MONITORING EFFECTIVENESS OF ROAD WILDLIFE MITIGATION FOR LARGE ANIMALS IN ONTARIO, CANADA

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ABSTRACT

This presentation documents methods, results, and conclusions from 46 months of monitoring (September 2011 to July 2015) mitigation measures on Highway 69 in Ontario, Canada. Mitigation measures included one wildlife overpass, one wildlife underpass, one creek bridge pathway, three reptile tunnels, 10 km fencing, 27 one-way gates, and 2 ungulate guards. Monitoring data was collected for one year prior to and three years post mitigation completion on a new highway alignment and existing highway. Monitoring methods entailed using snow tracking and motion activated cameras to evaluate both mitigation measures as well as highway permeability for Deer, Elk, Moose, Black bear, Lynx, Coyote, and Wolves.

All the target species above other than Lynx and Elk, have been documented using the 30 m wide overpass more than the nearby (800 m away) underpass (5 m x 5 m twin structures). The use of multiple cameras at each entrance and middle of each structure allowed usage rates defined as passages / passages + repels to be assessed. Black bear usage rates were similar at all structures, and Deer and Moose often repelled from the underpass more than the overpass. Deer used the overpass most in the summer and fall and Moose used the structure the most in the spring, during dawn and dusk periods. When comparing sex ratios (with antlers) of Moose and Deer using the overpass to those surrounding the overpass, more male Deer used the structure than expected. Relative abundance indices showed more ungulates at the crossing structures than surrounding the structures and the reverse was true for carnivores. This indicates that crossings are more readily used by ungulates, and carnivores need more time to habituate to and use the structures.

Wildlife-vehicle collision (WVC) data collected during the study period by commuting researchers showed at least a 50% reduction in WVCs along WVCs along the fenced section. WVCs that did occur were Black bears and Deer, and no WVCs with Moose and Elk have occurred post fencing. Higher than average Black bear collisions occurred the last year of monitoring and this may be because the spring bear hunt was reinstated in 2014.

Three seasons of snow tracking data were used to compare large animal crossing rates and presence along roads with varying traffic volumes and highway configurations (Deer, Moose, Elk, Lynx and Wolf). Wildlife presence, crossing rates and number of crossings were greatest on access roads with no traffic volume and decreased with increasing traffic volume and number of lanes. Collectively, these results indicate that four-lane highways are barriers to wildlife and crossing structures and fencing can alleviate this impact.

Monitoring the Highway 69 mitigation in addition to adjacent Highway 11 (100 km east) mitigation is continuing through 2015 and 2016. Due to variation in mitigation design between the two highways (i.e. fence height, fence design such as buried apron, use of jump-outs and varying underpass size the two concurrent monitoring projects will help provide recommendations on the most effective and efficient mitigation design for large animals in Ontario and elsewhere.

INTRODUCTION

There are numerous solutions to mitigate wildlife road mortality and road-barrier effects that have been outlined in numerous Best Management Practice documents (Huijser et al. 2007; Clevenger and Huijser, 2010; Huijser et al. 2015; MTO unpublished report). The most effective to date, especially for large animals, is the use of wildlife crossing structures and fencing prioritized at high-risk road sections. These measures are most often implemented when roads are being upgraded or twinned from two to four lanes (see examples in Clevenger & Waltho 2000, Gagnon et al. 2011). The most recognized long-term project for monitoring crossing structures and fencing effectiveness for large animals in Canada is in Banff National Park. There are now 166 km of wildlife fencing, 39 underpasses, and six overpasses along 83 km
of the Trans-Canada Highway that have been installed in four phases of highway construction (Clevenger and Barrueto 2014).

Research has shown that large animals may prefer different crossing structure designs and this may vary depending on movement type and species (Eco-Kare International 2014). Furthermore, some wildlife species such as carnivores may take longer to adapt to new wildlife mitigation than other species such as Deer. In light of this variability and the additional costs associated with mitigation it is essential to monitor road mitigation effectiveness in an adaptive rigorous approach that uses standard, consistent and rigour monitoring techniques for at least five years of monitoring.

