Effectiveness of wildlife mitigation measures for large- to mid-sized animals on Highway 69 in Northeastern Ontario

September 2011 to September 2016

Summary Report

April 2017
**Acknowledgements:**
This report was compiled and written by Kari Gunson and submitted to Andrew Healy, Ontario Ministry of Transportation (MTO) Northeastern Region Office as partial fulfillment of a retainer assignment number 5013-E-0028. The field work was completed as a collaborative effort between Laurentian University and Cambrian College in the first two years of monitoring. Special thank-you to Keith Munro, Dr. David Lesbarreres, Dr. Josef Hamr, and D. McGeachy that have provided insight for study design and analysis throughout the monitoring period. Andrew Healy secured funding, managed progress meetings, provided technical information, invaluable review comments, and helped facilitate many logistical components of this project.

At the time of writing, The MTO has confirmed an additional three years of funding for effectiveness monitoring on Highway 69 commencing in October 2016. After completion, monitoring data will be compiled over an eight year time period in September 2019.

**The report should be cited as:**

**Picture Contributions:**
Kari Gunson, Wes Kowbasniuk, Jessica Fortin, Andrew Healy

**Field and Technical Support:**
Wes Kowbasniuk, Eco-Kare International
William Carrigan, Eco-Kare International
Keith Munro, Eco-Kare International
Kelly Boadway, Eco-Kare International
Jessica Fortin, Eco-Kare International
David McGeachy, Eco-Kare International
Sean Boyle, Laurentian University
Vincent Billy, Laurentian University
Kaitlyn Read, Cambrian College

**Report Reviewers:**
Andrew Healy, Environmental Planner, Northeastern Region, Ministry of Transportation
# Table of Contents

1 Summary ........................................................................................................................................... 1

2 Background Information .................................................................................................................. 4

3 Study Area ...................................................................................................................................... 7
   3.1 Road upgrade timeline .............................................................................................................. 7

4 Wildlife Monitoring Overview ....................................................................................................... 10
   4.1 Data collection .......................................................................................................................... 10

5 Wildlife Crossing Structures .......................................................................................................... 14
   5.1 What animals use the structures? ............................................................................................. 14
   5.2 What animals use the wildlife overpass? .................................................................................... 15
   5.3 What wildlife use underpasses? ................................................................................................ 19
      5.3.1 Large box culvert ................................................................................................................ 19
      5.3.2 Reptile tunnels ..................................................................................................................... 22
   5.4 What wildlife use creek bridge pathways? .................................................................................. 26
      5.4.1 Lovering Creek bridge ....................................................................................................... 26
      5.4.2 Murdock River crossing ..................................................................................................... 29
   5.5 What structure do wildlife prefer? ............................................................................................. 31
   5.6 Are there seasonal wildlife patterns of use? .............................................................................. 35
   5.7 Are there sex- and age-related wildlife patterns of use .............................................................. 38

6 Do One-way Gates Work? .............................................................................................................. 40

7 Ungulate Guards ............................................................................................................................. 43

8 Overall Effectiveness ...................................................................................................................... 46
   8.1 How often are wildlife on the roadside of the fence? ............................................................... 46
   8.2 Is there a reduction in wildlife-vehicle collisions? ................................................................. 49

9 References ....................................................................................................................................... 51

Appendix A Acronyms ....................................................................................................................... 52
List of Tables

Table 1: Overview of camera monitoring and research objectives on Highway 69 and Highway 11 intended for this report and for future summaries................................................................. 9

Table 2. Definition of interaction terms used to describe wildlife response to mitigation measures using cameras for effectiveness monitoring......................................................... 11

Table 3: A summary of passage rates (use/use + repel) at the wildlife crossing structures on Highway 69 (below). .......................................................................................................... 32

Table 4: A summary of wildlife-vehicle collisions from 2003 to 2015 before and after large animal fencing was installed........................................................................................................ 50

List of Figures

Figure 1. Study area illustrating location of wildlife crossing structures and fencing on Highway 69 ............................................................................................................................................. 8

Figure 2: Number of animal use and repels at overpass (Sep 2012 – Sep 2016).................... 17

Figure 3: Frequency of independent animal observations on overpass and at adjacent access road.............................................................................................................................................. 17

Figure 4: Summary of large and mid-size animal use and repels at wildlife underpass. ........ 20

Figure 5: Frequency of independent animal observations at underpass and at adjacent access road............................................................................................................................................. 20

Figure 6: Summary of large and mid-size animal use at reptile tunnels. .............................. 23

Figure 7: Summary of large and mid-size animal use at Lovering Creek bridge pathway. .... 27

Figure 8: Passage rate comparison on overpass and underpass (above).................................. 32

Figure 9: Summary of seasonal use of large and mid-size animal at overpass. ....................... 36

Figure 10: Proportion of female and male deer at overpass and underpass............................ 39

Figure 11: Number of animal passages through one-way gate.............................................. 41
List of Videos

In addition to the compilation of bar charts, pictures and summaries found in this report, there is a compilation of videos on the Eco-Kare website (https://eco-kare.com/wildlife-monitoring/).

The videos are also available on YouTube at the following links:

- ‘Monitoring the wildlife overpass’ https://youtu.be/egE0thbEv5s
- ‘Monitoring the wildlife underpass’ https://youtu.be/khggFxFlBGc
- ‘Monitoring the one-way gates’ https://youtu.be/IFG0U93WzFw
- ‘Monitoring the ungulate guards’ https://youtu.be/KJ1McMH6hY
- ‘Monitoring overview and conclusions’ https://youtu.be/sz1eZ1Du1L8
1 Summary

This report documents the methods, results, and conclusions from five years of monitoring (September 2011 to September 2016) mitigation measures on Highway 69 (south of Sudbury and north of Parry Sound) in Ontario, Canada. The mitigation measures include one wildlife overpass, one wildlife underpass, two creek bridge pathways, three reptile tunnels, 16 km (32 km both sides) of wildlife fencing, 27 one-way gates, and 2 ungulate guards. Monitoring data was collected for one year prior to and four years after mitigation measures were completed on a 10 km section of highway that was expanded from two lanes to four lanes. The four lane expansion consisted of 6 km of new alignment and 4 km of twinning the existing highway. Monitoring methods entailed using snow tracking and motion activated cameras to evaluate effectiveness of mitigation measures for large animals: White-tailed deer, elk, moose, Black bear, wolves, and mid-sized animals: Canada lynx, coyote, and Red fox.

A total of 1,863 independent wildlife interactions were recorded at all the crossing structures in the study area. All the target species above other than lynx and elk have been documented using the 30 m wide overpass much more than any of the other structures. Although animals prefer the overpass, all structures combined provide a cost-effective, multi-species mitigation system. With the exception of one creek bridge pathway, crossing structures were placed on a new highway alignment that bisects a wide diversity of habitats including river gorges, wetlands, and terrestrial forests that provide safe crossing opportunities for a diversity of large and small animals.

