Can passages be shared by humans and wildlife?

How human co-use of underpasses affects the tendency of mammals to cross beneath a high traffic highway

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BACKGROUND

- Roads and highways have rapidly become ubiquitous features in developed landscapes around the world. From the year 2000 to 2009, the rate of paved road development globally was 1.3 million additional lane-km per year (Dulac 2013).
- In order to track suitable climate, terrestrial species globally are rapidly moving northward at a rate of 16.9 km / decade (Chen *et al.* 2011).
- The addition of fencing and crossing structures to highways is shown to decrease roadkill by 83% for large mammals (Rytwinski *et al.* 2016)
- If human use of crossing structures is a deterrent for specific wildlife, it may defeat all efforts to mitigate the effects roads on these populations.
- Extending across 83 million acres, the Northern Appalachian / Acadian ecoregion retains the largest expanse of intact forest in the contiguous United States (Anderson 2006) – which has now been bisected by a high traffic, four lane highway, autoroute 10 est.

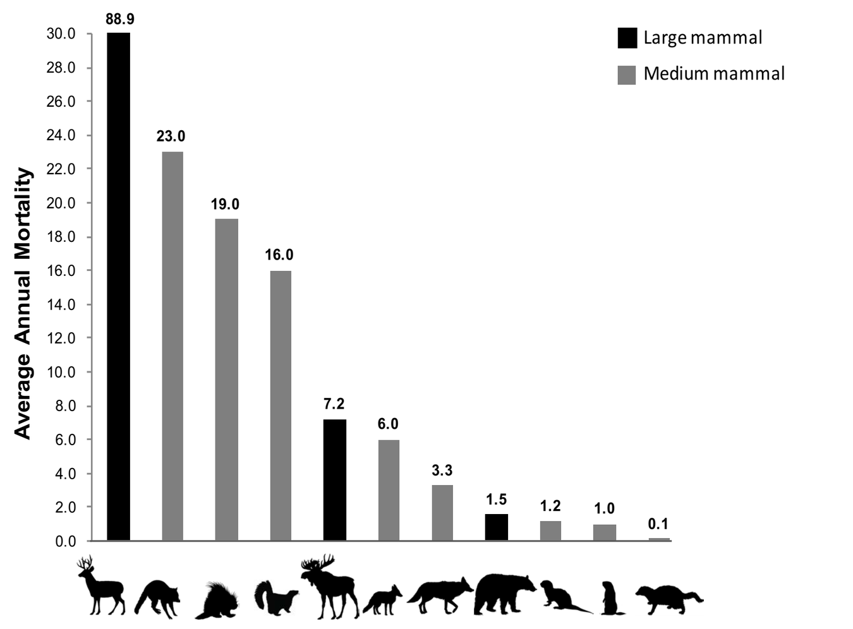
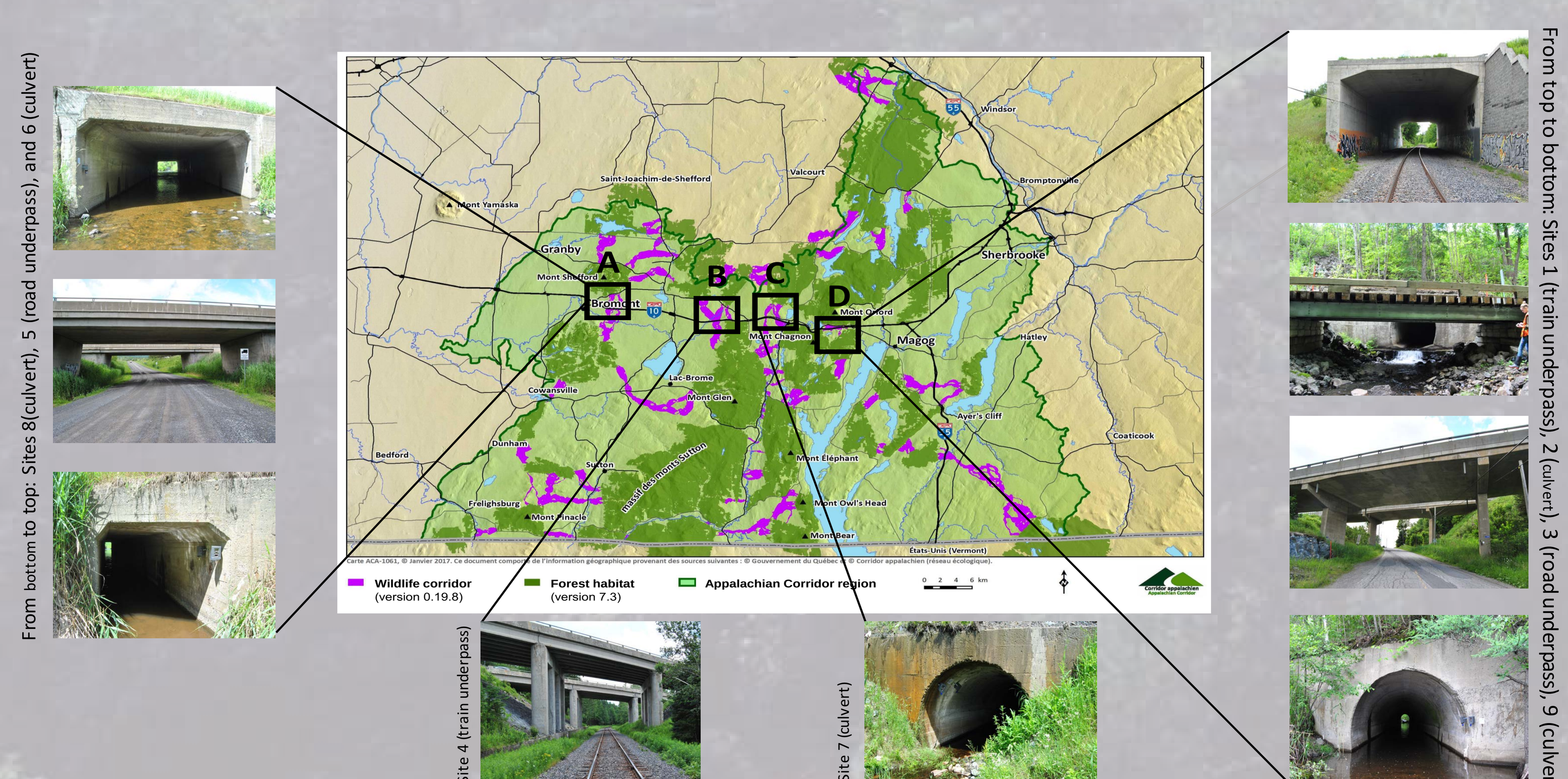


