A comparison of turtle and snake passage at drainage culverts along two major highways in North America

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Figures inserted at end of document

Abstract

This paper focuses on 2 case studies that monitored turtle and snake use of existing and new drainage culvert structures with exclusion wildlife fencing along two major highways in North America: Highway 83 (Valentine National Wildlife Refuge, Nebraska, U.S.A.) and Highway 69 (boreal forest in Ontario, Canada). Turtle and snake passage through drainage culverts was monitored in both studies using remote motion-triggered game cameras positioned at the top of one entrance to each culvert. Both studies found that the freshwater turtle and snake species present used a variety of drainage culverts to cross the road. These reptiles approached the culverts equally, but once they entered, their crossing rates were significantly different (81% for turtles and 63% for snakes). Although these studies showed that reptiles will use a variety of drainage culverts, further research is required to define the characteristics of the culvert underpasses that these animals will use. This study also shows that snakes are less willing than turtles to use these culverts, which may be due to changes in temperature between the tunnel entrance and the ambient environment.

Keywords: drainage culvert, highway mitigation measures, snakes, turtles, wildlife crossing structure

Introduction

Drainage culverts are used to convey water under roads, railroads, trails, or similar obstructions. Often, when placed correctly, these structures also provide connectivity for semi-aquatic animals such as amphibians and reptiles (see review in OMNR, 2016). A road improvement project may provide an opportunity to retro-fit or enhance existing culverts to facilitate use by amphibians and reptiles or to include additional culverts at specific habitat for crossing opportunities. Enhancement of existing culverts entails installing a new and improved culvert, e.g. by increasing size (upsizing) to facilitate wildlife passage at the same location.

Although little research has been conducted to evaluate what type of culverts are preferred by turtles and snakes, it is thought that size, temperature, amount of light, and extent of water flow can all influence the use of structures by these animals (see Sievert and Yorks, 2015 for turtles, and OMNR, 2016 for turtles and snakes).

Water flow can be modified by varying the size, placement, or materials of the culvert, or by implementing baffles to impede or slow down the water current. All vegetation and other debris that may block passage should be cleared. For culverts to be most effective for use by wildlife, exclusion fencing is also required to direct animals towards the structure’s entrance, as well as provide a barrier to exclude animals from the road (Dodd et al. 2004).

In this paper, data were used from two monitoring projects that implemented similar monitoring methods to evaluate turtle and snake use of existing and upsized drainage culverts. These data were specifically used to document and compare use of these structures by both snakes and turtles.

Study sites

Valentine Wildlife Refuge

The first study site is located on U.S. Highway 83 in the Valentine National Wildlife Refuge in Nebraska, U.S.A (figure 1a). The study area was a 19.3 km stretch of Highway 83 that runs through a sandhill ecosystem that is comprised of alternating valleys and ridges (Huijser et al., 2017). Each valley on both sides of the 2-laned highway features a lake, and water flow across the highway is facilitated by 11 drainage culverts. Of the 11 culverts, all but one were designed for drainage purposes and are between 0.9 and 1.2 m in diameter (figure 2a). In the early 2000’s, wildlife exclusion fence was installed along 5 road sections (from 240 to 650 m at each section of highway) crossing some of the dune valleys (figure 2b). The fence was chain link with no overhang, 90 cm tall and buried 3.8 cm into the ground (figure 2b).

Boreal forest

The second site is located on Highway 69 in the boreal forest of Ontario, Canada (figure 1b). The area is characterized as a recreational cottage country region with few residential inhabitants. The highway bisects the Georgian Bay Biosphere Reserve as well as a large expanse of Canadian Shield rock, extensive wetlands, and rivers. The study area is along 5 mitigated sections of a 4-laned highway that spans 160 km between Port Severn and Sudbury, Ontario. Each mitigated section has various-sized culverts that were designed specifically for drainage, and several were placed on higher ground built specifically for terrestrial wildlife passage. The culverts intended for both wildlife and drainage movement ranged from 1.2 m diameter corrugated steel pipe culverts up to 2.4 m high × 3.3 m wide concrete box culverts (see example in figure 2c). Reptile exclusion fencing was installed along all 5 mitigated sections that abut each of the culverts monitored. Fencing on four of the sections consisted of metal mesh wire attached to metal posts that extends 0.8 m above and 0.2 m below-ground (figure 2c). Fencing on the most northerly section consisted of buried geotextile material attached to the base of large animal fencing (Baxter-Gilbert et al. 2015).

