*Title*: Wildlife crossing structure size, distribution, and adherence to expert design recommendations

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**DATA AVAILABILITY**

All code and supporting data to reproduce this analysis in its’ entirety can be found at <https://github.com/ctlamb/Wildlife-Overpass-Dimensions>

**Abstract**

Wildlife crossing structures paired with exclusion fencing have proven to successfully reduce animal vehicles collisions while still allowing for connectivity across roadways. Managing animal mortality and subpopulation connectivity is crucial to the successful species and landscape stewardship. Highway mitigation projects are large economic investments that remain on the landscape for many decades, so governments and planning agents strive to balance cost and benefit and build cost-effective structures with the greatest positive impact on local wildlife. Ideal dimensions of overpasses and underpasses vary by species, but scientists generally suggest that overpasses are at least 50 meters wide, with some recommending up to >100 m for large mammal crossings. Optimal width can also depend on structure length, with longer structures requiring additional width, leading experts to suggest a width to length ratio of 0.8. We sought to assess how these recommendations manifested in practice—where agencies use this information to design structures and build structures while also balancing costs and logistical challenges—and the degree to which historical structures conform to current recommendations. Internationally, countless wildlife crossings have been constructed to reduce the negative impacts of roadways that bisect landscapes. Included in our review was a sample of 84 overpasses located in North America, Europe, Asia, and Oceania. The average width of wildlife overpasses was 45.5 m, similar, but slightly narrower than the 50 m width generally recommended by scientists. Further, the width to length ratio was 0.67, which was lower than recommendations. As found in many studies, greater overpass width encourages greater overpass use, but increased width often comes with escalating building costs. As we show here, agencies are likely using the minimum widths as their initial target, and then settling on a smaller width once financial and logistical constraints are considered. Overpass width is an important aspect of crossing success for sensitive species such as grizzly bears and elk who tend to be very selective in terms of wildlife crossing structure choice. Indeed, our review revealed that overpasses targeted at the largest animals were often constructed with the greatest widths. We recommend that agencies focused on sustaining or improving large mammal connectivity should strive for the recommended minimum overpass width of 50 m and width to length ratios >0.8, while implementing efficacy monitoring that can compared across structures and projects to refine future designs.

**Introduction**

Roads provide essential connection corridors for people and goods across the world but can be challenging features for wildlife to cross safely and have myriad environmental consequences (Clevenger and Huijser 2011). Decades of research have shown that roads can degrade and fragment habitat, create barriers to animal movement and be a major source of animal mortality (Clevenger and Huijser, 2011). Roads can be especially challenging when considering large mammals that occupy large home ranges and face reduced dispersal success because of behavioural avoidance of roads or direct road mortality, sometimes leading to reduce genetic diversity and population viability (Kusak et al. 2009; Sijtsma et al. 2020). Under the increasingly apparent stresses of climate change, animal mortality from Wildlife Vehicle Collisions (WVCs) combined with reduced dispersal abilities may exacerbate risks to wildlife populations (Lister et al. 2015). Creative solutions to combat these threats, especially on highways, are needed.

A solution that is gaining in popularity is the construction of wildlife crossing structures (Sijtsma et al. 2020). Wildlife crossing structures reduce wildlife mortality from WVCs (Kintsch at al. 2021), while still promoting road permeability (National Academies of Sciences, Engineering, and Medicine, 2008). These structures are often met with little to no public resistance because they provide added benefits to motorists (i.e. increased safety and reduced costs related to WVCs) without altering the flow of traffic. In fact, when wildlife crossing structures are paired with adequate wildlife fencing, studies have found up to a 92% decrease in reported WVCs (Kintsch et al. 2021). For example, in Banff National Park, a series of crossing structures and fencing along an 82 km section of the Trans Canada Highway reduced wildlife collisions by 80%, and reduced collisions with common species such as deer and elk by 96% (Clevenger and Barrueto 2014).

