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White Paper: The Incorporation of Wildlife Crossing Structures into TxDOT's Projects and Operations

Nan Jiang, Ph.D.
Patricia Cramer, Ph.D.
Lisa Loftus-Otway

February 2019; Published June 2019

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TxDOT Project 0-6971: Incorporating Wildlife Crossings into TxDOT's Project Development, Design and Operations Processes

Performing Organization: Center for Transportation Research The University of Texas at Austin 3925 W. Braker Lane, 4th Floor Austin, Texas 78759	**Sponsoring Organization:** Texas Department of Transportation Research and Technology Implementation Office P.O. Box 5080 Austin, Texas 78763-5080

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Executive Summary

Each year an average of 7,585 crashes that involve either wild or domestic animals are reported to the Texas Department of Transportation (TxDOT) (TxDOT crash data, 2010–2017). From 2010 to 2017, 160 people lost their lives in these crashes and hundreds more sustained injuries. The crash data are limited, however, in that they represent only crashes where a police report is created. Many more animal-vehicle collisions occur where an individual might not either report the crash or file a claim on their insurance, and the animal may be hurt but moves away into cover, or may be killed but not noted through the official police process. The number of large mammals killed could be five to ten times higher (Olson, 2013; Donaldson and Lafon, 2008). To reduce these collisions, and make Texas roads safer for the traveling public, it is important to provide opportunities for wildlife to cross beneath or above the roadway via wildlife crossing structures.

TxDOT commissioned the Center for Transportation Research (CTR) at the University of Texas at Austin to conduct this research project to review the state of the practice in animal-vehicle conflict mitigation options and provide guidance. This research project summarized national and statewide efforts to reduce animal-vehicle conflict, analyzed the animal-involved crash data in Texas, developed a methodology to identify animal-vehicle crash hot spots, and evaluated the benefits and costs of developing certain wildlife crossing structures. To make consideration of wildlife crossings a routine part of the TxDOT project development procedure, this project also recommended language modifications to 18 TxDOT manuals and developed a guidelines document on wildlife crossing structures. The project findings demonstrate that data-driven, carefully planned, and well-designed wildlife crossing structures can enhance traffic safety significantly, are cost-effective, and ensure that TxDOT plays a considerable role in preserving wildlife for the benefit of future Texans.

The purpose of this white paper is to provide a high-level overview concerning animal-vehicle conflict, including these elements:

- What are the safety and economic impacts of animal-vehicle conflict?
- Under what conditions should wildlife crossing structures be considered?
- How can planners identify the optimal mitigation strategies and what implementation issues need to be considered?
- What are some successful experiences from Texas and other states?

Developing wildlife crossing structures or other mitigation strategies is a complicated process, one that needs to be supported by detailed data analysis. Its success is highly dependent on the collaboration within and among different divisions within TxDOT and also other relevant wildlife and resource agencies. The findings and final products of this project are expected to help make wildlife crossing structure consideration and creation a regular part of TxDOT’s project development procedure and contribute to TxDOT’s role as a leading state in reducing animal-vehicle conflict issues.

Chapter 1. Introduction to Animal-Vehicle Conflict

Every year in the U.S. millions of wild animals die, and approximately 200 humans are killed and thousands seriously injured because of wildlife-vehicle interactions, creating economic losses of over $1 billion annually (Donaldson and Lafon, 2008). A crash can be caused by drivers swerving to avoid hitting an animal, or by direct vehicle-animal collisions.

Texas has a large and diverse wildlife community, across 12 distinct ecoregions, yet a wild animal population's survival can be affected by transportation infrastructure and vehicles. As Texas's human population grows, the paths of humans and wildlife will continue to intersect. These collisions diminish human safety and cost Texas citizens millions of dollars every year in vehicle damage, medical costs, carcass pickup and disposal, and other associated time and monetary costs.

State Farm Insurance tracks wildlife-vehicle collisions annually and estimates that 1 out of 169 U.S. drivers will have a claim from hitting a deer, moose, or elk in any given year. State Farm's analysis of 2015 data found the average claim cost was $4,135 (State Farm, 2015). According to the Insurance Institute for Highway Safety, Texas has twice as many motorists killed in vehicles colliding with wild animals than any other state (Catto & Catto, 2016).

> Analysis of Texas crash data from 2010 to 2017 found 60,685 crashes reported an animal encounter as the first harmful event, resulting in 160 human deaths and thousands of human injuries.

Currently, Texas is ranked third among all states in terms of the number of animal-vehicle collision related insurance claims; San Antonio and Austin are the two Texas cities experiencing the greatest number of incidents (National Insurance Crime Bureau, 2018). Many property-damage-only crashes go unreported across the U.S., and wildlife researchers found 5.26 (Olson, 2013) to 9.7 (Donaldson and Lafon, 2008) large wildlife species carcasses for every reported wildlife crash.

> These animal collisions cost Texas citizens millions in direct costs every year, while decimating some animal populations and creating clean-up and disposal costs for TxDOT and local governments.