The use of multiple cameras at each entrance and middle of each structure allowed passage rates to be evaluated (cross/ cross + repels). Passage rates are informative measures because they do not depend on animal abundance at each crossing structure, allowing comparisons between structures and species. Passage rates were as high as 95% for all animals using the overpass. Black bear passage rates were similar at all structures. Deer and Moose were repelled from the underpass about 40% of the time, and repels consistently decreased over the 4 year post construction monitoring period. Collectively, all animals repelled approximately 60% of the time at the reptile tunnels and the underpass. Passage rates were high at the creek bridge pathways at both Murdock River and Lovering Creek bridge. Monitoring at Murdock River and Lovering Creek crossing is challenging because full camera coverage is difficult with 2 to 4 cameras due to large open area and rugged terrain associated with the drainage corridors.

Deer used the overpass 1028 times and preferred passage in the summer and fall, and moose used the structure 127 times and mostly in the spring. When comparing the sex ratios (based on seasonal visibility of antlers) of moose and deer using the overpass to those surrounding the overpass, more male deer were observed than expected. These patterns are likely due to the rut.
when white-tail deer bucks are more active and less cautious than usual. Moose likely used the structure more in the spring due to increased movements in search of salt and other aquatic vegetation after a nutrient low winter diet.

Of the large animals, deer and Black bear are able to breach the exclusionary fencing regularly. Deer are going around fence ends, and Black bear are able to enter the highway right-of-way at ungulate guards, one-way gates, fence-ends, and are able to go under the fence. Moose seldom breach the fence.

To assess whether the underpass, overpass and associated fencing were working, the number of animals by species captured from snow-tracking and camera observations were compared between each structure and its associated access road. Observations were summarized when all cameras were functional (March 2013 to September 2016). Animal frequency by species was counted from both snow tracking observations and each of two monitoring cameras on each access road and at each structure. The overpass had six and the underpass had three cameras operational and only data captured from one camera at each of the east and west approach were used. To avoid duplicate counts an animal of the same species on the same day was counted as one observation.

Moose and deer were observed significantly more at the overpass than the surrounding access road. Deer were significantly observed less at the underpass than the surrounding access road. Moose use the underpass as expected and Black bear use both the overpass and underpass as expected. These findings suggest that deer are actively using the overpass and have integrated the structure to facilitate movement and to feed within their home range. Further, the underpass is providing additional opportunity for large animals primarily moose and bears and less so deer as they prefer the overpass.

An evaluation of wildlife-vehicle collision data (Ontario Provincial Police, unpublished data 2003-2015) has shown an overall 71% reduction of wildlife-vehicle collisions for deer, moose and Black bear. When examining the highway maintenance patrol carcass records, research observations, and the OPP collision data by species, collisions with deer and moose have decreased the most while collisions with Black bear have slightly increased.

Application of lessons learned in an adaptive management approach would increase effectiveness of this mitigation system and others. The following modifications could increase the system’s effectiveness:

- Large animal fencing should be buried into the ground to inhibit animals from going under the fence;
- Modify one-way gate structure placement inwards from fence, and increase the number and/or spacing of curved prongs so black bears cannot squeeze through;
- It is also recommended to research and test alternative designs for ungulate guards that deter animals from walking across and deer jumping;
- Electro-mats may also be considered as an option at road interchanges and other fence gaps;
- Improved fence end treatments that include fence extensions away from highway, or creation of rock boulder fields that tie-into rocky steep road embankments.
2 Background Information

*Why are wildlife crossing structures needed?*

Wildlife move within home ranges to access food, mates and to successfully rear young. When a highway or road bisects these home ranges, animals may cross the road. These wildlife movements can be specific, for example deer moving from summer foraging areas to overwintering areas, or can be less specific and occur throughout the active season. For example, sometimes animals wander onto roads to feed at road-sides and/or in the median. When both an animal and a vehicle are on the road there is a potential safety hazard for both motorists and animals, especially when a collision involves large animals such as moose. Wildlife crossing structures allow animals too safely cross a road, the more opportunity for safe crossings the less likely that motorists and animals will collide.

*Where are wildlife crossing structures needed?*

Research has shown that animals tend to cross roads in the same locations. This is known from studies that compile information from snow-tracking, telemetry or even from where wildlife-vehicle collisions have occurred previously. The likely locations where animals cross roads are where good habitat exists on both sides and/or when the road bisects a wildlife movement corridor. Other factors to consider for placement of crossing structures are property ownership, existing topography, surrounding land-use, and suitability to install wildlife fencing on the highway.

In addition to above, research has shown that animals may be more willing to cross a highway through a crossing structure than on the highway itself (Dodd et al. 2012). This is because the traffic or the road poses a barrier and animals are unwilling to cross. The highway than fragments animal habitat and lessens the availability of resources, e.g. food and water for the animal. Research shows that after crossing structures are installed on an existing road animals learn to use crossing structures for safe passage across roads that were once barriers.

*What type of crossing structures do larger animals prefer?*

Large animals in the context of Highway 69 and this report are comprised of White-tailed deer (*Odocoileus virginianus*), moose (*Alces alces*), elk (*Cervus elaphus*), Eastern wolf (*Canis lycaon*), and Black bear (*Ursus americanus*). However, data for mid-sized animals such as Canada lynx (*Lynx Canadensis*), bobcat (*Lynx rufus*), coyote (*Canis latrans*), and Red fox (*Vulpes vulpes*) were also included for comparison.
Two types of crossing structures are used for large animals on highways: overpasses and underpasses. Overpasses are bridges that allow animals to move over the road, and underpasses are tunnels that allow animals to move under the road. Underpasses vary in size and structure and generally those that are more open are preferred by most animals except Black bears and cougars. Ungulates such as moose and White-tailed deer will use smaller more enclosed box structures (less than 5 m h x 5 m w) if that is what is available; however the length of the structure should be minimized, and frequency of use may be compromised at these small structures. This can sometimes be achieved by integrating an open median into 4 lane highways. Research has shown that wildlife overpasses work better for ungulates and some carnivores because they are more open; i.e. they are not bounded by a structure overtop.

**Why is wildlife fencing needed?**

Wildlife fencing is a key element for optimizing use of wildlife crossings. Wildlife fencing plays two roles. First, animals are excluded from the highway and Wildlife-Vehicle Collisions (WVCs) are reduced. Second, wildlife fencing funnels animals to wildlife crossing structures where they can safely cross the road. Research has shown that when both fencing and wildlife crossings are combined, they will reduce the barrier effect of the highway and decrease the number of Wildlife-vehicle Collisions (WVC).

Exclusion fencing does not usually span the entire road length and typically ranges in length from several kilometres to tens of kilometres. Short sections of fencing (about less than 3 km) can lead to a fence end issue where animals travel past the fence end and onto the road right-of-way (ROW) (Cserkész et al. 2013; Huijser et al. 2016) posing a higher risk of WVC.