The Ministry of Transportation, Northeastern Region initiated a monitoring project in September 2011 aimed at evaluating the effectiveness of mitigation measures, e.g., crossing structures, fencing, and one-way gates for large wildlife on Highway 69 (Figure 1, Table 1). Other questions being evaluated are the effectiveness of snow tracking and motion activated camera data to evaluate mitigation effectiveness. Snow tracking data was also used to measure permeability rates of wildlife as a function of traffic volume and highway configuration. Highways that are barriers to movement provide rationale for implementation of crossing structures and fencing to reduce barrier highway effects (Dodd et al. 2012).

Throughout the monitoring project data collections and evaluations were optimized to expand measuring mitigation effectiveness beyond a simple count of crossing structure use by wildlife. Mitigation effectiveness was evaluated by measuring the following:

- Crossing structure effectiveness for each target species
  - Crossing structure design
  - Seasonal use (post-construction 3 years)
  - Sex and age-level use of wildlife crossing structures
- Fencing effectiveness
  - Reduction in wildlife road mortality
  - Reduction in wildlife breaches
- One-way gate effectiveness
- Highway permeability
  - Crossing locations
  - Highway configuration, two lanes vs. four lanes
  - Traffic Volume

**STUDY AREA**

The study area is 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.

Monitoring was initiated in September 2011 while Highway 69 was being expanded from 2 to 4 lanes. This section of highway included a new 4-lane alignment (6.8 km) east of the highway (Figure 1). The main study area for this monitoring spanned approximately 12 km from Nelson Road Interchange to Lovering Creek bridge (Figure 1). The new four-lane section of Highway 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 (where the wildlife crossing structures are located), 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).

Data collected for wildlife road-kill is considered post-construction in November 2012 when the wildlife fencing was continuous and complete. Data collected at the crossing structures is considered post construction as of June 30th 2012, because fencing abutted all the structures, and two lanes were opened to motorists. Mitigation measures that are being monitored, pictures and their description are included in each relevant section.
Mitigation Effectiveness Monitoring on Highway 69

FIGURE 1 Study area for Highway 69 monitoring (Eco-Kare International 2014).
DATA COLLECTION

The main method for data collection was the use of 25 to 30 Reconyx infrared motion detected cameras placed at mitigation measures throughout the study area. Data was collected and cameras were maintained for power and alignment approximately one time a month. In addition to camera monitoring, snow tracking data was also used to supplement animal interactions with the mitigation measures as well as with highway sections that varied in traffic volume and presence of wildlife fence.

Wildlife behaviour from both snow tracking and camera data was compiled and summarized into an ‘action’ group (Table 1). A wildlife ‘action’ from the camera data 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 fence intrusions, and wildlife presence and behaviour both inside and road-side of the fence (Table 1).

TABLE 1 Definition of interaction terms used to describe wildlife response to mitigation measures using camera, and tracking surveys as tools for effectiveness monitoring

