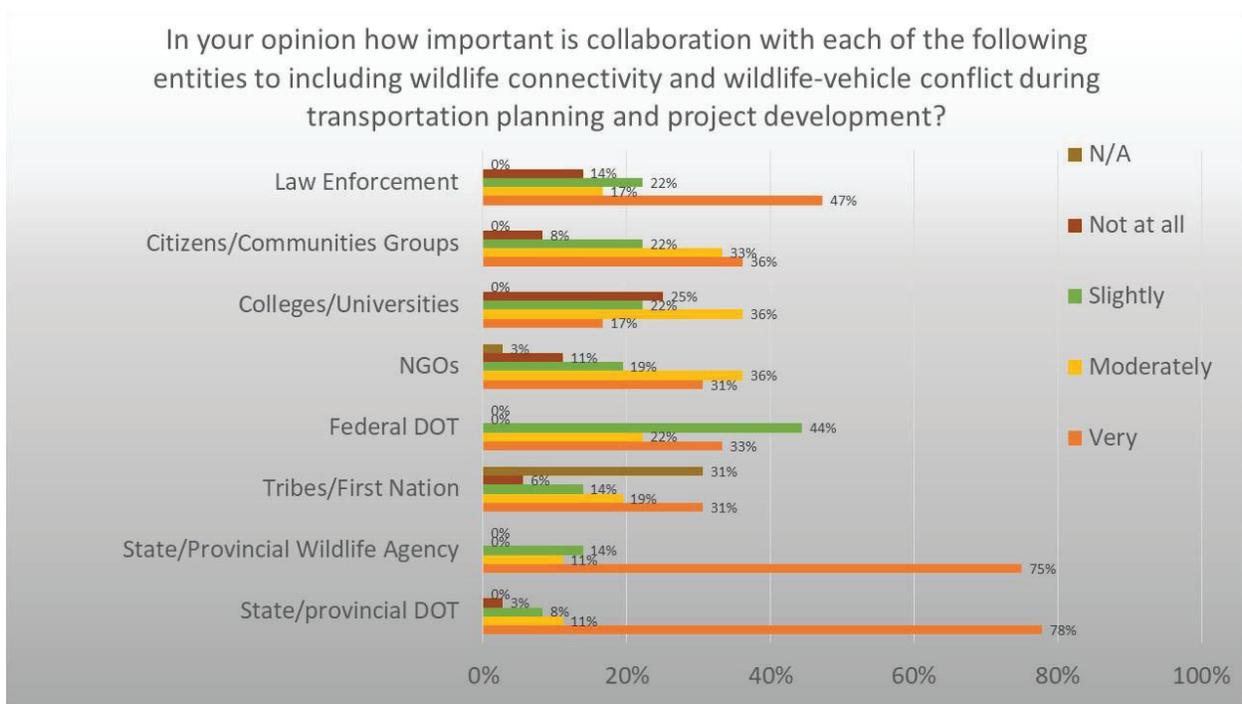
MPO survey participants were asked to rate the importance of collaboration with eight different entities, using a Likert scale.

#### **4. In your opinion, how important is collaboration with each of the following entities to including consideration of wildlife connectivity and wildlife-vehicle conflict during transportation planning and project development?**

The percentage of respondents rating each of the following entities as ‘Very Important’ or ‘Moderately Important’ collaborators:

- 1) State/Provincial DOTs/MoTs (89%);
- 2) State/Provincial Wildlife Agencies (86%);
- 3) Citizens/Community Groups (69%);
- 4) Non-Governmental Organizations (67%);
- 5) Law Enforcement (64%);
- 6) US DOTs (55%);
- 7) Colleges/Universities (53%); and
- 8) Tribes/First Nations (50%).

The results are presented in greater detail below (Figure 12).



**FIGURE 12. RATING OF COLLABORATION WITH DIFFERENT ENTITIES TO INCLUDE CONSIDERATION OF WILDLIFE.**

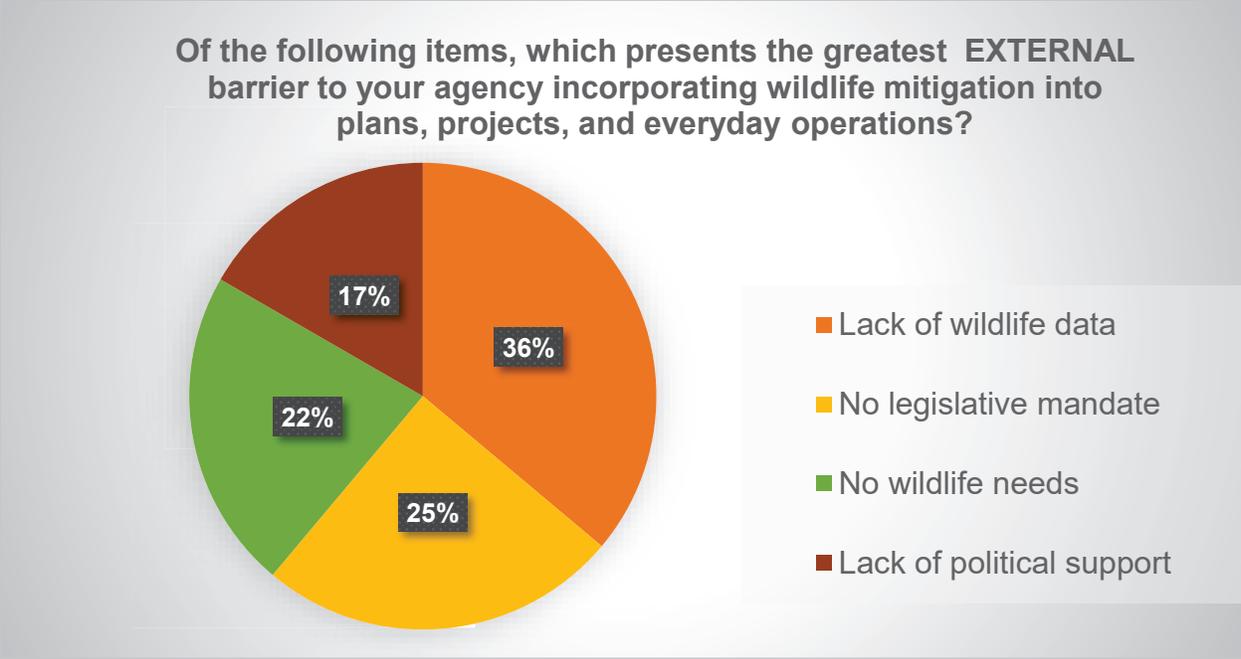
*Barriers External and Internal to the Agency*

The survey presented a list of four barriers external to the agency for the incorporation of wildlife mitigation into transportation planning within the MPO’s. Respondents could only choose one of the options.

**5. Of the following items, which presents the greatest barrier to your agency incorporating wildlife mitigation into plans, projects, and everyday operations? Select one.**

- No need to incorporate wildlife mitigation into transportation planning
- Lack of wildlife movement data
- No legislative mandate to construct wildlife crossings or mitigation
- Political climate, i.e., lack of high-level political support outside of the agency

Results are presented collectively below (Figure 13).



**FIGURE 13. RATINGS OF BARRIERS EXTERNAL TO THE AGENCY TO INCORPORATING WILDLIFE CONCERNS.**

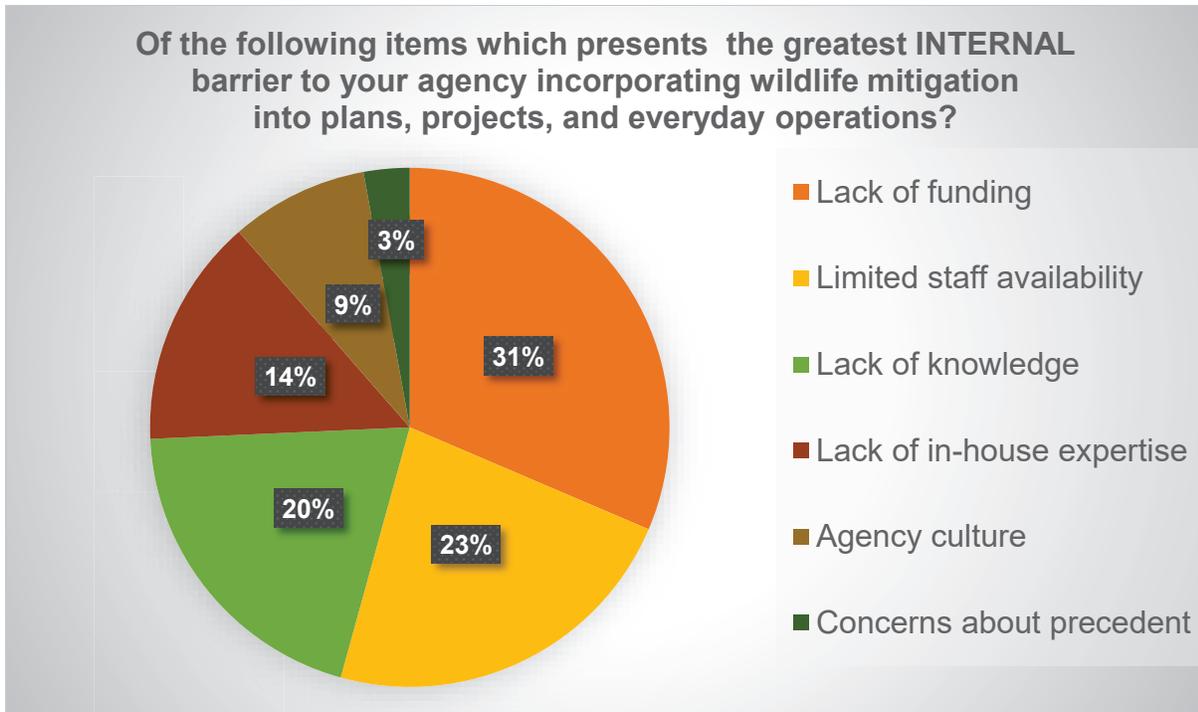
Participants of the survey were asked about barriers within their agency that limited wildlife mitigation actions.

**6. Of the following items which presents the greatest barrier to your agency incorporating wildlife mitigation into plans, projects, and everyday operations? Select one.**

The barriers from inside the agency were ranked by respondents' choices:

- 1) Lack of funding (31%);
- 2) Limited staff availability (23%); and
- 3) Lack of knowledge (20%)
- 4) Lack of in house expertise (14%)
- 5) Agency culture (9%)
- 6) Concerns about precedent (3%).

The overall results are presented below, (Figure 14).



**FIGURE 14. BARRIERS WITHIN AGENCY FOR INCORPORATING WILDLIFE CONCERNS.**

Participants were asked:

**Please include a written response if you would like to describe your answer in greater detail [Optional]**

In addition to the above identified barriers, respondents cited a lack of ability to influence the state DOT that actually implements projects and complexity in integrating projects into State DOT plans and local jurisdiction plans. All comments are presented in [Appendix B](#).

*Recommendations from MPO Respondents*

**7. What are the top 3 elements that could assist Metropolitan Planning Organizations in improving their ability to include considerations for wildlife connectivity and wildlife-vehicle conflict in transportation planning?**

Reponses are presented in Table 6 in the same order they were written by respondents. Data and funding were the top first and second elements suggested. Training and education and a will within an agency were a third theme.

**TABLE 6. RESPONSES TO THE QUESTION OF THE TOP THREE ELEMENTS TO ASSISTING MPO'S IN THEIR ABILITY TO CONSIDER WILDLIFE.**

<b>Recommendation 1</b>	<b>Recommendation 2</b>	<b>Recommendation 3</b>
Identification of high crash locations	Concepts to address these issues (how do we reduce conflict?)	Identification of migratory corridors and crossing locations
Funding	Mandate legislatively	data
More support from state DOT	Better data	Better education about the topic
Funding	Data	Low-Cost Mitigation Strategies
Education	Data	funding
Guidance documents	Templates	Webinar (that would also be recorded) discussing how to incorporate into documents
Better mapping and data, include larger geo context	Funding for mitigation in projects	Range of solutions for range of species
Committed funding to improvements (fiscal constraint)	Wildlife tracking data	Wildlife conflict/crash data
Data; coordination for data	Cost effective recommendations or implementation techniques	Impacts or outreach from agencies heading up this effort (our MPO has never heard much)
Resources to analyze issues	Understanding of motivations in this discussion	Predictable funding source for large projects
Amount of wildlife vehicle collisions that take place	Shared Data	Internal want
Shared Guidance/Expertise	Ability to identify cost/benefit of projects	Additional Staff
Grant funding from DCR or DEQ to hire a consultant to undertake this analysis for our region	Direction from above i.e. legislature	Encourage collaboration with FDOT design and engineering prior to construction contract.
Data driven mapping of wildlife movements, include multiple species	Funding	Identified funding for design and construction of facilities
Data	Require coordination with FDEP and water management	Additional funding for staff with this sort of expertise at the regional level

Recommendation 1	Recommendation 2	Recommendation 3
Availability of Data	Best practices for mitigation for specific species	Data Supporting Need for Planning and Investment
Land use review authority	State DOT Requirements and guidance	State DOT policy on wildlife roadway management
GIS shapefiles and or maps	Design of Replacement Infrastructure or Adaptations	Data is by MPO planning area, county, municipality, or Census Tract
Identification of endangered species in the planning area	Adequate knowledge of wildlife movement / tendencies	Increased funding for mitigation.
FHWY requirements and guidance	Data is in GIS format	Information/Resources
Funding for Physical Improvement	Political support outside of the agency.	Requirement for funding
Get the information communicated to MPO.	Training	Greater political support
Wildlife incident data by location	State agencies working together (DNR + DOT)	Wildlife movement data
Regularly collected wildlife data	greater influence over project implementation	Training on wildlife mitigation techniques
Incorporating these considerations into permit requirements.	Mitigation techniques	
Funding	Coordination with regulators and data scientists	
Guidance	More information on wildlife movements	
Wildlife data		
Funding availability		
Regulatory mandate		
A sense among the jurisdictional staff and policy-makers that it was important		

**Discussion**

Both surveys revealed:

- Regardless of a respondent’s agency’s level of experience with wildlife mitigation, the results were similar in terms of identified needs and barriers to incorporating wildlife accommodations.

- Respondents from both surveys found that the greatest barriers to incorporating wildlife considerations were lack of funding and a lack of legislative mandates to consider wildlife.
- Collaboration with wildlife agencies was considered important to respondents in both surveys.
- A consistent theme was a need to enact change in the agency culture to consider wildlife concerns. The respondents' comments mentioned this could be achieved through legislative action, or a changes at the headquarters and local level offices of the agencies.

It is important to note that states are incorporating wildlife concerns into standard operating procedure, and because of this, they can no longer keep track of specific dedicated wildlife crossing structures. Washington, Minnesota, and Massachusetts' respondents mentioned this. Thus our efforts to track the numbers and types of mitigation placed or upgraded and retrofit structures is eventually diminishing as incorporate of wildlife concerns become standard operating procedure.

Another interesting result was the 28 states and provinces out of 31 that responded to the transportation agency survey question 1 indicated that replacement structures were upsized for wildlife and enhancements were made on structures and infrastructure to promote wildlife passage. This finding indicates that consideration of wildlife movement needs has become more common than may have been determined from solely looking at the number of wildlife crossing structures a state or province has created, and since a similar survey was given in 2004-2006 (Bissonette and Cramer 2008). These actions may be most affordable and most feasible mitigation strategies across all states and provinces. The use of these methods may indicate the approach to inclusion of wildlife needs in transportation has begun in most states and provinces and may start with these smaller actions in some jurisdictions, rather than larger wildlife mitigation projects. These actions, along with the very informative comments received from the respondents indicate the US and Canada are progressing as nations and as collections of state and provincial departments and ministries of transportation toward including wildlife concerns as a matter of everyday business practices.

The respondents of the MPO survey revealed very little progress has been made within these agencies. It appears a lack of data, training, understanding, funding, and legislative mandate all work to keep the status quo of the way these agencies conduct business with respect to wildlife. Fortunately, survey respondents of the MPO survey indicated the same needs for change as transportation agency participants: the need for dedicated funding for wildlife, data to inform, training and education, and fundamental changes in the agency attitude and approach to including wildlife concerns in transportation processes. The information from these surveys helped to form the remainder of the research presented in this report, and will continue to guide the research in completing the remainder of the tasks in this study.

## Chapter 3 Partnerships

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### Overview

This study is part of the Wildlife Vehicle Collision (WVC) Reduction and Habitat Connectivity Pooled Fund Study of 2018-2022. This pooled fund study (PFS) seeks to identify cost-effective solutions that integrate highway safety and mobility with wildlife conservation and habitat connectivity. This is a collaborative project through the U.S. Federal Highway Administration Transportation Pooled Fund Program. Contributing partners include the Departments of Transportation (DOTs) of Alaska, Arizona, California, Iowa, Michigan, Minnesota, New Mexico, Oregon, Washington, and Nevada. The Nevada DOT administers this project. Canadian partners include the Ontario Ministry of Transportation (MoT), and Parks Canada. The non-profit, ARC Solutions, Incorporated is also a partner. Representatives from these organizations serve on the Technical Advisory Committee (TAC) for this study. The goal of this greater project is to reduce wildlife-vehicle collisions (WVC) for the safety of motorists and wildlife, and to promote and restore wildlife connectivity.

### Introduction

The research team's experience and work on this project allowed for the identification and presentation of several successful agency approaches that transportation and Metropolitan Planning Organization (MPO) agencies embraced to help increase the consideration of wildlife in transportation. In this chapter the researchers present twelve

case studies of Departments of Transportation (DOT's), MPO's, and Federal Agencies' approaches that include the reduction of wildlife-vehicle collisions (WVC) and wildlife connectivity needs in transportation processes.

The case studies focus on:

- A wildlife program's success within a transportation agency
- Working partnerships
- Gaining support with outside partners for wildlife crossing structures
- Consideration of construction project ecological impacts
- A method for benefit-cost analysis of wildlife-vehicle collision crash data
- Recommendations for changes to DOT manuals
- Potential legal changes on how MPOs plan for environmental concerns
- A wildlife and ecological education program in a department of transportation
- A state's legislative actions to plan for and mitigate for wildlife movement
- Partnerships to advance wildlife-highway mitigation
- Funding opportunities at the county-regional level, and
- A federal agency civil engineer perspective.

# The Wildlife Program of the Environmental Management Branch of the British Columbia Ministry of Transportation and Infrastructure: A Model for Institutional Cohesion

Leonard E. Sielecki, PhD

Patricia Cramer, PhD

## Introduction

Transportation agencies' responsibilities to address wildlife movements and reduce wildlife-vehicle collisions typically are spread among the environmental, traffic safety, planning, design, and maintenance divisions within the agency. There are also responsibilities to collect data, plan for, monitor, maintain, and publicly promote wildlife mitigation within the agency's districts across the state or province. As a result of these silos of responsibility, there is typically no point person or program within the agency to help promote and guide these efforts as they progress. A shining exception is the Wildlife Program of the British Columbia Ministry of Transportation and Infrastructure (BCMOTI); the cornerstone of wildlife protection on British Columbia highways. The Wildlife Program offers a model for incorporating the existing wealth of professional and applied knowledge and experience found in provincial transportation agencies across Canada with local external expertise to develop and deliver cost-effective wildlife protection initiatives. In turn, the program serves both the needs of the Ministry of Transportation and Infrastructure (MoTI), and wildlife species affected by transportation.

The Wildlife Program has evolved over the last 25 years as BCMOTI's approach to wildlife-vehicle collision monitoring and mitigation and provides a single point of contact for all wildlife/highway related issues. The program administers the Ministry's Wildlife Accident Reporting System (WARS), Wildlife Exclusion System Improvement Program, and the Wildlife Monitoring Program. While its primary objective is public safety through the reduction of wildlife-vehicle collisions on provincial roads and highways under the Ministry's jurisdiction, the program strives to support Provincial wildlife protection goals when opportunities arise along provincial roads and highways. Often big, well-funded projects attract the most public attention. However, while many of the projects supported by the Wildlife Program are small and low profile, collectively they contribute substantially to the protection of wildlife and safety of road users along provincial roads and highways.

The Wildlife Program is funded through the agency's rehabilitation budget. It began 25 years ago with an annual budget of \$20,000, primarily for data entry. When the agency established the Wildlife Exclusion Improvement Program to address the needs of ageing wildlife exclusion systems, the WARS program was immediately incorporated into it. The annual budget of the combined program is approximately \$600,000. The program has one Headquarter agency staff member responsible for all its operations.

The manager of the program draws upon and collaborates with agency staff throughout the agency for its expertise as needed. The positive and supportive agency environment for wildlife protection makes it possible to mobilize staff and resources in a very timely and cost-effective manner.

The program is instrumental in BCMOTI's efforts to protect wildlife with five main components: (1) monitoring, analysis and evaluation, (2) policy and design standards development, (3) wildlife mitigation, (4) research and innovation, and (5) communications, stakeholder participation, and outreach. These components are described in greater detail, below.

### **Monitoring, Analysis, and Evaluation**

Extensive monitoring, data collection, and analysis provide the foundation to support decision making for wildlife protection investments along highways in British Columbia. These data include WARS data for all highways under the agency's jurisdiction in British Columbia, and collections of wildlife photos collected by the agency's Wildlife Monitoring program. The Wildlife Program is able to identify problematic wildlife-vehicle collision locations and emerging species-related collision trends by drawing upon over 40 years of highway-related wildlife mortality data that is kept in WARS. Wildlife-vehicle collision carcass locations are reported with GPS coordinates and immediately imported via a Ministry Sharepoint site into the new WARS analysis tool, making mapping extremely fast and simple.

Over the last decade, the Wildlife Program established a network of wildlife monitoring cameras at each of BCMOTI's dozens of wildlife crossing structures. The Wildlife Program wildlife monitoring ranges from the big picture for province-wide implications to extreme narrow focus for species-specific issues, such as badger use of structures, bear use of roadside area seasonal signs, mountain goat and moose use of salt intercept feeding stations, and the installation of amphibian directional fencing and toadlet salvage activities to help protect western toads, to name a few.

BCMOTI partners with the BC Ministry of Forest, Lands, Natural Resource Operations and Rural Development to radio collar wildlife along provincial highway corridors to obtain greater knowledge and insight into the wildlife-highway interface. BCMOTI has supported tracking elk movements along Highways 3 and 93 near the BC/Alberta border, Big Horn Sheep movements along Highway 3 near



**FIGURE 15. MOUNTAIN GOATS USE A SALT LICK INSTALLED BY THE BCMOTI THAT DRAWS THE ANIMALS AWAY FROM THE HIGHWAY. PHOTO CREDIT: BRITISH COLUMBIA MINISTRY OF TRANSPORTATION AND INFRASTRUCTURE.**

the Canada/US border, deer movements along Highway 97C in the BC Interior, and Roosevelt Elk movements along Highway 18 on Vancouver Island.

### **Policy and Design Standards Development**

A transportation agency's ability to successfully navigate environment regulation, and design wildlife crossing structures requires supportive internal guidance and leadership. For BCMOTI, the Wildlife Program acts as a liaison between BCMOTI staff and the external environmental agencies. The Program advocates for both wildlife interests and responsible engineering designs, operations and practices between BCMOTI and the other provincial agencies. They accomplish this by working closely with BCMOTI engineers and technicians, consultants, and material suppliers to design wildlife-friendly infrastructure that protects wildlife. After extensive review and evaluation, the results of this process are formalized in BCMOTI's Standard Specifications for Highway Construction. Thus, the Program helps to design standards that then institutionalize wildlife mitigation designs.

### **Wildlife Mitigation**

The Wildlife Program operates in two basic modes: reactive and proactive. The reactive mode deals with unexpected or unpredicted wildlife events, such as toadlet migrations across highways or herds of Mountain goat emerging on highways to lick winter road salt. An example of a reactive role was played out in the winter of 2019, when the Wildlife Program personnel worked with volunteers from the town of Lardau to place salt feeding stations away from Highway 31 to coax mountain goats away from the road where they were at risk of dying from collisions while they licked road salts. In a proactive mode, the Wildlife Program is now identifying other locations and potential species at risk of licking salts along highways where winter road salt use may be increasing due to changes in climate and/or highway maintenance activities. Examples of some of the most progressive actions are listed below.

BCMOTI designed and constructed Canada's first wildlife overpass in 1987 as part of the Okanagan Connector (Highway 97C) wildlife exclusion system. Website:

<https://www.tranbc.ca/2015/08/19/why-we-use-wildlife-overpasses-on-bc-highways/>

The wildlife crossing structures associated with the Highway 97C wildlife exclusion system have been regularly monitored for wildlife use since 2013. Website:

<https://www.tranbc.ca/2018/03/02/bc-highway-wildlife-cam-captures-moose-selfie-and-more/>

And: <https://www.youtube.com/watch?v=q53ByJzuDGQ> And:

<https://twitter.com/TranBC/status/1259511805149356032>

BCMOTI developed the specifications for two radar-based wildlife detection systems currently operating on Highway 3 in the southeastern corner of British Columbia, bordering Idaho and Montana. BCMOTI Regional and District engineering, traffic safety, electrical and environmental staff collaborated closely on the design and

implementation of the systems. The systems have been installed in locations where deer, Big Horn Sheep and elk related collision rates are among the highest in British Columbia. Website: <https://www.tranbc.ca/2016/07/27/behind-the-scenes-bc-wildlife-trucks-saved-from-collision/> And: <https://www.tranbc.ca/tag/wildlife-detection-system/> And: <https://www.tranbc.ca/2015/10/21/on-the-case-for-safety-wildlife-detection-systems-on-highway-3/>.



**FIGURE 16. BRITISH COLUMBIA MINISTRY OF TRANSPORTATION AND INFRASTRUCTURE WILDLIFE DETECTION SYSTEM. PHOTO CREDIT: C. RAZZO.**

### **Research and Innovation**

The Wildlife Program develops new approaches by accessing the knowledge and imagination of BCMOTI's staff. The solutions vary from infrastructure advancements to increasing public awareness. Infrastructure advancements can include the new design of wildlife jump out ramps. Moving an idea from a concept to reality on an operating highway requires input and buy-in from a wide range of Ministry interests. The complexity of developing the new generation of effective wildlife protection solutions requires the combined efforts of experts from an increasingly wide range of professions. As an example, BCMOTI is working closely with researchers in the Electrical Engineering Department at the University of Victoria on developing a wildlife-friendly, tunable color lighting system for bridge decks. The goal of the project is to modify bridge deck lighting to produce species-specific wildlife friendly conditions while providing road users a safe crossing structure. One early development in this research has been the successful application of Artificial Intelligence (AI) and Deep Learning to identify and differentiate between wildlife and humans in photos taken by monitoring cameras.



financial staff to planners and engineers to help establish a common wildlife appreciation and awareness mindset. Presentations to professional engineer associations, and to the non-engineering branches of BCMOTI are also regularly scheduled. Over the last 25 years, corporate sentiments towards protecting wildlife have evolved considerably to reflect evolving public sentiments. The success of the Wildlife Program is a reflection of the concern for wildlife that now exists at all levels in the agency.



**FIGURE 19. OUTREACH WAS EXTENDED TO SENIOR MINISTRY EXECUTIVES. PHOTO CREDIT: L. SIELECKI.**

The Wildlife Program is a key component of BCMOTI's ongoing efforts to support Provincial and local goals to preserve and protect wildlife. The program also strives to support greater Provincial wildlife goals when opportunities unique to BCMOTI develop. One important way this is done is through stakeholder working groups. Regional wildlife and transportation working groups are formed with BCMOTI as the lead agency, and meet on a quarterly basis. Members are invited and represent other agencies, First Nations, and NGO's. Stakeholders collaborate on data collection, wildlife protection initiative development, and funding.

As an example of these localized effort, the Wildlife Program established the Kootenay Wildlife Protection Initiative to address residents' concerns for mountain goats, bighorn sheep, grizzly bear, and Rocky Mountain elk. The multi-faceted initiative has capitalized on new opportunities for collaboration with local stakeholders to develop and deliver innovative solutions to protect wildlife.



**FIGURE 20. THE INITIATIVE LOGO.**

A recent effort involves the Eastern British Columbia Wildlife Working Group. The Highway 3 project between Sparwood and the Alberta border will retrofit three bridges to enable wildlife movements beneath them. Members of the group are working together to also obtain non-government sources of funding to build a wildlife overpass. These efforts also tie into regional wildlife connectivity as a key location for the Yellowstone to Yukon (Y2Y) initiative (website: <https://y2y.net/>).

An increasingly important target audience for the Wildlife Program's wildlife awareness messaging is future road users. The goal of the Wildlife Program's ongoing youth group outreach efforts is to raise wildlife awareness among future drivers, years before they even start thinking of getting their drivers licenses.

By making wildlife awareness a subconscious element early in a road user's mind, there is the opportunity to pre-condition future road users to expect wildlife along provincial roads and highways. By investing resources in raising wildlife awareness among future road users, there is potential for greater societal payback in the years to come. For the last five years, the Wildlife Program has been contributing resources to youth-oriented activities, such as the BC Wildlife Federation's Wild Kidz summer camps and CoreySafe - Coalition of Riders Educating Youth Program (C.O.R.E.Y.), a BC non-profit promoting motorcycle safety for youth. Websites: <https://bcwf.bc.ca/wild-kidz-camp/>, and <http://www.coreysafe.com/>.



**FIGURE 21. CHILDREN INVOLVED IN WILDLIFE AWARENESS FOR CHILDREN THROUGH WILDKIDZ. PHOTO CREDIT: ELKE WIND, WILD KIDZ.**

The Wildlife Program staff network with road ecologists in transportation agencies across Canada and around the globe, attending conferences and as invited advising experts.

### **Future Actions**

The future holds additional challenges. The implications for climate change loom large for transportation agencies working to protect wildlife and road users along their networks. Wildlife habitats evolving from changing temperature and precipitation regimes add elements of uncertainty, to infrastructure investments made to protect wildlife and road users, previously unimagined. Transportation agencies will need to know more about the environments they work in and become more proactive in their approaches to dealing with wildlife issues. The BCMOTI Wildlife Program will be there to assist the ministry with these challenges.

### **References and Websites**

British Columbia Ministry of Transportation and Infrastructure Website on wildlife near roads: <https://www.tranbc.ca/tag/bc-wildlife/>

British Columbia Ministry of Transportation and Infrastructure Website on how the agency is protecting bears and motorists from collisions:

<https://www.tranbc.ca/2012/01/05/thinking-bear-smart-to-protect-wildlife/>

and how to avoid Bear Jams:

<https://www.tranbc.ca/2018/05/24/bear-jams-what-they-are-and-how-to-avoid-them/>

The agency also provided an article in 2018 on how wildlife salt licks were placed away from the highway to keep mountain goats from becoming involved in collisions:  
<https://www.tranbc.ca/2018/11/08/gettin-licky-with-it-intercept-salt-patch-saves-the-day/>

BCMOTI is conducting extensive wildlife camera monitoring of the Red-listed American Badger movement through badger underpasses installed along Highway 97 in the Interior of British Columbia. Website:  
<https://www.tranbc.ca/2019/04/17/burrowing-badger-caught-on-bc-wildlife-underpass-cam/>

A link to many of the wildlife stories mentioned in this case study:  
<https://www.tranbc.ca/category/going-green/wildlife-mitigation/>

British Columbia wildlife overpasses:  
<https://www.tranbc.ca/2015/08/19/why-we-use-wildlife-overpasses-on-bc-highways/>

Ministry wildlife blogs (The Ministry has a very popular Wildlife Wednesday blog series):  
<https://www.tranbc.ca/2018/03/02/bc-highway-wildlife-cam-captures-moose-selfie-and-more/>

<https://www.tranbc.ca/2020/08/13/its-amazing-to-see-wildlife-crossings-like-never-before/>

Motorcyclists and vulnerable road user blog:  
<https://www.tranbc.ca/2018/05/16/see-and-be-seen-how-to-avoid-wildlife-on-your-motorcycle/>

Seasonal, species specific advisory:  
<https://www.tranbc.ca/2019/10/28/rutting-season-is-here-watch-for-deer/>

## Montana Working Partnerships

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Dale Becker, MS

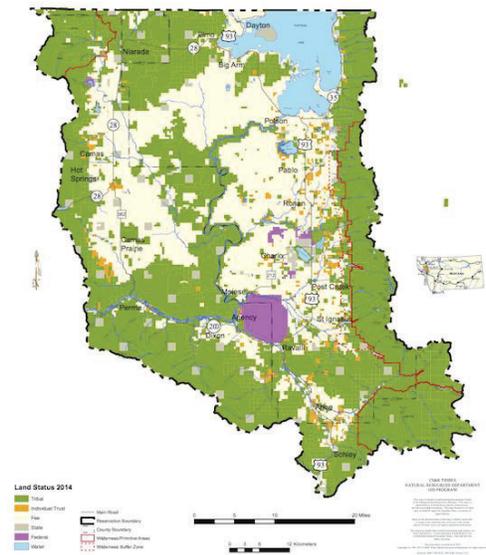
Patricia Cramer, PhD

### Introduction

Montana's rich and diverse wildlife populations are a beloved resource of its citizens and a major safety challenge for its state transportation agency. Through collaboration with citizens, agencies, and tribal nations to reduce wildlife-vehicle conflicts and their aftermath, the Montana Department of Transportation (MDT) grew into a leadership role by developing partnerships that became blueprints for collaborative successes for transportation agencies across the U.S. The three case studies below demonstrate the two-decade history of how MDT developed in its collaborative partnerships for planning, building, maintaining, and mitigating for highways.

