- News Bulletin -

Monitoring the use and effectiveness of wildlife passages for small and medium-sized mammals along Highway 175: Main results and recommendations

Jochen Jaeger, Ariel Spanowicz, Jeff Bowman, Anthony Clevenger

Nº 8 – December 2017

Roads and traffic negatively impact many wildlife populations because they increase wildlife mortality, are barriers to animal movement and reduce the amount and quality of available habitat. There is increasing concern about the reduction in connectivity for wildlife across roads. If efforts are not made to reduce these effects there could be severe consequences for ecological processes and wildlife populations, such as higher mortality, higher vulnerability of the populations, unbalanced sex ratios, lower reproduction rates, reduced gene low, loss of biodiversity, and shifts in community composition (van der Ree et al. 2015). Many effects have a response delay, i.e., they become visible only after some time (several years or several decades). Mitigation measures are measures taken to alleviate, at least to some degree, these negative impacts.

Photos: Concordia University

- During the widening of Highway 175 between Québec City and Saguenay from two to four lanes (in 2006 - 2011), 33 wildlife underpasses for medium-sized and small mammals were constructed along the highway between km 60 and km 144.
- They are among the first designated wildlife passages for medium-sized and small mammals in the province of Québec.
- About two thirds (133 km) of the total length of HWY 175 between Quebec and Saguenay (210 km) traverse the Réserve Faunique des Laurentides (RFL). Large parts of the road are directly adjacent to the Parc National de la Jacques-Cartier (PNJC).
- Exclusion fences for medium-sized mammals were placed on both sides of each passage entrance. They are about 100 m long on either side, 90 cm high with a 6 cm x 6 cm mesh size.

Four types of wildlife passages for medium-sized and small mammals on Highway 175

Photo 1: Pipe culvert (PC), or round concrete culvert (n = 6)

Photo 2: Box culvert with a wooden ledge (WLC) (n = 4)

Photo 3: Box culvert with a concrete ledge (CLC) (n = 7)

Photo 4: Box culvert with a concrete walkway (CWWC) (n = 1)

This research project had three main objectives:

1. To characterize the locations and rates of vehicle collisions with medium-sized and small mammals and to evaluate the changes in the frequency of highway-related mortality due to the mitigation measures.
2. To determine the performance of the four types of wildlife passages for medium-sized and small mammals.
3. To assess how well the mitigation measures provide for the permeability of the highway for individuals and for gene flow across the road, with a focus on the American marten.

Four types of wildlife passages for medium-sized and small mammals on Highway 175:

(1) Pipe culvert (PC), also called round concrete culvert: This is a pipe made of concrete (TBA = *tuyau de béton armé*) or of PEHD (*polyéthylène de haute densité*), usually of a diameter of 60 or 90 cm (in French: *ponceau sec*, or *tuyau circulaire*),

(2) Box culvert with a wooden ledge (WLC): This type of box culvert includes on one side a wooden ledge attached to the wall of the culvert by metal support beams and screws (in French: *ponceau avec tablette de bois installée en porte-à-faux*),

(3) Box culvert with concrete ledge (CLC): This box culvert includes on one side a concrete ledge, which was originally included in the conception and production of the culvert, higher above the water than the concrete walkway of the CWWC (in French: *ponceaux avec pied sec de type tablette de béton*),

(4) Box culvert with concrete walkway (CWWC): This box culvert includes on one side a walkway made of concrete, which was originally included in the conception and production of the culvert, at lower height than the concrete ledge of the CLC (in French: *ponceau avec une banquette de béton*).

Photo 5: Installation of *Reconyx* cameras in the wildlife passages

Photo 6: Large-fauna fence (top part) and medium-sized fauna fence (bottom part)