<table>
<thead>
<tr>
<th>Action Type</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crossing Structure and One-Way Gates:</td>
<td></td>
</tr>
<tr>
<td>Cross or Through</td>
<td>Individual is documented as travelling across (in the middle) of the overpass structure, or approaching the underpass and Lovering Creek bridge wildlife path, and is not documented turning around.</td>
</tr>
<tr>
<td>Approach</td>
<td>Individual is captured on only one approach camera clearly moving towards or away from structure. For one-way gates an approach is used to classify an individual that looks at or deviates from path to ‘check-out’ the structure, but continues on same path.</td>
</tr>
<tr>
<td>Repel</td>
<td>Individual about to enter/use the structure but abruptly turns around moving away from structure.</td>
</tr>
<tr>
<td>Look</td>
<td>Similar to approach but possibly biased because occurs at night and individual changes direction to look at infrared illumination from camera.</td>
</tr>
<tr>
<td>Ignore</td>
<td>No deviation from path or movement behaviour when moving by structure.</td>
</tr>
<tr>
<td>Fence</td>
<td></td>
</tr>
<tr>
<td>Road-side</td>
<td>Fence intrusion, e.g., individual present on the road-side of the wildlife fence.</td>
</tr>
<tr>
<td>Safe-side</td>
<td>Individual present on the safe-side of the wildlife fence, data used to measure presence, movement direction, and behaviour of animal along fence.</td>
</tr>
<tr>
<td>Fence ends, Texas Gates</td>
<td></td>
</tr>
<tr>
<td>Road-side</td>
<td>Fence intrusion, e.g., individual present on the road-side of the wildlife fence.</td>
</tr>
<tr>
<td>Safe-side</td>
<td>Individual present on the safe-side of the wildlife fence, data used to measure presence, movement direction, and behaviour of animal along fence.</td>
</tr>
<tr>
<td>Breach - Toward Hwy</td>
<td>Individual moves past or around the fence end toward the highway; this is also referred to as a breach in the fence.</td>
</tr>
<tr>
<td>Breach - Away Hwy</td>
<td>Individual moves past or around the fence end away from the Highway; this is also referred to as a breach in the fence.</td>
</tr>
<tr>
<td>Approach</td>
<td>Individual looks at the fence or deviates from path to inspect the fence, and continues on same path. May approach from either side of the fence.</td>
</tr>
<tr>
<td>Ignore</td>
<td>Individual is moving or gazing in the vicinity of the fence end, but is not interacting with the fence at all. Movement is not directional with respect to the fence.</td>
</tr>
<tr>
<td>Action Type</td>
<td>Definition</td>
</tr>
<tr>
<td>-------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Repel</td>
<td>Individual approaches the fence end, then abruptly turns away and does not pass the fence.</td>
</tr>
<tr>
<td>Access road, or Highway</td>
<td></td>
</tr>
<tr>
<td>Parallel</td>
<td>Animal(s) are noted as travelling alongside an access road or highway.</td>
</tr>
<tr>
<td>Cross</td>
<td>Animal(s) are noted as crossing an access road or highway</td>
</tr>
<tr>
<td>Approach</td>
<td>Animal(s) approach access road or highway and turnaround</td>
</tr>
</tbody>
</table>

**WILDLIFE OVERPASS**

Structure Type: 30 m wide bridge with ~ 2 m high concrete noise berms on both sides; vegetation plantings completed in summer 2012.

Monitoring: Three posts installed at each east and west entrance and one post in the middle, with a total of two cameras at each post. Snowtracking completed approximately 8 times in winter months.

In addition two cameras installed along access road approaching wildlife overpass to measure observed use with expected use. A Relative Abundance Index (RAI) [(number of photos*100)/(# of trap nights)] where number of trap nights is the total # of cameras multiplied by operation days, was used to standardize abundance of animals at access roads and at crossing structures and measure whether animals used the structures more than expected.

Target Species: Large to medium sized animals, most specifically White-tailed deer (*Odocoileus virginianus*), Moose (*Alces alces*), Black bear (*Ursus americanus*), Wolves (*Canis lycaon*), Coyotes (*Canis latrans*), Red Fox (*Vulpes vulpes*) and small mammals (Rabbits, Groundhogs, and Racoons).

Results: Camera and snow-tracking data; Post-construction data (July 1<sup>st</sup> 2012 to July 20<sup>th</sup> 2015).

- Deer have used the structure over 800 times, Moose almost 90 times, followed by Black bear, Fox, Coyote and Wolves;
- Animals rarely repel from the structure;
- Carnivore abundance was higher on the access road compared to the overpass. Moose and Deer showed the opposite trend and were more abundant on the overpass than the access road;
- Lynx was the only carnivore that did not use the overpass but were observed on the overpass access road in small numbers.
FIGURE 2 Post-construction monitoring results (camera and snowtracking data) and photo from wildlife overpass (MTO unpublished data).
Seasonal Use

Methods and Results: Camera and snow-tracking data; Post-construction data (July 1st 2012 to July 20th 2015). Note data was used from June 2012 to allow a full three months of data for summer in the 2012 and 2013 year. Summer (June, July, August); Fall (September, October, November); Winter (December, January, February); Spring (March, April, May).

Target species: White-tailed deer (*Odocoileus virginianus*), Moose (*Alces alces*), Black bear (*Ursus americanus*), Wolves (*Canis lycaon*), Coyotes (*Canis latrans*).