Wildlife crossing structures can be subdivided into two classes: underpasses and overpasses, which respectively allow wildlife to cross under or over the roadway (Clevenger and Huijser 2011). Many highway WVC mitigation projects employ both structure types to promote roadway permeability for the greatest number of species (Huijser et al.;Clevenger and Waltho; 2000, Cramer, 2012). Clevenger and Huijser (2011) suggest that large wildlife overpasses are an optimal crossing structure choice for the greatest variety of species. Furthermore, various carnivores and ungulates (ex: bears, moose, wolves, lynx deer, elk and desert bighorn sheep) prefer large, open overpasses compared to more constricted underpasses (Ament et al. 2021; Clevenger and Waltho, 2005; Kusak et al., 2009). Specifically, when standardized for number of structures and days monitored, Kintch et al. 2021, found there were approximately 4.8 times more successful mule deer passages on overpasses compared to underpasses. However, underpasses cost less and can used in between overpasses to pass some animals, and are an effective part of an overall crossing system which includes both types of structures connected by fencing along stretches of highways. A mix of underpasses and overpasses can also be ideal to facilitate connectivity at a community level as some animals, especially smaller and more cryptic species, prefer underpasses for crossing, while larger mammals often prefer more open structures such as overpasses and large underpasses.

One of the major decisions when undertaking one of these projects, is planning the dimensions of the crossing structures. For the purposes of this study, we focus on wildlife overpasses, which are defined as all above grade structures that cross over roads and/or other human infrastructure. Overpasses are large infrastructure investments that are more easily compared dimensionally than the many styles of underpasses. Similar terms used in literature to describe overpasses include landscape bridges, green bridges and ecoducts. Wildlife overpasses are often preferred by a greater number of species than underpasses (Clevenger and Huijser, 2011) but often also cost significantly more (McGuire and Morrall, 2000). Overpass width is an important design consideration because wider overpasses create more open and natural crossing areas for many large mammals, as opposed to narrow crossings that may deter crossings if animals feel uncomfortable and hesitant to cross. However, wildlife overpasses are costly structures, often $5-15 million dollars, and wider structures cost more than narrower ones. Transportation agencies thus attempt to build structures whose dimensions satisfy the ecological role the structures are designed to support while delivering the project in a cost-effective manner.

A growing body of research suggests that large mammals prefer to cross on overpasses that generally exceed 50 meters wide. Ford et al. (2017) suggests that large overpasses >50m in width serve as crucial passages for family units of Grizzly Bears whose survival is crucial to population viability. Also, in Banff National Park, more generally, elk, grizzly bear, wolf and deer passage rates were positively linked to structure width (Clevenger and Waltho, 2005). Similar evidence from Pfister et al. (1997) suggests that crossing structures in Europe that were less than 20 meters were used significantly less than wider structures, and that 50 m should be considered a minimum width for large mammal overpasses. Building on these empirical studies, Clevenger and Huijser 2011, recommended large mammal overpasses to be 50-70 m wide over 4 lane highways. As pointed out Pfister et al. (1997), ideal widths must also consider the length of the structure, where exceptionally long structures may require width beyond the >50 m recommendation. The European Transportation Handbook addresses this consideration by recommending width to length ratios >0.8 for overpasses.

With increasing global support and investment in wildlife overpasses, the purpose of this review is to gather a sample of the wildlife overpasses across the world, assess their dimensions in relation to current expert recommendations, and explore best practices for designing and monitoring overpass effectiveness. We conducted a literature review to assess where wildlife overpasses have been built and assessed the length and width of each against expert design recommendations. While crossing structure effectiveness (i.e., the ability to promote animal crossings) has been assessed within individual projects (eg. Ford et al. 2017), currently published works often do not use study designs, such as before-after-control-impact designs, that generate effectiveness effect sizes that are translatable across the vastly different ecological and environmental contexts within which the worlds’ wildlife overpasses are situated (Rytwiniski et al. 2015, van der Grift et al. 2012). Although the number of animals crossing each structure is often recorded, few projects have measures of how many animals were available to cross, thus two structures might have the same number of animals crossing them, but if one was built in an area with double the animal abundance, the crossing effectiveness of these two structures would be quite different. Due to these data deficiencies, we do not assess crossing effectiveness for each structure. Instead, we propose a monitoring design that would allow for robust measures of effectiveness within and amongst projects, allowing for a globally coherent assessment of effectiveness. Collectively, our review aims to provide practitioners with a summary of current overpass design guidelines, how dimensions for built structures relate to these guidelines, and how future overpasses and monitoring designs can be optimized to increase wildlife use and contribute to a growing body of effectiveness measures.

