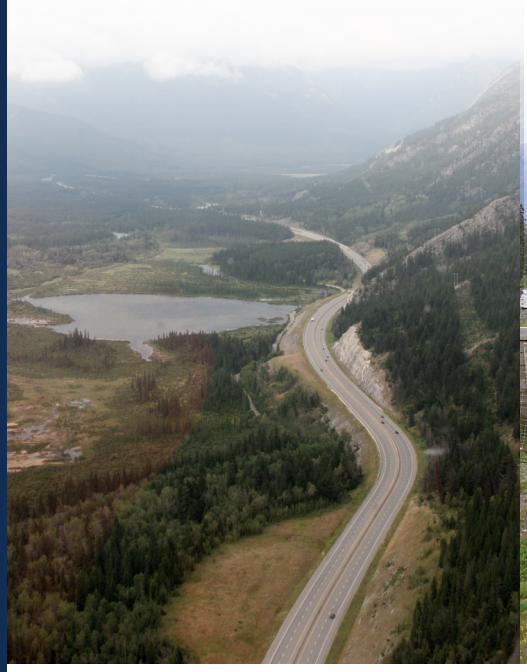
Crossing to Safety

An Executive Summary of the

FHWA Handbook for Design and Evaluation of Wildlife Crossing Structures in North America



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Prepared for
Federal Highway Administration
US Department of Transportation

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This document is an Executive Summary of the Handbook for Design and Evaluation of Wildlife Crossing Structures in North America prepared for the Federal Highway Administration (FHWA) by the Western Transportation Institute at Montana State University.

The objective of the handbook is to provide technical guidelines for the planning, design and evaluation of wildlife crossing structures that facilitate the safe movement of wildlife across roads and increase motorist safety. The handbook provides information on how to increase the effectiveness of established designs and recommends ways to design for particular species and species groups in different landscapes. The guidelines can be used for wildlife crossings on new or existing highways, highway expansions, and bridge reconstruction projects.

Since this summary document is intended as an overview of wildlife crossing structures, full technical guidelines and sources are not included.

In much of the North American West, road networks are extensive and the volume of traffic on rural roads has sharply increased, as wild lands are progressively being developed and suburbanized. This new frontier phenomena results in vast changes in land use patterns and the alteration of natural habitats that leads to increased motorist-wildlife conflicts. In the East, the footprint of road systems is relatively stable compared to the growing New West phenomena. Nevertheless, traffic volumes in the East continue to rise on existing roads; suburban areas are expanding amidst a general trend of increasing deer populations.

ACKNOWLEDGEMENTS

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FOR MORE INFORMATION

For more detailed information about the research sources and guidelines, please consult the full report, available from the FHWA:
Clevenger, A. P. and M.P. Huijser. 2009. **Handbook for Design and Evaluation of Wildlife Crossing Structures in North America**. Department of Transportation, Federal Highway Administration, Washington D.C., USA.

To contact the authors directly or to learn more about the Road Ecology research program at the Western Transportation Institute, please visit the WTI website: **www.westerntransportationinstitute.org**

PHOTO CREDITS

Photos courtesy of WTI/MSU, T. Clevenger or M. Huijser unless indicated otherwise.

Introduction

How Wildlife Crossing Structures improve motorist safety and protect wildlife populations

The massive 4 million-mile system of public roads in the United States is used by more than 200 million vehicles. By all projections, the system – and the number of people who use it – will continue to grow substantially over the next 25 years.

Traffic and roads play a significant role in many major environmental challenges, including the long-term sustainability of wildlife populations. Roads traverse landscapes, bisect ecosystems and disturb local habitats. The presence of roads with traffic can affect wildlife in numerous ways:

- Roads and associated traffic result in loss of wildlife habitat and reduced habitat quality.
- Some animals may be attracted to roadways, but roads may also limit wildlife access to key resources.
- Roads fragment wildlife populations into smaller and more vulnerable subpopulations.
- Roads can significantly increase wildlife mortality. The total number of motor vehicle accidents with large wildlife each year has been estimated at one to two million in the United States and at 45,000 in Canada.

The intersection of wildlife and transportation corridors can also affect human safety and mobility. More critically, these accidents can cause costly damage, serious injury, or even death.