- Wildlife use increased in the summer months for Moose, Bear, and Deer over the three years of monitoring; Increased Deer use in the summer is most likely due to increased forage opportunities with new vegetation growth; while decreased winter use can most likely be attributed to winter snow-fall and climate;
- Use of overpass increased in the winter months for Wolves over the three years of monitoring;
- Overall use for Deer and Moose was high in the first year of monitoring, dropped in the second year, but picked up again in the third year;
- Canids are using the structure more over time;
- Black bear use peaked in the 2013/14 year but use may have decreased in 2014/15 due to the road-kill of three adult Black bears near the wildlife overpass from October 2013 to May 2014.
FIGURE 3 Post-construction seasonal use and photo from wildlife overpass (*MTO unpublished data*).
Sex-Related Use

Methods and Results: Camera data only; Post-construction data between June and December for 2012, 2013, and 2014. Males were classified from camera pictures that showed Deer and Moose with antlers between June and December when antlers are well-defined. Sex and age-related ratios were calculated on both the overpass and compared to camera data in the surrounding areas, i.e. cameras placed at one-way gates and access roads. Chi-squared tests (p<0.05) were used to measure whether the ratios differed between the overpass and surrounding landscape.

Target species: White-tailed Deer (*Odocoileus virginianus*), Moose (*Alces alces*),

- On the overpass, 17 Moose were assessed and 88% were female and 12% were male (Table 2). The sex ratio between the area surrounding the overpass was not significantly different from the sex ratio of Moose using the wildlife overpass (p value >0.05).
- In the area surrounding the overpass there were 707 observations of Deer; 25% were male and 75% were female. Of the 495 Deer using the overpass where sex could be determined, 57% were male and 43% were female and this was significantly different than that surrounding the overpass (X^2=266.42, d.f.=3, P<0.001; Table 2).
- Deer use of the overpass was sex biased towards males who used it 2.3 times more than expected.

### TABLE 2 Observed and (expected) overpass crossings for male and female Moose and Deer from June to December of 2012, 2013, and 2014 (*Eco-Kare International 2014*)

<table>
<thead>
<tr>
<th></th>
<th>Moose</th>
<th>Deer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>Observed</td>
<td>2</td>
<td>15</td>
</tr>
<tr>
<td>Expected</td>
<td>4.42</td>
<td>12.41</td>
</tr>
<tr>
<td>Chi Square</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>P</td>
<td>-</td>
<td>p&gt;0.05</td>
</tr>
</tbody>
</table>

WILDLIFE UNDERPASS

One Large Box Culvert

Structure Type: Twinned concrete structures 5 m wide x 5 m tall, x 24.1 m long, grass seeded on clay substrate.

Monitoring: Two cameras at each entrance and one camera in middle of structure. Snow tracking completed approximately 8 times in the winter months.

In addition two cameras installed along access road approaching wildlife overpass to measure observed use with expected. A Relative Abundance Index (RAI) [(number of photos*100)/(# of trap nights)] where number of trap nights is the total # of cameras multiplied by operation days, was used to standardize abundance of animals at access roads and at crossing structures and measure whether animals used the structures more than expected.

Target Species: Large to medium sized animals, most specifically White-tailed deer (*Odocoileus virginianus*), Moose (*Alces alces*), Black bear (*Ursus americanus*), Wolves (*Canis lycaon*), Coyotes (*Canis latrans*) and Red Fox (*Vulpes vulpes*).

Results: Camera and snow-tracking data; Post-construction data (July 1st 2012 to July 20th 2015).
- Moose have used the underpass the most (46 times) followed by Deer (31 times) and Fox, Bear and Coyote;
- Moose and Deer regularly repel from the underpass more so than the other animals that used the structure, e.g. Bear and Coyote;
- All species with the exception of Moose, were more abundant on the underpass access road than at the underpass. Moose were two times more abundant at the underpass (RAI 4.1) than along the access road (RAI=2.04).

![Graph showing underpass use and repels for different species](image)

**FIGURE 4** Post-construction monitoring results (camera and snowtracking data) and photo from one large box culvert wildlife underpass (*MTO unpublished data*).