### US Highway 93 and the Confederated Salish and Kootenai Tribe

In the 1990's, MDT and the Federal Highways Administration (FHWA) announced a proposal for reconstruction of a 52-mile portion of U. S. Highway 93 (US 93) that traverses the Flathead Indian Reservation between the communities of Evaro and Polson, Montana. The preferred option of a divided four-lane highway was a major point of contention between MDT and the Confederated Salish and Kootenai Tribes (CS&KT) due to impacts to cultural, historical and natural resources and the lack of appropriate mitigation. Thus, the project stalled for a decade. Then in late 1999 negotiations resumed and progress was made on several contentious issues. In December, 2000 a Memorandum of Agreement (MOA) – US 93 Evaro to Polson - was signed by representatives of the three government agencies. The MOA resulted in consideration of a wide variety of issues and concerns important to Tribal people and their culture, including wildlife and wildlife habitat (Becker 1996; Federal Highway Administration and the Montana Department of Transportation 1995). This agreement also set the course for development of the highway reconstruction designs as well as agreed upon mitigation measures.



**FIGURE 22. MAP OF THE CONFEDERATED SALISH KOOTENAI TRIBES' LAND, US 93 AND NEARBY TOWNS, MONTANA. TAKEN FROM [WWW.CSKTRIBES.ORG/](http://WWW.CSKTRIBES.ORG/)**

## The People Factor

All parties involved viewed improvements to US 93 as important, whether for public safety, cultural, or ecological perspectives. To reach the final outcome, the key staff changes among the three governments over time helped to develop mutual respect which was essential as the negotiations, and later the project planning and design phases proceeded. That respectful working relationship provided valuable exchanges of ideas, rationale, and knowledge between everyone involved. The diversity of the three governments the agencies represented was an interesting aspect of the process, but the diversity of people, which included administrators, managers, and staff from varied backgrounds (engineers, planners, archeologists, cultural resource specialists, and biologists) also added to the unique nature of the effort. Their combined efforts and knowledge collectively enhanced the project planning efforts and the quality of the project. The CS&KT worked closely with other government agencies at the local, county, state and federal levels in an attempt to decrease the adverse impacts of activities upon Tribal resources.

## Outcomes of the Project

The team of partners identified sites for potential wildlife crossing structures through identification of where the greatest numbers of wild animals were being killed, analyses of habitat features, and remote sending cameras placed near wildlife trails (Becker et al. 1993). Collectively, the information provided by these methodologies assisted in indicating where animal use was occurring and the degree of that use as documented in the pre-construction monitoring report by Hardy et al. (2007). Wildlife crossing structures were designed and placed to ensure maximum opportunities for wildlife passage across the highway right-of-way by all local species.

Ultimately 40 wildlife underpasses were constructed through the use of structural steel plate pipes, Con-span arches, or reinforced concrete boxes, and seven bridges over streams and larger rivers (ranging from 40 feet to 361 feet in length and with a minimum of 12 feet of vertical clearance) to facilitate wildlife crossing the highway right-of-way. One wildlife overpass was constructed with approximate dimensions of 25.5 feet high x 198 feet wide at the apex.

Wildlife exclusion fence, 8 feet high with wing fence was placed in areas of highest wildlife use. Continuous fencing throughout the entire project was not planned due to the excessive costs, difficulty in dealing with the numerous access points to the highway, and the fact that most collisions with larger wildlife species generally occurred at selected locations.



**FIGURE 23. US 93 CONSPAN ARCH WILDLIFE CROSSING BRIDGES. PHOTO CREDIT. P. BASTING.**

## Lessons Learned

The assemblage of the right people from all three governments was necessary to break the stalemate on this project. It was crucial to have leaders who were able to build personal and working relationships, work together, build trust, listen and learn from each other so that a greater vision could be achieved. A dispute resolution process assisted by clearly laying out rules, roles and responsibilities that each party was to abide by.

Other lessons learned were, that despite our best efforts to review plans, some details were occasionally overlooked, such as places where fencing should have been extended or jump-outs that might have been sited at better locations. The flexibility of the technical design committee members working together and maintaining open communications created a cooperative and productive environment to deal with these types of issues.

In order to construct the roadway over a 52-mile segment of highway, 8 separate construction projects were bid, often times with more than one project under construction at any given time. Open and free communication proved crucial. MDT construction project managers handled new ways of doing business, constant demands on their time and intense workloads from managing multiple construction projects simultaneously. Some issues required rapid on-site changes, but by having fundamental trust and commitment to work together and get the job done, everyone worked through these issues to appropriate conclusions. Early coordination between CS&KT and MDT staffs to develop corridor-wide special provisions also greatly aided in reducing project-by-project workload to draft special provisions for contracts and provided consistency and predictability on many issues for contractors and MDT project managers.

Ongoing activities occurring elsewhere at the time indicated that the ability and innovation to do something positive for wildlife and habitat in designing a highway are both possible and practical. These activities are certainly preferable to the traditional means of highway planning. As a result, the potential for designing and building a highway that integrates into the landscape were accomplished. This hugely collaborative partnership helped solve many of the environmental issues and helped MDT learn how to better interact with citizens such that mutual concerns can be addressed and resolved if we listen and respect each other with a commitment to working together to solve issues at hand.



**FIGURE 24. US 93 WILDLIFE OVERPASS NEAR EVARO, MONTANA. PHOTO CREDIT: P. BASTING.**

## **MDT and The Blackfoot Challenge Composting Story**

In the mid-2000's, MDT Missoula district's maintenance supervisor Doug Moeller approached MDT Missoula district biologist Pat Basting with a problem. The Montana Department of Environmental Quality had just issued a citation to MDT maintenance crews in Hamilton regarding hauling and dumping of deer carcasses in the Bitterroot Valley of Montana. The age old practice was now in the spotlight and under criticism as the human population of western Montana rapidly expanded during this time. In addition, MDT could no longer haul carcasses to the facility in Missoula that they'd used for years because the facility went out of business. Thus, MDT had to act fast to figure out a way to address handling road-killed animals.

MDT started looking into composting carcasses and Doug attended training in Maine to learn more about the process Maine DOT was using. Initially MDT felt that the Clearwater Junction maintenance yard in the Blackfoot Valley would serve as a good test site for composting. Although a longer haul for the Bitterroot maintenance crews, MDT knew the maintenance crew in the Blackfoot Valley also had large carcass disposal problem. Pat thought a local organization, the Blackfoot Challenge (BFC) might be interested in participating in a composting site, as their livestock carcass collection program had been beset by the same problem MDT faced with the closure of the same facility used to haul carcasses to for disposal. Pat was attending the BFC wildlife working group meetings for some time as MDT's representative working with local citizens.

The BFC is a grassroots organization that began in the early 1970s, when landowners along the Blackfoot River recognized the need to build partnerships with public agencies in order to address natural resource threats facing the watershed (<https://blackfootchallenge.org/>, 2020). Pat reached out to the BFC about their interest or concerns in MDT placing a composting facility at the local MDT maintenance yard near Clearwater Junction in the Blackfoot Valley. The BFC livestock carcass collection program began in 2003 to reduce the number of ranch "boneyards" where livestock that die on the ranch are buried. These boneyards attract large carnivores including bears and wolves to scavenge for food, increasing the potential for predation on ranches as well as the potential for more conflicts with humans. The program depended on collaborative partnership with the local ranchers and the development of trust on the value of the program. Since the program began, the number of



**FIGURE 25. GRIZZLY BEAR APPROACHES THE ROAD IN NORTHERN MONTANA. PHOTO CREDIT: P. BASTING.**

producers participating increased to nearly 120 covering 1.2 million acres in four counties.

The BFC was concerned that the presence of black and grizzly bears and wolves in the valley may complicate the new, unknown and un-tested idea MDT was proposing, and asked MDT to consider another location. If MDT developed and tested composting in a different location and it worked out, the BFC agreed they'd tour the facility and re-consider.

At first some MDT staff felt that since they owned the property at Clearwater Junction, they should be able to do what they want whether the BFC agreed or not. However, Pat explained that it was important to work within the local social norms, values and customs established in the BFC area and encouraged more open dialogue rather than making a hasty decision.

After coordinating with MT Department of Environmental Quality, MT Department of Livestock, and MT Fish Wildlife and Parks (MFWP), MDT opened its first composting facility in 2007 near the town of Victor, Montana. The facility had residential neighbors on both sides. However, due to the location being out of sight and the operation being run as a top-notch facility by the maintenance foreman out of Hamilton, no issues with smell or attraction of scavenging wildlife to the area were reported. The facility composted over 700 deer in one year. MDT then asked the BFC to tour the facility as well if they were still interested in learning more about the composting operation.

The BFC toured the Victor facility and talked at length with Doug Moeller and local Clearwater Junction maintenance foreman Bruce Friede who would be running the facility. The BFC had concerns about fencing the composting yard to keep predators and other scavengers away. After further discussions, the BFC offered an exchange, if they could haul their livestock carcasses from their carcass collection program to the MDT



**FIGURE 26. MDT CARCASS COMPOSTING FACILITY AND THE PROCESS PROCEDURE FOR DECAYING CARCASSES. PHOTO CREDIT: MDT.**



**FIGURE 27. MDT CARCASS COMPOSTING FACILITY AT CLEARWATER JUNCTION, MONTANA. PHOTO CREDIT: MDT.**

Clearwater Junction facility they in collaboration with MFWP would pay for and install electric fencing around the entire facility and the BFC would pay to have a well drilled to provide water to the composting yard. MDT and the BFC agreed, developed a MOA and thus began a groundbreaking collaboration between the MDT and the BFC. By working together and building a working relationship built on open communication, trust and respect this effort created a win-win situation for both MDT and the residents of the Blackfoot Valley. Currently the facility still operates separate composting bins for domestic livestock and road-killed wildlife.

### **State Highway 83 Seeley Swan Highway**

A purchase of property adjacent to a state owned wildlife management area led to a unique collaboration and analysis of the value of those lands for wildlife with respect to road effects, which in turn allowed a complex mitigation project to be completed. In the early 2000's, MDT proposed to improve State Highway 83 from Clearwater Junction to the town of Seeley Lake. Initially, MDT worked extensively with MFWP biologist Mike Thompson, University of Montana wildlife professor Kerry Foresman and citizens through the National Environmental Protection Act (NEPA) process to design an overpass and underpass. Unfortunately, despite overwhelming citizen support, local political leaders did not back the proposed wildlife mitigation and the project was shelved. Then in 2009 local MFWP biologist Jay Kolbe reached out to MDT Missoula district biologist Pat Basting when there was a 53 acre parcel up for sale advertised as a trophy home subdivision. This land was immediately adjacent to the Blackfoot Clearwater Wildlife Management Area (BCWMA) managed by MFWP. This land was also critical winter range and a migration corridor for mule and white-tailed deer and elk coming onto the BCWMA.

MFWP and MDT agreed that if MDT would acquire the 53-acre parcel of land directly adjacent to the wildlife management area, and transfer it to the wildlife agency, it would serve as mitigation for the wildlife and habitat impacts from the proposed highway projects, Seeley Lake South and Clearwater Junction North. Decades earlier, the BCWMA was established using Pittman Robertson Federal funding to acquire the land. Since MDT needed to acquire right of way land from the BCWMA for the highway projects, MDT had to perform an analysis of potential highway project impacts upon MFWP lands for the purpose of coming to agreement of suitable 4f mitigation regarding lands acquired by MFWP through the use of Pittman-Robertson funds, as required by: 23 CFR 771.135 Section 4(f) (49 U.S.C. 303), the Pittman-Robertson Wildlife Restoration Act (64 Stat. 595; 16 U.S.C. Sec.669 et. Seq.) and MCA 87-1-708 Assent to Pittman Robertson Act - authority of department.

At this point MDT had to calculate the value of the MFWP lands impacted through two methods; through monetary value, and valuation of wildlife habitat impacted as required by section 4f and the Pittman-Robertson Wildlife Restoration Act. Initially, MFWP estimated the potential direct and indirect impacts of the proposed highway projects to

be approximately 100 acres. To run MDT's analyses, Pat used the concept of the 'road effect zone' (Forman and Deblinger 2000) where the effect is "many times wider than the road itself"; and considered the traffic, or the "traffic effect zone" which is a key component of the overall road effect zone and includes increases in visual stimuli, sound, vibration and pollution with increases in traffic level. Through his analysis, Pat proposed that the reduction in habitat effectiveness of the land adjacent to the road be reduced by 40 percent based upon the fact that the ungulates utilizing this winter range have a higher tolerance to human activity and they are more likely to utilize available habitat due to the critical importance of the winter range despite the presence of the highway.

In addition, he proposed that the "road-effect zone" was 330 feet on either side of the highway. MFWP lands are adjacent to the highway either on one side or both for approximately 8 miles. Of the 8 miles, approximately half of that (roughly 4 miles) MFWP owns the land on both sides. Using these numbers, the "road-effect zone" relative to habitat effectiveness was close to 477 acres. After reducing the acreage acquired to rebuild the highway (17 acres) the total dropped down to 460 acres. This acreage was then used to calculate the monetary value of the functional habitat loss to MFWP lands.

A monetary analysis was done by using appraisal values of MFWP lands to be acquired for the highway projects relative to the value of the 53 acres proposed in the exchange. In addition, a calculation of the value of average annual wildlife mortality along the stretch of highway was also added into the equation:

- Appraised Value of 53 Acre Mitigation Parcel: ~\$1.6M
- Value of Functional Habitat Loss to MFWP Lands: ~\$1.3M
- Average Annual Value of Deer and Elk lost through WVC: ~\$183K
- Remaining Difference ~\$112K

In the end the land was acquired and transferred to MFWP to become part of the BCWMA. The remaining outstanding value was established as a regional 4f mitigation bank to be used by MDT on future projects. The final hurdle was getting US Fish and Wildlife Service approval on the 4f mitigation proposal and analysis. This was accomplished not only due to the sound analysis methods herein described but also the level of support the project received between the agencies leadership and politically. A project like this would not have happened without the professional trust and working relationships built between MDT and MFWP staff working on this project. This was a win-win-win project. The MDT benefited because the highway projects were able to move forward, MFWP benefited because a critical threat of development to land adjacent to the BCWMA was averted with the benefit of adding an additional 53 acres to the lands managed in the BCWMA and finally, the citizens of Montana benefited on both accounts mentioned above.

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## Gaining Support for Including Wildlife Crossings in Transportation Projects

Loran Frazier, PE

### Introduction

During the late 1990's and early 2000's, Montana was experiencing accelerated population growth and traffic with a notable increase in wild animal collisions. Wildlife professionals were voicing frustrations regarding the reluctance and resistance to include wildlife mitigation measures in transportation projects. This report summarizes experiences gained from projects constructed in western Montana where the Missoula district personnel were the first ones in the state to include multiple wildlife crossings in a project corridor. At this time there wasn't a roadmap, guidebook, or directions available for effective placement of mitigation measures or structure types. Canada had just installed a few crossings near Banff National Park. Most wildlife crossing cases and discussions were based on opinions that focused on habitat connectivity, highway safety or a desire for increased environmental stewardship. Plenty of technical help was available from scientists, safety engineers, and others to recommend locations and design crossing structures. This article shares experiences and often overlooked, but necessary, actions to build support and secure policy changes and funding to successfully implement wildlife crossings in transportation projects. These actions are presented in three steps:

- 1) Follow the Money – Determine the Decision Makers
- 2) Build the Message
- 3) Communication Strategy

These steps are illustrated with the challenges and steps taken by the District Administrator, in the Missoula District of the Montana Department of Transportation (MDT) along the U.S. Highway 93 (US 93) transportation corridor during 1999 to 2005.

### 1) Follow the Money - to Determine the Decision Makers

For every transportation project there is someone or group of decision makers with the authority to decide how the funds are spent. To make any change in the status quo, you need to understand who governs the funds. In this case, funding for highway projects was primarily supplied from federal and state sources – fuel, auto, and truck taxes and fees. This meant that the Federal Highway Administration (FHWA) and the MDT were stewards of the funds. In addition, politicians were involved:

- Federal Level - Two Senators, one Representative, President, and Secretary of Transportation
- State Level – Governor, Director of MDT, Transportation Commission, State Senate Transportation Oversight Committee and House Transportation Committee
- Local Level – County Commissioners
- Internal – Planning, Maintenance, Finance, and District Administrators; Highways, Traffic, Bridge, Hydraulics, and Safety Engineers.

To change the status quo and start including wildlife accommodations in the highway program, it was necessary to gain consent from the majority of these decision makers in the executive and legislative branches of the state government. Building that support required supplying them with information so they could consent to the changes and justify their support to include them.

Since funds are a scarce resource in just about all public agencies, there are also internal politics to contend with. Division leaders were scuffling to add to their budgets and would often use external politics to support raiding another division's funds. These in-fighting arguments within the DOT had to be addressed. It became apparent that a comprehensive information package was needed and a strategy developed to provide the information to all the people internally and externally involved with prioritizing and funding state transportation projects.

## 2) Build the Message

The primary target audience would be the elected and appointed politicians involved in overseeing transportation funds. The message needed to be easily identifiable and defensible as well as easily understood. When building the case, the sage advice used was: use big letters, small words, and short sentences - all backed up by homework and facts to communicate with legislators and other politicians. The short message conveyed was that Wildlife Crossings:

- **Increased Safety**
  - By reducing collisions with wildlife, people have less injuries and property damage.
  - Reduce employee and equipment exposure when removing carcasses.
  - With fewer carcass to pick-up; fewer chances of back injuries.
  
- **Reduced Maintenance Costs**
  - Fewer carcasses to haul to disposal area. (At the time carcasses were being frozen in semi-trailers and hauled to processor out of state).
  - Reduced back injuries, led to reduced Worker's Comp Insurance.



**FIGURE 28. RESULTS OF A COLLISION WITH ELK ON US 93 SOUTH OF MISSOULA. PHOTO CREDIT: L. FRAZIER.**



**FIGURE 29. MONTANA DEPARTMENT OF TRANSPORTATION MAINTENANCE CREW PICK UP OF CARCASSES FROM ONE SECTION OF US 93, AND TRANSFERRING CARCASSES TO A REFRIGERATED TRUCK. PHOTO CREDIT: L. FRAZIER.**

- **Preserved Montana Values**
  - Wildlife on the landscape is one of things that makes Montana special and why people live and want to move here. Providing safe crossings for wildlife of all types helps keep that intact.
  
- **Others Have Done It**
  - At the time, a few DOT leaders such as Pennsylvania and Florida informed me that they had included deer, bear, and panther crossings in highway projects.
  - Canada had just constructed a number of crossings in Alberta near Banff.
  - Wildlife accommodations were frequently included in road projects in Yellowstone and Glacier National Parks, funded by the Western Federal Lands program.
  
- **Montana Had Done It Before**
  - Structures and guide fences on US 2 near Glacier Park to reduce mountain goat collisions near a mineral lick.
  - Signs and warning flashers for bighorn sheep near Thompson Falls.
  - Included wildlife mitigation measures on Highway 191 near West Yellowstone.
  
- **Were Worth the Investment**
  - Although hard to quantify, reductions in accident numbers, carcass removal costs, and back injuries, were noticeably reduced where wildlife crossings were placed.
  - In many cases a structure of some type was needed in the location. So, increasing the size to accommodate wildlife was a small increase in cost.
  - Wildlife mitigation costs were generally less than 10% of the overall project cost.
  - Adding a couple feet to a bridge length over a stream not only benefitted wildlife to cross under the roadway on terrestrial pathways, it made permitting easier, often reduced wetland and stream impacts, and required less scour protection of the abutments.
  - Some of the crossings were considered mitigation for endangered species, primarily grizzly bears and wolves as enhancing habitat connectivity.



**FIGURE 30. THIS CULVERT ON US 93 NORTH WAS ENLARGED TO ACCOMMODATE WILDLIFE PASSAGE IN ADDITION TO WATER FLOW.**



**FIGURE 31. THIS BRIDGE ON US 93 IN THE BITTERROOT VALLEY WAS LENGTHENED TO ACCOMMODATE WILDLIFE PASSAGE. PHOTO CREDITS: L. FRAZIER.**

- **Were Just the Right Thing to Do**

- Many Montanans who grew up around agricultural operations understand that when you take something from the land, you need to give something back to sustain your lively hood. Grow a crop, need to add fertilizer. Graze an area, let it rest and recover. Wildlife crossings are a way of giving back for the impacts of building a road.
- Concerns for the expansion of US 93 through the Confederated Salish & Kootenai Tribe's Reservation included wildlife which is an important part of their culture. The highway also crossed the landscape of their homeland, their national park. -Including wildlife accommodations was considered part of the cultural mitigation features included in the project.

### **Due Diligence – The Homework**

Homework to support wildlife crossings involved addressing issues that others believed were more worthy of transportation dollars, identifying challenges that could be solved with wildlife crossings, and providing analyses that showed the benefit wildlife crossings could provide to society. To be defensible, part of the homework in developing a message is to identify potential issues that could be used against your proposed change and issues that could be solved with wildlife crossing mitigation. The additional cost of wildlife crossings was an imposing issue to tackle, especially in light of other pressing needs for limited funds. During the early 2000s, there were parts of the state that still did not have paved main highways. Wildlife crossings were perceived by some as an overindulgence when they didn't have the basics. This was voiced at a committee hearing that (the DOT) was "wasting money to save tick ridden deer when you could be using that money to get us out of the mud." Another major issue was that costs for highway maintenance operations were rising and state gas tax revenues were flattening out, limiting spending options. Defense of funneling money to wildlife crossings would have to acknowledge these realities, while also demonstrating a payback to the citizens.

Additionally, several challenges began to mesh together identifying wildlife crossings as a solution to multifaceted issues in four highway corridors in western Montana and several more throughout the state.

- Projects along US 93 between Idaho and Canada were contentious, frequently in the press, and had issues that wildlife crossings could address.
- Highway 83 through the Seeley-Swan Valleys and Highway 200 near the Idaho border were experiencing increases in animal collisions.
- Three large transportation corridor projects were at stalemates with different challenges. The growing human population in the corridors was increasing highway traffic resulting in amplified congestion and accidents. One corridor was locked up in federal appellate court, one stalemated for 22 years of disagreement with a Tribal Government, and one was in the process of being challenged in federal court. Wildlife accidents were significant in all three corridors and throughout Montana.

The pressure was on to find solutions and better serve the traveling public by constructing safer highways.

- The worker's compensation premiums were on the rise. Lower back injuries topped the list and were escalating.
- There were increasing numbers of road-kill carcasses and a decrease of disposal sites. More homes were being constructed along the highways resulting in increasing complaints about deer carcasses. The costs of disposing of the carcasses was rising due to longer hauls, rendering plants and landfills no longer accepting roadkill, and operating refrigerator trailers.
- There were escalating requirements from permitting agencies, primarily due to the bull trout just being listed and new flood plain requirements.

The process of putting numbers and costs to wildlife collisions was critical to the message that the wildlife mitigation infrastructure could pay for itself. Part of the oath in becoming an engineer is that safety of the public is paramount. The first concern and concentration was reducing the injuries and property damage from wildlife and vehicle collisions. FHWA and state DOTs have a safety program that places values on accidents and compares those values against the cost of the improvements. The average cost of a property damage crash at that time was \$3,000 to \$5,000, the average injury accident cost was \$75,000 and average fatality was \$1,000,000. Staff was assigned to compile the wildlife collision accident records and apply the safety formulas to identify hotspot wildlife crash locations and determine if crossings or other mitigation measures could be justified using the existing processes. A handful locations were justified by the safety process, but many others fell short using this method. Also, when comparing the accident report collision numbers against the carcass pick up, there were many more collisions than were reported. With this discrepancy identified, maintenance staff was directed to more accurately record carcass removal locations. More accurate carcass data from maintenance would develop a better case for supporting construction of wildlife crossings.

The most compelling case used as an example to support wildlife crossing costs was the Hamilton Maintenance Section along US 93 where approximately 700 deer carcasses were removed from highways each year, nearly two a day for a small area of Montana that covered 1/3 of the Hamilton-Lolo Highway 93 project corridor. The taxpayers in this section were paying \$2.1 to \$3.5 million annually, just in property damage crash costs at the time. Not only did the deer carcasses from those collisions need to be loaded into the trucks, they needed to be driven to a disposal site as the age-old method of simply dragging them out of sight was no longer feasible. When the rendering plant 52 miles away stopped taking carcasses, they were frozen in a refrigerator semi-trailer and trucked 220 miles to a plant in Spokane, Washington that would take them. This drastically increased maintenance costs.



**FIGURE 32. THE MDT HAMILTON MAINTENANCE CREW'S MORNING HAUL IN THE BITTERROOT VALLEY PRIOR TO WILDLIFE CROSSING STRUCTURES. PHOTO CREDIT: L. FRAZIER.**

An item that was difficult to pin a total cost on was the worker's compensation issue and back injuries. Each injury was different and medical records were considered personal, so the medical costs were not easily obtained and couldn't be shared publicly. What was found and could be shared was that lower back injuries were on the rise in the District and the number one cause of back injuries was from moving animal carcasses. This finding resulted in development of a district plan to reduce injuries when moving carcasses and finding ways to reduce animal collisions.



**FIGURE 33. L. FRAZIER USED THIS COMIC TO BREAK THE ICE AT COMMITTEE MEETINGS.**

### 3) Communication Strategy

Transparency of decisions to include wildlife crossings in projects was a key factor in gaining support from the decision makers. Informal discussions and idea-bouncing regarding wildlife collisions and crossings were held with the Deputy Director and Director of MDT prior to instructing staff to gather carcass data, spend time on safety analysis, investigate practices, identify beneficial locations, and start designing structures. After doing the homework (good data and facts), the information was tested with internal MDT staff and peers. The ideas of including wildlife crossings and locations were then discussed with the Transportation Commission, FHWA Leaders, and Governor. After getting their approval, Missoula and headquarters' MDT staff began spreading the message to State Legislators, County Commissioners, and citizens at focus groups and public meetings for the projects. Formal presentations were given to both the State Senate and House Transportation Committees where they ultimately approved including wildlife crossings in MDT's budget, which was approved by the Governor.

During this process at the state level and internally at MDT, the idea of including wildlife crossings was challenged; why the change, why spend money on something besides asphalt and bridges, and why waste money building bridges a little longer than they needed to be for water flow? This is where the homework and analysis by dedicated staff came into play. One of the most used homework examples was the sheer number of wild animal carcasses MDT maintenance workers collected statewide and that moving carcasses was the number one cause of back injuries. It was a good reason to include them.

Also, during this time period, Federal Highways was beginning to push their environmental stewardship program along with environmental streamlining. These efforts complemented each other and resulted in discussions with MDT, local FHWA and the Secretary of Transportation staff regarding the benefits of wildlife crossings. Additionally, signing a Memorandum of Agreement with the Confederated Salish and Kootenai Tribes, MDT and FHWA in 2001 created interest in wildlife crossings and landscape concepts as part of a cultural mitigation package mixed with safety features on a national highway. This interest from DOT leadership in Washington DC, helped pave the way for additional general allocations and some congressional earmark funding for wildlife crossings, especially on the Confederated Salish and Kootenai reservation.



**FIGURE 34. EXCHANGING IDEAS AND INFORMATION ABOUT THE PROJECT; AN ESSENTIAL PART OF BUILDING CONSENT AND TRUST. PHOTO CREDIT: L. FRAZIER.**

Probably, the most effective help was the tremendous support from citizens who reached out to their elected officials in support of funding wildlife crossings. This added reinforcement to MDT staff dedicated to wildlife crossings, reasoning for the change and frankly, sealed the deal, and made it happen at the state and federal level. One example of the active public support was from a local group who was advocating for a bridge that would be exclusively used as a wildlife crossing. Original plans were for a smaller underpass structure at the location due to the funding budget, but the citizens were passionate about a bridge. It was a good location that connected a National Wildlife Refuge with National Forest, but there just wasn't the additional funding to build it. The citizens took the initiative to get additional funding for the crossing. The plans were changed and included the bridge in the project. It is called Dawn's Crossing and is one of the more successful wildlife crossings in the Bitterroot Corridor. (see Cramer and Hamlin 2017).



**FIGURE 35. DAWN'S CROSSING ON US 93 IN THE BITTERROOT VALLEY, MONTANA. NAMED IN HONOR OF ITS FUNDING CHAMPION. PHOTO CREDIT: L. FRAZIER.**

*Editor's Note*

In the early 2000's these wildlife crossing structures were built. Today, US 93 in Montana has more wildlife crossing structures than any other road in North America, with over 75 dedicated wildlife crossings and additional structures in the planning stages. The above detailed strategies worked in this large reconstruction project of US 93. The continued challenge is to keep the momentum gained during the series of projects on US 93, moving forward with smaller projects across the state.

Cramer, P. and R. Hamlin. 2017. Evaluation of Wildlife Crossing Structures on US 93 in Montana's Bitterroot Valley. Final Report to Montana Department of Transportation.  
[https://www.mdt.mt.gov/research/projects/env/us93\\_wildlife.shtml](https://www.mdt.mt.gov/research/projects/env/us93_wildlife.shtml)

## Construction Project Impacts and the Seven Dwarfs of Implementation

Terry Brennan, Retired PE, USDA, Forest Service

The environmental documents for construction impacts of road projects often do not take into account many off-site activities and land disturbance that are necessary for road construction. This may be an oversight or a sense that the impacts are minor and unlikely to change the document decision. The larger area impacts of construction activities must be identified and be a part of the planning process for construction and reconstruction projects to allow for the smooth construction implementation to take place, and to build or reconstruct a linear feature that has the least impact on the natural environment. Most, if not all, of the following items are necessary for any construction project implementation, not just for wildlife related projects. These concerns need to become part of the construction contract and National Environmental Protection Act (NEPA) planning documents well before the project is begun.

The contractor's possible need for use or access areas outside the road right-of-way, are a part of the construction activity. Rather than try to identify these impacts during the construction activity, it is often better for all concerned partners to identify the areas, plan for their use in the construction plans and specifications, and then identify how the area is remediated at project completion. The project design team may be able to utilize an area that has already been disturbed to help the construction activity and heal that disturbance as part of the construction project. This often creates a win-win solution for all partners involved; the contractor has a use area and the department can remediate a past disturbance area. These impact areas can be identified as the Seven Dwarfs because they have a small impact on the environmental analysis, they may be short term in nature, yet prove very large in facilitating the successful healing, rehabilitation and minimization of construction impacts. They must be addressed early in the design process in order for additional environmental clearances to be obtained and well thought out plans and specifications developed.

The Seven Dwarf impacts to consider include:

1. Borrow and waste sites, material balance,
2. Contractor use/staging areas,
3. Water for construction,
4. Contractor access and detours,
5. Geotechnical investigation access,
6. Relocation of utilities and their impacts, and
7. Document required mitigation of impacts.

## 1. Borrow and Waste Sites, Material Balance

One part of construction project design and implementation is balancing the excavated material within the project limits. In order to lessen the overall project impact on the alignment, i.e. raise the grade to eliminate material or lower the grade to develop material, an alternative consideration might be to look for alternate borrow or waste sites outside the immediate project limits. Available borrow or waste sites that are agreed to prior to design can often help provide a win-win scenario for all the concerned parties.

While the design team does their best to provide accurate excavation quantities, a contractor utilizing the excavated and in place earthwork to provide a construction material for the contractor's use is an often-overlooked contractor effort. The contractor's motive is often to reduce his project costs. This effort can change the material quantities for the project and having already identified offsite areas can help all partners attain a better project. The alternative to on site material development is for the contractor to purchase those same materials from a commercial supplier. If the contractor can identify aggregate types of material, asphalt product ingredients or select backfill materials, he may not need to purchase that material from a commercial source but may develop these materials from on-site resources. The effort near or on the construction site to process products may necessitate a larger contractor staging area and the cost of mobilizing the processing plant could be a far less cost than a purchase and haul cost of similar materials. While this issue is not often available during construction, if it is thought about before construction, it can help heal or alleviate other construction impacts.



**FIGURE 36. CONTRACTOR SORTING MATERIAL FOR RIP RAP AND AGGREGATE PRODUCTION IN ARIZONA, STATE ROUTE 188, AND ON THE TONTO NATIONAL FOREST. PHOTO CREDIT: T. BRENNAN.**

The excavation quantities specified in the contract need to include the volume of material to fully implement the intended project requirements. Any of the planned obliteration projects including detours, contractor access routes, abandoned roads or contractor use areas need to be included in the summary of excavation quantities in the contract drawings. It is essential that the necessary soil to remediate the project be saved for these activities. Additional excess material could be utilized to provide wildlife

escape ramps over a ROW fence, landscape material around a wildlife passage structure, placed in an area to be used as a trailhead or vista site or stockpiled for another future wildlife crossing structure. These preapproved locations would provide the design team the ability to continue the design, knowing other material sources or waste sites are already approved for use.

It is also important to consider preserving a set aside area for topsoil and soils with native seed embedded in them. In order to facilitate revegetation, topsoil is often salvaged and reused. Identifying where these materials can be stockpiled for a short term impact, necessitates that these areas be identified and included in the construction documents. The same planning needs to be done for erosion and sediment control impacts.

## 2. Contractor Use/Staging Areas

A contractors' activities include a large amount of equipment and administrative office space. Aside from office trailers and large earthmoving equipment, other items that a contractor typically requests for storage or staging land identification may be gasoline and/or diesel fuel storage, possibly explosive materials, as well as other contractor supplies, i.e., filter fabric, erosion control products and culvert piping. While a simple answer might be to say "no use of land outside of the ROW will be authorized", or "Private land will be used for contractor supplies and use in the area." these types of answers may not provide the best long-term project impact solutions. On some of the project



**FIGURE 37. CONTRACTOR USE AREA, ARIZONA'S STATE ROAD 260, ON THE TONTO NATIONAL FOREST. PHOTO CREDIT: T. BRENNAN**

areas, there might be some old dumping area used by individuals in the past. As a tradeoff to use such an area, the contractor is usually more than willing to reshape the area after construction and block off access routes to leave the area in better shape after the project completion. While use areas and excavation waste areas can be very large areas, if there is careful consideration to what remains after the contractor's activities, these areas can become a long-term benefit for wildlife by providing additional habitat or watering ponds or other animal friendly mitigation.