**Methods**

***Literature Review and Identifying Overpasses***

A literature review was conducted to locate and identify overpasses around the globe to quantify key characteristics. Key words included “wildlife overpass”, “eco-duct”, “green bridge”, and “wildlife crossing structure”. The search engines Google and Google Scholar were used to collect pertinent peer-reviewed literature, government reports, websites, and overpass locations. Supporting information from these sources was used to locate the structures in Google Earth Pro 7.3.4.8248. Overpasses were included in the review if they were visible on Google Earth Pro, if they had distinct start and endpoints, if they were built with the intention of crossing large-bodied (>5 kg) mammals and if sufficient supporting information was available in order to locate the structures.

***Measuring Dimensions***

The width and length of overpasses was estimated using the path tool in Google Earth Pro 7.3.4.8248. Harrington et al. 2017 compared Google Earth Pro path measurements to physical measurements of road features and found an average error rate of 1.45% for on-road features, supporting the use of Google Earth Pro as a scientific measurement tool. We also tested the accuracy of the path tool on objects of known length, 91.44 meter (100 yard) long football fields, to assess reliability. Across 20 NFL and NCAA football fields, we found an average error rate of 0.2% (see Appendix A). The width of overpasses was measured based on the “usable” width over which animals could pass at the narrowest, center point of each structure (Figure 1). The length was estimated by measuring the distance between the natural topography “breaks” where the landscaped structure meets the adjoining piece of land (Figure 1). Because elevation change along structures is minimal it was assumed to have a negligible effect on measurement.

**A screenshot of a computer

Description automatically generated with low confidence**

**Figure 1.** An example of the process used to to measure overpass dimensions in Google Earth Pro. Shown here is theYoho National Park Overpass in British Columbia. The white lines represent the structure dimensions (N/S = Width, E/W = Length), which are measured using the path tool.

**Results**

We identified 84 individual wildlife overpasses across the world (Figure 2). The majority of the 84 wildlife overpasses were concentrated in northern latitudes (n=77) (Latitude >40 °) and amongst the wealthier nations in the world such as Canada (n=9), United States (n=13), Germany (n = 10), Holland (n=28) and Croatia (n=5).

A map of the world

Description automatically generated with medium confidence

Figure 2. A) Map of the 84 large mammal crossing structures found in the literature review. Two clusters of overpasses were found in B) western North America, and C) Europe, western Asia, and Australia.

All structures were built between 1986-2018 and targeted the conservation and passage of large mammals (>5 kg). Across the 84 overpasses, the average width was 45 m, an average of 4 lanes were crossed, and an average width to length ratio of 0.67 was observed (Table 1). Figure 3 shows the distribution of overpass width’s that highlights a slight skew towards larger widths along with some prominent outliers. The Croatian overpasses account for all the outliers with exceptionally large widths (>100m). The overpass with the smallest width (6m) in this subset was the first overpass built in Canada in 1990, the Trepanier Creek Overpass in British Columbia**.** The average dimensions for constructed overpasses fell below the expert-recommended width of > 50 m for 62% of structures sampled (n=52), and below the recommended width to length ratio of 0.8 for 76% of structures sampled (n=64).

As seen in Table 2, the literature review located 4 major overpasses that cross both a roadway and a railway. Qualitatively, these structures were generally wider and longer than those that did not include railways. Overpass width increased with increasing primary target species body size (p=0.019, Figure 4A), but did not change through time (p=0.63, Figure 4B).