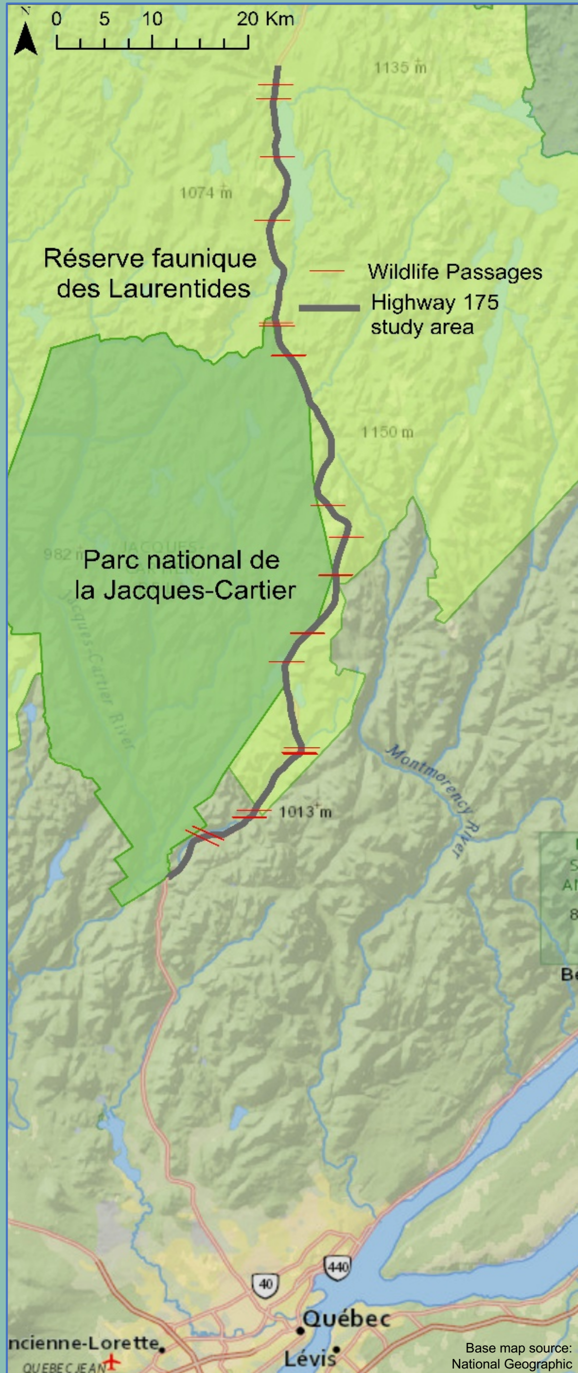


Figure 1: Locations of the 18 wildlife passages that were studied in this project in 2012-2015

Objective 1: Road Mortality

- Road mortality surveys were done to evaluate by how much the wildlife passageways (combined with fences for medium-sized fauna) reduce the traffic mortality of medium-sized and small mammals.
- In every 2-week session, the researchers searched for roadkill or injured animals three days in the evenings (before sunset), followed by one day without a survey, and six days in the early mornings (just after sunrise).
  - This procedure was performed in four summers (June - September from 2012-2015).
  - A total of 306 road mortality surveys were performed.
- During four summers, 893 carcasses were detected comprising 13 different species or taxonomic groups. Porcupines were found most often, followed by red foxes, woodchucks, striped skunks, and snowshoe hares.
- The presence of shrubby vegetation in the median strip separating the two directions of the highway and proximity of the forest to the highway increased the number of road-kill for medium-sized mammals (> 1 kg).
- None of the species were identified as at-risk, endangered or threatened.
  - More mobile species are more negatively affected by road mortality than less mobile species because they interact with roads more often.
  - Species with lower reproductive rates and longer generation times are more susceptible to road effects because they are less able to rebound from population declines resulting from road mortality.

Table 1: Characteristics (species traits and behavioral responses) that influence the vulnerability of species to the impacts of roads and traffic. (Source: Rytwinski and Fahrig 2015, modified)

Relevant species characteristics	Effects of roads and/or traffic		
	Road mortality	Habitat loss and reduced habitat quality	Habitat fragmentation and reduced connectivity
Life history variables:			
Low reproductive rate	x	x	x
Long generation time (lifespan)	x	x	x
High intrinsic mobility	x		
Large area requirements and low natural density	x	x	x
Large body size	x	x	x
Multiple resource needs	x		x
Behavioral responses to roads:			
Attraction to roads	x		
Road surface avoidance			x
No vehicle avoidance	x		
Traffic disturbance avoidance		x	x
No road or traffic disturbance avoidance	x		

Table 2: Total numbers of dead mammals detected on the road by species and by year (mortality surveys: K. Bélanger-Smith and J. Plante; Bélanger-Smith 2015, Plante 2016)

Species	2012	2013	2014	2015	Total
North American Porcupine	94	112	81	87	374
Unidentified small mammal	40	15	27	20	102
Unidentified mammal	18	23	16	10	67
Red Fox	19	15	12	6	52
Woodchuck	8	9	19	11	47
Mice spp.	40	3	2	1	46
Striped skunk	14	18	4	6	42
Snowshoe Hare	16	10	9	6	41
Vole and Bog Lemming spp.	27	1	2	3	33
Shrew spp.	19	3	6	3	31
American Red Squirrel	9	3	2	5	19
Raccoon	9	1	2	0	12
Jumping Mouse spp.	5	2	0	2	9
North American Beaver	1	5	0	2	8
Weasel spp.	1	2	0	0	3
Canada lynx	0	0	1	1	2
Northern Flying Squirrel	2	0	0	0	2
American Marten	0	0	0	1	1
American Mink	1	0	0	0	1
Star-nosed mole	0	0	0	1	1
Wolf	0	0	0	0	0
River Otter	0	0	0	0	0
Fisher	0	0	0	0	0
Common Muskrat	0	0	0	0	0
Total	***323***	***223***	***183***	***165***	***893***

Fencing appears to reduce road mortality within the fenced sections, but our sample size was too low for statistical significance. However, road mortality was higher at the fence-ends than within both the fenced and the unfenced sections. Accordingly, the combination of the fenced section with the higher mortality at the fence-ends (the "fence-end effect") did not result in a reduction of road mortality compared to unfenced sections. Longer fences are likely to be more effective.