**What are escape measures?**

Escape measures are used in combination with exclusion fencing. These measures are designed to allow wildlife to move one-way through the fence. In other words, when an animal has breached the fence, e.g. at fence ends, and are now on the roadside of the fence, movement back to the safeside (inside) of the fence is possible. For large animals, on Highway 69 one-way gates were implemented to address this issue.

**The fence end effect?**

Wildlife often travel along fences until they are able to move in their intended direction. The fence end effect is when animals follow the fence until the end and there is a higher probability of WVC within an identified distance of the fence end. At fence ends, there are several mechanisms used to deter animals from moving onto the road or along the ROW. Supplementary measures such as rock piles or rock fields, or perpendicular fence extensions away from the road.
can deter animal movement onto the road. Fence tie-ins are also often used. Tie-ins, strategically place fence-ends at rock cliffs, or steep highway cliffs which are difficult for animals to navigate.

When roads intersect other roads, there is a break in the wildlife fencing. Ungulate guards, also known as Texas gates (further described in this report), are often used at road intersections to deter animals from moving through the fence gap and accessing roads with high traffic volumes. Ungulate guards are typically only used on low-volume roads.

None of these solutions are designed for all species and some solutions work better in a specific situation than others. Steep inclines have proven to be effective for keeping moose off the Highway 69 ROW (Eco-Kare International 2014). However some animals, e.g. deer, will navigate fence-ends tied into moderate inclines. Other animals like wolves and Black bear will walk over ungulate guards, and deer may jump over the gate. Canada lynx, Black bear and smaller animals will use the one-way gates the wrong way. In all circumstances the animals are now on the roadside of the fence and pose a safety risk to motorists (Eco-Kare International 2014). The goal is to assemble all these measures together into an effective mitigation strategy that alleviates the occurrence of WVC and allows animals to safely move across the road.

The Ontario Ministry of Transportation, Northeastern Region initiated a monitoring project in September 2011 aimed at evaluating the effectiveness of a mitigation strategy on Highway 69 near Estaire, Ontario (Figure 1, Table 1). This report summarizes findings from this evaluation study looking at all mitigation measures separately then combining findings to determine overall effectiveness of the strategy.
3 Study Area

The study area is located in Northeastern Ontario, near the unincorporated town of Estaire approximately 40 km south of Sudbury on Highway 69. The landscape surrounding the highway is low human density and is characterized as a recreational cottage country region. The highway bisects large expanses of Canadian Shield rock cuts, extensive wetlands, and several river gorges. Weather in the area is characterized by warm and often hot summers and long, cold, winters with heavy snow fall. The uninhabited town of Burwash and unincorporated community of Estaire are the only formalized communities near the study site. Burwash is comprised of abandoned dwellings and much of the land is now used by the Department of Defence and the Ministry of Natural Resources and Forestry (MNRF). Annual average daily traffic volume (AADTV) along the highway is approximately 5,750 vehicles (MTO 2010).

3.1 Road upgrade timeline

On June 28th, 2005, it was officially confirmed that Highway 69 would be expanded to four lanes from Parry Sound north to Highway 17 in Sudbury. Construction began in 2005 on the segment extending southward from Sudbury to just south of Estaire (Nelson Road Interchange), and opened on November 12, 2009. In September 2011 (when this monitoring began), the next southern phase (approximately 10 km) was in construction which included twinning (3.2 km) and a new 4-lane alignment (6.8 km) east of the highway (Figure 1). This 10 km four-lane section of highway (Trout Lake road to Lovering Creek bridge) was opened to traffic in phases in the summer and fall of 2012. First, on June 6th, 2012 two lanes of traffic (now northbound lanes) were opened for vehicle use on the new alignment, diverting vehicles away from what is now termed old Highway 69 (Figure 1). Following this, on August 8th, 2012 all lanes of traffic on the new alignment and on the northerly twinned section were open for vehicle use (Figure 1). Wildlife mitigation measures constructed as part of this upgrading included four underpasses, one overpass, one Creek bridge pathway, and 10.5 km of fenced highway.

After this phase, highway expansion from 2 to 4 lanes continued south, and large animal mitigation measures were installed along Highway 69 up to Crooked Lake road. One additional wildlife crossing opportunity was created at Murdock River bridge where 8 m wildlife pathways were created north and south of the river. An additional 5.5 km of large animal fencing was installed. This section of highway expansion began in August 2012 and finished in September 2015. The study site is now comprised on one continuously fenced 16 km section of Highway 69 that spans from Trout Lake road to Crooked Lake road (Figure 1).
Figure 1. Study area illustrating location of wildlife crossing structures and fencing on Highway 69
Table 1: Overview of camera monitoring and research objectives on Highway 69 and Highway 11 intended for this report and for future summaries.

<table>
<thead>
<tr>
<th>Mitigation Measure</th>
<th>Monitoring Duration</th>
<th>Camera Monitoring Effort</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overpass</td>
<td>Sep 2011 to Sep 2016</td>
<td>Six cameras (two each bolted to wood posts at east, west approach and middle of structure).</td>
<td>30 m wide deck on rocky outcrop footings, with soil base for plantings; vegetation dense in summer.</td>
</tr>
<tr>
<td>Underpass</td>
<td>Sep 2011 to Sep 2016</td>
<td>One camera at each east and west approach and in middle of structure.</td>
<td>5 m x 5 m box culvert box culvert with open median (15.3 m) and wing walls at entrance.</td>
</tr>
<tr>
<td>Reptile Tunnel (Underpass)</td>
<td>Feb 2014 to Sep 2016</td>
<td>Four to six cameras placed at three reptile tunnels.</td>
<td>Three 2.4 m high x 3.4 m wide x 24.1 m long twinned with wing walls box culvert with open median; some water flow and pooling and growth of aquatic vegetation.</td>
</tr>
<tr>
<td>Lovering Creek bridge</td>
<td>Sep 2011 to Sep 2016</td>
<td>Two cameras placed at each entrance along 2 m wide wildlife ledge on north side.</td>
<td>Large open span bridge over creek valley; rocky trails along creek; 2 m ledge elevated up from creek on north side.</td>
</tr>
<tr>
<td>Murdock River bridge</td>
<td>Jan 2015 to Sep 2016</td>
<td>Four cameras placed at each SE, NE, SW, and NW abutment.</td>
<td>Large open span bridge over river valley; two 8 m wide gravel paths on north and south side for wildlife movement.</td>
</tr>
<tr>
<td>One-way Gate</td>
<td>Sep 2011-Sep 2016</td>
<td>Selected one-way gates monitored (12 during study period); Placed on fence on road-side.</td>
<td>One-way gates with spring loaded tines that are curved inwards for animal movement from roadside to safe side; tines only move one-way and spring back. 26 gates in total (14 on the east side, 10 on the west side, and two gates at Highway 637 and 69 interchange, and one gate at the Lovering Creek bridge.</td>
</tr>
<tr>
<td>Large Animal Exclusion Fencing</td>
<td>Sep 2011 to Sep 2016</td>
<td>Six cameras placed at northern fence end at Trout Lake Road, Nelson fence, and Killarney interchange fence-ends for 6 months to 1.5 years.</td>
<td>Approximately 32 km (both sides of highway) or 16 km fenced section from Trout Lake Road to Crooked Lake road completed in Sep 2012 and second phase completed in Jan 2016; two 50 m fence gaps where highway is raised with steep roadside inclines; wildlife fencing is not buried with an apron; no outrigger fence extension at top.</td>
</tr>
<tr>
<td>Ungulate Guards</td>
<td>Oct 2013, to July 2015</td>
<td>Two ungulate guards (aka Texas gates) used at north and south Highway 637 and Burwash road intersections</td>
<td>9 m wide, 4.5 m span along the road, bars are 14 cm apart.</td>
</tr>
</tbody>
</table>
4 Wildlife Monitoring Overview