These societal costs do not include the ecological costs of potentially losing wildlife populations. For example, the Texas endangered ocelot population has dwindled to fewer than 50 individuals. Each animal death due to vehicle collisions decreases the species' chance of surviving into the future. TxDOT is required to develop mitigation options for animals with threatened and endangered status as designated by the U.S. Fish and Wildlife Service (USFWS), such as the ocelot. The mitigation often includes incorporating wildlife crossing structures into transportation plans or on an existing road. The next chapter outlines the process to determine when to implement such a crossing.

Chapter 2. Why and When to Consider Wildlife Crossing Structures and Mitigation Strategies

Many mitigation measures can be taken to connect habitats and wildlife populations and increase motorist safety while lowering wildlife mortality. Iuell et al. (2005) summarized these measures into five categories:

- Wildlife overpasses.
- Wildlife underpasses.
- Specific measures: fencing, gates and escape ramps, signage, vehicle-animal detection systems, speed reduction, lighting, and reflectors.
- Habitat adaptation: manage habitat and right-of-way, intercept feeding.
- Infrastructure adaptation: modify road infrastructure (curbs, drainage, gates, etc.) to better accommodate wildlife movement (e.g., increase the width of road median).

State departments of transportation (DOTs) have been installing various types of wildlife crossings as they have developed, or re-developed, highways, bridges, culverts, and landscaped public rights-of-way. In many instances, the cost of including wildlife-crossings in transportation projects is a relatively small percentage of the overall cost of highway projects. For example, the inclusion of more than 40 wildlife crossings in the reconstruction of a 56-mile segment of US 93 in Montana added just $9 million (averaging $225,000 per crossing) to the $133 million project.

The TxDOT Pharr District has retrofit existing structures and built new wildlife crossing structures for the ocelot. Pharr District has retrofit structures on SH 100 to accommodate wildlife so they can use the culverts as de facto crossing structures, at a cost of approximately $6.6 million. The installation of eight wildlife crossing structures on FM 106 and major structural repair to the roadway itself in total cost about $14.6 million. According to the monitoring results, over 20 different species of animals have used these structures. For example, in August 2018 at a camera tracking station, an ocelot was spotted in front of a crossing on SH 100, validating the cost and efforts.

2.1. Data Analysis

Data should drive the decision process when determining whether to construct wildlife crossing structures. An analysis of crash data can help determine locations where frequent animal-vehicle crashes pose a serious safety issue to motorists.

Crash data provide pertinent information regarding the location, severity, intensity, and other characteristics of animal-vehicle crashes. A careful analysis of this type of data should form the basis of the decision-making process.

TxDOT's Crash Records Information System (CRIS) database contains detailed information about all reported crashes in Texas since 2010. A query created by setting "First Harmful Event" equal to "Animal" generates all animal-vehicle crashes in a specified location and time frame. The "TxDOT Guidelines for Reducing Wildlife-Vehicle Conflict and Promoting Wildlife Connectivity" developed by this project (0-6971 Final Report Appendix I) details the process of extracting animal-vehicle crash data using the TxDOT Crash Query Tool.

> The final report of this project contains examples of the methods used to analyze the statewide animal-vehicle crash data.

With the extracted data on animal-related crashes, users can perform Geographic Information Systems (GIS) hot-spot analyses to identify animal-vehicle collision hot spots at the local, TxDOT District, or statewide levels. In turn, the hot spots can be prioritized for actions to accommodate wildlife movement with retrofits to existing structures that promote wildlife connectivity, in future TxDOT projects, or as stand-alone projects to install wildlife mitigation.

The map in Figure 2.1 demonstrates wildlife-vehicle collision crash hot spots in Texas based on crash rate calculated using average wildlife-vehicle crash count from 2010 to 2016 and 2016 vehicle miles traveled information. The "TxDOT Guidelines for Reducing Wildlife-Vehicle Conflict and Promoting Wildlife Connectivity" developed in this project includes detailed instruction on how to conduct the hot-spot analysis. This analysis considers traffic volume, crash severity, and other factors to identify the locations with the greatest safety concern. With the hot spots identified, specific mitigation strategies can be developed based on the roadway infrastructure conditions, environmental conditions, animal species and activity patterns, and other factors of the specific spot.