[Insert figures 1 & 2 here]

Methods

At both study sites, one remote-triggered camera (Reconyx PC800 or PC900 model) was installed at the top of one entrance of the selected culverts to monitor wildlife use (figure 2a). At the Valentine Refuge, cameras were set to motion detection only, and at the boreal forest site, cameras were set to both time lapse (10-15 seconds) and motion settings. In addition, rocks were placed at the bottom of the culvert to funnel wildlife under the camera's field of view (figure 2a). When water was present, rocks were placed up to the height of the water and adjusted as water levels fluctuated to optimize the capture of wildlife movements. At the Valentine Wildlife Refuge, cameras were placed at 8 culvert ends and were operational from April 1st to September 30th, 2016. At the boreal forest site, cameras were placed at 18 culvert ends and were operational from June to September in 2015, 2016, and 2017.

Passages by turtles and snakes occurred when animals moved into the culvert and were not seen moving out of the culvert the same day. A turnaround was when the animal was seen as moving into the structure, past the camera, and turning around and moving out of the structure the same day.

The proportion of passages and turnarounds at each culvert for both sites combined were tallied for both turtles and snakes. A Pearson's Chi Square analysis was then used to measure whether the proportion of snakes that crossed the structure differed to that of turtles.

Results

Valentine wildlife refuge

Of the 8 culverts monitored, the cameras recorded 55 (79%) passages by turtles (38 Snapping turtles (*Chelydra serpentine*), 9 Painted turtles (*Chrysemys picta*), 8 Blanding's turtles (*Emydoidea blandingii*), and 14 (21%) turned around. There were 3 species of snakes detected at the culverts: Eastern garter snake (*Thamnophis sirtalis*), Eastern racer (*Coluber constrictor*), and Bullsnake (*Pituphis catenifer*). Of the snakes that entered the culverts 60% (68) were passages, while 40% (45) turned around.

Boreal forest

Of the 18 culverts monitored, the cameras recorded 71 (83%) passages by turtles (39 Snapping turtles, 27 Painted turtles, and 5 Blanding's turtles, and 15 turtles (17%) entered the culvert and turned around. Five species of snakes were observed at the culverts: Eastern garter snake (18 observations); Eastern hognose snake (*Heterodon platirhinos*, 9 observations), Massasauga rattlesnake (*Sistrurus catenatus,* 1 observation), Eastern Milksnake (*Lampropeltis triangulum*, 2 observations) and watersnake (*Nerodia sipedon*, 14 observations). Of all the snakes that used the culverts, 31 (70%) were passages by snakes, and 13 (30%) turned around. All of the reptile observations were at 12 culverts, of which 2 were dry and never had water in them, and 10 had water flow at some point during the monitoring periods.

When combining observations from the two study sites combined: turtles (n = 155) and snakes (n = 157) entered into the drainage culverts in almost equal numbers; however, turtles were more likely to continue through the tunnel 81% of the time as opposed to only 63% of the time for snakes (figure 3). This difference in crossing rates was significant (χ^2 **=** 12.8944; df = 1, $p = 0.0003$).

[Insert figure 3 here]

Conclusion

Further analyses need to be conducted to evaluate species-specific preference of culverts based on water levels, size, and proximity to suitable habitat - similar to a study completed for small mammals in Banff National Park (Clevenger et al. 2001). Although, this study did not evaluate the type or size of culverts that reptiles will use to cross a major highway, preliminary results have shown that reptiles will use a variety of drainage culverts equal to or less than 2.4 m high × 3.3 m wide to cross under roads. It also suggests that turtles are more ‘willing to use’ these structures than snakes.