Fig. 1. Average annual roadside mortality along A-10-est, QC, within the Appalachian Corridor region (see map below). Data collected by MTMDET from 2005 to 2016.

METHODS

- Spanning 75 km between the towns of Granby and Sherbrooke, QC, four sections of Highway 10 East were selected (A-D), where the predicted wildlife corridors were intersected by the four-lane highway (see map below; Daguet *et al.* 2015).
- All underpasses within these sections with a minimum opening area of 1.5 m^2 were deemed accessible and suitable for use by medium to large sized mammals (n = 9).
- Reconxy Hyperfire HC600 motion and infrared detection cameras were used for continuous observation of animal and human activity at all crossing structures.
- Logistic regression analysis was ran for the effect of human activity on the probability of presence, full crossing, and aversion of each species mobility guild individuals. Analysis was conducted at 3 temporal divisions: weekly, daily, and daylight/night activity.

- **We predicted that high rates of human activity would result in low rates of discoveries and full crossings of the passage by mammals, and high rates of passage aversions.**



RESULTS

1. What diversity and frequency of mammal use is seen at each underpass?

Over a maximum period of 315 continuous observation days at each underpass, a total of 1450 individuals from 9 mammalian species were observed (Table 1).

Table 1. The total number of individuals detected at each crossing structure for each species of medium and large mammals. The number in brackets represents the percentage of full crossings by mammals per confirmed approaches at crossing structure.

