ecokare international

Ontario

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

September 2011
to
September 2019

Assignment No. 5013-E-0028

Summary Report for Public Dissemination

FINAL

October 2020

A Sandhill crane family using the overpass

Young male moose exiting Healey Underpass

The report should be cited as:

Eco-Kare International. 2020. Effectiveness monitoring of wildlife mitigation measures for large- and mid-sized animals on Highway 69 in Northeastern Ontario: September 2011 to September 2019. Submitted to the Ontario Ministry of Transportation, North Bay, Ontario, Canada, 73 pp.

Acknowledgements:

This project documents eight years of continuous monitoring of wildlife mitigation on a Highway in Ontario, Canada, a duration very seldom seen in road ecological research. Long-term monitoring showed changes of use of crossing structures over the time period, primarily increased use by the Canada lynx. In the last year of monitoring, families of Sandhill cranes used the overpass and one of the larger box culverts. In addition, there were increased passages of juvenile ungulates with adults using the larger box culverts.

Special thank-you to project managers Andrew Healey and Terri Rogers with the Ministry of Transportation who understood the value of long-term monitoring and to the Ministry for securing funding for the research. An additional thank-you to FRI Ecological Services in North Bay, Ontario for their support in the latter years of this research, and to David Lesbarrères from Laurentian University, and Josef Hamr, retired professor from Cambrian College in the earlier years of this research. There were various field technicians involved in data collections, the primary two involved throughout are listed below.

Field and Technical Support:

William Carrigan, Eco-Kare International
Wes Kowbasniuk, Eco-Kare International

Report Reviewers:

Terri Rogers, Senior Environmental Planner, Northeastern Region, Ministry of Transportation (most recent version)
Andrew Healy, Head, Environmental Delivery, Northeastern Region, Ministry of Transportation (first iteration in 2016)

Table of Contents

List of Tables

List of Figures

1 Summary

This report documents methods, results, and conclusions from eight years of monitoring (September 2011 to September 2019) wildlife mitigation measures on Highway 69 in Ontario, Canada. Measures included the following:

- Five concrete box underpass structures;
- Two bridge pathways alongside Murdock River, and one pathway along Lovering Creek;
- One wildlife overpass;
- Large animal exclusion fencing on both sides of the highway alongside three mitigated phased sections of highway;
- Twenty-seven one-way gates, and;
- Two ungulate guards.

Monitoring data was collected for one year prior to and seven years after mitigation measures were completed on a new highway alignment and existing highway called Burwash section. Additional mitigated sections (referred to as Bot and Healey) were added to the monitoring program when completed. Monitoring methods entailed using snow tracking and motion-activated cameras to evaluate effectiveness of mitigation measures for large animals: deer, elk, moose, black bear, wolves, and mid-sized animals: lynx, bobcat, coyote, and red fox.

There were 75 data acquisitions (1,657,377 pictures) obtained from cameras over a 96-month (8 year) monitoring period (September 13th, 2011 to September 19th, 2019). A total of 6,973 independent wildlife interactions were recorded at all the mitigation measures in the study area. All the target species listed above other than 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 strategy. Structures are placed where the highway bisects a wide diversity of habitats including river gorges, wetlands, and terrestrial forests and provide crossing opportunities for a diversity of large and small animals that also includes birds, mammals, amphibians and reptiles.

The use of multiple cameras at each entrance and the middle of each structure allowed through passages to be confirmed. All confirmed passages and approaches (only observed on one camera but clearly entering or exiting the structure) were summarized into ‘use’. Passage rates were evaluated as the number of use/use + repels. Repels were animals that were clearly observed as moving into or onto the structure and then abruptly turning around.

Canid, black bear and deer passage rates were the highest (>90%) followed by moose (88%). Canids and black bears may be more prone to using crossing structures to move across roads

because they are predators, while prey species such as moose and deer are instinctively more skittish. When adult moose and deer travel with young, the animals were noticeably more wary and hesitant to cross the Burwash underpass. Moose and deer repels decreased at the Burwash underpass over the monitoring period and this is likely because more animals are learning to use the underpass as they grow older.

Generally, animals prefer to use more open structures such as the overpass and the pathways under bridges at waterways, as they lend to a more 'natural' experience while crossing a road. Although animals are using the bridge pathways, fewer animals were observed at these structures likely because animals can evade the monitoring camera field-of-view and cross under the structure alongside the creek. In addition, the pathway at Lovering Creek bridge was only 2 metres wide and required a steep climb up a rocky slope on the west side. Terrestrial pathways that are graded with soft substrate, and wider such as at Murdock River bridge will likely facilitate passage by more wary ungulates such as deer and moose.

