

NCHRP 25-25, Task 113

ROAD PASSAGES AND BARRIERS FOR SMALL TERRESTRIAL WILDLIFE SPECIES

CONSIDERATIONS FOR FENCE-ENDS, ACCESS ROADS, AND ESCAPE OPPORTUNITIES

Prepared for:

AASHTO Committee on Environment and Sustainability

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ESCAPE OPPORTUNITIES AND ACCESS ROADS

This document summarizes the considerations for measures associated with barriers (walls or fences), specifically,

- barrier-end treatments aimed at reducing the likelihood that animals end up between the barriers at a barrier-end (fence-end or the end of a wall) and reducing the likelihood of a concentration of animals crossing just beyond the barrier-end;
- access road treatments aimed at reducing the likelihood that animals end up between the barriers along the road corridor at breaks in the barrier; and
- escape opportunities, including jump-outs or escape ramps, aimed at providing animals with an escape opportunity from the road corridor so that they can return to the safe side of the barrier.

This summary is based on the literature review, survey report, and the knowledge and experience of the authors. The literature review and survey report are available as separate documents produced for this project (NCHRP 25-25, Task 113).

A. GENERAL CONSIDERATIONS

General considerations include design, operation and maintenance issues for barrier-end treatments, access road treatments, and escape opportunities for small animal species (smaller than a coyote (*Canis latrans*)). The remainder of this document uses the term “fences” rather than “barriers,” although the term “fences” should be interpreted broadly (i.e., interchangeable with a wall).

No matter how long a fenced road section is, it will always have a fence-end on each side. Fence-ends are “messy” and can suppress the effectiveness of a fenced road section, especially when the fenced road section is relatively short (Huijser et al. 2016). Animals can also follow a fence and cross the road near the fence-end, resulting in a concentration of animal crossings (a fence-end run) and potentially also collisions at or near the fence-end. The longer a fenced road section is, the greater the probability that access roads or driveways and associated breaks are found along the fence. Treatments at access roads and barrier ends can help reduce intrusions into the fenced road corridor. No matter how well designed and constructed a fence is, how long it is, or how much attention is given to fence-end and access road treatments, some animals will end up inside the fenced road corridor. Therefore, it is important to provide escape opportunities. Escape opportunities include jump-outs or escape ramps or gates. These measures are aimed at allowing animals to escape the fenced road corridor so that they can return to the safe side of the barrier.

Characteristics

The terms and concepts related to access roads, barrier end, and escape opportunities are illustrated in Figure 1 (see also Huijser et al. 2015).