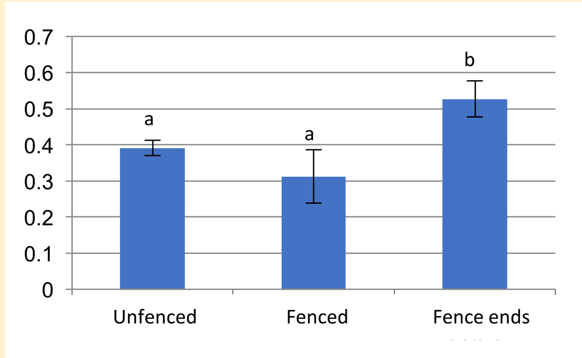
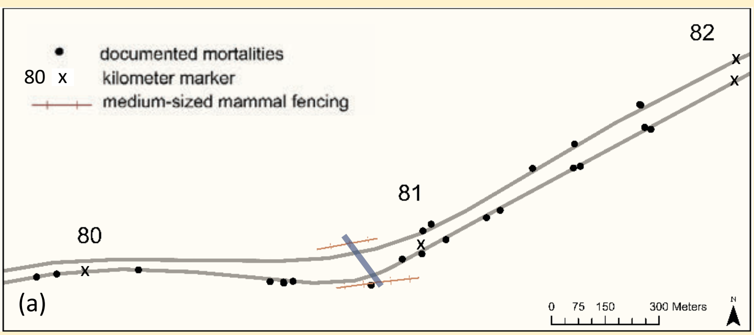


Figure 2: Average numbers of roadkill per 100 m road segment per segment type for species > 1 kg (Plante 2016).



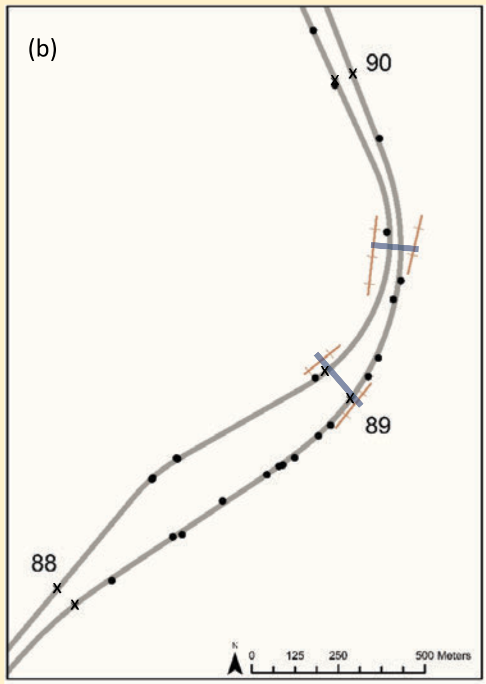
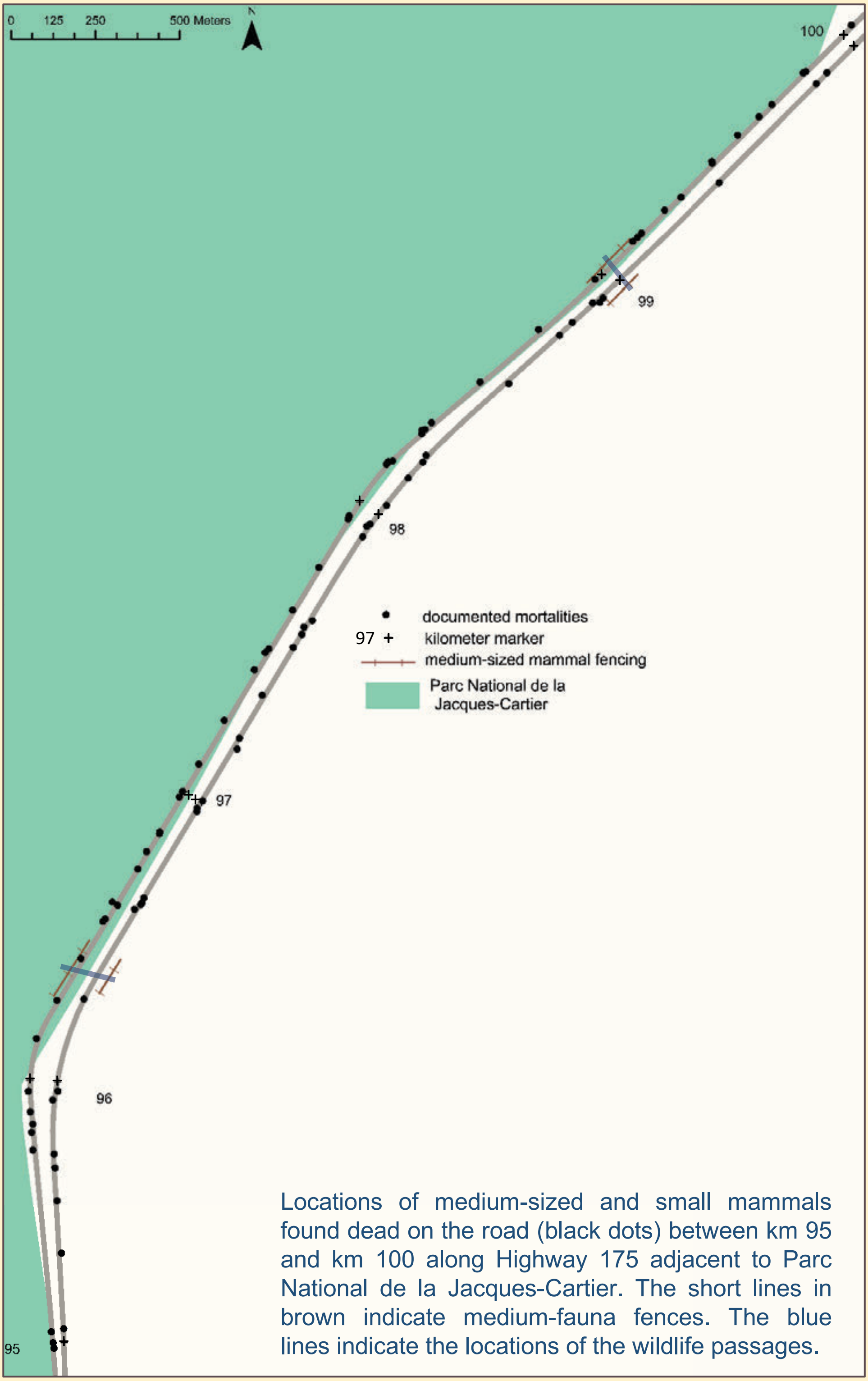