Monitoring the interactions of large animals with mitigation measures (Table 1) was completed using two methods. The primary method for data collection was the use of 24 to 31 motion triggered infrared cameras placed at mitigation measures throughout the study area. Approximately one time per month the picture data was obtained, the battery level was checked, and the cameras were either realigned or moved to an improved monitoring site. In addition to camera monitoring, snow-tracking was also used to supplement information about animal behaviour in relation to mitigation measures.

4.1 Data collection

Data was collected approximately one time per month, or 56 times, from 24 to 31 camera monitoring locations during the period from September 2011 to September 2016 (Photo 5; Photo 6). All picture data was processed using picture processing software and each independent wildlife interaction was entered into an Excel spreadsheet database. Interactions were assigned a unique Action code (Table 2) for all fence ends, one-way gates, jump-outs, crossing structures and ungulate guards. A wildlife interaction was independent if it occurred more than five minutes from the previous interaction in a picture series. Cameras placed at one-way gates were also used to measure presence of wildlife on the roadside of the fence, e.g. fence breach and was used to supplement interpretation of mitigation effectiveness.

All wildlife interactions at mitigation measures are summarized for the time period between July 1st, 2012 (when the new alignment was opened to traffic) and September 9th, 2016. On June 30th, 2012, Highway 69 was open to traffic and the majority of crossing structures and wildlife fencing abutted all crossing structures. All gaps in wildlife fencing were closed by November 2012. Each mitigation measure is summarized independently with pictures, a corresponding video and description included in each relevant section.

In addition to camera monitoring, any tracks in snow and dirt that were found during routine snow tracking and camera data acquisition surveys were recorded for all large animals that interacted with the mitigation measures (Table 2; Photo 2; Photo 3; Photo 4). Similar to the camera data, an interaction or wildlife use of a structure from species-specific tracks in sand or snow, pellets and scat, or live wildlife sightings was assessed by assigning an action code (Table 2). In addition, all animal movements from snow surveys were cross referenced with the camera data to avoid duplication of information.
Table 2. Definition of interaction terms used to describe wildlife response to mitigation measures using cameras for effectiveness monitoring.

<table>
<thead>
<tr>
<th>Interaction Type</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Crossing Structures and Ungulate Guards</strong></td>
<td></td>
</tr>
<tr>
<td>Cross</td>
<td>Individual is documented as travelling across the structure (caught on 2 cameras, or caught on a middle camera only) and is not documented turning around. For guards, animal crosses structure.</td>
</tr>
<tr>
<td>Approach</td>
<td>Individual is captured on only one approach camera (a camera at one end of the structure or the other) clearly moving towards or away from structure.</td>
</tr>
<tr>
<td>Repel</td>
<td>Individual about to enter/use the structure but abruptly turns around moving away from structure. For guards, animal approaches and turns around.</td>
</tr>
<tr>
<td><strong>One-Way Gate</strong></td>
<td></td>
</tr>
<tr>
<td>Through</td>
<td>Individual goes through the gate. Usually from the roadside to the safeside of the fence (as intended), but occasionally the reverse, especially for smaller- to mid-sized animals.</td>
</tr>
<tr>
<td>Approach</td>
<td>Individual looks at the gate or deviates from path to inspect the structure, but doesn't use it and continues on same path. May approach from either side of the gate.</td>
</tr>
<tr>
<td>Look</td>
<td>Similar to approach but biased because occurs at night and individual changes direction to look at infrared illumination from camera.</td>
</tr>
<tr>
<td>Repel</td>
<td>Individual looks like it is about to travel through the gate, but turns back quickly and does not go through.</td>
</tr>
<tr>
<td>Ignore</td>
<td>Individual seen on camera, but no deviation from path or movement behaviour when moving by gate. Often grazing.</td>
</tr>
<tr>
<td><strong>Fence</strong></td>
<td></td>
</tr>
<tr>
<td>Roadside</td>
<td>Fence intrusion, e.g., individual present on the roadside of the wildlife fence.</td>
</tr>
<tr>
<td>Safeside</td>
<td>Individual present on the safeside of the wildlife fence.</td>
</tr>
</tbody>
</table>
Photo 1: Lynx tracks found on side of Highway 69 in fresh snow

Photo 2: Wolf and deer tracks in Reptile Tunnel

Photo 3: Elk track on new Highway Alignment

Photo 4: Black bear track in mud near Underpass
| Photo 5: Camera on tree on Overpass Access road | Photo 6: Camera on fence monitoring animal movement along fence and one-way gate |
5 Wildlife Crossing Structures

5.1 What animals use the structures?

A total of 1,242,400 pictures were processed from cameras that captured data for 46,566 monitoring days on Highway 69. Of these 87,106 or 7.0% were pictures of animals, and 5,080 independent wildlife interactions with mitigation measures were recorded.

Camera monitoring targeted large animals by positioning cameras at approximately adult deer height (~1.3 m high) at the structures (Figure 8 right). However, the cameras were still able to capture small mammals 13% of the time and birds 1% of the time at the crossing structures. Small animal species included fishers, weasels, beavers, raccoons, groundhogs, skunks, squirrels, chipmunks, mink, otter, turtles and muskrats. Bird species included Wild turkey, American bittern, Great blue heron, Canadian geese, and Mallard ducks.
5.2 What animals use the wildlife overpass?

Structure Type: 30 m wide level bridge with ~ 2 m high concrete walls on both sides; deck placed on rocky outcrops; vegetation plantings completed in May 2012.

See https://youtu.be/egE0thbEv5s

Monitoring methods:

- Three posts installed at each east and west entrance and in middle of structure;
- Two cameras placed on each post for a total of six monitoring cameras;
- Two cameras placed on trees along adjacent access road at west side of structure, approximately 500 m apart;
- Independent counts of animals by species at access road compared to animals that are captured at the overpass as repel, cross, or approach on the two SW and SE approach cameras from March 2013 to September 2016;
- Independent counts at both the overpass and access road are defined as: an animal of the same species counted more than one time on the same day at one or both cameras was grouped into one observation;
- Snow tracking surveys completed approximately 8 times each of five winter seasons along access road and underpass from 2011 to 2016;
- Monitoring summarized for from July 1st 2012 to September 9th 2016 when new alignment was open for traffic.