Deer used the overpass more than expected and use increased during the summer and fall periods. Moose used the structure the most in the spring. When comparing the sex ratios (with 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 larger animals, black bears are able to breach the exclusionary fencing. Black bears are able to enter the highway right-of-way at ungulate guards, one-way gates, fence-ends, and are able to go under and over the fence. Moose seldom breach the fence. Deer have been noted travelling around fence ends, breaching a fence gap at a steep highway slope and jumping over the ungulate guard.

An evaluation of Wildlife-Vehicle Collisions (WVCs) using Ontario Provincial Police reported collision locations have shown an overall reduction (74%) of collisions after installation of the exclusion fencing. When examining the number of wildlife carcasses recorded by the highway maintenance patrol and the research team, collisions with deer and moose have decreased but collisions with black bears have not.

Application of monitoring conclusions in an adaptive management approach would increase effectiveness of the mitigation system. Improvements to the Burwash exclusion fencing include burying the fence so that black bears and other smaller animals cannot move underneath and closing off the one-way gates where animals are moving through the wrong-way. It is also recommended to modify the ungulate guards based on other designs in North America that

have proven effective. These modifications may include increasing the width between the bars so animals cannot walk across, or increasing the width of the guard to prevent deer from jumping over.

It is recommended to extend the large animal fencing at the Bot section to span the rocky outcrops between Crooked Lake road and Lovering Creek bridge on both sides of the highway; as well as extending the large animal fence northerly from Trout Lake road to Makynen bridge where several elk and moose have been involved in collisions. In addition, vegetation such as meadow grasses should be planted adjacent to the Burwash underpass and Murdock Creek pathway to attract ungulates to the structure, as observed on the wildlife overpass.

2 Background Information

Why are wildlife crossing structures needed?

Wildlife cross roads to move around their home range: essentially to access food and mates, and to successfully raise young. When a highway or road bisects these home ranges, animals cross the road. These crossings can be specific, for example during migrations, ungulates move from summer and fall foraging areas to overwintering grounds or can be less specific and occur when seeking mates or food during its active season. For example, sometimes animals wander onto roads to feed at road-sides and/or in the medians.

When both an animal and a vehicle are on the road this poses a potential safety hazard for both motorists and animals, especially when a collision involves large animals such as moose. When an animal and a vehicle collide the end result is a collision that may result in an injury or death for the animal (road-kill) and may also cause injury or death for the motorist.

When animals are unwilling to cross highways due to vehicular traffic or because of the inhospitable habitat of the road itself, the highway fragments habitat and isolates animals in small patches of habitat. This is known as the 'barrier effect'. 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). When animals learn to use crossing structures along roads for safe passages connectivity is restored and required resources are accessible, and risk of collisions are reduced.

Where are wildlife crossing structures needed?

Research has shown that some animals tend to cross roads in the same location. This is known from studies that compile information from snow-tracking, telemetry or even from where WVCs have occurred previously. Likely locations that animals cross roads is where preferred habitat exists on both sides of the highway or when the road bisects a wildlife movement corridor. Other factors to consider for placement of crossing structures are property ownership, existing topography, as well as surrounding land-use.

What type of crossing structures do larger animals prefer?

Large animals adjacent to Highway 69 include 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. In most cases, it was difficult to differentiate between the Eastern wolf and coyote due to cross-breeding.

Two types of crossing structures are used for large animals on highways: overpasses and underpasses. An overpass is a bridge that allow animals to move over the road, while an underpass is a tunnel that allows animals to move under the road. Research has shown that wildlife overpasses work better for all animals because vegetation can grow on-top of the structure and they are more open; i.e. they are not bounded by a structure with vehicles over-top. Underpasses vary in size and structure and generally those that are more open (larger with open medians) are used more regularly by ungulates such as Moose and White-tailed Deer.

Why is wildlife exclusion fencing needed?

Wildlife fencing is a key element for functioning wildlife crossing structures. Wildlife fencing plays two roles. First animals are excluded from the highway and wildlife-vehicle collisions are avoided. Second, wildlife fencing funnels animals to wildlife crossing structures where they can safely cross the road. Research has shown that when enough wildlife crossing opportunities occur, both fencing and wildlife crossing structures collectively reduce the 'barrier effect' and occurrence of road-kill.

What are escape measures?

