

NCHRP 25-25, Task 113

ROAD PASSAGES AND BARRIERS FOR SMALL TERRESTRIAL WILDLIFE SPECIES

EXPERT SURVEY REPORT

Prepared for:

AASHTO Committee on Environment and Sustainability

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The opinions and conclusions expressed or implied are those of the research agency that performed the research and are not necessarily those of the Transportation Research Board or its sponsoring agencies. This report has not been reviewed or accepted by the Transportation Research Board Executive Committee or the Governing Board of the National Research Council.

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1. INTRODUCTION

1.1. Background

This study was conducted for the AASHTO Committee on Environment and Sustainability, with funding provided through the National Cooperative Highway Research Program (NCHRP) Project 25-25, Task 113. The study aims to synthesize information on highway mitigation for small terrestrial wildlife species, especially on reducing direct road mortality and providing safe crossing opportunities. It includes a literature review including an annotated bibliography, a survey of practitioners and researchers, “hot sheets” for quick reference and practical recommendations, and a repository of design examples of mitigation measures for the target species groups. For this project, small terrestrial animal species were defined as: amphibians, reptiles, and mammals smaller than coyotes. This excludes species that fly (e.g. bats) or species that are (mainly) arboreal. The project is restricted to highways and other paved roads. This excludes trails, dirt roads, and gravel roads.

This report documents the findings of the survey of practitioners and researchers. It reflects the current state of practice in mitigating direct road mortality and providing safe crossing opportunities for the species groups identified above. The researchers were especially interested in measures aimed at keeping animals off the highway (e.g. fences or other barriers) and measures that allow animals to move between the habitat on the two sides of a road (e.g. underpasses or overpasses). The results of the survey will help to provide guidance to future projects aimed at reducing direct road mortality and maintaining habitat connectivity for small terrestrial animal species.

1.2. Species and Mitigation Measures Included in this Report

This survey is focused on small terrestrial animal species, specifically amphibians, reptiles, and mammals smaller than coyotes. This means that flying animals (e.g. bats, birds) and species that are mainly arboreal (e.g. squirrels) were not the focus of the survey.

The researchers designed the survey around three types of measures:

- Measures aimed at keeping small terrestrial animal species animals off the highway (e.g. fences or other barriers)
- Designated safe crossing opportunities specifically designed for small terrestrial animal species (especially designated underpasses or overpasses).
- Modifications to existing structures (e.g. bridges, culverts) that were built for other purposes but where the modifications were aimed at increasing the use of these structures by small terrestrial animal species.

1.3. Science, Practice, and Best Practice

The literature review (see separate document) summarizes the status of the science regarding the effectiveness of measures aimed at reducing direct road mortality and reducing the barrier effects of roads and traffic for small animal species (Figure 1). The survey (this report) documents what is reported to have been implemented, regardless of whether it is effective in reaching the objectives. It reflects the “current state of practice”, with the limitation that it is limited by what was reported by the respondents, and how it was reported by the respondents. Thus, a practice may exist, but if the practice was not reported by the respondents, or if it was under- or over-reported, or if it was wrongly reported by the respondents, it was either not included in this report or it resulted in inaccurate reporting. On the other hand, the literature review may miss practices that have been implemented, are believed to be effective, but have not been formally evaluated yet for their effectiveness in the literature. That is why continuous interaction between the “science” and “practice” is important; the practice can benefit from the science, and the science can benefit from the practice.

A “best practice” can be defined as a combination of practice and science; it is implemented and, based on science, it is known to be effective in reaching the objectives. Identifying “best practices” is of course much more useful than simply describing “practices in general”.

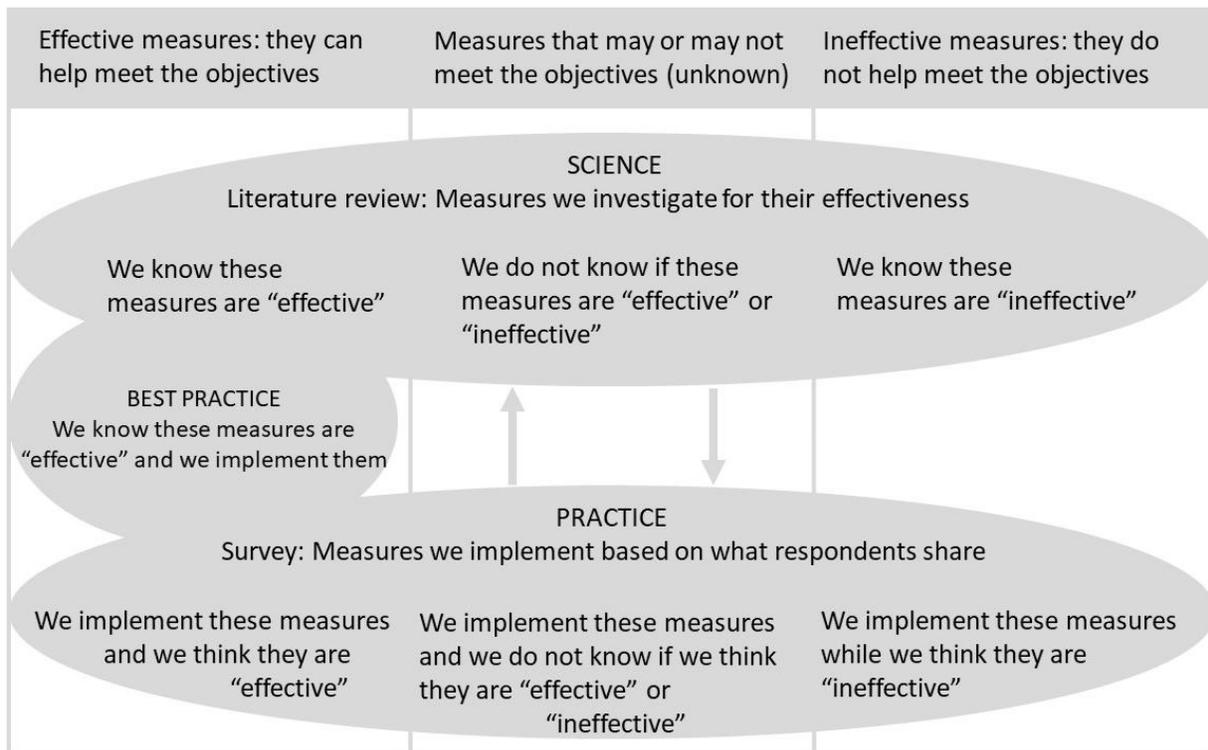


Figure 1: Science, Practice, and Best practice.

2. SURVEY METHODS

2.1. Organization of Survey

The survey had three main sections based on the purpose of the different mitigation measures.

- Reducing direct road mortality of the animals.
- Providing designated safe crossing opportunities for wildlife, with an emphasis on wildlife crossing structures built especially for small terrestrial animal species (i.e. underpasses and overpasses).
- Providing safe crossing opportunities for wildlife through the use or modification of existing structures originally designed and built for other purposes.

Within each section, the survey questions were organized around the three main species groups:

- Amphibians
- Reptiles
- Terrestrial mammals smaller than coyotes

This report summarizes the most important findings of the survey. The survey questions are included in Appendix A. The individual species that the mitigation measures were designed for are listed in Appendix B. The tables summarizing the responses to each survey question are included in Appendix C. The respondents were also asked to submit design plans, “as-built” technical drawings and images of the mitigation measures. A list of the submitted design plans, technical drawings, and images are included in Appendix D. A selection the submitted material will be included in a repository (separate product) within the scope of this project.

The survey design allowed respondents to skip questions if they so desired. The survey design also allowed multiple responses for some questions, if appropriate.

2.2. The Target Population

The researchers invited a wide range of practitioners and researchers involved with road ecology projects to participate in the survey. While the survey targeted transportation agency personnel, natural resource agency personnel, other practitioners, and researchers in the United States and Canada, researchers and practitioners from elsewhere were also invited to share their knowledge and experience. The researchers encouraged the target population to send the survey invitation on to other individuals that may have experience with or knowledge of measures aimed at reducing direct road mortality and at providing safe crossing opportunities to small terrestrial wildlife species. The researchers sent the survey to approximately 890 individuals, but the true number of people that received the survey through forwarding may be much higher.

The researchers sent the survey invitation to employees from transportation and natural resource management agencies in each state and province in the United States and Canada, the Federal Highway Administration, attendees of the 2017 ICOET (International Conference on Ecology and Transportation), individual road ecology researchers and practitioners (e.g. universities,

NGO's (US Fish & Wildlife Service), and members of the Transportation Research Board's Committee ADC30 (Committee on Ecology and Transportation) and the Wildlife, Fisheries, and Transportation (WFT) Listserv (CTE, 2018). These contacts were obtained through Louis Berger's, Eco-Kare International's and WTI-MSU's databases from past surveys.

2.3. Survey Review and Follow-Ups

The survey questions are included in Appendix A. The survey was deemed exempt from review by the Institutional Review Board at Montana State University. The survey was opened on 21 September 2018 and closed on 27 December 2018. Several reminders were sent to the target population while the survey was still open. Towards the end of the survey, the researchers selected the respondents that indicated they would be sending supplemental information, especially technical drawings and images of the mitigation measures. The researchers approached these respondents and additional individuals that the researcher knew had design plans or images of certain mitigation projects (n= 53) and asked them to send the material and sign a form permitting the inclusion of this material in the products for this NCHRP project (see Appendix D).

3. SURVEY RESULTS

3.1. Respondents

There were 156 respondents that answered at least one question of the survey. The researchers did not calculate a response rate as the number of people who received the invitation to participate in the survey was unknown. Almost half of all respondents (47%) were employees from state or provincial transportation agencies (Figure 2). State or provincial natural resource management agencies represented 17%. Federal or national natural resource management or transportation agencies. NGO's, private businesses, universities or research institutes, tribal, regional or municipal governments or agencies each represented between 1-8% of all respondents (Figure 2). Most of the respondents came from the United States (n=106, 68.0%) or Canada (n=43, 27.6%), reporting on projects from 39 states and 6 provinces.

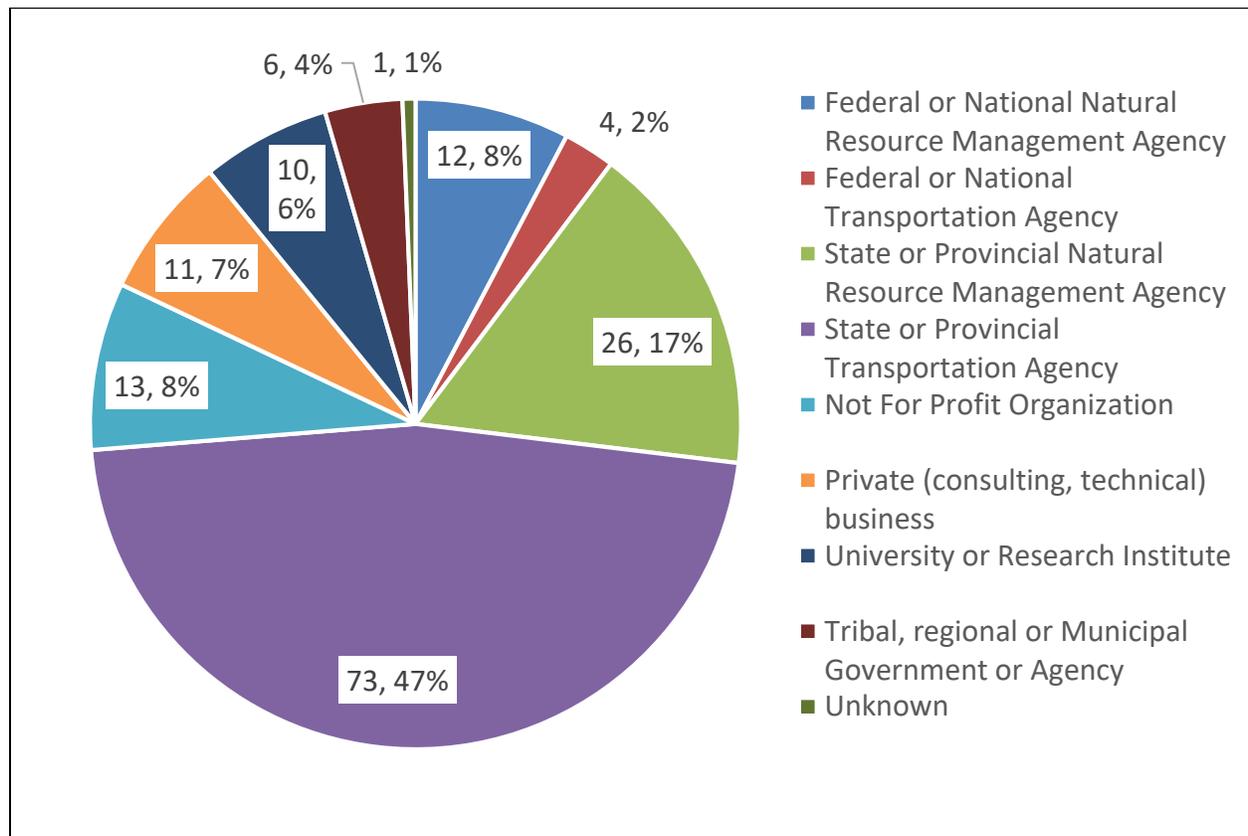


Figure 2: Respondent affiliation (n = 156).

The respondents came from all regions we distinguished for this report (Figure 3). Central Canada and the South West of the United States were especially well represented.



Figure 3: Number of respondents by geographic region.

3.2. Concerns or Policies that Triggered Mitigation Measures

Mitigation measures for small animal species were mostly triggered by regulatory status, unnatural mortality (including direct road mortality), the barrier effect of roads, and general concern for biological conservation (Figure 4). Habitat loss, public or political pressure (regardless of laws or regulations), human safety concerns related to small animal-vehicle collisions, and noise, light, pollution, or other disturbances originating from the road did not trigger the design or implementation of mitigation measures nearly as often (Figure 4). Other reasons for the design or implementation of mitigation measures for small animal species included “regulations for larger species allowed consideration for smaller species”. Other respondents commented that mitigation measures had also been designed or implanted for other small animal species, or species groups, outside the work scope of this survey. These include bats, pollinators, and a snail species. Note that the construction of a very wide and long new transportation corridor has created opportunities for the implementation of mitigation measures for small animal species that may not have been implemented otherwise. It is efficient to implement wildlife mitigation measures when a transportation corridor is constructed or reconstructed.

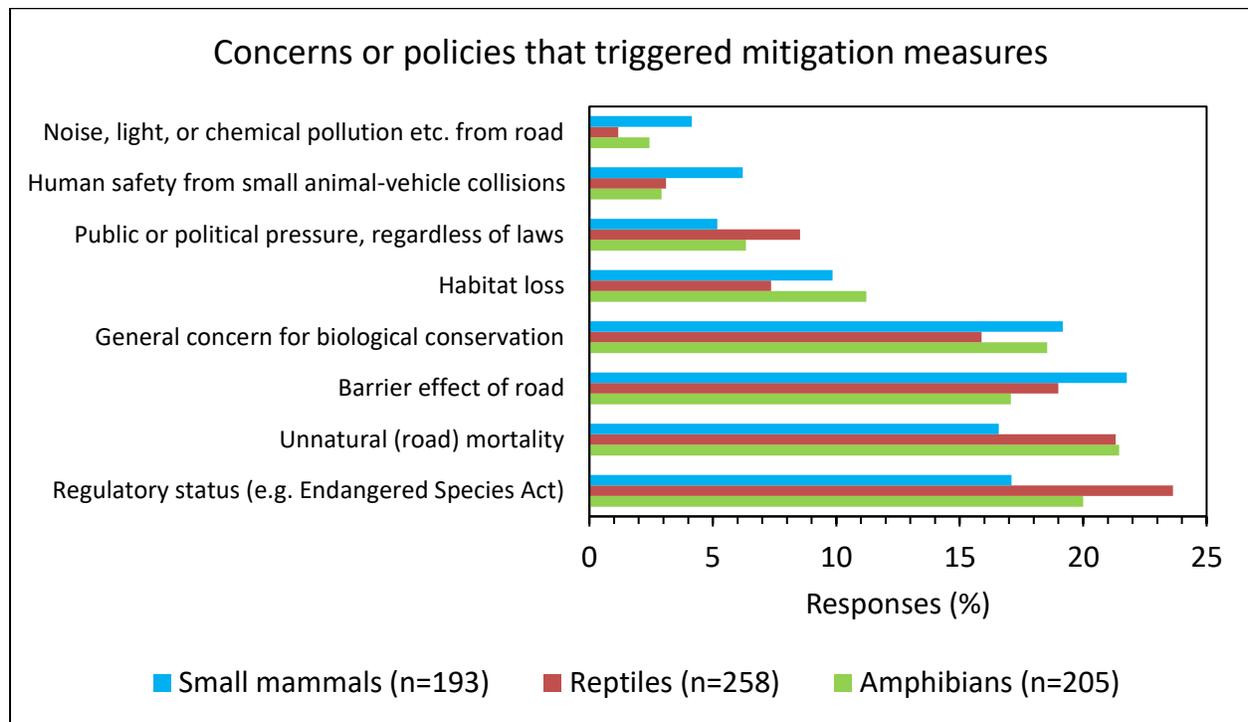


Figure 4: Concerns or policies that triggered the design or implementation of mitigation measures. Note that a respondent could list multiple concerns or policies for each species group.

3.3. Geographical Spread of Mitigation for the Species Groups

The researchers identified for which species groups mitigation measures were designed or implemented in different regions across the United States and Canada (Figure 5). Based on the responses to the survey, mitigation measures for small animal species are widespread particularly in the North East and throughout Canada, but potentially relatively infrequent in the North Western United States.

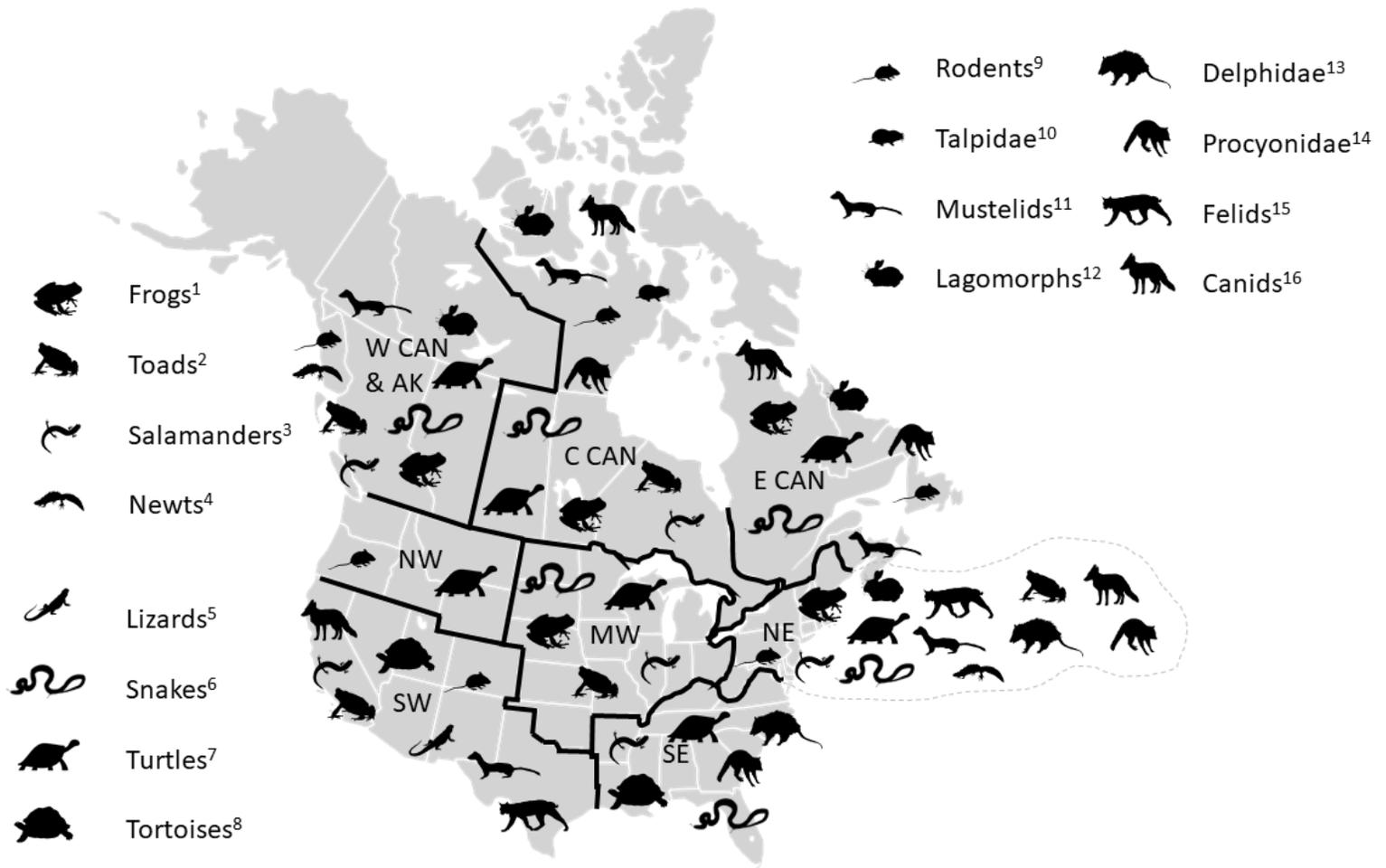


Figure 5: Species groups for which mitigation measures were designed or implemented in different regions in the United States and Canada. Credit statements for animal icons on the next page.