Results and Conclusions (Figure 2; Figure 3; Photo 7 to Photo 14):

- Deer used the wildlife overpass 1028 times, comprising 69% of the total wildlife use on the overpass likely because they are feeding on-top of the structure;
- Other large animals that used the overpass were moose 127 times, followed by Black bear (114), Red fox (82), coyote(42) and wolves(15);
- All large animals (Red fox and larger) that were at the overpass crossed it 95% of the time;
- Small mammals were observed using the structure such as rabbits, raccoons, groundhog and porcupines; birds spotted on the structure include a Common Yellow-throat and Wild turkey;
- One Bobcat was observed prior to the highway opening for construction;
- All large animals have used the overpass, except for lynx that have been observed on the overpass access road two times (Figure 3) and elk whose home ranges do not overlap with the structure;
Fisher’s Exact Tests showed significantly more ungulates: deer (p<0.0001) and moose (p=0.018) were observed on the overpass than along the adjacent access road and Black bears were observed similarly at both locations;

Bears were observed more often at the access roads in 2013 and 2014, likely because the bears were denning close to the camera station which would likely bias the data.
Figure 2: Number of animal use and repels at overpass (Sep 2012 – Sep 2016)

Figure 3: Frequency of independent animal observations on overpass and at adjacent access road

Photo 7: Wildlife overpass both lane

Photo 8: Wildlife overpass SB lanes
Photo 9: Wolf approaching west side of overpass

Photo 10: Moose going onto west side of overpass

Photo 11: Wild turkey crossing overpass

Photo 12: Two bucks dueling ontop of overpass

Photo 13: Lynx on access road at overpass

Photo 14: Doe and fawn approaching overpass
5.3 What wildlife use underpasses?

5.3.1 Large box culvert

Structure Type: Two twinned concrete structures under the NB and SB lanes; each structure is 5 m wide x 5 m tall, x 24.1 m long and there is an open median; wing-walls at each entrance to structure. Grass seeded on clay substrate.

See https://youtu.be/khggFxFlBGc

Monitoring methods:

- Two cameras at each entrance and one camera in middle of structure;
- Two cameras placed on trees along adjacent access road at west side of structure, approximately 500 m apart;
- Independent counts of animals by species at access road compared to animals that are at the underpass as approaching, repelling or crossing at the east and west entrance cameras from March 2013 to September 2016;
- Independent counts at both the underpass and access road are defined as: an animal of the same species counted more than one time on the same day at one or both cameras was grouped into one observation;
- Snow tracking surveys completed approximately 8 times each of five winter seasons along access road and underpass from 2011 to 2016;
- Monitoring summarized from July 1st 2012 to September 9th 2016 when new alignment was open for traffic.

Results and Conclusions (Figure 3; Figure 4; Photos 16-23)

- Moose have used the underpass the most (48 times) followed by Deer (34), Red fox (12), Black bear (8) and Coyote (4);
- Wolves are the only animal that have been documented at the access road and have not used the underpass;
- Moose and Deer were repelled from the underpass almost as many times as they used the structure, crossing the structure 52% and 49% of the time; bears only repelled one time;
- Fisher’s Exact Tests showed deer were observed significantly fewer times at the underpass than at the access road (p=0.0001), moose were observed more times at the underpass, and black bear fewer times at the underpass than the access road but these relationships were not significant (p=0.45).
Figure 4: Summary of large and mid-size animal use and repels at wildlife underpass.

Figure 5: Frequency of independent animal observations at underpass and at adjacent access road.

Photo 15: Underpass entrance with wing-walls
Photo 16: Open median and fencing
Photo 17: Doe approaching underpass at west side

Photo 18: Fox with kill approaching underpass

Photo 19: Bear exiting underpass

Photo 20: Two moose entering underpass

Photo 21: Moose entering underpass

Photo 22: Moose turned around and exiting underpass
5.3.2 Reptile tunnels

Structure Type: Three twinned concrete structures under the NB and SB lanes; each structure is 3.4 m wide x 2.4 m high x 24.1 m long with open median and wing walls; water accumulation in spring and tapering off in late summer; any standing water freezes in tunnels in winter.

See https://youtu.be/khggFxFlBGc

Monitoring methods:

- One to two cameras at the entrance of each of the three tunnels; monitoring for large and mid-sized animals from January 2015 to September 2016, and snow tracking completed approximately 8 times each winter season from September 2011 to September 2016;
- Cameras placed approximately 1 m high or on-top of structure to target large animals;
- Concurrent reptile monitoring (cameras placed 30 cm from water level to obtain pictures of passing turtles): June to September in 2015 and 2016 (Eco-Kare International 2017);
- These tunnels were designed for smaller animals specifically the Blanding’s turtle (Emydoidea blandingii) that is Threatened in Ontario;

Results (Figure 6; Photo 23 to Photo 28):

- Tunnels are providing some connectivity for large animals: three Moose, two Deer, and one Wolf have used the tunnel over 1.5 years of monitoring;
- Coyote regularly use the structures (22 times) followed by Red fox (11 times);
- Overall large animals that approach the structure use it 67% of the time, deer have repelled 75% of the time and moose 50% of the time;
- Frequency of ungulate use at structures is low (5 observations) as compared to at the larger underpass (82 observations); passage rates may change with larger sample size;
- A diversity of other animals were captured using the tunnels; small mammals: weasels, beavers, martens, mink; reptiles: Snapping and Painted Turtles (Eco-Kare International 2017) and birds include American bittern, Great blue heron, geese and ducks.

Conclusions:

- The reptile tunnels are providing wildlife crossing opportunities for more than the intended animals-Blanding’s turtles;
- Smaller aquatic animals are using these structures the most because they are located where the highway bisects aquatic wetland habitat;
- Large animals likely don’t regularly use the structures due to a combination of factors such as size, icy substrate in winter months, and flooded conditions from spring to fall.
Figure 6: Summary of large and mid-size animal use at reptile tunnels.

Photo 23: Reptile Tunnel with water pooled and aquatic vegetation in median

Photo 24: Open median with fencing at Reptile Tunnel
Photo 25: Moose approaching reptile tunnel

Photo 26: Deer approaching reptile tunnel
Photo 27: Coyote approaching reptile tunnel

Photo 28: Least Bittern approaching reptile tunnel
5.4 What wildlife use creek bridge pathways?

5.4.1 Lovering Creek bridge

Structure Type: Two metre creek pathway constructed upwards from river gorge on north side under open bridge span; adjacent to rugged, rocky trails that follow east and west into the forest along the creek.