Wildlife Crossing Structures – A Mitigation Success Story

Over the last decade, transportation and natural resource management agencies have become increasingly aware of the effects that roads have on wildlife. As these agencies plan for road construction, expansion, or improvements, they work to avoid, mitigate or compensate for any adverse impacts on the surrounding environment.

Wildlife crossing structures represent one mitigation tool that can be used as part of an overall ecological preservation plan. As their name implies, wildlife crossing structures are usually overpasses or underpasses that help animals cross from one side of a road to another.

Wildlife crossing structures are gaining interest with transportation agencies worldwide. Interest in these structures is growing primarily because they are one of the most effective mitigation measures for increasing habitat connectivity across roads and reducing wildlife-vehicle collisions.

Crossing structures are a costly investment. Transportation and natural resource agencies need thorough technical guidance for the planning, design and evaluation of wildlife crossing mitigation for the measures to be most effective. Technical guidelines and best management practices have not been articulated and are still much in need for many North American wildlife species and their habitats. The FHWA Handbook for Design and Evaluation of Wildlife Crossing Structures in North America is the

product of an extensive collection and synthesis of current literature, knowledge, and research regarding the current practices in wildlife crossing mitigation. It provides a sound scientific basis for effective planning, policy and implementation of mitigation aimed at reducing both habitat fragmentation and wildlife-vehicle collisions. Moreover, the handbook describes how to increase the effectiveness of established designs and recommends ways to design for a range of species and species groups in North America.

The Handbook and this Executive Summary are organized to address the three most common planning questions:

- Where should wildlife crossing structures be located?
- What should they look like?
- How will I know if they are working?

Planning and Placement

Where should structures be located?

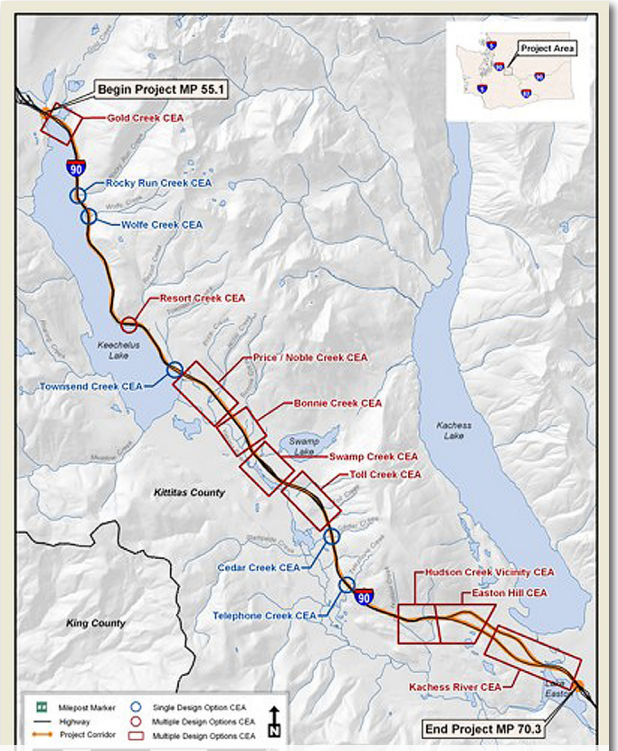
Planning for wildlife crossing structures requires a long-term approach. The lifespan of crossing structures is 75 to 80 years; moreover, agencies must understand how to predict wildlife conservation concerns and integrate them with a growing infrastructure and a changing landscape.

While each structure must be planned individually to address the specific needs, there are common elements to the planning process for all wildlife crossing structures.

Project-level vs. Landscape-level planning

In general, two different scales of habitat connectivity planning are used. Wildlife crossing structures and other mitigation measures can be developed at the project level or the systems or landscape level.