Chart, box and whisker chart

Description automatically generated

**Figure 3.** Dimensions of 84 wildlife overpasses included in the review.

Chart, box and whisker chart

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**Figure 4.** A) Overpass width in relation to the body size for target species at the overpass (n=56 overpasses where target species could be discerned), B) Overpass width based on the year each overpass was built (n=40 overpasses where year of construction could be discerned).

**Table 1**: Parameters of major wildlife overpasses and underpasses across the world. Min and max shown in brackets.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Mean Width to Length ratio** | **Mean Width (m)** | **Mean Length (m)** | **Mean number of lanes spanned** |
| **All Sampled Overpasses (n=84)** | 0.67 (0.11-3.08) | 46 (6-200) | 78 (20-170) | 4 (0-9) |
| **North American Overpasses (n=22)** | 0.69 (0.11-1.52) | 40 (6-60) | 66 (20-116) | 4 (2-8) |
| **Europe and Asia Overpasses (n=62)** | 0.67 (0.13-3.08) | 48 (10-200) | 83 (21-170) | 4 (0-9) |
| ***Expert Recommendation*** | *>0.8* | *>50* | *-* | *-* |

**Table 2:**  Wildlife overpasses that are built over both a road and railway. See Appendix B for Google Earth images of overpasses that cross both roads and railways.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Country** | **Name** | **Lat** | **Long** | **Width (m)** | **Length (m)** | **Number of Roadway Lanes** | **Number of Railway tracks** |
| Belgium | Wuustwezel Ecoduct | 51.41321 | 4.70194 | 60 | 134 | 5 | 2 |
| Holland | Noordnout Ecoduct | 52.06557 | 5.32468 | 53 | 96 | 6 | 2 |
| Holland | Hulshorst Ecoduct | 52.34611 | 5.71477 | 52 | 145 | 4 | 2 |
| Switzerland | Stock wildlife crossing | 47.16354 | 7.30771 | 74 | 82 | 2 | 2 |
|  |  |  | **Mean** | 59.8 | 114.3 | 4.3 |  |

**Discussion**

Our review revealed that wildlife overpasses have been constructed in many countries across the world over the past forty years. In total we identified 84 structures that were distributed between North America, Europe, southeast Asia, and Australia. Wildlife overpasses were predominantly located in northern latitude, wealthier countries. We found few records of overpasses in many of the worlds’ most abundant areas of large mammals such as southern Africa and Asia, and south America. The overpasses within our sample were primarily built to allow safe passages of large mammals such as deer, elk, moose, sheep, wolves, and bears, of which most structures were successfully allowing such passages after construction. As reviewed by Rytwinski et al. (2016). the crossing systems that these overpasses were a part, which also included exclusion fencing and underpasses, have been successful in reducing collisions between wildlife and vehicles by over 80%. Comparing the built dimensions of overpasses to expert recommendations, we found that wildlife overpasses were generally built slightly below the minimum standards recommended by experts. The goal of these standards is to facilitate overpass designs that are effective in achieving sufficient crossings of target species and providing adequate conservation return on infrastructure investments. Although there was considerable variation in overpass dimensions the average dimension of structures being built remained similar through time. Consistent with evidence that larger bodied animals prefer wider crossing (Clevenger and Waltho 2005, Kusak et al. 2009) the structures that were built for large bodied target species were the widest structures.