## 3. Water for Construction

One of the larger construction impacts upon natural resources is construction water - not only for immediate water use, but in order to provide for water storage for dry period uses. The main uses of this water are for embankment compaction and dust control. While landscape irrigation and aggregate material development are also important, water for material compaction can be extremely consumptive.

Based on a need for 35 gallons per cubic yard of embankment, the requirement for water may exceed 50,000 gallons per day. This supply must be planned for prior to contract preparation. Large water ponds may be necessary to hold water needed during dry or seasonal periods. If other water sources are available in the project area, access to them and other long-term impacts need to be identified and mitigated.



**FIGURE 38. WATER STORAGE POND, ARIZONA'S STATE ROAD 260, ON THE TONTO NATIONAL FOREST. PHOTO CREDIT: R. INGRAM**

#### **4. Contractor Access and Detours**

This item is more impactful on new alignment locations, as reconstruction is mainly in the existing ROW. The need for both of these items is often outside of the direct contracting limits of disturbance. Often times detours or contractor access can be utilized for multiuse access needs. Thus, careful consideration of these issues may limit additional unnecessary disturbance or provide for an additional old project impact that needs healing and closure. If this direct impact is not covered in the original environmental document, additional environmental clearance may be required, especially on Federal, State or Tribal lands. Riparian habitat during bridge construction needs to be given thorough review to save the critical habitat in and around wildlife bridges and other animal crossing locations.



**FIGURE 39. CONTRACTOR ACCESS FOR BRIDGE CONSTRUCTION, ARIZONA'S STATE ROAD 188, TONTO NATIONAL FOREST. PHOTO CREDIT: T. BRENNAN.**

#### **5. Geotechnical Access**

Subsurface investigation for design parameters is a known activity for design implementation. Road access for these geotechnical activities with large equipment is necessary. Being able to control the contractors' access and think about the soon to

follow construction project access, can help save existing vegetation that may be critical wildlife habitat. As with all the construction impacts of the seven dwarfs, once the vegetation is gone, it is very difficult to remediate or replace. By making every effort to think about the following steps in the construction process early on, the impact on critical areas by contractors' activities for geotechnical activities and the entire construction process can be minimized.

## 6. Utility Relocation Impacts

Road corridors are often used to transport more than vehicles. Utilities often traverse the corridor that is being constructed. Preplanning for the relocation of these utilities is necessary to minimize the area and location of the disturbance. These activities often occur prior to the main contractors' construction activities. As with the previously discussed geotechnical access, the relocation of these utilities may negatively impact the long-term success of a wildlife crossing by removing critical habitat or stopping movement of wildlife through an area with a pipeline, electrical distribution center, fence or other type of infrastructure. Having the utility company place the infrastructure outside the known critical areas may not be the easiest or cheapest location for the utility company, although it might be the best long-term solution for remediation for current or past project impacts.

## 7. Document Required Mitigation of Impacts and Consider Mitigation Banking

Construction projects require mitigation for project identified impacts. The original NEPA document does require an offset of impacts, but usually does not identify the location or specify an amount until the project design has been completed and the overall impacts have been quantified. If the mitigation project locations are outside of the previously approved project areas, additional NEPA compliance may be required. In lieu of additional NEPA documents another option that a project team might use would be to add the mitigation costs for the current impacts to an already approved mitigation banking program.

Mitigation banking continues to be a win-win solution for highway construction impacts.

Having the preapproved mitigation projects is often a benefit to transportation construction agencies. Wildlife improvement projects can be identified as a part of this mitigation banking project development, helping both small and large projects add to the larger mitigation banking process. Utilizing mitigation banking can provide a known and



**FIGURE 40. COMPLETED BRIDGE CONSTRUCTION, INCLUDING REHABILITATION OF ACCESS AND EROSION CONTROL, ARIZONA'S STATE ROAD 260, TONTO NATIONAL FOREST. PHOTO CREDIT: T. BRENNAN.**

agreed to project and cost. The highway construction department can proceed with design or construction with little to no delay in schedule.

### **In Summary**

Mitigation for and implementation of the impacts from the seven dwarfs will allow a thorough discussion of the desired results and will allow for well thought out project drawings and specifications in the construction contract. With consideration of these above specific impacts and desired outcomes spelled out in the NEPA document and contracts, all of the bidding contractors understand what is expected of their efforts. While unanticipated project developments are always expected for any construction project, remediation and identification for these known construction activities allows for a smooth construction project startup and a finished project that restores the natural landscape and processes outside of the ROW.

## Colorado's Western Slope Wildlife Prioritization Study Benefit Cost Analysis

Pat Basting, BS

The Colorado Department of Transportation (CDOT) and Colorado Parks and Wildlife (CPW) sought a more comprehensive approach to assist in evaluating potential wildlife-highway mitigation projects. Currently in Colorado, CDOT does not include wildlife and residual values in a benefit-cost analysis for wildlife mitigation projects. The research team on the Colorado Western Slope Wildlife Prioritization Study (WSWPS), led by Jacobs Engineering, developed a hybrid benefit-cost technique, drawing from both CDOT Traffic and Safety Engineering and CDOT's Division of Transportation Development (DTD) methodologies to allow potential wildlife-highway mitigation projects across the Western Slope to be compared (Kintsch et al. 2019). This hybrid approach, summarized below, is designed to provide a more comprehensive evaluation than is currently possible with the formula used by CDOT Traffic and Safety Engineering.

There are two benefit-cost approaches used by CDOT; the Traffic and Safety Engineering Branch uses the Vision Zero Suite (VZS), and the Division of Transportation Development uses the U.S. Department of Transportation (USDOT) method. The VZS analyses are used to identify crash locations above expected norms for a facility, then uses an expense-based approach to calculate benefit-cost derived from the AASHTO Highway Safety Manual. CDOT Traffic and Safety Engineering slightly modifies AASHTO values to be more specific to Colorado and avoid over-valuing fatalities. The USDOT method is used when applying for federal funding grants or using federal bond funding (U.S. Department of Transportation 2018). This method uses the accepted economic theory of willingness to pay, whereby values for fatalities, injuries, and property damage only (PDO) accidents are not based upon actual costs, but societies willingness to pay to avoid such accidents in the first place.

The research team identified a need to include the residual value of wildlife mitigation beyond the typical benefit-cost analysis service life because wildlife crossing structures typically have a design life (75 years or more) that exceeds the analysis period used in benefit-cost equations (20 to 30 years). The USDOT recommends assessing the residual value of the remaining asset life when project assets have useful lifetimes that continue beyond the end of the analysis period (U.S. Department of Transportation 2018).

Current methods for integrating wildlife values into benefit-cost analysis include using statutory values assigned by a state legislature for wildlife that are unlawfully taken (Cramer et al., 2016; Wakeling et al., 2015) or using the hunting value of the animal

expressed as the probability that an animal will be successfully harvested by a hunter (Huijser et al., 2009). However, study panel members believed that both approaches underestimate the economic value of mule deer and elk in relation to their benefits to Colorado's economy. The research team worked with CPW and CDOT to develop an alternative approach based on an accepted economic theory of contingent valuation, which is used to assign dollar values to nonmarket resources, such as wildlife or other environmental values (U.S. Fish and Wildlife Service 2011). The contingent valuation method uses statistically valid public surveys to calculate net willingness to pay, or consumer surplus. Accordingly, this technique was used to identify the maximum amount that a hunter would pay for the opportunity to hunt mule deer or elk, beyond hunting fees or trip expenses. While still conservative, the following values were calculated for mule deer and elk in Colorado in 2018 dollars:

Mule Deer Value = \$2,061

Elk Value = \$2,392

These values were then integrated into the benefit-cost equation. The research team synthesized actual costs of wildlife-highway mitigation from recent projects (2016 through 2018) across Colorado and developed costs for the various components of a mitigation project, such as wildlife underpasses and overpasses of varying dimensions, deer guards, fencing, and escape ramps. These cost estimates were then reviewed by CDOT contracting cost estimators. After reviewing maintenance costs on existing mitigation projects, the research team determined to use a maintenance cost of 1 percent over the life of the structure in the WSWPS benefit-cost formula.

In addition, the team reviewed the literature to determine how best to estimate the effectiveness of various wildlife mitigation measures. For road-based improvements, estimating the change in the number of fatalities, injuries, and amount of PDO can be calculated using crash modification factors, which relate different types of safety improvements to crash outcomes (U.S. Department of Transportation 2018). The team calculated crash modification factors for different mitigation measures, which were included in the benefit-cost analysis.

The newly created hybrid benefit-cost analyses developed during this study was developed by the research team with CDOT Traffic and Safety Engineering and DTD to allow potential wildlife-highway mitigation projects across the Western Slope to be compared. This hybrid approach, shown below, is designed to provide a more comprehensive evaluation than is currently possible with the formula used by CDOT Traffic and Safety Engineering; however, this approach is not as comprehensive as the DTD/USDOT approach, which can also consider several variables not considered here, such as value of time savings and emission reductions. Such a detailed benefit-cost analysis is only relevant in the context of a larger roadway improvement project and is not needed to evaluate where wildlife-highway mitigation will have the greatest benefit for the investment.

Most wildlife-highway mitigation projects are more likely to be funded by state grants than by highly competitive national grants. Therefore, the team applied the Traffic and Safety Engineering crash costs and discount rate in its hybrid approach. Complete benefit cost inputs and calculations can be viewed in the Benefit-cost worksheet at <https://www.codot.gov/programs/research/pdfs/2019/WSWPS>. Below (Table 7) is a comparison of how benefit cost elements are evaluated.

**TABLE 7. COLORADO’S WESTERN SLOPE WILDLIFE PRIORITIZATION STUDY BENEFIT-COST EQUATION VARIABLES AND VARIOUS BENEFIT-COST EVALUATIONS.**

Benefit Cost Equation Element	Evaluation Approach		
	Traffic and Safety Engineering Evaluation	Division of Transportation Development (DTD)	WSWPS Hybrid Approach
<b>Crash Costs</b>	Derive from AASHTO	Derive from USDOT	Use traffic and safety costs
<b>WVC Timeframe</b>	10-year average	10-year average	10-year average
<b>Discount Rate</b>	5 percent	7 percent	5 percent
<b>Infrastructure Life Span</b>	20 years	30 years	30 years
<b>Residual Value</b>	Not considered	CDOT DTD/USDOT methodology	CDOT DTD/USDOT methodology
<b>Wildlife Value</b>	Not considered	Non-monetized benefit	Deer value = \$2,061 Elk value = \$2,392

Using inputs discussed above, a sophisticated and practical automated Excel tool for calculating benefit-cost was created by Anthony Vu (CDOT Traffic & Safety Engineering) with significant input from the research team and Dr. Oana Ford (CDOT DTD). The hybrid approach discussed above allows decision makers to evaluate wildlife mitigation benefits and costs for purposes of comparing wildlife mitigation projects and potential use of other CDOT Regional discretionary funds to be used in helping pay for wildlife mitigation. In addition, this Excel worksheet tool, also calculates benefit-costs using the CDOT Traffic and Safety Engineering and DTD methods so that it may be used by CDOT staff for planning purposes and aiding in determining potential funding sources for mitigation projects. Specifically, the CDOT Traffic and Safety Engineering benefit-cost formula and valuations would be used for state Traffic and Safety Engineering grant applications. DTD would use the USDOT benefit-cost methods and valuations for federal grant applications.

The link for the West Slope Study documents:

<https://www.codot.gov/programs/research/pdfs/2019/WSWPS/view>

## Texas Department of Transportation Manuals

Patricia Cramer, PhD

Lisa Loftus-Otway, JD

One of the ways to enact change across a state or provincial department/ministry of transportation is to provide instructions for that change in the manuals of the dozens of divisions and professions within the agency. In 2017 Texas Department of Transportation (TxDOT) with the University of Texas, Center for Transportation Research led a research project to update TxDOT division manuals with recommendations based on the state of the science and practice on wildlife crossing structures and mitigation across the U.S.

The research team investigated current TxDOT and multiple state DOT manuals from across the U.S. to determine how planning, design, and maintenance for wildlife concerns would be added to each manual. The project researchers also provided guidance for animal-vehicle conflict data collection, and mitigation options. The final report summarized national and state-level efforts to reduce animal-vehicle conflict, analyzed Texas's animal-vehicle collision (AVC) data, explained how to identify AVC hot spots, and provided benefit-cost ratios for various AVC mitigation efforts across the TxDOT highway system. Additionally, guidance was provided on the reduction of wildlife-vehicle conflict and the promotion of wildlife connectivity.

The project recommended specific language modifications to 18 TxDOT manuals to help ensure that consideration of wildlife-vehicle conflict and wildlife connectivity became standard business procedure, Table 8. Recommended changes included: definitions of terms, such as wildlife corridors; how to include wildlife crossing structures in the planning process; the reporting of carcasses by maintenance staff; maintenance and repair of structures and fences for wildlife; consideration of wildlife when establishing speed zones; the review of animal-vehicle conflict in project planning; and the examination of wildlife-vehicle crash hotspots for transportation programming, along with dozens of other recommendations.

The project findings demonstrated that data-driven, carefully planned, and well-designed wildlife crossing structures can enhance traffic safety significantly, and are cost-effective within much of the TxDOT infrastructure. The recommended changes for the 18 manuals were under review by TxDOT divisions at the time of this writing.

**TABLE 8. TEXAS DEPARTMENT OF TRANSPORTATION MANUALS SELECTED FOR REVISIONS FOR CONSIDERATION OF WILDLIFE-VEHICLE CONFLICT AND HABITAT CONNECTIVITY.**

Access Management	Manual on Uniform Traffic Control Devices
Bridge Design	Plans, Specifications and Estimate Development
Bridge Project Development	Procedure for Establishing Speed Zones
Construction Contract Administration	Project Development Process
Design and Construction Information Systems	Roadside Vegetation Management
Highway Safety Improvement Program	Roadway Design
Landscape and Aesthetics Design	Traffic Safety Program
Maintenance Management	Transportation Planning
Maintenance Operations	Transportation Programming and Scheduling



**FIGURE 41. THE TxDOT PHARR DISTRICT, BASED IN THE SOUTHERN TIP OF TEXAS, ENCOMPASSES THE LAGUNA ATASCOSA NATIONAL WILDLIFE REFUGE, HOME TO THE OCELOT.**

The presence of this endangered species predicated a partnership between the U.S. Fish and Wildlife Service and TxDOT to build wildlife crossing structures that could accommodate ocelot and other wildlife. The lessons learned in this district helped to inform the recommendations for the TxDOT manuals. Photo credits: left photo, P. Cramer, right, ocelot TxDOT and US Fish and Wildlife Service.

Click here for [the website for the project and publications](#):

Loftus-Otway, L., N. Jiang, P. Cramer, N. Oaks, D. Wilkins, K. Kockelman, and M. Murphy. 2019. Incorporation of wildlife crossings into TxDOT's Projects and Operations. The University of Texas at Austin, Center for Transportation Research. Final Report, Technical Report 0-6971-1. 322 pages. URL: <https://library.ctr.utexas.edu/ctr-publications/0-6971-1.pdf>.

Video of the Project: <https://www.youtube.com/watch?v=YuCR-zGSbcA>

## The MPO Connection: The Potential for Integrating Wildlife Crossing Consideration as a Standardized Process into Transportation Plans and Programs

Lisa Loftus-Otway, JD

Metropolitan Planning Organizations (MPOs) are designated entities in urbanized and suburbanized areas throughout the U.S. which sit at a critical cusp to become the drivers and generators of planning for wildlife crossings within their jurisdictions. MPOs are tasked by federal law to represent urbanized areas with more than 50,000 people (23 United States Code (U.S.C.) 134, 23 U.S.C. 150, and 49 U.S.C. 5303, as amended ) and to develop long range metropolitan transportation plans (MTP) that in turn become on-the-ground projects through the short range transportation improvement programs (TIP). These MTP and TIP are the fundamental drivers of transportation plans and project development within U.S. urban-suburban areas, and offer the 400 plus MPOs opportunities to include wildlife concerns in transportation. In turn, the state DOTs must include approved MPOs' MTP and TIP's in the overall state Long Range and STIP plans. The MPO transportation planning process is thus a critical but often overlooked piece of state transportation planning that could be improved to include wildlife concerns. The MPO transportation planning process is described in some detail below along with recommendations on how the process can be adapted to assure wildlife concerns are considered.

MPOs represent populations from 50,000 to over 18 million people, thus not all have the same capacities in terms of staffing and technical expertise to conduct AVC analyses or to develop wildlife crossing structures. For example, during this study's survey development, the researchers found that: (1) many small MPOs have just three employees; (2) many MPOs are in small urban areas, and have staff that may be housed within the county/city departments of transportation and/or planning, and so host joint duties; and, (3) the MPOs are political creatures, whose oversight boards are comprised of elected officials, public agency officials, and sometimes state officials, and require consensus to develop plans/projects (23. Code of Federal Regulations (C.F.R.) (d) (1) (1)-(iii)). However, wildlife crossing structures represent key safety components of transportation planning, and help ensure the MPOs populations can have access to wildlife as a resource, for tourism activities, and ensure the MPOs meet federal and state protection for endangered species. Most MPOs include areas that are wildlife habitats, or are adjacent to suburban and rural areas with wildlife, or are close to national/state parks and wildlife areas. Thus, the number of MPO staff or residents within the jurisdiction are not the best indicators of the need for and ability to plan for wildlife crossing structures.

## Requirements Under the Law

MPOs are required under federal law to develop a long range metropolitan transportation plan (MTP) of no less than 20 years (23 C.F.R. §450.324) and a short term TIP covering no less than 4 years (23 C.F.R. 450.326). Both of these plans are required to access federal transportation funding, and in many instances state transportation funding. The MTP process requires adherence to 11 planning factors, one of which is assessment of environmental mitigation activities and potential areas to carry these out (23. C.F.R 450.324 (f) (10)). Within the TIP processes the TIP *shall* also include for each phase (e.g. preliminary engineering; NEPA/environment; right of way, design, construction) sufficient descriptive material. For example, type of work could include wildlife crossing structures at known hotspots (23 C.F.R 450. 326 (g) (1)). So, in both of these planning documents there are places in which the MPOs can begin to carve out plans and project scopes for wildlife crossing structures and other mitigation.

In addition, within the TIP, each project or project phase included *shall* be consistent with the approved MTP (23 C.F.R §450.326 (i)), so if a wildlife crossing issue is noted in the environmental assessment area of the MTP, the TIP can then develop out a project to redress this issue. Once the TIP is approved by the MPO and the Governor, it *shall* be included within the DOT produced State Transportation Improvement Program (STIP) without change and directly by reference (23 C.F.R. 450.328 (b)). So the DOT's cannot amend or change in any way, the individual TIPs.

The MPOs can also undertake a multimodal, systems-level corridor or subarea planning study as part of the MTP process (23 C.F.R 450.318). These studies can result in development of multiple elements including purpose and need statements, preliminary screening, basic description of the environmental setting and/or preliminary identification of environmental impacts, and mitigation (23 C.F.R. 450.318 (a) (1, (3), (4) and (5))). The MPOs can also utilize an optional framework for development of programmatic mitigation plans within the MTP process to address potential environmental impacts of future projects (23 CFR 450.320). The MPOs here – according to statutory language - *will* determine scope and contents in consultation with the Federal Highway Administration / Federal Transit Administration and other agencies who have jurisdiction and special expertise over the resources being addressed in the plan. Scope can include a plan that is within a defined geographic area, or on a resource such as aquatic, wildlife habitat (which are listed within the examples in the statute). Content can include assessment of a corridor, identification/inventory of resources within a geographic area, assessments of opportunity for improvement of overall quality of identified resources, adoption of standard measures or operating procedures for types of impacts, and adaptive management procedures (23 C.F.R. 450.320).

Within this setting, there are opportunities for wildlife and transportation professionals to provide assistance and guidance to MPOs to undertake hot spot analysis for AVC, identification of critical habitat areas, cost estimates for mitigation and design descriptions from wildlife vehicle crossings that have been developed around the U.S. and globally. Some MPOs have already developed wildlife crossing structures and they can also provide critical input and training to other MPOs to help get them started in developing wildlife crossings mitigation.

### **The Easy Inclusion Route for Change**

Current federal law already affords opportunities within statute and regulation for MPOs to be the ‘drivers’ of developing wildlife crossing structure discussion and development: This is what we call the easy inclusion route, not necessitating federal statutory amendment. The MTP and multimodal, systems-level corridor or subarea planning study offers ample opportunities using current language and specific requirements to plan for wildlife crossing structures, and to identify mitigation options for impacts as well as a choice of potential future mitigation options. Most notably, because within the TIP *each project or project phase included shall be consistent with the approved MTP*, the MTP should be the first phase of identification, analysis and discussion of wildlife crossing structures because of the need for consistency. The TIPs also have another weapon in their arsenal to assist in integrating wildlife crossings: once the TIP is approved by the MPO and the Governor, *it shall be included within the State Transportation Improvement Program (STIP) without change and directly by reference (22 C.F.R. 450.328 (b))*. So, there is latitude here, to begin discussion and identification of AVC issues within the MTP process and to develop actual mitigation activities within the TIP, that the DOTs then amalgamate into the STIP without a change. This also provides a revenue stream identification and flow from MTP through to TIP.

### **The Hard Inclusion Route for Change**

This route would require changes within 23 United States Code (U.S.C.) 134, 23 U.S.C. 150, and 49 U.S.C. 5303, as amended and Code of Federal Regulations Title 23: Highways Part 450—Planning Assistance And Standards Subpart C—Metropolitan Transportation Planning and Programming to require MPOs to not only begin preliminary identification of environmental impacts and environmental mitigation, but to require hot spot analysis for AVC, rather than the mere ‘assessment’ of the existing condition of the natural and human environmental resources required in 23 C.F.R. 450.320 (a) (2)(i).

### **Future research**

Future areas that should be researched to help identify how wildlife movement and AVC can be included in MPO transportation planning include:

- Review MPO plans to determine the level and quality of mitigation plans and activities
- Review MPO in-house processes and procedures to develop guidance for the smaller versus larger MPOs.

### **Further Reading**

Link to Electronic Code of Federal Regulation

URL: [https://www.ecfr.gov/cgi-bin/text-idx?tpl=/ecfrbrowse/Title23/23tab\\_02.tpl](https://www.ecfr.gov/cgi-bin/text-idx?tpl=/ecfrbrowse/Title23/23tab_02.tpl)

Link to Electronic Code of Federal Regulation – Planning and Research

URL:

<https://www.ecfr.gov/cgi-bin/text-idx?SID=c896c7551ca61d30f7d9559ed495f3d6&mc=true&tpl=/ecfrbrowse/Title23/23C1subchapE.tpl>

## Highways & Habitats Training for Vermont Transportation Agency Staff: Intangible Magic

Patricia Cramer, PhD

Taken from an interview with Chris Slesar of VTrans

Vermont Transportation Agency (VTrans) created a slow wave of change concerning wildlife within the agency by inspiring change from within its people. The Highways & Habitats for VTrans personnel has been a successful program that brings transportation professionals from all disciplines into the road ecology conversation.

VTrans identified habitat connectivity as an important consideration in the development of transportation projects. With financial support from FHWA, VTrans regularly offers a three-tiered series of trainings and seminars to help VTrans staff better understand the relationship between transportation and wildlife connectivity and habitat needs. In turn, personnel from every division within VTrans have learned of the needs of wild animals of all sizes to move to critical habitat and their vulnerability to traffic and roads. As course graduates move into higher positions within VTrans, they become more empowered to implement programmatic changes and project improvements that affect wildlife connectivity and habitat. The cultural changes from these trainings have occurred over decades, and from the highest levels of VTrans to the local maintenance personnel, in effect, creating an intangible magic within the agency.



**FIGURE 42. PARTICIPANTS IN THE HIGHWAYS AND HABITATS COURSE LEARN ABOUT WILDLIFE TRACKS. PHOTO CREDIT: VTRANS.**

Chris Slesar, a co-creator of the program, relayed two stories of how the course may have helped influence actions at the agency, from the local level to executive decisions. Personnel in one of the VTrans districts identified an area where snapping turtles were getting hit on the road. In the Highways & Habitats training, ecologists showed the class participants in that district how the turtles in a nearby wetland were attracted to the berms on the road right of way (ROW) to lay and incubate eggs, thus placing the females in danger of being killed as they moved near and across the road. The district graduates of the course took old and discarded W-beam guard rail and repurposed it as a retaining wall, north and south of a culvert near a pond where turtles were getting killed on the road. The district then back filled the new retaining

wall with stone that wasn't conducive to laying eggs. The intent was to both guide the turtles to the culvert and make the road berm less attractive to nesting females. In essence, they used ingenuity from their areas of interest to help turtles in their everyday actions.

Recently, the VTrans Chief Engineer was presented with evidence from staff of the need to upgrade a culvert replacement on Route 9 near Searsburg to a full bridge to allow for wildlife connectivity not only near the highway, but regionally. A key VTrans wildlife expert conducted a benefit-cost analysis of the bridge upgrade and completed an exhaustive review of the benefits of re-establishing wildlife connectivity in the area. The Chief Engineer was supportive and called the decision to upgrade the project from a \$300,000 culvert to a \$3 million bridge a common sense decision about public investments. This engineer is not a graduate of the Highways and Habitat course, but is surrounded by course participants in his office. In essence, the engineer understands regional connectivity is important to wildlife, while also stating that this is action does not open the door for every culvert replacement to become a bridge.

### **Institutionalized Awareness**

Since 2002 the Highways & Habitats Program has trained agency personnel on the ecology and practice of wildlife movement with respect to roads. The education and discussions from these sessions come back to the personal question for participants, "What can you do in your job for wildlife?" This is asked of personnel from the management to plow drivers. In earlier years the course required a commitment of one full day a month for six months for participants. They would meet in the field and learn of wildlife ecology from vernal ponds and how breeding salamanders need to cross roads on cold rainy spring nights, to working with fisheries biologists to shock water ways and work with fish. The course has since evolved into three tiers of participation.



**FIGURE 43. PARTICIPANTS DISCUSS MITIGATION OPTIONS UNDER A VTRANS BRIDGE. PHOTO CREDIT: VTRANS.**

Tier One of the program is to inspire. It has been developed into an on-line 90-minute training tutorial for individuals to become acquainted with transportation ecology and become inspired as to actions they can do in their positions to help wildlife, in small

and large ways. It will be available to not only VTrans but also personnel in municipalities.

Tier Two is designed to empower participants to have a voice and role. It is three days of field course training over six months. It is offered every year. There is a palatable “magic” for participants of seeing wildlife and their signs in the wild, holding a snake, seeing turtles up close, handling fish, etc., that make this Tier the most important part of the training. Participants brain storm solutions at locations such as bridge sites. The field component is also beneficial for project managers, for them to be able to say, “We’d love to do these things for wildlife, but we can’t afford it. How do we maximize funds and do the right thing?” These visits result in dynamic conversations that are never exactly the same from class to class.



**FIGURE 44. A VTRANS PARTICIPANT HANDLES A SNAKE FOR THE FIRST TIME. PHOTO CREDIT: VTRANS.**

Tier Three is structured to empower engineers to have the tools to make technical improvements. It will be a classroom course, offered every other year. This is a still developing part of the educational program, but the initial organization of Tier Three is for people with experience, with tools to design infrastructure for wildlife to present their experiences and work with the engineers. The goal is to have experienced engineers speaking with other engineers. The wildlife mitigation solutions that may be considered big and bold in western states and Canadian provinces are probably not indicative of what the VTrans engineers will be working with in their careers. They need instructions on small infrastructure retrofits and designs that can facilitate wildlife and fish movement at smaller scales, in the mountainous roads of Vermont.

### **Culture Change**

Chris Slesar is by training an anthropologist, and he gave words of wisdom as to how the success of this program can be repeated in other places. It is based on change. Most people think culture is static, and change occurs when something big happens. The anthropologists understand culture is in a constant state of flux. Changes at the micro level can happen and change culture. The small changes at VTrans, some presented here as examples, are the agents of change. The leaders that have undergone that change can make things happen at a greater level, and those little changes add up.

## New Mexico's Legislators Integrate Wildlife Concerns into Agency Actions

Patricia Cramer, PhD

New Mexico state legislators understand the importance of reducing wildlife-vehicle collisions (WVC) and promoting wildlife connectivity. Since 2003, the state has enacted four memorials/laws/acts that direct New Mexico Department of Transportation (NMDOT) and New Mexico Department of Game and Fish (NMDGF) to cooperatively address WVC issues and pursue funding to mitigate top priority areas. In 2019, New Mexico became the first state to enact a Wildlife Corridors Act, with the New Mexico Wildlife Corridors Act. With this Act, it is now law for the NMDGF Mexico Department of Game and Fish to work together in identifying and addressing top priority areas for wildlife connectivity across New Mexico roads. This Act and the resulting Wildlife Corridors Action Plan may become a model for other states to codify how states bring wildlife movement concerns into transportation plans and projects, and how stakeholders participate in this effort.

New Mexico's legislative mandates began with House Joint Memorial 3, passed in 2003. It resulted in a critical mass workshop that brought together approximately 100 participants who identified 30 priority WVC road segments. The participants recommended these areas be further evaluated for WVC mitigation measures. The resulting map and report led to the development of the Tijeras Canyon Safe Passages Project which was completed in 2008.

In 2011, New Mexico legislators passed House Joint Memorial 10. As a result, NMDOT, NMDGF, the University of New Mexico Division of Government Research (DGR), and New Mexico State Police participated in a workshop that again identified areas of highest risk for WVC. DGR identified 54 highway segments that had at least 10 crashes in five years involving large animals. Additional analysis was performed on these segments that identified areas that had at least five human injury crashes. This resulted in funding of the US 64/84 Pilot Project located between Tierra Amarilla and Chama. This project involved roadway vegetation control to increase sight-distances and the installation of illuminated warning signs.

In 2013, New Mexico legislators passed House Memorial 1 and Senate Memorial 11. The legislation was drafted by Wild Friends, a youth education program organized by the University of New Mexico Institute of Public Law. It again resulted in a workshop that identified and prioritized 32 road segments with high incidences of WVC. It further directed NMDOT and NMDGF to seek Highway Safety Improvement Program (HSIP) dollars to fund at least one WVC mitigation project. Two game fence projects were successfully funded, which exceeded legislative goals. Game fence projects were

constructed along I-25 at Raton and US 550 south of Cuba. These projects excluded large mammals from the roadway and directed them to safely cross through existing concrete box culverts and bridges. The effectiveness of these projects is currently being evaluated through FHWA research dollars.

In 2019, state legislators worked with the National Wildlife Federation, Defenders of Wildlife, Wildlands Network, tribal entities, and other stakeholders to develop and pass the New Mexico Wildlife Corridors Act. It directs NMDOT and NMDGF to develop a comprehensive Wildlife Corridors Action Plan that would identify and prioritize important areas for wildlife movement and key barriers, such as roads, to those movements. The Act directed that approaches to address wildlife-vehicle conflict areas would not only enhance safety to the traveling public, but also consider critical wildlife movement areas. The Act marks an advanced approach to mitigating WVC by: (1) identifying areas important for large mammal movements across the state first, (2) then identify where those movement corridors intersect with roads and highway, and (3) then prioritize mitigation projects through publication of a projects list. It also is unique in that there is state-wide stakeholder participation in prioritizing mitigation projects once the scientists identify the important movement corridors and areas where wildlife come into conflict with vehicles. The specifications in the Act dictate how the NMDOT and NMDGF will consistently analyze data, prioritize potential projects, and construct necessary mitigation.

The Act did not change institutional practices at NMDOT or NMDGF, but rather provided



**FIGURE 46. PARTICIPANTS IN THE 2013 WORKSHOP. PHOTO CREDIT: M. WATSON.**



**FIGURE 45. ELK PHOTOGRAPHED USING THE AREA BENEATH THE U.S. 550 RIO PUERCO BRIDGE. PHOTO CREDIT: J. GAGNON, AZGFD, & NMDOT.**

direction and the opportunity to identify critical wildlife-vehicle conflict areas through more robust GIS analysis that incorporates both ecological and WVC data. Past efforts directed by past legislation utilized less robust analysis using primarily WVC data. The Act further directed both NMDOT and NMDGF to consider input from stakeholders, tribes and the general public.

The WVC mitigation projects developed up through 2020 have resulted in three (3) wildlife crossing structures in one project, and nine major mitigation projects that exclude large mammals from the roadway and provide safe wildlife passage through existing bridges and other drainage structures. In essence, New Mexico started its wildlife mitigation program modestly, in small steps rather than with a large project with multiple wildlife crossing structures. As the New Mexico Wildlife Corridor Action Plan is developed, it will be of interest if the results lead to one or more projects where a wildlife crossing structure is built in a priority location for wildlife. These types of projects, while much more expensive than wildlife exclusion fence projects, are a standard of change that indicate an agency is truly beginning to include wildlife connectivity and the reduction of WVC in their standard operating procedures.

The Wildlife Corridors Act of 2019 can be found at the website:

<https://wildlandsnetwork.org/wp-content/uploads/2019/04/New-Mexico-Wildlife-Corridors-Act-2019.pdf>

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Cramer, P., J-L. Cartron, K. Calhoun, J. Gagnon, S. Cushman, H.Y. Wan, J. Kutz, J. Romero, T. Brennan, J. Walther, C. Loberger, H. Nelson. 2021. New Mexico Wildlife Corridors Action Plan 2020 Progress Report. To New Mexico Department of Transportation. URL:  
[https://dot.state.nm.us/content/dam/nmdot/Infrastructure/EDS/2020ProgressReport\\_WildlifeCorridorsActionPlan\\_1-26-2021.pdf](https://dot.state.nm.us/content/dam/nmdot/Infrastructure/EDS/2020ProgressReport_WildlifeCorridorsActionPlan_1-26-2021.pdf)

## Building Partnerships to Advance Wildlife-Highway Mitigation in Colorado

Julia Kintsch, MS

As with many state departments of transportation and state wildlife agencies across the nation, the Colorado Department Transportation (CDOT) and Colorado Parks and Wildlife (CPW) remained largely isolated from one another through much of their histories. While relationships varied from one office to the next, to a large extent, the two agencies lacked a mutual understanding of the common threads of their missions, including maintaining wildlife habitat connectivity in Colorado during transportation planning and development. The agencies conducted project-specific consultations as required, but information exchanges and discussions were generally limited to site-specific projects. Neither agency fully appreciated the constraints of the other, and as a result, opportunities to jointly pursue large-scale planning and design new projects with common benefits were missed.

