THE CASE FOR A NATIONWIDE COMMITMENT TO A SYSTEMATIC
NETWORK OF HIGHWAY CROSSINGS FOR WILDLIFE

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ABSTRACT

Wildlife-vehicle collisions are a growing problem and represent an increasing percentage of the accidents on our roads. The latest US transportation act authorized officials to reduce vehicle-caused wildlife mortality and maintain habitat connectivity across roadways. We present the case why we should set our minds, efforts and monies towards a nationwide commitment to a systematic network of wildlife crossings. In the last 20 years, studies have increasingly shown the successes of wildlife crossing structures in reducing wildlife-vehicle collisions and allowing safe passage. Crossing structures are effective mitigation measures with many benefits including increased motorist safety, monetary savings from property damage, wildlife protection, connected habitats, genetically viable wildlife populations and resiliency to changing climate. To attain a systematic network of crossings many local, state, tribal, and federal agencies need to collaborate on projects where their missions overlap. We propose a handful of modest improvements that would significantly improve the legal framework supporting implementation of wildlife crossing structures. We also suggest partnerships be used as a tool to advance wildlife crossing structures. We provide case studies that illustrate, people and agencies care and wish to contribute to make wildlife crossing projects happen. If we can follow through on most of our recommendations the result will be a transformed US road network that benefits people and is sensitive to the needs of wildlife.

Keywords: Cost-Benefit Analysis, Crossing structures Motorist safety, Partnerships, Wildlife mortality
INTRODUCTION

A quick glance at a United States (US) road map reminds us it’s an amazing example of engineered infrastructure (Sanderson et al. 2002). Despite being an asset for people, this same network is a major source of disruption for native wildlife that coexists on the landscape. And thus a tension exists – the efficient movement of goods and people while simultaneously addressing the needs of wildlife. In 2005, the US Congress under the “Safe, Accountable, Flexible, and Efficient Transportation Equity Act: A Legacy for Users” (SAFETEA-LU) directed the Secretary of Transportation to conduct a national study – which found that wildlife-vehicle collisions (WVCs) “are a growing problem and represent an increasing percentage of the accidents on our roads.” (Huijser et al. 2007). In 2012, the next iteration of the US transportation act known as “Moving Ahead for Progress in the 21st Century Act,” (MAP-21), authorized federal, state, municipal and tribal highway officials to reduce vehicle-caused wildlife mortality and to maintain habitat connectivity across roadways (23 USC §§ 101 et seq. (Center for Large Landscape Conservation 2012).

To reduce WVCs and to allow wildlife to safely cross roads requires a transformation in our collective thinking about how the US road network is designed. We can alter it from a network exclusively designed to serve the needs of people to one that also proactively and consciously accounts for the needs of wildlife. This will require strong transportation leadership, coordinated planning among transportation, wildlife and related agencies and a dedicated funding stream.

The purpose of this paper is to present the case for why it makes good sense to set our minds, efforts and monies towards a nationwide commitment to a systematic network of wildlife crossings. The focus of our attention is primarily high speed, high volume roads, although we acknowledge lower volume and lower speed roads may also require wildlife mitigation. Healthy wildlife populations and connected habitats are the goal. Wildlife crossing structures are the tools. The result will be a transformed US road network that benefits people and is sensitive to the needs of wildlife. This paper represents the collaborative work of engineers, ecologists, biologists, landscape architects and policy experts. The objectives were to:

1. clarify the ecological, economic, social and safety benefits of wildlife crossing structures, and
2. identify policies, funding mechanisms and partnerships that further their widespread adoption.

The consequences of not acting are to continue to risk the loss of human and animal life, to spend over $8 billion dollars a year in collision-related expenses (Huijser et al 2007), and to jeopardize the rich wildlife heritage we share as a nation. We have a limited timeframe in which to act to ensure that wildlife are given the opportunity to thrive despite continued fragmentation of wildlife populations and their habitat.