Figure 3: Locations of medium-sized and small mammals found dead on the road (black dots) between km 80 and km 82 (a) and between km 88 and km 90 (b) along Highway 175. The short lines in brown indicate medium-fauna fences. Note the frequent occurrence of roadkill locations in the proximity of the fence-ends. The blue lines indicate the locations of the wildlife passages.



Locations of medium-sized and small mammals found dead on the road (black dots) between km 95 and km 100 along Highway 175 adjacent to Parc National de la Jacques-Cartier. The short lines in brown indicate medium-fauna fences. The blue lines indicate the locations of the wildlife passages.

Figure 4: On this 5-km stretch of road, during the 4 summers of surveys, 52 medium-sized and small mammals were found dead on the southbound lanes (on the left, closer to the park), while 36 mammals were found dead on the northbound lanes (on the right). Note the frequent occurrence of roadkill locations in the proximity of the fence-ends.

The true number of animals killed on the road is much higher, because:
(1) detection probability of roadkill is < 100%,
(2) some injured animals move off the road and die next to the road, but are not detected in the surveys,
(3) some carcasses are removed from the road by scavengers or are completely destroyed by vehicles before they could be detected in the next survey,
(4) mortality surveys were done for only 4 months out of 12 months in each year.

Objective 2: Effectiveness of the Wildlife Passages

The use of 18 wildlife passages by animals was observed continuously from June 2012 to August 2015 (night and day, year-round) using digital cameras (*Reconyx HC 600*). They were installed at either entrance of each passageway.

Complete crossings were documented for *all* of the 18 wildlife passages that were monitored by at least one medium-sized and one small mammal species. The total number of photos recorded was 227,720 between end of May 2012 and end of August 2015. Of these, 97,889 photos (43%) showed mammals. The photos documented 14,344 visits of the wildlife passages by mammals. They included 1851 complete crossings (13%), while 28% were explorations (animal was seen entering and exiting by the same camera), and 59% were unknowns (it was not possible to determine from the photos if the animal moved through the entire passage or returned).

These results demonstrate that the new wildlife passages **are being used by small and medium-sized mammals**, only four to six years after their construction (depending on their time of construction).

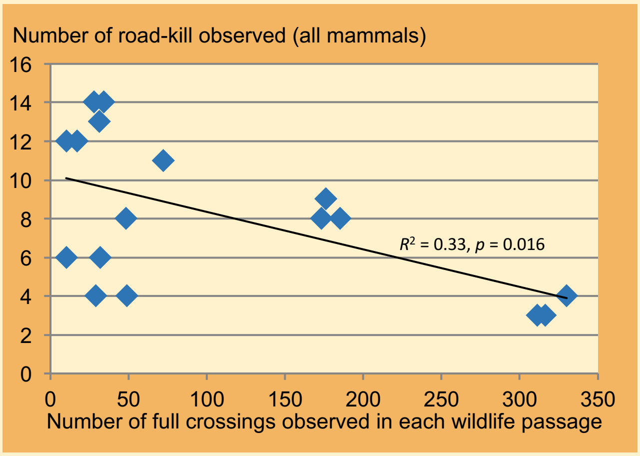


Figure 5: Road mortality within the fenced sections (and close to the fence-ends) is lower at wildlife passages that are used more frequently, except for porcupines.

The true numbers of visits and complete crossings are likely much higher than the numbers observed, because the cameras have a detection rate of less than 100% (about 80-85% for medium-sized mammals and about 50-55% for small mammals).

Photo 7: Camera in a box culvert with a concrete walkway (CWWC)

However, during the time of the study, some species were never documented of performing a full crossing in any type of wildlife passage, including American marten, fisher, Canada lynx, and northern flying squirrel. Only one full crossing was documented for river otter, only six for red fox, and only 10 for North American porcupine and raccoon.

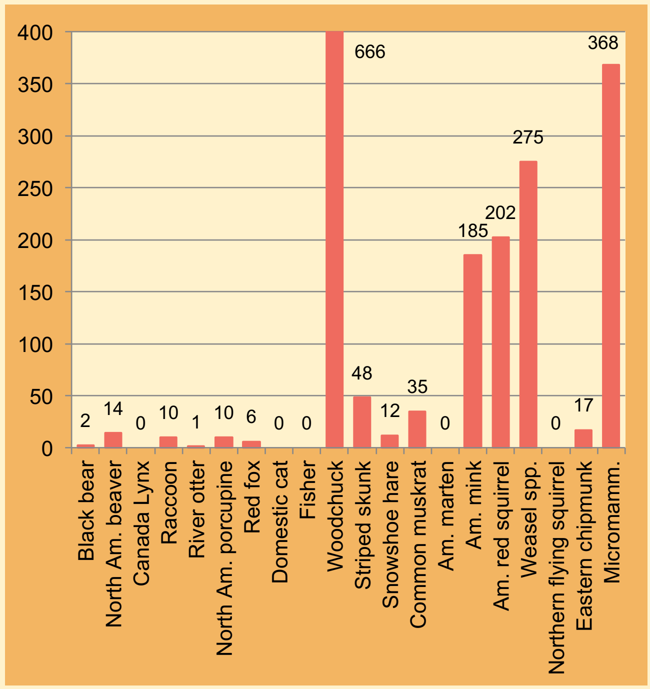


Figure 6: Number of complete crossings observed (by species) (monitoring of the use of the wildlife passages: K. Bélanger-Smith and A. Martinig; Martinig and Bélanger-Smith 2016)

Overall performance of the types of wildlife passages: The pipe culverts and wooden ledge culverts are more effective than the concrete ledge culverts.