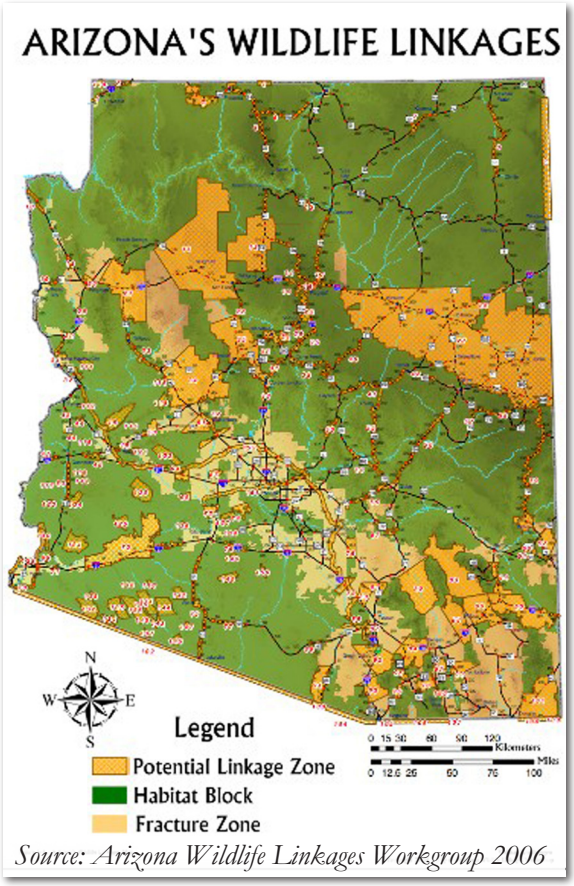
The project-level approach is usually focused on a transportation corridor and its specific transportation objectives. This approach is commonly used by transportation agencies because it is well- defined and addresses multiple



Source: Washington State Dept of Transportation

management concerns. For example, a wildlife crossing structure might be incorporated into projects to reconstruct a segment of roadway with a need for safe animal passage and a high rate of wildlife-vehicle collisions.

The systems- or landscape-level approach is becoming more common, as agencies consider how wildlife crossing structures fit into the larger landscape. This approach requires planners to consider large-scale spatial considerations and future land use change. It ensures that wildlife



Source: Arizona Wildlife Linkages Workgroup 2006

are not only crossing a roadway safely, but that animals will have long-term access to their entire habitat. Systems-level planning generally requires a greater commitment of time, resources and cooperation from multiple agencies; however, it has several benefits:

- Promotes the identification of key habitat zones and connectivity linkage areas and their proximity to transportation corridors;
- Helps agencies prioritize mitigation projects according to financial, scheduling or ecological criteria; and
- Helps multiple agencies work together to address long-term transportation and wildlife needs, climate change and other challenges.

Planning Resources

Deciding where to locate wildlife crossing structures requires adequate tools and resources to identify the most suitable sites for crossing structures at the project-level and systems-/landscape-level. Many resources are available that can help define important wildlife habitat linkages across roads and identify key areas for mitigation:

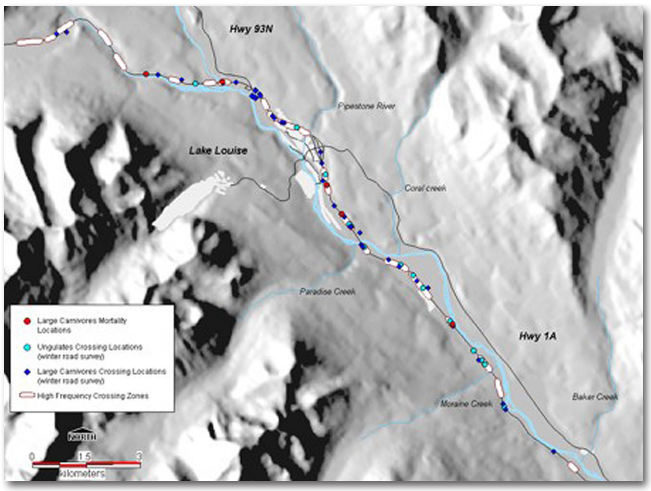
- Aerial photos
- Land cover-vegetation maps
- Topographic maps
- Landownership maps
- Wildlife habitat maps
- Wildlife movement model data
- Wildlife ecology field data

Field research provides invaluable data on where wildlife interact with roads, either crossing or attempts to cross. Field data can be collected using various techniques including:

- Road-kill data to identify mortality hotspots
- Radio and satellite telemetry to monitor animal movements around roads

- Capture-mark-recapture to study wildlife distribution and population density
- Road surveys to determine crossing locations
- Track beds to estimate the number of crossings at specific locations
- Camera detection to study wildlife distribution and abundance
- DNA sampling to identify individual animals, their gender and general crossing areas

GIS-based movement models can be used to identify key habitat linkages, evaluate habitat fragmentation resulting from human activities, and reveal areas where high-



ways are permeable to wildlife movement. These models simulate the movements of wildlife across habitats and landscapes and can be used to help select specific locations for wildlife crossing structures. The models are most effective when derived from real field data and tested with an independent data set.