**Three Smaller Box Culverts**

Structure Type: Twinned concrete structures 3.4 m wide x 2.4 m high x 24.1 m long with some water flow in spring and tapering off in late summer; any standing water freezes in tunnels in winter.
Monitoring: Two cameras at each entrance of two tunnels; snow tracking completed approximately 8 times in the winter months. Cameras placed approximately 1 m high on wall of structure to target large animals.

Target Species: These tunnels were designed for Blanding’s Turtles (*Emydoidea blandingii*) however were also monitored to investigate whether large to medium sized animals, most specifically White-tailed deer (*Odocoileus virginianus*), Moose (*Alces alces*), Black bear (*Ursus americanus*), Wolves (*Canis lycaon*), Coyotes (*Canis latrans*) and Red Fox (*Vulpes vulpes*) used them.

Results: January 2015 to July 2015.

- A diversity of animals were captured using the reptile tunnel, including a Snapping Turtle; several other Snapping Turtles and Painted Turtles were documented using the tunnel as part of another study (MTO, 2015 unpublished data)
- Tunnels are providing some connectivity for larger animals, i.e. three Moose, two Deer, and two Wolves over one year of monitoring and are very permeable for small mammals and use by turtles (intended species) is currently being assessed.
FIGURE 5 Monitoring results from January to July 2015 (camera and snowtracking data) and photo from three smaller box culvert wildlife underpass (MTO unpublished data).
Wildlife Creek Bridge Pathway

Structure Type: Two metre creek bridge pathway constructed on north side of river gorge under open bridge span; connected to rugged, rocky trails along the creek that wildlife will follow under the highway, however wildlife can also follow the river and not be captured on the cameras.

Monitoring: Two cameras at each entrance and one camera on access trail approaching wildlife pathway. Snow tracking completed approximately 8 times in the winter months.

Target Species: Large to medium sized animals, most specifically White-tailed deer (*Odocoileus virginianus*), Moose (*Alces alces*), Black bear (*Ursus americanus*), Wolves (*Canis lycaon*), Coyotes (*Canis latrans*) and Red Fox (*Vulpes vulpes*).

Results: Camera and snow-tracking data; Post-construction data (July 1st 2012 to July 20th 2015).

- Of the larger animals Black Bears have used the structure the most (10 times);
- The pathway is relatively used more by mid to small animals
CROSSING STRUCTURE COMPARISON

Methods: Wildlife use and passage rate defined as: (approaches + passages)/(approaches + passages + repels) was compared between species and the three crossing structures that have been monitored for three years post construction.

Results: Post construction data from July 1st, 2012 to July 20th, 2015

- Wildlife use for all species is highest at the overpass than at the other two structures, followed by the underpass and Lovering Creek wildlife pathway:
• Wolves have not yet been documented using the large box culvert.

**TABLE 3 Wildlife use of crossing structures (overpass, underpass, Lovering Creek bridge, and reptile tunnels) from July 1st, 2012 to Jul 20th, 2015 (MTO unpublished report).**

<table>
<thead>
<tr>
<th>Structure</th>
<th>Moose</th>
<th>Deer</th>
<th>Bear</th>
<th>Wolf</th>
<th>Coyote</th>
<th>Fox</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overpass</td>
<td>88</td>
<td>857</td>
<td>65</td>
<td>18</td>
<td>34</td>
<td>59</td>
<td>1121</td>
</tr>
<tr>
<td>Underpass</td>
<td>46</td>
<td>31</td>
<td>8</td>
<td>0</td>
<td>4</td>
<td>11</td>
<td>100</td>
</tr>
<tr>
<td>Lovering Creek bridge</td>
<td>2</td>
<td>5</td>
<td>10</td>
<td>3</td>
<td>19</td>
<td>20</td>
<td>59</td>
</tr>
<tr>
<td>Total</td>
<td>139</td>
<td>895</td>
<td>83</td>
<td>23</td>
<td>64</td>
<td>93</td>
<td>1297</td>
</tr>
</tbody>
</table>