Credit statements for the animal icons Figure 5:

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- ¹ <http://www.supercoloring.com/silhouettes/frog> by Natasha Sinagina
- ² <http://www.supercoloring.com/silhouettes/toad> by Sam Fraser-Smith
- ³ <http://www.supercoloring.com/silhouettes/salamander> by Natasha Sinagina
- ⁴ <http://www.supercoloring.com/silhouettes/newt> by Rainer Theuer
- ⁵ <http://www.supercoloring.com/silhouettes/bearded-dragon> by Natasha Sinagina
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- ¹¹ <http://www.supercoloring.com/silhouettes/weasel> by Bob Comix
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- ⁷ https://www.flaticon.com/free-icon/turtle-facing-right_84024 by Flaticon
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3.4. Measures Aimed at Reducing Direct Road Mortality

Barriers were by far the most frequently implemented measure to reduce direct road mortality for all three species groups, followed by outreach to drivers and warning signs (Figure 6). Reducing the posted speed limit, reducing the design speed, permanent road closure or road removal, seasonal road closures, and night-time road closure were rarely implemented. The “other” category consisted of measures primarily intended to provide a crossing opportunity (e.g. designated crossing structures, culverts) and to reduce the time the animals spent on the road (scuppers in median barriers). Capturing and relocating animals, and vegetation management to create unattractive habitat close to the highway were also mentioned by the respondents.

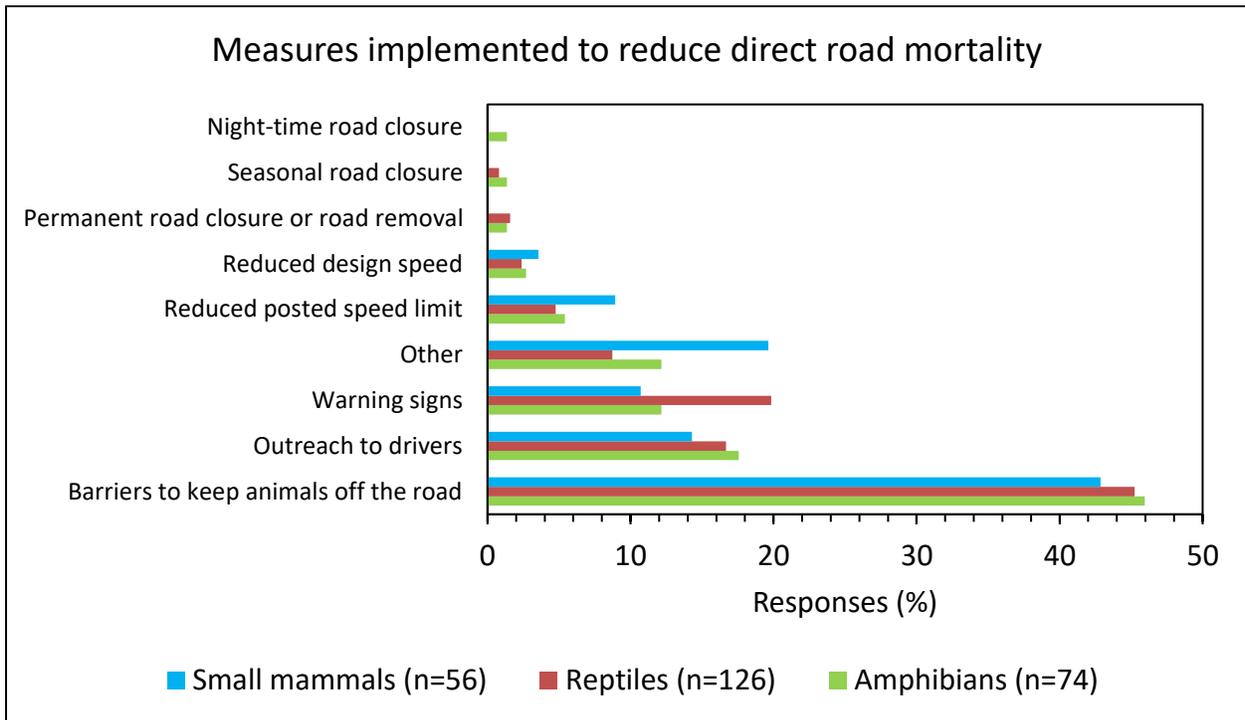


Figure 6: Measures that have been implemented to reduce direct road mortality. Note that a respondent could list multiple measures for each species group.

3.5. Barriers

The respondents identified the species or species groups that barriers were designed or implemented for. For roads in the USA or Canada, barriers were most frequently designed for reptiles, followed by amphibians and small mammal species (Figure 7). Individual species for which barriers were designed for are listed in Appendix B.

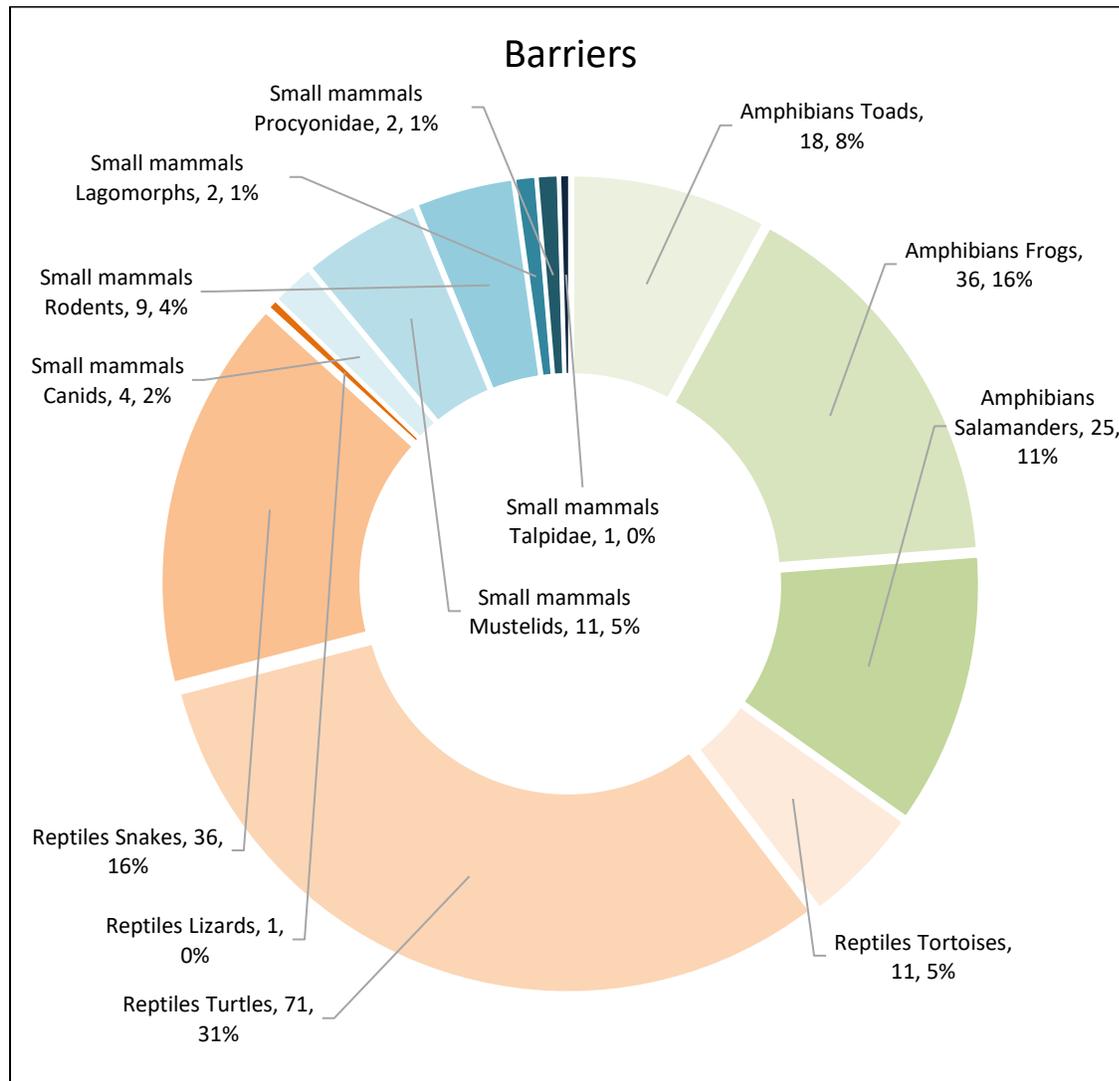


Figure 7: Target species groups mentioned by the respondents for the design of barriers along roads in the USA and Canada. Amphibians (n=79): Toads, Frogs, Salamanders; Reptiles (n=119): Turtles, Tortoises, Snakes; Small mammals (n=29): Mustelids, Rodents, Canids, Lagamorphs, Talpidae.

Most of the barriers were not evaluated for their effectiveness in reducing direct road mortality (Appendix C). The researchers selected information on barriers for the three species groups that the respondents indicated has reduced direct road mortality by at least 70% (Tables 1, 2, 3).

Effective barriers for amphibians consisted usually of plastic sheets and had a height in the categories 26-50 cm (0.81-1.6 ft) or 51-75 cm (1.61-2.5 ft), used wooden posts, and were usually dug into the ground 6-10 cm (>2-4"). The amphibian barriers were not integrated with a fence built for other purposes, they had a climbing deterrent (e.g. a lip or overhang on top of the barrier), and the barriers were connected to potential crossing structures.

Effectives barriers for reptiles consisted usually of plastic sheets, chain-link fence or geotextile^{*1}, and had a height in the categories 26-50 cm (0.81-1.6 ft) or 51-75 cm (1.61-2.5 ft), used wooden posts, and were usually dug into the ground 11-15 cm (>4-6"). The reptile barriers were usually not integrated with a fence built for other purposes, about half of them had a climbing deterrent (e.g. a lip or overhang on top of the barrier), and the barriers were connected to potential crossing structures. The respondents only reported on one effective barrier for small animal species which was designed for multiple taxa: Mustelids, Rodents, Lagomorphs, Procyonidae, Talpidae. This does not allow for conclusions on what the characteristics are of effective fences for small mammal species or sub groups.

Maintenance issues with the barriers were extremely varied (Appendix C). However, for barriers designed for amphibians and reptiles, vegetation overgrowing the barriers, erosion, fallen trees, snow and ice damage, barrier material degradation within five years, contraction and expansion of the barrier material, and poor barrier installation were the most common maintenance issues. For small mammals the most common maintenance issues were fallen trees and poor barrier installation.

The total road length for a barrier project was very variable (Appendix C). However, 1-2 km (0.62-1.24 mi) was most frequently mentioned by the respondents for amphibians and reptiles. For small mammals the road length was longer (>10 km (>6.23 mi)). The total length of the road section equipped with a barrier was similar to that of the total road length for the project (Appendix C). However, for amphibians and reptiles, barrier sections were also frequently implemented on shorter road sections 50-250 m (165-820 ft). Barriers were typically present on both sides of a road. Some projects had multiple fenced road sections with gaps in between, whereas others had continuous barriers without gaps.

For amphibians and reptiles, respondents reported that it was typical to monitor animal presence on the road (both dead and alive) (Appendix C). Monitoring was less frequent for small mammals (Appendix C). For amphibians and reptiles, road surveys for animals on the road was typically 2-5 years, both before and after barrier construction. The surveys were usually limited to a certain season only. Surveys for animal presence on roads were typically conducted multiple times per week. Studies typically did not include a control (unmitigated road section with no barrier present).

When animals breached a barrier, it was typically because of openings or gaps in the road section with a barrier, including those caused by erosion (Appendix C). Barriers were usually inspected, but inspection frequency varied wildly.

^{*1} While the researchers normally do not question the information provided by the respondents, it is important to note that geotextile fabric easily tears and is also subject to erosion. Geotextile fabric may work as a temporary barrier, but it is not recommended as a more permanent barrier.

Table 1: Characteristics of effective barriers for amphibians ($\geq 70\%$ reduction in direct road mortality) (N = number of responses, grey = most frequent). Each value for a parameter has an associated count of responses, but the different parameters are summarized independently.

	Barrier material	N	Barrier height	N	Post material	N	Integrated with fence built for other purposes?	N	Buried into ground (e.g. apron or lip) and depth	N	Climbing deterrent	N	Constructi on cost per meter (3.28 ft) barrier	N	Connected to potential wildlife crossing structure	N
Toads	Fence: plastic sheets	4	0-25 cm (0-0.8 ft)	1	Wood	3	No	4	>0-5 cm (>0-2")	1	Yes	3	\$81-90	1	Yes	6
	Fence: geotextile	1	26-50 cm (0.81-1.6 ft)	2	None	1			6-10 cm (>2-4")	2	No	1				
	Other: heavy rigid polymer matrix-ERTEC	1	51-75 cm (1.61-2.5 ft)	3	Metal	1			11-15 cm (>4-6")	3						
					Plastic	1										
Salamanders	Fence: plastic sheets	4	0-25 cm (0-0.8 ft)	1	None	2	No	6	>0-5 cm (>0-2")	2	Yes	4	\$41-50	1	Yes, designated structure	7
	Fence: geotextile	1	26-50 cm (0.81-1.6 ft)	3	Wood	3			6-10 cm (>2-4")	3	No	2	\$81-90	1	Yes, not designated structure	1
	Wall: plastic	1	51-75 cm (1.61-2.5 ft)	4	Metal	2			11-15 cm (>4-6")	3			>\$100	1		
	Wall: concrete	1			Plastic	1										
	Other: heavy rigid polymer matrix-ERTEC	1														
Frogs	Fence: geotextile	1	26-50 cm (0.81-1.6 ft)	2	Wood	2	No	3	6-10 cm (>2-4")	2	Yes	2	\$41-50	1	Yes, designated structure	2
	Fence: plastic sheets	1	51-75 cm (1.61-2.5 ft)	1	Metal	1			11-15 cm (>4-6")	1	No	1			Yes, not designated structure	1
	Wall: plastic	1														

Table 2: Characteristics of effective barriers for reptiles ($\geq 70\%$ reduction in direct road mortality) (N = number of responses, grey = most frequent). Each value for a parameter has an associated count of responses, but the different parameters are summarized independently.

	Barrier material	N	Barrier height	N	Post material	N	Integrated with fence built for other purposes?	N	Buried into ground (e.g. apron or lip) and depth	N	Climbing deterrent	N	Construction cost per meter (3.28 ft) barrier	N	Connected to potential wildlife crossing structure	N	
Tortoises	Fence: chain-link	1	76-100 cm (2.51-3.3 ft)	2	Metal	2	No	1	11-15 cm (>4-6")	1	Yes	1		1	Yes, designated	1	
	Fence: woven wire	1					Yes, r-o-w/livestock fence	1	16-20 cm (>6-8")	1	No	1		1	No	1	
Turtles	Fence: chain-link	2	26-50 cm (0.81-1.6 ft)	1	Metal	4	No	8	No	1	Yes	5	\$0-10	1	Yes, not designated	6	
	Fence: plastic sheets	2	51-75 cm (1.61-2.5 ft)	4	Wood	2	Yes, r-o-w/livestock fence	1	>0-5 cm (>0-2")	2	No	5	\$11-20	2	Yes, designated	2	
	Fence: woven wire	2	76-100 cm (2.51-3.3 ft)	5	Plastic	1	Other	1	6-10 cm (>2-4")	1			\$21-30	1	Yes, designated and not designated	1	
	Wall: concrete	1			Other	2			11-15 cm (>4-6")	2			\$31-40	1	No	1	
	Wall: plastic	1			None	1			16-20 cm (>6-8")	1			\$81-90	1			
	Other: Rigid Polymer Matrix	1							21-25 cm (>8-10")								
	Other	1							26-50 cm (>10-20")	2							
Snakes	Fence: geotextile	3	51-75 cm (1.61-2.5 ft)	4	Wood	3	No	4	11-15 cm (>4-6")	2	No	3	\$0-10	1	Yes, designated	2	
	Fence: chain-link	2	76-100 cm (2.51-3.3 ft)	1	Metal	1	Yes, r-o-w/livestock fence	1	16-20 cm (>6-8")		Yes	2	\$81-90	1	Yes, not designated	1	
					Other	1			21-25 cm (>8-10")	1					Yes, designated and not designated	1	
									26-50 cm (>10-20")	2					No	1	

Table 3: Characteristics of effective barriers for small mammals (multiple taxa) ($\geq 70\%$ reduction in direct road mortality) (N = number of responses, grey = most frequent). Each value for a parameter has an associated count of responses, but the different parameters are summarized independently.

	Barrier material	N	Barrier height	N	Post material	N	Integrated with fence built for other purposes?	N	Buried into ground (e.g. apron or lip) and depth	N	Climbing deterrent	N	Constructi on cost per meter (3.28 ft) barrier	N	Connected to potential wildlife crossing structure	N
Small mammals (multiple taxa)	Fence: geotextile	1	51-75 cm (1.61-2.5 ft)	1	Wood	1	No	1	11-15 cm ($>4-6''$)	1	Yes	1			Yes, designated	1

3.6. Safe Crossing Opportunities: General

The respondents mostly provide safe crossing opportunities for small animal species through crossing structures (underpasses or overpasses) (Figure 8). The second most common method to move individuals, especially amphibians and reptiles, between two sides of a road is through actively carrying them to the other side of the highway. This may include capturing the animals with pitfalls along a barrier on one side of the highway, and then carrying them to the other side of the highway, often by volunteers. Rarely are at-grade crossing opportunities (e.g. signs, speed bumps etc.) implemented for the purpose of providing safe crossing opportunities.

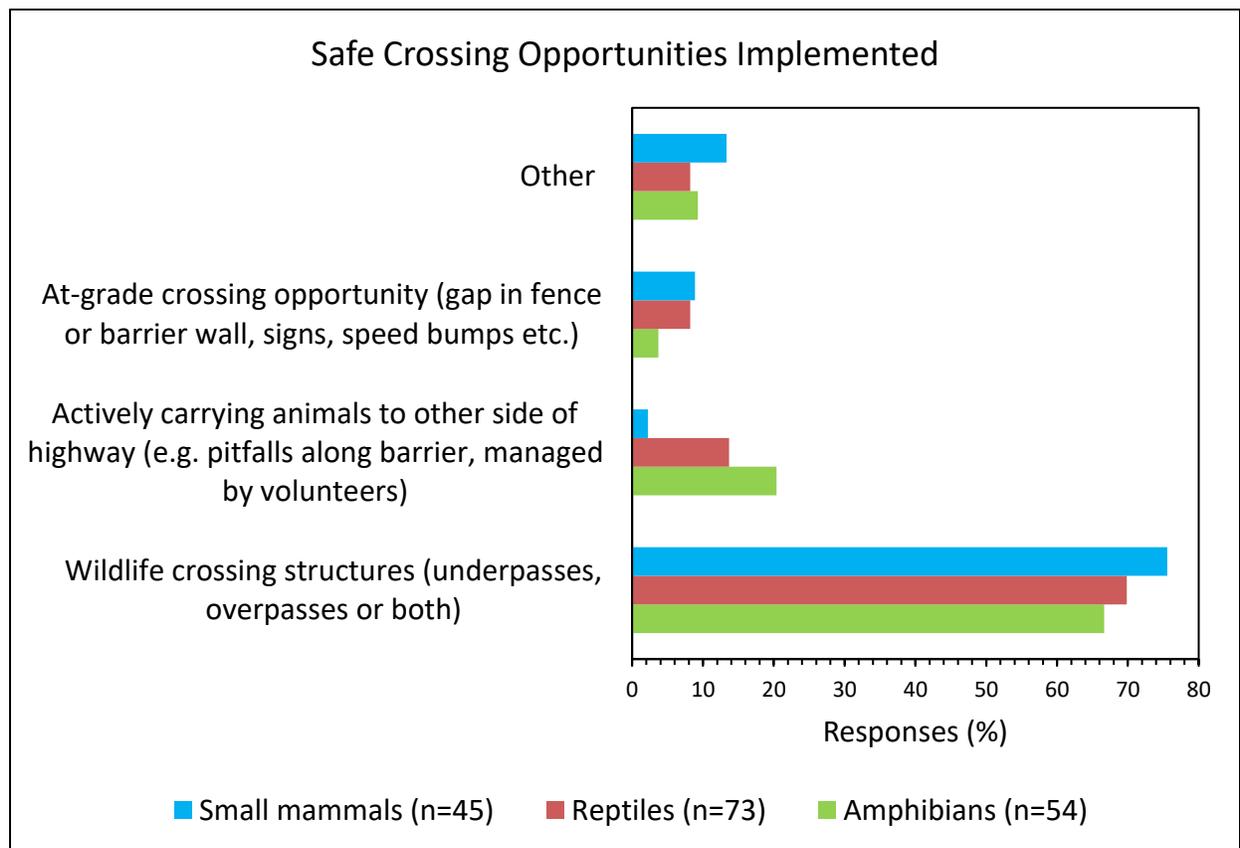


Figure 8: Safe crossing opportunities implemented to reduce the barrier effect of roads. Note that a respondent could list multiple measures for each species group.