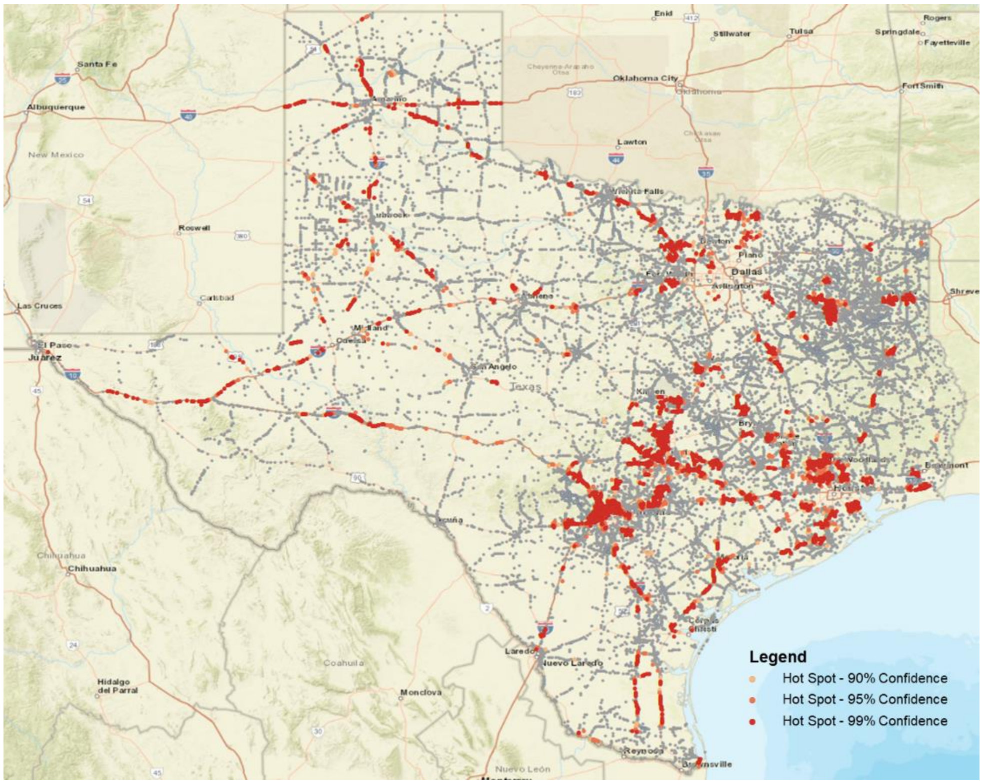

Figure 2.1. Wildlife-vehicle collision crash hot spots in Texas

2.2. Economic Savings to Motorists

From 2010 through 2017, 60,685 animal-related crashes were reported in Texas. During these eight years, there was an annual average of 7,585 animal-related crashes, 19 fatal crashes, 108 suspected serious injury crashes, and 410 non-incapacitating injury crashes, which all average a total cost of over $647 million per year for Texas motorists[1].

The benefit-cost analysis conducted in this project showed high benefit-cost ratios for implementing different types of mitigation, especially when underpasses/overpasses are combined with fencing. The benefit-cost equation uses the structures' initial construction costs and annual maintenance costs. The benefits are many, but can be difficult to quantify (e.g., restoring habitat continuity, positively impacting public perception, etc.), and as such were not included in the benefit calculations. The benefits were chiefly the costs saved from the reduction of crashes.

[1] Costs are calculated using TxDOT 2018 crash costs: $3.5 million per fatal or serious injury crash, $0.5 million per non-incapacitating injury crash.

The map in Figure 2.2 displays the 100 network links (the red dots on the map) that returned the highest benefit-cost ratios from this project's analysis of introducing an underpass structure with wildlife fencing. Additional structures and maps, as well as the analysis details, are provided in the final report (0-6971-1).

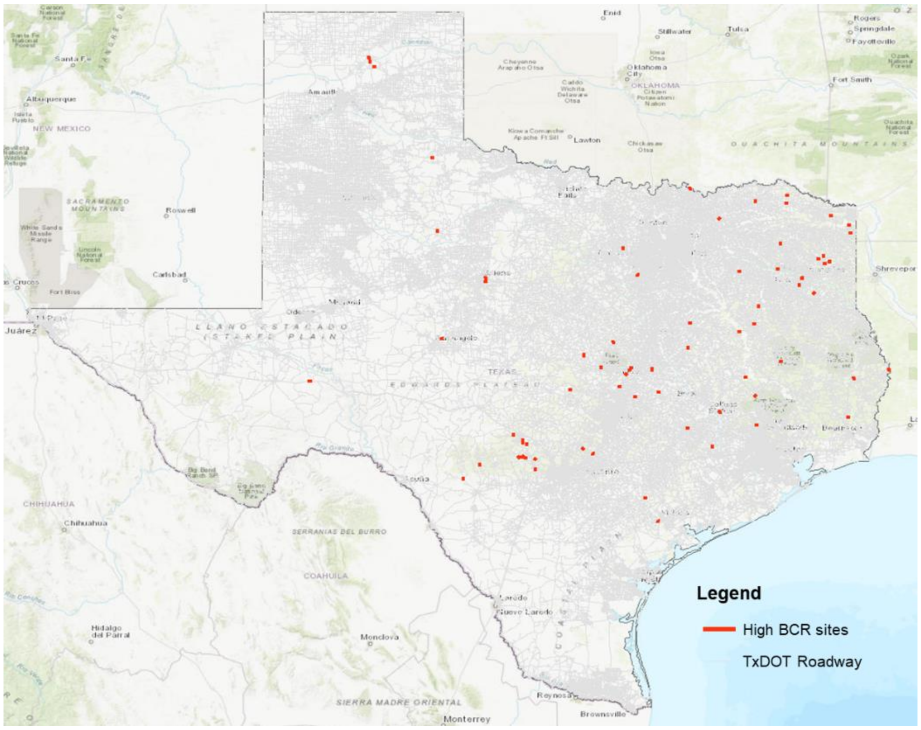

Figure 2.2. Sites on the Texas roadway network that may benefit most from intervention in the form of an underpass structure

In summary, wildlife crossing structures and mitigation strategies should be considered when crash data indicate that animal-vehicle conflict poses a serious safety concern and the benefit of the structure outweigh the construction and maintenance cost.