While multiple factors have prompted increased interagency collaboration in recent years, the cumulative successes of simple, but effective and well-publicized small-scale wildlife-highway mitigation projects such as the construction of wildlife fencing escape ramps along highway US 550 near Ridgway State Park have gone a long way towards promoting greater communication and collaboration. The increased trust and confidence resulting from these small-scale efforts combined with a multi-agency seasonal driver awareness campaign increased the engagement of both agencies over time and allowed greater collaboration to tackle larger projects such as the one on State Highway 9 (SH 9) in Grand County.



**FIGURE 47. THE COLORADO STATE ROAD 9 WILDLIFE OVERPASS AND SIX OTHER STRUCTURES HAVE HAD OVER 80,000 MULE DEER AND OTHER WILDLIFE SUCCESSFUL MOVEMENTS, INCLUDING THIS MOOSE. PHOTO CREDIT: J. RICHERT, BLUE VALLEY RANCH.**

The SH 9 project was initially spurred by funding from a conservation ranch adjacent to the highway corridor. A broad array of public and private entities came together to raise additional funds, ultimately prompting CDOT to advance the project under a one-time grant opportunity. This safety improvement project included the construction of two wildlife overpasses, five large underpasses, and ten miles of wildlife exclusion fencing and associated mitigation features designed in close collaboration with CPW. In just the first few years following construction, these structures boasted tens of thousands of

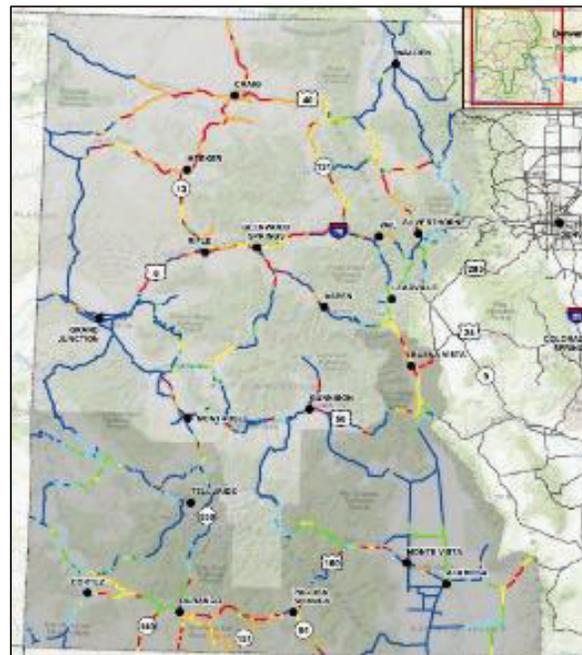
successful mule deer crossings and many other wildlife, and the mitigation has resulted in an 89% decrease in wildlife-vehicle collisions.

Building on these and other local successes, in 2017, CDOT, CPW and FHWA joined forces to host a two-day interdisciplinary Wildlife and Transportation Summit. The Summit invited agencies and organizations representing an array of interests to share ideas and expertise around improving highway safety and protecting wildlife populations and movement corridors. Participants included representatives from multiple state and federal agencies, local and state policymakers, non-profit organizations, foundations, academia, wildlife experts, and public and private stakeholders. The Summit established new partnerships around common goals and developed broad recommendations and identify funding to improve highway safety and protect wildlife populations.



**FIGURE 48. PARTICIPANTS IN THE 2017 SUMMIT VISIT THE SR 9 WILDLIFE MITIGATION TO DISCUSS LESSONS LEARNED. PHOTO CREDIT: P. CRAMER.**

A direct result of this gathering was the formation of the Colorado Wildlife and Transportation Alliance to carry forward the momentum generated by the Summit. The Alliance is led by an inter-organizational Steering Committee composed of representatives from CDOT, CPW, FHWA, the USDA Forest Service, the Bureau of Land Management, the Southern Ute Tribe, Rocky Mountain Elk Foundation, and the Mule Deer Foundation. The initial tasks of the Committee were to define a mission and vision, and to develop an action plan. The action plan identifies specific goals, actions and timelines, and led to the formation of technical teams to broaden the capacity of the Alliance. The primary goals and associated technical teams are focused in four arenas: 1) education and outreach, 2) partnerships and funding, 3) policy, and 4) data coordination and planning.



**FIGURE 49. WEST SLOPE WILDLIFE PRIORITIZATION STUDY RESULTING MAP OF PRIORITY ROAD SEGMENTS. TAKEN FROM KINTSCH ET AL. 2019.**

In addition, the Summit and subsequent formation of the Alliance coincided with the Western Slope Wildlife Prioritization Study, a CDOT and CPW-funded research study to prioritize highway segments for mitigation across Colorado's Western Slope (Kintsch et al. 2019). In 2020, this regional study is being expanded to the Eastern slope and Plains so that transportation planners and resource managers will be equipped with a complete statewide prioritization to guide future mitigations projects and funding.

Combined, these concurrent efforts are generating broader support and leaving Colorado better positioned to address wildlife-highway conflict. In 2019, Colorado Governor Jared Polis signed an Executive Order on Big Game Winter Range and Migration Corridors and Wildlife Crossings, which explicitly reinforces the ongoing work of the Alliance, including revising an interagency Memorandum of Understanding to streamline collaboration between CDOT and CPW; and identifying policy, regulatory or legislative opportunities that will ensure the ongoing conservation of seasonal habitat and migration corridors.

Diverse public and private partnerships have proved essential from the beginning of Colorado's journey to address wildlife-highway conflict. Partnerships at multiple scales from local to statewide have proven essential for increasing education and awareness; leveraging funding; and achieving on-the-ground results benefitting people and wildlife. Given the multiple complexities involved, coordinated actions across jurisdictions and interests will continue to be required.

Link to the CPW-CDOT MOU

<https://www.codot.gov/programs/environmental/wildlife/cdot-and-cpw-mou-signed>

SR 9 promotional videos

<https://cpw.state.co.us/hwy9>

Annual Reports posted on CDOT:

<https://www.codot.gov/programs/research/pdfs/2019/SH9Yr3/view>

2017 Summit Video

<https://www.codot.gov/programs/environmental/wildlife/wildlife-transportation-summit>

The Colorado Wildlife and Transportation Alliance

<https://coloradowildlifeandtransportationalliance.com/>

The link for the West Slope Study docs

<https://www.codot.gov/programs/research/pdfs/2019/WSWPS/view>

Link to Governor Polis' executive order

<https://www.codot.gov/programs/environmental/wildlife/governor-signs-wildlife-exec-order>

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Kintsch, J., P. Cramer, P. Singer, and M. Cowardin. 2021. State Highway 9 Wildlife Crossings Monitoring Final Report. Study Number 115.01. Report to Colorado

Department of Transportation. URL: <https://www.codot.gov/programs/research/pdfs/2021-research-reports/state-highway-9-wildlife-mitigation-monitoring>

## Securing Funding for Wildlife Connectivity - A Golden Moment in Pima County, Arizona

Norris Dodd, MS

Sherry Ruther, MS

Jeff Gagnon, MS

Reduced transportation revenues and increasing competition for available construction funding make it difficult for state and local Departments of Transportation to focus on efforts beyond maintenance of current infrastructure. This unavoidably limits the opportunity for projects of the scope and scale appropriate to incorporate major wildlife crossing structures. In Arizona, however, the Arizona Department of Transportation (ADOT) and Regional Transportation Authority (RTA) took advantage of a golden moment to leverage funds approved in 2006 by the voting public to successfully incorporate major wildlife crossing structures into improvement projects for two state highways.

Residents of Pima County, which is located in south-central Arizona, have a long history stretching back to the early 1920's, of preserving their natural resources and open spaces. More recently, starting in 1998, the Pima County Board of Supervisors initiated the Sonoran Desert Conservation Plan, a long-term vision intended to balance the community's economic health and vigor with the preservation of the area's natural and cultural heritage. This vision spring-boarded two significant accomplishments that benefit local and regional wildlife resources. In 2004, county voters approved a \$174 million open space bond package that resulted in Pima County's control and management of over 200,000 acres of open space which include areas important to preserve critical wildlife linkage areas. Later in 2006, voters once again rose to the occasion and authorized a half-cent excise tax to be collected over the next 20 years by RTA which is an independent local government established by the state and managed by the Pima Association of Governments. That 20-year authorization would



**FIGURE 50. STATE ROAD 77 WILDLIFE OVERPASS, NORTHWEST OF TUCSON, IN PIMA COUNTY, ARIZONA. PHOTO CREDIT: J. GAGNON, ARIZONA DEPARTMENT OF GAME AND FISH.**

generate \$2.1 billion for safety, transit, environmental, and economic vitality programs. Of that \$2.1 billion, \$45 million (2.1%) would be set aside and used over the next 20 years to specifically address wildlife connectivity and linkage issues created by transportation infrastructure.

An RTA Wildlife Linkages Subcommittee reviews and evaluates all proposals seeking access to the \$45 million. Their recommendation is then forwarded up through the RTA governance structure culminating with the RTA Board's decision to fund or not fund the request. Funding for projects is available to local jurisdictions and partners including ADOT for projects along planned or existing roads and state highways. Projects can include:

- Design and construction of crossing structures included in planning for new roads and highways or planning of major expansions of existing roads and highways.
- Retro-fitting existing roads and highways with wildlife crossing structures.
- Research designed to improve decision making such as wildlife movement patterns, suitable types of crossing structures, and appropriate crossing locations.

One of the first projects to receive funding was a refinement of the 2006 statewide *Arizona Wildlife Linkages Assessment* to provide more detail on important linkage areas that occur within the boundaries of Pima County. Both these assessments inform evaluations of and funding for projects including the two highways that are the subject of this article and which have received the largest funding allocations to date.

There are critical wildlife linkage areas within Pima County that State Routes (SR) 86 and 77 bisect. When ADOT initiated the planning phases to make significant improvements to these state roadways, they opened the door for a once in a life-time opportunity to improve connectivity of these important linkages. Local conservation advocates and RTA coordinated with ADOT to develop wildlife crossing elements that could be incorporated into their improvement projects. Ultimately, the RTA Board approved the funding requests and through a series of separate allocations have



**FIGURE 51. STATE ROUTE 86 RETROFIT UNDERPASS INSTALLATION FUNDED BY THE PIMA COUNTY RTA, AND MOUNTAIN LION CROSSING THROUGH THE STRUCTURE SOON AFTER COMPLETION. PHOTO CREDITS: NORRIS DODD.**

provided over \$20.7 million to improve wildlife connectivity and reduce wildlife-vehicle conflicts:

- \$14 million for construction of wildlife crossing structures and fencing on these two state routes: 2 underpasses on SR 86 and an underpass and overpass (the Sonoran desert's first) on SR 77, all completed in 2014.
- \$200,000 for post-construction monitoring projects at the SR 77 crossing structures conducted by the Arizona Game and Fish Department to determine the effectiveness of the structures. As of November 2019, over 9,200 successful crossings have been documented.
- \$6.5 million to incorporate 2 overpasses along SR 86 at locations within the Tohono O'odham Nation (TON) for implementation in 2020.



**FIGURE 52. BOBCAT PHOTOGRAPHED USING THE SR 77 UNDERPASS. PHOTO CREDIT: J. GAGNON, ARIZONA GAME AND FISH DEPARTMENT.**

These accomplishments are unquestionably having a profound positive impact on wildlife resources and driver safety. However, the reality is that nothing ever works out as expected and at this moment there is a great deal of uncertainty about more projects of this scale and impact. Consequences of the 2007-2008 economic downturn have adversely affected realization of the full \$2.1 billion. Expectations are that these RTA Wildlife Linkage funds are already nearly spent. ADOT's construction funding is also likely to remain limited for the immediate future. Yet, there is reason to aspire to more golden moments, as there are plans to ask voters to reauthorize the RTA for another 20 years and maintain an allocation to fund more transportation-wildlife connectivity projects.

Links for more information

Arizona Wildlife Linkages Assessment

URL: <https://azdot.gov/business/environmental-planning/programs/wildlife-linkages>

Arizona Game and Fish Monitoring Research Progress Report for SR 77 December 2019, URL:

<http://www.rtamobility.com/documents/ProjectReview/SR-77-ProgressReport-2019-12-11.pdf>

Pima County Wildlife Connectivity Assessment

URL:

<http://www.rtamobility.com/documents/pimacountywildlifeconnectivityassessment.pdf>

RTA Wildlife Linkages 2016

URL: <http://www.rtamobility.com/documents/pdfs/RTAWLL/2016/RTAWLL-2016-06-10-RTA42-BudgetReport-2016-05-26.pdf>

Sonoran Desert Conservation Plan

URL: <https://www.sonorandesert.org/learning-more/sonoran-desert-conservation-plan/>

## A Federal Agency Perspective

Terry Brennan, PE, Retired, USDA Forest Service

As population in the metropolitan Phoenix area continued to increase during the 1990's, the Arizona Department of Transportation (ADOT) included many improvement projects that involved crossing Federal lands administered by the USDA Forest Service on the Statewide Transportation Program. The Tonto National Forest is located in immediate proximity to the Phoenix metro area. ADOT spent over \$500 million expanding much of their highway system across the Tonto National Forest over a ten- year period. Multiple projects that included dozens of wildlife crossing structures were an integral part of these projects while including numerous bridges and large culverts that incorporated many facets of adaptive management and lessons learned. With each project design and construction project, the design and construction team incorporated the best ideas from each construction segment to make the next project even better. One of the lessons learned during this process would be to get involved as early in the process as feasible



**FIGURE 53. TWO OF THE LARGE WILDLIFE CROSSING BRIDGES ON STATE ROAD 260, PAYSON, ARIZONA. PHOTO CREDIT: T. BRENNAN.**

### **Obtaining Wildlife Data to Provide Wildlife Crossing Infrastructure**

As most DOT employees are aware, changes to designs that are requested later than at a 30 percent design stage, are very difficult and costly to implement. This may be due to numerous issues, but more often than not, it is a scheduling delay that often causes a pushback on any requested modifications. With the advent of these possible delays, it is imperative to obtain the wildlife input from various sources as early as possible in the design process and be able to implement wildlife connectivity solutions. This information can come from a number of sources.

### **Important Information Sources**

From the survey respondents in this study's on-line survey for transportation agency personnel, two of the most important sources for wildlife information were wildlife

collision crash data and hotspot analysis of the crash data reported. This is very important information to a design engineer, but they must be cautious as to how to interpret the data results. All engineers want to eliminate safety hazards and WVC that are a safety hazard. But the solution might not be exactly where the collisions are taking place. Other factors may cause the animals to be forced to a different area to cross the highway. For this reason, wildlife expertise should be consulted before project implementation.

### **Obtaining Critical Approval at Key Critical Path Times.**

The implementation of the ADOT highway construction program on the Tonto National Forest, was administered by a liaison position and financed by the ADOT as a reimbursable expense from Federal Highways. This position allowed ADOT to go to one individual to obtain answers to the process for approval or clearances from the land management agency (The USDA Forest Service). Often times the DOT does not understand the organizational structure or approval process in the federal agency. It was the liaison position responsibility to help ADOT obtain these approvals. This helped provide both cost effective solutions and on time product delivery.

### **Continuity for Projects from Planning to Construction to Maintenance**

DOT's often have specific groups that have a small piece of the total project. During the project implementation there is a planning group, a design group, a construction contractor and finally the maintenance section. Being able to pass on the historical decisions helps the implementation by the construction contractor. This can be accomplished by having the design groups that completed the construction plans included as a part of the monthly meetings with the contractor during the construction process. By doing this, the designers are able to make timely changes for the project's benefit or explain future project impacts that might not be readily apparent to the construction team at the current time and provide for continuity through the project completion.

Another predesign project impact to be dealt with is the geotechnical investigation necessary for a new or reconstructed bridge. Being able to think of a contractor's access for the larger construction activity during this part of the project can help in minimizing the disturbance in critical habitats utilizing one access for multiple entries.



**FIGURE 54. CONTRACTOR STAGING AREA INSIDE THE ARIZONA STATE ROAD 188 ROW. PHOTO CREDIT: R. BRENNAN.**

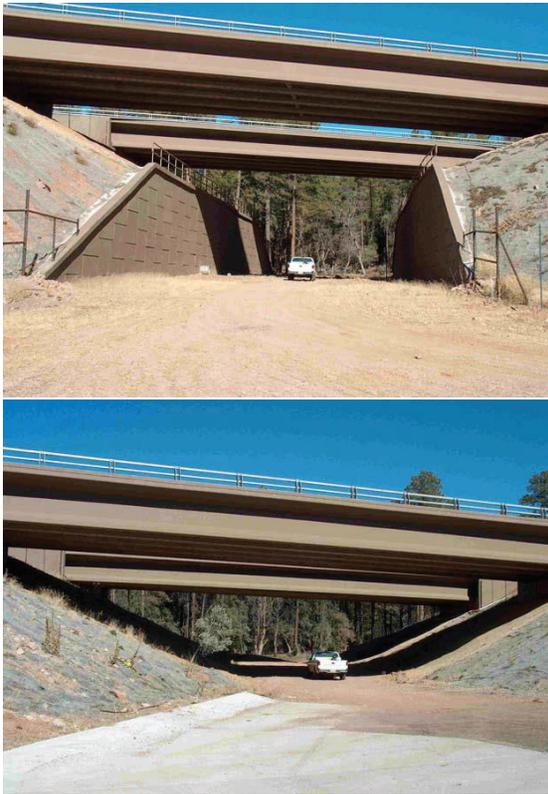
### **Identifying Project Impacts Outside the Identified Right of Way**

All construction projects require additional land disturbance outside of the existing ROW and National

Environmental Protection Act (NEPA) cleared areas. Clearances could be obtained in an orderly manner and project design plans incorporated into the construction contract by identifying these impacts early in the design process. These plans included the areas of disturbance and the remediation of the contractors' activities. This created a win-win for all parties. The contractor had a known staging area, detour or waste site, the land management agency got a new trailhead or past dumping area closed and remediated, wildlife enjoyed increased habitat and the DOT met its timeline objective by having clearances obtained before contract award

### **Adaptive Management for Wildlife Crossings**

The scheduling of numerous projects allowed for lessons learned during the project development. One lesson learned was the threat to animals from large retaining walls by predators as they proceed through the space under the bridge. This was alleviated in some cases by the use of a full depth bridge abutment. This solution removed the retaining walls as well as provided a better natural environment under the bridge to ease the animals' anxiety. The need for fencing to funnel the animals to the structure and reduce the animals getting onto the highway has been a part of the construction implementation. To reduce the amount of wildlife fencing, natural barriers or landforms were often used, when appropriate, to act as a fencing replacement.



**FIGURE 55. ARIZONA STATE ROUTE 260 WILDLIFE CROSSING BRIDGES WITH AND WITHOUT RETAINING WALLS. PHOTO CREDIT: T. BRENNAN.**

Water outlet velocities under bridges and culvert ends often require energy dissipaters. A typical engineered solution is to place large rock rip rap in these locations. Alternate design solutions will allow better accessibility for wildlife movement.

### **Modifying Existing Infrastructure**

As the need for replacement of an aging infrastructure continues and increases across the country, we can help solve wildlife connectivity issues as projects are compiled and scheduled on the State Transportation Improvement Plan (STIP). As discussed above, obtaining WVC data can help identify key locations for wildlife crossing structures as projects are designed.

### **Key Points for Better Project Implementation**

- Get involved early with accurate and current data to provide the best wildlife crossing solutions.
  - Speaking to the engineer, it is often identified that the biologists may not have all the studies or data they would wish, in order to provide their input. The biologist must give their input with their best judgement at the time rather than delay the project in order to obtain more data or a better analysis. The DOT has a schedule and a timeline for completion and will continue their design process in order to meet their target completion date.
    - Review the upcoming year State Transportation Improvement Plan to know what construction and reconstruction projects are planned
- Use safety of the traveler and eliminating WVC's as a basis to suggest the project manager of the importance of the request.
- If the project is crossing Federal, Tribal or Provincial lands, identify who in the agency has the ultimate decision making authority. Keeping that individual updated

in the design process will help alleviate unknown impacts from the project implementation.

- Usually, allowing a larger construction disturbance on the short term, can provide a better solution in the long term. The USFS engineer has the responsibility to balance the long term land impacts and the DOT project implementation. An example of this might be the allowance by the land agency to widen the ROW so flatter cut and fill slopes might be constructed and to be able to revegetate properly or to have the DOT stockpile excess excavated material outside of the project limits, for use on a future construction project. Try thinking of the long term reclamation needs and not the immediate ground disturbance. This is important because maintenance funds usually are provided by the state and not the federal government. Do it right the first time and heal the areas of impact.
- Identify water sources for construction activities in the project plans as water is one of the largest resource impact items necessary for a contractor's activities.
- Wildlife structure implementation done correctly can be complex. There are numerous sources available that have valuable information. A few that might be useful include:
  - International Conference on Ecology and Transportation: [www.icoet.net](http://www.icoet.net);
  - Wildlife Crossing Handbook: Design and Evaluation in North America (Clevenger and Huijser 2011); and
  - Arc Solutions: [www.arc-solutions.org](http://www.arc-solutions.org).

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## Chapter 4 Data Requirements

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### Overview

This study is part of the Wildlife Vehicle Collision (WVC) Reduction and Habitat Connectivity Pooled Fund Study of 2018-2022. This pooled fund study (PFS) seeks to identify cost-effective solutions that integrate highway safety and mobility with wildlife conservation and habitat connectivity. This is a collaborative project through the U.S. Federal Highway Administration Transportation Pooled Fund Program. Contributing partners include the Departments of Transportation (DOTs) of Alaska, Arizona, California, Iowa, Michigan, Minnesota, New Mexico, Oregon, Washington, and Nevada. The Nevada DOT administers this project. Canadian partners include the Ontario Ministry of Transportation (MoT), and Parks Canada. The non-profit, ARC Solutions, Incorporated is also a partner. Representatives from these organizations serve on the Technical Advisory Committee (TAC) for this study. The goal of this greater project is to reduce wildlife-vehicle collisions (WVC) for the safety of motorists and wildlife, and to promote and restore wildlife connectivity.

### Introduction

Data are key to identifying challenges and potential solutions. The objective of this chapter was to identify and describe data required for integration of wildlife mitigation projects into transportation procedures such as project prioritization, planning, and implementation.

There are two types of data needs for transportation agencies to consider wildlife movement concerns and the reduction of wildlife-vehicle conflict: transportation data, and ecological-related data. The data must also be analyzed, mapped, and combined to better understand and model where there may be wildlife-vehicle conflicts. In this chapter we describe the kinds of data, maps, and analyses needed, and give examples of how these has been implemented in the U.S. and Canada. A summary and hyperlinks to the text of all the data requirements are presented below in Table 9.

**TABLE 9. DATA REQUIREMENTS FOR INTEGRATION OF WILDLIFE MITIGATION INTO TRANSPORTATION PROCEDURES.**

Type of Data	Specific Types of Data to Explore and Gather
<b>Transportation Data</b>	
	<a href="#"><u>Identify the Scope, Extent and Cost of WVC Crashes</u></a>
	<a href="#"><u>Carcass Data, Mapping, and Analysis</u></a>
	<a href="#"><u>Traffic Volume Data</u></a>
	<a href="#"><u>Culvert and Bridge Inventory Listings and Maintenance</u></a>
	<a href="#"><u>Transportation Planning Documents</u></a>
	<a href="#"><u>Costs of Recent Wildlife Mitigation Infrastructure</u></a>
	<a href="#"><u>Funding Sources</u></a>
<b>Ecological Data</b>	
	<a href="#"><u>Wildlife Habitat Maps</u></a>
	<a href="#"><u>Wildlife Linkages and Corridor Maps</u></a>
	<a href="#"><u>Wildlife Locational Data</u></a>
	<a href="#"><u>Wildlife Movement Abilities and Needs</u></a>
	<a href="#"><u>Pre-Construction and Other Wildlife Mitigation Monitoring</u></a>
	<a href="#"><u>State Wildlife Action Plan and Species Recovery Plan</u></a>
	<a href="#"><u>Needs Assessment from Wildlife Agency</u></a>
	<a href="#"><u>Land Ownership and Use</u></a>
	<a href="#"><u>Identify Permanent and Perennial Water Sources</u></a>
	<a href="#"><u>Topography</u></a>
	<a href="#"><u>Climate Change</u></a>

## Transportation Data

### Introduction

Transportation data are important in identifying the scope of the problem of wildlife-vehicle conflict with large animals, the safety aspect for motorists involved in wildlife collisions, and to identify areas in need of accommodating wildlife. The opportunities to accommodate wildlife can be built into standard transportation processes.

### Identify the Scope, Extent, and Cost of WVC with Crash Data Analyses

Analyses of reported crash data can help identify the extent of all animal and specifically wildlife collisions, hotspot areas, species involved, and costs. Reported crash data are

the only data on collisions with animals that are consistently collected across time and space, everywhere in the U.S. and Canada. These data are from traffic safety personnel, such as highway patrol, police, sheriff, wildlife conservation officers, etc. when they are called to report a crash. While some locations within a state or province may have robust carcass collection reporting, this is typically not the case over entire states, provinces, and nations. Reported crash data are thus the most appropriate crash data type to use to analyze the magnitude and scope of crashes with animals over a broad region.

This research project has compiled five years of animal crash data for all 50 U.S. states as of 2018 crash numbers. There is annually on average, a minimum of 346,000 reported crashes with all animals. Some states do not record wildlife separately, so this the closest estimate to the extent of the problem. Of these crashes, there are on average 201.82 fatal crashes with animals annually. The cost of all these crashes, based on severity of injuries, fatalities, and property damage only, is over \$10.1 billion annually, using the Federal Highway Administration (FHWA) 2018 estimates for crash costs (Harmon et al. 2018). See Chapter 3, Transportation Data for the full report on all U.S. States and the country overall.

### *Crash Analyses to Identify Extent of Wildlife-Vehicle Collisions*

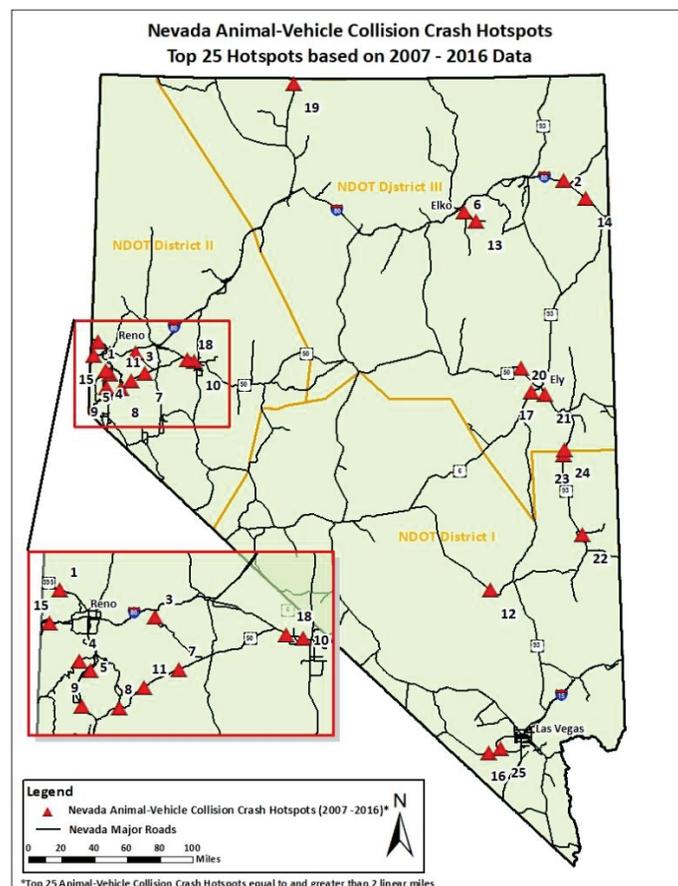
An analyses of crash records for a specific jurisdiction is a first step to learning and presenting the magnitude of the challenge. Crash records are but a fraction of the number of actual collisions with animals. Olson (2013) found 5.26 times more large mammal carcasses at the edge of the road and in the Right-of-Way of Utah highways than the number of crashes reported on those highways. In Virginia, Donaldson (2017) found up to 8.5 times more deer carcasses than reported in crashes. Therefore, the crash data reporting of extent is but a first step in presenting the problem of wildlife-vehicle collisions. See Nevada's study (Cramer and McGinty 2018) for how these data can be presented to demonstrate the numbers of crashes across different jurisdiction and over time, and as percentages of overall crashes.

### *Crash Hotspot Mapping to Identify Hotspot Areas*

Animal-vehicle crash data can be mapped with methods that allow prioritization of crash hotspots. There are wildlife collisions, collisions with domestic animals such as livestock and pets, and there are all animal collisions. While this study targets wildlife conflict, there are at times, limited choices in the use of wildlife crash data. All animal-vehicle crash data covers all types of animals. This may be important in crash hotspot analyses; thus the term animal-vehicle crash data is used here. There are two general geo-spatial modeling (maps in computers, typically with ArcGIS) methods to analyze the aggregation of crash locations: Kernel Density Analysis, and Optimized Hotspot Analysis using the Getis-Ord Gi statistic. Both analyses are typically run in ArcGIS. The Kernel Density method was run in earlier years of hotspot mapping and is still used as a method that is convenient, easy to learn, and easy to visually present hotspots to non-

scientific audiences. However, this method breaks the map into pixels and runs analyses based on neighboring pixels, often placing top hotspot locations at the junctions of two or more roads, due to the search method in the software. Kernel density analyses have been used in mapping Washington's, Idaho's (Cramer et al. 2014), and South Dakota's wildlife-vehicle collision hotspots (Cramer et al. 2016).

Getis-Ord has become, across the globe, the accepted best method to analyze animal-vehicle collisions to create statistically sound hot spots (Garrah et al. 2015, Kociolek et al. 2016, Shilling and Waetjen 2015). The hotspots that result from Getis-Ord are based on an aggregation of occurrence data or crash data. Getis-Ord and Optimized Hotspot Analysis in ArcGIS has been used to prioritize animal and wildlife hotspots in Nevada (Cramer and McGinty 2018, Figure 56), Utah (Cramer et al. 2019) and at the time of this writing were being used for New Mexico (Cramer et al. 2021) and Arizona. These maps allow for transportation agencies to then incorporate wildlife mitigation into forthcoming projects, and to possibly expedite wildlife mitigation projects due to the urgency of an area's wildlife-vehicle conflict.



**FIGURE 56. MAP OF NEVADA'S TOP 25 PRIORITY REPORTED ANIMAL-VEHICLE COLLISION CRASH HOTSPOTS EQUAL TO OR GREATER THAN TWO MILES LONG, BASED ON 2007-2016 DATA, DERIVED FROM GETIS-ORD ANALYSIS 95 PERCENT AND GREATER CONFIDENCE INTERVALS.**

A third method to identify priority hotspots is to combine crash data with other information to provide a more robust modeling effort. These prioritization methods are presented in the Colorado Western Slope Wildlife Prioritization Study case study in Chapter 3 of the master document, are presented in Kintsch et al. (2019), and were used in Idaho, South Dakota, and Nevada (Cramer et al. 2014, 2016, Cramer and McGinty 2018).

### *Crash Analyses to Identify Species Involved*

All states and provinces collect some form of crash data that indicate if an animal was involved. Approximately 25 percent of those states and provinces collect adequate information to determine if the animal was wild or domesticated, as learned from the crash data survey conducted in this study. Most states have forms to indicate if the animal was wild or domestic. Less than 10 states have choices for the species of the animal to be included in the reporting of crashes. Information on species involved is important to begin the process of identification of the prescribed wildlife mitigation. If species cannot be identified from crash data, carcass data become a de facto assistant in identifying the species most involved in crashes in certain areas (see below).

### *Crash Costs Analyses*

State Traffic Safety funds, or Highway Safety Improvement funds are options for wildlife mitigation projects that involve larger animals such as deer and elk. Transportation agency personnel typically look at historic crash data in an upcoming project area to make recommendations to reduce crashes and can perform a benefit-cost analysis of the proposed project's potential ability to reduce these crashes and pay for itself. These crash analyses help justify the use of traffic safety funds for wildlife mitigation.

Benefit-cost is the framework for analyzing a range of benefits and costs in monetary terms (Federal Highway Administration 2014). General guidelines for performing benefit-cost analysis for WVC in a given area are presented below. The analysis uses data available from the transportation agency, and if wildlife values are used, from the wildlife agency.

#### *1. Estimate Costs of WVC from WVC Reported Crash Data*

For each year of data analyses, typically taking a five-year average, find the number of reported crashes with wildlife and the number of each type of crash severity, from property damage only (PDO, or Type O), to the three injury types – possible (Type C), Minor (Type B) and Potential Serious (Type A), and Fatal Crashes (Type K). The next step is to obtain two different types of average cost to society for those crashes. In the U.S., the first crash estimate is to use the most recent Federal Highway Administration cost estimates. Here we use Harmon et al. (2018) estimates derived for FHWA. The

second cost type is that of the transportation agency, which is typically calculated differently. As an example, Table 10 below presents FHWA 2018 and Utah DOT 2019 crash values. The crash values typically vary in each state and province due to differences in economic factors in the various areas, and how an agency prioritizes different crash types.