The most common implemented avoidance measure for small animal species is rerouting a road away from the most sensitive areas (Figure 9). The most frequently reported compensation measures include creating new habitat patches, improving the connectivity between these habitat patches, and increasing the size of existing habitat patches (Figure 9). Interestingly, alternate modes of transportation (e.g. railroad) were never implemented.

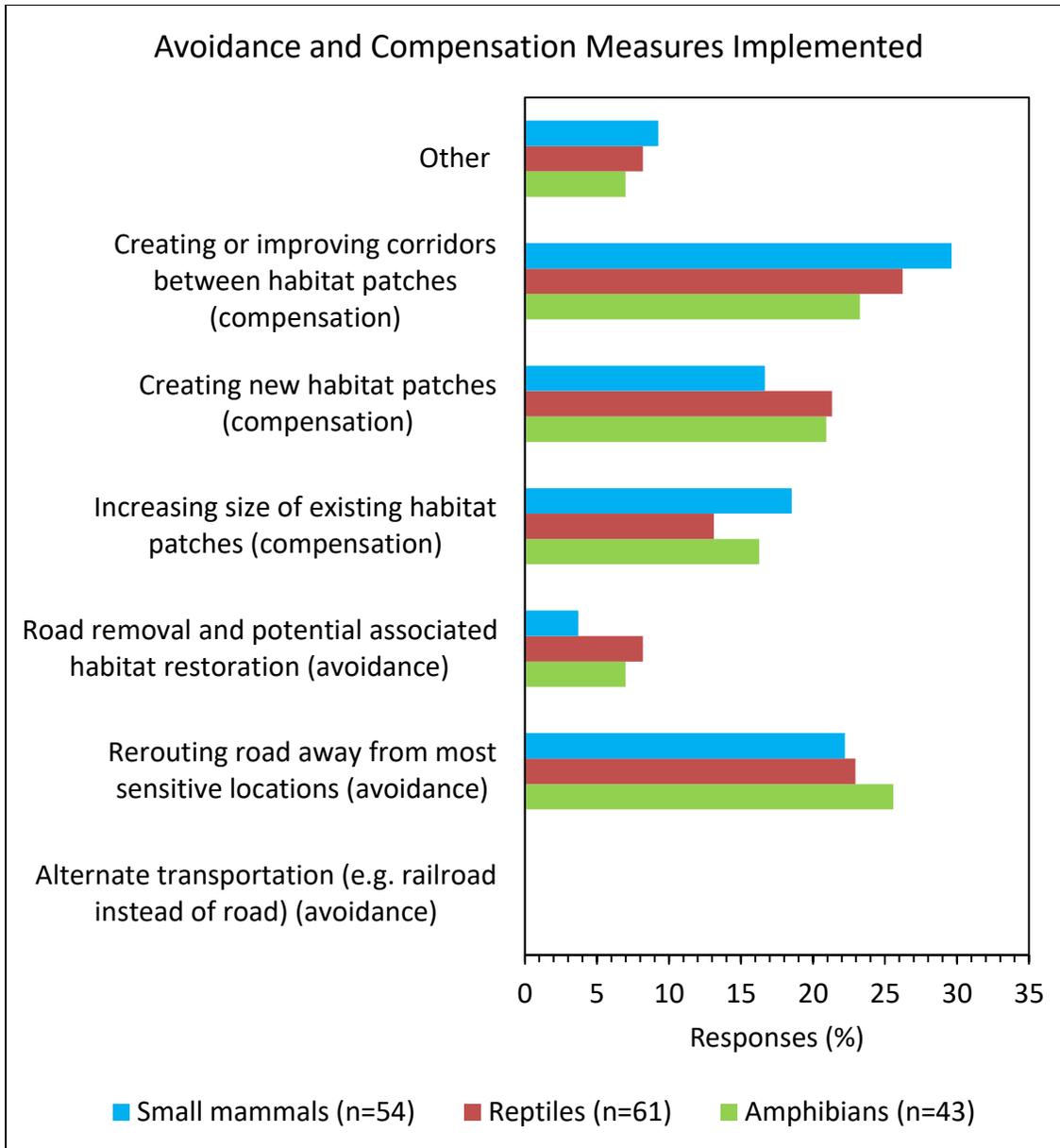


Figure 9: Avoidance and compensation measures implemented to reduce the barrier effect of roads. Note that a respondent could list multiple measures for each species group.

3.7. Designated Wildlife Crossing Structures

The respondents identified the species or species groups for which designated wildlife crossing structures were designed or implemented for (Figure 10). For roads in the USA or Canada, designated wildlife crossing structures were most frequently designed for amphibians, closely followed by reptiles. Designated crossing structures for small mammal species were less frequently designed or constructed. Individual species for which designated crossing structures were designed for are listed in Appendix B.

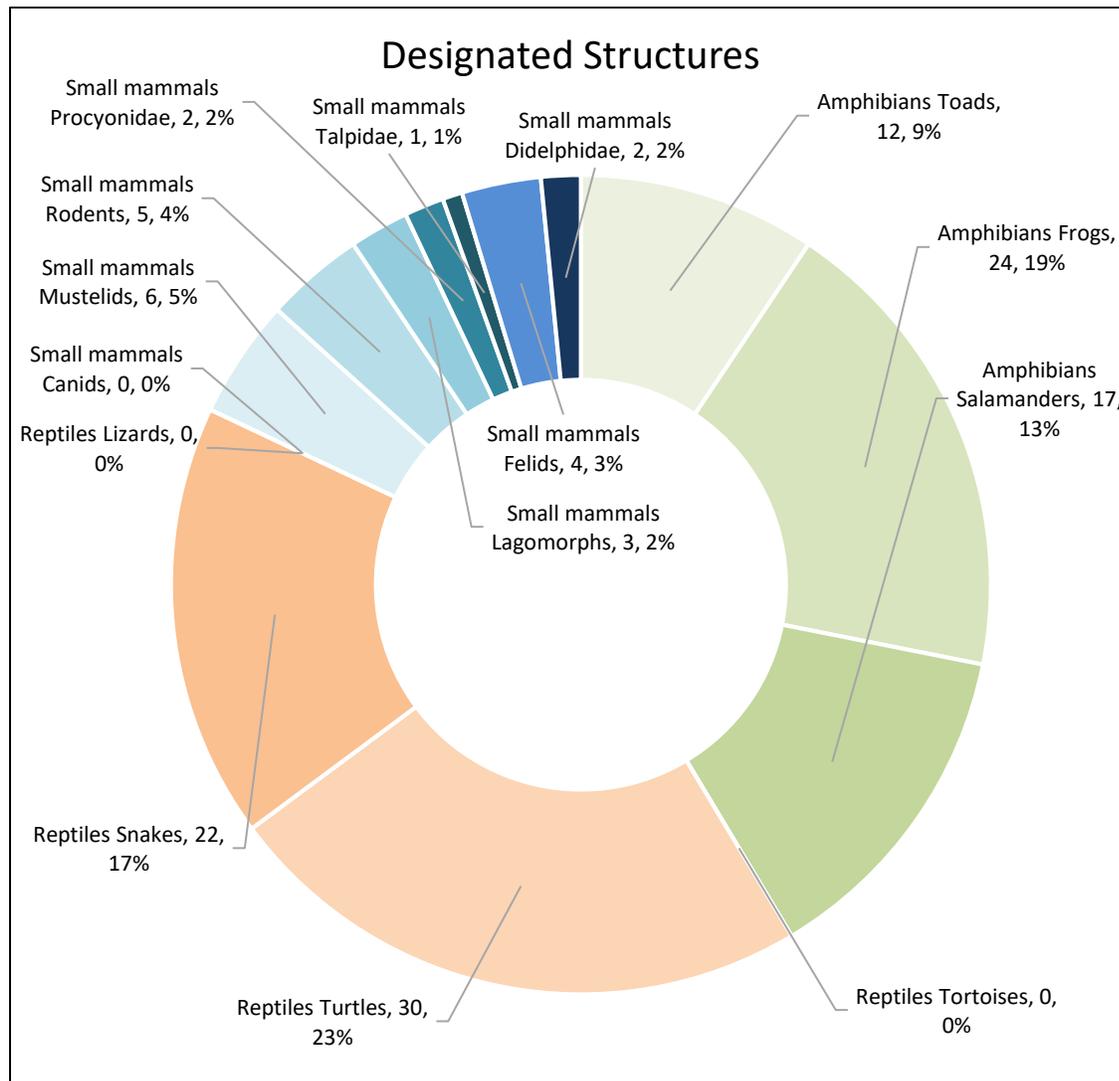


Figure 10: Target species groups mentioned by the respondents for the design and implementation of dedicated wildlife crossing structures in the USA and Canada. Amphibians (n=53): Toads, Frogs, Salamanders; Reptiles (n=52): Turtles, Tortoises, Snakes; Small mammals (n=23): Mustelids, Rodents, Canids, Lagomorphs, Talpidae.

Most of the designated wildlife crossing structures (53.1% of the responses) were not evaluated for their effectiveness in reducing the barrier effect (unknown, no objective) (Appendix C). The researchers selected information on designated structures for the three species groups that the respondents indicated were either “effective” or “very effective” in reducing the barrier effect of the road (Tables 4, 5, 6). Effective designated crossing structures for amphibians usually were underpasses with a bottom*¹ (e.g. a culvert), had a width in the categories between 26-50 cm (0.9-1.6 ft) and 176-200 cm (5.8-6.6 ft), a height in the categories between 26-50 cm (0.81-1.6 ft) and 101-125 cm (3.4-4.1 ft), an open roof structure (slots), and cover (e.g. root wads, or rocks and boulders).

Effective designated crossing structures for reptiles usually were underpasses with a bottom (e.g. a culvert), had a width in the categories between 26-50 cm (0.9-1.6 ft) and >2-3 m (6.7-10.0 ft), a height in the categories between 26-50 cm (0.81-1.6 ft) and >2-3 m (6.7-10.0 ft), either a closed or an open roof structure (e.g. grate or slots), and either cover or no cover inside the underpass. The respondents only reported on one effective designated crossing structure for small animal species which was designed for multiple taxa: Mustelids, Rodents, Lagomorphs, Procyonidae, Didelphidae, and Felids. This does not allow for conclusions on what the characteristics are of effective designated crossing structures for small mammal species.

Designated wildlife crossing structures were typically built in low numbers: one to a handful of structures rather than dozens (Appendix C). Many of the designated wildlife crossing structures had a level pathway for small animal species, a funneling structure (e.g. wing walls) to guide small animal species towards the structure, and natural substrate on the bottom of the structure (Appendix C). Erosion, flooding, and overgrown vegetation blocking the entrances were the most frequently reported maintenance issues with designated structures for small animal species.

The total road length considered part of the project for designated wildlife crossing structures for small animal species ranged from a ≤ 50 m (≤ 164 ft) up to about >10 km (>6.23 mi) (Appendix C). Road width (i.e. tunnel or culvert length) was typically ≤ 50 m (≤ 164 ft). This width was typically covered by one structure without an opening in a potential median. Most of the designated crossing structures for small animal species were associated with barriers (e.g. a fence or wall). Neighboring designated crossing structures were typically spaced hundreds of feet up to a few miles apart. The habitat surrounding designated crossing structures for small animal species was varied and included mostly wetlands, forests and mixed habitat (Appendix C).

Many of the designated crossing structures for small animal species were monitored for wildlife use, including but not limited to, the target species (Appendix C). The monitoring effort typically related to one or up to five structures. Wildlife cameras using either motion/heat sensors or cameras on a time-lapse, were the most frequently used monitoring method to detect small animal species using designated wildlife crossing structures. Small animal species use of designated wildlife crossing structures was typically monitored for one up to three years, and 51 responses indicated monitoring efforts lasted at least one year or season. Fewer respondents (n=41) also indicated that connectivity data across the road were collected before construction of the structure.

*¹ While the researchers normally do not question the information provided by the respondents, it is important to note that bottomless structures may function better than structures with a bottom (see literature review).

Table 4: Characteristics of effective designated crossing structures for amphibians (effective or very effective in reducing barrier effect through providing a satisfactory level of connectivity) (N = number of responses, grey = most frequent). Each value for a parameter has an associated count of responses, but the different parameters are summarized independently.

	Crossing structure type	N	Width (diameter) structure	N	Height (diameter) structure	N	Openings in roof underpass	N	Design guidelines specify cover	N	Construction (US \$)	N
Toads	No information available											
Salamanders	Underpass, bottom	2	51-75 cm (1.7-2.5 ft)	1	26-50 cm (0.9-1.6 ft)	1	no	1	No cover	1	45001-50000	1
	Underpass, no bottom	1	151-175 cm (5.0-5.7 ft)	1	51-75 cm (1.7-2.5 ft)	1	yes, open slots	1	Cover: branches/rootwads	1	300001-400000	1
			176-200 cm (5.8-6.6 ft)	1	101-125 cm (3.4-4.1 ft)	1	yes (other)	1	Cover: other	1		
Frogs	Underpass, bottom	3	26-50 cm (0.9-1.6 ft)	1	26-50 cm (0.9-1.6 ft)	1	no	2	No cover	1	45001-50000	1
	Underpass, no bottom	1	151-175 cm (5.0-5.7 ft)	1	101-125 cm (3.4-4.1 ft)	1	yes, open slots	1	Cover: branches/rootwads	1	300001-400000	1
			176-200 cm (5.8-6.6 ft)	2			yes (other)	1	Cover: rocks/boulders	1		
									Cover: other	1		

Table 5: Characteristics of effective designated crossing structures for reptiles (effective or very effective in reducing barrier effect through providing a satisfactory level of connectivity) (N = number of responses, grey = most frequent). Each value for a parameter has an associated count of responses, but the different parameters are summarized independently.

	Crossing structure type	N	Width (diameter) structure	N	Height (diameter) structure	N	Openings in roof underpass	N	Design guidelines specify cover	N	Construction (US \$)	N
Tortoises	No information available											
Turtles	Underpass, bottom	7	26-50 cm (0.9-1.6 ft)	1	51-75 cm (1.7-2.5 ft)	1	no	4	No cover	3	≤1000	1
			51-75 cm (1.7-2.5 ft)	1	76-100 cm (2.6-3.3 ft)	1	yes, open grate	3	Cover: rocks/boulders	1	6001-7000	1
			76-100 cm (2.6-3.3 ft)	1	176-200 cm (5.8-6.6 ft)	1	yes, open slots	1	Cover: other	2	200001-300000	1
			176-200 cm (5.8-6.6 ft)	1	>2-3 m (6.7-10 ft)	1						
			>2-3 m (6.7-10.0 ft)	2								
Snakes	Underpass, bottom	4	26-50 cm (0.9-1.6 ft)	2	26-50 cm (0.9-1.6 ft)	1	no	3	No cover	3	300001-400000	1
	Underpass, no bottom	1	151-175 cm (5.0-5.7 ft)	1	101-125 cm (3.4-4.1 ft)	1	yes, open slots	1	Cover: rocks/boulders	1		
			176-200 cm (5.8-6.6 ft)	1			yes (other)	1	Cover: other	1		
			>2-3 m (6.7-10.0 ft)	1								

Table 6: Characteristics of effective designated crossing structures for small mammals (effective or very effective in reducing barrier effect through providing a satisfactory level of connectivity) (N = number of responses, grey = most frequent). Each value for a parameter has an associated count of responses, but the different parameters are summarized independently.

	Crossing structure type	N	Width (diameter) structure	N	Height (diameter) structure	N	Openings in roof underpass	N	Design guidelines specify cover	N	Construction (US \$)	N
	Small mammals	Underpass, bottom	6	26-50 cm (0.9-1.6 ft)	2	26-50 cm (0.9-1.6 ft)	1	no	3	No cover	2	15001-20000
Underpass, no bottom		2	76-100 cm (2.6-3.3 ft)	1	76-100 cm (2.6-3.3 ft)	4	yes, open grate	3	Cover: other	5	100001-200000	3
Overpass (above road)		1	101-125 cm (3.4-4.1 ft)	2	101-125 cm (3.4-4.1 ft)	2	yes (other)	3	Cover: artificial (describe)	2	300001-400000	1
			126-150 cm (4.2-4.9 ft)	3	>2-3 m (6.7-10 ft)	1						
			151-175 cm (5.0-5.7 ft)	1								

3.8. Modified Structures Originally Built for Other Purposes

The respondents identified the species or species groups for which modifications were designed or implemented to structures originally built for other purposes (Figure 11). For roads in the USA or Canada, modifications to existing structures were most frequently designed for amphibians, closely followed by reptiles. Modifications for small mammal species to existing structures were relatively infrequently designed or constructed. Individual species for which modifications to existing structures were designed for are listed in Appendix B.

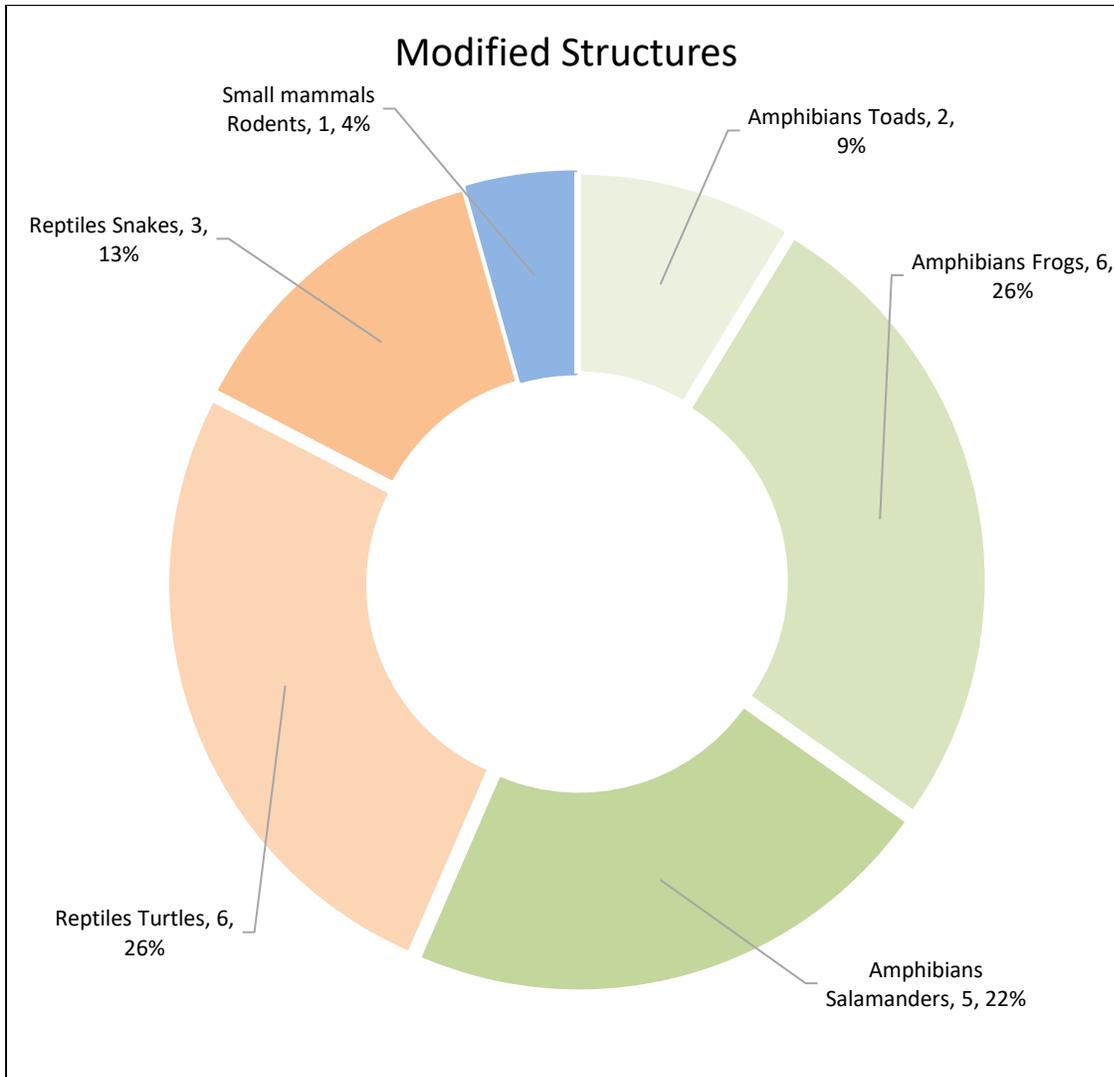


Figure 11: Target species groups mentioned by the respondents for the design and implementation of modified structures in the USA and Canada. Amphibians (n=13): Toads, Frogs, Salamanders; Reptiles (n=9): Turtles, Tortoises, Snakes; Small mammals (n=1): Mustelids, Rodents, Canids, Lagamorphs, Talpidae.