- Passage rates were highest at the overpass for all larger species; and Black Bear tend not to repel from both the underpass and overpass
- Moose and Deer followed a similar pattern with high passage rates close to 1 for the overpass but decreased to approximately 0.5 at the underpass and Lovering Creek bridge
- On average all wildlife used the three crossing structure types 84% of the time

**TABLE 4 Passage rate for Deer, Moose, Black bear, Wolf, Coyote, and Fox at the overpass, underpass, Lovering Creek bridge, and Reptile tunnels from July 1st, 2011 to Jul 20th, 2015**

<table>
<thead>
<tr>
<th>Passage Rate</th>
<th>Moose</th>
<th>Deer</th>
<th>Bear</th>
<th>Wolf</th>
<th>Coyote</th>
<th>Fox</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overpass</td>
<td>0.97</td>
<td>0.97</td>
<td>0.98</td>
<td>0.90</td>
<td>0.81</td>
<td>0.97</td>
<td>0.93</td>
</tr>
<tr>
<td>Underpass</td>
<td>0.55</td>
<td>0.56</td>
<td>0.89</td>
<td>n/a</td>
<td>1.00</td>
<td>1.00</td>
<td>0.80</td>
</tr>
<tr>
<td>Lovering Creek bridge</td>
<td>0.50</td>
<td>0.50</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>0.95</td>
<td>0.83</td>
</tr>
<tr>
<td>Average</td>
<td>0.63</td>
<td>0.67</td>
<td>0.96</td>
<td>0.97</td>
<td>0.92</td>
<td>0.92</td>
<td>0.84</td>
</tr>
</tbody>
</table>

**ONE–WAY GATES**

Structure Type: Curved prong gates along fence to allow animals one-way passage from the road-side to the safe-side (26 installed in study site)

Monitoring: The number of one-way gates monitored with cameras ranged from 6 to 15 during the study period. Gates also monitored with snow tracking surveys approximately 8 times a winter season.

Results: Pre and Post construction data from September 1st, 2011 to July 20th, 2015; only includes data obtained from animals on the road-side of the fence

- Black Bear have used the gates the most (6 times) followed by Deer (4 times), and Elk and Moose have not yet used the one-way gates
- Small mammals (Rabbits, Racoons, and Groundhogs), Lynx, and Black Bear have been documented using the gates the wrong way from safe-side to road-side on a few occasions.
FIGURE 7 Monitoring results (camera and snowtracking data) and photo from one-way gates (MTO unpublished data). Includes pre- and post-construction data from September 1st, 2011 to July 20th, 2015; only includes data obtained from animals on the road-side of the fence.

HIGHWAY PREMEABILITY

Objective: Evaluate whether animal crossing behaviour changed due to varying traffic volumes and road types

Methods: Road driving surveys were conducted along Old Highway 69 during high traffic volumes (2011-2012) and during low traffic volumes (2012-2013 and 2014-2015) and also along two control sections, one 5 km stretch of highway and two access roads with no traffic. When wildlife interactions with the roads were recorded the following interactions were noted (Table 1):
1) A crossing event if the animal tracks crossed the road from one side to the other, 
2) An approach if the animal approached the road but did not cross it, or, 
3) Parallel if they animal tracks moved parallel with the road.

Results:

- The independent data (one count when more than one track for the same species within 300 m) used for analyses were 86 tracks (permeability analysis), 181 (presence analysis), and 101 for the crossing rate;
- The Old Highway 69 was most permeable for all large animals (Figure 8 top left) when traffic volumes were less than 500 vehicles per day and there were two lanes of traffic;
- Large animals were much more abundant and crossed the road along the access roads followed by the Old Highway 69 with two lanes and minimal traffic and than the twinned highway (Figure 8, top right and bottom left);
- The presence of animals that also crossed the highway were very similar when traffic volumes were diverted to the new alignment on Old Hwy 69 suggesting that one year of data may not be adequate to assess change in animal present along roads;
- More years of ‘Before’ data would have greatly supplemented this analysis and the data should be analysed for statistical significance using a Before-After-Control-Impact Design.
FIGURE 8. Permeability (cross / cross + approach; "top"), Presence (cross + approach + parallel / km / surveys; "middle"), and Crossing rates (crosses / length / surveys; "bottom") for all large animals for three highway types with high, moderate, low and no traffic volumes over three winter tracking seasons (Eco-Kare International, 2014)