Species	Total number of medium and large mammals detected at crossing structures								
	Train underpass		Road underpass		Culvert				
	1	4	3	5	2	6	7*	8*	9*
Black bear	-	-	-	-	1 (100%)	-	-	-	-
Bobcat	2 (100%)	20 (100%)	-	1 (100%)	-	-	-	-	-
Coyote	2 (100%)	1 (100%)	-	4 (100%)	-	-	-	-	-
Deer	58 (78%)	91 (92%)	1 (0%)	26 (79%)	39 (0%)	83 (12%)	1 (0%)	17 (0%)	2 (0%)
Fisher	1** (0%)	1 (100%)	-	-	-	-	-	-	-
Mink	-	-	-	-	27 (4%)***	-	2 (100%)	1 (0%)	-
Raccoon	5 (100%)	21 (95%)	-	586 (99%)	41 (100%)	252 (90%)	10 (100%)	4 (100%)	24 (0%)
Red fox	32 (97%)	2 (100%)	-	2 (100%)	-	-	3 (100%)	-	1 (0%)
Woodchuck	4 (100%)	5 (100%)	-	-	1 (100%)	-	1 (100%)	-	-
TOTAL	**104 (87%)**	**141 (95%)**	**1 (0%)**	**619 (99%)**	**110 (40%)**	**336 (68%)**	**17 (94%)**	**24 (19%)**	**27 (0%)**
Daily human activity	5.1	3.4	237.3	29.2	0.1	1.5	0.3	2.3	0.2

* Sites 7, 8, and 9 were observed for only 6 weeks between July and August 2017
** The fisher observed at site 1 was visually observed at site.
*** The mink at site 2 had an ice burrow within the culvert, but only crossed to the other side of the culvert on one occasion. This is likely because the other end of the culvert was barricaded by a wall of ice from highway run-off.

Train underpasses (sites 1 and 4)

- The highest diversity of mammal species was seen at train underpasses, with 7 species of large and medium mammals using the underpasses to cross highway 10 est. White-tailed deer, red fox and bobcat were the most frequent users.
- On average, 2.7 and 4.1 mammals crossed the underpass per week at site 1 and 4, respectively.
- 86.9% and 94.1% of crossing structure approaches resulted in full crossings through the underpasses at site 1 and 4, respectively.

Road underpasses (sites 3 and 5)

- No mammals were observed to use the underpass at site 3 to cross – this is likely due to the average use by 1690 cars per week.
- Site 5, where only 200 cars passed per week, displayed high use by raccoon and red fox, with an average presence of 19 individuals per week.
- Less than one deer per week, on average, was detected at the road underpass, and of these, 78.6% crossed through the structure.

Water culverts (sites 2, 6, 7, 8, and 9)

- At all culvert sites (except site 9) raccoon, red fox and woodchuck had crossing success rates of 100%, and were seen in the highest numbers and frequencies.
- Deer were never observed to use circular water culverts to cross, although one attempt was made at site 2 (see photo below, right). During the months of July and August, when a dry path was present, deer successfully crossed through the large box culvert (site 6).
- Weekly crossings at culverts ranged from 4.2 to 0 mammals per week.

References

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2. Does human activity decease mammal use at crossing structures, and at what temporal division is this seen (ie. per week, per day, during daylight or night hours)?

- No significant effects were found for weekly, daily, daylight hour or nightly human activity on the likelihood of mammal use or aversion at crossing structures.
- Weeks, days, and nights with high human activity displayed increasing likelihood of presence of medium and large mammals.
 (Site 1, weekly activity : n = 32, β = 0,233, SE = 0,0994, z = 2,349 , p < 0,02; site 4, nightly activity: n = 223, β = 0,356, SE = 0,137, z = 2,607, p < 0,01; site 5, daily activity : Figure 2, below)