Modifications to existing structures mostly included a level pathway for small animal species, an elevated pathway above water (e.g. a shelf in a culvert with water), a funneling to help guide small animal species towards the structure, natural substrate on the bottom of the structure, and water at or near the structure (Figure 12). Cover, structure or vegetation was often provided near the entrances to the structures.

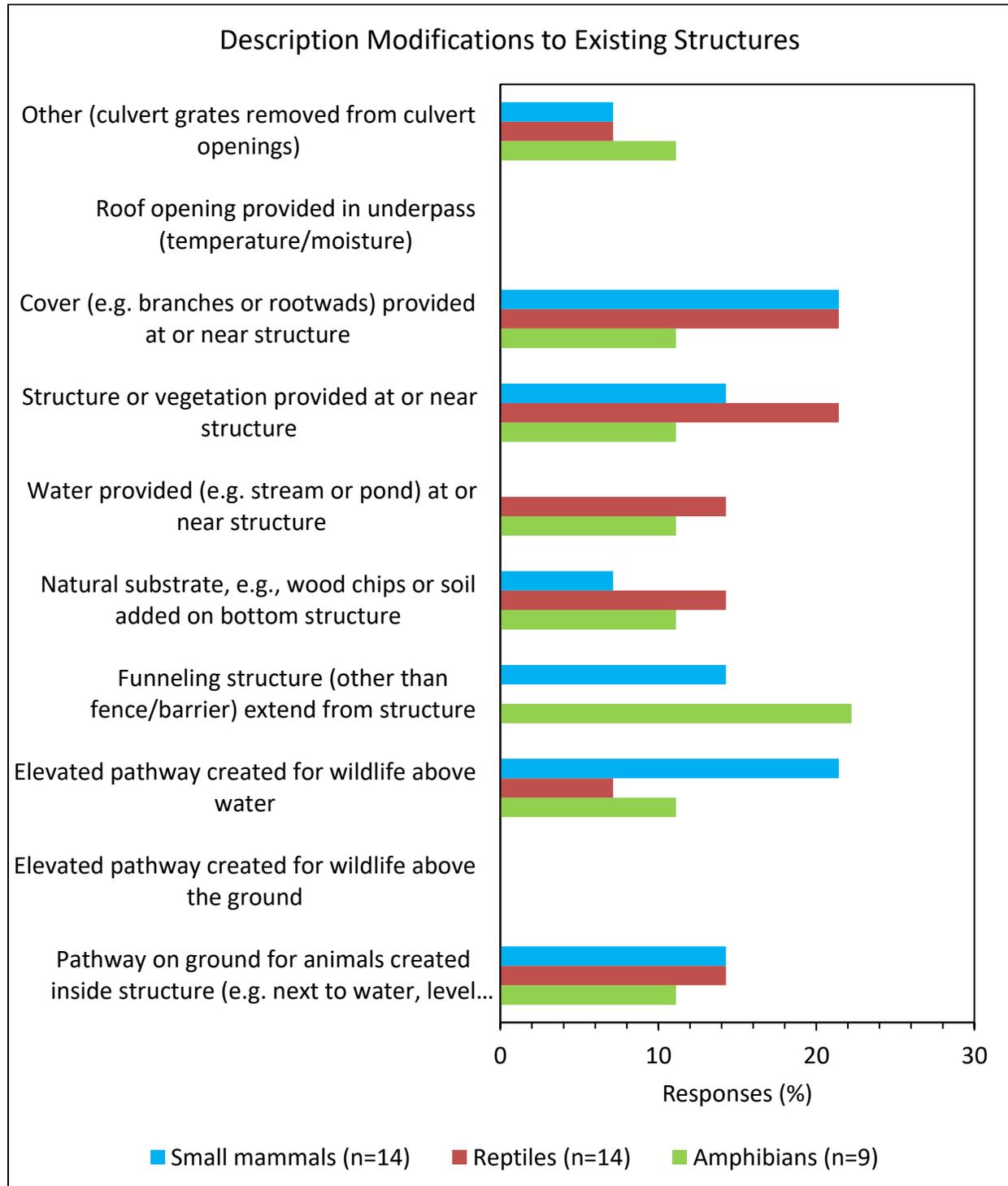


Figure 12: Description of the modifications to existing structures originally built for other purposes.

Most modifications to existing structures were not evaluated for their effectiveness in reducing the barrier effect of the road (Appendix C). The researchers selected information on modifications to existing structures for the three species groups that the respondents indicated were either “effective” or “very effective” in reducing the barrier effect of the road (Tables 7, 8). The number of effective modifications was so low that the researchers cannot conclude what characteristics are usually associated with providing a satisfactory level of connectivity through modifications to existing structures. Nonetheless, most of the modifications were made to structures that had a bottom (e.g. culverts), that were originally design for water, and that were connected to barriers. Maintenance issues associated with modifications to existing structures were mostly vegetation growing over the entrances of the structure and flooding (Appendix C).

The modified structures were typically monitored for wildlife use, including, but not limited to, the target species (Appendix C). The number of modified structures that were monitored for wildlife use typically ranged between 1 and 10. The structures were usually monitored with a wildlife camera, either triggered by motion and heat or set on a time-lapse. Before the modification was implemented, most of the structures had not been monitored for potential wildlife use. After the modification was put in place, monitoring typically lasted between 1 to 3 years (or seasons).

Table 7: Characteristics of effective modifications to existing structures for amphibians (effective or very effective in reducing barrier effect) (N = number of responses, grey = most frequent). Each value for a parameter has an associated count of responses, but the different parameters are summarized independently.

	Modification	N	Primary purpose of structure	N	Structure type	N	Width of structure	N	Height of structure	N	Barrier connected to the structures?	N	Construction cost per structure for modification (US \$)	N
Toads	No information													
Salamanders	Funneling structure (other than fence/barrier) extend from structure	1	Water	1	Underpass, bottom	1	51-75 cm (1.7-2.5 ft)	1	51-75 cm (1.61-2.5 ft)	1	Yes, both sides of road, continuous	1	≤1000	1
Frogs	Funneling structure (other than fence/barrier) extend from structure	1	Water	2	Underpass, bottom	2	51-75 cm (1.7-2.5 ft)	1	51-75 cm (1.61-2.5 ft)	1	Yes, both sides of road, continuous	1	≤1000	1
							176-200 cm (5.8-6.6 ft)	1			Yes, both sides of road, but with gaps	1		

Table 8: Characteristics of effective modifications to existing structures for reptiles and small mammals (rodents) (effective or very effective in reducing barrier effect) (N = number of responses, grey = most frequent). Each value for a parameter has an associated count of responses, but the different parameters are summarized independently.

	Modification	N	Primary purpose of structure	N	Structure type	N	Width of structure	N	Height of structure	N	Barrier connected to the structures?	N	Construction cost per structure for modification (US \$)	N
Tortoises	No information													
Turtles	?	2	Water	2	Underpass, bottom	2	101-125 cm (3.4-4.1 ft)	1	101-125 cm (3.31-4.1 ft)	1	Yes, both sides of road, but with gaps	1		
							176-200 cm (5.8-6.6 ft)	1			Yes, both sides of road, continuous	1		
Snakes	?	1	Water	1	Underpass, bottom	1	176-200 cm (5.8-6.6 ft)	1			Yes, both sides of road, but with gaps	1		
Rodents	Elevated pathway created for wildlife above water	1	Water	1	Underpass, bottom	1	76-100 cm (2.6-3.3 ft)	1	151-175 cm (4.91-5.7 ft)	1	No fence or barrier wall	1	5001-6000	1

3.9. Additional Information Needs

Dozens of respondents indicated that more research is needed into the design of effective barriers (type, height, length, reduce maintenance, reduce costs), designated wildlife crossing structures, and modifications to existing structures for all three species groups (listed and unlisted species) (Appendix C).

Additional needs or comments (modified, clarified, made more concrete by the researchers) are listed below. Note that some of the comments are listed under more than one heading when appropriate.

Roadkill or general wildlife mortality along roads

- Monitoring methods to detect small animal species as roadkill.
- Vegetation management can influence small mammal populations in the right-of-way and in turn can make right-of-ways attractive to predators, especially birds such as barn owl. Information is needed on how to not create population sinks for e.g. barn owl.
- Encourage or enforce the use of biodegradable erosion control techniques. Plastic mesh entraps small species (e.g. snakes). Zinc or galvanized coating of metal objects can be harmful to amphibians.
- Reduce direct road mortality of species scavenging on other road-killed animals.

Barriers

- Design wildlife barriers to be robust, stand up to erosion, vegetation maintenance, potential wildlife.
- Reduce maintenance for barriers (especially issues related to freeze-thaw cycles).
- Configuration of barrier-ends, curved ends (reduce fence-end effect).
- Address gaps in barriers, e.g. at side roads and driveways.
- Opportunities to escape the road corridor equipped with a barrier (fence or wall).
- Direction and oversight during construction in the field.
- Similar information needs to be compiled for bats, birds, and arboreal animal species.

Crossing structures

- Make structures (underpasses and overpasses) built for large mammals also suitable for small animal species (habitat, including potential need for water, remove or fill in riprap and other barriers, cover, etc.).
- Monitoring wildlife use of designated structures or modified structures and investigating whether the objectives of the project are reached, often does not happen.
- Direction and oversight during construction in the field.
- Similar information needs to be compiled for bats, birds, and arboreal animal species.
- Appropriate distance between adjacent crossing structures for different species and species groups.

Tools and techniques

- Monitoring methods to detect small animal species as roadkill.
- Protocols, methods for identification and prioritization of mitigation sites.
- Monitoring methods to detect small animal species (especially ectotherms) use of structures (e.g. The Hobbs Active Light Trigger (HALT) camera system for small animal species (Hobbs & Brehme, 2017).
- Monitoring wildlife use of designated structures or modified structures, and investigating whether the objective of the project are reached, often does not happen.

Maintenance

- Reduce maintenance for barriers (especially issues related to freeze-thaw cycles).
- Vegetation management can influence small mammal populations in the right-of-way and in turn can make right-of-ways attractive to predators, especially birds such as barn owl. Information is needed on how to not create population sinks for e.g. barn owl.
- Encourage or enforce the use of biodegradable erosion control techniques. Plastic mesh entraps small species (e.g. snakes). Zinc or galvanized coating of metal objects can be harmful to amphibians.
- Design wildlife barriers to be robust, stand up to erosion, vegetation maintenance, potential wildlife.

- Funding for maintenance and monitoring needs to be incorporated into budgets, not just the construction.

Stakeholders, funding, processes, outreach

- Outreach to advise people on removing small animal species from roads (especially turtles).
- Coordination between different stakeholders.
- Increase coordination for mitigation when addressing fish passage and terrestrial and semi-aquatic species.
- Field visits with stakeholders to increase understanding of the issues, outreach, expose transportation agencies to the impacts of roads on wildlife and how we can address them.
- Funding structures for avoidance, mitigation, and compensation measures for small species,
- Funding opportunities for highway wildlife may need to be linked to new housing developments and the associated roads.
- Road mitigation practices should be or become part of standard road improvement designs.
- Need to show and understand landscape level effects, meta-populations context, and the benefit of identifying, prioritizing, and implementing mitigation.
- Need to know about the different types and level of impact of different types of roads on wildlife, e.g. low traffic volume roads, dirt and gravel roads, including those on federal lands, not only high traffic volume and high-speed highways.
- Funding for maintenance and monitoring needs to be incorporated into budgets, not just the construction.
- Direction and oversight during construction in the field.

4. REFERENCES

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Hobbs, M.T. & C.S. Brehme. 2017. An improved camera trap for amphibians, reptiles, small mammals, and large invertebrates. PLoS ONE 12(10): e0185026. <https://doi.org/10.1371/journal.pone.0185026>

5. APPENDIX A: SURVEY

SECTION 1: Introduction and your affiliation

The Western Transportation Institute at Montana State University (WTI-MSU) is conducting a survey for the National Cooperative Highway Research Program. We aim to summarize experiences and the current state of practice to understand and mitigate the impact of highways and traffic on small terrestrial animal species; amphibians, reptiles, and mammals smaller than coyotes. We are especially interested in measures aimed at keeping these animals off the highway (e.g. fences or other barriers) and measures that provide safe crossing opportunities (e.g. underpasses or overpasses). The results will help to provide guidance to future projects aimed at reducing direct road mortality and maintaining habitat connectivity for small terrestrial animal species. We invite researchers and practitioners involved with highways and small animal species, especially from the United States and Canada, to share their knowledge and experience. If you know of other experts who have information relevant to this survey, please forward the survey link to them: <https://www.surveymonkey.com/r/7Z636ZQ>

The survey is voluntary and you are under no obligation to complete the survey. If you prefer not to answer a certain question, please skip it. The survey is extensive and aims to capture detailed information. A PDF of the survey questions is available from WTI-MSU (for e-mail see below). You can use the PDF to look up the requested information before opening up the survey on the website. If you have the information readily available, the survey may take about 30 minutes. If the question options do not allow you to adequately describe your situation, you may use the 'other' boxes to explain, or send us an email. You may pause the survey at any point and return to continue the survey later.

While no personally identifiable information will be published or distributed to others, we may want to contact you for additional information. If you agree to be contacted for more information, please provide your contact information at the beginning of the survey.

For more information on this survey, please contact Dr. Marcel Huijser, senior research ecologist, Western Transportation Institute at Montana State University, email: mhuijser@montana.edu.

Please respond to the survey before or on 1 November 2018.

1. Please check the option that best describes your affiliation

- State or Provincial Transportation Agency
- Municipal Transportation Agency
- State or Provincial Natural Resource Management Agency
- Federal or National Transportation Agency
- Federal or National Natural Resource Management Agency
- University or Research Institute
- Private (consulting) business
- Not For Profit Organization

Other (please specify)

2. What State/Territory/Province in the USA or Canada are your projects located in?

3. If your projects are not in the United States or Canada, what other part of the world are they located in?

4. If you agree to be contacted for more information, please provide your contact information. Note: We will not share or publish your name or contact information. You do not have to provide your name or contact information if you prefer not to.

Your Name (first, last)

Affiliation (if applicable)

State/Province

Country

Email Address

Phone Number

SECTION 2: Impacts of roads and traffic on small terrestrial animal species

5. If you have been involved with the design or implementation of mitigation measures along highways for small terrestrial animal species, which concerns or policies triggered the design or implementation? Note: please only check the most important concerns or policies for each species group.

	Habitat loss	Unnatural (road) mortality	Barrier effect of road	Noise, light, or chemical pollution or other disturbances originating from road	Human safety from small animal vehicle collisions	General concern for biological conservation	Regulatory status (e.g. Endangered Species Act)	Public or political pressure, regardless of laws or regulations
Amphibians	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Reptiles	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Mammals smaller than coyotes	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Other (please specify)

SECTION 3a: Reducing direct road mortality of small terrestrial animal species

6. Section 3 contains questions related to measures designed to reduce direct road mortality (e.g. fences and barrier walls, but road closures are also a possible measure). Section 3 does not include questions about safe crossing opportunities. Questions about safe crossing opportunities, with a focus on wildlife crossing structures (underpasses and overpasses), are part of section 4.

Question: Have you or your organization designed, implemented, or investigated measures aimed at reducing direct road mortality for small terrestrial animals?

- Yes (please proceed to Section 3b)
- No or "Don't know" (please proceed to Section 4)

SECTION 3b: Reducing direct road mortality of small terrestrial animal species

7. This section (Section 3) contains questions related to measures designed to reduce direct road mortality (through e.g. road closures, fences, barrier walls). Section 3 does not include questions about safe crossing opportunities. Questions about safe crossing opportunities, especially wildlife crossing structures (underpasses and overpasses), are part of section 4.

Question: What type of measures aimed at reducing direct road mortality have you or your organization implemented? Please check all measures that apply for each species group.

	Barriers to keep animals off the road	Permanent road closure or road removal	Seasonal road closure	Night-time road closure	Warning signs
Amphibians	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Reptiles	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Mammals smaller than coyotes	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Other (please specify)

8. This is a continuation of the previous question and table

	Reduced posted speed limit	Reduced design speed	Outreach to drivers	Other (please describe)
Amphibians	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Reptiles	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Mammals smaller than coyotes	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Other (please specify)

9. The following questions in section 3 b relate to barriers designed to keep small terrestrial animal species off the highway (e.g. fences or barrier walls). Please skip the remainder of section 3b if no barriers were designed or implemented.

You may have information on multiple barrier designs for each species group. This survey allows you to provide information for up to three barrier designs per species group. If you have information on more than three barrier designs for a species group, please provide information on the barrier designs that were considered most effective in keeping the target species off the road.

Question: What target species were the barriers designed for? Please list the target species for up to three different barrier designs per species group. Please enter names in following format: common name (scientific name).

Target species: Although barriers may function for multiple animal groups, only list the species that were considered when designing the barrier.

If there is more than one species for a particular barrier design, please enter multiple species names in the text box associated with that design.

Amphibians, design 1	<input type="text"/>
Amphibians, design 2	<input type="text"/>
Amphibians, design 3	<input type="text"/>
Reptiles, design 1	<input type="text"/>
Reptiles, design 2	<input type="text"/>
Reptiles, design 3	<input type="text"/>
Mammals smaller than coyotes, design 1	<input type="text"/>
Mammals smaller than coyotes, design 2	<input type="text"/>
Mammals smaller than coyotes, design 3	<input type="text"/>

10. You may have information on multiple barrier designs for each species group. This survey allows you to provide information for up to three barrier designs per species group. If you have information on more than three barrier designs for a species group, please provide information on the barrier designs that were considered most effective in keeping the target species off the road.

Note: the barrier designs in this question are associated with the target species you may have listed in the previous question. For example, if you have a barrier design for the "target species" desert tortoise (*Gopherus* spp.) and you entered the name of this target species behind "Reptiles, design 2" in the previous question, then enter the barrier characteristics for the desert tortoise behind "Reptiles, design 2" in the table below.

Question: What were the design characteristics, effectiveness, and costs of the different barrier designs?

Fence = extends above ground level

Retaining wall = back side is integrated with roadbed

	Barrier material	Height of barrier	Post material	Integrated with a fence built for other purposes?
Amphibians, design 1	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Amphibians, design 2	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Amphibians, design 3	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Reptiles, design 1	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Reptiles, design 2	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Reptiles, design 3	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Mammals smaller than coyotes, design 1	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Mammals smaller than coyotes, design 2	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Mammals smaller than coyotes, design 3	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

Other (please specify)

11. This is a continuation from previous question and table.

Please use the scroll bar under table to see all the columns.

	Buried into ground (e.g. apron or lip) and depth	Climbing deterrent (lip, overhang)	Effectiveness in reducing direct road mortality (if measured)	Construction cost per meter (3.28 ft) barrier length (US \$)	Connected to potential wildlife crossing structure	What is the primary surrounding habitat?
Amphibians, design 1	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Amphibians, design 2	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Amphibians, design 3	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Reptiles, design 1	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Reptiles, design 2	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Reptiles, design 3	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Mammals smaller than coyotes, design 1	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Mammals smaller than coyotes, design 2	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Mammals smaller than coyotes, design 3	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

Other (please specify)

12. For the barrier designs described above, did you experience any design, construction, or maintenance issues?

Please use the scroll bar under table to see all the columns.