THE BASICS, COSTS AND BENEFITS OF WILDLIFE CROSSING STRUCTURES

For many years, transportation planners and wildlife biologists have sought effective solutions to the issues of WVCs and the barrier effect of highways on wildlife (Putman 1997, Glista et al. 2009). Initially, transportation departments were reluctant to invest taxpayer funds to build
wildlife crossing structures with little or no guarantee that animals would use them. The public and even many biologists originally believed that most animals would not use the structures. However, in the last 20 years, studies have increasingly shown the successes of wildlife crossing structures in reducing wildlife-vehicle collisions and allowing wild animals to safely cross highways (Clevenger et al. 2001, Sawyer et al. 2012, Van der Ree et al. 2015).

What are Wildlife Crossing Structures
The term wildlife crossing structure describes a variety of structures that are designed or retrofitted to provide safe passage for wildlife above or below a highway (Clevenger and Huijser 2011). Structures are often used in combination with fencing to increase their effectiveness. Structures range from the large and expansive to the small and obscure, hardly noticeable to drivers (Figure 1). Although wildlife crossing structures are not standardized designs, they can be categorized as two major types; overpasses and underpasses.

Wildlife Overpasses
Wildlife overpasses are some of the largest crossing structures. They extend habitat over highways and are considered to be the most effective means of re-connecting habitat over roadways.

Wildlife Underpasses
A wildlife underpass is essentially a “wildlife tunnel” or passage structure below a highway. Existing bridges and culverts can be replaced or retrofitted to enhance passage by terrestrial or aquatic organisms. Underpasses come in many different types and sizes, long span bridges which can keep habitats intact and nearly undisturbed below the roadway. Bridges typically span at least 20 feet across a waterway. Culverts are often smaller than bridges and typically box, round or elliptical. The larger the underpass the greater the diversity of wildlife able to use them. Small underpasses are used by species such as frogs, salamanders and squirrels and for some, may be the only safe way to cross a highway.

Costs of Installing Wildlife Crossing Structures
Direct monetary costs of ungulate-vehicle collisions
Ungulates such as deer, elk, and moose are the source of over 90 percent of wildlife-vehicle collisions with large animals and their related costs in North America (Huijser et al. 2007). Table 1 shows the average cost per collision that ranges from $6,617 for deer to $30,769 for moose (Huijser et al. 2009).

Cost effectiveness thresholds
For mitigation to be cost-effective there needs to be a break-even point or a dollar value threshold. Because we know the cost of different mitigation measures per year (Table 2), and their effectiveness at reducing wildlife-vehicle collisions (see Huijser et al. 2007), we can calculate the break-even point for sections of highway with high wildlife-vehicle collisions rates.
FIGURE 1. Examples of wildlife crossing solutions. Sketch reprinted with permission from Darin Martens.

<table>
<thead>
<tr>
<th>Description</th>
<th>Deer</th>
<th>Elk</th>
<th>Moose</th>
</tr>
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<tbody>
<tr>
<td>Vehicle repair costs per collision</td>
<td>$2,622</td>
<td>$4,550</td>
<td>$5,600</td>
</tr>
<tr>
<td>Human injuries per collision</td>
<td>$2,702</td>
<td>$5,403</td>
<td>$10,807</td>
</tr>
<tr>
<td>Human fatalities per collision</td>
<td>$1,002</td>
<td>$6,683</td>
<td>$13,366</td>
</tr>
<tr>
<td>Towing, accident attendance, and investigation</td>
<td>$125</td>
<td>$375</td>
<td>$500</td>
</tr>
<tr>
<td>Hunting value animal per collision</td>
<td>$116</td>
<td>$397</td>
<td>$387</td>
</tr>
<tr>
<td>Carcass removal and disposal per collision</td>
<td>$50</td>
<td>$75</td>
<td>$100</td>
</tr>
<tr>
<td>Total</td>
<td>$6,617</td>
<td>$17,483</td>
<td>$30,760</td>
</tr>
</tbody>
</table>

Huijser et al. (2009) compared the number of deer-, elk-, and moose-vehicle collisions per kilometer per year to the actual cost of different mitigation measures and the realized effectiveness of each technique.