Chapter 3. How Can We Do This?

3.1. TxDOT's Recent Research

In this project, the CTR research team conducted detailed data analysis using Texas animal-vehicle crash data, including animal-vehicle crash characteristics analysis and hot-spot analysis. This study also estimated the benefit-cost ratio of implementing different types of mitigations and identified roadway segments that generate high benefit-cost ratios for implementing certain types of mitigation strategies.

Based on the data analysis conducted in this project and the experience shared by several TxDOT districts and DOT personnel in other states, the research team developed the document, "TxDOT Guidelines for Reducing Wildlife-Vehicle Conflict and Promoting Wildlife Connectivity" as well as recommended language modifications for existing TxDOT manuals. With the guidance of these manuals and the information included in this project's final report, wildlife crossings can be smoothly incorporated into TxDOT's project development, design, and operation processes.

3.2. TxDOT's Inclusion of Animal-Vehicle Conflict Mitigation into the Planning Process

Wildlife crossing structures not only enhance motorists' safety but also protect our environment. This section describes completed wildlife collision mitigation strategies in the Pharr District and Lufkin District and how they were incorporated into transportation projects.

3.2.1. Pharr District: Box Culverts/Bridges (or Underpasses) for Ocelots

TxDOT's Pharr District budgeted $5 million for four wildlife crossing structures under SH 100 in a scheduled construction project (between Laguna Vista and Los Fresnos) to reduce ocelot deaths. Cameras monitoring these structures recorded more than 850 individual animals of various species using one of the crossing structures in one year. An ocelot was photographed looking into the crossing, although it did not use the crossing (Figure 3.1). Bobcats have also been documented passing through structures and using them as a day bed. University of

Texas Rio Grande Valley students monitor the structures for TxDOT, and in 2018 created a video[2] of animals using one of these crossing structures on SH 100.

(a) Ocelot looking into a crossing on SH 100

(b) Bobcat using an underpass on SH 100

Figure 3.1. Ocelot near and bobcat using wildlife crossing structures on SH 100 in Pharr District (Source: Robin Gelston from Pharr District)

Between 2014 and 2018 the Pharr District constructed 12 wildlife crossing structures (underpasses) on FM 106 (8) and SH 100 (4). They vary in size and shape but the majority of them are box culverts greater than 5 feet high by 5 feet wide, some with ledges (or steps approximately 2 feet high and 1.5 feet wide) and some without ledges. Box culverts with ledges are used when a wildlife crossing structure is placed in an existing drainage ditch. On SH 100 the wildlife crossing structures were placed in association with wildlife exclusion fence and wildlife guards. There were two wildlife guard designs: nine guards had round bars, and nine had the flat bar grated design. No escape ramp or exits were installed at that time; however, some have since been placed. FM 106 had only associated wildlife exclusion fences. Adaptive management and design changes made in the field throughout the building process helped to create culverts with ledges that extended beyond the water bodies present. This helped animals to move above the water to enter, traverse, and exit the wildlife crossing structures (see Figure 3.2).

In the Pharr District, wildlife crossing structures and guards are handled as "design in progress." This designation allows for necessary changes identified in the field during construction. These changes are then added to the next project's standard.

Another example of the District's adaptive design changes is the update that was made to the original round pipe wildlife guards. These originally had 3-inch diameter pipes and a 4-inch I-beam to hold up the pipes. Unfortunately, cameras

[2] https://www.youtube.com/watch?v=ZcA1cv3y6Ac

documented that the repel rate (0.77) of these guards was lower than anticipated. The District modified the design to reduce the size of the pipes and I-beam to improve the repel rate for the different species that attempted to cross these wildlife guards. This new design will be used on the next project with wildlife crossing structures planned on FM 1847.

Figure 3.2. FM 106 wildlife crossing box culvert with ledges and ramps, which facilitate animal use of structure. Photo Courtesy of L. Loftus-Otway

The Pharr District has identified multiple factors to consider in the placement of wildlife crossing structures fencing and guards. These have included habitat for the particular species, location of conservation lands, travel corridors of species, known mortality locations of the particular species, landscape, water table, drainage patterns, utility location, driveways, wetlands, TxDOT right-of-way location, and driver expectation. All the wildlife crossing structures on SH 100 and FM 106 were placed with these factors considered.