*Adherence to expert-based recommendations*

While the length of an overpass may largely be decided by the width of the road and local topography, we found that overpass widths can range between 6-200m and are generally decided based on expert recommendations for dimensions best suited to allow passage of target species and cost constraints. The average overpass width falls within the recommendations laid out by the European Transportation Agency (COST 341 Handbook) (40-50m) but outside of the 50-70m recommendations from Clevenger and Waltho 2011, Pfister et al.1999 and Renard et al. 2008. In Banff NP, Clevenger and Waltho 2005 investigated the structural attributes of 13 different crossing structures, in relation to species passage. For species such as elk and white-tailed deer, and wolf, passage was positively impacted by width and negatively impacted by length. As seen in Table 2, a subset of structures cross both railways and roadways. The average width of these structures was 60 m, which is within the recommended width range of recent studies and reports. An increased structure width associated with railways may be desirable in its ability to reduce noise levels for animals using the structure. Furthermore, by virtue of crossing both roads and railways, structures in Table 2 generally have a greater length. According to the COST 341 Handbook, as structures increases in length their width should also increase at a ratio of 0.8. Therefore, with a mean length of ~114m, the structures are only about ~66% as wide as recommended by the COST 341 Handbook.

Notably, 77% of structures in this review did not meet the recommended minimum 0.8 W:L ratio established by the European Transportation Agency (COST 341 Handbook). The W:L ratio recommendation is often less prominent, or absent, in both the peer reviewed literature and transportation handbooks on overpass dimension recommendations. As such, the focus on width as a static quantity, rather than a dimension that needs to be considered in concert with length, may be poorly communicated to transportation professionals in the current literature. Future projects should consider that longer overpasses must also be wider to facilitate animal passage.

In Croatia, telemetry tracked bears, wolves and lynx showed a clear preference for very wide overpasses (100+) and negative selection towards narrower crossing structures (underpasses, viaducts etc) (Kusak et al. 2009). These findings suggest greater structure width can “funnel” animals to achieve a greater crossing frequency than expected. Following this research, three additional overpasses were constructed in Croatia with widths of 120, 150 and 200m (Kusak et al. 2009). The Croatia overpasses appear to be outliers for width and lengths, and clearly deviate from the width of overpasses built in North America, none of which exceed 60 m. With so few >60 m overpasses built in the world, and few implemented studies assessing crossing structure efficacy, it is difficult to assess the ideal width with the current data (Rytwiniski et al. 2015, van der Grift et al. 2012). However, the accumulated evidence suggests that transportation professionals should target widths of 50-70 m for four lane highways, and adjust width for differing numbers of lanes and target species, while aiming for a width:length ratio of 0.8.

Scientists and transportation professionals should strive to develop a standardized measure of structure efficacy to inform future investment in crossing structures (as pointed out by Rytwiniski et al. 2015, van der Grift et al. 2012 as well). Such investment is likely to increase, for example in July 2021, the USA passed the INVEST in America Act, a five-year highway bill that includes $100 million per year for crossing structures. To guide these future investments, a standardized procedure for measuring crossing efficacy should be developed that can overcome differing ecological conditions between structures and projects that hamper comparisons. One option that is easily integrated into current monitoring programs with remote cameras is to include remote cameras on wildlife trails a few hundred meters away from the structure. A similar design has been previously suggested by Rytwiniski et al. (2015) as part of their plea for increased use of rigorous study designs, such as before-after-control-impact designs, for evaluating road mitigation effectiveness. With such a design, investigators can get a sense of species detection rates between cameras on the structure and those nearby, allowing for a transparent measure of effectiveness that is relative to the local site conditions. For example, a structure that has 10 elk detections per week and 100 elk detections per week nearby on wildlife trails (i.e., 10:100, or 0.1) would be less effective than a structure that had 80 elk detections per week on the structure and 110 elk detections per week nearby on wildlife trails (i.e., 80:110, or 0.72).

*Cost effectiveness*

In the Netherlands, Sitjsma et al. (2020) found that overpasses present a less cost-effective solution than underpasses. They argue that the high construction costs of overpasses outweigh their absolute benefit to local biodiversity, making underpasses a more cost-effective solution. The authors, however, concede that their threat-weighted ecological quality cost-effectiveness analysis fails to differentiate between “different species and nature types”. As a result, in places with more diverse and abundant assemblages of large mammals, overpasses may become more cost effective. Indeed, Ford et al. 2017 performed a cost-effectiveness analysis of grizzly bear *(Ursus arctos)* crossings at 5 crossing structure types in Banff National Park, Canada. Using a demographic-specific cost-effectiveness economic model, they found that especially amongst family units, overpasses are more cost effective than underpasses. Amongst singleton bears, the cost effectiveness of overpasses and underpasses were similar. The findings between the two studies illustrate how the results of cost-effectiveness analysis may vary at different scales of study and target species assemblage.