For example, the average cost of building and maintaining a wildlife passage with fencing is $18,123 per year. A threshold of 3.2 deer-vehicle collisions per kilometer (km) per year is sufficient for installing fencing and one wildlife underpass so that the annual cost savings from the reduced collisions equals the annualized cost of constructing and maintaining the mitigation measures. The threshold value for collision rates with elk and moose are even less, 1.2 and 0.7 collisions per km per year, respectively.

TABLE 2. Threshold values for different mitigation measures used to reduce deer-vehicle collisions by >80%. Adapted from Huijser et al. 2009.

<table>
<thead>
<tr>
<th>Mitigation Measure</th>
<th>$ Cost (2007)/yr</th>
<th>Deer/km/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate 1</td>
<td>3%</td>
<td>3%</td>
</tr>
<tr>
<td>Fence</td>
<td>$6,304</td>
<td>1.1</td>
</tr>
<tr>
<td>Fence, underpass &amp; jump-outs</td>
<td>$18,123</td>
<td>3.2</td>
</tr>
<tr>
<td>Fence, under &amp; overpass, jump-outs</td>
<td>$24,230</td>
<td>4.3</td>
</tr>
<tr>
<td>ADS 2</td>
<td>$37,014</td>
<td>6.4</td>
</tr>
<tr>
<td>Gap, ADS &amp; jump-outs</td>
<td>$28,150</td>
<td>4.9</td>
</tr>
<tr>
<td>Elevated roadway</td>
<td>$3,109,422</td>
<td>470</td>
</tr>
<tr>
<td>Road tunnel</td>
<td>$4,981,333</td>
<td>752.8</td>
</tr>
</tbody>
</table>
Do Wildlife Crossing Structures Work and How Do They Benefit People?
Wildlife crossing structures have a proven track record for promoting safe passage across highways in North America. More than 15,000 crossings by 16 species of animals were recorded at six underpasses along State Route (SR) 260 in Arizona over a seven-year period (Dodd et al. 2007). More than 49,000 crossings by mule deer were recorded at seven large culvert underpasses along US 30 in Wyoming in the first three years (Sawyer et al. 2012). More than 4,300 desert bighorn sheep crossed three overpasses on US 93 in Arizona in just over two years (Arizona Game and Fish Department 2015). More than 150,000 crossings by 11 species of large mammals were detected between 1996-2014 at over two dozen crossing structures on the Trans-Canada Highway in Banff National Park, Alberta (Clevenger and Barrueto 2014).

Increased motorist safety
Wildlife-vehicle collisions are a serious and growing source of human injuries, deaths, and tremendous property loss. There are an estimated 1-2 million WVCs each year in the US, with 26,000 human injuries and 200 human deaths; the total economic impact exceeds $8 billion/year (Huijser et al. 2007). As such, motorist safety is the primary driver of many projects mitigating highway impacts to wildlife.

Wildlife crossing structures also have a proven track record for reducing wildlife-vehicle collisions: crossing structures and fencing on the Trans-Canada Highway in Banff National Park reduced WVCs involving all large mammals by >80% and ungulates >94% in a two-year pre-construction versus two-year post-construction analysis (Clevenger et al. 2001). A retrofit fencing project linking three existing crossing structures on Arizona SR 260 reduced elk-vehicle collisions by 98% over 6 years (Dodd et al. 2007). Seven small underpasses and fencing on US 30 in Wyoming reduced mule deer-vehicle collisions by 81% in the 3 years after their installation (Sawyer et al. 2012).

Monetary Savings
As the rates of wildlife-vehicle collisions have increased over the past two decades, agencies are increasingly seeking to mitigate highways in more cost-effective ways. Wildlife crossing structures reduce WVCs, thus effectively reducing the many costs to society, e.g., fatalities, human injury, property damage, loss of hunting revenue, etc. (Conover et al. 1995). These estimated annual benefits from reduced wildlife-vehicle collisions have exceeded $200,000/mile (Dodd et al. 2012).