No Data. When agencies lack data for planning the location of wildlife crossing structures, there are other options. Wildlife experts can be consulted to help develop expert-based habitat suitability models or conduct rapid assessments. Local knowledge can also be used to identify key movement areas.

The most critical part of site selection is compatibility of adjacent land use, in the present and future. Mitigating highways for wildlife is a long-term process lasting many decades. Wildlife crossings will only be as effective as the land management strategies developed around them.

DESIGN

What Should Structures Look Like?

Once a location has been determined, a specific design is needed that best meets the goals of the project. The design must take into account the following considerations:

- Wildlife species the structure is intended for
- Primary function of the structure (connect habitats, improve safety, etc.),
- Wildlife habitat connectivity potential at the site
- Physical topography and limitations of the site
- Potential types of wildlife crossing structures suitable for site
- Supporting infrastructure required (e.g., fencing, escape ramps)
- Management of adjacent lands
- Integration of structure with the larger wildlife corridor network

Wildlife crossing structures come in a variety of shapes and sizes and can be divided into 11 different design types. This section provides an introduction to the 11 structures, with general information regarding dimensions (minimum and recommended),and species suitability. Most designs can be adapted to accommodate the requirements of additional non-target species.

The handbook contains more comprehensive guidelines for each of these designs and species in North America including design details, local habitat management, landscaping, maintenance, etc.

Overpass Design

1. Landscape bridge – Designed exclusively for wildlife use. Due to their large size they are used by the greatest diversity of wildlife and can be adapted for amphibian and reptile passage.

Dimensions:

- Minimum Width: 230 ft (70 m)
- Recommended Width: >330 ft (>100 m)
- Fence/berm (height): 8 ft (2.4 m)
- Soil depth: 5-8 ft (1.5-2.0 m)

Species recommendations:

- Ungulates: Moose, Elk, Deer, Pronghorn, Bighorn Sheep, Mountain Goat
- Carnivores: Black Bear, Grizzly Bear, Wolf, Coyote, Fox, Cougar, Bobcat, Lynx, Wolverine, Fisher, Marten, Badger, Weasel
- Low mobility medium-sized mammals
- Small mammals
- Reptiles

2. Wildlife overpass – Smaller than landscape bridges, these overpass structures are designed exclusively to meet needs of a wide range of wildlife from small to large.

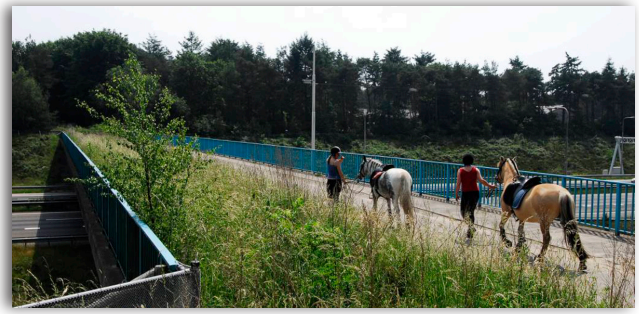
Dimensions:

- Minimum Width: 130-165 ft (40-50 m)
- Recommended Width: 165-230 ft (50-70 m)
- Fence/berm (height): 8 ft (2.4 m)
- Soil depth: 5-8 ft (1.5-2.0 m)

Species Recommendations:

- Ungulates: Moose, Elk, Deer, Pronghorn, Bighorn Sheep, Mountain Goat
- Carnivores: Black Bear, Grizzly Bear, Wolf, Coyote, Fox, Cougar, Bobcat, Lynx, Wolverine, Fisher, Marten, Badger, Weasel
- Low mobility medium-sized mammals
- Small mammals
- Reptiles

3. Multi-use overpass – Generally the smallest of the wildlife overpasses, these structures are designed for mixed wildlife-human use. This wildlife crossing type is best adapted in human disturbed environments and will benefit species adapted to regular human activity and disturbance.