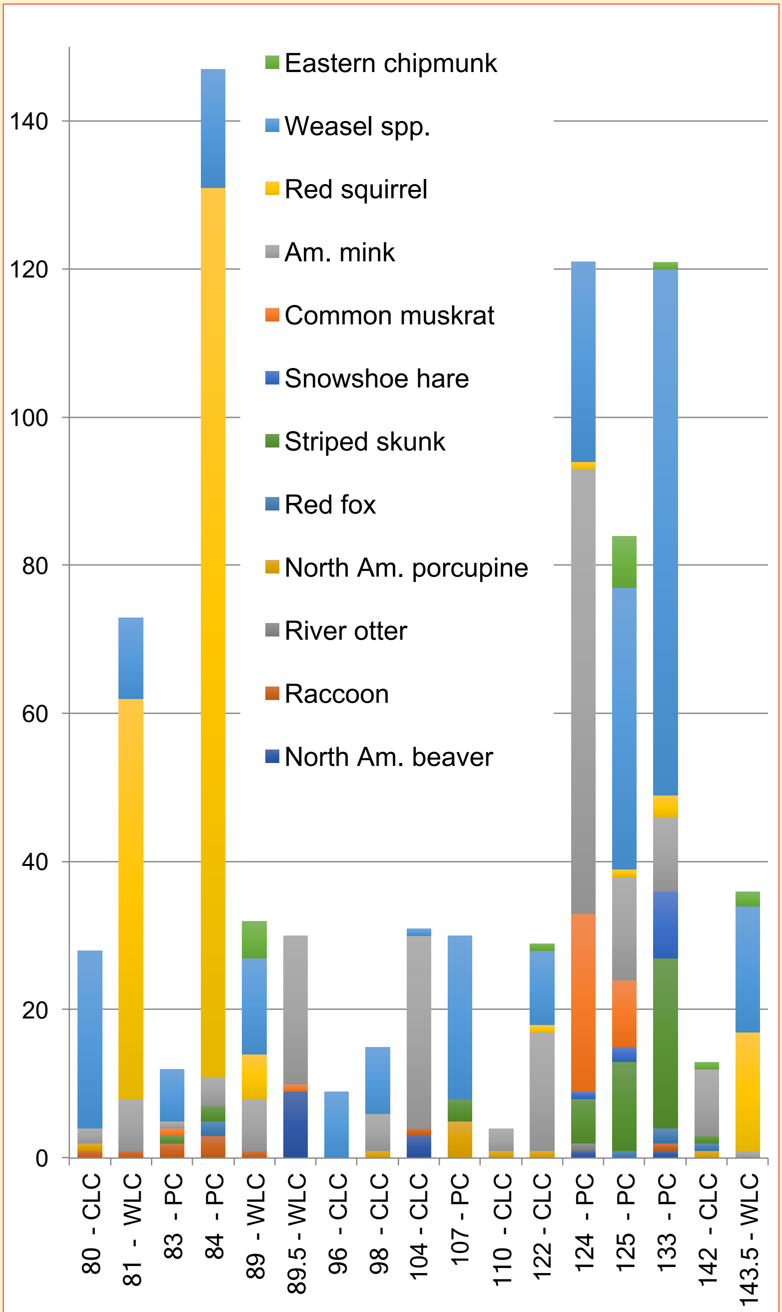


Figure 7: Number of complete crossings observed at each wildlife passage by species (without woodchuck and micromammals; ordered by body mass).

Table 3: Overall effectiveness of three types of wildlife passages along HWY 175, based on the data observed in 2012-2015 (– = not effective, * = slightly effective, ** = satisfying or good, *** = very good). The species are ordered by decreasing body mass (largest to smallest). Passage type CWWC was not included because of low sample size (*n* = 1).

Species	Effectiveness of three types of wildlife passage		
	PC	WLC	CLC
North Am. beaver	*	**	*
Canada lynx	–	–	–
Raccoon	**	*	*
River otter	*	–	–
North Am. porcupine	*	–	*
Red fox	**	–	*
Fisher	–	–	–
Woodchuck	***	***	*
Striped skunk	***	–	*
Snowshoe hare	*	–	–
Common musk rat	**	*	–
Am. marten	–	–	–
Am. mink	***	***	***
Red squirrel	***	**	*
Weasel spp.	***	**	**
Northern flying squirrel	–	–	–
Eastern chipmunk	**	**	*
Micromammals	***	*	*
Overall effectiveness (on a scale of 0 to 10)	5.8	3.3	2.7

The pipe culverts (PC) are generally the most effective.