Wildlife Protection
With 1-2 million large wild animals killed by cars every year; this mortality can significantly impact wildlife populations and threaten long-term population persistence, especially for threatened and endangered species (Huijser et al. 2007). Highways are the leading cause of mortality for some wide-ranging mammals (Maehr et al. 1991, Brandenburg 1996). They have been responsible for population declines among many amphibian populations (Hels and Buchwald 2001, Gibbs and Shriver 2005). By physically separating wildlife from traffic, crossing structures protect individual animals from death or injury (Forman et al. 2003).
**Connected Habitats**

Habitat connectivity is the degree to which habitats are linked on the landscape to facilitate wildlife movement and access to important resources for eating and mating (Crooks and Sanjayan 2006). Permeability is the degree to which the roadway features offer safe crossing opportunities for wildlife to access habitats on the other side. High-traffic highways with average daily traffic greater than 7000 vehicles/day constitute nearly total barriers to passage by most wildlife. Some highways with traffic as low as 100 vehicles per hour are barriers to grizzly bears (Waller 2015).

**Genetically Viable Wildlife Populations**

Highways can act as barriers that can isolate wildlife populations and alter gene flow and diversity (Riley et al. 2006). A system of wildlife crossing structures can allow individual animals to disperse and mate with individuals in other populations. Grizzly bear populations across western Canada and the northern U.S. have been documented as being genetically isolated by highways (Proctor et al. 2005). Recent research provided compelling evidence that wildlife crossing structures maintain genetically viable populations of black and grizzly bears that otherwise would be isolated by a high volume highway (Sawaya et al. 2014).

**Resiliency to Climate Change**

With changing climatic patterns and increasingly frequent extreme weather events that wreak havoc on transportation infrastructure, wildlife crossing structures can help increase resiliency. The installation of oversized drainage structures can help accommodate increasingly frequent and large flood events, while at the same time better serve as effective wildlife crossing structures that promote highway permeability and habitat connectivity. Increasing landscape connectivity has been recognized as the top strategy for helping species respond to a changing climate (Heller and Zavaleta 2009).

**What Type of Wildlife Crossing Structure is Best?**

The two main objectives of most, if not all, wildlife crossing mitigation are: 1) to connect habitats for wildlife populations and 2) reduce mortality of wildlife on roads. That said, no two projects mitigating highways for wildlife are the same. After nearly two decades of monitoring and research, however, here are some lessons learned:

- Wildlife crossing structure design, size, and placement are important considerations that influence how different species respond to structures (Forman et al. 2003, Beckmann et al. 2010). There is no one-size-fits-all solution since many design considerations are site- and species-specific (Clevenger and Huijser 2011).

- Species exhibit preferences for certain types of crossing structures. Some species (grizzly bears, moose, wolves, elk, deer, desert bighorn sheep) tend to use large, open structures, while others (black bears, cougars) use more constricted structures with less light (Clevenger and Barrueto 2014, Gagnon et al. 2011, Sawaya 2014).

- Wildlife crossing structures designed and managed for multiple species help maximize biodiversity conservation.
It takes time for wildlife to find, learn and habituate to new crossing structures. This learning curve can be several years for even the most adaptable species such as deer (Gagnon et al. 2011, Clevenger and Barrueto 2014). Thus, monitoring must be of sufficient duration to properly evaluate the effectiveness of wildlife crossing structures.

How well wildlife crossing structures perform is partly dependent upon the land management that surrounds them. Transportation and land management agencies need to coordinate in the short- and long-term to ensure that tracts of suitable habitat are available adjacent to wildlife crossing structures (Clevenger and Huijser 2011).

Fencing is a critical component of a successful mitigation strategy involving wildlife crossing structures because fencing deters animals from entering the highway and directs them to the structures (Clevenger et al. 2001). Without fencing, crossing structures are much less effective.

Prioritizing and Planning
Prioritization is essential to focus limited resources to locations of the highest collision-risk and conservation priority. State Departments of Transportation (DOTs) are beginning to use west-wide Crucial Habitat Assessment Tools (CHATs) to more efficiently and effectively inform transportation and conservation planning across the West (Western Governors Association 2008). Non-western state wildlife agencies possess similar tools and digital data in the form of wildlife habitat conservation maps, which when merged with State-wide Transportation Improvement Program (STIP) plans, facilitates the integration and coordination of transportation and wildlife habitat networks well in advance. By prioritizing conservation improvements through consistent, data-based planning, state DOTs can cost-effectively address state and regional conservation needs in the short- and long-term.