Dimensions:

- Minimum Width: 32 ft (10 m)
- Recommended Width: 50-82 ft (15-25 m)

• Fence/berm (height): 8 ft (2.4 m)
• Soil depth: 1.6-3.2 ft (0.5-1.0 m)

Species Recommendations:
• Ungulates: Elk and Deer
• Carnivores: Coyote, Fox, Bobcat, Fisher, Marten, Badger, Weasel
• Low mobility medium-sized mammals
• Small mammals
• Reptiles

4. Canopy crossing – These structures are designed exclusively for semi-arboreal and arboreal species that commonly use canopy cover for travel. They meet the needs of species not built for terrestrial travel and that generally have difficulties crossing open, non-forested areas.

Dimensions:
• Ropes at least 3 in (8 cm) diameter.
• Wooden platforms at least 1 ft (30 cm) wide.
• Two steel cables parallel to one another, separated by 8-12 in (20-30 cm) with a nylon net fabric between the cables.

Species Recommendations:
• Semi-arboreal mammals, including: Tree Squirrels, Flying Squirrels, Fishers, Martens, Raccoons, Ringtails, Coatis and Opossums.

Underpass design

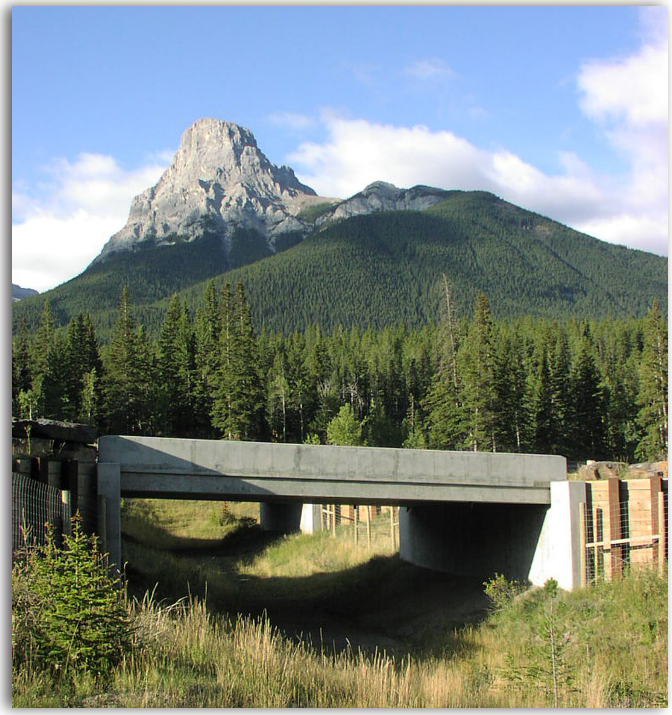
5. Viaduct or flyover – The largest of underpass structures for wildlife use, but usually not built exclusively for wildlife movement. The large span and vertical clearance of viaducts allow for use by a wide range of wildlife. Structures can be adapted for amphibian and reptiles, semi-aquatic and semi-arboreal species.

Source: Ministere des Transports du Quebec

Dimensions:
• Minimum Width: 20 ft (7 m)
• Recommended Width: >40 ft (>12 m)
• Minimum Height: 10 ft (4 m)
• Recommended Height: >15 ft (>4.5 m)

Species Recommendations:
• Target species will vary based on dimensions

6. Large mammal underpass - Not as large as most viaducts, but the largest of underpass structures designed specifically for wildlife use. Designed for large mammals but small- and medium-sized mammals use readily as well.



Dimensions:
• Minimum Width: 23 ft (7 m)
• Recommended Width: >32 ft (>10 m)
• Minimum Height: 13 ft (4 m)
• Recommended Height: >13 ft (>4 m)

Species Recommendations:
• Ungulates: Moose, Elk, Deer, Pronghorn, Bighorn Sheep, Mountain Goat
• Carnivores: Black Bear, Grizzly Bear, Wolf, Coyote, Fox, Cougar, Bobcat, Lynx, Wolverine, Fisher, Marten, Badger, Weasel
• Low mobility medium-sized mammals
• Small mammals
• Reptiles

7. Multi-use underpass – These structures are similar to the large mammal underpass, but designed for co-use between wildlife and humans. These structures can be retrofit bridges for wildlife passage or designed specifically for co-use. They may not be adequate for all wildlife and are most commonly used by generalist species common in human-dominated environments (e.g., urban habitats).