Objective 3: Permeability of the highway for American martens

A combination of VHF radiotelemetry, capture-mark-recapture, digital cameras in the wildlife passages, and genetic analysis was used. We used a 2-lane highway as a control site (HWY 381, Charlevoix). We captured 32 martens along HWY 175, of which only 16 could be collared (because of low body mass of the others), and 20 along HWY 381, of which we could collar only 12. We calculated the genetic relatedness among 29 of the individuals that we caught in the vicinity of HWY 175 and among 20 individuals in the vicinity of HWY 381 in order to test if the highways are acting as barriers to gene flow.

After three-years of study (2013-2015), between 7% and 27% of our radio-collared martens had crossed HWY 175. This interval is a result of a total of four different martens getting to the opposite side of the highway, but we are certain for only one marten that it crossed the road by its own means. In contrast, the percentage of martens crossing HWY 381 was much higher (55%). Our results indicate that martens are able to cross the mitigated 4-lane highway, but do so less often than martens along the 2-lane highway that served as a control site. The findings suggest that the 4-lane highway is a stronger barrier than the 2-lane highway even though it is mitigated by wildlife passages, while the 2-lane highway is not mitigated. In accordance with these results, the genetic analysis detected a negative relationship between genetic relatedness and presence of the road, indicating that gene flow may be reduced at the 4-lane highway, but not at the 2-lane highway.

In addition, martens along the 2-lane HWY 381 use the regular drainage culverts, which have been in place for more than 25 years, long enough for habituation. In order to be able to answer the question if habituation will occur along HWY 175, long-term monitoring is necessary.

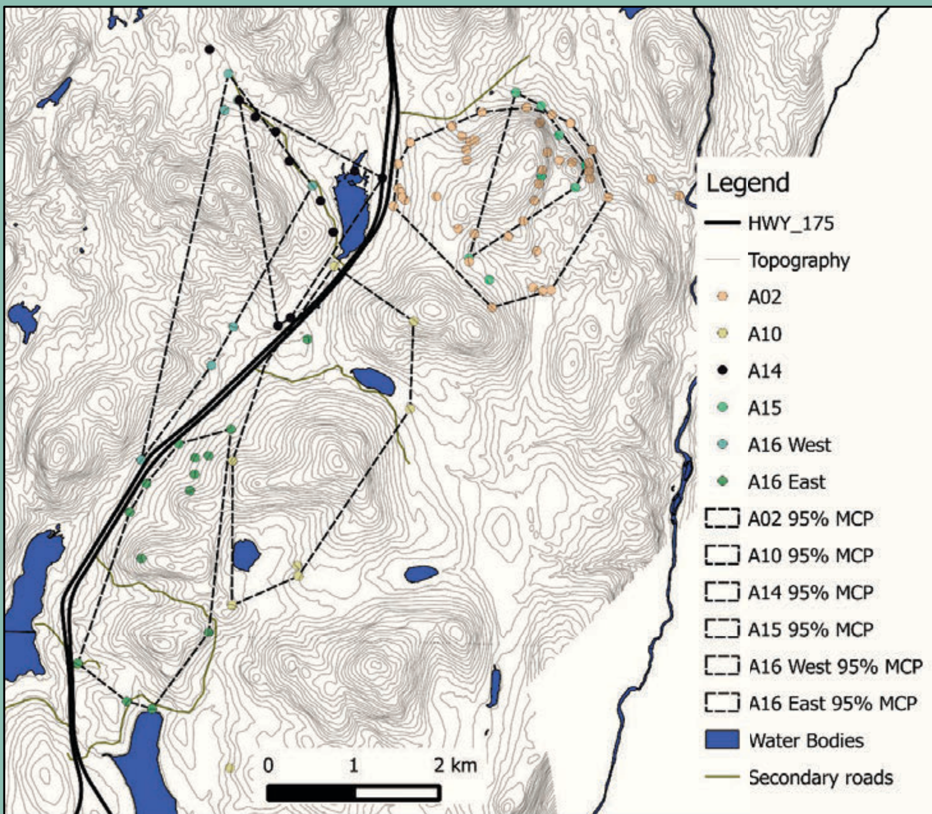


Figure 8: Marten home ranges along HWY 175 with data of martens whose locations were obtained between July 2014 and July 2015. Points represent estimated locations of martens; dotted black lines represent the minimum convex polygons (MCP) using 95% of the points (map prepared by J. Gaitan).

Recommendations

Based on the results, we provide 16 recommendations, 9 of which relate to possible improvements of road mitigation measures and 7 relate to monitoring and research. Some of them include (for the complete list see the final report):

- Use of a variety of types of wildlife passages and exploration of some new passage types for porcupines, red foxes, river otters, snowshoe hares, American martens, fishers and Canada lynx is recommended.
- Box culverts with a concrete ledge seem to be less effective than the pipe culverts and box culverts with a wooden ledge. For example, the average number of complete crossings per passageway was 183.3 individuals for PC-type passages, followed by 139.5 individuals for WLC-type passages, and the lowest was recorded for CLC-type passages with 27.6 individuals. Adding sheets of wood onto the concrete surface of their ledges could improve their performance.
- Passageways should preferably be constructed without an opening in the median.
- Increasing the vegetation cover between the forest and the entrances of the passageways is recommended, while forest removal should be avoided in the sections in which wildlife passages will be installed.

Photo 8: American marten using a regular drainage culvert along HWY 381.