	Barrier material not suited	Erosion	Flooding	Fallen trees	Vegetation overgrowing	Frequent removal or mowing of vegetation	Mowing damages barrier material	Barrier material degrades within 5 years	Snow and ice damage	Contraction and expansion of material	Vandalism	Poor barrier installation	High frequency barrier inspections	Barrier not suitable for target species (describe)	Other (describe)
Amphibians, design 1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Amphibians, design 2	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Amphibians, design 3	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Reptiles, design 1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Reptiles, design 2	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Reptiles, design 3	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Mammals smaller than coyotes, design 1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Mammals smaller than coyotes, design 2	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Mammals smaller than coyotes, design 3	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Other (please specify)

13. This question is not about different barrier designs, but it is about different projects. The project letters are not necessarily related to the barrier design numbers in the previous questions. Each project relates to a road section with a certain length. Note that each project may have included multiple barrier designs.

	Total length of road section considered part of the project	Total length of road section equipped with a barrier (mitigated on 1 or both sides of highway)	Barrier on both sides of road?
Amphibians, project A	<input type="text"/>	<input type="text"/>	<input type="text"/>
Amphibians, project B	<input type="text"/>	<input type="text"/>	<input type="text"/>
Amphibians, project C	<input type="text"/>	<input type="text"/>	<input type="text"/>
Reptiles, project A	<input type="text"/>	<input type="text"/>	<input type="text"/>
Reptiles, project B	<input type="text"/>	<input type="text"/>	<input type="text"/>
Reptiles, project C	<input type="text"/>	<input type="text"/>	<input type="text"/>
Mammals smaller than coyotes, project A	<input type="text"/>	<input type="text"/>	<input type="text"/>
Mammals smaller than coyotes, project B	<input type="text"/>	<input type="text"/>	<input type="text"/>
Mammals smaller than coyotes, project C	<input type="text"/>	<input type="text"/>	<input type="text"/>

Other (please specify)

14. This question is about research or monitoring direct road mortality for the different projects described in the previous question. Each project relates to a road section with a certain length. Note that each project may have included multiple barrier designs.

For the projects described above, what type of monitoring was conducted to evaluate the effectiveness of the barriers in reducing direct road mortality?

	Were on-road surveys conducted and what type of data were collected?	How long were road surveys conducted BEFORE construction?	How long were road surveys conducted AFTER construction?	How often were road surveys conducted?
Amphibians, project A	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Amphibians, project B	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Amphibians, project C	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Reptiles, project A	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Reptiles, project B	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Reptiles, project C	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Mammals smaller than coyotes, project A	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Mammals smaller than coyotes, project B	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Mammals smaller than coyotes, project C	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

Other (please describe below)

15. This is a continuation of the previous question and table.

Control = road with no barrier mitigation (e.g. unmitigated) for comparison to mitigated section

Please use the scroll bar under table to see all the columns.

	Did you include control, e.g. unmitigated sections with no barrier?	If or when animals breached the barrier/fencing what was the primary cause?	How often were inspections and associated maintenance conducted on the barriers?
Amphibians, project A	<input type="text"/>	<input type="text"/>	<input type="text"/>
Amphibians, project B	<input type="text"/>	<input type="text"/>	<input type="text"/>
Amphibians, project C	<input type="text"/>	<input type="text"/>	<input type="text"/>
Reptiles, project A	<input type="text"/>	<input type="text"/>	<input type="text"/>
Reptiles, project B	<input type="text"/>	<input type="text"/>	<input type="text"/>
Reptiles, project C	<input type="text"/>	<input type="text"/>	<input type="text"/>
Mammals smaller than coyotes, project A	<input type="text"/>	<input type="text"/>	<input type="text"/>
Mammals smaller than coyotes, project B	<input type="text"/>	<input type="text"/>	<input type="text"/>
Mammals smaller than coyotes, project C	<input type="text"/>	<input type="text"/>	<input type="text"/>

Other (please describe below)

16. Do you have specifications, design plans, as-built drawings, or photos of barriers specifically designed for small terrestrial animal species that you permit us to use in publications (report, website) resulting from this project? If yes, then please send them by email to Marcel Huijser (mhuijser@montana.edu) with the appropriate credits and or upload them to a file exchange server and inform us by email (mhuijser@montana.edu). We can send you a permission form for copyrighted material.

- Yes, I will send illustrations of barriers and WTI-MSU can use them in publications associated with this survey
- No

SECTION 4a: Providing safe crossing opportunities for small terrestrial animal species

17. The previous section (Section 3) contained questions related to measures designed to reduce direct road mortality with a focus on barriers (i.e. fences and barrier walls). The current section (Section 4) focuses on safe crossing opportunities for small terrestrial animal species, with an emphasis on wildlife crossing structures (underpasses and overpasses). Note that wildlife crossing structures are not the only measure that can provide safe crossing opportunities; for example, road removal also results in safe crossing opportunities for wildlife.

Question: Have you or your organization designed, implemented, or investigated mitigation measures aimed at providing safe crossing opportunities for small terrestrial animal species across a road? This question relates to measures specifically designed for small terrestrial animal species, as well as adaptations of measures originally designed for other purposes.

- Yes, I have information on safe crossing opportunities for small terrestrial animal species (please proceed below to Section 4b)
- No or "Don't know" (please proceed to Section 5)

SECTION 4b: Providing safe crossing opportunities for small terrestrial animal species

18. This section (Section 4) focuses on safe crossing opportunities for small terrestrial animal species, with an emphasis on wildlife crossing structures (underpasses and overpasses). Note that wildlife crossing structures are not the only measure that can provide safe crossing opportunities; for example, road removal also results in safe crossing opportunities for wildlife.

What type of measures aimed at providing safe crossing opportunities for small terrestrial animal species across roads have you or your organization implemented? Please check all measures that apply for each species group.

	Wildlife crossing structures (underpasses, overpasses or both)	Actively carrying animals to other side of highway (e.g. volunteer program with amphibians)	At-grade crossing opportunity (gap in fence or barrier wall, with or without signs, speed bumps etc)	Other (please describe)
Amphibians	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Reptiles	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Mammals smaller than coyotes	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Other (please specify)

19. Have you or your organization implemented avoidance or compensation measures for the impact of roads and traffic on small terrestrial animal species? Please check all measures that apply for each species group.

	Alternate transportation (e.g. railroad instead of road) (avoidance)	Rerouting road away from most sensitive locations (avoidance)	Road removal and potential associated habitat restoration (avoidance)	Increasing size of existing habitat patches (compensation)	Creating new habitat patches (compensation)	Creating or improving corridors between habitat patches (compensation)	Other (please describe)
Amphibians	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Reptiles	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Mammals smaller than coyotes	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Other (please specify)

20. Do you have information on crossing structures (i.e. underpasses or overpasses) that were designed, implemented or modified for small terrestrial animal species?

- Yes, I have information on structures (i.e. underpasses and overpasses) that were specifically designed for small terrestrial animal species (please proceed with question 23)
- Yes, I have information on structures originally designed for other purposes (e.g. livestock, large wild mammals, hydrology) but that were modified for small terrestrial animal species (please proceed with section 4c)
- Yes, both of the above (please proceed with question 23)
- No (please proceed to Section 5)

21. The following questions in section 4b relate to crossing structures (i.e. underpasses and overpasses) specifically designed to provide safe crossing opportunities for small terrestrial animal species across roads.

You may have information on multiple crossing structure designs for each species group. This survey allows you to provide information for up to three structure designs per species group. If you have information on more than three structure designs for a species group, please provide information on the structure designs that were considered most effective in providing safe crossing opportunities for the target species.

Question: What target species were the structures designed for? Please list the target species for up to three different structure designs per species group. Please enter names in following format: common name (scientific name).

Target species: Although structures may function for multiple animal groups, only list the species that were considered when designing the structure.

If there is more than one species for a particular structure design, please enter multiple species names in the text box associated with that design.

Amphibians, design 1

Amphibians, design 2

Amphibians, design 3

Reptiles, design 1

Reptiles, design 2

Reptiles, design 3

Mammals smaller than coyotes,
design 1

Mammals smaller than coyotes,
design 2

Mammals smaller than coyotes,
design 3

22. You may have information on multiple crossing structure designs (i.e. different types of underpasses and overpasses) for each species group. This survey allows you to provide information for up to three structure designs per species group. If you have information on more than three structure designs for a species group, please provide information on the structure designs that were considered most effective in providing safe crossings for the target species.

Note: the structure designs in this question are associated with the target species you may have listed in the previous question. For example, if you have a structure design for the "target species" desert tortoise (*Gopherus* spp.) and you entered the name of this target species behind "Reptiles, design 2" in the previous question, then enter the structure characteristics for the desert tortoise behind "Reptiles, design 2" in the table below.

Question: What were the design characteristics, effectiveness, and costs of the different crossing structure designs that were specifically designed for small terrestrial animal species?

Note: Effectiveness relates to whether and to what degree the objectives for wildlife movement or habitat connectivity were reached. Note: if no objectives were formulated or if effectiveness was not measured, effectiveness cannot be assessed by definition.

Note: for round structures, enter the diameter for height and width.

	Crossing structure type	Width (diameter) of structure	Height (diameter) of structure	Number of structures implemented of this design
Amphibians, design 1	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Amphibians, design 2	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Amphibians, design 3	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Reptiles, design 1	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Reptiles, design 2	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Reptiles, design 3	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Mammals smaller than coyotes, design 1	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Mammals smaller than coyotes, design 2	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Mammals smaller than coyotes, design 3	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

Other (please specify)

23. This is a continuation from the previous question and table.

	Openings in roof underpass or culvert (allow for similar temperature and humidity inside)	Design guidelines specify cover inside underpass or on top of overpass?	Effectiveness in reducing road barrier effect	Construction (including materials) cost per structure (US \$)
Amphibians, design 1	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Amphibians, design 2	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Amphibians, design 3	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Reptiles, design 1	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Reptiles, design 2	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Reptiles, design 3	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Mammals smaller than coyotes, design 1	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Mammals smaller than coyotes, design 2	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Mammals smaller than coyotes, design 3	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

Other (please specify)

24. This is a continuation from the previous question and table.

Please check all that apply.

	Pathway on ground for animals created inside structure (e.g. next to water, level path on slope)	Elevated pathway created for wildlife above the ground	Elevated pathway created for wildlife above water	Funneling structure (other than fence/barrier) extend from structure	Natural substrate, e.g., wood chips or soil added on bottom structure
Amphibians, design 1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Amphibians, design 2	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Amphibians, design 3	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Reptiles, design 1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Reptiles, design 2	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Reptiles, design 3	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Mammals smaller than coyotes, design 1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Mammals smaller than coyotes, design 2	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Mammals smaller than coyotes, design 3	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Other (please specify)

25. For the crossing structure (underpasses or overpasses) designs described above, did you experience any design, construction, or maintenance issues?

This is a wide table with 11 columns.

	Erosion issues	Flooding	Overgrown vegetation blocking entrance(s)	Frequent mowing or removal of vegetation	Crossing structure exposed to wear and tear (e.g. vehicles driving on top of structure)	Vandalism	Poor underpass or overpass installation or construction	High frequency of crossing structure inspections	Underpass or overpass in hind sight not suitable for target species (please describe)	Beaver-exclusion device required	Other (please describe)
Amphibians, design 1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Amphibians, design 2	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Amphibians, design 3	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Reptiles, design 1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Reptiles, design 2	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Reptiles, design 3	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Mammals smaller than coyotes, design 1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Mammals smaller than coyotes, design 2	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Mammals smaller than coyotes, design 3	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Other (please specify)

26. This question is not about different structure designs, but it is about different projects.
 The project letters are not necessarily related to the structure design numbers in the previous questions.
 Each project relates to a road section with a certain length.
 Note that each project may have included multiple structure designs.

Please use the scroll bar under table to see all the columns.

	Total length of road section considered part of the project	Typical road width (=structure length)	Typical structure and potential median	Barrier (fence or barrier wall) connected to the structures?	Average distance between crossing structures (if more than 1 structure)	Describe primary habitat surrounding structure(s)
Amphibians, project X	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Amphibians, project Y	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Amphibians, project Z	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Reptiles, project X	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Reptiles, project Y	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Reptiles, project Z	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Mammals smaller than coyotes, project X	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Mammals smaller than coyotes, project Y	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Mammals smaller than coyotes, project Z	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

Other (please specify)

27. What type of monitoring was conducted to evaluate the effectiveness of the crossing structures (underpasses or overpasses) in providing safe crossing opportunities to small terrestrial species?

	Were crossing structures monitored for target species use?	How many crossing structures were monitored?	How were crossing structures monitored for animal use?
Amphibians, project X	<input type="text"/>	<input type="text"/>	<input type="text"/>
Amphibians, project Y	<input type="text"/>	<input type="text"/>	<input type="text"/>
Amphibians, project Z	<input type="text"/>	<input type="text"/>	<input type="text"/>
Reptiles, project X	<input type="text"/>	<input type="text"/>	<input type="text"/>
Reptiles, project Y	<input type="text"/>	<input type="text"/>	<input type="text"/>
Reptiles, project Z	<input type="text"/>	<input type="text"/>	<input type="text"/>
Mammals smaller than coyotes, project X	<input type="text"/>	<input type="text"/>	<input type="text"/>
Mammals smaller than coyotes, project Y	<input type="text"/>	<input type="text"/>	<input type="text"/>
Mammals smaller than coyotes, project Z	<input type="text"/>	<input type="text"/>	<input type="text"/>

Other (please specify)

28. This is a continuation from the previous question and table.

	How long was wildlife connectivity across the road monitored BEFORE construction of the structures?	How long was wildlife use monitored AFTER construction of the structures?
Amphibians, project X	<input type="text"/>	<input type="text"/>
Amphibians, project Y	<input type="text"/>	<input type="text"/>
Amphibians, project Z	<input type="text"/>	<input type="text"/>
Reptiles, project X	<input type="text"/>	<input type="text"/>
Reptiles, project Y	<input type="text"/>	<input type="text"/>
Reptiles, project Z	<input type="text"/>	<input type="text"/>
Mammals smaller than coyotes, project X	<input type="text"/>	<input type="text"/>
Mammals smaller than coyotes, project Y	<input type="text"/>	<input type="text"/>
Mammals smaller than coyotes, project Z	<input type="text"/>	<input type="text"/>

Other (please specify)

29. Do you have specifications, design plans, as-built drawings, or photos of crossing structures (i.e. underpasses or overpasses) specifically designed for small terrestrial animal species that you permit us to use in publications (report, website) resulting from this project? If yes, then please send them by email to Marcel Huijser (mhuijser@montana.edu) with the appropriate credits or upload them to a file exchange server and inform us by email (mhuijser@montana.edu). We can send you a permission form for copyrighted material.

- Yes, I will send illustrations of structures and WTI-MSU can use them in publications associated with this survey
- No

30. Do you have information on other crossing structures (underpasses or overpasses) that were NOT SPECIFICALLY designed for small terrestrial animal species but that were later modified for small terrestrial animal species? This includes structures that were originally designed for other purposes such as drainage, livestock, or for large wild mammal species only)

- Yes (please proceed to Section 4c)
- No or "don't know" (please proceed to Section 5)

SECTION 4c: Providing safe crossing opportunities for small terrestrial animal species

31. The following questions relate to existing structures (underpasses or overpasses) that were NOT SPECIFICALLY DESIGNED for small terrestrial animal species. For example, their original design may have been for drainage, livestock, or large wild mammals only. If you have information on MODIFICATIONS TO STRUCTURES ORIGINALLY BUILT FOR OTHER PURPOSES to encourage use by small terrestrial animals species, please answer the following questions.

You may have information on multiple modifications for each species group. This survey allows you to provide information for up to three modifications per species group. If you have information on more than three modifications of structures for a species group, please provide information on the modifications that were considered most effective in providing safe crossing opportunities for the target species.

Question: What target species were the modifications designed for? Please list the target species for up to three different modification designs per species group. Please enter names in following format: common name (scientific name).

Target species: Although modifications to existing structures may benefit multiple animal groups, only list the species that were considered when designing the modification.

If there is more than one species for a particular modification, please enter multiple species names in the text box associated with that design.

Amphibians, modification 1	<input type="text"/>
Amphibians, modification 2	<input type="text"/>
Amphibians, modification 3	<input type="text"/>
Reptiles, modification 1	<input type="text"/>
Reptiles, modification 2	<input type="text"/>
Reptiles, modification 3	<input type="text"/>
Mammals smaller than coyotes, modification 1	<input type="text"/>
Mammals smaller than coyotes, modification 2	<input type="text"/>
Mammals smaller than coyotes, modification 3	<input type="text"/>

32. You may have information on multiple modifications for each species group. This survey allows you to provide information for up to three modifications per species group. If you have information on more than three modifications of structures for a species group, please provide information on the modifications that were considered most effective in providing safe crossing opportunities for the target species.

Question: Please check the characteristics of the individual modifications, and please provide more information in the "other/more information" box.

	Pathway on ground for animals created inside structure (e.g. next to water, level path on slope)	Elevated pathway created for wildlife above the ground	Elevated pathway created for wildlife above water	Funneling structure (other than fence/barrier) extend from structure	Natural substrate, e.g., wood chips or soil added on bottom structure	Water provided (e.g. stream or pond) at structure	Structure or vegetation provided at or near structure	Cover (e.g. branches or rootwads) provided at or near structure	Roof opening provided in underpass (temperature/moisture)
Amphibians, modification 1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Amphibians, modification 2	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Amphibians, modification 3	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Reptiles, modification 1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Reptiles, modification 2	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Reptiles, modification 3	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Mammals smaller than coyotes, modification 1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Mammals smaller than coyotes, modification 2	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Mammals smaller than coyotes, modification 3	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Other / more information (please specify)

33. What are the characteristics of existing structures (underpasses or overpasses) that were originally built for other purposes (e.g. drainage, livestock, large mammals only) and that were later modified to encourage use by small terrestrial animal species?

Note: this question relates to the structures that were modified. Please describe the structures that received the modifications described above. If more than one structure type or dimension received a particular modification, please describe the most typical structure that received that modification.

Note: for round structures, enter the diameter for height and width.

This is a wide table, please scroll to the right to see all the columns.

	Primary purpose of structure	Structure type	Width of structure	Height of structure
Amphibians, modification 1	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Amphibians, modification 2	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Amphibians, modification 3	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Reptiles, modification 1	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Reptiles, modification 2	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Reptiles, modification 3	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Mammals smaller than coyotes, modification 1	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Mammals smaller than coyotes, modification 2	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Mammals smaller than coyotes, modification 3	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

Other (please specify)

34. This is a continuation from the previous question and table.

	Number of structures with this modification	Barrier (fence or barrier wall) connected to the structures?	Effectiveness in reducing barrier effect highway	Construction cost per structure for modification to make it suitable for target species (US \$)
Amphibians, modification 1	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Amphibians, modification 2	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Amphibians, modification 3	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Reptiles, modification 1	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Reptiles, modification 2	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Reptiles, modification 3	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Mammals smaller than coyotes, modification 1	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Mammals smaller than coyotes, modification 2	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Mammals smaller than coyotes, modification 3	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

Other (please specify)

35. For the modifications to structures (underpasses and overpasses) described above, did you experience any design, construction, or maintenance issues?

This is a wide table with 11 columns.

	Erosion issues	Flooding	Vegetation overgrowing the entrances too much	Frequent mowing or removal of vegetation	Modification does not stand up to wear and tear	Vandalism	Poor modification or construction	High frequency of inspections for modification	Modification in hind sight not suitable for target species (please describe)	Beaver-exclusion device required	Other (please describe)
Amphibians, modification 1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Amphibians, modification 2	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Amphibians, modification 3	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Reptiles, modification 1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Reptiles, modification 2	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Reptiles, modification 3	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Mammals smaller than coyotes, modification 1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Mammals smaller than coyotes, modification 2	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Mammals smaller than coyotes, modification 3	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Other (please specify)

36. What type of monitoring was conducted to evaluate the effectiveness of the modifications to structures (underpasses or overpasses) originally built for other purposes?