Dimensions:
- Minimum Width: 16.5 ft (5 m)
- Recommended Width: >23 ft (>7 m)
- Minimum Height: 8.2 ft (2.5 m)
- Recommended Height: >11.5 ft (>3.5 m)

Species Recommendations:
- Ungulates: Elk and Deer
- Carnivores: Coyote, Fox, Bobcat, Fisher, Marten, Weasel, Badger
- Low mobility medium-sized mammals
- Small mammals
- Reptiles

8. Underpass with waterflow – An underpass structure designed to accommodate the needs of moving water and wildlife. These underpass structures are frequently used by some large mammal species, but their use depends largely on how it is adapted for their specific crossing needs. Small- and medium-sized mammals generally utilize these structures, particularly if riparian habitat or cover is retained within the underpass.

Dimensions:
Dimensions will vary depending on width of the active channel of waterflow (creek, stream, river). These guidelines are for the dimensions of the wildlife pathway along the active channel and the height of underpass structure.
- Minimum Width: 6.5 ft (2 m) pathway
- Recommended Width: >10 ft (>3 m) pathway
- Minimum Height: 10 ft (3 m)
- Recommended Height: >13 ft (>4 m)

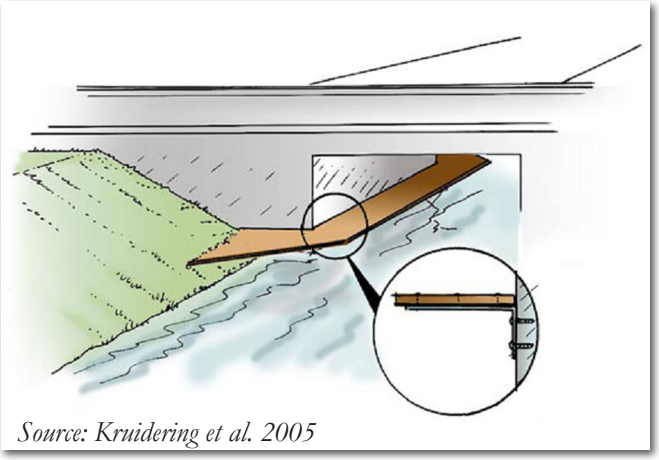
Species Recommendations:
- Ungulates: Elk and Deer
- Carnivores: Black Bear, Coyote, Fox, Cougar, Bobcat
- Semi-aquatic Mammals: Mink, River Otter, Muskrats
- Small mammals

9. Small- to medium-sized mammal underpass – This design is one of the smaller wildlife crossing structures. It is primarily designed for small- and medium-sized mammals, but species use will depend largely on how it is adapted for specific crossing needs.

Dimensions:
Dimensions will vary depending on the target species. Structures generally range from 1 ft to 4 ft (0.4-1.2 m) diameter culverts or underpass structures.

Species Recommendations:
- Carnivores: Coyote, Fox, Fisher, Marten, Badger, Weasel
- Low mobility medium-sized mammals
- Small mammals
- Reptiles

10. Modified culvert – This crossing is adaptively designed for use by small and medium-sized wildlife associated with riparian habitats or irrigation canals. Adapted dry platforms or walkways can vary in design and are typically constructed on the lateral interior walls of the culvert and above the high-water mark.



Source: Kruidering et al. 2005

Dimensions:
The dimensions of bridges for carrying water are a function of the hydrologic condition and needs of the area. The design and dimensions of walkways for wildlife will also vary depending on the target species.
- Walkways: Recommended minimum > 1.5 ft (0.5 m) wide.
- Access ramps: Recommended <30 degrees slope.

Species Recommendations:
- Carnivores: Fisher, Marten, Weasel
- Semi-aquatic mammals: Mink, River Otter, Muskrats
- Low mobility medium-sized mammals
- Small mammals
- Amphibians
- Reptiles

11. Amphibian and reptile tunnels – This crossing is designed specifically for passage by amphibians and reptiles, although other small- and medium-sized vertebrates may use it as well. Many different amphibian and reptile designs have been used to meet the specific requirements of a species.