TRANSFORMING THE US ROAD NETWORK TO BENEFIT PEOPLE AND WILDLIFE
A systematic approach to mitigating wildlife impacts from highways is challenging because, no single agency is responsible for sustaining movement of animals across the landscape. Adhering to agency missions often creates a ‘silo’ approach, making it difficult for agencies to collaborate. However, to accomplish the goal of maintaining healthy wildlife populations through reduced vehicle collisions and improved wildlife movement potential, many local, state, tribal, and federal agencies need to collaborate on projects where their missions overlap (see Beckmann et al. 2010).

Here are some examples of the challenges of agency collaboration and some possible solutions:

- Highways traverse all national forests in the country, yet those highways are often managed by another federal agency or a state DOT. Federal transportation and land management agencies have missions and approaches that may not overlap. However, these same agencies can create crucial partnerships in mitigating wildlife movement across highways. The DOTs have excellent engineering design skills and resources, while
the natural resource agencies manage the land that serves as wildlife habitat and have the knowledge of wildlife movements and behavior needed to design effective mitigation.

- Generally, long-range transportation capital improvement plans do not have wildlife crossing provisions. Land management plans rarely include provisions for wildlife movement across highways. This could be overcome by implementing standardized wildlife conservation clauses in Memoranda of Understandings (MOU) between federal or state or transportation or land management agencies.

- Federal or state natural resource agencies are often too busy to productively participate in early coordination for transportation agencies and often wait until final plans are nearly completed to review for permitting and regulatory purposes. Early coordination among state and federal agencies could lead to more efficient scheduling of projects as well as increased opportunities for mitigation. States could encourage more timely and useful natural resource agency participation in the planning process by providing standardized and more easily interpretable Statewide Transportation Improvement Programs (STIPs).

- Timelines vary greatly among agencies and schedules for planning, projects, and funding are often misaligned, such that opportunities are missed. States that include wildlife connectivity goals in their State Wildlife Action Plan increase their opportunity to identify and prioritize wildlife corridors.

- States are increasingly limited in maintenance funds for new and aging infrastructure, thus they are reluctant to add to their maintenance workload with wildlife crossing structures. While federal funds can pay for construction of wildlife crossing structures, states bear the burden of maintenance. Aging infrastructure may be eligible for rehabilitation funds from FHWA, depending on their rating. The ability to include the cost of maintenance in funding proposals for new construction would reduce the state burden of implementing wildlife crossing structures.

- Even though wildlife do not recognize jurisdictional lines in their movements, states have little incentive to work across state boundaries, and may even be prohibited from working across borders. Federal agencies thus have a major opportunity to help facilitate seamless coordination among adjacent states much in the way the Western Governors’ Association is striving to do (Western Governors Association 2008).

- Multiple agencies result in multiple missions and priorities. Agencies may have contradictory or conflicting laws, regulations and mandates. Agencies with good working relationships can creatively and legally leverage funding and opportunities to accomplish implementation of wildlife crossings, even though funding for planning and implementing highway projects may be vastly unequal.

Melding Missions

Natural resource, land management and transportation agencies have several overlapping areas of interest that can be used to dovetail transportation objectives with wildlife connectivity objectives. In 2006, a suite of federal agencies developed a planning framework called Eco-
Logical, to encourage agencies to work together in a formalized manner early in highway
development, thus allowing for all stakeholder missions to be considered as part of the project
objectives (Brown 2006). Since its inception, the FHWA has encouraged interagency and public-
private partnerships to engage in more frequent cooperative efforts, data sharing, and more
streamlined projects with better environmental outcomes.