Exclusion fencing does not usually span the entire road length and typically ranges from several kilometres to tens of kilometres for large animals. Short sections of fencing are more likely to pose a 'fence-end effect' where animals travel past the fence-end and onto the road right-of-way (ROW) (Cserkész et al. 2013; Fairbank 2013). Often the fence-end effect results in a higher occurrence of wildlife-vehicle collisions at the fence-end.

When an animal moves around the fence-end or through a breach-point in the fence the animal is now trapped on the road-side of the highway environment. Escape measures are therefore used in combination with exclusion fencing. These measures are designed to allow wildlife to move one-way past the fence away from the road-side environment back to the safe-side or inside of the fence. On Highway 69, both one-way gates and jump-outs designed for large-sized animals have been implemented to address this issue.

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 perpendicular fence extensions away from the road can deter movement onto the road. Strategic fence tie-ins are also used by designing the fence-end to tie into rock cliffs, bridge abutments, or steep highway cliffs that make it difficult for animals to navigate, reducing access to the highway ROW.

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 the highway ROW. Ungulate guards are typically used on low-volume roads that intersect highways.

None of these solutions are designed for all species and some solutions work better in a specific situation than others. Steep inclines have been proven to be effective for excluding moose from the highway ROW on Highway 69 (Eco-Kare International 2014). However, some animals, e.g. deer, will navigate fence-ends tied into steep inclines. Other animals like wolves and black bear will walk over ungulate guards, and deer may jump over the guard. Black bear, lynx, red fox and smaller animals will use the one-way gates the wrong way. In all circumstances the animals are now on the road-side of the fence and pose a safety risk to motorists (Eco-Kare International 2014). The challenge is to assemble all these measures together into an effective mitigation strategy that reduces the occurrence of wildlife-vehicle collisions to acceptable threshold and allows as many animals as possible to safely move across the road.

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

3 Study Area

The study area is in Northeastern Ontario, near the unincorporated town of Estaire, located in Burwash Township, 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, 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. Annual average daily traffic volume (AADTV) along the highway is approximately 5,750 vehicles (Ministry of Transportation 2010).

3.1 Road upgrade timeline

On June 28, 2005, it was officially confirmed that Highway 69 would be expanded to four lanes 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 program began), the next southern phase (approximately 10 km) was in construction which included twinning and a new 4-lane alignment (6.8 km) east of the highway (Figure 1). This section of highway herein termed Burwash, spanned from Trout Lake road to Lovering Creek bridge and 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). Mitigation measures included four underpasses, one overpass, one bridge pathway, and 21 km of continuous fencing along both sides of the 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 intersection (referred to as Bot). Two additional bridge pathways (on the north and south side) under the Murdock River bridge were integrated to facilitate wildlife movement across the highway. Additionally, 5.6 km of intermittent large animal fencing was installed between rocky outcrops. This highway expansion began in August 2012 and finished in September 2015 (Figure 1).

In 2016, as part of a highway re-pavement project, wildlife exclusion fencing for both large animals and reptiles was added to a 9.6 km section of Highway 400 south of Parry Sound, west of the town of MacTier (referred to as Healey). There was one dual-purpose underpass (4 m high by 4 m wide) built to allow recreational use (snowmobile and All-Terrain-Vehicle (ATV)), as well as wildlife use. This structure has a paved road running through it and was monitored for wildlife use beginning in November 2016 when the monitoring cameras were set-up.