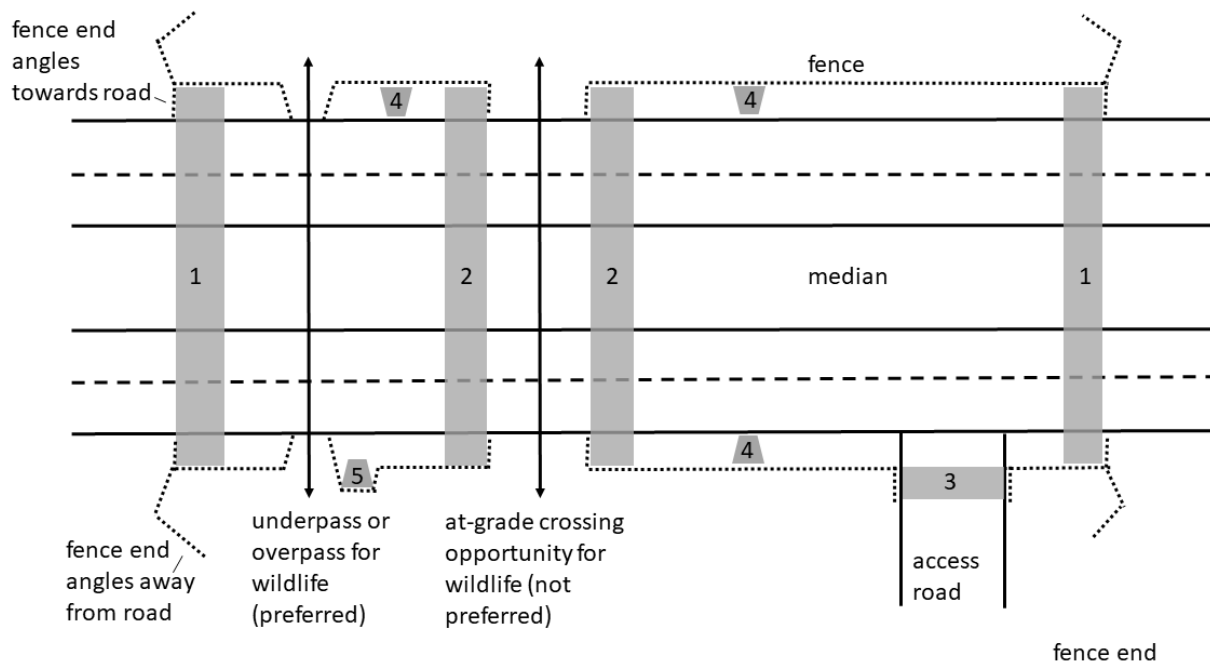


Figure 1: Schematic representation of a divided highway with a median, wildlife fences, and associated escape and access road control measures. 1 = fence-end treatments (e.g., fence-end close to pavement, fence in median, wildlife guard or electric mat embedded in pavement and potentially also between pavement and fence, and in median), fence angled away from the road to discourage animals that follow the fence to cross just beyond the fence-end, 2 = measures to encourage wildlife to cross the highway perpendicular at an at-grade wildlife crossing opportunity (similar measures to a fence-end), 3 = access road treatments (e.g., gate, wildlife guard, or electric mat across access road), 4 = escape opportunities for wildlife allowing them to leave the fenced road corridor and access the safe side of the fence (e.g., escape ramps or jump-outs, gates), and 5 = escape opportunity at a “bulb-out” with reduced disturbance from the road corridor (see text).

Fence-end Treatments

Length of the Fence: Wildlife fences and wildlife crossing structures are typically installed at locations where concentrations of wildlife-vehicle collisions occur. To be effective in reducing wildlife-vehicle collisions, the fence needs to be present along the entire hotspot or crossing location. However, the fence needs to extend farther than the actual hotspot to prevent animals that approach the road at the hotspot from simply walking to the fence-end and crossing at grade. The radius or diameter of the home range for the target species in combination with the length of the “hotspot” can be used to decide on the appropriate length of the fence. In summary, the length of a fence should not only cover a collision hotspot, but it should also cover an adjacent buffer zone. This dictates the location of a fence-end and thus potential intrusions into the fenced road corridor and a potential fence-end run.

Use Local Topography and Habitat Characteristics: The local topography and surrounding habitat are important considerations when deciding on the exact location of a fence-end. At a microscale, the location of fence-ends may coincide with topography or other landscape features, such as rock cliffs, to reduce the probability of animals moving around the fence-end, entering the fenced road corridor at a fence-end, or concentrating crossings just beyond a fence-end. Steep slopes (road cuts or fills), river crossings, or areas with relatively

high levels of human presence and disturbance are good examples of where one may choose to have a fence-end (Figure 2). The fence may also simply extend beyond a habitat that may be associated with the target species; this is also expected to reduce the probability of a fence-end breach.



Figure 2: *Examples of small animal fence-end tied into steep rocks (fence is about 2 feet [60 centimeters] tall). A small animal following the fence would not be able to travel around the fence-end and would likely travel back from where it came. Photo Credit: Kari Gunson.*

Examples of Fence-end Treatments: Once the location of a fence-end has been decided, additional treatments can help further reduce the likelihood that animals enter the fenced road corridor at the fence-end and the likelihood of a fence-end run:

- Provide safe crossing opportunities (e.g., underpasses, overpasses) at fence-ends.

- Bring the exclusion fence close to the edge of the pavement at the fence-end to reduce the likelihood that animals end up in the roadway as they wander in the right-of-way at the fence-end (Figures 1 and 3). Fence posts in the clear zone may need to be accompanied by guard rail or Jersey barriers to deflect vehicles that have left the pavement and to avoid vehicles hitting the fence post head-on. Note that bringing the fence-end closer to the road may also require a barrier in the pavement (e.g., a wildlife guard or electric mat, see next bullet point)) and that fence-ends close to the edge of the pavement can also be combined with the fence-end angling away from the road (a “split fence-end,” see Figure 1 and bullet point after Figure 6).