	Were structures and modifications monitored for target species use?	How many and type of structures monitored?	How were structures monitored for animal use?
Amphibians, modification 1	<input type="text"/>	<input type="text"/>	<input type="text"/>
Amphibians, modification 2	<input type="text"/>	<input type="text"/>	<input type="text"/>
Amphibians, modification 3	<input type="text"/>	<input type="text"/>	<input type="text"/>
Reptiles, modification 1	<input type="text"/>	<input type="text"/>	<input type="text"/>
Reptiles, modification 2	<input type="text"/>	<input type="text"/>	<input type="text"/>
Reptiles, modification 3	<input type="text"/>	<input type="text"/>	<input type="text"/>
Mammals smaller than coyotes, modification 1	<input type="text"/>	<input type="text"/>	<input type="text"/>
Mammals smaller than coyotes, modification 2	<input type="text"/>	<input type="text"/>	<input type="text"/>
Mammals smaller than coyotes, modification 3	<input type="text"/>	<input type="text"/>	<input type="text"/>

Other (please specify)

37. This is a continuation from the previous question and table.

	How long was effectiveness monitoring conducted BEFORE modification?	How long was effectiveness monitoring conducted AFTER modification?
Amphibians, modification 1	<input type="text"/>	<input type="text"/>
Amphibians, modification 2	<input type="text"/>	<input type="text"/>
Amphibians, modification 3	<input type="text"/>	<input type="text"/>
Reptiles, modification 1	<input type="text"/>	<input type="text"/>
Reptiles, modification 2	<input type="text"/>	<input type="text"/>
Reptiles, modification 3	<input type="text"/>	<input type="text"/>
Mammals smaller than coyotes, modification 1	<input type="text"/>	<input type="text"/>
Mammals smaller than coyotes, modification 2	<input type="text"/>	<input type="text"/>
Mammals smaller than coyotes, modification 3	<input type="text"/>	<input type="text"/>
Other (please specify)	<input type="text"/>	

38. Do you have specifications, design plans, as-built drawings, or photos of modifications of existing structures (underpasses or overpasses) that were originally built for other purposes (e.g. drainage, livestock, large mammals only) and that were later modified to encourage use by small terrestrial animal species and you permit us to use in publications (report, website) resulting from this project? If yes, then please send them by email to Marcel Huijser (mhuijser@montana.edu) with the appropriate credits or upload them to a file exchange server and inform us by email (mhuijser@montana.edu). We can send you a permission form for copyrighted material.

- Yes, I will send illustrations of modifications to structures and WTI-MSU can use them in publications associated with this survey
- No

SECTION 5: More Information

39. Can you share research protocols (methods), and results (reports, articles, proceedings) used to investigate the effectiveness of measures aimed at keeping the target species off the highway and measures aimed at providing safe crossing opportunities?

If yes, then please send them by email to Marcel Huijser (mhuijser@montana.edu) with the appropriate credits or upload them to a file exchange server and inform us by email (mhuijser@montana.edu).

- Yes, I will send research protocols by e-mail or upload to a file exchange server
- No

40. Please check the area of mitigation for small animal species where more research is required.

	Effective barriers to keep animals off highway	Effective crossing structures to get animals to other side of highway	Other (please describe)
Amphibians	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Reptiles	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Mammals smaller than coyotes	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Other (please specify)

41. Please comment below on any additional insights or lessons learned from projects that are related to roads, traffic and small terrestrial animal species.

Thank you very much for participating in this survey. Your information will provide baseline information that can be shared and used to improve mitigation measures for terrestrial animals smaller than coyotes.

Please consider sharing additional materials for this project, such as photos, as-built drawings with specifications, and research reports and publications. Please send them by email to Marcel Huijser (mhuijser@montana.edu) or upload them to a file exchange server and inform us by email (mhuijser@montana.edu). Also please indicate whether you permit these materials to be used in the final NCHRP report or website that are deliverable for the project. We can send you a permission form for copyrighted material. Also please indicate appropriate credits for the individual and/or agency.

6. APPENDIX B: TARGET SPECIES OR SPECIES GROUPS MENTIONED BY RESPONDENTS FOR BARRIER DESIGN AND IMPLEMENTATION

Species group	Target Species	Barriers	Designated crossing structures	Modified structures
"Amphibians"			5	
Toads	Arroyo toad (<i>Anaxyrus californicus</i>)	4	2	
	Western toad (<i>Anaxyrus boreas</i>)	4	4	
	Boreal toad (<i>Bufo boreas boreas</i>)	1	1	
	American toad (<i>Bufo americanus</i>)	3	3	
	Yosemite toad (<i>Anaxyrus canorus</i>)	2		
	Great Basin spadefoot (<i>Spea intermontana</i>)	1	1	
	Canadian toad or Dakota toad (<i>Anaxyrus hemiophrys</i>)			1
	Toad spp.	3	1	1
	<i>Outside USA/Canada</i>			
	Common toad (<i>Bufo bufo</i>)	1	1	
Salamanders	Mole salamanders (<i>Ambystoma</i> spp.)	1	1	
	Tiger salamander (<i>Ambystoma tigrinum</i>)	1	1	1
	Blotched tiger salamanders (<i>Ambystoma tigrinum melanostictum</i>)	1		
	California tiger salamander (<i>Ambystoma californiense</i>)	4		
	Spotted salamander or yellow-spotted salamander (<i>Ambystoma maculatum</i>)	6	4	
	Blue-spotted salamander (<i>Ambystoma laterale</i>)	3	3	
	Long toed salamander (<i>Ambystoma macrodactylum</i>)	2	2	
	Northwestern salamander (<i>Ambystoma gracile</i>)	3	2	2
	Red-backed salamander (<i>Plethodon cinereus</i>)	1	2	
	Salamander spp.	3		
	Red-spotted newt (<i>Notophthalmus viridescens viridescens</i>)		1	
	Rough-skinned newt or roughskin newt (<i>Taricha granulosa</i>)		1	2
	<i>Outside USA/Canada</i>			
	Common newt (<i>Trituris vulgaris</i>)	1	1	
Frogs	Northern red-legged frog (<i>Rana aurora</i>)	4	2	2

	Green frog (<i>Lithobates clamitans</i> or <i>Rana clamitans</i>)	3	3	
	Leopard frog (<i>Lithobates</i> or <i>Rana</i> spp.)	1	2	
	Northern leopard frog (<i>Rana pipiens</i>)	1		
	American bullfrog (<i>Lithobates catesbeianus</i> or <i>Rana catesbeiana</i>)	1	1	
	Wood frog (<i>Lithobates sylvaticus</i> or <i>Rana sylvatica</i>)	4	3	
	Mink frog (<i>Lithobates septentrionali</i>)	1	1	
	California red-legged frog (<i>Rana draytonii</i>)	1		
	Spring peeper (<i>Pseudacris crucifer</i>)	2	4	
	Pacific tree frog (<i>Pseudacris regilla</i>)	5	1	2
	Gray treefrog (<i>Hyla versicolor</i>)	1	1	
	Chorus frog (<i>Pseudacris</i> spp.)	1	1	
	Western chorus frog (<i>Pseudacris triseriata</i>)	2	2	
	Blanchard's cricket frog (<i>Acris crepitans blanchardi</i>)	2	1	
	Frogs (Anura)	7	2	2
	<i>Outside USA/Canada</i>			
	Common frog (<i>Rana temporaria</i>)	1	1	
"Reptiles"			3	
Tortoises	Morafka's or Sonoran desert tortoise (<i>Gopherus morafkai</i>)	5		
	Mojave desert tortoise (<i>Gopherus agassizii</i>)	1		
	Desert tortoise (<i>Gopherus morafkai</i> or <i>Gopherus agassizii</i>)	3		
	Gopher Tortoise (<i>Gopherus polyphemus</i>)	2		
Turtles	Blanding's turtle (<i>Emydoidea blandingii</i>)	17	10	2
	Common snapping turtle (<i>Chelydra serpentina</i>)	13	5	1
	Painted turtle (<i>Chrysemys picta</i>)	7	5	
	Western painted turtle (<i>Chrysemys picta bellii</i>)	2		
	Midland painted turtle (<i>Chrysemys picta marginata</i>)	2		
	Northern diamondback terrapin (<i>Malaclemys terrapin terrapin</i>)	2		
	Diamondback terrapin (<i>Malaclemys terrapin</i>)	3		
	Wood turtle (<i>Glyptemys insculpta</i>)	5	5	1
	Spotted turtle (<i>Clemmys guttata</i>)	3	1	
	Western pond turtle (<i>Actinemys marmorata</i>)	1		
	Eastern box turtle (<i>Terrapene carolina carolina</i>)	2		
	Northern map turtle (<i>Graptemys geographica</i>)	1	1	

	Ornate box turtle (<i>Terrapene ornata ornata</i>)	1		
	Bog turtle (<i>Glyptemys muhlenbergii</i>)	1	1	
	Alabama red-bellied turtle (<i>Pseudemys alabamensis</i>)	1		
	Turtles (Testudines)	10	2	2
Snakes	Butler's gartersnake (<i>Thamnophis butleri</i>)	5	3	
	Red-sided garter snake (<i>Thamnophis sirtalis parietalis</i>)	1	1	
	Garter snake (<i>Thamnophi</i>)	2	2	
	Common garter snake (<i>Thamnophis sirtalis</i>)		1	
	Terrestrial gartersnake (<i>Thamnophis elegans</i>)		1	
	Eastern racer (<i>Coluber constrictor</i>)		1	
	Eastern foxsnake (<i>Pantherophis gloydii</i>)	5	2	
	Eastern massasauga rattlesnake (<i>Sistrurus catenatus catenatus</i>)	4		1
	Massasauga rattlesnake (<i>Sistrurus catenatus</i>)	1		
	Rattlesnakes (Crotalinae)	1		
	Western rattlesnake (<i>Crotalus oreganus</i>)		2	
	Gopher snake (<i>Pituophis catenifer</i>)		1	
	Brown snake (<i>Storeria dekay</i>)	2	1	
	Eastern hog-nosed snake (<i>Heterodon platirhinos</i>)	1		
	Western hognose snake (<i>Heterodon nasicus</i>)	1		
	Gray ratsnake or gray rat snake (<i>Pantherophis spiloides</i>)	1		
	Northern redbelly snake (<i>Storeria occipitomaculata occipitomaculata</i>)		1	
	Redbelly snake (<i>Storeria occipitomaculata</i>)	1	1	
	Northern water snake (<i>Nerodia sipedon</i>)	1		
	Milk snake (<i>Lampropeltis triangulum</i>)	1	1	
	Rainbow snake (<i>Farancia erythrogramma</i>)	1		
	Louisiana pine snake (<i>Pituophis ruthveni</i>)	1		
	Northern pine snake (<i>Pituophis melanoleucus lodingi</i>)	1		1
	Snakes (Serpentes)	6	1	1
	Eastern indigo snake (<i>Drymarchon couperi</i>)		1	
	Rubber boa (<i>Charina bottae</i>)		1	
	Sharp-tailed snake or sharptail snake (<i>Contia tenuis</i>)		1	
	<i>Outside USA/Canada</i>			
	Grass snake (<i>Natrix natrix</i>)	1	1	
Lizards	Flat-tail horned lizard (<i>Phrynosoma mcallii</i>)	1		
	<i>Outside USA/Canada</i>			

	slow worm (<i>Anguis fragilis</i>)	1	1	
	Viviparous lizard (<i>Lacerta vivipara</i>)	1	1	
"Mammals"			8	
Canids	San Joaquin kit fox (<i>Vulpes macrotis mutica</i>)	2		
	Red fox (<i>Vulpes vulpes</i>)	1		
	Fox	1		
	<i>Outside USA/Canada</i>			
	Red fox (<i>Vulpes vulpes</i>)			
Felids	Canada lynx (<i>Lynx canadensis</i>)		3	
	Bobcat (<i>Lynx rufus</i>)		1	
Mustelids	Mustelids (Mustelidae)	1		
	American mink (<i>Neovison vison</i>)	2	1	
	Striped skunk (<i>Mephitis mephitis</i>)	1		
	North American river otter (<i>Lontra canadensis</i>)	2		
	American pine marten (<i>Martes americana</i>)	1	1	
	Weasel (<i>Mustela</i> spp.)	2	1	
	Skunks (Mephitidae)	1	2	
	American badger (<i>Taxidea taxus</i>)	1	1	
	<i>Outside USA/Canada</i>			
	Eurasian badger (<i>Meles meles</i>)	1		
	Pine marten (<i>Martes martes</i>)	1		
	Polecat (<i>Mustela putorius</i>)	1		
	Stoat (<i>Mustela erminea</i>)	1		
	Weasel (<i>Mustela nivalis</i>)	1		
Rodents	Groundhog or woodchuck (<i>Marmota monax</i>)	1		
	Muskrat (<i>Ondatra zibethicus</i>)	1		
	Eastern chipmunk (<i>Tamias striatus</i>)	1		
	North American beaver (<i>Castor canadensis</i>)	1		
	North American porcupine (<i>Erethizon dorsatum</i>)	1		
	Voles (Arvicolinae)	1	1	
	Rodents	1		
	American red squirrel (<i>Tamiasciurus hudsonicus</i>)	1		
	Mouse (Muroidea)	1		

	North American porcupine (<i>Erethizon dorsatum</i>)		1	
	American red squirrel (<i>Tamiasciurus hudsonicus</i>)		1	
	Western gray squirrel (<i>Sciurus griseus</i>)		1	
	Stephens' kangaroo rat (<i>Dipodomys stephensi</i>)		1	
	Preble's Meadow jumping mouse (<i>Zapus hudsonius preblei</i>)			1
	<i>Outside USA/Canada</i>			
	Red squirrel (<i>Sciurus vulgaris</i>)	1		
	Hazel dormouse or common dormouse (<i>Muscardinus avellanarius</i>)		1	
Lagomorphs	Snowshoe hare (<i>Lepus americanus</i>)	1		
	Rabbits (Leporidae)	1	2	
	Snowshoe hare (<i>Lepus americanus</i>)		1	
Procyonidae	North American raccoon (<i>Procyon lotor</i>)	2	2	
Talpidae	Moles (Talpidae)	1	1	
Didelphidae	Virginia opossum (<i>Didelphis virginiana</i>)		2	

7. APPENDIX C: SUMMARY TABLES FOR THE SURVEY QUESTIONS

BARRIERS

Q 10: Barrier material reported for excluding small animal species.

Barrier material	Amphibians	Reptiles	Small Mammals
Fence: chain-link	2	11	7
Fence: geotextile	5	18	1
Fence: plastic sheets	7	7	
Fence: woven wire	5	21	8
Wall: concrete	2	6	
Wall: plastic	3	4	
Other (metal guardrail)	1		1
Other (railroad ties)	1		
Other (chain link + 1/4-inch mesh woven wire)		1	
Other (4 ft. plastic mesh)		1	

Q 10: Barrier height reported for excluding small animal species.

Height barrier	Amphibians	Reptiles	Small mammals
0-25 cm (0-0.8 ft)	2	2	
26-50 cm (0.81-1.6 ft)	13	6	
51-75 cm (1.61-2.5 ft)	15	26	2
76-100 cm (2.51-3.3 ft)	2	26	3
101-125 cm (3.31-4.1 ft)		6	1
126-150 cm (4.2-4.9 ft)			1
151-175 cm (4.91-5.7 ft)		1	3
176-200 cm (5.71-6.6 ft)		3	1
>200 cm (>6.6 ft)		1	5

Q10: Post material reported for barriers aimed at excluding small animal species.

Post material	Amphibians	Reptiles	Small mammals
Concrete	1	3	
Metal	9	32	11
Plastic	6	5	
Wood	13	24	4
None	2	4	

Q10: Fence for small animal species integrated with a fence built for other purposes?

Integrated with a fence built for other purposes?	Amphibians	Reptiles	Small mammals
No	26	39	3
Yes, Fence for humans	1	7	
Yes, Large mammal fence	1	6	9
Yes, r-o-w/livestock fence	3	9	
Yes, Other		5	

Q11: How deep is the barrier for small animal species buried into the ground?

Buried into ground (e.g. apron or lip) and depth	Amphibians	Reptiles	Small mammals
No	1	4	4
>0-5 cm (>0-2")	7	6	
6-10 cm (>2-4")	10	9	
11-15 cm (>4-6")	6	15	2
16-20 cm (>6-8")		13	4
21-25 cm (>8-10")		5	1
26-50 cm (>10-20")	1	9	3
51-75 cm (>20-30")	2	2	1

Q11: Does the barrier have a climbing deterrent (e.g. a lip or overhang)?

Climbing deterrent (lip, overhang)	Amphibians	Reptiles	Small mammals
No	14	37	8
Yes	16	32	4

Q11: How effective is the barrier in reducing direct road mortality?

Effectiveness in reducing direct road mortality (if measured)	Amphibians	Reptiles	Small mammals
0% (ineffective)	1	1	
20%		1	1
30%		1	
40%	2		
50%		2	1
60%	1	1	
70%	2	3	
80%	2	6	1
90%	1	5	
100% (very effective)	3	5	
Don't know	17	27	5
Not measured	4	16	4

Q11: What are the construction costs of the barrier?

Construction cost per meter (3.28 ft) barrier length (US \$)	Amphibians	Reptiles	Small mammals
\$0-10	5	5	
\$11-20	4	4	1
\$21-30		2	
\$31-40		1	
\$41-50	3	5	
\$51-60		1	
\$61-70		1	
\$81-90	1	2	
>\$100	1	2	
Don't know			1
Unknown	16	45	12

Q11: Is the barrier connected to a potential wildlife crossing structure?

Connected to potential wildlife crossing structure	Amphibians	Reptiles	Small mammals
No	5	17	1
Yes designated structure	18	28	8
Yes not designated structure	5	11	
Both designated and not designated	3	8	2
Unknown	2	2	3

Q11: What is the primary surrounding habitat of the barrier?

What is the primary surrounding habitat?	Amphibians	Reptiles	Small mammals
Wetland	3	12	
Grassland	1	2	
Mixed habitat	3	11	3
Forest	2		1
Open-forest mix		1	
Unknown			1

Q 12: Maintenance issues with the barriers.

Maintenance issues	Amphibians	Reptiles	Mammals
Barrier material not suited	5	12	2
Erosion	9	25	3
Flooding	2	14	3
Fallen trees	6	20	5
Vegetation overgrowing	12	26	3
Frequent removal or mowing of vegetation	4	10	
Mowing damages barrier material	5	12	
Barrier material degrades within 5 years	4	16	
Snow and ice damage	6	15	4
Contraction and expansion of material	6	10	2
Vandalism	3	7	4
Poor barrier installation	4	15	7
High frequency barrier inspections	4	3	
Barrier not suitable for target species (describe)	1	1	
Other: wildfire melted plastic barriers	1		
Other: painting plastic creates problems	1		
Other: barrier not tight to ground			1
Other: vehicles crash into barrier		1	

Q 13: Total length of the road section considered part of the barrier implementation project.

Total length of road section considered part of the project	Amphibians	Reptiles	Small mammals
≤50 m (≤164 ft)	2	1	
51-100 m (165-328 ft)	3	1	
101-150 m (329-492 ft)	1	3	
151-200 m (493-656 ft)	1	3	
201-250 m (657-820 ft)	1	3	
251-300 m (821-984 ft)		1	
301-350 m (985-1148 ft)	2	2	
351-400 m (1149-1312 ft)	1	1	
451-500 m (1477-1640 ft)	2	3	1
501-550 m (1641-1804 ft)	1	3	
551-600 m (1805-1969 ft)	1		
601-650 m (1970-2133 ft)			1
651-700 m (2134-2297 ft)		1	1
701-750 m (2298-2461 ft)		1	
751-800 m (2462-2625 ft)			
801-900 m (2626-2953 ft)			
901-1000 m (2954-3281 ft)			
901-1000 m (2954-3281 ft)	2	4	2
1-2 km (0.62-1.24 mi)	9	9	
>2-3 km (1.25-1.86 mi)	2	2	
>3-4 km (1.87-2.49 mi)	3	4	1
>4-5 km (2.50-3.11 mi)	1	1	
>5-6 km (3.12-3.73 mi)		2	1
>6-7 km (3.74-4.35 mi)	2	5	1
>7-8 km (4.36-4.97 mi)			
>8-9 km (4.98-5.59 mi)	2	2	2
>9-10 km (5.60-6.22 mi)	2	4	
>10 km (>6.23 mi)	1	10	4
Unknown	4	4	

Q13: Total length of the road section equipped with a barrier (mitigated on one or both sides of highway).