**TABLE 10. CRASH INCIDENT TYPE AND COSTS ESTIMATED BY U.S DEPARTMENT OF TRANSPORTATION, 2018, AND UTAH TRANSPORTATION DEPARTMENT, 2019.**

<b>Incident Description</b>	<b>US DOT 2018 Cost Estimate per Occurrence (US Dollars) *</b>	<b>Utah DOT Cost Per Occurrence 2019 (US Dollars) **</b>
Fatal (Type K)	\$11,295,400	\$2,707,000
Potential Serious Injuries (Type A)	\$ 655,000	\$2,707,000
Minor Injuries (Type B)	\$198,500	\$233,500
Possible Injuries (Type C)	\$125,600	\$131,700
Property Damage Only (PDO, Type O)	\$11,900	\$12,300

\* Harmon et al. 2018. \*\* Cramer et al. 2019.

The user calculates two overall values of the crashes with wildlife: the FHWA value, and the state or province value. The user multiplies the FHWA and then their agency values for each crash type by the average number of those reported crashes over the time frame, for this case, five years. The user then divides the resulting five-year value of reported crashes by five for an annual average of the value of reported crashes overall for the area of concern. If there is a specific road segment where these crashes are occurring, this evaluation can be conducted and then divided by the number of miles (or kilometers) to get a crash cost per year per mile.

For some analyses, the crash value alone is enough to warrant an action to mitigate the WVC. For others, there is a need to conduct the benefit-cost analysis to see if a proposed mitigation could pay off over the years it is in place. If the benefit-cost analysis meets a certain criteria set by the state or federal agency such as Federal Highway Administration, it can help elevate these projects during priority planning. The following steps are for those types of analyses, but are not part of an official Federal Highway Administration method.

***2. Estimate Cost of WVC On Wildlife Populations Estimated from WVC Carcass Data***

The value of the wild animals killed can be estimated from carcass data, as an addition to the crash values. Each state estimates the value of individual wild animals of different species in the case of the state prosecuting poachers. These values can be used to estimate the value of the wildlife lost to WVC. Colorado DOT has created a robust method to analyze wildlife value that helps to raise the value of wildlife killed, see Kintsch et al. (2019), and Chapter 3 Case Study of Colorado’s Western Slope Wildlife Prioritization Study Benefit Cost Analysis.

### ***3. Estimate The Percentage Decrease in WVC Crashes the Mitigation Is Expected to Provide***

Huijser et al. (2009) analyzed 10 wildlife mitigation studies and their reductions in WVC and found an average of an 86 percent reduction in either WVC crashes or carcasses. The estimate can be varied to understand the degree of WVC crashes needed to have the project pay for itself over time. In Oregon, ODOT uses the standard 85 percent reduction based on wildlife mitigation on US 93 south of Bend (C. Bowman, Oregon DOT, personal communication, 2021). In Colorado, the State Highway 9 wildlife mitigation project reduced WVC crashes by over 90 percent (Kintsch et al. 2021). A reduction estimate between these two values would be typical of a benefit-cost analysis, and can be supported by these and other studies in the efficacy of wildlife mitigation to reduce WVC.

Note, if the projected mitigation action does not include wildlife crossing structures with wildlife fencing, the anticipated reduction in WVC would be significantly lower than a 90 percent estimate.

### ***4. Estimate Life Span of the Mitigation***

Structures such as bridges and culverts are built to last at least 50 years. Fencing may have a shorter lifespan if the quality is not to high standards. In most cases, bridges are built to last 75 years. In Nevada, wildlife crossing structure designs are expected to have a 75 to 80-year lifespan (N. Simpson, Nevada DOT, Personal communication, 2020).

### ***5. Estimate The Benefit of the Potential Wildlife Mitigation in Reducing Crashes***

The overall benefits of the wildlife mitigation are estimated based on the cost of the annual average number of crashes with wildlife, the percentage reduction of crashes the mitigation is expected to provide, and how many years the mitigation is expected to function. To get this estimate, the annual cost of WVC crashes is estimated from combining five years of data and dividing by five for a specific location, it is then multiplied by expected percentage decrease in WVC crashes the mitigation will provide, and then multiplied by the number of years the mitigation is expected to last. See below.

(Annual Value of WVC Crashes + Wildlife) x (% WVC Reduction) x (Number of Years Mitigation Lasts)

This equation will give the total benefits over the life of the infrastructure.

### ***6. Estimate Cost of the Mitigation Plus Its Maintenance Over Time***

The cost of mitigation should include how much extra the wildlife mitigation is adding to an existing project, or cost of a standalone project. For example, if a culvert is enlarged to accommodate wildlife, the difference in cost from a culvert that would have been installed for other needs is subtracted from the cost of a larger culvert that is built to accommodate wildlife. Costs of fences, escape ramps, and wildlife guards or double

cattle guards also need to be brought into the cost estimates. In addition, annual cost for maintenance of the structure or fencing needs to be incorporated into the final cost over the lifetime of the structure. See below for obtaining costs of recently completed mitigation for guidance.

### *7. Input Values into a Benefit-Cost Equation*

Place benefit values in the numerator, and costs in the denominator. Find the quotient. The resulting quotient is reflective of the predicted cost-effectiveness. If the ratio value is one or greater, the project is predicted to pay for itself. If less than one, the project is predicted to not pay for itself in prevented crashes based on the past five years of crash data, and over the life span predicted. This value does not predict future crash numbers or increasing costs of crashes.

Benefit/Cost Ratio =

$$\frac{\text{Annual Benefits in Reduced WVC} \times \% \text{ WVC Reduction} \times \text{No. Years Mitigation Lasts}}{\text{Estimated Project Cost} + \text{Maintenance}}$$

### *8. Determine How Long It Would Take for Project to Pay for Itself*

The project can also be analyzed by the expected amount of time it would take to pay for itself. The value of reduced WVC averaged each year is divided into the expected cost to see how many years of savings would add up to the total cost.

Reported crashes are a fraction of the actual number of collisions with animals. When the crash number is multiplied by correction factors from Utah (Olson 2013) and Virginia (Donaldson 2017) that were derived from the number of carcasses collected in these areas related to reported crashes, the number of large animals killed is from 5.3 to 8.5 more than reported crashes. These numbers do not account for smaller mammals, birds, or reptiles killed by vehicles. Thus, because of this underestimation, the crash data analysis is just the first step in analyzing the potential wildlife-vehicle conflict.

The type of vehicles, passenger vehicles versus tractor trailers that make up the traffic volume can influence how accurate the crash data are. The more tractor trailers (semi-trucks), the less accurate the crash data, as these motorists do not typically report collisions with animals. This makes trucking routes' traffic volume influence crashes reported with wildlife, potentially skewing the crash data to less than would be reported by State or Provincial Public Safety crash reporting systems because there are no accidents to respond to, and in turn no reports. However, in areas where DOT maintenance staff are diligent about collecting carcass data, there are potentially higher levels of reported carcasses.

### *Carcass Data Collection, Mapping and Analysis*

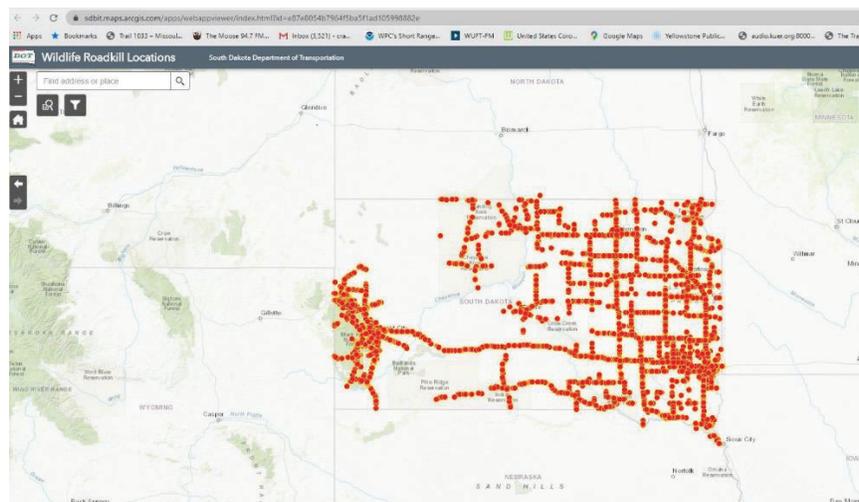
Carcass data are much more numerous than crash data and typically reveal more than crash data do about the animals killed, such as their species, gender, age, and numbers

killed at a location. However, carcass data are not consistently collected in space and time in almost all locations in the U.S. and Canada. Typically, agency maintenance personnel or outside contractors collect the carcasses that pose additional risk to motorists (in the road or on the shoulder) and are required to report that carcass data. These personnel are most recently using phone and computer applications to record the carcass data. Carcasses are ubiquitous enough that transportation, wildlife, and law enforcement personnel can report their locations. Citizens are also becoming more involved in carcass data reporting, on both phone and computer systems, however precautions and liability must be considered and understood by citizens and transportation agencies before promoting this type of data collection. In states and provinces where there is a fully functioning computer system for inputs and immediate mapping of carcass data, users can map the carcass data to learn of the hotspot locations, species most often killed along specific road stretches, and other important facts and trends. Several examples of these approaches are provided below.

Idaho Game and Fish has an open wildlife carcass reporting system that is based on computer entries. The state allows for salvaging carcasses as long as the person files a Roadkill/Wildlife Salvage Report: <https://idfg.idaho.gov/species/roadkill/add>. This website allows for queries and mapping of the carcass data.

The University of California at Davis, Road Ecology Center has a public website for reporting and mapping carcasses: <https://roadecology.ucdavis.edu/hotspots/map>.

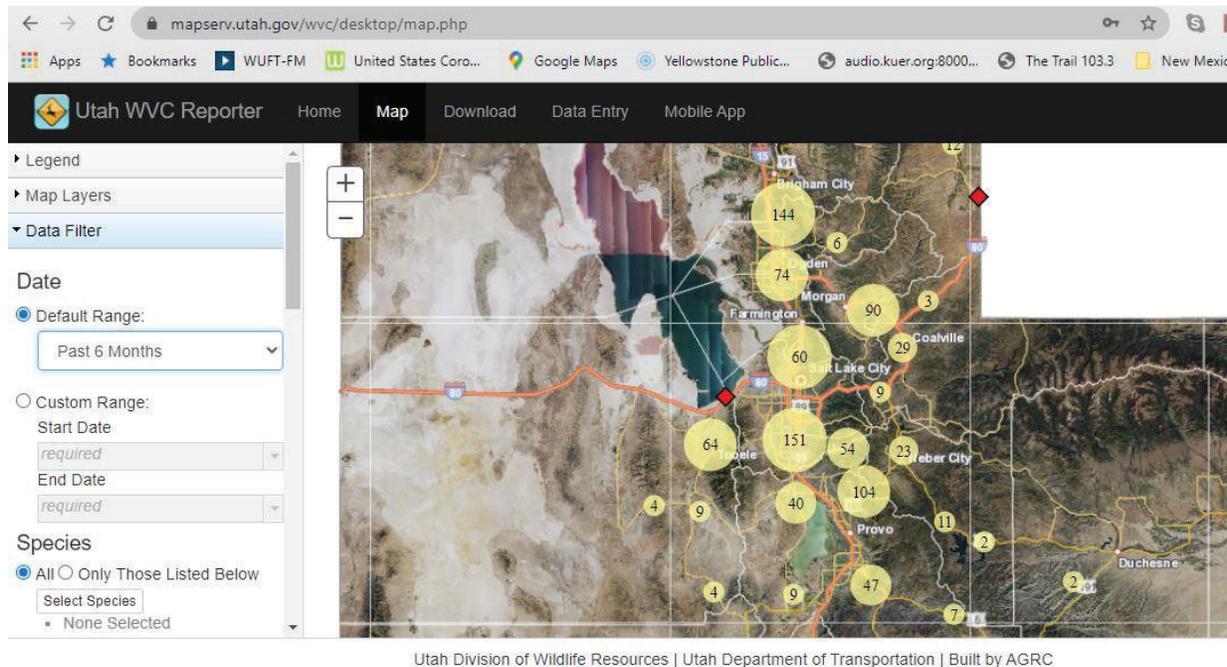
South Dakota was able to quickly create a simple carcass collection system with Survey 123 for ArcGIS. Their carcass collection contractors now use it daily (Figure 57). (<https://sdbit.maps.arcgis.com/apps/webappviewer/index.html?id=e87e8054b7964f5ba5f1ad105998882e>).



**FIGURE 57. SOUTH DAKOTA WILDLIFE CARCASS COLLECTION MAP, JUNE 2019 – JULY 2020.**

Utah created a smartphone app that is user restricted to the Utah DOT carcass contractors and agency personnel (Olson et al. 2014). The app allows mapping of the carcasses in real time and aggregates the carcass numbers at various scales to allow viewers to see the top hotspots at any scale:

<https://mapserv.utah.gov/wvc/desktop/index.php>. See Figure 58, below.

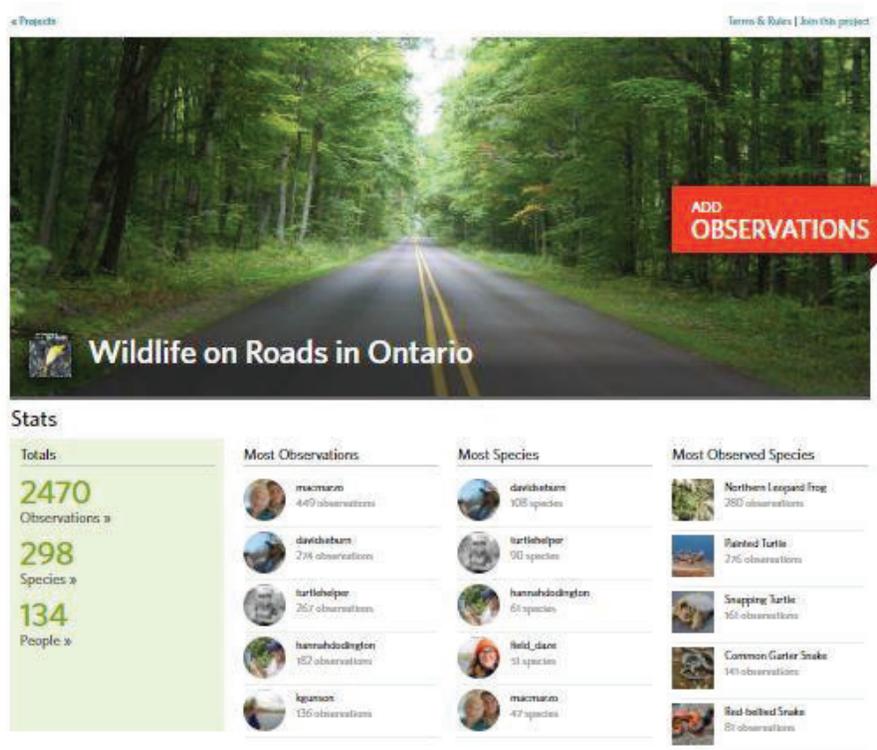


**FIGURE 58. UTAH MAP OF CARCASSES COLLECTED IN THE SALT LAKE CITY AREA FROM DECEMBER 5, 2019-JUNE 5, 2020.**

Smaller animals such as turtles, salamanders, tortoises and small mammals are typically treated differently when their carcasses are found or searched for along roads. The above carcass collection applications and websites do allow for reporting of animals as small as can be identified, and the databases include frogs, turtles, and small mammals to mention a few. However, contractors hired by transportation agencies to collect carcass data are not typically paid to report animals smaller than a dog or fox. It is the work of scientists and citizens concerned about these smaller animals that typically creates the carcass databases to identify areas of smaller animal-vehicle conflict.

For example, Ontario Canada has eight species of turtle and all are listed as Species at Risk federally, and road mortality is listed as a threat for six of these (Gunson and Schueler 2019). There is a Wildlife on Roads INaturalist project conducted, where citizen scientists submit their small animal live and dead on the road data to an online site: (<https://inaturalist.ca/projects/wildlife-on-roads-in-ontario>). In the first year there were over 2,000 observations recorded (Figure 59).

For guidelines for survey efforts to collect carcass data for reptiles and amphibians see Langen et al (2007), Ontario Ministry of Natural Resources and Forestry (2016), and Gunson and Schueler (2019).



**FIGURE 59. ONTARIO'S iNATURALIST WEBSITE TO REPORT LIVE AND DEAD AMPHIBIANS AND REPTILES ALONG ROADS. [HTTPS://INATURALIST.CA/PROJECTS/WILDLIFE-ON-ROADS-IN-ONTARIO](https://inaturalist.ca/projects/wildlife-on-roads-in-ontario)**

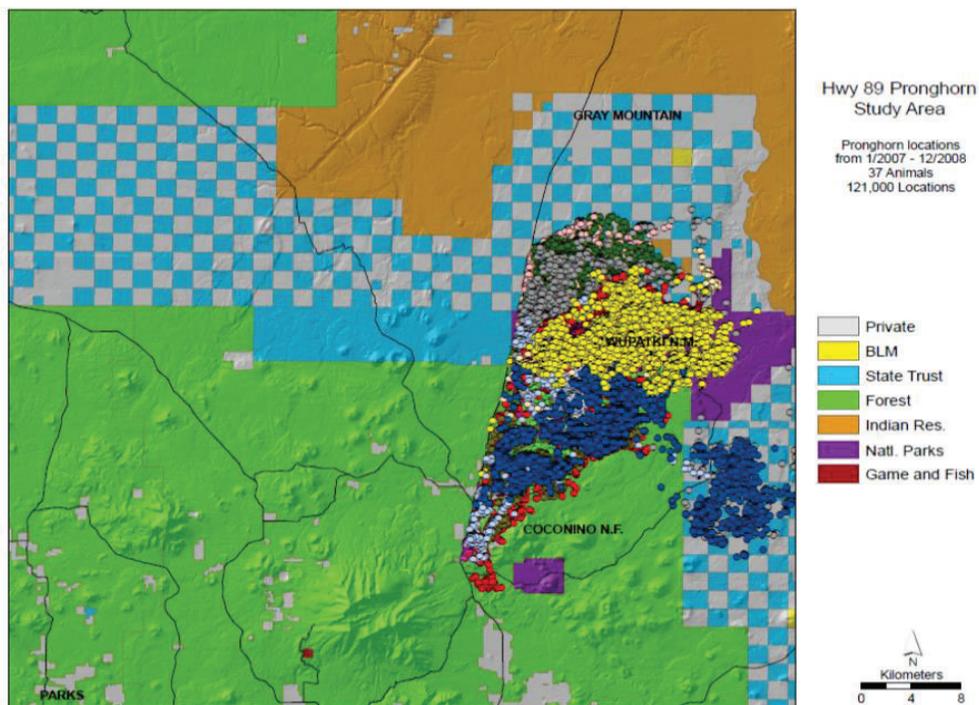
If transportation agencies desire additional information on the scope and magnitude of wildlife vehicle collisions beyond crash data, carcass data are the best source of learning of species, and places where animals are getting killed but are not showing up in crash reports. This is especially important for smaller animals. However, carcass data are not collected uniformly across most jurisdictions, as are the crash data. Thus, the data can be informative of number of types of species involved in crashes, but not truly representative of total numbers of animals killed across a state, province, or other jurisdiction. These data can also be collected with reference to the nearest mile post rather than being more spatially accurate. Therefore, numbers of carcasses should NOT be used to prioritize one area over another, rather they should be used to inform specific mitigation within an area already defined hotspot. In Washington, WSDOT works diligently to collect accurate carcass data with hand held computer devices, and it has helped to identify problem areas for wildlife and guide mitigation efforts (G. Kalisz, WSDOT, personal communication, 2020).

When making comparisons across large jurisdictions, carcass data can be used if it is explicitly understood some areas will have more regular reporting than others, and the prioritizing is used to demonstrate these inequalities. It is also important in helping a state prioritize wildlife mitigation. Carcass data identify the species involved and seasonal trends.

When analyzing a road segment or corridor, the carcass data collected by the same personnel can be compared among one-mile road segments to find areas in need of mitigation. This information then can inform what the best mitigation options are in the short and long term.

### Traffic Volume Data

Traffic volumes are important indicators of the ability of various species of animals to get across a road. Transportation agencies publish estimated average annual daily traffic volumes (AADT) for roads they administer. Traffic can cause a barrier effect and thus looking at crash and carcass data in higher traffic volume areas does not address the problem of vehicles for the animal populations that do not even attempt to cross a road or highway. For example, pronghorn in northern Arizona are nearly completely fragmented by fenced right-of-ways with high traffic (Figure 60) to the point where genetic consequences were notable (Theimer et al. 2012).

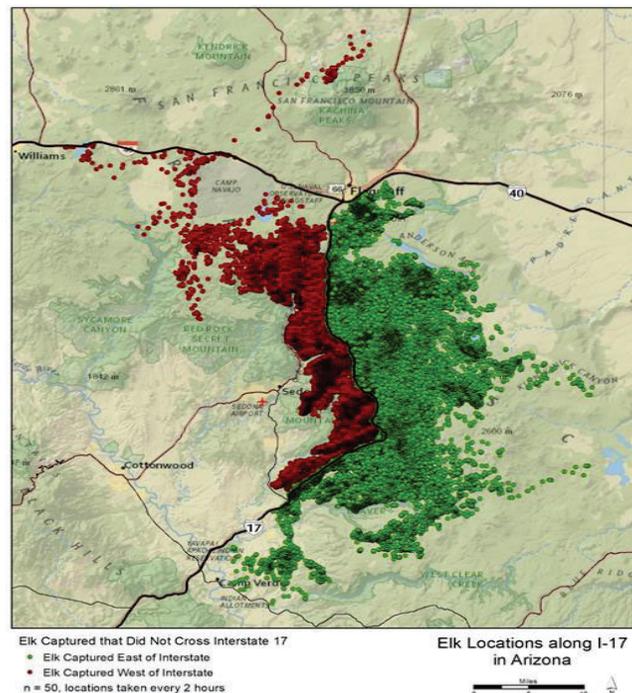


**FIGURE 60. FRAGMENTATION OF GPS COLLARED PRONGHORN ALONG US 89 (AADT 8,000) IN NORTHERN ARIZONA. FIGURE CREDIT: ARIZONA GAME AND FISH DEPARTMENT.**

Traffic also creates greater habitat fragmentation than roads alone, thus higher volume roads are most problematic for wildlife. Ecologists working with engineers and planners can consider a species' risk-avoidance response to traffic. Risk avoidance is an animal's instinct about how to react to a threat. It can freeze, move in a zig zag pattern, turn and confront the source of risk, run quickly in front of the risk, etc. These behaviors affect how the species will fare in the face of vehicles and traffic volumes of a specific road. These behaviors help to make appropriate decisions on mitigating the road and traffic for wildlife movement (Jacobson et al. 2016).

For example, in Oregon Coe et al. (2015) found that deer-vehicle collisions increased with AADT, but peaked at 8,000 vehicles per day. Once the AADT went over that threshold, mule deer-crash records decreased, due in large part to fewer deer attempting to cross the highway. This was true of those higher traffic volume locations, as well as in the historic mule deer migration pathways.

Movements of even larger animals such as elk can be greatly hindered by high traffic volumes. Although collisions with elk along I-17 in northern Arizona are quite common, a less notable consequence of the road are the numbers of elk that can't get across this highway. Gagnon et al. (2013) documented that nearly 50 percent of collared elk did not cross I-17 even though most elk approached it (Figure 61).



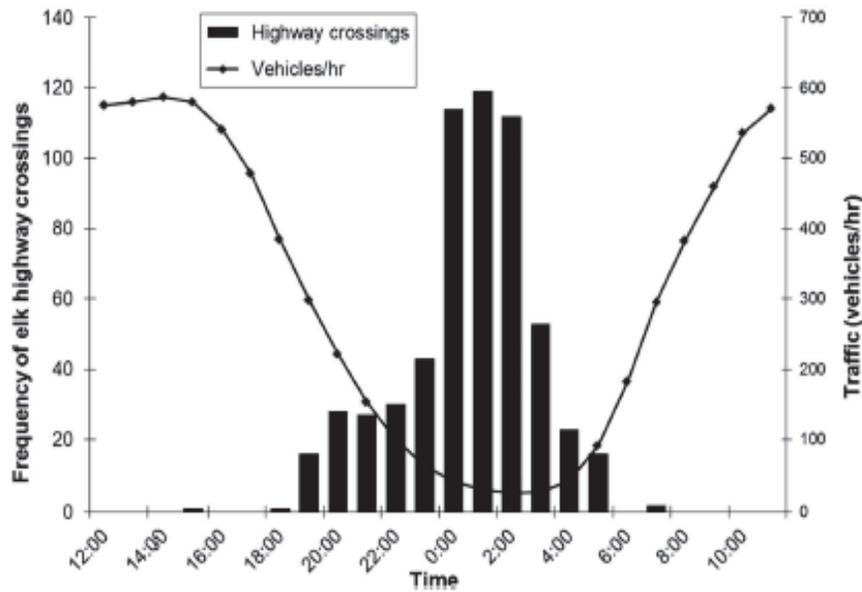
**FIGURE 61. FRAGMENTATION OF ELK POPULATIONS IDENTIFIED THROUGH GPS COLLAR DATA ALONG INTERSTATE 17 IN ARIZONA. FIGURE CREDIT: ARIZONA GAME AND FISH DEPARTMENT.**

Charry and Jones (2009) conducted an exhaustive meta-analysis of studies that documented traffic volume effects on wildlife. They found traffic volumes of 10,000 vehicles per day formed an almost complete barrier to all terrestrial wildlife. As AADT values decrease, there is still some permeability for animals to cross the roads during low traffic times, mainly at night (Gagnon et al. 2007, Dodd and Gagnon 2011). Smaller animals are still highly challenged by these traffic levels. If the smaller animals are reptiles or amphibians, night movement is not typically an option, since cold-blooded species do not always move at night. When species are small such as desert tortoises, and move only during daytime hours, as much as 10 vehicles per day can prove too risky for successful crossing (Jacobson et al. 2016). Traffic volume matters to all wildlife, even to flying invertebrates, and should be a data source included in the analyses of the need for wildlife mitigation and should be evaluated and based on target species' specific behaviors and needs.

Another important traffic volume set of data is the predicted future traffic volumes of an area under consideration. If the future traffic volumes are predicted to preclude wildlife from moving over the road safely, then these have to be accounted for in planning for wildlife in a transportation project and in long range transportation plans.

Traffic volume is not the only component of the traffic important to wildlife. Traffic characteristics are important to evaluating wildlife species' abilities to cross roads, and the accuracy of crash data. The time of day and pulses of traffic make a difference for wild animals trying to cross the road at similar times. For instance, if higher traffic volumes occur through areas with wildlife during the morning and evening "rush hours," and those wildlife species affected are also attempting to cross the road during similar times, there will be a greater barrier from the traffic than if the two did not occur at the same time. If traffic patterns are seasonal, and higher volumes occur when species of animal are approaching the road, or trying to cross it, there may be greater traffic barrier effects, than in other seasons. However, knowing the timing of the higher traffic volumes daily and seasonally helps to prescribe wildlife mitigation approaches.

Lower traffic volume rural roads in areas with species that exhibit crepuscular or nocturnal movements across roads may provide opportunities for alternative mitigation options, such as animal detection systems (Figure 62, Gagnon et al. 2015), versus roads where wildlife movements and traffic flows simultaneously peak (e.g. pronghorn along highways). In these latter instances wildlife crossing structures and fencing are the best option.



**FIGURE 62. SHIFT OF ELK MOVEMENT OVER HIGHWAY (HIGHWAY CROSSINGS) IN RESPONSE TO TRAFFIC FLOWS ALONG SR 260 IN ARIZONA. TAKEN FROM GAGNON ET AL. 2015.**

### Culvert and Bridge Inventory Listings and Maintenance Schedule

Databases of existing culverts and bridges are resources to use for examining the potential for retrofits of infrastructure for wildlife. Having that information on hand when looking at problem areas for wildlife-vehicle conflict will help evaluate lower cost potential solutions rather than a need for new structures. See Kintsch and Cramer (2011) for a standardized method for evaluating these existing structures for retrofitting for different taxa of wildlife.

These sites can also be ranked for suitability and prioritization as initiated by Arizona DOT (ADOT) in a proposal for future actions (Norris Dodd, personal communication). ADOT’s system ranks existing structures for suitable passage, from a high score for bridges and culverts where species passage is already present and documented and appears to be suitable for target species, to a low rating when the structures are greater than three miles apart and are not open enough for species’ passage. This allows the planners/biologists to see how the existing structures could be minimally retrofitted, cost effectively incorporated into larger planning efforts, and where an entirely new structures are needed to promote wildlife connectivity for the target species.

Knowledge of the existing culverts and bridges that could potentially be used by wildlife is also important in working with maintenance crews in keeping these areas cleared of debris and human encampments. Human encampments are something for law enforcement to eliminate and problems in these areas should be referred.

Many states and provinces, New Mexico for example, have placed wildlife exclusion fence (eight feet, 2.4 meters high) to existing bridges and culverts to funnel ungulates and other wildlife to use these structures to pass beneath highways in the state. Similarly, Arizona linked existing bridges with eight feet (2.4 meters) high fence and reduced collisions with elk by 97 percent while increasing elk and use of the bridges by as much as 217 percent (Gagnon et al. 2015). There are many opportunities with existing culverts and bridges for facilitating wildlife, and knowing where they are and their potential in planning, and in daily maintenance operations both help to facilitate wildlife connectivity and reduce wildlife-vehicle collisions.

Aging bridges and culverts also pose opportunities for including consideration of wildlife when the infrastructure is scheduled to be replaced. There are two suggestions from Parks Canada (T. Kinley, personal communication, 2021) that could improve wildlife connectivity for little added costs. The first idea is to take advantage of larger bridges and culverts being built in response to climate change. Longer bridges or larger culvert designed for future large flood events provide more room to accommodate terrestrial pathways for wildlife adjacent to the bridge abutments or walkway on the culvert walls. Even if these are damaged by more extreme hydrologic changes in the future, they are relatively inexpensive to replace. The second planning option is to ask for the original culvert to stay in place, and the replacement to be built “in the dry” adjacent to it. The new culvert could be the designated culvert for water flow, and the older culvert could then facilitate terrestrial wildlife movement. The remaining older culvert could also provide additional hydrological capacity for those larger 100 and 200-year floods.

### Transportation Planning Documents – Early and Often

*“Road Projects are like trains – slow to get rolling, averse to getting off track, and hard to slow down.”*

Tonjes et al. 2015

State and provincial long-range plans, state transportation improvement plans (STIP), Improvement Plans, transportation project plans, and MPO transportation plans, are all important to evaluating where future projects could impact and potentially mitigate for wildlife. The upcoming projects may not be in the direct area where specific wildlife-vehicle conflict has been identified, but if there is a project within several miles of the WVC high priority area, the information from these planning processes could inform the future project.

It is essential that transportation agency environmental staff review these long range, STIP, and later the design plans and provide input in the updates. Some U.S. state wildlife agencies provide input on the long-range plans and STIP as to where they think wildlife will be affected and should be mitigated for conflict. These documents are critical

to proactive measures to plan for wildlife and if not included at this stage reduce the potential for mitigation once funding is identified.

These planning documents are a place to start finding common ground in placing wildlife infrastructure in already planned projects. In fact, this long-range planning approach is how the majority of wildlife crossing structures have been created. For example, State Road 260 in Arizona, (Dodd et al. 2007), Interstate 75 in Florida (Foster and Humphrey 1995), and the US 93 projects in Montana and in Arizona (see Montana and Arizona case studies in Chapter 3 of the master document). The planning documents can also be used to inform any efforts to prioritize areas for wildlife mitigation with a prioritization score card for areas where wildlife mitigation is most needed and most likely to be feasible in conjunction with future projects. This information was included in a forthcoming ADOT project to be completed in 2021.

Once locations of projects are identified in the long-range planning efforts, early stage planning efforts can begin. These planning efforts include documents like scoping, environmental evaluations, and associated documents, such as Environmental Assessments (EA) or Environmental Impact Statements (EIS), and Design Concept Reports (DCR) or equivalent. Involvement by wildlife biologists throughout these processes can help ensure wildlife mitigation is included where appropriate. It is important to include wildlife collision reduction and connectivity in environmental assessments. For Parks Canada the key was to ensure that these things were identified as “valued components” of an environmental assessment for highway upgrades. Once they are, the mitigations (fencing, crossing structures, etc.) tend to follow fairly directly from the predicted impacts (T. Kinley, Parks Canada, personal communication 2020). Once these planning effort opportunities have passed it becomes extremely difficult to include options for wildlife because they can add significantly to the cost of an already approved budget.

Most transportation agencies have designated planning departments and planning documents compiled in a central location. They are updated yearly and can be completed in various increments including 10 year or 5 year plans.

An example of these design and planning documents for I-40 in northern Arizona can be found at: <https://origin.azdot.gov/planning/transportation-studies/i-40-from-bellefont-to-winona-study/documents>.

### Costs of Recently Completed Wildlife Mitigation Infrastructure

Most potential wildlife mitigation projects need to be evaluated with respect to the cost. If transportation agency staff can have the costs of the structures, fences, escape ramps, wildlife deterrents, driver warning systems, variable message board signs, and other measures readily available and kept up to date, the case for creating additional measures could be quickly and efficiently made. It is important that these past projects

be referenced as to where they occurred, and the year they were installed, also if they were standalone projects or incorporated into a new or reconstruction project, and the breakdown of costs for wildlife mitigation items included in those projects.

Unfortunately, this is not as easy as it sounds for many DOT's. For example, in Nevada most of their projects are bid as a lump sum. Therefore, the contractor provides a single cost for the entire project and there is no breakdown of individual components such as that towards fencing of an overpass. Additionally, if the mitigation measures are included into a larger construction project, many of the costs are absorbed into other actions such as the mobilization of the project, but if it is a stand-a-lone project, the mitigation absorbs those costs. With a lump-sum system it is hard to define exact costs associated with individual pieces of mitigation and the estimated prices can vary wildly.