LEGAL OR POLICY SUPPORT FOR WILDLIFE CROSSING STRUCTURES

In 2012, the U.S. Congress and the President broke new ground when they enacted the current
surface transportation law, known as Moving Ahead for Progress in the 21st Century Act, 23
U.S.C. §§ 101 et seq. (MAP-21). A watershed event, MAP-21 is the first national transportation
law to weave throughout its programs explicit authority for state, federal and tribal managers to
reduce the number of motorist collisions with wildlife and ensure connectivity among habitats
disrupted by roads. These provisions may be used to support the construction of wildlife crossing
structures, they do not require it. Nor does MAP-21 authorize a dedicated source of funding for
environmental mitigation, let alone for wildlife crossing structures. We propose a handful of
modest improvements that would significantly improve the legal framework supporting
implementation of wildlife crossing structures.

Federal Transportation Law

The following MAP-21 programs allow managers to use program dollars to fund wildlife-related
mitigation, including the construction of wildlife crossing structures:

• Surface Transportation Program (§ 1108) – Eligible projects under the Surface
Transportation Program include activities to mitigate hazards caused by wildlife.

• Highway Safety Improvement Program (§ 1112) – Eligible projects under the Highway
Safety Improvement Program include the addition or retrofitting of structures or other measures
(including the construction of wildlife crossing structures themselves) to eliminate or reduce
wildlife-vehicle collisions.

• Tribal and Federal Lands Transportation Programs and Federal Lands Access Program
(§ 1119) – Funding from these programs may be used to pay for environmental mitigation in or
adjacent to tribal land or Federal public lands to improve public safety and reduce vehicle-caused
wildlife mortality while maintaining habitat connectivity. The Federal Lands Transportation
Program includes a cap of $10,000,000 per fiscal year for eligible environmental mitigation
activities.

• Transportation Alternatives (§ 1122) – Funding from the Transportation Alternatives
Program may be used for a program or project activity to reduce vehicle-caused wildlife
mortality or to restore and maintain connectivity among terrestrial or aquatic habitats.

MAP-21 also requires state and metropolitan long-range transportation plans to include a
discussion of the types of potential environmental mitigation activities and potential areas to
carry out these activities, including activities – such as wildlife crossing structures – that may
have the greatest potential to restore and maintain the environmental functions affected by the
plan (§§ 1201-1202).
Improving Legal Support for Wildlife Crossing Structures

There are various improvements to enhance motorist safety, reduce wildlife mortality and conserve habitat connections that could be incorporated into the next transportation law, thereby balancing the nation’s goal of providing for the safe, efficient movement of goods and people, with its need to mitigate the effect of roads on valuable natural resources. By taking these few modest steps, Congress could greatly improve the legal framework supporting construction of wildlife crossing structures wherever they are needed.

1. Develop a standardized methodology for collecting and reporting wildlife-vehicle collision and carcass data and ensure public access to that data.

In some states, transportation agencies collect no wildlife-vehicle collision or carcass data at all. In others, data are collected inconsistently and haphazardly, using different methods. As a result, none of the three national databases for collecting crash information provides a reliable, standardized assessment of wildlife-vehicle collisions. Nor is there a national database for wildlife carcass data.

2. Enhance the ability of the FLMAs to meet MAP-21’s directive to mitigate wildlife-highway conflicts.

The Federal Lands Transportation Program (FLTP) improves multi-modal access within national parks, forests, wildlife refuges, Bureau of Land Management lands, and U.S. Army Corps of Engineers facilities. The Federal Lands Access Program (FLAP) provides funds for State and local roads that access the Federal estate. FLTP funding can be used to pay for environmental mitigation in or adjacent to Federal land open to the public to improve public safety, reduce vehicle-caused wildlife mortality and mitigate other harmful effects of roads. There is, however, a cap of $10 million per fiscal year for eligible activities. This limitation hinders the ability of the FLMAs to fulfill MAP-21’s directive to mitigate wildlife-highway conflicts.

3. Consider inflation in FLTP and FLAP, since there has not been an increase in the programs since before 2005.

FLTP has remained fairly flat at around $240 million per year (National Park Service 2013) under both SAFETEA-LU and MAP-21. The cumulative rate of inflation from 2006 thru March 18, 2014, based on the US government’s Consumer Price Index, was 16.5 percent, effectively reducing the program’s buying power and ability to meet its needs. Making a reasonable increase to restore FLTP and FLAP to their prior levels would help provide sufficient funds to enable federal land managers to fulfill MAP-21’s directives, including environmental mitigation.