FENCING EFFECTIVENESS

Structure Type: ~ 20 km continuous wire mesh fence spanning 10 km both sides of highway; 2.4 m high, steel poles; fence ends on north side tied into steep rocky highway embankments

Monitoring: evaluated with two performance measures 1) fence breaches, i.e. animals on road-side of fence with cameras and snow tracking data; and 2) wildlife-vehicle collisions collected by wildlife researchers (pre Sept. 2011 to October 31, 2012; post November 1, 2012 to September 1, 2014).

Results:

- Since October 31, 2012, when the fence was complete there have been 33 breaches of the fence by Deer;
- There have been 11 breaches by Black Bear documented near the south and north fence ends as well as near the overpass;
- One fence breach has been observed for Moose just south of Killarney and Highway 69 interchange on Highway 637; and none on Highway 69;
- There has been a 58% decrease in collisions post fencing and no documented collisions with Moose, Elk, or Wolves have occurred along the fenced section post fencing.

CONCLUSIONS

- The mitigation strategy in its entirety has contributed to less animals on the highway, reduced wildlife-vehicle collisions, and provided substantial permeability across the new highway alignment for mid- to large-sized mammals (Deer, Moose, Black Bears, Coyotes and Red Fox);
- Four years of monitoring have shown species-specific patterns of use at the three crossing structures. Ungulates (Deer and Moose) that are moving within the vicinity of both crossings are using them. Lynx are present in the vicinity of the structures but have not used the structures. Wolf use of structures is increasing and this may be related to more wolves in the area; Black Bear use is decreasing and this may be due to less bears in the area;
- Large ungulates tend to prefer the overpass as opposed to the underpass, but Moose are using the underpass more than expected;
- There are sex-related differences in use of the overpass by Deer, and more males tend to use the overpass than expected;
- There are seasonal differences in use of the overpass, and Moose and Deer have increasingly used the overpass more in the summer, but also use the overpass regularly in the fall and summer. A previous study has found that Moose used the overpass significantly more than expected in the spring and Deer used the overpass significantly more in the summer and fall (Eco-Kare International 2014). Animal use and movements in the winter is most likely fluctuating with snow fall and temperature;
- Currently, one-way gates have limited known effectiveness, and the use of the gates by animals the wrong way may negate any benefits; it may be possible to improve effectiveness with better
design. For example gates in New Brunswick have a perpendicular fence extension at the gate that may funnel and deflect animals to the gate opening:

- Snow tracking data has complemented evaluation of mitigation effectiveness for large animals and has provided information about passage of Deer at the one-way gate, and complemented passages of animals at crossing structures;

- Snow tracking data is also a useful technique for documenting fence breaches as well as evaluating the barrier effect of highways with varying traffic volumes (Eco-Kare International 2014) and results have shown that animals avoid high volume roads with 4 lanes more so than 2 lane highways with low traffic and access roads with no traffic. Crossing structures and fencing are an optimal measure to reduce this barrier effect (Dodd et al. 2012).

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At the time of writing, The Ministry of Transportation has confirmed an additional one year of funding for effectiveness monitoring on Highway 69, monitoring data will be compiled over a five year time period in 2016.

BIOGRAPHICAL SKETCHES

Kari Gunson is a self-employed road ecologist with 16 years of expertise with planning for and monitoring road-wildlife mitigation measures for both large and small animals in Ontario and elsewhere. Her work has led to over 16 peer-reviewed papers and five book chapters in the field of road ecology and Geographic Information Science.

Andrew Healy is a Senior Environmental Planner with the Ontario Ministry of Transportation. Since 2007, Andrew has been the chair of Northeastern Region’s Wildlife Mitigation Team, and has been directly involved with the design, implementation and monitoring of various collision mitigation measures, including the province’s first wildlife crossings and wildlife detection systems. Through this work Andrew has advanced the practice of wildlife mitigation in Ontario and is currently working towards the development of provincial standards.
REFERENCES