### Funding Sources

Cost is the number one reason transportation agencies do not construct more wildlife crossing structure mitigation (see Chapter 2 Survey Results). Preparing a case for wildlife consideration in transportation processes will have to include potential funding sources. Having that data/information will be valuable in how to build partnerships and present the information. Table 11 below lists potential sources of funding for wildlife mitigation.

**TABLE 11. POTENTIAL FUNDING SOURCES FOR WILDLIFE MITIGATION IN THE U.S.  
ADAPTED FROM CRAMER AND MCGINTY 2018.**

<b>Funding Source - Partner</b>	<b>Comments</b>
Local Governments	Counties and cities can conduct surveys, build cattle guards, and raise funds for wildlife mitigation. See Colorado Case Study in Chapter 3, and Kintsch et al. 2019.
State and Provincial Wildlife Agencies	These agencies can tap into state, provincial, and federal funding sources, such as Pittman-Robertson Funds in the U.S.
State/Provincial Traffic Safety Funds	This has traditionally been the main source of funding wildlife crossing structures for larger animals that cause more severe crashes with human safety concerns.
Federal Highway Safety Improvement Program	In the U.S. this is the HSIP fund that is available for projects that achieve significant reduction in traffic fatalities and serious injuries. However, the significance of wildlife-vehicle reported crashes may not be enough to tap into these funds.
Federal Tribal Transportation Program	In the U.S. TTP is the largest program within the Office of Federal Lands Highways and is to address the need of Tribal Governments for safe transportation.
Federal Nationally Significant Federal Lands and Tribal Projects	NSFLTP was established with the 2015 Transportation Act provides funding for construction and rehabilitation of nationally significant projects on federal and tribal lands.
Federal Lands Transportation Program for Federal Lands	FLTP funds projects that improve access to federal lands. Within each transportation act, each federal land agency is allocated a set amount for the coming five years. These funds can be accessed for projects on the specific agency's lands.
Federal Lands Access Program	FLAP or Access Program provides for projects on areas that are facilities that are located adjacent or in federal lands. FLAP calls out wildlife passage as a standalone category for funding.
Federal Transportation Alternatives Program	TAP was eliminated with the 2015 Transportation Act (FAST Act). It was replaced with set aside Surface Transportation Block Grants Program for transportation alternatives.
Federal Transportation Investment Generating Economic Recovery	TIGER funds for transportation projects are highly competitive and have not typically been used to fund wildlife mitigation projects, but they are not excluded from potential funding.

<b>Funding Source - Partner</b>	<b>Comments</b>
Non-Profit Organizations	Conservation organizations and sports people groups have helped dedicate funds to wildlife mitigation projects and will continue to do so in areas they deem important to their constituents.
Citizens Organizations and Private Funding	In multiple cases, private citizens have created non-profit organizations and raised tens of thousands to hundreds of thousands of dollars for wildlife mitigation.
Taxation	Citizens have voted to tax themselves for wildlife connectivity and the money has been used to create wildlife crossing structures. See the Pima County Case Study in Chapter 3 of the master document (Hyperlink)
License Plates	Since 2017 the Wyoming wildlife crossing license plate has raised over \$300,000 as of early 2021 dedicated to the construction of wildlife crossing structures and other mitigation options. See URL: <a href="http://wildlifecrossingswork.com/">http://wildlifecrossingswork.com/</a>

We present the following case study on the Utah-Arizona border to demonstrate a successful partnership using multiple funding sources.

### *Case Study: US Highway 89 Kanab and the Paunsaugunt Mule Deer Herd*

In 2013 the Utah Department of Transportation (UDOT) and Utah Division of Wildlife Resources (UDWR) worked together with multiple partners to create the US 89 Kanab-Paunsaugunt Project. The goal of the project was to direct a portion the Paunsaugunt mule deer herd through the three new wildlife crossing culverts and four existing structures to help reduce the mule deer-vehicle collisions as the animals migrated to and from the area near Bryce Canyon National Park on the Paunsaugunt Plateau in the summer and the Kaibab Plateau in Arizona in the winter. The project stretches for 12 miles in the Grand Staircase Escalante National Monument.

Partnering with UDWR and non-profits helped UDOT personnel to convince the Transportation Commission to allocate \$625,000 toward the project. Kane County, where the project is located, committed in-kind contributions by installing all the double cattle guards along the fence. The Bureau of Land Management (BLM), the managers of the Grand Staircase-Escalante National Monument, obtained a Federal Highway Administration Public Lands grant for approximately \$1.5 million. The Mule Deer Foundation donated \$100,000 in funds generated from the auction of mule deer hunting tags to help pay for the project fence. The Sportsmen for Fish and Wildlife organization had members volunteer to walk the fence line to look for holes in the fence, and donated signs on all gates stating users should close the gates for wildlife. The Arizona Game and Fish Department (AGFD) donated \$140,000 to the project; \$100,000 from the special hunting tag funds through the AGFD Habitat Partnership Committee, and \$40,000 in Big Game Donation funds. AGFD also assisted with camera setup and data recovery efforts, as part of the 5-year monitoring study (Figure 63, Cramer and Hamlin 2019). The partnership was so successful that UDOT and UDWR use this approach for the future wildlife mitigation projects across the state. UDWR habitat managers across the state are also finding ways to bring funds and volunteers to transportation project to fund fences, improve escape ramps, and adaptively manage existing infrastructure, which assist maintenance staff.



**FIGURE 63. MULE DEER WAIT TO MOVE THROUGH WILDLIFE CROSSING CULVERT UNDER US 89 EAST OF KANAB, UTAH. PHOTO CREDIT: P. CRAMER, UDOT, UDWR.**

## Ecological Data

### Introduction

Data and maps on wildlife locations, natural areas, water bodies, and other ecological information are critical for planning transportation projects. Ecological planning is vital at the earliest stage possible to inform the design and to determine how the cost and safety considerations are best managed to incorporate essential ecological needs (van der Ree et al. 2015). Incorporating ecological information early in the planning process helps to decrease the length of time it takes to accommodate wildlife in transportation projects, and reduce costs by accounting for wildlife as part of the way of doing business, and not as an add on late-in-the-game. Collecting these data also helps to build the case for needing to accommodate wildlife movement.

Traditional transportation agency approaches to wildlife have been to meet state and federal legal requirements. A broader approach is needed to consider wildlife needs to move while keeping roads safe for motorists. It involves looking at a range of species movement needs and the changes in the landscape that come from ecological processes such as fire, drought, and climate change. Planning for resilience is a goal that can in turn help determine many aspects of environmental planning.

### Wildlife Habitat Maps

The locations of where wildlife populations need to access areas on both sides of roads are identified not only through the crash and carcass records of unsuccessful wildlife movements, but also through what we know of the species, populations, and individual animals. There are animals that make it across roads alive, wildlife species that do not come near the road or attempt to cross, and animals that are too small to be accounted for in crash or carcass reports. It is critical to know if all these species are present in the lands and waterways near roads and need to be accommodated in transportation processes, not only planning for future projects.

Species habitat maps are typically compiled by wildlife agencies and consulted by transportation agency personnel. The usual species habitat examined is that of larger animals that cause crashes, such as deer, moose, and elk. Their habitat is typically mapped in large polygons representing seasonal ranges and the areas they need to migrate through to access those ranges. These data are typically very coarse and only general approximations. However, they can still be helpful at a coarse scale analysis.

There are also traffic and road conflicts with smaller animals such as reptiles and amphibians. While these species' populations are worthy of saving from vehicle collisions and habitat fragmentation, it is often the protected and listed species of reptiles, amphibians, small mammals, and invertebrates that warrant a habitat needs

analysis in transportation departments. The maps of the occupied habitat for these species are based largely on field location data, discussed below.

All these habitat maps would need to be gathered in consultation with state/provincial, local, non-profit, tribal, and military wildlife professionals in the areas under consideration. An early start on this process could begin with reviewing the State Wildlife Action Plan, or Provincial Wildlife Action Plan (see below).

### Wildlife Linkages and Corridor Maps

A common feature in the processes to locate optimal locations for wildlife crossing structures to promote wildlife connectivity is the inclusion of maps portraying wildlife linkages. Many states/provinces have created these maps through one or a combination of several processes. These maps can help prioritize locations for roadway mitigation for wildlife. There are several standard and additional evolving methods to create wildlife linkage maps.

1. In the rapid assessment process, workshops of agency personnel and other concerned individuals were conducted to use expert opinions to help determine where sections of road were perceived to be a problem for different wildlife species' movements.
2. Modeling wildlife habitat and probabilities of the target species to get through the landscape is typically done with software for wildlife corridors and linkages. See Appendix C for software available for these analyses.
3. Migration maps are being generated in large part due to the advent of more affordable GPS collars and in the western U.S., federal funding to collar hundreds of ungulates. Connectivity models can be both created and validated with the locations of GPS collared animals.

Western U.S. states' efforts to map connectivity for migration pathways of ungulates are coordinated through the U.S. Department of Interior Secretarial Order 3362, which both mandates and provides funds to help identify and protect large ungulate migratory corridors (See State Wildlife Action Plan below). This western states effort to map ungulate core habitat and migration pathways are following Wyoming's Dr. M. Kauffman's and Dr. H. Sawyer's initiative to model wildlife connectivity using Brownian Bridge modeling. The migration pathways can be viewed by the public on several state websites. The US Geological Survey central location to view progress is available at: [https://www.usgs.gov/news/new-maps-document-big-game-migrations-across-western-united-states?qt-news\\_science\\_products=1#qt-news\\_science\\_products](https://www.usgs.gov/news/new-maps-document-big-game-migrations-across-western-united-states?qt-news_science_products=1#qt-news_science_products). The 2020 publication, "Ungulate Migrations of the Western United States, Volume 1" (Kauffman et al. 2020) includes a published report, book and data archives of selected wildlife migration paths in Wyoming, Utah, Nevada, Arizona, and Idaho.

4. Linkages for smaller animals are typically mapped using habitat suitability models, road-kill carcass data, and the GPS locations of animals fitted with GPS locating devices. Some models use data on reptile and amphibian locations, others incorporate this and habitat preferences to predict where reptiles and amphibians are predicted to cross roads. Hotspot analysis of where these small animals are found as carcasses can be used to model where there are high numbers of animals and at specific locations (Andrews et al. 2015).

### Wildlife Locational Data

Telemetry data on collared wildlife and survey data on wildlife locations are important data points to evaluate where wildlife need to cross roads. These data can be sensitive information that need to be presented to the public in a manner that does not reveal locations where wildlife may be harassed or hunted by people who may use the data to pinpoint important locations for wild animals, and therefore should be handled with care. Locational data are collected from the state/provincial wildlife agency, universities with wildlife research programs, military bases wildlife research programs, county and regional agencies, Tribal wildlife programs, and non-profit organizations. Locational data can be used in point form – as GIS shape files of specific locations, they can be modeled to present home range polygons to demonstrate where wildlife are known to reside, and these points and polygons can be clipped to be represented in maps to only reveal where wildlife are within a certain distance from the road, as was done in Nevada with collared wildlife locations (Cramer and McGinty 2018).

NatureServe is a go to resource on line (<https://explorer.natureserve.org/>) for information on rare and endangered species and ecosystems in the U.S. and Canada. Their online guide provides information on over 100,000 species and ecosystems. The NatureServe Network is a hub for the Natural Heritage Program in all U.S. states (<https://www.natureserve.org/natureserve-network>). Contacting a state Natural Heritage Program Office directly as member of a state or federal agency can reveal records not available to the public, which are kept more general for the public resources for the protection of the rare species (<https://www.ncnhp.org/contact>).

NatureServe also produced a guide to estimate species' vulnerability and responses to climate change with a climate change vulnerability index (see Young et al. 2016). This guide is to a Microsoft Excel workbook that helps identify key factors to a specie's vulnerability to climate change. It is important to predict future scenarios of how the world will change climate wise, and human population and infrastructure build up wise as well.

The wildlife locational data are extremely helpful in assessing if there is a need to provide wildlife connectivity, and if so, where those wildlife crossing structures should be located based on present time conditions and predicted future changes. A recent

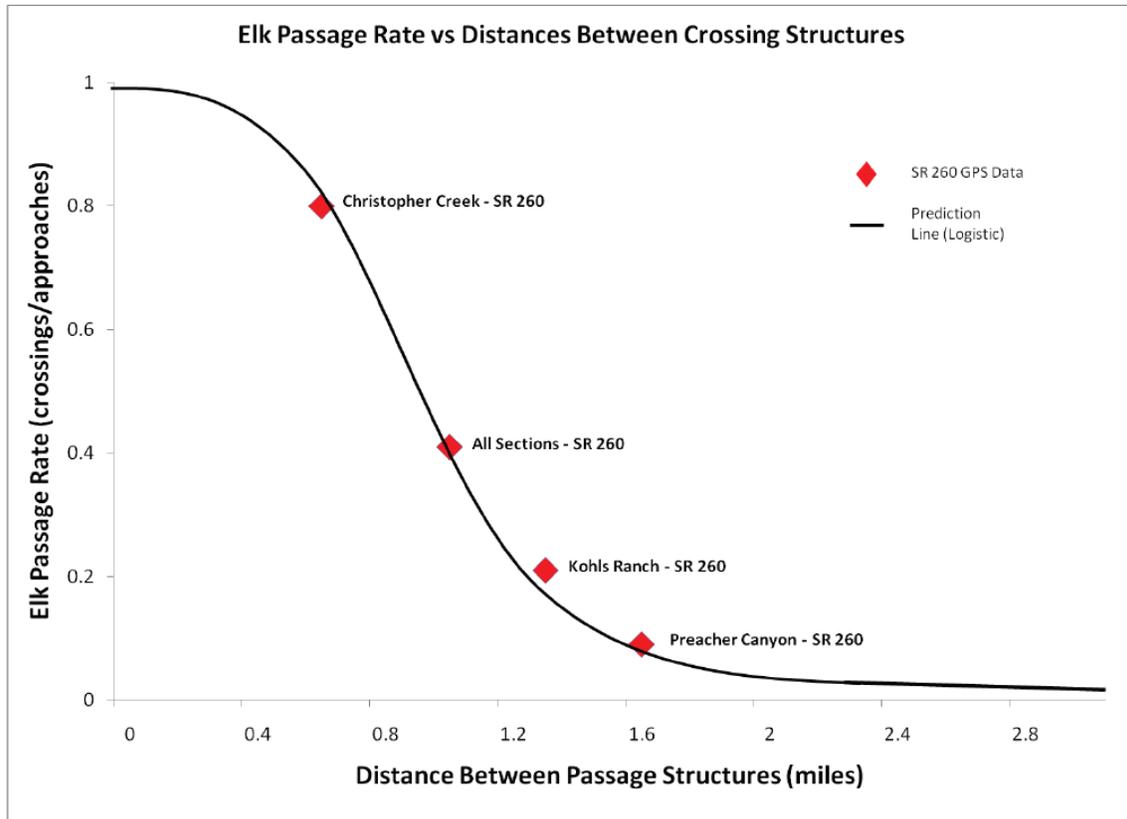
Washington study found GPS collared elk were crossing the road in areas where reported incidents were with collisions, thus supporting the assertion of where wildlife crossing structures were needed (Sevigny et al. 2021).

### Wildlife Movement Abilities and Needs

Locating where wildlife crossings should be placed, the spacing distance between them, and what species should be accommodated are very dependent on the target species' movement abilities and needs. Data on species' movement distances near the area of interest are important to determine placement of structures that wildlife can find in normal movements. Bissonette and Adair (2008) estimated the distances between structures for mammals should be based on the average daily movements of the species, animal size, and dispersal distances of the young adults when they leave their maternal home ranges. Daily home range distances for 71 percent of 72 mammal species in North America they examined are less than one mile. This means structures for most mammal species need to be spaced less than one mile apart. This statement represents the scientific data. However, practitioners in an agency world understand that this may not be possible with various cost and logistical constraints.

Data on how the animals of the species of interest in an area move and how far they typically move in their daily and dispersal movements should all come into play when locating where wildlife crossing structures are placed, and how many are needed to promote connectivity.

For example, the ability of elk to cross State Route 260 in Arizona was significantly decreased as distances between crossing structures increased (Figure 64, Dodd et al. 2012a).



**FIGURE 64. ABILITY OF ELK TO CROSS STATE ROUTE 260 (PASSAGE RATE) COMPARED TO DISTANCE BETWEEN WILDLIFE CROSSING STRUCTURES (DODD ET AL. 2012A).**

Wildlife locational data are also important in determining daily movements of the target species in the study area. Modeling movements of collared animals can help demonstrate the most important areas these animals need to cross the road.

Animal movement abilities are also important. Data on the target species' mode of locomotion, its anti-predator response, and ability to move the distances needed to get across roads and highways all play into how to create the most appropriate structures. Jacobson et al. (2016) proposed four categories of animals' behavioral responses on the perceived danger of traffic: Nonresponders- those that continue their movements without apparent reactions to approaching vehicles, Pausers- those that stop or freeze in response to approaching vehicles, Speeders- those that move faster with nearby vehicles approaching, and Avoiders- animals that stay away from vehicles on the roads all together. Animal type of movement, from those that are semi-aquatic animals and may need water bodies to move beneath roads, to butterflies and other aerial invertebrates that may need to be diverted up above the flow of traffic to fly safely across a highway all need to be considered when proposing the types and locations of mitigation.

## Pre-Construction Monitoring and Other Mitigation Monitoring Results

If wildlife species have been monitored in an area near proposed transportation projects, their movements near the areas of the road are instrumental in determining where the populations of animals need to cross the road. In Arizona, AGFD's monitoring of ungulate populations with GPS collars prior to road projects have been instrumental in locating and designing the best wildlife crossing structures and fences for elk (Dodd et al. 2012b) bighorn sheep (Gagnon et al. 2017), and pronghorn (Sprague et al. 2013).

In Montana, Cramer and Hamlin (2017) monitored the locations of future wildlife crossing structures along US 93 to help determine performance measures for the structures once they were completed (Cramer et al. 2017). Pre-construction monitoring is instrumental in both the long term planning of wildlife crossing structures, and in evaluating how well they work in comparison to pre-construction conditions. The Arizona case study below helps illustrates the importance of wildlife monitoring data.

## *Case Study: Pre-Construction Planning for Wildlife Crossing Locations in Arizona - Bringing It all Together*

As roadway projects reach planning phases, having data-driven recommendations help facilitate productive discussions on roadway mitigation options. AGFD and ADOT worked together for almost two decades to provide recommendations that could be incorporated into ADOT's planning processes (see section on Transportation Planning Documents). Advanced coordination is necessary to meet the timelines required by ADOT to allow for incorporation of wildlife features into planning documents,.

For several highway projects in Arizona, AGFD with funding from ADOT utilized GPS location and movement data to help identify locations for wildlife crossing structures which carried more weight than speculative assessments. This is especially important for animals that do not cross roads or are inhibited by excessively high traffic volumes as carcass data become less accurate or non-existent for some species and roads. This is especially true for pronghorn, which can stand at right-of-way fences and never move across the roads they need to traverse. AGFD then combined the GPS data with multiple other factors that are important to this decision making process. These other factors including crash and carcass data, when available, to identify focal areas for mitigation, land ownership and use to evaluate the potential for future development to negate mitigation efforts, juxtaposition of railroads, current land use, or current or future human activity that would minimize the effectiveness of mitigation, topography or terrain used to identify cut and fill slopes for structure type options such as underpasses or overpasses, location of existing structures that may be suitable for wildlife passages, wildlife ability for passage structure spacing, species specific design where necessary, and where available modelling efforts have occurred to help supplement priorities.

Examples of these projects can be found at the following links:

[https://apps.azdot.gov/files/ADOTLibrary/publications/project\\_reports/pdf/az647.pdf](https://apps.azdot.gov/files/ADOTLibrary/publications/project_reports/pdf/az647.pdf)

[https://apps.azdot.gov/files/ADOTLibrary/publications/project\\_reports/pdf/spr706.pdf](https://apps.azdot.gov/files/ADOTLibrary/publications/project_reports/pdf/spr706.pdf)

[https://apps.azdot.gov/files/ADOTLibrary/publications/project\\_reports/pdf/az626.pdf](https://apps.azdot.gov/files/ADOTLibrary/publications/project_reports/pdf/az626.pdf)

[https://apps.azdot.gov/files/ADOTLibrary/publications/project\\_reports/pdf/az619.pdf](https://apps.azdot.gov/files/ADOTLibrary/publications/project_reports/pdf/az619.pdf)

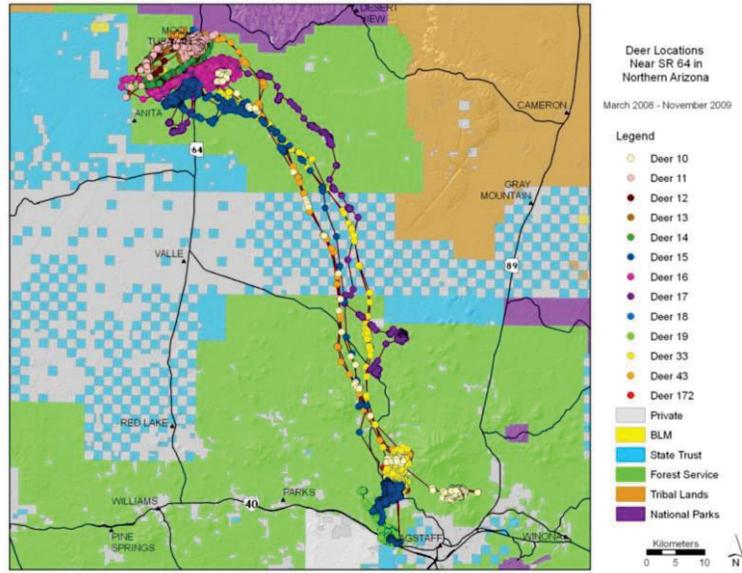
## State Route 64

Forty-two percent of all single-vehicle collisions with wildlife on State Route 64 led to the ADOT Research Center funding the Wildlife Accident Reduction Study. This occurred during the early planning stages to upgrade State Route 64 to facilitate the increasing number of visitors to Grand Canyon National Park. Data collected from this study can be used to inform recommendations on wildlife crossings if funded.

To gather data for this study, AGFD captured elk, pronghorn, and mule deer and fitted them with GPS collars that collected locations every 2 hours (Figures 65-67). These maps and data helped ADOT determine the best placement for future wildlife crossing structures.

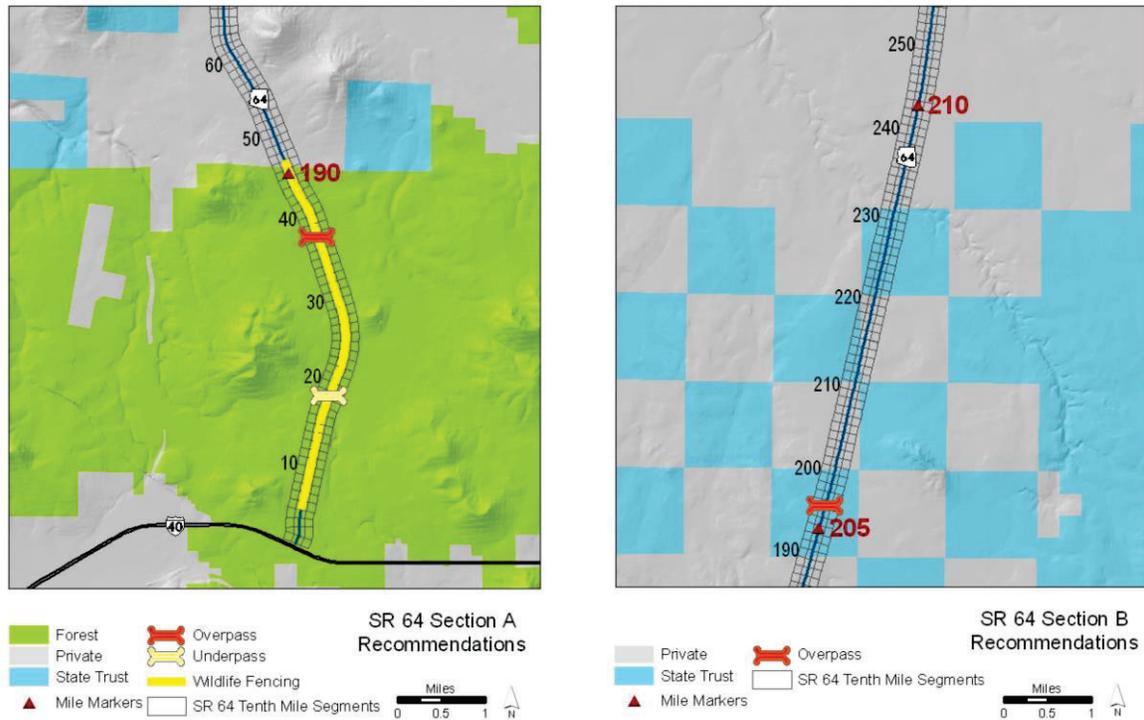


**FIGURE 65. RELEASE OF A GPS COLLARED PRONGHORN TO GATHER DATA ON WILDLIFE MOVEMENTS ALONG STATE ROUTE 64 IN ARIZONA. ELK AND MULE DEER WERE ALSO COLLARED FOR THIS STUDY. PHOTO CREDIT: ARIZONA GAME AND FISH DEPARTMENT.**



**FIGURE 66. GPS MOVEMENT DATA GATHERED ALONG STATE ROUTE 64 FOR FUTURE WILDLIFE MITIGATION OPTIONS. FIGURE CREDIT: ARIZONA GAME AND FISH DEPARTMENT.**

Data on GPS locations displayed in the previous figure helped AGFD and ADOT plan for the locations of where wildlife crossing structures would best benefit the collared animals' movements, below.



**FIGURE 67. EXAMPLE OF LOCATIONS OF POTENTIAL WILDLIFE CROSSING STRUCTURES BASED ON RANKINGS THAT INCLUDE GPS COMBINED WITH MULTIPLE CRITERIA.**

## State Wildlife Action Plan and Species Recovery Plan

U.S. State Wildlife Action Plans are blueprints for each state on the management goals for common and more rare species of wildlife, and their natural communities both terrestrial and aquatic, in the state into the next five years. These plans identify the species with the greatest conservation need and species the state would like to keep common. The plans are starting to focus on promoting actions that can be applied at a large scale, rather than on specific species. Any type of infrastructure project planning should cross reference these plans and their maps to help identify if species of some type of concern or if greater conservation actions are located in the project area that the state wildlife agency would want to see take place. All U.S. State Wildlife Action Plans can be accessed at: <https://www.fishwildlife.org/afwa-informs/state-wildlife-action-plans>.

*Note: The Washington State Wildlife Action Plan Link at the above site is not working, thus Washington's Plan is available at: <https://wdfw.wa.gov/species-habitats/at-risk/swap>*

Canadian species at risk can be identified with a review of species recovery plans at the Wildlife Preservation Canada Conservation Action Plan (<https://wildlifepreservation.ca/conservation-action-plan/>).

Provincial Action Plans can be searched at the Canadian Federal Government website: <https://species-registry.canada.ca/index-en.html#/documents?documentTypeld=11&sortBy=documentTypeSort&sortDirection=asc&pageSize=10>

A new type of Action Plan has evolved in recent years in Western U.S. states; the Interior Secretarial Order 3362 State Wildlife Action Plan. In 2018 the U.S Interior Secretary established [Secretarial Order 3362](#); Improving Habitat Quality in Western Big-Game Winter Range and Migration Corridors. This order directed all departments under the Department of Interior (Bureau of Land Management – BLM, US Fish and Wildlife Service – USFWS, and the National Park Service – NPS) to coordinate with state wildlife agencies in 11 western states to identify, enhance, and improve the quality of big game winter range and migration corridor habitat on Interior Department Lands. The order specified protecting these types of lands for Rocky Mountain elk, mule deer, and pronghorn, and a host of other species. Each of the 11 states has published an Action Plan with respect to this order, identifying three to five top migration corridors and two to three research priorities.

To view any of the 11 states' Action Plans, visit: URL: <https://www.nfwf.org/programs/rocky-mountain-rangelands/improving-habitat-quality-western-big-game-winter-range-and-migration-corridors/state-action-plans>

Each wildlife agency also tracks the locations of populations of threatened and endangered wildlife species. Consultation with wildlife agency personnel would be important to identifying potential locations of these protected species.

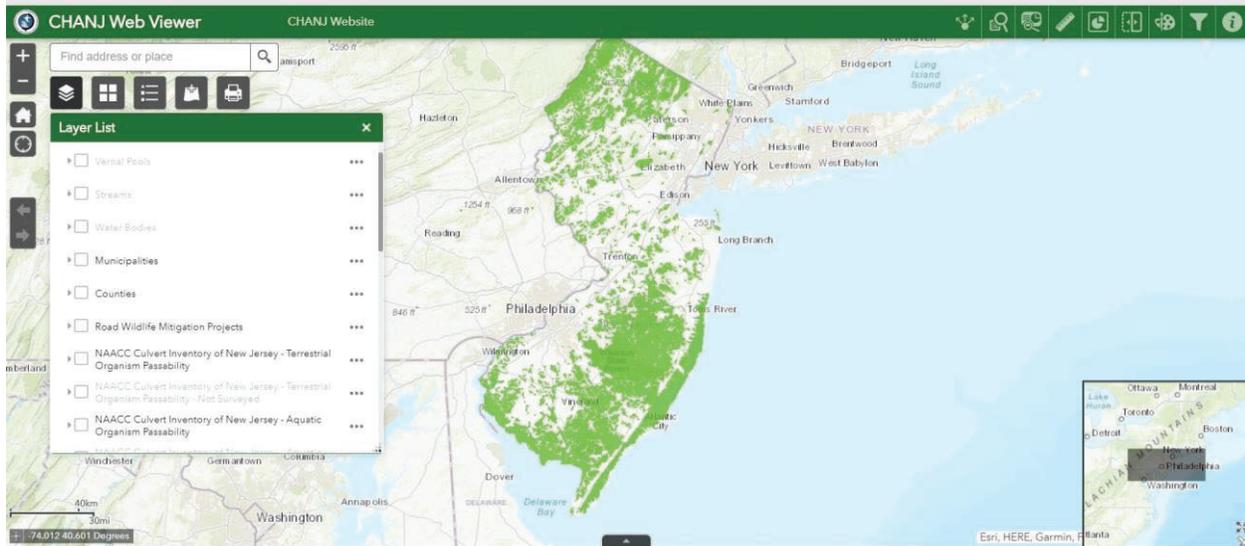
### Needs Assessment from Wildlife Agency on Potential Projects

Habitat and locational maps of wildlife created in GIS are limited in their ability to show areas important to wildlife with respect to roads. There may be specific populations of wildlife that are in danger of being extirpated in part due to collisions with vehicles or the effects of roads causing complete fragmentation. Geo-referenced data typical of habitat maps and hotspot modeling may not highlight these populations due in part to their low numbers, and also potentially their small size. It is critical that any transportation planning in areas where wildlife still exist also include conversations with wildlife professionals in the state/provincial, federal, and Tribal agencies.

These conversations can alert the transportation department to potentially important areas for wildlife, that if not accounted for, could be the cause of later delays and increased costs to a transportation project that belatedly incorporates mitigation for these animals. These areas can include special local areas of populations more common species that would be overlooked outside the wildlife agency.

For example, bighorn sheep populations may be in danger of disappearing in part from collisions with vehicles, yet their numbers do not rise to the level of a hotspot in crash modeling. Smaller animals such as turtles typically do not have representation in crash and often carcass data. Their populations can be at risk of being wiped out with just a few dozen vehicle collisions with nesting females. Wildlife agencies may also be interested in re-establishing populations extirpated from areas in large part because of the highway and traffic. Examples are mule deer populations that have moved to a different migratory area such as those in Bend Oregon along US 97, or the Rocky Mountain bighorn herd that moved along US 191 in Morenci, Arizona, or that have been wiped out because of an interstate, such as the Sublette Mule Deer Herd in southern Idaho along Interstate 84. It can also include areas where there is high tractor trailer traffic, and thus reported crash data poorly reflects the extent of the problem because truck drivers rarely report crashes. Examples include: US 6 in Utah, I-17 and I-40 in Arizona, and US 30 in Montpelier, Idaho.

In New Jersey, the Division of Fish and Wildlife created the “Connecting Habitat Across New Jersey” (CHANJ) program, a strategic plan for wildlife conservation that identifies key areas and actions needed to preserve and restore habitat for terrestrial wildlife (Figure 68). The website provides tools to bring up interactive maps and other resources to guide wildlife habitat connectivity efforts across the state, URL: <https://www.state.nj.us/dep/fgw/ensp/chanj.htm>. An instructive video for the public helps to educate on the efforts: <https://youtu.be/6UbBcTUfz1U>.



**FIGURE 68. THE NEW JERSEY CHANJ WEB VIEWER FOR WILDLIFE CONNECTIVITY.**  
 URL:

<https://njdep.maps.arcgis.com/apps/webappviewer/index.html?id=53339ff12f27488d8462e5e2c4c21b5c>.

These considerations will help avoid potential delays and cost for the transportation project, should they be considered later in the processes.

### Land Ownership and Use

Data and planning for wildlife will need to examine the potential for installing wildlife crossings, fencing and other mitigation in an area based on land ownership. While some road mitigation such as driver warning systems may work on private land stretches, wildlife crossing structures are typically placed in areas where development will not negate their effectiveness. This does not preclude placing mitigation efforts adjacent on private land, but it is important that the land be protected from development in perpetuity if this option is pursued. Counties may be important in future zoning actions in areas where wildlife connectivity across roads is crucial. States such as Montana, Idaho, and Colorado have worked with land conservation groups to help secure conservation easements on such places. It is also possible to arrange land purchases or swaps as a tool to ensure protection in perpetuity for infrastructure and wildlife. As an example, Nevada DOT purchased private land along US 93 to protect continued wildlife movements to a wildlife underpass (N. Simpson, Nevada DOT personal communication, 2020).