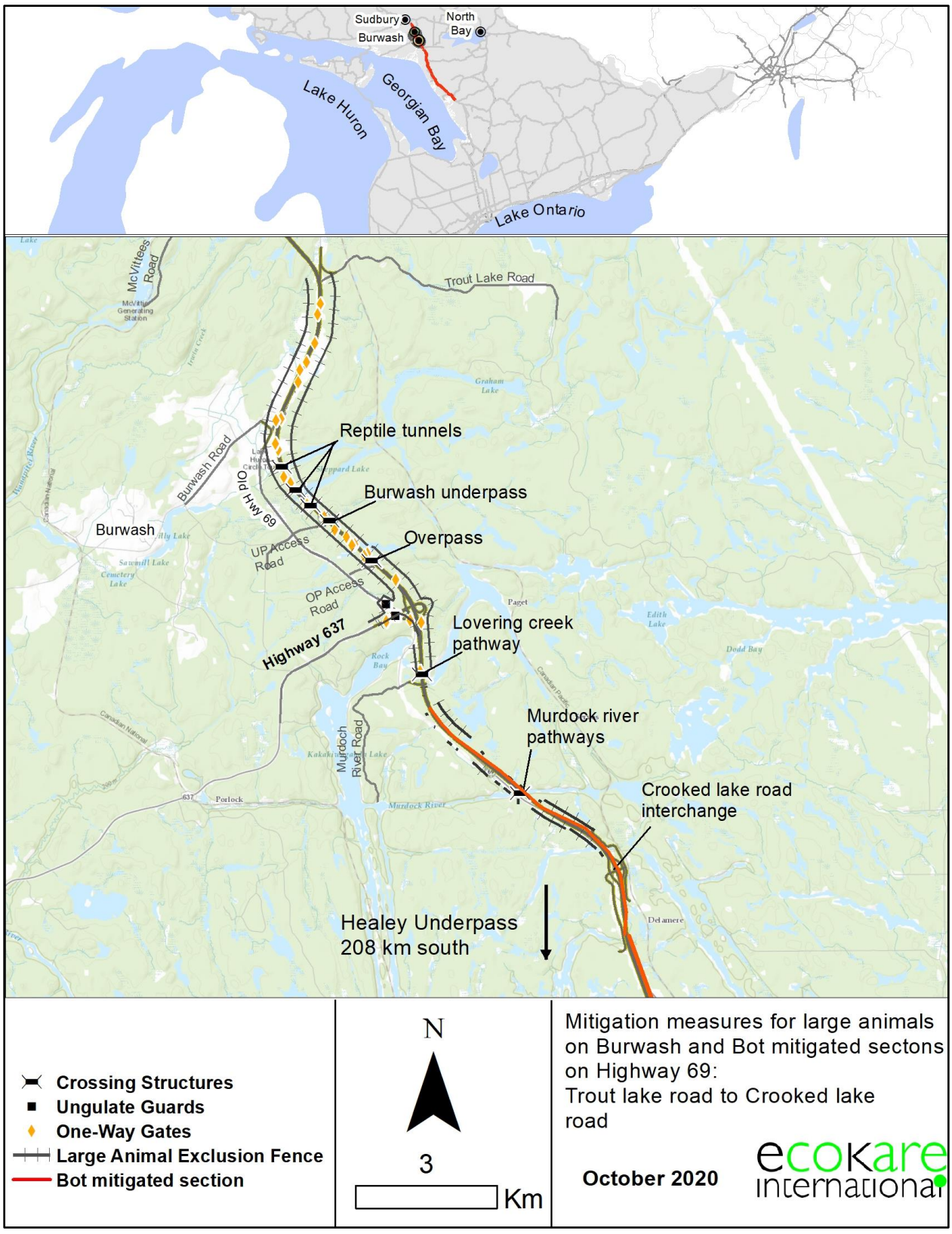


Figure 1: Study area along Highway 69 monitored from September 2011 to September 2019

Table 1: A description of the types of wildlife crossing structures and the monitoring procedures to evaluate wildlife use on Highway 69, in the three mitigated sections described above.

Mitigation Measure	Monitoring Duration	Camera Monitoring Description	Specifications
Overpass (1)	Sep 2011 to Sep 2019	Six cameras (two each bolted to wood posts at the east, and middle of the structure).	30 m wide deck on rocky outcrop footings, with soil base and matured meadow grasses, bushes, trees and debris piles.
Burwash Underpass (1)	Sep 2011 to Sep 2019	One camera at each east and west approach and in middle of structure.	5 m x 5 m box culvert with open median (15.3 m) and wing walls at entrance.
Healey Underpass (1)	Nov 2016 to Aug 2018	One camera at each east and west approach and in middle of structure.	4 m x 4 m box culvert with open median wing walls at entrances and paved trail through-out.
Reptile Tunnels (3 underpasses)	Feb 2014 to Sep 2019	One to two cameras placed at each of three reptile tunnels.	Three 2.8 m high x 3.2 m wide box culvert with open median; some water flow and pooling and growth of aquatic vegetation in median and at entrances to tunnels.
Lovering Creek bridge	Sep 2011 to Sep 2016	Two cameras placed at each entrance along 1 m wide wildlife ledge on north side.	Large open span bridge over creek valley; rocky forested slopes at entrances and level bench along north side of structure.
Murdock River bridge	Jan 2016 to Sep 2019 (south side); Jun 2016 to Oct 2017 (north side)	Two cameras at each approach along the north and south side of the creek-bridge pathways. Four cameras total.	Large open-span bridge over river valley; Two 8 m wide gravel paths on north and south side for wildlife movement.
One-way Gate	Sep 2011-Sep 2016	Selected one-way gates monitored (12 during study period); Placed on road-side of fence viewing towards gate; Six gates continually monitored entire study period.	One-way gates with aluminum spring loaded tines that are curved inwards for animal movement from road-side to safe-side. Tines only move one-way and are meant to spring back after an animal moves through. 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.
Burwash Large Animal Exclusion Fencing	Sep 2011 to Sep 2016	Six cameras placed at fence-ends at Trout Lake road, Nelson Interchange fence-ends, and Killarney Interchange from 6 mos to 1.5 years. Snow-tracking along mitigated section. WVC collected by	Approximately 21 km (both sides of highway) of wildlife fencing from Trout Lake Road to Lovering Creek bridge completed in September 2012, Two 50 m fence gaps where highway traverses steep terrain. Wildlife fencing is not buried with an apron. No outrigger fence extension at top.