Source: Parks Canada

Source: Parks Canada

Dimensions:
- The width of amphibian/reptile tunnel will increase with tunnel length. The width of rectangular tunnels generally range from 3 feet to seven feet, and the diameter of circular tunnels range from 3 feet to 8 feet.
- Maximum distance between tunnels: 150 ft (45 m), but a 200 ft (60 m) distance could be used if guiding walls/fences are funnel-shaped to guide amphibians to tunnel.
- Minimum height of guiding wall/fence: 1.25 ft (0.4 m); 2.0 ft (0.6 m) for some jumping species.

Species Recommendations:
- Amphibians
- Reptiles

The handbook also provides design details for :
Fencing - Large mammals
Fencing - Small and medium vertebrates
Gates and Ramps

MONITORING

How will I know if they are Working?

Monitoring is an integral part of mitigating road impacts on wildlife crossings. Criteria used to measure performance, however, will depend on the intended purpose of the wildlife crossing(s). Monitoring and research can range from a simple, single-species population within the highway corridor to more complex ecological processes and functions within a regional landscape.

Pre-construction monitoring helps ensure appropriate structure design and baseline data collection for good study design. Post-construction monitoring follows pre-construction data collection and can be used to adaptively manage future transportation projects. Evaluation findings are often critical for demonstrating that the fiscal investment in mitigation has produced valuable benefits to the environment and the general public.

Wildlife crossing structures are designed to allow animals to move across highways and connect habitats and subpopulations. Therefore, crossing structures should allow for the following five basic biological functions:

- Increase animal movements across roads with reduced mortality rates
- Access key biological resources including critical foods, cover, and breeding areas
- Facilitate seasonal or annual migrations, subadult dispersal or recolonization after long absences
- Relocate in response to environmental changes or natural disasters
- Maintain stability within wildlife communities and ecosystems over the long-term

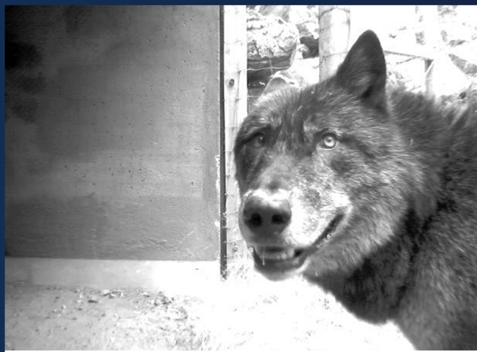
These five functions can be used to guide the development of an effective monitoring plan. Not all ecological functions may be of management concern for transportation and land management agencies, particularly those at the more complex end of the scale; however, they will be for most land and natural resource management agencies. Monitoring plans will consist of establishing baseline conditions, setting monitoring objectives and methods, selecting target species and developing study designs.

Monitoring Techniques

There are a variety of wildlife survey methods available today. Methods range from the relatively simple (reporting of wildlife-vehicle collisions) to complex (capture and radio-collaring of individual animals). Techniques should be selected based primarily on the goals and parameters of the monitoring plan, but may also be dependent on available resources or study area limitations. The following table provides an overview of monitoring methods and their cost for different objectives and target species.