Pharr District personnel found that the process of customizing the standard box culvert and bridge designs to act as a wildlife crossing structures needed to be approved and designed by the Bridge Division. This can be a lengthy process as it falls outside the normal standard design specifications. This customization takes time that needs to be planned for. This project recommends TxDOT embed some of the Pharr District designs into the design manual that provides current standard designs specification to allow for faster implementation. Plans, Specifications and Estimate drawings for these designs can be found in the 0-6971 final report or obtained from the Pharr District or the TxDOT Bridge Division.

3.2.2. Lufkin District: Bridge Replacement Leads to Longer Span

The Lufkin District undertook a bridge replacement project to lengthen the spans on two bridges to provide adequate space for wildlife species to cross underneath SH 21. This roadway has two bridges a short distance apart—one bridging the Attoyac River main channel and another bridging the relief channel. The Lufkin District decided to create a single structure spanning both the river and the relief channel, providing ample space for large terrestrial species to cross below while also preventing impacts to bridge infrastructure. This model of an extended bridge can help keep the construction out of the 100-year floodplain, thereby helping to reduce the need for specific permits. The plan, profile, and bridge layouts depict the new structure overlaid on the existing structure, demonstrating the additional area provided beneath the bridge (interested readers can refer to the 0-6971 final report). The new bridge is close to 1,200 feet long. Bridge plans and schematics can be obtained from Lufkin District or TxDOT's Bridge Division.

3.3. Example Costs

The costs of wildlife crossing structures are highly dependent on the specifications of the structure and the local environmental conditions. Following are some rough costs of different structures based on TxDOT's past experiences:

- Underpass costs depend on the culvert size (5x5, 6x5, 8x5, 7x7, 10x7, 10x5, 6x4) and whether a ledge is involved; costs have ranged from $12,000 to $200,000. Larger or longer culverts can cost upwards of $500,000 or more.
- Bridges (44x6 or 74x6.5) range from $167,030 to $450,000. Bridges with longer spans and additional lanes of traffic can cost upwards of millions of dollars.
- Fencing costs depend on the height and material used (stainless steel or PVC coated) and the foundation requirement (simply buried or placed in concrete); cost ranges from $11.00 to $22.50 per linear foot.
- Wildlife guards cost approximately $28,500 each in the Pharr District.
- Annual maintenance costs have not been calculated at this time. These would include fence repair and upkeep, clearing debris from the culvert, and vegetation control at the entrances of structures.

3.4. Choosing Options to Mitigate Animal-Vehicle Collisions

The “TxDOT Guidelines for Reducing Wildlife-Vehicle Conflict and Promoting Wildlife Connectivity” document developed in this project contains detailed guidelines for choosing types of mitigation for potential retrofits and new construction. Table 3.1 is a summary of those potential mitigation options.

Table 3.1 Choosing Mitigation Options (source: Cramer et al., 2016)

Measure	Level of Difficulty to Deploy (Time and Effort)	Effectiveness	Use across the U.S	Cost
1. Actions that Target Wildlife Behavior				
1.a. Detract Wildlife from Roadsides				
Supplemental feeding away from the road to draw animals from the roadside	Low	Unknown	Low	Low
Vegetation management	Low	Low-Medium	Unknown	Low
1.b. Deter Wildlife from Roadway				
Wildlife deterrent devices mounted on roadside posts that produce noise & reflect light	Medium	Low	Low	Medium
Boulder fencing	Low	Medium	Low	Low
Reflectors, whistles	Low	Low	High	Low
1.c. Exclude Wildlife from Road and Provide Below- or Above-grade Crossings				
Wildlife fencing with wildlife or double cattle guards & escape ramps	Medium	High	High	Medium to High
Wildlife crossing structures with wildlife fencing, escape ramps & guards	High	High	High	High
1.d. Reduce Wildlife Populations				
Sharpshooting deer in suburban areas to reduce population	Low-Medium	Medium-High	Medium	Low
2. Actions that Target Drivers				
2.a. Public Education and Awareness				
Public awareness campaigns	Medium	Largely Unknown	High	Low
2.b. Signage				
Static driver warning signs	Low	Low	High	Low
Variable message boards	Low	Low-Medium	High	Low
2.c. Speed Reduction				
Wildlife crossing zones with a reduced motorist speed limit	Low	Low-Medium	Low	Low

Measure	Level of Difficulty to Deploy (Time and Effort)	Effectiveness	Use across the U.S	Cost
2.d. Driver Warning Systems				
Thermographic cameras to detect wildlife on or near the road – used in a vehicle or along the road with a driver warning system	High	Medium (Experimental)	Low	High
Animal detection systems with driver warning signs	High	Low-Medium	Low	High

Chapter 4. Procedures for Developing Animal-Vehicle Conflict Mitigation with Examples

The actions DOTs take to mitigate animal-vehicle collisions can be condensed into five steps, as shown in Figure 4.1.