Total length of road section equipped with a barrier (mitigated on 1 or both sides of highway)	Amphibians	Reptiles	Small mammals
≤50 m (≤164 ft)	2	1	
51-100 m (165-328 ft)	5	1	
101-150 m (329-492 ft)	2	4	
151-200 m (493-656 ft)	1	2	
201-250 m (657-820 ft)	2	5	
251-300 m (821-984 ft)	2	1	
301-350 m (985-1148 ft)	3	3	1
351-400 m (1149-1312 ft)	1	1	
451-500 m (1477-1640 ft)		2	1
501-550 m (1641-1804 ft)	1	2	
551-600 m (1805-1969ft)			
601-650 m (1970-2133 ft)			
651-700 m (2134-2297 ft)			
701-750 m (2298-2461 ft)		3	
751-800 m (2462-2625 ft)			
801-900 m (2626-2953 ft)			
901-1000 m (2954-3281 ft)	2	4	2
1-2 km (0.62-1.24 mi)	5	9	
>2-3 km (1.25-1.86 mi)	2	3	1
>3-4 km (1.87-2.49 mi)	2	4	1
>4-5 km (2.50-3.11 mi)		3	
>5-6 km (3.12-3.73 mi)	1	1	2
>6-7 km (3.74-4.35 mi)		2	
>7-8 km (4.36-4.97 mi)	1	2	
>8-9 km (4.98-5.59 mi)	1	2	1
>9-10 km (5.60-6.22 mi)	1	1	
>10 km (>6.23 mi)	1	4	2
Unknown	3	5	1

Q13: Barrier present on both sides of the road?

Barrier on both sides of road?	Amphibians	Reptiles	Small mammals
No, one side of road only	3	7	
Yes, but some sections only on one side	4	11	1
Yes, both sides of road, but with gaps	12	16	7
Yes, both sides of road, continuous	18	31	4

Q 14: Were on-road surveys conducted and what type of data were collected?

Were on-road surveys conducted and what type of data were collected?	Amphibians	Reptiles	Small mammals
No	5	15	4
Yes: alive and dead	26	36	2
Yes: only dead on road	1	5	4
Yes: other (describe)		1	
Unknown	5	5	3

Q14: How long were road surveys conducted before construction or implementation of the barriers?

How long were road surveys conducted BEFORE construction?	Amphibians	Reptiles	Mammals
Seasonal: 1 yr	5	10	2
Seasonal: 2-5 yrs	15	18	
Seasonal: >5 yrs	2	3	1
All year: 1 yr			
All year: 2-5 yrs			1
All year: >5 yrs			
Unknown	10	13	6

Q 14: How long were road surveys conducted after construction or implementation of the barriers?

How long were road surveys conducted AFTER construction?	Amphibians	Reptiles	Mammals
Seasonal: 1 yr	5	7	1
Seasonal: 2-5 yrs	17	23	2
Seasonal: >5 yrs	1	2	1
All year: 1 yr			
All year: 2-5 yrs		2	1
All year: >5 yrs	1		
Unknown	6	11	6

Q 14: How often were road surveys conducted?

How often were road surveys conducted?	Amphibians	Reptiles	Mammals
Every day	3	4	
6 times/wk			1
5 times/wk	3	4	1
4 times/wk		2	
3 times/wk	5	9	2
2 times/wk	5	6	1
1 time/wk	5	4	
2 times/mo	1	2	1
1 time/mo			
<1 time/mo			
never		2	
Other (describe)	6	5	
Unknown	6	12	5

Q 15: Did you include a control, e.g. unmitigated road sections without a barrier?

Did you include control, e.g. unmitigated sections with no barrier?	Amphibians	Reptiles	Small mammals
No	11	25	2
Yes: no gap between unmitigated and mitigated	8	9	2
Yes: gap between unmitigated and mitigated	7	11	3
Unknown	6	7	5

Q 15: If or when animals breached the barrier or fence, what was the primary cause?

If or when animals breached the barrier/fencing what was the primary cause?	Amphibians	Reptiles	Small mammals
Opening between mitigated sections	2	5	2
Gap within a mitigation section	2	10	1
Drainage wash-out/erosion	4	8	
Vandalism			1
Material deterioration		1	
Other (describe)	7	10	1
Unknown	11	15	8

Q 15: How often were barriers inspected and how often was associated maintenance conducted?

How often were inspections and associated maintenance conducted on the barriers?	Amphibians	Reptiles	Small mammals
1 time/wk	4	5	1
1 time/mo	8	8	1
4 times/yr	1	1	
3 times/yr	1	1	
2 times/yr	2	3	1
1 time/yr	3	6	1
<1 time/yr	1	1	
Never	1	4	
Other (describe)	4	12	1
Unknown	6	9	7

SAFE CROSSING OPPORTUNITIES: GENERAL

Q 18: What type of measures aimed at providing safe crossing opportunities for small terrestrial animal species across roads have you or your organization implemented?

What type of measures aimed at providing safe crossing opportunities for small terrestrial animal species across roads have you or your organization implemented?	Amphibians	Reptiles	Small mammals
Wildlife crossing structures (underpasses, overpasses or both)	36	51	34
Actively carrying animals to other side of highway (e.g. volunteer program with amphibians)	11	10	1
At-grade crossing opportunity (gap in fence or barrier wall, with or without signs, speed bumps etc.)	2	6	4
Other	5	6	6

Q19: Have you or your organization implemented avoidance or compensation measures for the impact of roads and traffic on small terrestrial animal species?

Have you or your organization implemented avoidance or compensation measures for the impact of roads and traffic on small terrestrial animal species?	Amphibians	Reptiles	Small mammals
Alternate transportation (e.g. railroad instead of road) (avoidance)	0	0	0
Rerouting road away from most sensitive locations (avoidance)	11	14	12
Road removal and potential associated habitat restoration (avoidance)	3	5	2
Increasing size of existing habitat patches (compensation)	7	8	10
Creating new habitat patches (compensation)	9	13	9
Creating or improving corridors between habitat patches (compensation)	10	16	16
Other (please describe)	3	5	5

DESIGNATED WILDLIFE CROSSING STRUCTURES

Q 22: Designated wildlife crossing structure type for the three species groups.

Crossing structure type	Amphibians	Reptiles	Small mammals
Underpass, bottom	22	31	15
Underpass, no bottom	6	7	7
Overpass (above road)		4	4
Unknown	4		

13/66

Q 22: Width (or diameter) of designated wildlife structures.

Width (diameter) of structure	Amphibians	Reptiles	Small mammals
0-25 cm (0-0.8 ft)	1		
26-50 cm (0.9-1.6 ft)	4	6	4
51-75 cm (1.7-2.5 ft)	2	3	3
76-100 cm (2.6-3.3 ft)	4	4	4
101-125 cm (3.4-4.1 ft)	3	3	2
126-150 cm (4.2-4.9 ft)	4	4	2
151-175 cm (5.0-5.7 ft)	1		
176-200 cm (5.8-6.6 ft)	2	2	1
>2-3 m (6.7-10.0 ft)	2	6	
>3-4 m (10.1-13.1 ft)	1	3	2
>4-5 m (13.2-16.4 ft)		2	1
>5-6 m (16.5-19.7 ft)			
>6-7 m (19.8-23.0 ft)			
>7-8 m (23.1-26.2 ft)			
>8-9 m (26.3-29.5 ft)			
>9-10 m (29.6-32.8 ft)			1
>10-20 m (32.8-65.6 ft)		1	2
>20-30 m (65.7-98.4 ft)			
>30-40 m (98.5-131.2 ft)	2		
>40-50 m (131.3-164.0 ft)		1	1
>50-60 m (>164.1-196.9 ft)			
>60-70 m (197.0-229.7 ft)			
>70-80 m (229.8-262.5 ft)			
>80-90 m (262.6-295.3 ft)			
>90-100 m (295.4-328.1 ft)			
>100 m (>328.1 ft)		2	
Unknown	5	1	1

Q 22: Height (or diameter) of designated wildlife structures.

Height (diameter) of structure	Amphibians	Reptiles	Small mammals
0-25 cm (0-0.8 ft)	2		
26-50 cm (0.9-1.6 ft)	5	6	2
51-75 cm (1.7-2.5 ft)	3	3	3
76-100 cm (2.6-3.3 ft)	6	6	4
101-125 cm (3.4-4.1 ft)	4	4	4
126-150 cm (4.2-4.9 ft)	1	3	
151-175 cm (5.0-5.7 ft)			
176-200 cm (5.8-6.6 ft)		4	1
>2-3 m (6.7-10 ft)	1	3	4
>3-4 m (10.1-13.1 ft)	2	1	1
>4-5 m (13.2-16.4 ft)			
>5-6 m (16.5-19.7 ft)			
>6-7 m (19.8-23.0 ft)			
>7-8 m (23.1-26.2 ft)			
>8-9 m (26.3-29.5 ft)			
>9-10 m (29.6-32.8 ft)			1
>10-20 m (32.9-65.6 ft)			
>20-30 m (65.7-98.4 ft)			
>30-40 m (98.5-131.2 ft)			
>40-50 m (131.3-164.0 ft)			
>50 m (>164.0 ft)			
Not applicable (overpass)		2	1
Unknown	4	3	1

Q 22: Number of designated wildlife structures implemented of this design.

Number of structures implemented of this design	Amphibians	Reptiles	Small mammals
1	9	18	7
2	6	6	2
3	3	1	1
4	1	2	1
5	1	2	1
6		1	1
7			1
8		1	1
9			1
10			
11			
12		1	
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			
>25			2

Q 23: Openings in roof underpass or culvert (allow for similar temperature, and humidity inside).

Openings in roof underpass or culvert (allow for similar temperature and humidity inside)	Amphibians	Reptiles	Small mammals
no	11	23	15
yes, open grate	4	6	1
yes, open slots	8	7	1
yes (other)	1	2	3
unknown	2	1	

28/62=45%

Q 23: Do the design guidelines specify cover inside underpass or on top of overpass?

Design guidelines specify cover inside underpass or on top of overpass?	Amphibians	Reptiles	Small mammals
No cover	11	18	10
Cover: branches/root wads	1	4	2
Cover: rocks/boulders	4	2	3
Cover: artificial (describe)		1	3
Cover: vegetation		4	1
Cover: other	6	8	3
Unknown	2	3	

Q 23: Effectiveness of the designated crossing structures in reducing the barrier effect.

Effectiveness in reducing road barrier effect	Amphibians	Reptiles	Small mammals
Not implemented	1	1	2
No objectives formulated	1	3	
Effectiveness unknown	9	22	8
Ineffective			
Marginally effective	4	1	3
Effective	4	7	6
Very effective	3	3	3

Q 23: Construction (including materials) cost per designated wildlife crossing structure (US \$)?

Construction (including materials) cost per structure (US \$)	Amphibians	Reptiles	Small mammals
≤1000		2	
1001-2000			
2001-3000			
3001-4000			
4001-5000		2	
4001-5000			
6001-7000		1	
7001-8000			
8001-9000	1		
9001-10000			1
10001-15000	1	2	
15001-20000		3	2
20001-25000	2	1	1
25001-30000			
30001-35000			1
35001-40000	1		1
40001-45000			1
45001-50000	1		
50001-60000			
60001-70000		1	
70001-75000			
75001-80000			
80001-85000			
85001-90000	1		
90001-100000		1	
100001-200000	2	2	1
200001-300000		1	
300001-400000	1		
400001-500000		1	
>500000		1	
Unknown	11	15	12

Q 24: Design characteristics designated wildlife crossing structure?

Species group	Amphibians	Reptiles	Small mammals
Pathway on ground for animals created inside structure (e.g. next to water, level path on slope)	8	10	9
Elevated pathway created for wildlife above the ground	1		7
Elevated pathway created for wildlife above water	3	5	12
Funneling structure (other than fence/barrier) extended from structure (e.g. wing walls)	10	11	9
Natural substrate, e.g., wood chips or soil added on bottom structure	14	21	10

Q 25: Design, construction or maintenance issues.

Design, construction, or maintenance issues	Amphibians	Reptiles	Small mammals
Erosion issues	8	8	5
Flooding	7	12	5
Overgrown vegetation blocking entrance(s)	8	7	1
Frequent mowing or removal of vegetation			
Crossing structure exposed to wear and tear (e.g. vehicles driving on top of structure)	1	3	
Vandalism			3
Poor underpass or overpass installation or construction	1	1	1
High frequency of crossing structure inspections	1	1	
Underpass or overpass in hind sight not suitable for target species		2	2
Beaver-exclusion device required			
Other (please describe)	2	4	6
Other (temperature inside did not fluctuate with surroundings)	1		
Other (icing inside structure, snow drifting at entrance)	1	1	1
Other (insufficient barrier maintenance)	1	1	1

Q 26: Total length of the road section considered part of the project.

Total length of road section considered part of the project	Amphibians	Reptiles	Small mammals
≤50 m (≤164 ft)	4	4	2
51-100 m (165-328 ft)			
101-150 m (329-492 ft)	1		
151-200 m (493-656 ft)	1	2	1
201-250 m (657-820 ft)			
251-300 m (821-984 ft)	1	1	
301-350 m (985-1148 ft)	1		
351-400 m (1149-1312 ft)	1	1	2
401-450 m (1313-1476 ft)	2	1	
451-500 m (1477-1640 ft)		1	
501-550 m (1641-1804 ft)			
551-600 m (1805-1969 ft)			
601-650 m (1970-2133 ft)			
651-700 m (2134-2297 ft)		1	
701-750 m (2298-2461 ft)		1	
751-800 m (2462-2625 ft)			
801-900 m (2626-2953 ft)			
901-1000 m (2954-3281 ft)	2	2	2
1-2 km (0.62-1.24 mi)	5	3	1
>2-3 km (1.25-1.86 mi)	2	2	
>3-4 km (1.87-2.49 mi)	1	1	1
>4-5 km (2.50-3.11 mi)	1	1	1
>5-6 km (3.12-3.73 mi)		1	
>6-7 km (3.74-4.35 mi)	1		
>7-8 km (4.36-4.97 mi)			
>8-9 km (4.98-5.59 mi)	1		1
>9-10 km (5.60-6.22 mi)		4	
>10 km (>6.23 mi)	3	3	10
Unknown	5	3	

Q 26: Typical road width (=structure length).

Typical road width (=structure length)	Amphibians	Reptiles	Small mammals
≤50 m (≤164 ft)	23	27	10
51-100 m (165-328 ft)	4	2	6
101-150 m (329-492 ft)		3	3
151-200 m (493-656 ft)			
>200 m (656 ft)	5	1	1
Unknown	4		

Q 26: Typical structure and potential median.

Typical structure and potential median	Amphibians	Reptiles	Small mammals
1 structure, no opening median	22	23	9
1 structure, with opening median	3		1
2 structures, separated by median		3	5
Don't know	5	5	2

Q 26: Barrier (fence or barrier wall) connected to the structures?

Barrier (fence or barrier wall) connected to the structures?	Amphibians	Reptiles	Small mammals
No fence or barrier wall	2	2	7
Yes, sometimes only on 1 side	3	4	3
Yes, both sides road, with gaps	8	11	2
Yes, both sides road, continuous	9	12	5

Q 26: Average distance between crossing structures (if more than 1 structure is present).

Average distance between crossing structures (if more than 1 structure)	Amphibians	Reptiles	Small mammals
≤50 m (≤164 ft)	1		
51-100 m (165-328 ft)	1	2	
101-150 m (329-492 ft)		1	
151-200 m (493-656 ft)		1	
201-250 m (657-820 ft)	2	1	
251-300 m (821-984 ft)	1		
301-350 m (985-1148 ft)		1	
351-400 m (1149-1312 ft)		1	
401-450 m (1313-1476 ft)	1		
451-500 m (1477-1640 ft)			
501-550 m (1641-1804 ft)			
551-600 m (1805-1969 ft)			
601-650 m (1970-2133 ft)			
651-700 m (2134-2297 ft)		1	
701-750 m (2298-2461 ft)			
751-800 m (2462-2625 ft)			
801-900 m (2626-2953 ft)		1	
901-1000 m (2954-3281 ft)			
1-2 km (0.62-1.24 mi)	1	1	6
>2-3 km (1.25-1.86 mi)	1		
>3-4 km (1.87-2.49 mi)			2
>4-5 km (2.50-3.11 mi)			
>5-6 km (3.12-3.73 mi)			
>6-7 km (3.74-4.35 mi)			
>7-8 km (4.36-4.97 mi)			
>8-9 km (4.98-5.59 mi)			
>9-10 km (5.60-6.22 mi)			
>10 km (>6.23 mi)			
Unknown		1	

Q 26: The primary habitat surrounding the structures.

Describe primary habitat surrounding structure(s)	Amphibians	Reptiles	Small mammals
Wetland	5	8	1
Stream		1	
Lake			2
Grassland		3	
Forest	2	4	4
Mixed	4	5	2
Rocky			

Q 27: Were crossing structures monitored for target species use?

Were crossing structures monitored for target species use?	Amphibians	Reptiles	Small mammals
No	6	5	2
Yes: only for target species	1	6	3
Yes: not only target species	17	19	16
Unknown	3	2	

Q 27: How many crossing structures were monitored?

How many crossing structures were monitored?	Amphibians	Reptiles	Small mammals
None		2	
1	7	11	6
2-5	10	10	4
6-10	2	3	4
>10			5
Unknown		1	

Q 28: How were the crossing structures monitored?

How were crossing structures monitored for animal use?	Amphibians	Reptiles	Small mammals
Tracking: sand	1		
Tracking: marble dust			
Tracking: pads/paper			1
Camera: motion/heat	2	4	17
Camera: time lapse	9	10	
Pit-falls	2	2	
Life traps			
Other (describe)	5	9	
Unknown		2	
Other (HALT cameras)	1		
Other (mark-recapture with dye)	1		
Other (radio telemetry)	1		1
Other (genetic samples)	1		
Other (PIT tags)	3		

Q 28: How long was wildlife connectivity across the road monitored before construction of the structures?

How long was wildlife connectivity across the road monitored BEFORE construction of the structures?	Amphibians	Reptiles	Small mammals
No	4	12	7
1 year (or season)	2	3	6
2 years (or seasons)	6	2	3
3 years (or seasons)	3	6	1
4 years (or seasons)			
5 years (or seasons)	1	1	1
>5 years (or seasons)	4	2	
Unknown	4	5	3

Q 28: How long was wildlife connectivity across the road monitored after construction of the structures?

How long was wildlife use monitored AFTER construction of the structures?	Amphibians	Reptiles	Small mammals
No	2	5	1
1 year (or season)	2	2	1
2 years (or seasons)	3	6	2
3 years (or seasons)	8	10	8
4 years (or seasons)	2	2	3
5 years (or seasons)		1	1
>5 years (or seasons)	2	1	2
Unknown	2	3	1

MODIFIED STRUCTURES ORIGINALLY BUILT FOR OTHER PURPOSES

Q 32: Modifications to structures originally built for other purposes.

Modifications	Amphibians	Reptiles	Small mammals
Pathway on ground for animals created inside structure (e.g. next to water, level path on slope, fill in riprap)	1	2	2
Elevated pathway created for wildlife above the ground			
Elevated pathway created for wildlife above water	1	1	3
Funneling structure (other than fence/barrier) extend from structure	2		2
Natural substrate, e.g., wood chips or soil added on bottom structure	1	2	1
Water provided (e.g. stream or pond) at or near structure	1	2	
Structure or vegetation provided at or near structure	1	3	2
Cover (e.g. branches or root wads) provided at or near structure	1	3	3
Roof opening provided in underpass (temperature/moisture)	0	0	0
Other (culvert grates removed from culvert openings)	1	1	1
<p>Passage Bench - a modification to riprap under a bridge over water to connect shoreline use and connectivity along the river. Aggregate surfacing - filling of riprap voids to reduce turtle entrapment. Plus maybe allowing for nesting. Compost grouting of riprap - filling of voids with compost and seeding with native vegetation. This 'naturalization' of riprap allows for animal movement though could also benefit insects. Natural net erosion control blanket /prohibition of welded plastic mesh products - prevents entrapment of small animals in the right of way culvert design - offsetting multiple barrels so one or more are dry during normal flow conditions to allow for animal passage culvert design - over sizing single small culverts to allow greater opportunity for animal passage tree clearing policy is institutionalized in right of ways (bats)</p>			

Q 33: Primary purpose of the modified structures.

Primary purpose of structure	Amphibians	Reptiles	Small mammals
Water	6	10	2
Large wildlife		1	1
Livestock			
Farm equipment			
Non-motorized traffic			
Motorized traffic, unpaved			
Motorized traffic, paved			1
Unknown			

Q 33: Structure type of the modified structures.

Structure type	Amphibians	Reptiles	Small mammals
Underpass, bottom	4	7	2
Underpass, no bottom	2	4	2
Overpass (above road)			

Q 33: Width of the modified structures.