Turtles and snakes are ectothermic animals which means they cannot control their body temperature internally and instead their temperature varies with environmental conditions. Temperatures in larger, more open culverts are generally thought to be similar to the ambient environment temperatures at the culvert entrance compared with smaller, darker structures. Therefore, larger, more open crossings might be more conducive for reptile crossings. However, more research is required to evaluate whether temperature differentials between the ambient environment and the drainage culvert entrance is such that snakes are less willing to enter (see example in Colley et al., 2017). It is also possible that turtles are more likely to cross through fenced underpass structures such as culverts in June, when the majority of the field work was conducted, because they are likely females searching for nesting sites.

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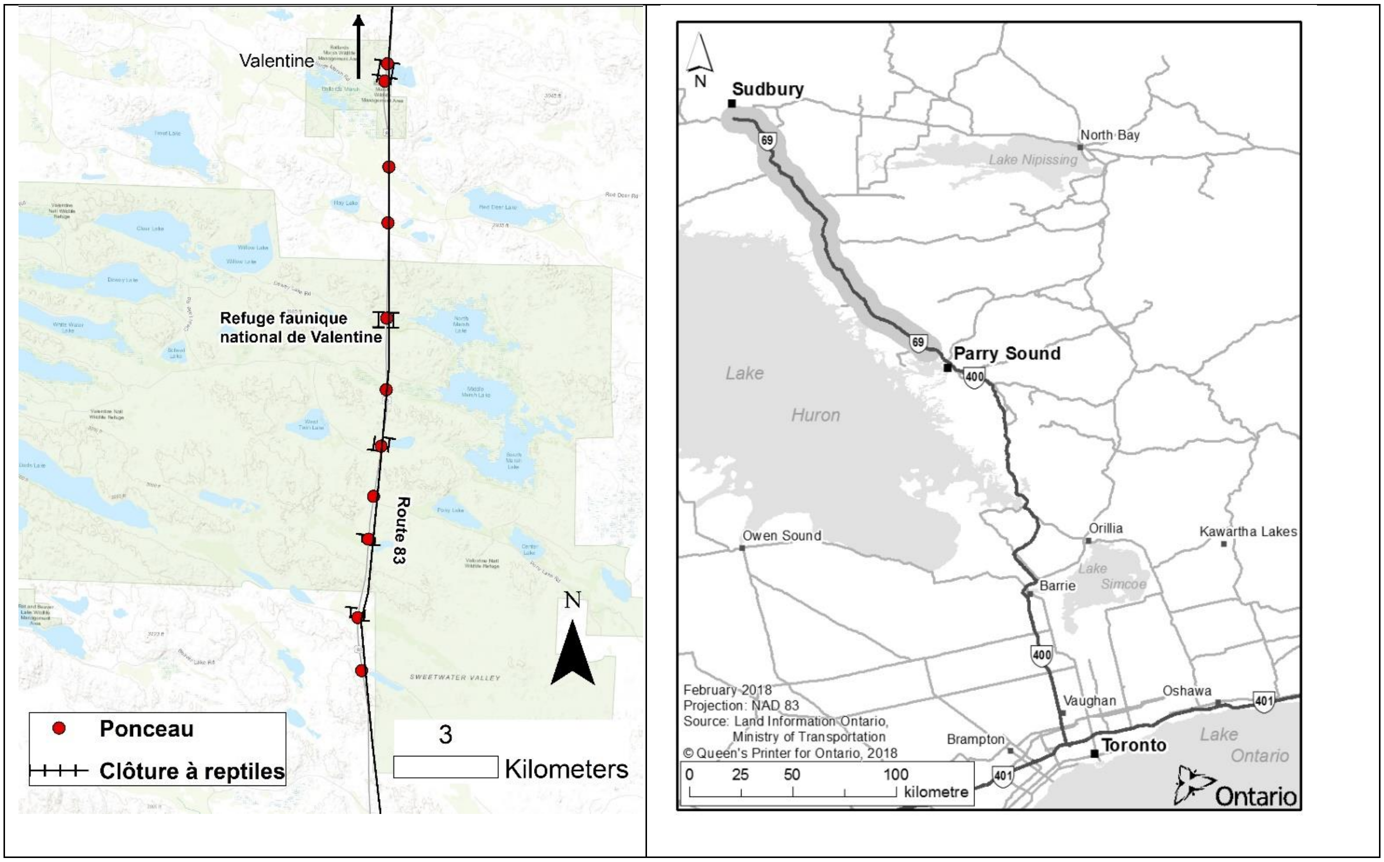