Cost is likely the main constraint limiting transportation agency ability to consistently meet expert recommendations for overpass dimensions. A wildlife crossing project being developed along Highway 3 in the southern Rocky Mountains of Canada provides a case-study where transportation professionals, scientists, conservation organizations, industry partners, and First Nations are working to create a cost-effective design in a working landscape. The “Reconnecting the Rockies: BC” project is focused along a 27 kilometer stretch of highway 3 in southeastern BC, where movement corridors for deer, elk, sheep, moose, bear, wolf, wolverine, and cougar all intersect with a busy highway. The project will feature two purpose-built underpasses, eight retrofitted bridges to allow wildlife passage, and an overpass located in the critical Alexander-Michel corridor will be a main feature of the project. The overpass will be the most expensive aspect of the project and multiple designs have been proposed and costed. The overpass will span a length of 75 meters across two lanes of road and a railway line. The preferred overpass design, which was costed for three different widths, 40, 50, and 70 meters wide, which respectively cost an estimated $6.2, $7.3, and $9.7 million dollars. Although there is some slight efficiency of scale as widths increase—with the cost per meter of width decreasing from $0.155 million per meter for the 40-meter structure, to $0.139 million per meter for the 70 meter structure—the overall increase in price as overpass width increased meant that compromises needed to be made to accommodate the restricted budget available for this project. While construction has not yet started on this structure, the collaborative group is currently finishing the design phase of the project and favours the 50 meter wide structure, which meets the expert recommendations for the target species (a diverse assemblage of large mammals), incorporates some savings with scale, but falls in the middle ground for price option available. The Reconnecting the Rockies example highlights the real-world trade-offs that are required, and the tension between increasing costs and structure efficacy, which can be optimized through pairing expert design recommendations and innovated engineering support.

*Recommendations for future overpass designs*

Our review of overpass dimensions suggests that transportation agencies are often building structures slightly below expert design recommendations. Although a structure that is 50-70 meters wide is likely ideal, we appreciate that a 40 meter structure and associated crossing system infrastructure is often still of great benefit to the wellbeing of wildlife and people who travel highways in the area. We conclude that transportation agencies should continue to strive for overpasses that are 50-70 meters wide, if targeted at large mammals, and widths should be appropriately increased if structures become longer than 75 meters. When smaller bodied animals are targetted, widths can be narrower.

Standardized monitoring designs that can be used to compare structure efficacy across structures will help inform optimal dimensions in the future. We provide one such design where remote cameras can be deployed on structures and on nearby wildlife trails to estimate a detection ratio that incorporates and controls for the local abundance of wildlife and ecology surrounding the structure. Optimizing design recommendations will help to make crossing structures as effective for wildlife as possible while using limited funding as efficiently as possible.

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**APPENDIX**

|  |  |  |
| --- | --- | --- |
| **Appendix A Stadium Name** | **Location** | **Length(m) measured using Google Earth path tool** |
| Empower Field at Mile High | Denver, CO | 91.8 |
| FedExField | Landover, Maryland | 91.7 |
| FirstEnergy Stadium | Cleveland, OH | 91.5 |
| Heinz Field | Pittsburgh, PA | 91.6 |
| Highmark Stadium | Orchard Park, New York | 91.6 |
| Levi's Stadium | Santa Clara, CA | 91.5 |
| Lumen Field | Seattle, WA | 91.3 |
| MetLife Stadium | East Rutherford, NJ | 92.4 |
| Paul Brown Stadium | Cincinnati, OH | 91.5 |
| Raymond James Stadium | Tampa, FL | 91.6 |
| Soldier Field | Chicago, IL | 91.7 |
| TIAA Bank Field | Jacksonville, FL | 91.7 |
| 3MG Stadium | Orlando, FL | 91.5 |
| Aggie Memorial Stadium | Las Cruces, NM | 91.4 |
| Alaska Airlines Field at Husky Stadium | Seattle, WA | 91.8 |
| Albertsons Stadium | Boise, ID | 90.9 |
| Allen E. Paulson Stadium | Statesboro, GA | 91.6 |
| Alumni Stadium | Chesnut Hill, MA | 91.5 |
| Amon G. Carter Stadium | Fort Worth, TX | 91.7 |
| Apogee Stadium | Denton, TX | 91.8 |