See https://youtu.be/BXpJvXf59rE

Monitoring methods:

- Two cameras at each entrance and one camera on access trail approaching wildlife pathway or ledge to document animal presence in vicinity of structure;
- Cameras do not necessarily capture all wildlife passage under structure, wildlife may cross out of sight from cameras along creek;
- Snow tracking completed approximately 8 times in each of five winter seasons from 2011 to 2016;
- Monitoring summarized from when highway was opened to traffic: July 1st 2012 to September 9th 2016.

Results (Photo 29-Photo 36) and Conclusions:

- Mid-sized mammals such as Red fox (26 times) and coyotes (23 times) are using this passage most frequently and rarely repell (Figure 7);
- Of the ungulates, deer have used the structure the most (9 times), and moose two times;
- Moose are not very abundant in and around the structure, and this is reflected in low use and passage rates;
- Black bears have used the structure 15 times and wolves 3 times and both species have not been observed turning around at the structure.
Figure 7: Summary of large and mid-size animal use at Lovering Creek bridge pathway.

Photo 29: Lovering creek ledge under NB lanes

Photo 30: 2 m wildlife ledge under SB lanes
Photo 31: Male moose approaching wildlife ledge from east side

Photo 32: Several deer approaching wildlife ledge from east side

Photo 33: Coyote approaching wildlife ledge from west side

Photo 34: Red fox exiting wildlife ledge at west side

Photo 35: Wolf exiting wildlife ledge at west side

Photo 36: Black bear entering structure, east side
5.4.2 Murdock River crossing

Structure Type: Eight metre wildlife pathway constructed on both the north and south side of river gorge under an open bridge span; pathway follows moderate terrain of river; substrate gravel path.

See https://youtu.be/BXpJvXf59rE

Monitoring methods:

● Four cameras at each of the four northeast, southeast, southwest, and northwest bridge abutments along wildlife pathway;
● Monitoring conducted from January 13th 2016 to September 9th 2016.

Results and Conclusions (Photo 37 to Photo 42):

● Two moose, 4 deer, 2 coyote, and 1 Red fox have used the structure in the first 9 months of monitoring; wolves were observed for the first time in January 2017;
● Preliminary monitoring has shown that no animals have repelled from the structure and a diversity of animals are crossing.
Photo 37: 8 m wide pathway at NW entrance

Photo 38: Wildlife crossing at Murdock River

Photo 39: Deer approaching bridge at NE side

Photo 40: Wolf crossing at southwest side

Photo 41: Moose exiting crossing at NW side

Photo 42: Coyote crossing at southwest side
5.5 What structure do wildlife prefer?

Monitoring methods:

● Wildlife use is defined as an animal that travels onto or into the structure (action code=cross and approach) and does not turn around;
● Passage rate is \( \frac{\text{use}}{\text{use} + \text{repel}} \);
● This index was used to compare what structure large and mid-sized animals preferred to use to cross under or over the highway;
● Monitoring summarized from July 1\text{st} 2012 to September 9\text{th} 2016 after the new alignment was opened to traffic on June 6\text{th} 2012 and large animal fencing abutted the crossing structures.

Results (Table 3; Photo 43-Photo 46)

● Wildlife use for all species is much higher at the overpass than at the other structures;
● Animals used the overpass 14 x more than the large underpass;
● The passage rate for all animals was 95% at the overpass as opposed to 57% at the underpass;
● Passage rates for moose and deer at the underpass increased from 42% to 58%, while passage rates declined from 100% to 90% at the overpass in four years of monitoring;
● There were very few repels at the overpass for all species (77 times or 5%) and when comparing species willingness to cross the structure Red fox, moose and deer crossed 95% of the time while coyotes only crossed 79% of the time;

Conclusions:

● Wildlife overpasses are the optimal crossing structure type for providing safe passage for all large and small animals over roads likely due to the increased openness, opportunity for vegetation growth, and less noise on-top of structure;
● Deer passage rate at the overpass likely decreased over time because more deer approached overpass to graze and then turned around to go back the way they came;
● Closed box underpass structures emit vibrations or noise from vehicle traffic within the structure which may disturb sensitive species;
● As the size (width, height) of an underpass decreases and length increases, use by ungulates generally decreases;
● Wildlife pathways with no barriers, integrated into riparian bridge structures, optimize wildlife crossing opportunities because water courses are natural wildlife corridors; All structure types combined provide a cost-effective multi-species strategy that optimizes implementation into the existing landscape bisected by the highway.
Figure 8: Passage rate comparison on overpass and underpass (above)

Table 3: A summary of passage rates (use/use + repel) at the wildlife crossing structures on Highway 69 (below).

<table>
<thead>
<tr>
<th>Structure</th>
<th>Openness Ratio (WxH/L)</th>
<th>Date Monitor</th>
<th>Moose</th>
<th>Deer</th>
<th>Black bear</th>
<th>Wolf</th>
<th>Coyote</th>
<th>Red fox</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overpass</td>
<td>NA</td>
<td>Jul 12 - Sep 16</td>
<td>0.95</td>
<td>0.96</td>
<td>0.94</td>
<td>0.88</td>
<td>0.79</td>
<td>0.95</td>
<td>0.95</td>
</tr>
<tr>
<td>Underpass</td>
<td>(5X5)/24=1.04 (open median)</td>
<td>Jul 12 - Sep 16</td>
<td>0.52</td>
<td>0.49</td>
<td>0.89</td>
<td>NA</td>
<td>1</td>
<td>1</td>
<td>0.57</td>
</tr>
<tr>
<td>Lovering Creek bridge</td>
<td>NA</td>
<td>Jul 12 - Sep 16</td>
<td>0.5</td>
<td>0.64</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0.93</td>
<td>0.90</td>
</tr>
<tr>
<td>All Reptile Tunnel</td>
<td>(3.3x2.8)/24=0.39 (open median)</td>
<td>Jan 15 - Sep 16</td>
<td>0.5</td>
<td>0.25</td>
<td>0.5</td>
<td>1</td>
<td>0.79</td>
<td>0.92</td>
<td>0.67</td>
</tr>
<tr>
<td>Murdock River bridge</td>
<td>NA</td>
<td>Jan 16 - Sep 16</td>
<td>1</td>
<td>1</td>
<td>NA</td>
<td>NA</td>
<td>1</td>
<td>1</td>
<td>1.00</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>0.76</td>
<td>0.92</td>
<td>0.91</td>
<td>0.90</td>
<td>0.86</td>
<td>0.95</td>
<td>0.89</td>
</tr>
</tbody>
</table>
Photo 43: Highway 69 wildlife overpass top view and adjacent forest
Photo 44: Aerial view of Underpass before highway was opened

Photo 45: Highway 69 wildlife ledge on north side of Lovering Creek bridge

Photo 46: Reptile tunnel being installed into new highway construction
5.6 Are there seasonal wildlife patterns of use?