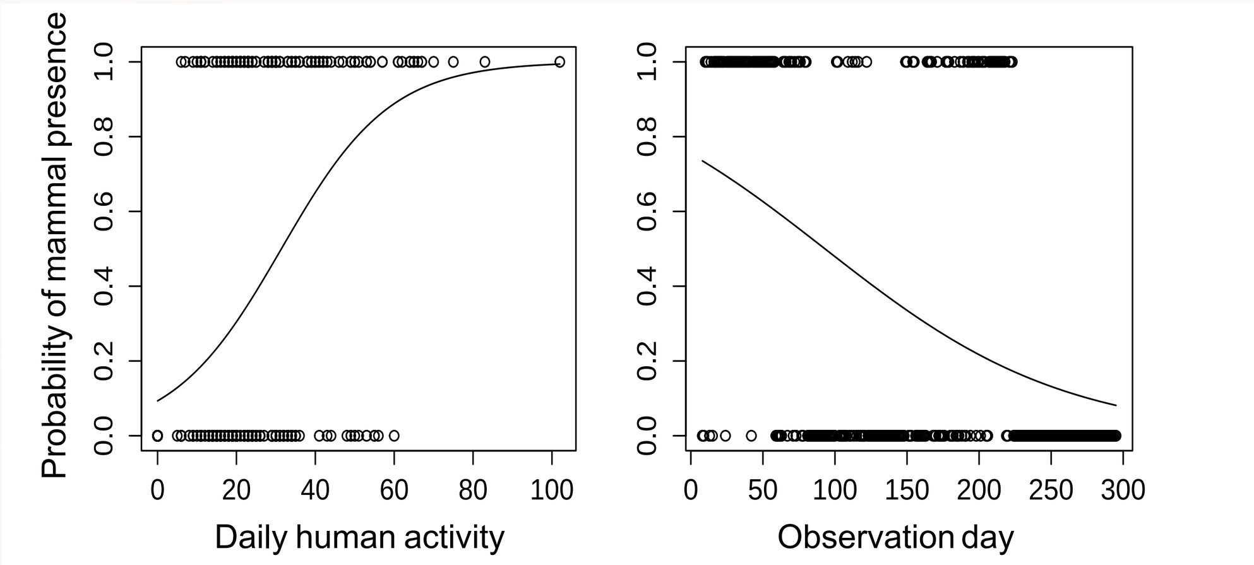

Fig. 2. Logistic regression analysis on the probability of medium and large mammal presence (1) or absence (0) explained by daily human activity (left) or observation day (right) at road underpass site 5. Days with high numbers of humans at the road underpass had an increased probability of mammal presence at underpass (n = 216, β = 0.0421, SE = 0.0101, z = 4.159, p < 0.001). Observation day (from October 2016 to May 2017) did not significantly explain the likelihood of mammal presence (n = 216, β = -0.003, SE = 0.0024, z = -1.408 , p = 0.16).

- The observation that no mammals were detected using the high-use road underpass at site 3 is very likely due to human activity (237 humans passing per day); there is great structural similarity to the low-use road underpass at site 5, yet weekly human activity is much lower, and mammal use is very high (Table 1).

CONCLUSION & RECOMMENDATIONS

- Train underpasses, low-traffic road underpasses, and water culverts can serve as wildlife crossing structures for numerous species of medium to large mammals.
- Logistic regression analysis for events occurring *within each structure individually* did not show that increasing levels of human activity at underpasses decrease the likelihood of mammal discoveries of, or use of crossing structures, nor increase aversion at individual crossing structures.
- However, no mammal crossings were observed at the underpass with the highest degree of human activity, where 237 humans passed per day at road underpass (site 3). Comparisons between passages could not statistically be made due to low sample size of observed underpasses (n = 9) of diverse structure types.
- Temperature is likely responsible for increasing both human and mammal presence at crossing structures (Figure 2). Other co-variables, such as water level and structure type are likely important.
- This study is being continued for another year to account for these co-variables and increase mammal observations.
- **To increase the use of the existing underpasses by medium and large mammals, we supply the following recommendations:**
 i. To facilitate mammal use of culverts and decrease mortality, fencing should be installed along A-10-est in areas of high animal activity and mortality hotspots (Daguet 2015), notably within km 80-85, 94-106 and 109-115
 ii. The addition of *dry paths* within all water culverts to allow for year-round access
 iii. The addition of an *earthen path* at the train underpass of site 1, to encourage use by hooved animals which show aversion to large gravel
 iv. Notwithstanding recommendations for wildlife mitigation measures in existing structures, the construction of new *purpose-built wildlife structures* should be considered whenever possible on critical sections of A-10 est

ACKNOWLEDGMENTS

We would like to thank the **MTMDET** for providing the mortality data, permission to access the sites, and their support for this project, as well as **Corridor appalachien** for the coordination of this project, and all of our **volunteers** who helped with field work and photo analysis.