Mitigation Measure	Monitoring Duration	Camera Monitoring Description	Specifications
		maintenance and Ontario Provincial Police (OPP) evaluation.	
Bot Large Animal Exclusion Fencing	Nov 2016 to Mar 2019	Snow-tracking along mitigated section. WVC data collected by maintenance and OPP evaluation.	Approximately 5.6 km (both sides of highway) of intermittent large animal fencing between rocky outcrops, some reptile fencing at bottom of fence in some sections further south.
Ungulate Guards	Mar 2020 to Jul 2015	Two ungulate guards (aka Texas Gates) used where fence crosses Burwash road and Murdock River road.	9 m wide, 4.5 m span along the road, steel bars are 14 cm apart.

4 Wildlife Monitoring Overview

Monitoring the interactions of large animals with mitigation measures (Table 1) was conducted using two methods. The primary method for data collection was the use of 22 to 30 motion triggered infrared cameras placed at mitigation measures throughout the study area. Approximately once a month, picture data were 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 were collected approximately one time per month, a total 75 times, from 22 to 30 camera monitoring locations during the period from September 2011 to September 2019 (Photo 5; Photo 6). All picture data were processed using phot 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 thirty minutes from the previous interaction in a picture series. Cameras placed at one-way gates were also used for several purposes: 1) measure the presence of wildlife on the road-side of the fence, e.g. breach; 2) measure the proportion of females and males in surrounding areas, and 3) evaluate effectiveness of gates.

In addition to camera monitoring, any tracks in the snow and dirt that were found during routine snow-tracking and camera data acquisition were recorded for all large animals that interacted with the mitigation measures (Photo 2; Photo 3; Photo 4). Similar to the camera data, species-specific tracks in sand or snow, pellets and scat, or live wildlife sightings were assessed with the same rules as the camera data and assigned 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 the Action Code to describe the wildlife response to mitigation measures using cameras and snow-tracking as tools for effectiveness monitoring.

Action Code	Definition
Crossing structures and ungulate guards	
Cross	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 walks/jumps over the guard.
Approach	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 the structure.
Repel	Individual about to enter/use the structure but abruptly turns around moving away from structure. For guards, animal approaches and turns around.
Ignore	Individual seen on camera, but no deviation from path or movement behaviour when moving by structure. Often grazing.
Approach (Look/Graze)	Similar to approach but possibly biased because individual comes onto overpass to graze or browse and then turns-around, or stops and looks at camera (especially at night) and then turns around. These were biased and not included in evaluations.
One-way gate	
Through	Individual goes through the gate. Usually from the road-side to the safe-side of the fence (as intended), but occasionally the reverse, especially for smaller animals.
Approach	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.
Repel	Individual looks like it is about to travel through the gate, but turns back quickly and does not go through.
Ignore	Individual seen on camera, but no deviation from path or movement behaviour when moving by gate. Often grazing.
Fence	
Road-side	Fence intrusion, e.g., individual present on the road-side of the wildlife fence.
Safe-side	Individual present on the safe-side of the wildlife fence.

Photo 1: Lynx tracks found on the side of old 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 Burwash underpass

Photo 5: Camera on tree on overpass access road

Photo 6: Camera on wing-wall at Healey east entrance to underpass

Photo 7: Data acquisition on wildlife overpass in winter

Photo 8: Moose tracks through Burwash underpass

5 Wildlife Crossing Structures

5.1 What Animals use the Structures?

A total of 1,657,377 photos were processed from cameras on Highway 69. Of these 130,613, or 7.9%, were pictures of animals, and 6,973 independent wildlife interactions with mitigation measures were recorded. Although not targeted for monitoring, there were 70 birds (11 species) and 861 small mammals (15 species) observed at the crossing structures. The majority of the small mammal (76%) and bird (47%) occurrences were at the reptile tunnels because the cameras were able to detect smaller animals within smaller structures but also because many common aquatic animals used these structures, such as mallard ducks, river otter, beaver, and muskrats.