Methods and Result (Figure 9, Photo 47 to Photo 55):

- Seasons were defined as summer (June, July, August); fall (September, October, November); winter (December, January, February); and spring (March, April, May) for all large- and mid-sized animals (Red fox not included) that used the overpass;
- Year 1 is defined from Sep-2012 to Aug-2013; Year 2=Sep-2013 to Aug-2014; Year 3=Sep-2014 to Aug-2015 and Year 4=Sep 2015 to Aug 2016;
- Animal use by species fluctuated greatly in the four years of monitoring except for use by deer, which decreased over the four years of monitoring;
- A summary of deer in the vicinity of the study area (access road and along fence) also showed a reduction in deer from 406 to 75 and this was extremely correlated (Pearson correlation coefficient = 0.93);
- Moose use was noticeably higher in the spring months in three of the four years;
- Contrary to moose, deer tend to use the overpass more in the summer and fall;
- Black bear used the overpass equally in the summer and fall for each year of monitoring;
- Wolves and coyote use both peaked at the same time in Year 3

Conclusions:

- A decline in deer use is attributed to changes in deer abundance and movement and not due to an unwillingness to use the structure;
- Moose have salt deficient winter diets and in the spring move to obtain salt from roadside ditches which may explain an increase in spring overpass use;
- Deer use is highest in the fall rut season, likely because male deer are more aggressive and moving more to mark territories, and to search for mates;
- Observations of wolves and coyotes are low on the overpass and this is similar to that seen at the other structures and adjacent areas of the new highway.
Figure 9: Summary of seasonal use of large and mid-size animal at overpass.

Photo 47: Winter landscape on overpass
Photo 48: Fall October colours on overpass
Photo 49: Two moose exiting overpass in winter
Photo 50: Deer enjoying summer meadow in June
Photo 51: Red fox leaving tracks on overpass
Photo 52: Young moose in June on overpass
Photo 53: Young moose in spring thaw
Photo 54: Wolf on overpass on Christmas Eve
5.7 Are there sex- and age-related wildlife patterns of use

Methods & Results (Figure 10; Photo 55 to Photo 58):

- Only the underpass and overpass were looked at because sample size was greatest;
- The number of times a juvenile moose (calf) or deer (fawn) was seen on the overpass and underpass with an adult was summarized;
- On 44 occasions, juvenile (fawn) deer were seen on the overpass with adult female deer (doe);
- On 12 occasions, juvenile (calf) moose were seen on the overpass with adult female moose (cow);
- On 9 occasions, fawns were seen using the underpass, and on 8 occasions calves were seen using the underpass with cows;
- Sex of ungulates (deer and moose) was defined for the fall and summer months when antlers are clearly visible (male), or not (female) in the pictures;
- Fisher’s Exact test was used to compare if the proportion of females and males using each structure was different than the proportion of females and males in surrounding areas (access roads, and along fence);
- Significantly more male deer and fewer female deer were observed on the overpass than were observed in surrounding areas;
- There was no sex-related differences for deer and moose that used the underpass.

Conclusions:

- Offspring that learn to use the overpass at an early age will likely use the crossing structures throughout their life-time;
- More male deer likely use the overpass in summer and fall months than expected because males move larger distances than females, and in the fall rut season are moving to find mates and defend territories.
Figure 10: Proportion of female and male deer at overpass and underpass

Photo 55: Male deer grazing on overpass in August

Photo 56: Cow moose entering underpass

Photo 57: Doe and fawn using overpass in winter

Photo 58: Bear and cubs on overpass
6 Do One-way Gates Work?

Structure Type: Curved prong gates along fence to allow animals one-way passage from the roadside to the safeside (26 installed in study site); some are placed in-line with fence, and other set-back with fence forming a V pattern to funnel animals to gate.

See https://youtu.be/IFG0U93WzFw

Methods:

- Fifteen different gates monitored, 6 monitored consistently during the study period;
- Snow tracking surveys completed approximately 8 times each of five winter seasons at one-way gates from 2011 to 2016;
- Monitoring summarized from September 2011 to September 2016;
- All animal records were defined as animal moving safeside to roadside (not as intended) and moving roadside to safeside (as intended);

Results (Figure 11.; Photo 59 to Photo 66):

- On Highway 69, animals passed through the one-way gates roadside to safeside as intended 26 times;
- 100% of all 4 deer passages were as intended, and 76% of all 13 bears captured moving through gates were as intended;
- 0% (2 total), 75% (4 total), and 50% (18 total), lynx, coyote and fox passages respectively were as intended;
- Small mammals (rabbits, raccoons, and groundhogs) have used the gates in both directions;
- Moose and elk have not used the structures.

Conclusions:

- One-way gates are working for deer (not travelling through the wrong-way) but need to be improved to facilitate passage;
- Gates need to be modified by constructing an outrigger fence extension perpendicular to the fence that will funnel animals into the gate;
- Similar to this idea, gates may be positioned in a V design so that animals moving along the fence are funneled into the gate;
- Prongs that are wider or are closer together may hinder wrong-way passage by bears, and other mid-size animals;
- Rigorous experimental research is needed that modify designs to evaluate effectiveness and retro-fits applied to the Highway 69 strategy.
Figure 11: Number of animal passages through one-way gate

Photo 59: One-way gate in-line with fence with fence

Photo 60: One-way gate set-back from fence.
Photo 61: Bear exploring one-way gate.

Photo 62: Lynx Using one-way gate not as intended safeside to roadside.

Photo 63: Bear using gate as intended.

Photo 64: Deer using gate set-back from fence.

Photo 65: Moose approaching gate roadside.

Photo 66: Deer using gate roadside to safeside.
7 Ungulate Guards

Structure Type: Similar to Texas gates, round bars 9 m wide along width of road, 4.5 m wide along length of road, and bars are 14 cm apart. The two guards are located at Murdock River road, south of Highway 637, and at Burwash road, north of Highway 637.

See https://youtu.be/KJ1McMHi6hY

Methods:

- Monitoring at two sites with one camera intermittently from Oct 2013, to July 2015;
- All animal records were defined as an animal crossing (breaching), or repelling from the gate.

Results (Photo 67 to Photo 74):

- Twenty-six animals were documented crossing or repelling from the guards;
- 14 Red fox, 1 deer (jumped), 2 wolves, 2 coyotes, 1 Black bear, and 1 lynx moved across the guard;
- The guards successfully repelled 1 deer, 2 wolves, and 2 coyotes;
- One elk crossed the guard but its legs fell through the bars;
- No moose have been detected at the guards

Conclusions:

- More animals were able to breach the guards than were repelled but the target animals are ungulates: one deer of two repelled; one elk fell through, and no moose were detected;
- Other research projects in Banff, Alberta (Clevenger & Barrueto 2014) and Montana (Huijser et al. 2016) have showed similar results and have recommended Electro-mats;
- Design modifications such as increasing the width between bars and/or lengthening the gate along the road may improve effectiveness;
- Rigorous research that manipulates the guard designs and monitors subsequent behaviour of ungulates is urgently needed to assess effectiveness of guards at road intersections and other fencing interruptions.