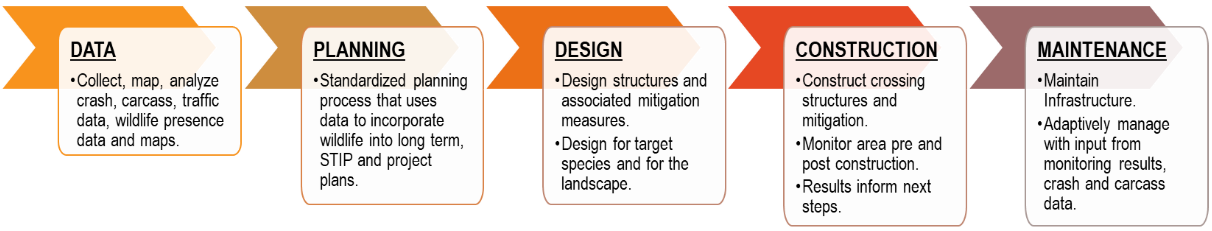

Figure 4.1. Steps to mitigate transportation for wildlife

4.1. Data

In the Data step, the transportation agencies collect crash data. Then researchers, traffic safety staff, and environmental staff access the data to query for reported collisions with wildlife and livestock, locate potential areas of wildlife presence from telemetry data, and habitat maps and examine road traffic volumes. These data analyses lay the foundation for developing effective mitigation strategies.

4.1.1. Crash, Carcass, and Wildlife Locational Data

While all states have standardized crash data collection from traffic safety officers, many states have developed standard operating procedures for collecting more details on the types of animals associated with collisions (e.g., in Nevada, the officers have a 14-species pull-down menu to select from when reporting an animal-vehicle collision). Crash data are crucial to locating the extent of a wildlife-vehicle conflict problem areas because it is the only data systematically collected in the same manner across a state.

> Smartphone apps and computer software allow users to enter carcass data with accurate GPS locations, and are becoming increasingly more prevalent across the U.S.

Several states have created carcass data collection smartphone apps and computer software that are used by state agency staff, and in some instances the public, to log data on animal carcass sightings along roads. If DOTs and wildlife agencies have access to more specifics about animal-vehicle collisions—including location, animal species, and other factors—these agencies can create more targeted and effective solutions.

- **Utah** developed a smartphone app in 2012 that is used by their carcass removal contractors, Utah DOT personnel, highway patrol, and Utah Division of Wildlife Resources personnel to automatically record the GPS location, as well as the species, gender, and age of the animal. The full record is uploaded to an interactive website once the user is within cell-phone range. The data are immediately available for mapping and analyses[3].
- **Washington** has software for carcass collection on maintenance workers' iPads, which uploads the information entered into the Washington DOT workbench online.
- **South Dakota** created a smartphone carcass app in a matter of weeks and, after testing in 2017, moved to require all carcass contractors to use the app in picking up carcasses.
- **Idaho** Department of Game and Fish has a website[4] developed in conjunction with the Idaho Transportation Department that is available for professionals and the public to upload carcass information. The site allows for information upload (no photos) and downloads. The site is beneficial in that it allows anyone to map carcasses online at any time and with different filters.

Wildlife locational data are used to assist in transportation planning. This helps prevent future potential delays and cost increases if important and legitimate wildlife concerns arise in the development of a transportation project. It also helps to protect motorists and wildlife from collisions. State wildlife agencies, USFWS, and academic institutions typically monitor wildlife with GPS collars and locators. These projects are also funded by DOTs. Data on these animals' locations can help to determine the need for wildlife crossing structures. Nature Serve, the Natural Heritage Program, and wildlife agencies in each state also maintain maps and plans that delineate important wildlife habitat. Every state has a Wildlife Action Plan as a starting point to learn of potential wildlife concerns relevant to future transportation plans. Taken together these data, maps, and plans can inform the following planning and design steps.

[3] https://mapserv.utah.gov/wvc/desktop/index.php

[4] https://fishandgame.idaho.gov/species/roadkill

4.1.2. Data Mapping and Analysis

Most states conduct analyses and mapping of the crash, carcass, and traffic volume data to some degree. Such efforts can result in either static maps or real-time applications, generated whenever an agency employee needs to map crash and carcass data. These maps are typically created with hot-spot modeling software to identify the areas of greatest concern for wildlife-vehicle conflict. DOTs are moving toward allowing any user to map crash and carcass data at any time, as needed.

- **Utah** has a mapping system that allows mapping of crash data in conjunction with carcass data, with many filter options[5].
- The University of **California**, Davis has a mapping function for the public or agencies to use to locate carcasses[5].

The analyses of the crash, carcass, and traffic volume data are not routinely conducted by multiple divisions or personnel within a DOT—typically it is the traffic safety engineers that examine overall crash data. In some states data analyses also include the examination of carcass data for trends in wildlife-vehicle conflict. However, DOTs across the board do not analyze crash, carcass, and other data to identify priority areas and then bring that insight, as a matter of course, into long-term and statewide transportation improvement program planning.