- Addition of wildlife passages (with fences) at mortality hotspots and at locations where vegetation is close to the road should be considered, e.g., when a regular drainage culverts is repaired or replaced, this is a good opportunity for transforming it into a wildlife passage.
- We recommend establishing norms and standards for road mitigation in Quebec.
- Good maintenance of the current fences is recommended.
- New wildlife passages should be combined with fences much longer than 100 m on either side.
- Fencing of road sections with mortality hotspots and the extension of existing fences to the next drainage culverts should be considered.
- Improvements in fence design would be useful, e.g., to address the fence-end effect.
- A study about the influence of the length of the fences on mortality at fence-ends would be desirable. Fences should be long enough that the increased road-kill numbers at the fence-ends (due to the displacement of crossing attempts of the animals) are compensated by sufficiently long fenced sections of the road in which road-kill numbers are low.
- Continued monitoring of the use of the existing wildlife passages can determine if more species habituate to the passages.
- Monitoring of the use of regular drainage culverts would be highly useful to determine if they could perhaps be as effective as wildlife passages if some fencing for medium-sized fauna were added.

Making good use of the large research potential of HWY 175 can make an important contribution to improved knowledge about the effectiveness of road mitigation. HWY 175 is particularly suitable for such research for several reasons, e.g., our study provides 4 years of baseline data about small and medium-sized mammals, which is a rare opportunity, and because the high numbers of animals being killed on HWY 175 result in larger sample sizes and in faster detection of the wildlife responses to modifications to the mitigation measures than in areas with lower wildlife mortality.

Conclusion

The implementation of 33 wildlife passages for small and medium-sized fauna along HWY 175 represents an important step in the right direction. The results of this study demonstrate **a major success for the existing wildlife passages along HWY 175**.

Driver safety is also an important consideration for small and medium-sized mammals. Estimates of human injuries and vehicle damages from accidents with small animals have recently become available in Maine: The Maine Department of Transportation reported 621 crashes involving animals *other* than deer, moose, bear and turkey between 2010 and 2014. The economic loss of those crashes was estimated at $ 7.4 million. Thirteen of those crashes resulted in an incapacitating injury and 25 in a non-incapacitating injury (Maine is 7% the size of Quebec and has only 1.33 million inhabitants).

Road mitigation is also a matter of halting biodiversity decline (as required by the internationally defined Aichi biodiversity targets set by the Convention on Biological Diversity, CBD) and of ensuring long-term maintenance of ecosystem services. Measures for road mitigation can be implemented effectively only if there is an awareness of the issue. Decision-makers and the general public alike should, therefore, be made more aware of the short-term and long-term ecological effects of roads and need to be informed about suitable mitigation measures.

Many road agencies have "environmental sustainability" as one of their goals and the only way to achieve such goal is to establish collaborative links between transportation agencies and ecologists and to support long-term and credible scientific research (van der Ree et al. 2011).

More information can be found here:

Final report of this project: ***Suivi de l'utilisation et de l'efficacité des passages à faune le long de la route 175 pour les petits et moyens mammifères. Projet R709.1.*** Rapport final pour le ministère des Transports, de la Mobilité durable et de l'Électrification des transports du Québec. Concordia University, Montréal. October 2017. 494 pp. Available online on the website of the Centre Documentation of the MTMDET at http://www.bv.transports.gouv.qc.ca/mono/1202547.pdf

Please contact Dr. J. Jaeger for an English copy.

Bélanger-Smith K (2015): Evaluating the effects of wildlife exclusion fencing on road mortality for medium-sized and small mammals along Quebec's Route 175. MSc thesis. Concordia University, Department of Biology. Available online at spectrum.library.concordia.ca/979605/

Fahrig L, Rytwinski T (2009): Effects of roads on animal abundance: An empirical review and synthesis. *Ecology and Society* 14(1): 21.

Martinig AR, Bélanger-Smith K (2016): Factors influencing the discovery and use of wildlife passages for small fauna. *J. Appl. Ecol.* 53: 825-836.

Plante J (2016): Caractérisation des lieux de mortalité de la faune de petite et moyenne taille le long de la route 175, Québec. MSc thesis. Concordia University, Department of Geography, Planning and Environment. Available online at spectrum.library.concordia.ca/981532/

Plante J, Jaeger JAG, Desrochers A: How do landscape context, fences, and wildlife passages influence roadkill locations of small and medium-sized mammals? (*article submitted*)

Rytwinski T, Fahrig L (2015): The impact of roads and traffic on terrestrial animal populations. In: van der Ree et al.: *Handbook of Road Ecology*. pp. 237-246.

Rytwinski T, Soanes K, Jaeger JAG, Fahrig L, Findlay CS, Houlahan J, van der Ree R, van der Grift EA (2016): How effective is road mitigation at reducing road-kill? A meta-analysis. *PLoS ONE* 11(11): e0166941.

van der Ree R, Jaeger JAG, van der Grift EA, Clevenger AP (2011): Effects of roads and traffic on wildlife populations and landscape function: Road ecology is moving towards larger scales. *Ecology and Society* 16(1): 48.

van der Ree R, Smith DJ, Grilo C (eds.) (2015): *Handbook of Road Ecology*. John Wiley & Sons, Oxford.