POWER IN PARTNERSHIPS

Partnerships can be used as a tool to advance wildlife crossing structures (Beckmann et al. 2010). As the case studies throughout this document illustrate, people and agencies care and wish to contribute to make these projects happen. It is crucial to also identify public and private interests and engage them to expand support, as well as achieve stakeholder “buy-in,” of wildlife crossing structures.
Five basic points of building partnerships

1. Emphasize not only an agency cooperation/commitment but also a personal connection between individual people with passion. Agency personnel are not permitted to advocate but this does not preclude exhibiting passion in other useful ways, such as offering local experience and technical expertise.

2. Create bigger private-public partnerships for the greater good; be careful when defining the partnerships. Define the specific purpose of the partnership, objectives, milestones, etc. to ensure understanding and a ‘roadmap’ of where the process is going and what the group hopes to achieve.

3. Explore opportunities to increase wildlife mitigation funding by using existing transportation program funding to leverage additional funds from other sources – public or private. This will decrease competition for limited transportation funds. Perhaps, due to the greater participation with those delivering matching funds, there will be a greater sense of shared achievement.

4. Timing is everything and there is a good time for certain partners. Participants will fall in and out of the process depending on the phase, and they will change over time. If possible, define project phases and identify the participants/partners that would be most helpful for each phase.

5. Partnerships can be risky (but rewarding) and therefore may require additional time to build trust. Partners may include a public interest advocacy groups that have been on the opposite end of project issues with the transportation agency. This type of partnership may feel risky but it will be better to have advocates and agencies working together to complete a wildlife mitigation project than being in opposition. Be clear about roles, process, and the group’s goals and uncomfortable partners can quickly become great allies.

Six main components of a collaborative process framework:

1. Purpose - There should be a well-defined problem and purpose that is being worked on. This will allow all parties to know what to expect. It should be flexible enough to allow new partners to join, particularly if they can help with funding (No. 2 above).

2. Members - Invite members who are affected and interested in the outcome of the collaboration. Members should have some authority to make decisions, (No. 1 above).

3. Activities - Be clear about what the scope of the project is, what data is needed, and what gaps there are in information that needs to be filled. Pick activities that are germane to the issues at hand.

4. Key Obstacles - Identify early potential points of friction and the needs of the participants. Strive for unity to attack problems rather than attacking the other participants based on small differences.
5. **Process** - Structure the meetings (workshop type, lecture, etc) to use time efficiently and maintain interest of participants. Set up a time frame so the process is efficient, to assure participants don’t lose interest.

6. **Products** - Identify a common goal. Define what the group wants as the outcome, and have a clear metric to identify when you have reached it. Allow for compromise if the outcome is not fully achievable.

**THE PATH FORWARD**

In the past decades we have witnessed broad, diverse and successful wildlife crossing structure deployments, from panther crossings in Florida, to bighorn sheep crossings in Arizona, to grizzly bear crossings in Montana, to salamander crossings in Vermont. Given this robust and growing body of work, the logical next step is to create a nation-wide systematic approach to reduce wildlife-vehicle collisions, conserve wildlife and promote connectivity across the US road network.

For a nation that celebrates its rich and diverse natural heritage, the challenge before us is to reweave our landscapes so that our surface transportation system fully considers, and takes responsibility for its effect on our valued wildlife. This appears to be the challenge for today, as well as the next generation of transportation and natural resource practitioners and policy makers.

The path forward has many facets, most of which are achievable actions that can be taken without delay with inspired leadership:

- **Stimulate the political will to create a transportation act that includes a programmatic approach to deploying wildlife crossing structures.** Science and research support the effectiveness of wildlife crossing structures. The transportation act should articulate the criteria for prioritizing problematic wildlife-vehicle collision areas, wildlife habitat corridors and other important locations for wildlife mitigation.

- **Acknowledge that multiple applications of fine scale local support of connectivity have large-scale impacts.** The most prevalent recommendation by scientists and ecologists to help wildlife adapt to climate disruption is to maintain landscape connectivity so they can move and adjust to changing circumstances. Thus, it is crucial that future transportation policy provides for safe wildlife passage across the road network no matter the jurisdiction.