To help determine if there are protected areas involved in the review of the area of concern, check the USGS National Landcover Database:

[https://www.usgs.gov/centers/eros/science/national-land-cover-database?qt-science\\_center\\_objects=0#qt-science\\_center\\_objects](https://www.usgs.gov/centers/eros/science/national-land-cover-database?qt-science_center_objects=0#qt-science_center_objects)

Parallel highways, rail lines, energy extraction and transmission lines and corridors, and water transmission canals, and even right-of-way fences can also pose a land use consideration for placement of wildlife crossing structures for wildlife connectivity. Mitigation placement will need to be created with thought as to how wild animals can also navigate these nearby impediments (van Riper and Ockenfels 1998, Sprague et al. 2013).

It is also necessary to determine if Tribal lands are present or near the area of concern for wildlife movement. Tribal governments and wildlife agencies within the Tribes will need to be notified, and coordinated in the planning stages. The U.S. Bureau of Indian Affairs published a map of federally recognized Indian Lands in the U.S. URL: <https://www.bia.gov/sites/bia.gov/files/assets/public/webteam/pdf/idc1-028635.pdf>

The Canada Government First Nations Interactive Map can help identify tribal lands as well, URL: <https://geo.aadnc-aandc.gc.ca/cippn-fnpim/index-eng.html>.

It is also important to ask, “Does future development, energy extraction, transmission lines and corridors, and other human infrastructure possibly threaten the wildlife population in the near future that would exacerbate the WVC problem?”

### Identify Permanent and Perennial Water Sources

To assess for the presence of wetlands, riparian areas, dry washes, and other areas where there is short or long term water with reptile, amphibian, mammal, bird or aquatic species’ populations that need to move across the landscape and would be affected by a road or railway across their home ranges, check the U.S. Fish and Wildlife Service National Wetlands Inventory: <https://www.fws.gov/wetlands/>.

The presence of wetlands and riparian areas can also provide a convincing strategy to bridge the wetlands entirely for the road infrastructure, thus eliminating wetland mitigation and permitting, while providing terrestrial connectivity along the sides of the aquatic connectivity. You may also find that your state and provincial resource agencies have additional GIS data on aquatic resources that are more detailed and have finer mapping than the typical databases that might help further define your area of interest.

### Topography

Many wildlife mitigation solutions are dependent on topography. Some terrestrial animals follow ridge lines, while others may follow natural draws and riparian habitat along water ways. Smaller animals such as turtles also follow topographic features, such as when females lay nests of eggs in terrestrial areas free of water. With the expected and unexpected changes that are to come with climate change (see Climate

Change section below), placing wildlife crossing structures in topographic features that animals can follow to access new resources will become even more critical.

Even in the flattest of locations, it is important to find win-win solutions for providing wildlife access below a road in areas where water could also be accommodated, or where it may be a better solution to channel wildlife over the road in an overpass. The topographic features could initially be located remotely with GIS technology, and more importantly, through field visits. In fact, field visits are a necessity. Sections of road with fill or cut slopes that fall in priority areas should be evaluated for underpass and culvert or overpass opportunities, respectively.

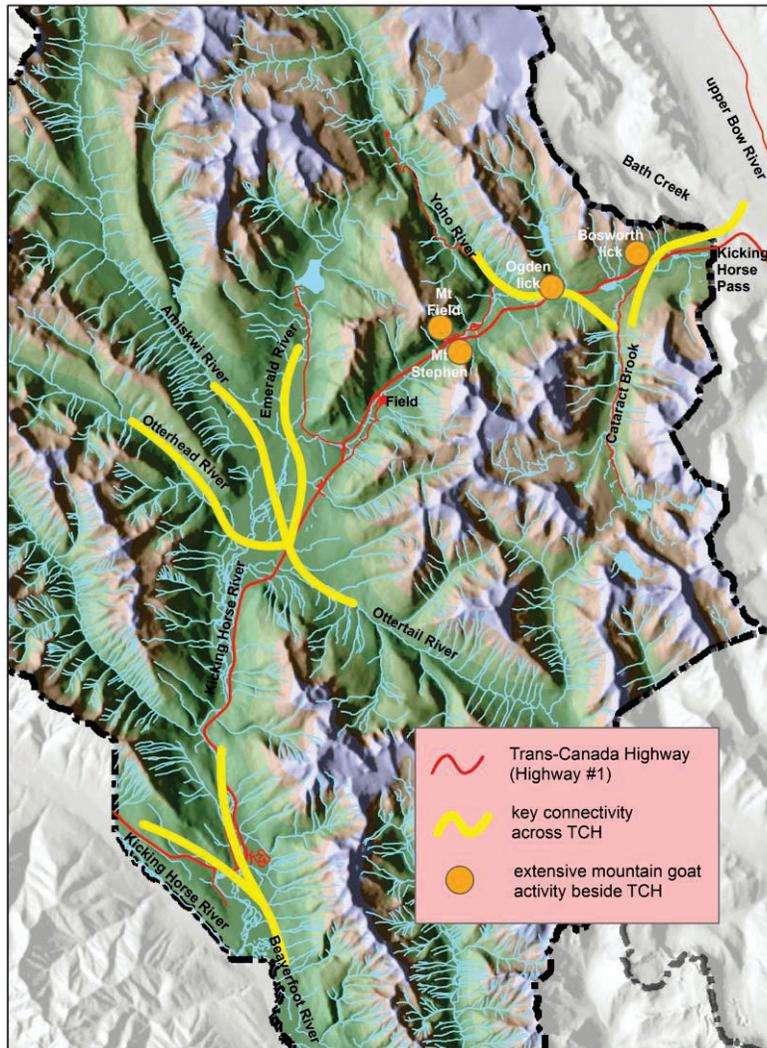
Topographic considerations are always conducted with other features in mind, such as human development, connectivity of the landscape features, and potential for wildlife to find the placed wildlife crossing structures. It is critical that wildlife professionals, which could include wildlife agency personnel, locate appropriate ridges, ravines, riparian corridors, and access points where multiple wildlife species could be expected to approach the road and find crossing structures.

Topographic features are less likely to change in 20 to 50 years than the ecosystem successional stages near the highway. Today's nearby forests may be next year's catastrophic fire, with no vegetation or cover for years. Vegetation that may attract species of animals to one side of the road may be changed by succession to another natural community that is less attractive. The effects of climate change decades into the future are difficult to predict. It is important to remember that topographic features are less likely to change than successional stages and ecological processes which are guaranteed to change in the future.

Below, an example is presented of how Parks Canada evaluated drainages as movement corridors in Yoho National Park with respect to the Trans Canada Highway.

### Case Study- River Drainages Are Natural Features to Place Wildlife Crossing Structures

In Canada's Yoho National Park, wildlife ecologist T. Kinley mapped where several river drainages converged across the Trans Canada Highway to locate where wildlife crossing structures would best facilitate wildlife movement north and south of the highway. These lines of river systems are combined with known locations of mountain goat activity along the highway.



**FIGURE 69. YOHO NATIONAL PARK, BRITISH COLUMBIA, LOCATIONS WHERE RIVER DRAINAGES CONVERGE NEAR THE TRANS CANADA HIGHWAY, AND WHERE WILDLIFE CROSSING STRUCTURES WERE NEEDED. MAP CREDIT: T. KINLEY, PARKS CANADA.**

## Climate Change

The current and future global changes in temperature, precipitation, sea levels, and disturbance processes mandate a broader approach to assessing transportation systems with respect to wildlife connectivity. Climate change necessitates a macro level – landscape perspective in space and over greater time scales than human careers. Data requirements to assess the risks to wildlife movements, and overall ecosystem resilience go beyond the scope of this report, but warrant serious consideration.

Examples of how to consider the scope of species' vulnerability to climate change include: looking at the landscape and finding where target species need to move to access current resources and in response to drier landscapes, or large fires, or range shifts of important plants or prey, or loss of habitat due to sea level rise, or less precipitation, and how transportation infrastructure would impede those movements. The goal for planning for climate change should be maintaining or restoring ecosystem resilience to these multiple stressors. A primer on these changes is presented by the National Fish, Wildlife and Plants Climate Adaptation Partnership (2012), with a 2021 update on the national strategy (National Fish, Wildlife, and Plants Climate Adaptation Network, 2021).

In 2021 the Association of Fish and Wildlife Agencies produced a toolkit to ensure climate change considerations are being accounted for and incorporated in the planning and implementation of terrestrial and aquatic connectivity initiatives (see link and reference in Literature Cited section, Albright et al. 2021).

Climate resiliency for wildlife and ecosystems is not the only kind of resiliency. The transportation systems themselves will need to be continually adapted for resiliency. The way transportation infrastructure can be adapted for climatic changes can support wildlife connectivity considerations. For example, spring time flooding from rapidly melting snow can be accommodated with larger stream simulated culverts and bridges which in turn could include terrestrial passage for wildlife and humans along those waterways. The 100 and 200 year floods are now much more common. Extending bridges and converting culverts to bridges that are up and away from the floodplain and beyond allow for greater amounts of area where wildlife can move beneath the road. Reducing transportation's impact on climate change, such as transitioning vehicle power to electric can help eliminate the carbon monoxide output and leaked oil from vehicles that move from transportation corridors into ecosystems, thus possibly helping more sensitive species such as amphibians and fish move near and beneath roadways.

## Summary

Information on both transportation and ecological resources is critical to considering and planning for wildlife connectivity and the reduction of wildlife-vehicle collisions and conflict. The greater the breadth and depth of the information, the more certain

transportation planners, engineers, and environmental staff of a transportation agency and its partners can be assured that most wildlife needs have been recognized and accounted for. In turn, these well researched data sources for transportation projects can greatly inform appropriate wildlife mitigation options that are coordinated seamlessly with other components of overall transportation procedures

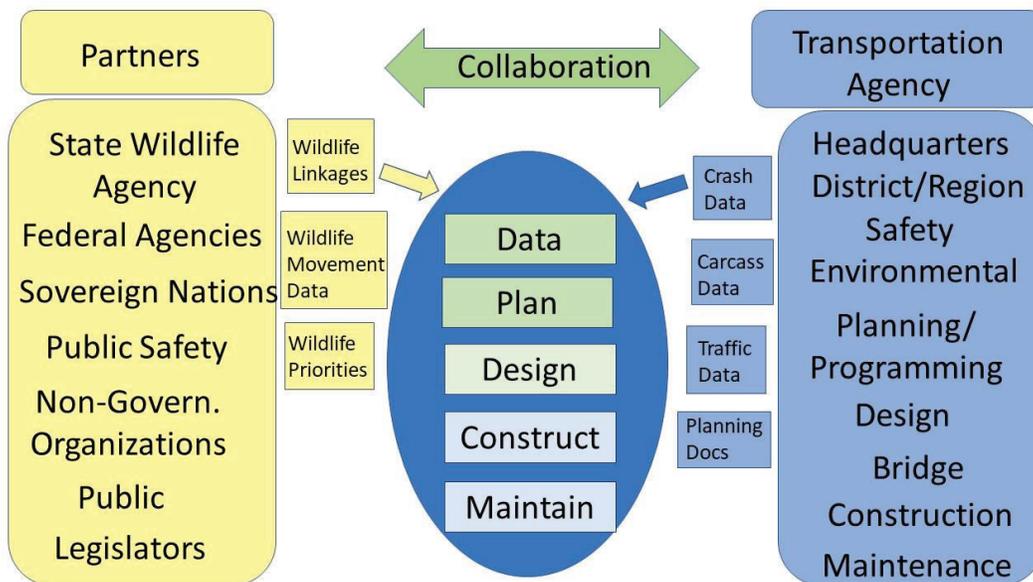
## Chapter 5. Pros, Cons, Gaps and Recommendations

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### Introduction and Overview

This chapter presents a succinct view of what was learned through this research and what could be improved concerning the strategic integration of wildlife concerns in transportation procedures. The guiding figure of this work is presented in Figure 70, which offers a high-level overview of all of the divisions within a transportation agency and their external partners involved in wildlife mitigation project planning, design, and construction, and how each of these entities contribute data and information that feed into these processes.



**FIGURE 70. THE TRANSPORTATION PROCESS, DATA NEEDED, TRANSPORTATION AGENCY DIVISIONS, AND OUTSIDE PARTNERS IMPORTANT TO THE CREATING OPPORTUNITIES FOR WILDLIFE TO BE PART OF TRANSPORTATION PROCESSES AND CONSIDERATIONS.**

### Comparison of Methods Presented in This Report

Various approaches used to assist in the inclusion of wildlife into transportation processes are presented, compared, and contrasted in Table 12, with specific recommendations for the best methods highlighted.

**TABLE 12. THE MOST BENEFICIAL APPROACHES TO INCLUDE WILDLIFE CONCERNS INTO TRANSPORTATION PROCESSES.**

Method	List Methods	Comparison of Methods
<b>Data</b>		
Crash Data	Reported by Law Enforcement Agencies to Department and Ministries of Transportation	<p>Best methods – those that include wildlife as first reported cause of incident and include at minimum a 12 species pull down menu for reporting officers to identify animal involved. This allows identification of best mitigation solutions for the specific area.</p> <p>Least Beneficial methods – only reporting animal as cause of collision, with no differentiation between wildlife and domestic. Also, no opportunity to report wildlife in 2<sup>nd</sup> and 3<sup>rd</sup> factors (or harmful event) as reasons for the crash.</p>
Carcass Data	Collected by transportation agency personnel, or contractors, and also agency personnel, and public	<p>Best methods – the transportation agency has full commitment from maintenance personnel or contractors collecting carcass data to consistently report exact locations through the automatic capture of GPS points, exact species, numbers of carcasses, and in a timely manner on a phone app that is immediately uploaded to an interactive mapping website for real time understanding of the situation across a jurisdiction. The state/province has a reporting tool for citizens to report live and dead wildlife, such as Ontario’s INaturalist website, or California’s Wildlife Observer Network.</p> <p>Least beneficial method – no reporting of carcass data across the jurisdiction.</p>
Map Hotspots	Map crash and or carcass hotspots with GIS technologies, including Kernel Density Analysis	<p>Best most scientific methods use ArcGIS Optimized Hotspot Analysis with the Getis-Ord statistic. This method requires a GIS professional and ecologist to understand differences in scale of analysis, multiple runs of the model, and consensus on best selection of variables. It gives a statistically sound map of top hotspots over a large and small scale.</p> <p>However, the easiest to carry out analysis is the Kernel Density Analysis, which can be run by an individual with a knowledge of ArcGIS and the scale of analysis. Its advantage is it is fast and easier than above, the downside is it makes hotspots in areas that converge, such as intersections of roads and results in a more coarse scale analysis.</p>

Method	List Methods	Comparison of Methods
Recent Mitigation Costs	Running list of recent mitigation projects in a jurisdiction	<p>Best method – is this list, with annual updates, with an explanation of the topography, land use, land ownership, number of lanes, of each project, and whether the project was stand-alone or integrated into another transportation project.</p> <p>Least beneficial method – is to only publish this list once and not update or place the project factors in the understanding of the costs. Or, to not identify and compile mitigation costs at all.</p>
Wildlife Habitat Maps	<p>Map overall state/province wide map of specie’s general habitat and</p> <p>Map specific known locations of species across state/province</p>	<p>Best Method – is the method that helps the transportation agency for the task at hand. A statewide coarse scale analysis gives the agency an overall idea of where to look for that species concerns. The fine scale maps of known locations of species help the agency see where there are actually animals of that species locally, and how they can be accommodated.</p> <p>Least Beneficial – when a state or province doesn’t periodically update species habitat maps.</p>
Wildlife Linkage Maps	<ol style="list-style-type: none"> <li>1. Rapid Assessment</li> <li>2. Modeling</li> <li>3. GPS data</li> </ol>	<p>Best Methods- are based on: 1- GPS locational data where animals’ locations have been tracked; 2-locational data for smaller species obtained by other scientific methods such as surveys; 3-carcass and crash data collection of animals of specific species. These data may be complemented with expert, local input to refine linkage maps. A less beneficial but still valid method is to perform a Rapid Assessment with a team of experts and maintenance personnel to learn of the problem areas along highways of interest.</p> <p>Less beneficial – Linkage modeling can be “aspirational” at best, meaning the areas where the scientists modeled wildlife locations without actual data on animals located there are hypothetical and should be taken as such.</p>
Wildlife Locational	1. Telemetry	Best Methods- are scientific studies or using scientific methods to

Method	List Methods	Comparison of Methods
Data	2. Survey 3. NatureServe	<p>conduct surveys or GPS collaring of wildlife movements. Collar data that report frequent location points is most useful for understanding factors influencing wildlife movement and roadway interactions.</p> <p>Second best – most wildlife species do not have large-scale scientific studies of population locations and movements. Therefore, widely accepted national programs such as NatureServe’s, are the first step in finding where the species’ populations are believed to occur. URL: <a href="https://www.natureserve.org/biodiversity-science/conservation-topics/species-mapping">https://www.natureserve.org/biodiversity-science/conservation-topics/species-mapping</a></p> <p>Least Beneficial Method – Demographic collar data studies that capture infrequent locations within seasonal ranges. These data are not adequate for documenting how wildlife move across the landscape.</p>
Climate Change	National Approach through Association of Fish and Wildlife Agencies and partners	<p>Best Method for a state or province is to follow a national level approach to protecting species and ecosystem functions, which would be assisted by including wildlife connectivity as part of transportation planning. The 7 goals put forth by this effort would be the critical for any agency to learn how their actions affect these goals: 1. Conserve habitat; 2. Protect ecosystem function – this is a critical component where transportation agencies are important to maintaining and restoring ecosystem functions; 3. Enhance capacity; 4. Adaptive management; 5. Increase knowledge; 6. Awareness and action; 7. Reduce other stressors. URL: <a href="https://toolkit.climate.gov/tool/national-fish-wildlife-and-plants-climate-adaptation-strategy">https://toolkit.climate.gov/tool/national-fish-wildlife-and-plants-climate-adaptation-strategy</a></p>
Climate Change Mapping	Predict species range shifts	<p>Best Method – the ArcGIS tool Linkage Mapper, has a Climate Linkage Mapper to help users plan for wildlife corridors following climatic gradients for predicting species’ range shifts.</p>
<b>Plan - Integration of Wildlife Movement Needs into Planning</b>		
Legislation for Wildlife Connectivity	Mandates for Transportation Agency to	<p>Best Method – legislative instructions developed in conjunction with transportation and wildlife agencies to mandate wildlife movement needs be considered in planning. New Mexico, Oregon, New Hampshire, and</p>

Method	List Methods	Comparison of Methods
	Consider Wildlife	Virginia as of 2021 all had Wildlife Corridors Acts to do just that. Colorado's Governor created a similar mandate, although unfunded. There is national legislation in the U.S. to identify and protect wildlife corridors that may become important sources of mandates and funding.
Transportation Agency and Partners' Alliance	Institute a Committee on Wildlife and Transportation	Best Method - the state or province creates an alliance of partners in agencies, non-profits, companies, Tribes, and others, to meet regularly and plan for prioritizing and instituting wildlife mitigation in upcoming projects and as standalone projects. Colorado's Wildlife and Transportation Alliance is an example of these successful partnerships. URL: <a href="https://coloradowta.com">https://coloradowta.com</a>
Memorandum of Understanding between Agencies	State wildlife and transportation agencies codify cooperation	Best Method – is an agreement that specifies how often the headquarters and regions/districts meet – from quarterly to annually, positions in each agency that are responsible for coordination, codify carcass data collection and sharing, planning for transportation, sharing of wildlife movement data. Less beneficial – no updates to MOA/MOU and little to no compliance or holding partners accountable.
Wildlife Agency comment on STIP	State/Province has annual meetings with Wildlife Agency to review STIP	Best Method – committees of the transportation and wildlife agencies that meet quarterly each year, and then annually to review STIP and upcoming projects. Take wildlife agency recommendations. Less Beneficial – transportation agency only contacts wildlife agency when STIP is out for public review.
Wildlife Monitoring & Mapping	State/Provincial Wildlife Agency monitors and maps wildlife of concern	Best Method – both common and more rare species have ongoing research programs on where the animals move, development threats, stressors, etc. Results are made available to transportation agency on a regular basis. Less Beneficial – mapping based on habitat modeling because of lack of exact locational data across jurisdictions. Other organizations, such as Land Management Agencies, Zoos, and Non-profits can also map these habitats.

Method	List Methods	Comparison of Methods
Linkage & Corridor Mapping	Transportation Agency uses Linkage Maps to Plan for Wildlife	<p>Best Method – transportation agency references linkage maps when conducting long term, STIP, and project planning. Works with wildlife agency to verify maps. Another approach is for the transportation agency to identify highway segments where mitigation investment will have the greatest benefit for wildlife. See Kintsch et al. 2019.</p> <p>Less Beneficial – these linkage maps are coordinated after projects are planned. There are also instances where transportation agencies do not endorse and use linkage and corridor maps developed by an outside entity such as a non-profit. Thus the valuable information is not used or accepted by the transportation agency.</p>
Standardize Wildlife Concerns in Manuals	Transportation Agency Mandates Wildlife Concerns in Multiple Professional Manuals	<p>Best Method – Texas DOT integrated wildlife concerns in 18 of the 24 manuals the agency has for various professions. It helped professionals in engineering, planning, landscape architecture, and other professions understand their role in promoting wildlife connectivity.</p> <p>Less Beneficial – design standards are not regularly updated to reflect new research and designs.</p>
Create checklist for wildlife needs in planning process	Transportation Agency Finds Points in Planning Where Wildlife Connectivity is Brought into Process	<p>Best Method – several state DOT’s have identified where in their planning processes wildlife connectivity needs can be addressed and considered when creating and selecting projects. States working on this include Colorado, Nevada, Minnesota, and Massachusetts.</p>
<b>Design - Wildlife Mitigation as Part of Project Development</b>		
Design for ecological connectivity	Maintain and restore ecological connectivity	<p>Best Method – rather than using a target species approach, Minnesota uses an ecological systems approach, for new and rebuilt structures to maintain and restore ecological connectivity along streams and rivers. Washington replaces culverts and bridges for water and fish connectivity.</p>

Method	List Methods	Comparison of Methods
		<p>States and provinces use stream simulation designs for aquatic and terrestrial connectivity in new and replaced culverts and bridges.</p> <p>Second best – systemically build larger culverts and bridges over waterways as a cost effective strategy for infrastructure resilience in the face of climate change, (for example, see Massachusetts’ approach).</p>
Slopes under bridges designed for wildlife	Wildlife pathways and back fill over rip rap.	<p>Best Method - Minnesota uses a standardized practice of placing a minimum of 3 feet (1 meter) of terrestrial pathways along water conveying structures for humans and wildlife, and to back fill soil over rip rap to allow for a more natural slope beneath bridges to allow for wildlife movement.</p> <p>Less Beneficial - address pathways for terrestrial wildlife on an individual project basis, which can result in lost opportunities.</p>
Offset secondary culverts	Additional culverts along waterways for flood flows and wildlife	<p>Best Methods – Minnesota placed secondary culverts along water conveying culverts to allow for terrestrial wildlife movement and provide additional flood flows. Parks Canada makes an effort to keep older culverts when replacement culverts are installed, to provide separate culverts for wildlife and drainage.</p>
Retrofit Existing Structures in Projects	Addition of Wildlife Exclusion Fence to Existing Structures	<p>Best Methods – in New Mexico, Arizona, and other states, when an upgrade project comes up, the DOT looks for opportunities to place 8 feet (2.4 meters) fence to existing bridges and culverts to funnel large wildlife to pass beneath the highway.</p>
Design Manuals	State/Province provides manuals for the design of wildlife infrastructure	<p>Best Methods – the state/provincial wildlife agency has a design manual for engineers and planners to follow. For example, Ontario has a Best Management Practices Manual for helping to build mitigation for amphibians and reptiles.</p>
<b>Construct – Wildlife Infrastructure</b>		

<b>Method</b>	<b>List Methods</b>	<b>Comparison of Methods</b>
Mitigation banking for construction	Preapproved wildlife mitigation	Best Method - Wildlife improvement projects can be identified as a part of mitigation banking project development, helping both small and large projects add to the larger mitigation banking process. Develop a wildlife mitigation crediting scheme to incentivize construction.
Construction Manual Recommendations	Include wildlife concerns in construction manual	Best Methods – Inform construction engineers and those overseeing contracts, on how to construct scientifically tested wildlife crossing structures, fences, escape ramps, and deterrents. Texas DOT sponsored research has made these recommendations for the “Design and Construction Information Systems” manual.
Fence Construction Guidelines	U.S. Manual	A Method- a single reference for construction guidelines for wildlife fences, escape ramps, and deterrents, (i.e. Huijser et al. 2015). This manual could be improved and upgraded.
<b>Maintain - Partnering to Research and Adaptively Manage</b>		
Transportation Agency provides funding for monitoring and then adaptively manages infrastructure from results	Partner with researchers and maintenance to maintain and improve infrastructure	Best Methods- the transportation agency pays for monitoring of infrastructure, and works with Maintenance staff to improve fencing, structures, access, signage, and carcass data collection to reduce wildlife-vehicle conflict in that specific area and jurisdiction-wide. Washington, Oregon, Nevada, Arizona, New Mexico, and Colorado for example, all have projects that have led to these partnerships and adaptive management.
Performance Measures	Research efficacy with pre-determined Performance Measures	Best Methods – In the U.S., Transportation Acts mandate performance measures for projects. Researchers of wildlife mitigation projects in Arizona, Utah, Colorado, Montana, and Alberta include performance measure for wildlife use of structures and reduction in wildlife-vehicle collisions in their research objectives and reporting to demonstrate infrastructure efficacy.

## Pros and Cons of Efforts and Recommendations for Change

There are many efforts that address wildlife connectivity and the reduction of wildlife-vehicle collisions; however, there are several consistent systemic approaches that continue to both promote these considerations, and have their challenges. In Table 13 below, we present consistent themes of transportation agency efforts, the pros and cons of such efforts, and we offer opportunities for improvement.

**TABLE 13. EFFORTS TO ADDRESS WILDLIFE CONNECTIVITY AND WILDLIFE-VEHICLE COLLISIONS, PROS, CONS, AND IMPROVEMENTS.**

<b>Effort</b>	<b>Pros</b>	<b>Cons</b>	<b>Opportunities for Improvement</b>
The number one way to get wildlife crossing structures is to include them in existing projects	Mitigation gets done in a timely manner and at a lower cost because it is spread over a larger project	May not be where efforts are most urgently needed. May not be top crash or wildlife connectivity area.	Funding for standalone wildlife crossing structure projects is needed at a national level, and may occur with the 2021 Transportation Act passage. Additional funding sources within Federal Highways that can be applied to wildlife crossing infrastructure would help provide additional funding opportunities.
Use the State Transportation Improvement Plan (STIP) and bridge and culvert replacement projects to identify potential projects that could incorporate wildlife concerns	For modest to no cost increases, a project could include wildlife crossing structures that were created by upgrading the size of already planned culverts and bridges, or other infrastructure.	Areas in greatest need of wildlife mitigation most typically are not addressed in STIP plans. The STIP areas may expend capital cooperation among agencies that could have been better spent on areas in greatest need.	The state wildlife agency should be reviewing the STIP in US States, annually, and have annual meetings with the transportation agency to discuss where wildlife need infrastructure to reduce wildlife-vehicle collisions and move safely. The environmental and traffic safety staff within a transportation agency put forth STIP projects that are meant to reduce wildlife-vehicle collisions and promote wildlife connectivity. This could help future STIP projects to be created specifically for wildlife.
Wildlife Crossing structure projects can be politically influenced	Some projects important to the public are completed through this process	These projects may not be the most urgent, or where wildlife most need to move	Scientific prioritization of statewide / province wide projects helps to eliminate biases in delivery. However, the legislative process is still a good place to formulate

Effort	Pros	Cons	Opportunities for Improvement
			funding opportunities for these projects.
The most ambitious wildlife crossing projects come with large highway improvement and new highway construction	These allow for multiple wildlife crossing structures, improve chances of success, and bring attention to wildlife needs. These projects can also jump start a state or provinces' wildlife crossing program.	When these projects are completed, the momentum for more structures and to adaptively manage the new structures can potentially become greatly reduced.	Transportation agencies need to institutionalize consideration of wildlife and continue to build these considerations into all project development. For example, in Minnesota, designing for the maintenance and restoration of natural processes through culverts and under bridges for all projects helps to maintain ecological and thus wildlife connectivity.
Institutionalize climate change resiliency in agencies and the transportation network	The transportation infrastructure survives with climate changes, and increasing opportunities for wildlife movement and ecological connectivity are delivered	Many professionals don't have enough ecological understanding to support these efforts, and this has not been done enough wide-scale to know best methods	State and provinces need to accept and admit climate change and human effects on ecosystems, and plan for those changes by ensuring ecological and climatic processes are provided for in the entire transportation process and infrastructure. Opportunities must be part of agency agendas to provide for wildlife, fish, and plants to adapt to a changing world. See <i>The Dasgupta Review on the Economics of Biodiversity</i> , to better understand nature's services and their contribution to society's well-being. See: <a href="https://www.nature.org/en-us/newsroom/jennifer-morris-statement-dasgupta-review/">https://www.nature.org/en-us/newsroom/jennifer-morris-statement-dasgupta-review/</a>

## Gaps to Be Addressed in The Current Science, And The Gaps in Understanding of How Transportation Planning Can Work to Promote Wildlife Mitigation Within the Planning Processes

Addressing gaps in the science and management of transportation ecology is an important part of this research. While this science and practice has grown tremendously in the past 20 years, there are still gaps in our knowledge. The following list presents the top additional research needs.

### 1. Research on Species Little Studied in North America

An important gap in the science, understanding, and practice is the addressing of smaller animal connectivity and movement needs in all states, provinces, and municipalities. These animals typically do not warrant safety considerations for motorists, and if there are no protected species there is little incentive for transportation professionals to consider these species. There is a need for sponsorship of studies of medium and smaller animals' conflict with roads and traffic, and best mitigation solutions.

An exception to this trend is in Ontario. Ontario Ministry of Transportation commissioned a Best Management Practices Manual for mitigating the effects of roads on reptiles and amphibians (Ontario Ministry of Natural Resources and Forestry 2016).

### 2. Standardized Methods for Monitoring and Researching Wildlife-Vehicle Conflict and Mitigation

There needs to be more than a study of methods of monitoring wildlife near roads and analyses of crash and carcass data. There needs to be an agency-organization standardization of these methods across the U.S. and Canada.

Currently there are efforts to standardize the collection of carcass data across U.S. states.

### 3. Long Term Studies of the Effects of Wildlife Mitigation Efforts

Despite our best intentions with placing wildlife exclusion fences and wildlife crossing structures along roads, there are negative consequences to these actions. These include the habitat fragmentation caused when medium sized and smaller animals are not accounted for in the placing of wildlife crossing structures, and their movement limitations don't allow for them to find and use the structures. GPS tracking devices on animals pre and post mitigation will help examine the movement patterns pre and post construction of animals and their survival over time with exclusion fence and wildlife crossing structures, and will help inform future efforts and adaptations to existing infrastructure.

#### 4. Different Types of Infrastructure and Evolving Technologies Need Research

There are various components to wildlife mitigation, from different exclusion fences, in road deterrents such as cattle guards, escape ramps, and shelves inside culvert to accommodate smaller animals. There will be a continuous need to study mitigation in relation to different species of animals, and to test and manage new technologies that deter animals with electric, detect animals moving near the road and warn drivers, and to refine artificial intelligence used to identify animals in these systems and in photo analyses.

#### 5. Regular Updated Best Management Practices Manuals

The science and practice of transportation ecology is evolving so quickly around the world, practitioners do not have a single point of reference to help them answer the many questions on efficacy of different infrastructure with respect to different animals and climates. An on-line Best Management Practices Manual that is updated annually and at least every five years is needed to share the information generated from studies and practices. Such a manual should offer guidance in the application of different mitigation techniques and how various species or landscape considerations such as species movement types (e.g., mitigation within a seasonal range versus along migration routes) and population habituations (e.g., to exurban development or recreation activities) may affect mitigation design.

#### 6. Additional Research and Management Actions Dealing with Climate Change Are Needed

Climate change is a major driver for transportation agencies to adapt their systems and approaches. Resilient ecosystems and agencies come about from planning for and adapting to these changes. The transportation network will hinder animal, fish, and plant movement as natural disturbances from climate change such as fire, flooding, hurricanes, drought, and extreme heat cause these species to have to move in order to survive. Long term research over decades is needed to see what the movement and adaptation needs are of species, ecosystems, and processes, and how transportation can work to restore and protect the necessary linkages for climate change adaptation movements.

## Identify How Administrators, Environmental Staff, Engineers, Planners, And Others Are Brought into The Practices of Integrating Wildlife into Transportation Planning and Daily Operations

In the on-line survey of transportation professionals conducted in this study in 2019 (see Chapter 2), the two themes that emerged were:

- 1) The need for the incorporation of wildlife awareness into the agency/corporate culture from the top down at the headquarters and local levels; and
- 2) Instilling a sense of environmental stewardship among personnel within transportation agencies.

These two themes are at the root of this entire study – bringing transportation agency professionals' awareness to a level that they choose to bring concerns for wildlife into their everyday duties and long term plans. In another survey question, 98 percent of respondents said that agency headquarters' support was very important or moderately important in the integration of wildlife accommodation into transportation planning and project development. Thus, actions from the top down are critical. How do these individuals and others learn enough about wildlife, ecosystems, and climate change to affect their thinking and decisions? There are several ways to affect this change. These include: education from within the agency; information and partners outside the agency; and carrots and sticks.

### Education from Within

As was demonstrated in the case study from Vermont, with its Highways and Habitats educational program (Chapter 3), an in-agency program of continuous learning of ecosystems and wildlife is necessary to affect change that works at the heads and hearts level. In British Columbia, the Wildlife Program within the Ministry of Transportation and Infrastructure has over 20 plus years created a model for institutional cohesion (see Chapter 3). These programs work because they inform, involve active participation, work with professionals at every level, and have been instituted for years to decades.