4.2. Planning

State DOTs are realizing the need to create a standard, transparent process to identify animal-vehicle conflict hot spots, coupled with cost-effective solutions that are defendable to the public. States that have successfully built dozens of wildlife crossing structures take the step of considering wildlife movement patterns with respect to roads. They use data on animal-vehicle collisions, wildlife agency habitat maps, and locational data from wild animals with GPS and radio collars. Most often, this information is brought into long-term planning processes in districts or regions with wildlife champions within the DOT. Several states have initiated and completed studies to create standardized data analyses procedures for reducing wildlife-vehicle collisions. Some of these state efforts are listed below.

- **Washington and Arizona** DOTs had wildlife crossing structures champions within their agencies who created a protocol for prioritizing actions to reduce wildlife-vehicle conflicts.

[5] https://udot.numetric.com/#/

- **Idaho** DOT and to some degree the **South Dakota** DOT created standardized data analyses procedure as recommended by the studies conducted by Dr. Cramer (Cramer et al., 2014; Cramer et al., 2016).
- **Nevada** DOT created identified priority areas of wildlife-vehicle collision in 2018 (Cramer and McGinty, 2018).
- **Montana** DOT created a Wildlife Accommodation Process (Harris and Traxler, 2018).
- **California**'s DOT (Caltrans) has a standard procedure for developing wildlife crossings, as shown in Figure 4.2 (Caltrans, 2009).

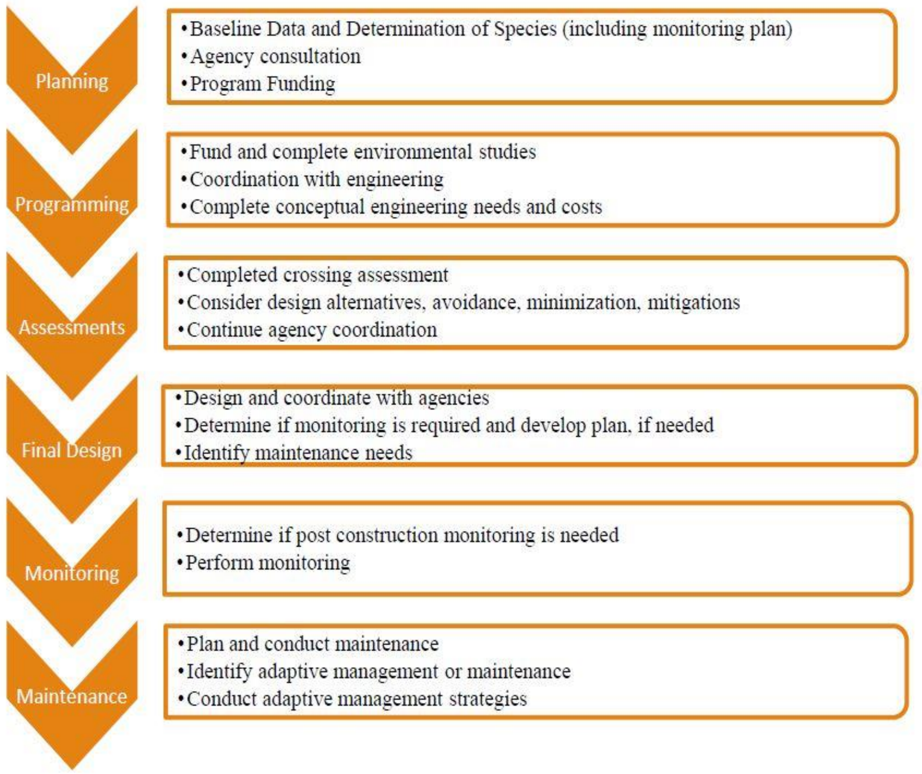

Figure 4.2. Synopsis of Caltrans decision tree phases for wildlife crossings (source: Harris and Traxler, 2018)

4.3. Design

The states with the more progressive programs to mitigate their roads for wildlife have standardized designs for various types of wildlife crossing structures, fences, escape ramps, and deterrents. Typically these designs target larger species, such as mule and white-tailed deer, elk, and bighorn sheep. Different designs are used for smaller animals, such as ocelots (in Texas), tortoises, and turtles.

4.4. Construction

The fourth step in developing wildlife crossing structures is the actual construction of the infrastructure, and monitoring the area pre- and post-construction to evaluate the structure's effectiveness according to performance measures. The "TxDOT Guidelines for Reducing Wildlife-Vehicle Conflict and Promoting Wildlife Connectivity" document developed by this project provides many examples of both construction and retrofit photos. Examples are shown for new construction in Figure 4.3 and for retrofits in Figure 4.4.