Figure 1: Location of the two study sites: a) Valentine Wildlife Refuge (Nebraska, USA) (Eco-Kare International) b) boreal forest site adjacent to Highway 69 (Ontario, Canada) (Queen's Printer for Ontario).

Figure 2a

Figure 2b

Figure 2c

Figure 2. Examples of the monitored culverts and exclusion fencing at the study sites: a) Camera set-up on a drainage culvert along Highway 83, Valentine National Wildlife Refuge, Nebraska, USA; b) Snapping turtle moving along chain link fence at Highway 83; c) box culvert with exclusion fencing and rocks to funnel animals under camera on Highway 69, Ontario, Canada. (Photo credits: Kari Gunson).

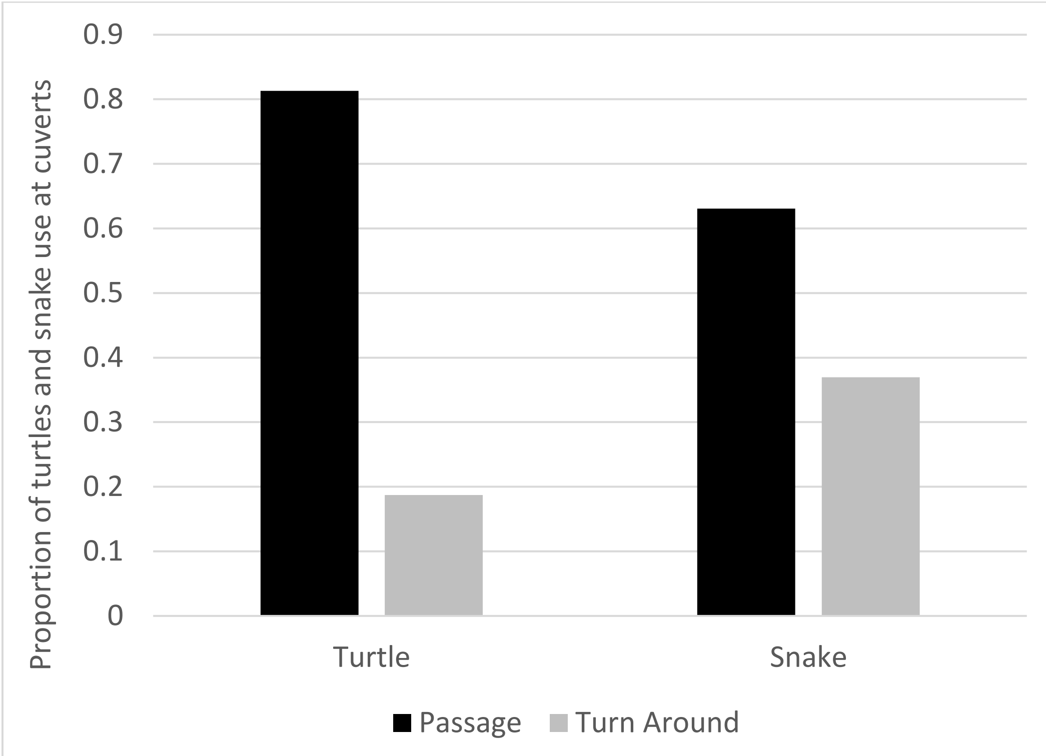

Figure 3: Percentages of turtle and snake passages and turnarounds at all culverts combined at the two study sites.