Width of structure	Amphibians	Reptiles	Small mammals
0-25 cm (0-0.8 ft)			
26-50 cm (0.9-1.6 ft)			
51-75 cm (1.7-2.5 ft)	1		
76-100 cm (2.6-3.3 ft)		2	1
101-125 cm (3.4-4.1 ft)		3	
126-150 cm (4.2-4.9 ft)			
151-175 cm (5.0-5.7 ft)			
176-200 cm (5.8-6.6 ft)	1	1	
>2-3 m (6.7-10.0 ft)	1	1	
>3-4 m (10.1-13.1 ft)			
>4-5 m (13.2-16.4 ft)		2	2
>5-6 m (16.5-19.7 ft)			
>6-7 m (19.8-23.0 ft)			
>7-8 m (23.1-26.2 ft)			
>8-9 m (26.3-29.5 ft)			
>9-10 m (29.6-32.8 ft)			
>10-20 m (32.8-65.6 ft)	1		
>20-30 m (65.7-98.4 ft)			
>30-40 m (98.5-131.2 ft)			
>40-50 m (131.3-164.0 ft)			
>50-60 m (>164.1-196.9 ft)			
>60-70 m (197.0-229.7 ft)			
>70-80 m (229.8-262.5 ft)			
>80-90 m (262.6-295.3 ft)			
>90-100 m (295.4-328.1 ft)			
>100 m (>328.1 ft)			
Unknown	2	2	1

Q 33: Height of the modified structures.

Height of structure	Amphibians	Reptiles	Small mammals
0-25 cm (0-0.8 ft)			
26-50 cm (0.9-1.6 ft)			
51-75 cm (1.7-2.5 ft)	1		
76-100 cm (2.6-3.3 ft)		1	
101-125 cm (3.4-4.1 ft)		2	
126-150 cm (4.2-4.9 ft)			
151-175 cm (5.0-5.7 ft)			1
176-200 cm (5.8-6.6 ft)		2	
>2-3 m (6.7-10.0 ft)		1	
>3-4 m (10.1-13.1 ft)			
>4-5 m (13.2-16.4 ft)	1		
>5-6 m (16.5-19.7 ft)			
>6-7 m (19.8-23.0 ft)			
>7-8 m (23.1-26.2 ft)			
>8-9 m (26.3-29.5 ft)			
>9-10 m (29.6-32.8 ft)			
>10-20 m (32.8-65.6 ft)			
>20-30 m (65.7-98.4 ft)			
>30-40 m (98.5-131.2 ft)			
>40-50 m (131.3-164.0 ft)			
>50-60 m (>164.1-196.9 ft)			
>60-70 m (197.0-229.7 ft)			
>70-80 m (229.8-262.5 ft)			
>80-90 m (262.6-295.3 ft)			
>90-100 m (295.4-328.1 ft)			
>100 m (>328.1 ft)			
Unknown	2	2	

Q 34: Number of modified structures.

Number of structures with this modification	Amphibians	Reptiles	Small mammals
1	2	2	
2			
3	2	3	
4		1	1
5		1	
6		2	
7			
8			
9			
10			1

Q 34: Barrier (fence or barrier wall) connected to the structures?

Barrier (fence or barrier wall) connected to the structures?	Amphibians	Reptiles	Small mammals
No fence or barrier wall	1		2
Yes, but some sections only on one side	2	3	
Yes, both sides of road, but with gaps	1	4	
Yes, both sides of road, continuous	2	3	

Q 34: Effectiveness in reducing barrier effect of the highway.

Effectiveness in reducing barrier effect highway	Amphibians	Reptiles	Small mammals
Not implemented	1		
No formal objectives	1	5	
Ineffective		1	
Marginally effective			
Effective	3	3	1
Very effective			
Unknown	1	2	1

Q 34: Construction cost per structure for modification to make it suitable for target species.

Construction cost per structure for modification to make it suitable for target species (US \$)	Amphibians	Reptiles	Small mammals
≤1000	1		
1001-2000			
2001-3000			
3001-4000			
4001-5000			
5001-6000			1
6001-7000			
7001-8000			
8001-9000			
9001-10000			
>10000			
Unknown	5	9	1

Q 35: For the modifications to structures (underpasses and overpasses) described above, did you experience any design, construction, or maintenance issues?

For the modifications to structures (underpasses and overpasses) described above, did you experience any design, construction, or maintenance issues?	Amphibians	Reptiles	Small mammals
Erosion issues			
Flooding	3	2	
Vegetation overgrowing the entrances too much	4	3	
Frequent mowing or removal of vegetation			
Modification does not stand up to wear and tear			
Vandalism			
Poor modification installation or construction	1	1	
High frequency of inspections for modification			
Modification in hind sight not suitable for target species		1	
Beaver-exclusion device required		2	
Other (please describe)	1		1
Other (Debris getting caught on shelf and needing frequent maintenance)			
Other (rip rap is barrier for amphibians)			
Other (vegetation in structures)			

Q 36: Were the modified structures monitored for wildlife use?

Were structures and modifications monitored for target species use?	Amphibians	Reptiles	Small mammals
No	2	3	
Yes: only for target species		2	
Yes: not only target species	4	6	3

Q 36: How many modified structures were monitored for wildlife use?

How many structures monitored?	Amphibians	Reptiles	Small mammals
1	2	2	1
2 to 5	2	4	
6 to 10		2	1
None	2	3	

Q 36: How were the modified structures monitored for wildlife use?

How were structures monitored for animal use?	Amphibians	Reptiles	Small mammals
Tracking: sand			
Tracking: marble dust			
Tracking: pads/paper			
Camera: motion/heat		3	2
Camera: time lapse	4	3	
Pit-falls			
Life traps			
Other (describe)			
Unknown			
Other (Camera: time lapse and heat/motion)	1	1	1

Q 37: How long was the effectiveness monitoring conducted before modification?

How long was effectiveness monitoring conducted BEFORE modification?	Amphibians	Reptiles	Small mammals
No	3	8	
1 year (or season)		1	1
2 years (or seasons)			1
3 years (or seasons)			
4 years (or seasons)			
5 years (or seasons)			
>5 years (or seasons)	2	2	
Unknown	1		

Q 37: How long was the effectiveness monitoring conducted after modification?

How long was effectiveness monitoring conducted AFTER modification?	Amphibians	Reptiles	Small mammals
No	2	3	
1 year (or season)		1	1
2 years (or seasons)		2	1
3 years (or seasons)	2	5	
4 years (or seasons)			
5 years (or seasons)			
>5 years (or seasons)	1		
Unknown	1		

INFORMATION NEEDS

Dozens of respondents indicated that more research is needed into both effective barriers and crossing structures for all three species groups (Table X).

Q 40: Please check the area of mitigation for small animal species where more research is required.

Please check the area of mitigation for small animal species where more research is required.	Amphibians	Reptiles	Small mammals
Effective barriers to keep animals off highway	40	46	39
Effective crossing structures to get animals to other side of highway	58	67	54
Other:			
Additional mechanisms and technologies for monitoring ectotherms	1	1	1
Cost effect camera monitoring techniques	1	1	1
Culverts	1	1	1
Effective ways to modify existing bridge structures, designed for other purposes, so that they can be used by amphibians	1	1	1
Effectiveness of turn-arounds and jump-outs (we are currently studying this also :)	1	1	1
Evidence of need (roadkill data, etc.) for design & implementation of passage or barriers for those species	1	1	1
I'd love to see more research in how to adapt existing crossings	1	1	1
Larger than coyotes as well...white-tailed deer, bobcat etc.	1	1	1
Length of barrier needed to effectively direct amphibians towards crossing structure without affecting them negatively in terms of physiological effects and redirecting them from their intended destination/overwintering grounds	1	1	1
Maintenance of constructed barriers has been challenging. Maintenance adds to operation cost and continued education of operations staff.	1	1	1
More research is required for all aspects of effective mitigation for reptiles, small mammals and amphibians	1	1	1
Or other needs of species not listed by USFWS as listed species	1	1	1

Other (please specify)	1	1	1
Reducing costs for effective barriers	1	1	1
research needed specific to snowshoe hares, which did not use the culverts	1	1	1
The length of the fence needed and the fence-end effect.	1	1	1
Ways to prevent secondary mortality as scavengers try to feed on roadkill and become roadkill themselves	1	1	1
We have been generalists in our approach to small animal protection in road right of ways. Research is needed to aid in site selections and prioritization...	1	1	1
While we have not directly mitigated small animal species, I do believe they have benefited from the overpasses and underpasses built for the large mammal migrations in the area.	1	1	1

8. APPENDIX D: MATERIALS SENT BY THE RESPONDENTS

Type of material	Contents	Target species group	Species	Measure	Name or area	State/Province	Permission form
Image	Black bear on concrete pathway in culvert with water	Small mammals		Concrete path in culvert adjacent to stream	Caribou?	Maine	yes
Image	Concrete pathway in culvert with water	Small mammals		Concrete path in culvert adjacent to stream	Caribou	Maine	yes
Image	Dry area next to stream in underpass	Amphibians, Small mammals		Terrestrial habitat in underpass for water	Lyman	Maine	yes
Image	Dry area next to stream in underpass	Amphibians, Small mammals		Terrestrial habitat in underpass for water	Lyman	Maine	yes
Image	Dry area next to stream in underpass	Amphibians, Small mammals		Terrestrial habitat in underpass for water	Lyman	Maine	yes
Image	Geotextile barrier attached to guard rail	Reptiles: turtles	Diamondback terrapin	Geotextile barrier attached to guard rail	Fisherman Island US Hwy 13	Virginia	yes
Image	Geotextile barrier attached to guard rail	Reptiles: turtles	Diamondback terrapin	Geotextile barrier attached to guard rail	Fisherman Island US Hwy 13	Virginia	yes
Image	Plastic mesh fence	Reptiles: turtles	Diamondback terrapin	Plastic mesh fence	Fisherman Island US Hwy 13	Virginia	yes
Image	Plastic mesh fence	Reptiles: turtles	Diamondback terrapin	Plastic mesh fence	Fisherman Island US Hwy 13	Virginia	yes
Technical drawings	Concrete barrier	Reptiles: turtles	Diamondback terrapin	Concrete barrier	Fisherman Island US Hwy 13	Virginia	yes
Written guidelines	Exclusion fence	Amphibians: toads	Arroyo toad	Exclusion fence	n/a	California	not yet
Poster	Culvert	Amphibians: salamanders	California tiger salamander	Culvert	Santa Barbara county	California	not yet
Technical drawings	Culvert	Amphibians: salamanders	California tiger salamander	Culvert	Santa Barbara county	California	not yet
Written guidelines and drawings	Exclusion fence	Reptiles: tortoise	Desert tortoise	Exclusion fence	n/a	California	not yet
Written guidelines and drawings	Exclusion fence	Small mammals		Exclusion fence	n/a	California	not yet
Image	Culvert	Amphibians: salamanders	California tiger salamander	Culvert	Santa Barbara county	California	not yet
Technical drawings	Exclusion fence	Small mammals	San Joaquin antelope squirrel and giant kangaroo rat				
Written guidelines and drawings	Exclusion fence	Reptiles: tortoise	Desert tortoise	Exclusion fence	n/a	California	not yet
Written guidelines and drawings	Exclusion fence	Reptiles: tortoise	Desert tortoise	Exclusion fence	n/a	Arizona	yes

Written guidelines	Exclusion fence	Reptiles: lizards	flat-tailed horned lizard	Exclusion fence	n/a	Arizona	yes
Image	Culvert with barriers	Amphibians		culvert	Hwy 4, Vancouver Island	British Columbia	yes
Image	Barriers	Amphibians		Barriers	Hwy 4, Vancouver Island	British Columbia	yes
Image	Barriers	Amphibians		Barriers	Hwy 4, Vancouver Island	British Columbia	yes
Image	Culvert with barriers	Amphibians		culvert	Hwy 4, Vancouver Island	British Columbia	yes
Images (many)	Fences and culvert	Amphibians: frogs, reptiles: turtles		Fences and culvert	TRCA Heart Lake Road	Ontario?	not yet
Powerpoint	Snake road mortality, culverts	Reptiles: snakes		culverts	White Lake Basin	British Columbia	?
Video	Rattlesnake using culvert	Reptiles: snakes		culvert	White Lake Basin	British Columbia	?
Images (many)	Researchers, cameras, culverts	Reptiles: snakes		culvert	White Lake Basin	British Columbia	?
Images (many)	Culvert installation	?????		culvert	Dorcas Bay Rd	Ontario	?
Report with images	Fences and culvert	Amphibians: toads	western toad	Fences and culvert	Ryder Lake	British Columbia	yes
Images	Fences and culvert	Reptiles: turtles	Blanding's turtle, Painted turtle	Fences and culvert	Gelert Rd	Ontario	?
Technical drawings	Fences and culvert	?????		Fences and culvert		Ontario	?
Technical drawings	Fence	Reptiles: snakes		Fence		Ontario	yes
Images	Fence	Reptiles: snakes		Fence		Ontario	yes
Technical drawings	Fence	?????		Fence		Ontario	yes
Guidelines	Fence	?????		Fence		Ontario	yes
Technical specification sheet	Fence	Reptiles: snakes		Fence		Ontario	yes
Technical drawings	Fence, smooth lower panels noise barrier	Reptiles: snakes		Fence, smooth lower panels noise barrier		Ontario	yes
Images	Fence, smooth lower panels noise barrier	Reptiles: snakes		Fence, smooth lower panels noise barrier		Ontario	yes
Technical drawings	Fence	Reptiles: snakes		Fence	Windsor Essex Parkway	Ontario	yes
Images	Fence	Reptiles: snakes		Fence	Windsor Essex Parkway	Ontario	yes

ACO brochure	Fences and culvert	Amphibians		Fences and culvert		n/a	Probably not
Image	Fences and culvert	?????		Fences and culvert			yes
Technical drawings	Fences and culvert	Reptiles: snakes		Fences and culvert	Matchette Rd	Ontario	yes
Technical drawings	Tunnel	Reptiles: snakes		Tunnel	Windsow Essex Parkway	Ontario	yes
Images	Aerial images overpass	?????		Overpass		Ontario	yes
Images	Culvert with cover and a gate	?????		Culvert with cover and a gate	Windsow Essex Parkway	Ontario	yes
Technical drawings	Culvert with cover and a gate	?????		Culvert with cover and a gate	Windsow Essex Parkway	Ontario	yes
Guidelines	Fill in riprap to make pathway in underpass	?????		Fill in riprap to make pathway in underpass		Minnesota	yes
Technical drawings	Smooth curbes, reduce barrier	Amphibians, Reptiles, small mammals		Smooth curbes, reduce barrier		Minnesota	yes
Guidelines	Smooth curbes, reduce barrier	Amphibians, Reptiles, small mammals		Smooth curbes, reduce barrier		Minnesota	yes
Guidelines	Fences	Small animals		Fences		Minnesota	yes
Info sheet anti-erosion netting	Anti erision netting and snakes	Reptiles: snakes		Anti erision netting and snakes		Minnesota	yes
Poster and technical drawings	Pathway through riprap in underpass	Small animals		Pathway through riprap in underpass		Minnesota	yes
Technical drawings	Fence	Small animals		Fence		Minnesota	yes
Images	Canopy bridge	Small mammals		Canopy bridge		UK	yes
Images	Concrete ledges in culvert with water	Small mammals		Concrete ledges in culvert with water		Quebec	yes
Images	Fence	Small mammals		Fence		Quebec	yes
Report with images	Underpasses	Small mammals		Underpasses	Hwy 407	Ontario	?
Technical drawings	Fence and underpass with cover	Small mammals		Fence and underpass with cover	Hwy 407	Ontario	?
Technical drawings	Fence and underpass with cover	Small mammals		Fence and underpass with cover	Hwy 407	Ontario	?
Image	Small mammal fence intergrated with large mammal fence	Small mammals		Small mammal fence intergrated with large mammal fence	Hwy 407	Ontario	?
Images	Fence and culverts with open slotted roof	Amphibians: salamanders	long-toed salamanders	Fence and culverts with open slotted roof	Waterton NP	Alberta	not yet
Images	Gentle curb, reduce barrier to amphibians	Amphibians: salamanders	long-toed salamanders	Gentle curb, reduce barrier to amphibians	Waterton NP	Alberta	not yet

Report with images	Barriers and tunnels for amphibians	Amphibians		Barriers and tunnels for amphibians	Canada	Canada	Probably not
Images	Barrier (metal guard rail) and amphibian tunnels	Amphibians: salamanders	long-toed salamanders	Barrier (metal guard rail) and amphibian tunnels	Waterton NP	Alberta	yes
Images	Fence and culverts with open slotted roof (also burnt from wildfire)	Amphibians: salamanders	long-toed salamanders	Fence and culverts with open slotted roof (also burnt from wildfire)	Waterton NP	Alberta	yes
Images	Gentle curb, reduce barrier to amphibians	Amphibians: salamanders	long-toed salamanders	Gentle curb, reduce barrier to amphibians	Waterton NP	Alberta	yes
Report with images	Culverts for snakes	Reptiles, small mammals, amphibians		Culverts for snakes	Nobel rd	Ontario	?
Report with images	Guidelines barriers amphibians and reptiles	Amphibians, Reptiles		Guidelines barriers amphibians and reptiles			Probably not
Report with images	Barriers and underpasses turtles	Amphibians, turtles	Blanding's turtle, snapping turtle	Barriers and underpasses turtles	Hwy 24	Ontario	Probably not
Technical drawings	Drainage culvert	Small mammals	Preble's meadow jumping mouse	Drainage culvert	Hwy 36	Colorado	yes
Technical drawings	Shelves in drainage culvert and dry wildlife underpass	Small mammals	Preble's meadow jumping mouse	Shelves in drainage culvert and dry wildlife underpass	Hwy 36	Colorado	yes
Technical drawings	Cover in culvert	Small mammals	Preble's meadow jumping mouse	Cover in culvert	Hwy 36	Colorado	yes
Technical drawings	Underpasses	Mammals	Canada lynx	Underpasses	?	Colorado	yes
Image	Culvert	?		Culvert		Colorado	yes
Image	barrier	?		barrier		Colorado	yes
Report with images	Shelves in drainage culvert and dry wildlife underpass	Small mammals	Preble's meadow jumping mouse	Shelves in drainage culvert and dry wildlife underpass	Hwy 36	Colorado	Probably not
Technical drawings	Culvert with raised pathway				Bridport	Vermont	yes
Image	Culvert	amphibians				Vermont	yes
Image	Culvert and fence					Vermont	?
Guidelines	Canopy bridge	small mammals		Canopy bridge		UK	yes
Images	Fence with jump outs			Fence with jump outs			yes
Images	Underpass with cover	small mammals, amphibians, reptiles		Underpass with cover			not yet
Technical drawings	culvert			Culvert	Hwy 100	Iowa	not yet
Technical drawings	fence attached to right-of-way fence	small mammals, amphibians, reptiles		fence attached to right-of-way fence		Iowa	not yet
Technical drawings	fence attached to right-of-way fence, for gated entrance	small mammals, amphibians, reptiles		fence attached to right-of-way fence, for gated entrance		Iowa	not yet
Technical drawings	Pond near turtle underpass	Reptiles: turtles		Pond near turtle underpass		Iowa	not yet
Images	underpass and barrier	amphibians, small mammals		underpass and barrier	Monkton/Vergennes	Vermont	not yet

Technical drawings	underpass and barrier	amphibians, small mammals		underpass and barrier	Monkton/Vergennes	Vermont	not yet
Technical drawings	animex fence	amphibians, reptiles, small mammals		animex fence		Ontario	?
Images	animex fence attached to guard rail	amphibians, reptiles, small mammals		animex fence attached to guard rail		Ontario	?
Monitoring protocol	animex fence	amphibians, reptiles, small mammals		animex fence		Ontario	?
Images	turtles in culverts	Reptiles: turtles		turtles in culverts		Ontario	?
Images	Installing cameras in culverts	Reptiles: turtles		turtles in culverts		Ontario	?
Design guidelines	Fences and underpasses	amphibians, reptiles, small mammals		Fences and underpasses	Edmonton	Alberta	
Images	fence, culverts	Reptiles: turtles	wood turtle	Geotextile barrier , culverts		Minnesota	not yet
Report	habitat improvement	Reptiles: turtles	wood turtle			Minnesota	not yet
Technical drawings	culvert	Reptiles: tortoises	desert tortoise	culvert	Red hills parkway	Utah	yes
Images	culvert with grate to let light in	Reptiles: tortoises	desert tortoise	culvert	Red hills parkway	Utah	yes
PDFs, notes	canopy crossings			canopy crossings		Washington	not yet
Images	sign, snakes on road	Reptiles: snakes				Alberta	yes