Wildlife Monitoring Methods

Monitoring Purpose	Monitoring Method	Target Species	Cost
Assess wildlife vehicle collision rate	Carcass removal by maintenance crews	Elk, deer, black bear, other large species	Low
	Wildlife vehicle collision reports by Highway Patrol	Elk, deer, black bear, other large species	Low
	Systematic driving surveys	Medium to large animals	High
Assess use/effectiveness of wildlife crossing structures	Remote Still Cameras or Video	Medium to large animals	Medium
	Track Beds	Medium to large animals	Medium
	Unenclosed Track Plates	Medium to large animals	Medium
	Enclosed Track Plates	Smaller mammals	Medium
	Hair Collection Devices with DNA methods	Select medium to large mammals	Medium/high
	Trap, tag & recapture/resight	Amphibians, reptiles, small mammals	Low
	GPS Collaring	Medium to large mammals	High
Assess rate of at-grade highway crossings by wildlife	Remote still cameras or video (random placement)	Medium to large mammals	Medium to high
	Remote still cameras or video (targeted placement)	Medium to large mammals	Medium to high
	Track Beds (random placement)	Medium to large mammals	Medium to high
	Track Beds (targeted placement)	Medium to large mammals	Medium to high
	Snow Track Transects	Medium to large mammals (active in winter)	Medium
	GPS Collaring	Medium to large mammals	High
Monitor wildlife use of locations throughout and adjacent to project area	Remote still cameras or video at scent locations	Medium to large mammals	Medium
	Track plots or track plates at scent stations	Small to large mammals	Medium
	Hair Collection Devices with DNA methods	Small group of targeted species	Low to high
	Snow tracking	Medium and large animals active in winter	Medium
	Scat detection dogs with DNA methods	3-4 targeted animals	Medium to high
	Trap, tag & recapture/resight	Amphibians, reptiles, small mammals	Low
	GPS Collaring	Medium to large mammals	High
Evaluate effectiveness of wildlife fencing	Highway maintenance crews report animals inside fencing	Medium to large mammals	Medium
	Highway patrol report animals inside fencing	Medium to large mammals	Medium
	Systematic checks of fence integrity	Medium to large mammals	Medium
	GPS Collaring	Medium to large mammals	High
Evaluate effectiveness of jumpouts	Remote still cameras or video	Medium to large mammals	Medium
	Track beds on top of jumpouts	Medium to large mammals	Medium



Example wildlife crossing structure hot sheet and table with suitability of wildlife crossing design types (1-11) for different species and taxa.

Box 4: Suitability of Wildlife Crossing Design Types for Distinct Wildlife Species and Taxa.

	Landscape bridge (Sheet 1)	Wildlife overpass (Sheet 2)	Multi-use overpass (Sheet 3)	Canopy crossing (Sheet 4)	Viaduct or flyover (Sheet 5)	Large mammal underpass (Sheet 6)	Multi-use underpass (Sheet 7)	Underpass with water flow (Sheet 8)	Small- to medium-sized mammal underpass (Sheet 9)	Modified culvert design (Sheet 10)	Amphibian and reptile tunnel (Sheet 11)
Ungulates											
Moose	●	●	⊗	—	●	○	⊗	○	⊗	⊗	—
Elk	●	●	●	—	●	●	●	●	⊗	⊗	—
Deer spp.	●	●	●	—	●	●	●	●	⊗	⊗	—
Pronghorn	●	●	⊗	—	●	?	⊗	○	⊗	⊗	—
Bighorn sheep	●	●	⊗	—	●	○	⊗	○	⊗	⊗	—
Mountain goat	●	●	⊗	—	●	○	⊗	○	⊗	⊗	—
Carnivores											
Black bear	●	●	⊗	—	●	●	⊗	●	⊗	⊗	—
Grizzly bear	●	●	⊗	—	●	○	⊗	○	⊗	⊗	—
Wolf	●	●	⊗	—	●	○	⊗	○	⊗	⊗	—
Coyote	●	●	●	—	●	●	●	●	●	○	—
Fox1 (*V. vulpes, Urocyon*)	●	●	●	—	●	●	●	●	●	○	—
Fox2 (*V. macrotis, V. velox*)	●	●	●	—	●	○	○	○	○	○	—
Cougar	●	●	⊗	—	●	●	⊗	●	⊗	⊗	—
Bobcat	●	●	●	—	●	●	●	●	⊗	○	—
Lynx	●	●	⊗	—	●	?	⊗	?	⊗	⊗	—
Wolverine	●	●	⊗	—	●	?	⊗	?	⊗	⊗	—
Fisher	●	●	●	●	●	○	●	○	●	●	—
Marten	●	●	●	●	●	○	●	○	●	●	—
Weasel	●	●	●	—	●	○	●	○	●	●	—
Badger	●	●	●	—	●	○	●	○	●	⊗	—
Low mobility medium mammals	●	●	●	—	●	●	●	●	●	●	○
Semi-arboreal mammals	○	○	○	●	○	○	○	○	⊗	⊗	⊗
Semi-aquatic mammals	○	○	○	—	○	○	○	●	○	●	○
Small mammals	●	●	●	○	●	●	●	●	●	●	○
Amphibians	○	○	○	—	○	○	○	○	○	●	●
Reptiles	●	●	●	—	●	●	●	○	●	●	○

Recommended/Optimum solution; ○ Possible if adapted to local conditions; ⊗ Not recommended; ? Unknown, more data are required; — Not applicable