Figure 3: Large mammal fence angled towards the paved road surface and a wildlife guard at a fence-end. While these measures were mainly designed for large mammals, this design principle may also have application for small animal species. Note that small animal species may require escape opportunities from the “pit.” Also note that “double-wide wildlife guards” are more effective in keeping ungulates from the fenced road corridor. Canada.

- Install wildlife guards or electric mats in pavement at the fence-end. Wildlife guards (Figure 3) or electric mats (Figure 4) need to be installed in the travel lanes to substantially reduce the likelihood that animals enter the fenced road corridor at a fence-end. However, while wildlife guards are effective for large ungulates, they are only marginally effective for species with paws (e.g., bears, felids, canids) (Allen et al. 2013). Wildlife guards can be effective for small animal species that may fall between the rods or grates of the guard. In these cases, there must be escape opportunities from the “pit,” either through a ramp or a side exit (Figures 5 and 6). Electric mats are effective for mammal species with paws, but they may pose problems for small animal species (especially amphibians and reptiles), and they may not withstand winter conditions.



Figure 4: *Electric mat at a fence-end and a large mammal electric fence angled towards the paved road surface. While these measures were mainly designed for large mammals, this design principle may also have application for small animal species, mainly small felids, canids, and other medium-sized mammal species with “paws.” Note that the electricity may result in problems for amphibians and reptiles. Also note that “double-wide wildlife guards” are more effective in keeping ungulates from the fenced road corridor. For more information on research of this electric mat, see Gagnon et al. (2010). USA.*



Figure 5: A wildlife guard at an access road in line with a fence designed for large mammals. Note that this wildlife guard has an escape ramp from the pit for small animal species. The Netherlands.



Figure 6: A wildlife guard at an access road in line with a fence designed for large mammals. Note that this wildlife guard design allows small animal species to escape towards the sides. Note that “double-wide wildlife guards” are more effective in keeping ungulates from the fenced road corridor. USA.

- Angle the fence away from the road at a fence-end (Figure 1 and 7). In some cases, a wildlife fence is angled away from the road at a fence-end. The fence may angle only slightly away from the road (e.g., 45°) or it may be perpendicular (90°) to the road in other cases. The main purpose of having a wildlife fence angle away from the road is to discourage animals from crossing the road at-grade at the fence-end; it helps avoid a “fence-end run” effect (see Case Study II). Note that it is possible to both bring a fence-end close to the edge of the pavement and have it angle away from the road; this results in a split fence-end (see Figure 1).



Figure 7: While this plastic corrugated pipe was not an effective barrier for northern diamondback terrapins (*Malaclemys terrapin terrapin*), the fence-end is angled away from the road at a considerable distance, encouraging turtles to turn back rather than cross at-grade at the end of the barrier. For more detail on this barrier, see Huijser et al. 2019).

Access Road Treatments

Treatments that keep small animal species from entering the fenced road corridor at access roads include the following designs:

- Gates. Gates are only applicable for low-volume roads and low-speed roads or trails (e.g., pedestrian or bicycle paths). For small animal species, care must be taken to leave no gaps between the ground and the bottom of the gate (Figure 8).
- Wildlife guards. Wildlife guards allow a small animal species to travel under the grate, similar to travelling through an underpass (Figures 9, 10, and 11).



Figure 8: A pedestrian gate with a “flap” to keep amphibians, mostly common toad (*Bufo bufo*), from the road corridor. The Netherlands.



Figure 9: A wildlife guard at a bicycle path to keep amphibians, mostly common toad (*Bufo bufo*), from the road corridor (visible in the background). The Netherlands.



Figure 10: A wildlife guard at a low volume dirt access road to keep amphibians, mostly common toad (*Bufo bufo*), from the road corridor (visible to the left). The Netherlands.



Figure 11: A wildlife guard at an access road in line with a fence designed for large mammals. Note that this wildlife guard has solid concrete edges associated with the pit. These ledges can be used by medium- and large-sized mammals to access the fenced road corridor. Therefore, these ledges should not be accessible at all anywhere. The situation in the image above has not been retrofitted yet; the concrete ledge is still accessible, despite the presence of the rubber flaps (aimed at large ungulates but likely ineffective from keeping them from using the concrete ledge). For more details on this wildlife guard design, see Allen et al. (2013). USA.