Also important is local champions within the agency, at headquarters and especially at district levels. See Chapter 3, and the case study, "Gaining Support for Including Wildlife Crossings in Transportation Projects," for an example of how the District Engineer worked with different groups and different approaches to include wildlife crossing structures and other actions in every day and long term processes.

These long term strategies within agencies are successful for small changes, incremental change, and systemic changes that help garner actions that support wildlife movement and minimize wildlife conflict.

## Information and Partners Outside the Agency

In the on-line survey of transportation professionals in this study, survey participants indicated the most important part of planning processes for including wildlife concerns were:

- 1) Collaboration with wildlife agencies; and
- 2) Inclusion of wildlife mitigation plans in the long range transportation plans.

The role of wildlife professionals outside a transportation agency is highly important and cannot be overstated. The wildlife agency can provide data, expertise, persuasion, and political support to transportation agencies interested in addressing the needs of wildlife. In states and provinces with the most ambitious wildlife mitigation programs, there is cooperation and even Memoranda of Understanding among agencies to define how the agencies work together. See Chapter 3, the case study, “Building Partnerships to Advance Highway-Wildlife Mitigation,” on how Colorado is working together in this light. Tribes and Sovereign Nations too have played pivotal roles in helping to partner with transportation agencies to build wildlife crossing structures and minimization of transportation project impacts, see Chapter 3, “Montana’s Working Partnerships” for an example of how this helped US 93 become a premier example of wildlife crossing structures across Tribal lands.

## Carrots and Sticks

Rewards and mandates to build wildlife mitigation into transportation both work, but from different angles. This research’s on-line survey participants indicated that the top two intra-agency barriers to wildlife mitigation inclusion in transportation plans, projects, and every day operations were lack of funding and agency culture. This is the root of creating actions to make change for wildlife. Agencies need a dedicated funding source, and motivation to change their culture away from of how things may have been carried out in the past. Funding sources (carrots) can be created outside the traditional scope of transportation. In Chapter 3, the case study, “Securing Funding for Wildlife Connectivity A Golden Moment in Pima County, Arizona,” readers learned of how the voters in the Tucson area voted to tax themselves for wildlife connectivity, which then created a funding source to build wildlife crossing structures. In the 2021 Transportation Bill, there is upwards of 500 million dollars slated for wildlife mitigation efforts. Carrots such as these can incentivize the inclusion of wildlife considerations. The “sticks” to consider wildlife can be legislative changes to create plans to promote wildlife connectivity, see Chapter 3, “New Mexico’s Legislators Integrate Wildlife Concerns Into Agency Actions.” They can also be institutional changes to operating manuals, see Chapter 3, “Texas Department of Transportation Manuals,” or changes in the Metropolitan Planning Organization processes of planning, see Chapter 3, “The MPO Connection.” Multiple small and large changes to funding sources and legislated mandates on how agencies operate can begin to create this sea of change needed at all levels and across all geographies.

## Summary

This report presents a breadth and depth of knowledge that can help the U.S. and Canada continue to improve considerations of wildlife in transportation processes. From this research, a companion manual on how to emulate lessons learned will be developed and completed in 2021-2022.

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## Appendix A – Literature Review

Patricia Cramer, PhD

Kimberly M. Andrews, PhD

### Guidance Resources for Planning for Wildlife in Transportation

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## Appendix B. Results of Survey: Transportation Agency and Metropolitan Planning Organizations Written Responses

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### Transportation Agencies' Written Responses

#### Question 1 -Wildlife Mitigation Efforts Since 2014

Question 1 of the survey, asking respondents what types of wildlife mitigation has their agency created since 2014 had several written responses presented below.

[Link to return to Question 1 results.](#)

**Since 2014, has your agency implemented any of the following mitigation measures for large or small wildlife? Check all that apply.**

- New dedicated wildlife crossing structures **with** wildlife exclusion fencing. Please note how many have been constructed since 2014: \_\_\_\_\_
- New dedicated wildlife crossing structures **without** wildlife exclusion fencing. Please note how many have been constructed since 2014: \_\_\_\_\_
- Wildlife exclusion fencing **without** crossing structures
- Replaced existing culverts or bridges with upsized structures to promote wildlife passage
- Enhanced or improved existing culverts or bridges to promote wildlife passage (e.g., add fence, add cover elements, remove sediment, create pathways, etc.)
- Animal detection systems or crosswalks

**Please include a written response if you would like to describe your answer in greater detail**

State/Province	Comments
Oregon	Oregon DOT has two wildlife under crossings in design/construction to be completed in the next three years. In all Oregon DOT existence, I do know we've spent about 5.25 million on wildlife features over 4 projects.
New Foundland	2 animal detection systems were installed in 2011 and one 17 km stretch of fencing in 2012. The animal detection systems (break beam) were removed because they were deemed ineffective and prone to outages. Fencing has been maintained and has require on minimal maintenance since 2012.
Massachusetts	Much of our wildlife accommodation efforts are through building larger culverts and bridges over waterways, as it is the most cost effective strategy for our agency. By small (relatively) increases in project cost across many culvert and bridge projects, we're able to improve wildlife passage at a much larger scale, than if we were focusing those dollars on just a couple dedicated wildlife tunnels each year.
North Dakota	One dedicated wildlife crossing with fencing has been completed with fencing/jumpouts, completed in 2017. A high flow structure (3

State/Province	Comments
	<p>cell box culvert) was also constructed as part of this project which functions as a wildlife crossing during drier parts of the year. Many many years ago, high chain link fence was installed along Missouri river in Mandan, ND to keep deer from crossing the interstate (there was a big WVC problem). No crossing was included with the exclusion fencing. We also buried some rip rap under a bridge on the interstate, creating a „Übench,Äù. No fencing was included, but the bench has made movement underneath the bridge possible with documented photos of deer, moose, waterfowl, turkeys, etc. We also bury riprap at culvert ends and sink box culverts.</p>
Washington	<p>The Snoqualmie Pass East project on I-90 is the only project constructing wildlife crossings in this recent time period. It's fairly difficult to distinguish between "dedicated" wildlife crossing structures and "upsized structures to promote wildlife passage." Many of the structures replace small corrugated steel culverts yet they are huge bridges, much larger than would ever be considered necessary to provide natural stream dynamics. There are also many small culvert crossings that have no hydrologic function and are strictly for wildlife passage. I don't know how many of these have been installed and more are being installed right now as the project continues to proceed toward completion. Also, a wildlife exclusion fencing project starts construction next month (September) and it is not associated with a "dedicated" wildlife crossing structure. It is associated with an existing bridge that provides exceptionally good conditions for providing safe passage.</p>
Virginia	<p>The "replaced existing culverts..." applies to 2 fish passage projects. We also have a pilot project of a buried cable animal detection system that was recently completed (but I didn't check the box for that because it's not formally implemented). VDOT is considering the installation of an animal detection system for elk on a new alignment roadway. However, construction of the new road has not been completed and the detection system is still in the discussion phase. Virginia Tech Sustainability Center installed animal detection systems as part of their SMART Highway/Road research center. The fencing project I believe tied into existing crossing structures but itself did not include the install of a new structure.</p>
Arizona	<p>New Box Culverts have been installed with skylights, reduced bends or turns to allow 'see-through' to other side of culvert. Wildlife-friendly right-of-way fence has been installed to promote crossing by elk, deer and antelope while keeping livestock in. Culverts also have installed rip-rap spillways with paved pathways in the rip-rap to accommodate wildlife passage.</p>
Tennessee	<p>The Tennessee Department of Transportation, Wildlands Networks, and National Parks Conservation Association is investigating an</p>

State/Province	Comments
	<p>eco-logical approach to reducing the number of wildlife-vehicle crashes, especially large mammals such as whitetail deer, black bear, and even elk. From 2014 to 2017, there were 248 wildlife-vehicle related crashes in Tennessee with the I-40 Pigeon River Gorge being one of the areas with the highest number of wildlife-vehicle crashes. This area is known to draw tourist from around the world for hiking, camping, and spotting and photographing black bear. From 2014 to 2018 in the I-40 Pigeon River Gorge, there has been a total of 19 bear crashes recorded with all of these being property damage crashes occurring at night between 7:30 PM and 4:00 AM. We attended a Wildlife Crossing Workshop and Peer Exchange in Maggie Valley, NC to learn about potential countermeasures for TDOT to implement to prevent vehicle to animal collisions along the interstate. The workshop and peer exchange mainly focused on elk and bear crashes along I-40 from the Newport exit to the TN/NC state also known as the Pigeon River Gorge in the Cherokee National Forest and located adjacent to the Great Smoky Mountains National Park. Lessons Learned include, but not limited to, wildlife crossing structures, fencing, and tracking wildlife. Tennessee does not currently have adequate wildlife crossing structures or fencing to prevent vehicle to animal collisions.</p>
Maine	<p>We are using Stream simulation design for crossings which can include a bank along the stream inside the culvert</p>
Nevada	<p>The above number is for large over-and under-passes along US 93, I-80, I-11, SR 160, and USA Parkway. We have also added in numerous culvert for desert tortoise not reflected in the above number.</p>
Minnesota	<p>It is a standard design feature to include a minimum 3ft passage bench on all MnDOT bridges. I've lost count how many. Though this feature has been around since 2004. It is uncommon to have fencing. A new design is now being included where bridge riprap does not have a bench, but the entire slope is backfilled to fill the voids and make the surface walkable. Three are going in this year. "Offset culverts" are considered for both flood flows and animal passage. With the dry culvert being animal passage during normal flow conditions. The only fencing we are working on is small animal fencing (primarily turtles). Tests on design are ongoing</p>

## Responses from Transportation Agency Question 1b- Target Species of Mitigation

[Link back to target species results](#)

State/Province	Comments on Target Species
New Mexico	Haven't built actual crossing structure but have built game fence for large ungulates.
Minnesota	Most bridges constructed over waterways include paths ("passage benches") to facilitate wildlife movement. It is uncommon to have fencing. Our structures have not specifically targeted any species. The intent is to maintain (or reconnect) ecological connectivity along our streams and rivers.
Alberta	Retrofits and accommodation for wildlife underpasses new bridges have occurred
Minnesota	Our structures have not specifically targeted any species. The intent is to maintain (or reconnect) ecological connectivity along our streams and rivers.
Oregon	Oregon DOT has two wildlife under crossings in design/construction to be completed in the next three years.
Delaware	Fish
Washington	Lichens and Fungus

## Responses to Transportation Agency Question 2 – Primary Compelling Factors for Wildlife Mitigation Efforts

[Link back to Question 2 results.](#)

Respondents' home state or province was withheld from comments to protect the identity of respondents if their opinions were not those of their agency. If a respondent indicated a state or province in their response, the information remained intact. The land on both sides was protected by the government and the entity that owned the road were all on board.

Each project had various components, but human safety and ESA requirements have been the primary concern in supporting mitigation.

We assume this entire survey considers efforts 2014 or later. We assume legislative action does not include ESA or other existing federal laws and regulations. Bighorn sheep and elk were being hit on the State's Highways and crossing signs were installed to warn the traveling public.

NYSDOT is very de-centralized and consideration is a function of staff knowledge, training statewide has been given to look at riparian corridors to widen culverts and include upland areas under structures (Culverts and Bridges). The VDOT Bristol District implements wildlife mitigation for many transportation projects. However, to date, this has not included wildlife crossings. These answers relate to 2 different projects. Safety hazard response is for research projects/implementation studying the effects of adding fencing to existing underpasses. "Private entities..." checkmark applies to an amphibian tunnel project currently in construction.

In the case of the I-90 East project, a variety of factors were influential in making the project happen, including several that were checked. However, the factor that wasn't offered was the special use permit the WSDOT had to obtain from the U.S. Forest Service and the fact that the Forest Service has its own planning document, the Northwest Forest Plan, that dictated the ways in which a permittee would need to comply with their plan to be permitted for something like a highway widening.

Primary factors leading to wildlife mitigation comes from our State Game and Fish Dept. Examples include USFS-required mitigation because of easement requirements; part of proposed federal action as described in project's biological assessment (section 7 ESA); one or two projects including wildlife undercrossings for mule deer as part of a curve correction project and safety factors.

There was no apparent option for this but our installations were due to NEPA requirements from say, USFS.

One undercrossing will be built due to NEPA requirement on USFS property.

DNR does have permit rules that require measures to maintain, enhance, or restore ecological connectivity.

MnDOT designs were developed to be utilized as on-site measures to do so. NO studies for placement are done, though they have been implemented as regular part of project design.

The Alberta Wildlife Watch Program is an Animal-Vehicle Collision Safety Program designed to improve driver safety while reducing the impacts that highways have on wildlife populations. This is done through the analysis of accurate animal carcass data for large bodied species at a district, region and provincial level to identify, validate and design for Animal-Vehicle Collision Prone Locations.

OTHER; research identified area of wildlife mortality. worked to reduce this mortality. The wildlife detection systems were implemented as a result of a Minister's directive

## Responses to Transportation Agency Questions 3 and 4 - Barriers to Mitigating for Wildlife

### [Return to Questions 3 and 4 results.](#)

Respondents' home state or province was withheld from comments to protect the identity of respondents if their opinions were not those of their agency. If a respondent indicated a state or province in their response, the information remained intact. There were 20 Comments from respondents to the external and internal to the agency barriers.

1. Wildlife mitigation is considered for all projects when wildlife needs are identified.
2. Agency is siloed by region and by division with little interaction between those that design crossings and those interested in seeing them used.
3. The greatest barrier is that there is no perceived need to implement specific wildlife crossings.
4. The AWW program integrates AVC analysis and mitigation from planning through to operations of the provincial highways. There are limited barriers in integrating AVC mitigation.
5. Lack of dedicated funding for connectivity mitigation and our culture.
6. I think we are doing pretty good overall. Though large stand-alone structures are not in the mix. Designs in our DOT typically also have secondary benefits (large culverts that also carry flood flows, ease of bridge inspections). Though fencing is a struggle to get into plans.
7. Oregon now has HB2834 requiring ODOT to consider wildlife passage in high collision areas but there is no funding attached to the legislation.
8. Lack of legislative mandate and funding are both factors. Ex: fish passage barrier remediation is a mandate in CA but with no dedicated funding and we are not meeting statewide goals for remediating these barriers.
9. Since spending money on wildlife mitigation wasn't common practice for many decades, it still isn't present in the agency culture to realize the necessity or value. There is also a long-standing culture of setting a precedence for future projects.
10. We've got some serious internal opposition, from maintenance, to wildlife barrier fencing. However, it's safe to say that our dire budget situation is a bigger impediment at this time.
11. While the answer to this question for individual projects is about lack of funding, I responded to the "everyday operations" portion of the question. The DOT environmental division sees wildlife crossings as a safety issue and therefore not

under their purview, but the safety staff are not fully aware of the problem and the fact that there are viable solutions.

12. For both of these questions, multiple answers could apply.
13. As noted earlier, decentralized Agency and many chefs and limited understanding. Lacking any regulatory requirements (typically) this is not perceived as a real need in many cases vs. an opportunity.
14. Bids for our current construction projects are coming in higher than budgeted for.
15. If it is not driven by human safety or ESA requirements, it is hard to get support from management to include 'ecological' needs when there are so many other immediate transportation needs.
16. It is the people at the highest levels of our state DOT that are resistant to funding or encouraging wildlife crossings. New Jersey is unique too in that the large ungulates we have are also a pest species (white-tailed deer) and bears are the only other concern for property damage. There are concerns about drivers swerving not to hit smaller animals and the emotional trauma resulting from that, but that hasn't been in the narrative as much.
17. Funding stand-alone wildlife crossing projects is challenging in the current political climate. Retrofitting existing infrastructure is also very challenging (numerous entrances, drainage issues, challenging tie-ins to existing culverts, etc).
18. None of the reasons listed in questions 4 and 5 have much bearing on the incorporation of wildlife mitigation into NWR projects. Two factors in NWR limit the use of the preferred mitigation measures presented in this survey (i.e., exclusion fencing, wildlife crossing structures and detection systems) those being practicality and effectiveness. 1 Practicality: In NWR wildlife occurrences are mostly random due to most of the region being Crown land in a natural state (i.e., there are few manageable corridors where animals "prefer" to cross where exclusion fencing, for example, could be implemented). In areas of higher human population densities there are increased collisions rates, but this is a function of increased traffic not necessarily concentrated wildlife crossings. That said, measures could be implemented here such as exclusion fencing; however, practical tie-ins for fencing are not easily identified and there is risk that wildlife crossing the roadway will be concentrated at fence ends. Furthermore, because most intersections are at-grade crossings in NWR, application of exclusion fencing could funnel animals into heavy traffic at or between intersections. 2 Effectiveness: There is a lack of supporting evidence that the preferred mitigation measures listed in this survey will be effective in NWR and perhaps other regions within the province, particularly the use of animal detection systems/cross walks. Mitigation measures would be better supported in NWR where proven empirical results show effectiveness and cost /benefits of these measures and they could be practically implemented.

19. The larger more encompassing barrier is that our infrastructure is improved on a conditions or needs basis-which means that wildlife mitigation implementation has to wait until an infrastructure need is identified.
20. While some stand-alone projects have been implemented to address hotspots for large wildlife-vehicle collisions (i.e. detection systems), it is not the typical model for implementation. Mitigation, in the form of modifications to existing infrastructure or new mitigation measures, is typically implemented in associated with a planned infrastructure rehabilitation project where a hotspot has been identified or legislatively mandated to implement. While there is provincial legislation for species at risk protection and recovery, there is no legislative requirement to implement mitigation measures for large wildlife movement so this is driven primarily by WVC data. Where Ontario Endangered Species Act authorizations are required for maintenance, rehabilitation and new construction of transportation infrastructure, authorization conditions may require MTO to implement site-specific mitigation measures such as crossing structures, fencing, replacement habitat for species at risk (i.e. typically small wildlife such as reptiles, birds, bats).

## Transportation Agency Respondents' Recommendations

### [Link to return to Respondents' Recommendation Results.](#)

Forty-seven comments were received from survey participants that provided recommendations for including wildlife mitigation in transportation.

1. Transportation agencies need dedicated funding in order to install structures and fencing for projects that are not safety related.
2. Legislation and wildlife-vehicle conflict hotspot analysis incorporated into an Action Plan.
3. Incorporate wildlife awareness in the corporate culture. Ensure new hires understand the implications of wildlife mitigation for wildlife protection and public (motorist) safety.
4. Data must be available supporting placement/replacement of structures.
5. Improvements will be dependent upon the species of concern in each state. There may be a wide variety of techniques and methods that may be applicable. Research results will be critical to DOTs in determining what might be viable solutions.
6. Considerations for wildlife crossings/mitigation needs to be integrated as early as possible in project planning.
7. Statewide wildlife corridors action plan or a Statewide wildlife-vehicle conflict plan that identifies and prioritize areas needing wildlife-vehicle collision mitigation. Support from Agency headquarters is also very important.
8. Dedicated funding for crossings incorporated into long-range plans and monitoring of structures when finished.
9. The easiest is to evaluate each bridge replacement not only for hydraulics but wildlife passage as well.
10. A collaborative approach with the government agencies that have the wildlife management/conservation mandate and the transportation ministry. Once that collaboration is established formally then both can work to identify how to collect the important and accurate data to develop a data driven decision making process.
11. Highlight Road safety. Most animals are not specifically protected but hitting a raccoon on a bridge approach is not good on many levels.
12. In Idaho, until it is mandated by the federal or state government, it will continue to be a low priority for the transportation department.
13. I'd suggest more focus be placed on instilling an environmental stewardship mindset - doing right by the environment. We can write all the policies and procedures we want but if there is no appetite for it, we stay status quo. We have to work on the culture from all angles, not just the policy angle.
14. Dedicated funding

15. Staff with the required expertise must be in place and they must be given the authority to have input into the development of long-term plans and work activities.
16. Data is needed to make sensible decisions. Likewise, unintended consequences need to be thoroughly examined before making decision. The movement or channelization of wildlife could result in introducing wildlife to areas they are either not welcomed or which may not be able to provide suitable habitat. Use of structures (culverts and fencing, for example) have to be backed up financially with maintenance funding.
17. To start with, our state needs to have the conversation to at least give the perception that we are concerned about the issue. Then we need to collect some data to determine if anything can be done.
18. First, we need the data. The need will have to rise to the top of a very long list of needs. I think we are getting very close. We then have to be crazy successful on our first attempt.
19. Complete research and implementation
20. Minimizing and mitigating impacts to wildlife should be assessed for every project, similarly to how wetlands are. Stream and wetland crossing structures should always be evaluated for their potential to be replaced with larger structures to accommodate the full suite of species expected to reside or move through the project area.
21. For a start, transportation agencies should recognize that wildlife connectivity should be a consideration in long-term planning.
22. Inclusion of mapped migration corridors, federally designated critical habitat, WVC hotspots into RTPs completed by MPOs, corridor plans done by DOTs, asset management and system planning documentation, and more. Include remediation goals into State Highway System Mgmt Plan, identify wildlife crossings as a transportation need/safety index similar to how calculations for cross-center line accidents are generated. Mandate inclusion of wildlife connectivity into project nomination forms, so project scoping teams at least have to address it. Development of standard plans for wildlife crossing project features. Bring in Maintenance, Environmental, and Highway Patrol into planning process (100% of the time). Develop wildlife crossing mitigation crediting scheme to incentivize construction.
23. Have agency buy-in (upper management) buy in that wildlife connectivity is an important consideration. Not only for wildlife, but for safety of the traveling public.
24. I cannot say that we've found the key to success, other than the perfect storm of environmental context, regulatory necessity, Support from diverse groups and pressure on the legislature which led to the design and construction of the I-90 East project. We've tried to lay the groundwork for additional projects, but few projects have moved forward. Right now, Planning Environmental Linkages is viewed as one way to get these environmental issues established early in the planning process so

they will be adequately deliberated and tested in the affected communities, potentially leading to funding for those that get the most traction. Will it work? I wish I knew.

25. There needs to be an initial top-down approach both at HQ and the Districts (when decentralized). Would also help to have the Governor establish a working group (or at least give his blessing in moving forward) to help set priorities since it really does involve two state agencies working together. Right now, it is a grass roots level action in our state agencies.
26. For our agency, incorporating wildlife crossings and other wildlife-crash mitigation measures is not done primarily because it doesn't have to be done. In addition, no division sees this as their responsibility (environmental sees it as a safety or planning issue, and vice versa). We are at the beginning of creating guidelines for wildlife crossing measures for our DOT, but at the most this will lead to small piecemeal efforts here and there. State bills that require these measures will be the solution to integrating these measures on a large scale and into the planning process.
27. It is important to establish communication and data sharing between the DOT and applicable resource agencies. Providing the DOTs with the appropriate wildlife population information is key. Training DOTs about the available methods and tools would be helpful. Sharing cost benefit analysis data and potential funding would also be helpful. Funding may be the most limiting factor.
28. Guidance that gives general recommendations to consider in transportation projects with training modules. Currently working at NYSDOT to build this into the Bridge and Culvert design manual. Currently doing annual statewide trainings to highlight the low-hanging fruit opportunities such as widening culverts when replacing culverts-typically good for current trend in larger storm events and generally good for connectivity. Consider a FHWA guidance, checklist, or requirement for project development
29. A regulatory mandate followed by funding
30. New funding needs to become available for wildlife crossing planning and projects.
31. Incorporate fully into routine business processes, not an "extra" consideration. Predictable, consistent, and transparent process for considering needs and feasibility of wildlife accommodations in project delivery
32. Early coordination with stakeholders to identify areas for possible wildlife crossing accommodations. Also, considering retrofitting existing structures instead of building new structures where possible.
33. Awareness should be prioritized throughout the transportation agencies of the importance of mitigating threats to wildlife from transportation projects and infrastructure. Funding sources should be identified and rigorously sought out to pay

for needed mitigation activities. Show the transportation agency the positive return on investments in wildlife protection measures, techniques and approaches.

34. Recognizing that wildlife crossings are a business need touching on improving public safety, increasing transportation resiliency, and maintaining habitat connectivity that may prevent the listing (state or federal) of new wildlife species.
35. Establishing Transportation Liaisons
36. Work with NGOs and Wildlife agencies to ensure long term viability
37. Early coordination with key stakeholders. DOTs should engage key division managers, leaders, and decision makers early on, including Maintenance when it comes to long-term maintenance and associated costs. A well-documented cost benefit analysis supports the long-term investment with crossing mitigation with key managers and design engineers at DOTs.
38. Include Indigenous Knowledge into the planning phases
39. Transportation agencies need to have a position dedicated to this topic. I find it hard to juggle all the biological needs of our DOT and know I could make much more progress if I could focus.
40. Environmental regulation requiring design to implement wildlife passage is likely the easiest path towards wildlife sensitive transportation programs. In Georgia, we are working to utilize WVC data to determine crossing hot spots, which may help influence design if there is a safety need.
41. More communication and coordination between wildlife biologists and transportation planners.
42. Development of Crash Reduction Factors (CRFs) that can be applied to animal vehicle collisions. These CRFs could be used to obtain Highway Safety Improvement Program funding for mitigation projects.

Valid points identified in survey:

- Developing a provincial/state prioritization of areas to improve wildlife connectivity/reduce collisions. Obtaining a pre-approval from senior administrators to address these areas during the next round of capital improvement/rehabilitation in the area.
- Liaise with the insurance industry to better capture the overall societal cost of wildlife/vehicle collisions.
- Developing standard drawings and contract language so transportation planners have the tools available at hand.
- Work with the public and private sector to fund future improvements in high profile areas (i.e. provincial/state parks).

Additional considerations from NER perspective:

- a. Conduct post-construction monitoring to ensure effectiveness

- b. Measures most effective when exclusion is incorporated (i.e. fencing)
  - c. Location of crossing is most important factor
  - d. Reducing gaps in fencing also vital
43. Identify what is practical including: regional considerations, infrastructure considerations, etc.
- Maintain provincial interagency databases. NWR Geomatics has compiled OPP collision data with MTO Maintenance road kill data into a comprehensive database and incorporated this information into a mapping tool to identify areas of high collision rates.
  - Identify what works considering: regionally specific considerations, site specific considerations, empirical evidence, cost/benefit, etc.

Consider how the mitigation measures can be easily transferable into contract language. Wherever possible use existing contract standards and provisions to incorporate mitigation measures – see comments on passage benches above for example. The only measures that will be done are those measures that are translated into standard contract language including capital contracts and maintenance contracts.

44. Bring outside agencies (provincial, research institutes, ICs) with wildlife movement data/information on board early in the life of the project. Consider a broader approach (i.e. landscape).

Require structural design reports to include information about how the structure can accommodate wildlife passage/movement. Promote interdisciplinary discussion.

45. Dedicated funding for such initiatives

More long-term planning

Build this into the scope of work for engineering assignments

Planning to allow for time to conduct the research in advance of construction

More knowledge sharing across jurisdictions

Have a clear plan for what happens after construction so when new things are built there is a long term plan for maintenance and monitoring. Who is responsible should be established as well.

Avoid areas that support wildlife habitat when planning new or expansion highway projects

Develop coordinated recording system of roadkill between maintenance contractors and Environmental/ Planning and Design Function. This way, during design, wildlife mortality can be identified ahead of time.

46. It needs to be a recognized priority politically and legislatively to ensure that funding is allocated to it, to make it a common, accepted consideration and practice.
47. A provincial wildlife strategy regarding wildlife movement considerations using a landscape-level approach to prevent/reduce wildlife-vehicle collision conflicts for both large and small wildlife would be beneficial to support a coordinated approach across all sectors in the province. This would require collaboration amongst key players including environment, natural resources, forestry and transportation

ministries, provincial police, and municipalities. Individual, sector-specific guidelines on wildlife mitigation do exist. For example, MTO has an Environmental Guide to Mitigating Road Impacts to Wildlife which outlines species considerations and design recommendations to assist MTO staff with mitigation planning, design and placement of both temporary and permanent mitigation measures along provincial roads. Our natural resources ministry also has multiple guidelines and policies for species at risk mitigation.

To complement road mortality data reporting, it would be beneficial to develop a mechanism to support/promote public reporting of wildlife crossings/sightings on roadways to identify locations with elevated wildlife-vehicle collision risk. These datasets together would be valuable in identifying hotspots with more accuracy.

## Metropolitan Planning Organizations' Written Responses

### Question 8 Comments on Questions 4 and 5 – Barriers

[Return to Questions 4 and 5 results.](#)

MPO survey respondent's comments concerning barriers.

1. If mitigation is required, or dedicated funding is available, mitigation planning and project development/implementation will take place. Nothing speaks like something being the law or being paid for.
2. Our agency lacks the staff and the political climate places wildlife mitigation as a lower priority.
3. This is not a topic that comes up, in part because this area is not a hot spot for wildlife migration, other than birds. In 20 years, there has been one wildlife crossings project proposed and it did not get built for lack of funding.
4. Lack of need is a driving factor. Not aware of any serious accidents within the MPO involving game in the area.
5. Other hurdles include complexities with integrating projects into DOT plans, land-use planning issues, private landowner/agriculture conflicts, fencing concerns
6. Federal Highway would have to require or at the very least highly recommend incorporation of wildlife corridor studies and mapping into corridor planning to ensure State DOTs would incorporate the need into their planning work for regional planning agencies.
7. This is not something we've ever thought about. We have a lot of mandates to follow and we aren't likely to spontaneously add wildlife considerations to all the other things we have to consider. It isn't applicable to most or any projects on the long-range plan, and it would be up to local govs & state transportation to consider it for those projects (not the MPO level). I'm not sure where this would be relevant in our long-range planning at all.
8. I would say a lack of opportunity (because much of our planning is high-level or 20 years out) and a lack of ability to influence the DOT, which implements projects.

## Appendix C. Linkage Analyses Software

In GIS modeling of maps, different software products are used to find the theoretical linkages for target species. The publicly available software for these analyses are presented below.

Adapted from Cramer et al. 2014.

**Circuitscape:** <http://www.circuitscape.org/>.

Borrows algorithms from electronic circuit theory to predict patterns of movement, gene flow, and genetic differentiation among plant and animal populations in heterogeneous landscapes. It complements least-cost path approaches because it considers effects of all possible pathways across the landscape simultaneously.

**Connect:** <http://www.unc.edu/depts/geog/lbe/Connect/>

A set of tools that helps researchers and conservation planners model landscape connectivity for multiple wildlife species in complex heterogeneous landscapes. This planning tool packages three connectivity modeling tools: Circuitscape, NetworkX, and Zonation into user-friendly geo-processing toolbox for ArcGIS 9.3

**Connectivity Analysis Toolkit (CAT):**

[http://www.klamathconservation.org/science\\_blog/software/](http://www.klamathconservation.org/science_blog/software/)

Combines several new connectivity analyses and linkage mapping methods in an accessible user interface. Through centrality metrics it evaluates paths between all possible pairwise combinations of sites on a landscape to rank the contribution of each site to facilitating flows across the network of sites, indicating continuous gradients of habitat quality. It helps one to avoid the focus on delineating paths between individual pairs of core areas characteristic of most corridor or linkage mapping.

**Conservation Corridor** <http://www.conservationcorridor.org/>.

North Carolina State University's site on the science of connectivity. This is not software, but tracks the latest news and peer-reviewed literature on wildlife corridors and connectivity, and aims to bring the information to practitioners.

**Corridor Design:** <http://corridordesign.org/>

Paul Beier, a leader in connectivity analyses, hosts this website for his software. It gives the user a suite of ArcGIS tools to design and evaluate corridors that have been carried out by the State of Arizona.

**Crucial Habitat Assessment Tool:** <https://wafwa.org/initiatives/chat/>

The Western Governors' Association helped to create a mapping tool at a coarse scale, to view each of the western states' existing and potential wildlife linkages.

**Landscape America:** <http://www.landscape.org/focus/connectivity/>

Helps to plan for connectivity for wildlife. Presents different methods and tools. It is meant to compliment. Compaction tool for North Carolina State University Conservation Corridor site.

**Linkage Mapper:** <https://code.google.com/p/linkage-mapper/>

A GIS tool designed to support regional wildlife habitat connectivity analyses. It was created for the Washington Wildlife Habitat Connectivity working group. Launched in 2013. It uses Circuitscape to ID pinch points within least-cost corridors and to analyze linkage network centrality. *Note: They have a Climate Linkage Mapper – that maps corridors following climatic gradients to facilitate species' range shifts under climate change.*

A Linkage Mapper and Omniscape Comparison Paper was published in 2020 and can help users decide which tool works best for their landscape and goals. See Gallo et al. 2020 for full reference. See URL:

[https://figshare.com/articles/book/Comparing\\_and\\_Combining\\_Omniscape\\_and\\_Linkage\\_Mapper\\_Connectivity\\_Analyses\\_in\\_Western\\_Washington/8120924](https://figshare.com/articles/book/Comparing_and_Combining_Omniscape_and_Linkage_Mapper_Connectivity_Analyses_in_Western_Washington/8120924)

**MultyLink:** <http://pascal.iseq.utl.pt/~rbras/MulTyLink/>.

An open source software application designed to select connectivity linkages for distinct types of habitats, under cost-efficient protocols. Looks at linkages free of barriers, [may not work for landscapes with roads]. Shows right on first page how it could be applied to climatic classes and protected areas. European created.

**NetworkX:** <http://networkx.github.io/>.

Software for the creation, manipulation, and study of the structure, dynamics, and functions of complex networks. It is made for anything with nodes and networks.

**Zonation:** <http://cbig.it.helsinki.fi/software/zonation/>.

A conservation planning framework from Helsinki. It produces a hierarchical prioritization of the landscape based on the occurrence levels of biodiversity features in sites or cells, by iteratively removing the least valuable remaining cell while accounting for connectivity and generalized complementarity.

## Literature Cited

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