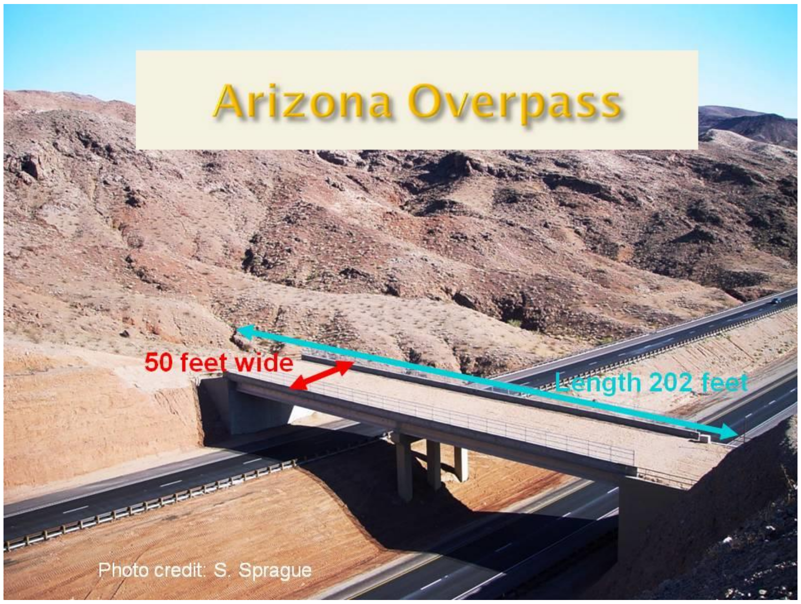

Figure 4.3. Desert bighorn sheep overpass on US 93 in Arizona. Photo courtesy of S. Sprague, Arizona Game and Fish Department.

Figure 4.4. Left: Minnesota DOT wildlife path created in rip rap; Right: Montana DOT wildlife shelf and an entrance ramp for smaller wildlife. Photos courtesy of P. Cramer.

4.5. Maintenance

The personnel who maintain wildlife mitigation infrastructure over the long term are critical to a successful project. Yet these on-the-ground staff members are often not included in the planning process, although their input may be helpful in determining the locations for wildlife crossings, configuring the structures, and helping create cost-effective solutions. Many of the wildlife-crossing success stories share a common element: maintenance personnel was involved long before the structures were constructed.

Maintenance personnel’s adaptive management of structures and fences is critical. Their carcass collection and recording activities are also important for locating wildlife-vehicle collision areas. When the wildlife crossing structures and other infrastructure are monitored pre- and post-construction, the results often give state DOTs and their partners opportunities to adaptively manage for effective solutions, and the maintenance personnel is often those who enact those actions.

For example, in TxDOT’s Pharr District. vegetation management has been important to the 12 wildlife crossing structures developed on SH 100. Pharr District landscape architects planted native species at most crossing structures. On SH 100 at the newly installed crossings, TxDOT staff planted all native species, and also integrated an innovative solar-powered watering system for the plants. Figure 4.5 shows the native plants at one end of the crossing. Plant maintenance will be part of the district maintenance staff’s responsibility, along with the environmental staff.

Figure 4.5. Native plants in front of wildlife crossing on SH 100 in Pharr District. Photo courtesy of L. Loftus-Otway

Also in the Pharr District, on SH 48, TxDOT designed a vegetation plan with over 250 plants consisting of 9 different native species in front of a crossing. TxDOT collaborated with USFWS on this effort. USFWS was responsible for planting the vegetation and TxDOT will be responsible for ongoing maintenance and upkeep.

Chapter 5. Conclusions

The research investigation into the state of the practice within the U.S., globally, and here in Texas revealed that mitigation strategies for animal-vehicle conflict are easier to implement than might be expected. These strategies deliver positive results, and alerting the public to these beneficial outcomes through social media can create a win-win situation for TxDOT and its districts.

Several Pharr District planners and engineers noted that their experience of building crossing structures gives them a strong sense of pride. They enjoyed telling their children that they just built something for animals to cross the roadway so that the animals won't get killed by vehicles—their children's excitement at this news was gratifying for these staff, as parents and as public servants.

Several TxDOT districts have already initiated programs to minimize animal-vehicle collisions, have seen successful results and can provide guidance on planning as well as plans, drawings, photos, and schematics. TxDOT's Pharr District has photo evidence of the highly endangered ocelot in front of one of its newly installed crossings—a major accomplishment that will solidify TxDOT's vital role in ensuring the protection and recovery of this species.

Five different species of animal had used this new crossing on SH 100 on July 11, 2018. Photo courtesy of L. Loftus-Otway

This research project was another important step that TxDOT's Environmental Affairs Division and Research and Technology Implementation Division undertook to look deeper into this issue and find solutions through a data-driven process. As demonstrated by the project's findings, if mitigation strategies are developed based on solid data analysis, careful study of the environmental conditions, and coordination among different divisions within TxDOT, the strategies can be cost-effective and deliver results. Mitigation strategies can substantially improve traveler safety, foster wildlife connectivity, alert TxDOT staff to the value in preserving the state's wildlife, and ensure that Texas will demonstrate leadership on this issue for other state DOTs.

Promoting wildlife crossings will also assist TxDOT in achieving the strategic plan goals of promoting safety, delivering the right projects, focusing on the customer, fostering stewardship, optimizing system performance, and valuing employees. Overall, preserving animal populations and saving motorists' lives are both high-value outcomes for Texas citizens.

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