Acknowledgements

Members of the project team and partners:
To put this project into place, the Ministère des Transports, de la Mobilité durable et de l'Électrification des transports du Québec (MTMDET) brought together a team of scientific researchers. Over the years, the team included: **Dr. Jochen Jaeger**, Concordia University; **Katrina Bélanger-Smith**, **Judith Plante**, and **April Martinig**, MSc students at Concordia University; **Dr. André Desrochers**, Laval University, Québec; **Rodrigo Lima**, **Robby Marrotte**, and **Jorge Gaitan-Camacho**, research associates at Concordia University; **Dr. Marianne Cheveau**, researcher at the Ministère des Forêts, de la Faune et des Parcs du Québec; **Carlos Zambrano**, **Evan Hovington**, and **Sarah Sherman Quirion**, field technicians; Mary-Helen Paspaliaris, Honor's student at Concordia University; **Dr. Anthony P. Clevenger,** WTI at Montana State University; **Dr. Jeff Bowman**, Ontario Ministry of Natural Resources and Trent University, Peterborough; and various research assistants: **Sandra Anastasio**, **Kenzie Azmi**, **Tanya Barr**, **Lisa Bidinosti**, **Josephine Cheng**, **Carling Dewar**, **Melanie Down**, **Joey O'Connor**, **Sarah Courtemanche**, **Megan Chan**, **Bertrand Charry**, **Megan Deslauriers**, **Valérie Hayot-Sasson**, **Amy Jones**, **Lasoi Ketere**, **Stephen Macfarlane**, **Rochelle Methot**, **Gregor Pachmann**, **Mary-Helen Paspaliaris**, **Dylan Robinson**, **Ariel Spanowicz**, and **Simon Tapper**.

The researchers have been supported by the members of an **Enlarged Advisory Committee**. This committee has included representatives of the main groups and organizations affected by the project: **Martin Lafrance**, *chargé de projet* at the MTMDET; **Éric Alain**, **Michel Michaud**, **Julie Boucher**, and **Audrey Turcotte**, MTMDET; **Yves Bédard,** MTMDET (now retired); **Héloïse Bastien**, **Dr. Pierre Blanchette,** and **Jean-François Dumont**, Ministère des Forêts, de la Faune et des Parcs du Québec; **Yves Leblanc**, AECOM Consultants Inc.; **Sylvain Boucher**, Réserve faunique des Laurentides, Sépaq; **Jean-Emmanuel Arsenault**, **Benoit Dubeau** and **Mathieu Brunet**, Parc national de la Jacques-Cartier, Sépaq; **Amélie D'Astous**, Huron-Wendat Nation; **Louis Desrosiers**, Ville de Stoneham; **André Rouleau**, Parcs nationaux des Hautes-Gorges-de-la-Rivière-Malbaie et des Grands-Jardins; **Hugues Sansregret**, Forêt Montmorency.

We also are very grateful to the Patrouille Secours and Sûreté du Québec in the RFL, the Camp Mercier, the Association régionale des trappeurs Laurentiens, the Association forestière des deux rives (AF2R), the Zec des Martres and various trappers for their support. We thank the Ministère des Transports, de la Mobilité durable et de l'Électrification des transports du Québec (MTMDET) for funding of this research project (2012 – 2017).

PRIMARY CONTACT: jochen.jaeger@concordia.ca, (514) 848 2424 ext. 5481.

You can find more information about this project in our previous 7 news bulletins:
No 1: https://spectrum.library.concordia.ca/980322/
No 2: https://spectrum.library.concordia.ca/980320/
No 3: https://spectrum.library.concordia.ca/980318/
No 4: https://spectrum.library.concordia.ca/981336/
No 5: https://spectrum.library.concordia.ca/980317/
No 6: https://spectrum.library.concordia.ca/980314/
No 7: https://spectrum.library.concordia.ca/981301/
and the final report: http://www.bv.transports.gouv.qc.ca/mono/1202547.pdf

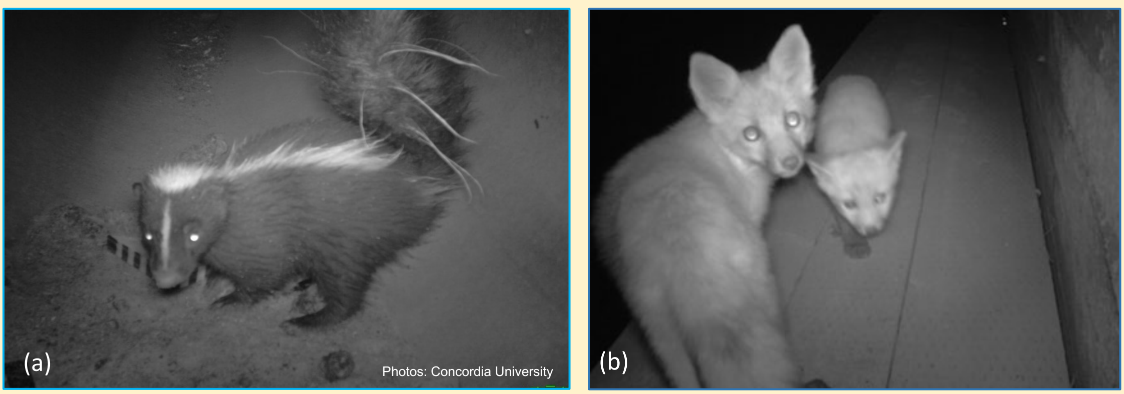


Photo 9: Animals using the wildlife passages along HWY 175, (a) striped skunk, (b) red fox with its young.