**Calculations**

**%Error**

= ((sum of measurements / n)-true vale) / true value)\*100%

= ((91.61-91.44)/91.11) \*100%

=0.2%

**Appendix B**

**Table 3: Species specific suitability of various wildlife crossing structures from (Clevenger and Huijser 2011)**

**Graphical user interface, table

Description automatically generated**

**Table 4: General Guidelines and Recommended Dimensions of Various Crossing structures** **adapted from** **(Clevenger and Huijser 2011)**

|  |  |  |
| --- | --- | --- |
| Type of structure | Species and Group | Dimensions Recommended |
| Landscape Bridge | All wildlife species Amphibians (if adapted) | W: >100m |
| Wildlife Overpass | Large mammals High-mobility medium-sized mammals Low mobility medium-sized mammals Small mammals Reptiles Amphibians (if adapted) | W: 50-70m |
| Mixed use: Wildlife and Human activities | Large mammals High-mobility medium-sized mammals Low mobility medium-sized mammals Small mammals Amphibians (if adapted) Reptiles | W: 15-40m |

Resources for Review:

[www.transportecology.info](http://www.transportecology.info)

[www.Wildlifeandroads.org](http://www.Wildlifeandroads.org) (Utah-based)

[www.Roadsandwildlife.org](http://www.Roadsandwildlife.org) (Ontario-based)

[https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=134712andinline](https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=134712&inline)

<https://www1.pewtrusts.org/-/media/assets/2020/02/reducing-wildlife-vehicle-collisions-by-building-crossingscllcpew-005.pdf>

<https://arc-solutions.org/wp-content/uploads/2017/04/ARC-Special-Pub-Design-Parameters.pdf>

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

Website resources

<https://structurae.net/en/structures/aich-wildlife-crossing>

<https://structurae.net/en/structures/kikbeek-wildlife-crossing>

<https://structurae.net/en/structures/suchdol-nad-odrou-wildlife-crossing-d1>

<https://structurae.net/en/structures/eckartswiller-wildlife-bridge>

<https://structurae.net/en/structures/wildlife-overpass>

<https://structurae.net/en/structures/wiesenhagen-wildlife-crossing>

<https://structurae.net/en/structures/beelitz-wildlife-crossing>

<https://structurae.net/en/structures/grunbrucke-nietheim>

<https://structurae.net/en/structures/hainholz-green-bridge>

<https://structurae.net/en/structures/klein-flothe-wildlife-overpass>

<https://structurae.net/en/structures/teupitz-wildlife-crossing>

<https://structurae.net/en/structures/laarderhoogt-wildlife-crossing>

<https://structurae.net/en/structures/woeste-hoeve-wildlife-crossing>

<https://structurae.net/en/structures/terlet-wildlife-crossing>

<https://structurae.net/en/structures/rengelbur-wildlife-crossing>

<https://structurae.net/en/structures/horka-wildlife-crossing>

<https://structurae.net/en/structures/gancani-ecoduct>

<https://structurae.net/en/structures/mostje-ecoduct>

<https://structurae.net/en/structures/isenberg-tunnel>

<https://structurae.net/en/structures/stock-wildlife-crossing>

* Swiss nation legislated 40m minimum width for crossing structures (French study).