Escape Opportunities

Escape opportunities, including jump-outs or escape ramps, are aimed at providing animals with an escape opportunity from the road corridor so that they can return to the safe side of the barrier.

Location: Escape opportunities are located on or alongside the barrier. Because intrusions into the fenced road corridor are most likely near fence-ends and access roads, escape opportunities should be installed at or near these locations. Escape opportunities are usually also installed near wildlife crossing structures because wildlife is expected to be present most frequently in these areas and may breach the fence. In addition, escape opportunities should be located throughout the fenced road corridor. For sensitive species, escape opportunities may be installed at a bulb-out in the fence (i.e., farther from the road, see symbol “5” in Figure 1), potentially obscured from the road through topography or vegetation. This allows the animals to calm down and figure out how to use the escape opportunity, relatively undisturbed by traffic and people.

Examples of Escape Opportunities: Escape opportunities from the fenced road corridor for small animal species can have the following designs:

- Jump-outs or escape ramps (Figures 12, 13, 14, and 15), which are earthen mounts that allow animals to climb up to the fence height and then jump or fall to the safe side of the barrier. The jump-outs should be low enough so that the animals will readily jump down to the safe side of the fence. At the same time, the jump-outs should be high enough so that animals will not jump or climb into the fenced road corridor. Given the different jumping and climbing abilities for different species, finding the optimal height for jump-outs is challenging. Examples of variants of jump-outs are wood steps for turtles in New Jersey (Zarate & Sherwood 2016), temporary one-way dirt mounds for toadlets in British Columbia (Biolinx Environmental Research 2013), and 1–3 foot (60–80 centimeter [cm]) vertical drop-downs for swamp wallabies (*Wallabia bicolor*) and koalas (*Phascolarctos cinereus*) in Australia (Goldingay et al. 2018). In Ontario, a corrugated steel pipe was implemented along Highway 69. This pipe was about 2 feet (60 cm) in diameter, 3.3 feet (1.0 meter) long, raised about 1.6 feet (50 cm) off the ground on the safe-side of the fence and at ground level on the road-side of the fence (Eco-Kare International 2019) (Figure 15). Another variant of jump-outs or escape ramps are branches stacked on the road-side of the fence (e.g., for small felids). Concerns about the design and effectiveness of jump-outs or escape ramps, or variants thereof include “wrong way” movements of the target species (Goldingay et al. 2018) and incorrect installation (Eco-Kare International 2019), poor use (Huijser et al. 2016b), and unknown effectiveness that may cause more harm than good.
- One-way gates (Figure 16) open when animals push against them from the road-side. The gates do not open when pushed from the safe side of the barrier.
- Barriers integrated into the road-bed (Figure 17) allow animals to approach the barrier from anywhere on the road-side and jump or fall down over the barrier onto the safe side.



Figure 12: *Jump-out for medium-sized and large mammals along an 8-foot (2.4-meter) tall wildlife fence. The Netherlands.*



Figure 13: *Jump-out for amphibians. The “cone” structure reduces the height of the jump-out. The cone-shape reduces the likelihood that animals will enter through the opening because they are expected to move along right next to the barrier rather than a bit farther back below the opening. California. Designed by ERTEC for a U.S. Geological Survey project. Photo Credit: Cheryl S. Brehme, Western Ecological Research Center, U.S. Geological Survey.*



Figure 14: An earthen ramp jump-out for amphibians. California. Photo Credit: Cheryl S. Brehme, Western Ecological Research Center, U.S. Geological Survey.



Figure 15: A jump-out made from corrugated steel pipe for small animal species (specifically turtles) used along a highway in Ontario, Canada. The pipe is raised on the safe side so animals cannot access it. On the road-side, the pipe is level with the ground. Photo Credit: Kari Gunson.



Figure 16: A one-way gate for Eurasian badgers (*Meles meles*). Note that the gate is temporarily propped open with a stick for the image to show that it opens when pushed from the roadside of the fence. The gate is positioned on a concrete footing. Ideally this footing should be cleared from debris on a regular basis to prevent the gate from not closing after use. The Netherlands.



Figure 17: A barrier wall for amphibians, specifically common toad (*Bufo bufo*). Animals that end up on the road between the barriers can jump back or fall back to the safe side at any point along the barrier section of road. The Netherlands.

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