- **Coordinate a common path forward among agencies.** Top ranking agency officials will need to be engaged, provide direction and offer guidance to align goals and objectives of the many, often disparate, transportation, wildlife, land management and environmental agencies participating in transportation planning and projects.

- **Make a concerted effort to invest in research and development (R&D).** Assuring an adequate percentage of each highway program is allocated to R&D could easily resolve this issue. Similarly, for the private sector, if it is well established that transportation and natural
resource agencies are making a concerted effort to deploy mitigation for wildlife, then innovation for smarter, less expensive, more effective measures will be rewarded.

- Work to increase awareness and understanding across many key groups in society, such as administrative leaders, politicians, transportation practitioners and the general public. Broadly speaking, all of these groups need to more fully understand the scientific, social and economic advantages to a systematic approach to wildlife mitigation and the application of wildlife crossing structures as a proven solution.

- Educate and cross-train students and professionals. Educational opportunities, both for the current workforce, and for engineers and natural resource students preparing for their careers at US universities and other institutions of higher learning needs to be broadened. Workforce training for those already in professional careers is currently sparse and sporadic for understanding the impacts of roads on wildlife and the solutions. Similarly, engineers, ecologists and planners receiving a university education, by in large, do not have courses, or portions of courses, dedicated to Road Ecology principles and practices.

A Solution to the Funding Conundrum

Under the current paradigm, wildlife mitigation competes with all the other needs of highway programs and numerous other priorities. When competing for safety improvement program dollars, the dilemma is that wildlife-vehicle collisions have a much lower severity ranking (i.e., fatality rates, serious injury rates) than other causes of crashes. Therefore, road segments with high WVC rates do not necessarily receive prioritization for safety dollars compared to roads that have high human fatality or injury rates.

What is needed is to remove the funding issue by making wildlife mitigation an independent highway program. If wildlife-vehicle collisions cost American drivers an estimated $6-12 billion a year, then having a highway wildlife program with funding at a level that allows transportation agencies to adequately address and reduce wildlife-vehicle collisions and provide for connectivity appears to be a rationale investment of public funds. Some estimate that the problem could be completely addressed in one generation. For example, if $1 billion a year was used for the next 20 years, 1,000 million-dollar crossings could be built each year and result in 20,000 crossings in a generation. This would make the U.S surface transportation system highly permeable and safer for wildlife and drivers, alike.

One possible revenue stream for this new highway program could be for a portion of each insurance claim that was made due to a crash with an animal be put in to a wildlife mitigation fund for the program. An agreeable portion (e.g., $10, $100) of each insurance claim would be sent to the fund by the insurer. Given there are an estimated 1-2 million wildlife-vehicle collisions each year, many resulting in insurance claims, this has the potential to generate billions of dollars for wildlife over a generation. And of course as the program is implemented, the need for funding will be reduced and parallel to this, the money generated by wildlife-vehicle collisions insurance claims will also be significantly reduced over time.
CONCLUSIONS

Making our surface transportation system more permeable for fish and wildlife movement and protecting drivers from millions of crashes with large animals each year is a daunting task, and there simply is no time like the present to take this on. The good news is there are no technical barriers stopping the US from solving this dilemma. Wildlife crossing structures are proven measures and cost-effective.

Everyone has a role to play in the transformation of the US road network as we know it. From the concerned citizen to the scientist or engineer, and all manner of experts and interested parties in between. It is also the responsibility of any agency in the road-wildlife-landscape interface to consider and work towards mitigating the impacts of roads and other transportation infrastructure on wildlife. Many state and national policies already support the use of dollars for this purpose. A dedicated funding stream will build on the investments already made and make it easier for more transportation practitioners and agencies to join in partnership towards the new norm of wildlife crossing structures as a standard practice across the US.

To make this issue evaporate, we, as a nation, simply need the political will, agency resolve and adequate funding to add to public support. Creating a transportation system that does what is necessary to deliberately co-exist with nature is a powerful contribution to our nation and the world.

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