Photo 68: Width of bars on top of guard.

Photo 69: Deer jumping over ungulate guard.

Photo 70: Wolf turning away from guard.

Photo 71: Bear crossing guard

Photo 72: Elk falling between bars.
Photo 73: Lynx crossing guard.

Photo 74: Wolf crossing guard.
8 Overall Effectiveness

See https://youtu.be/szleZ1Du1L8

8.1 How often are wildlife on the roadside of the fence?

Objective: Evaluate how many animals are able to breach the fence system (observed roadside along fence).

Methods:

- Fifteen one-way gates were monitored with cameras that also monitored movement of animals along the fence;
- Snow tracking was also completed along highway transects with and without fencing before (1 year) and after (3 years) fencing was completed;
- Movement of animals at fence at one-way gate stations was also monitored with snow-tracking approximately 8 times each winter season;
- A fence breach was defined as all animals roadside of the fence, all animals that went around a fence end toward the highway, and all animals that went through the one-way gates the wrong way;
- Only one observation was counted for multiple individuals of the same species and for observations of the same species that occurred more than once on each day.

Results (Photo 75 to Photo 80):

- Deer breached the fence system 39 times and the majority of the breaches were near fence ends or gaps: 51% were near the Highway 637 and 69 interchange where a fence gap exists, and 36% near the northern fence gap at Trout Lake road;
- Black bear breached the fence system 22 times, followed by moose 2 times and coyote 2 times;
- A Before-After-Control-Impact (BACI) analysis with snow tracking data showed that significantly less moose and wolf were present on the mitigated highway, and significantly more deer were present on the mitigated highway (results are limited because only one year ‘before’ data).

Conclusions:

- Of the large animal species the fencing system works best at excluding moose from the mitigated section of highway;
● Black bear are able to go through one-way gates, and can easily go under the fence where it is not flush with the ground;
● Deer but not moose are able to navigate the steep rocky slope at Trout Lake road and all animals are able to navigate the fence end at the Highway 637 interchange;
● An extension of the fence northerly at Trout Lake road to Makynen road would improve animal breaches;
● A fencing retro-fit such as inward fence extension at the Highway 637 interchange or an electro mat system at the highway interchange would improve fence breaches at the south end.
Photo 75: Moose on the road-side of fence

Photo 76: Deer on the safeside of fence near Highway 637 interchange.

Photo 77: Black bear on roadside of fence

Photo 78: 3 deer walking roadside of fence near Trout Lake road.

Photo 79: Elk on safeside of fence

Photo 80: Wolf tracks going around fence end at Highway 637 interchange.
8.2 Is there a reduction in wildlife-vehicle collisions?

Objective: Evaluate how many animals are involved in a wildlife-vehicle collision (WVC) before and after mitigation was installed.

See https://youtu.be/szleZ1Du1L8

Methods:

- The Ontario Provincial Police (OPP) compile WVC data for reported vehicle accidents greater than $1,000 in property damage;
- Highway maintenance patrols also collect information about where wildlife carcasses are picked up along the highway;
- The research team also collected information about WVC when they were found on the highway from 2011 to 2016;
- These data sets were evaluated to assess whether fencing and crossing structures reduced the number of WVC.

Results (Photo 81-Photo 82):

- A BACI analysis showed that there was a significant reduction in WVC reported to the OPP, and a reduction in ungulate carcass pick-ups before and after fencing was installed;
- There was an increase in Black bear WVC after fencing was installed although this was not statistically significant; bears are able to go under the fence and breach one-way gates and ungulate guards;
- The research team found two deer- and five Black bear-vehicle collisions in the mitigated fenced section on the New Alignment after the fence was completed in October 2012;
- The two deer collisions were likely associated with the Killarney fence-end at the Highway 69 and 637 interchange;
- Overall, there was a 71% reduction in Black bear, Moose and Deer collisions after fencing and crossing structures were functional (Table 4, MTO unpublished data);
- A species-specific evaluation shows that deer and moose collisions were reduced by 87%, while Black bear increased by 25% (Table 4, MTO unpublished data);

Conclusions:

- Recommended retro-fits to the fence to exclude bears and in some cases deer from the ROW include a buried apron, elimination of fencing at gaps at steep sections of highway; angled top wires to deter climbing and additional fencing to close off one-way gates;
- Fence end retro-fits such as large boulders and inward fence extensions may reduce fence breaches by all wildlife onto the highway.
Table 4: A summary of wildlife-vehicle collisions from 2003 to 2015 before and after large animal fencing was installed

<table>
<thead>
<tr>
<th>Year</th>
<th>Moose</th>
<th>Deer</th>
<th>Black bear</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>7</td>
<td>3</td>
<td>1</td>
<td>11</td>
</tr>
<tr>
<td>2004</td>
<td>6</td>
<td>3</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>2005</td>
<td>12</td>
<td>3</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td>2006</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>2007</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>2008</td>
<td>7</td>
<td>3</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>2009</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>2010</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td>2011</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>2012</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>5</strong></td>
<td><strong>2.5</strong></td>
<td><strong>0.8</strong></td>
<td><strong>8.3</strong></td>
</tr>
</tbody>
</table>

**After Fencing**

<table>
<thead>
<tr>
<th>Year</th>
<th>Moose</th>
<th>Deer</th>
<th>Black bear</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2014</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>2015</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>0.7</strong></td>
<td><strong>0.3</strong></td>
<td><strong>1</strong></td>
<td><strong>2.3</strong></td>
</tr>
<tr>
<td><strong>Change</strong></td>
<td><strong>87% decrease</strong></td>
<td><strong>87% decrease</strong></td>
<td><strong>25% increase</strong></td>
<td><strong>71% decrease</strong></td>
</tr>
</tbody>
</table>

Data Source: Ministry of Transportation

Photo 81: Bear roadside of wildlife fencing

Photo 82: Wolf killed on highway 69 unfenced section.
9 References


## Appendix A Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AADTV</td>
<td>Annual Average Daily Traffic Volume</td>
</tr>
<tr>
<td>BACI</td>
<td>Before-After-Control-Impact</td>
</tr>
<tr>
<td>MNRF</td>
<td>Ministry of Natural Resources and Forestry</td>
</tr>
<tr>
<td>MTO</td>
<td>Ministry of Transportation</td>
</tr>
<tr>
<td>NER</td>
<td>Northeastern Region</td>
</tr>
<tr>
<td>OPP</td>
<td>Ontario Provincial Police</td>
</tr>
<tr>
<td>ROW</td>
<td>Right-of-Way</td>
</tr>
<tr>
<td>WVC</td>
<td>Wildlife-Vehicle Collision(s)</td>
</tr>
</tbody>
</table>