Large- and mid-sized animals used the Burwash overpass structure the most (78%) followed by the Burwash underpass (11%), and animals used the reptile tunnels and Lovering Creek bridge almost equally (5-6%) (Figure 2, left). The three reptile tunnels were not monitored the entire time period and were grouped collectively. Use at the Lovering Creek bridge is likely under-estimated because some animals may cross below the wildlife pathway near the creek. White-tailed Deer used the structures at Burwash crossing structures the most (57%), followed by moose (15%). Bear, wolf/coyote and red fox used the structures almost equally (9-10%) (Figure 2, right).

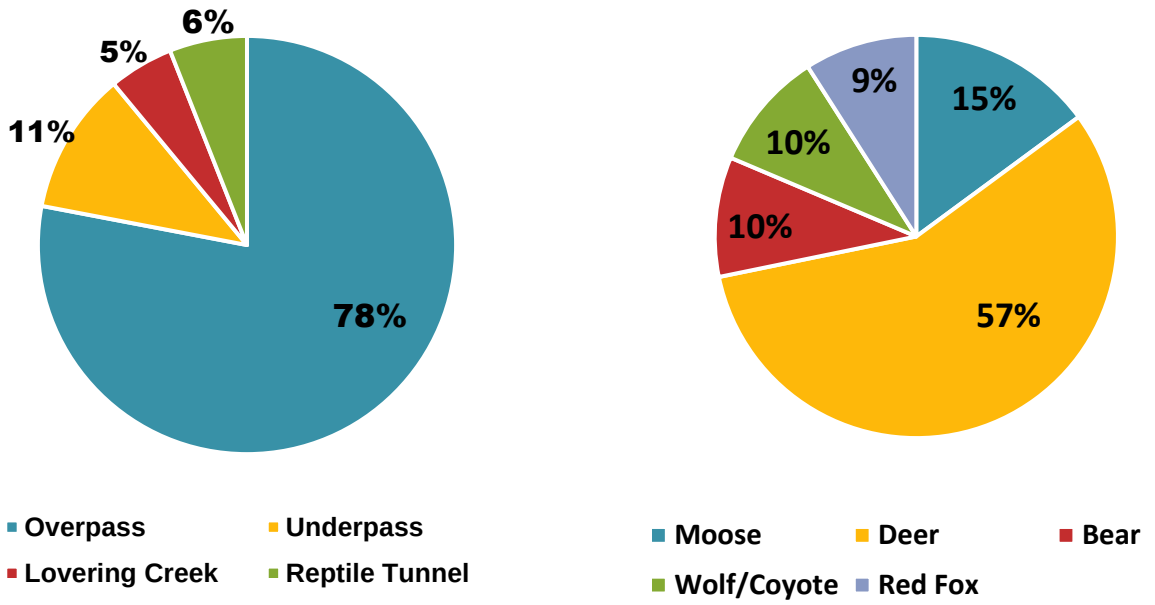


Figure 2: Percentages of large and mid-sized animals using the crossing structures along Burwash mitigated section on Highway 69 from July 2012 to September 2019.

5.2 Do Wildlife Overpasses Work?

Structure Type: 30 metre wide level bridge deck with ~2 m high concrete noise berms on both sides; deck placed on-top of rocky outcrops; vegetation plantings completed in summer 2012 (Photo 9; Photo 10; Photo 12).

Monitoring methods:

- Three posts installed at each east and west entrance and in the middle of the structure;
- Two cameras placed on each post for a total of six monitoring cameras;
- Snow-tracking completed approximately eight times during each of eight winter seasons from 2011 to 2019;
- Monitoring summarized for data collected after mitigation was finished between July 1st 2012 to September 13th 2019.

Results:

- Deer used the Burwash overpass 1,358 times, comprising 68% of the total wildlife use on the overpass (Figure 3);
- Other large animals that used the overpass were moose 251 times, followed by black bear (188), fox (105), coyote (79) and wolves (15);
- All large animals (red fox and larger) crossed the overpass 97% of the time;
- Small mammals were observed using the structure such as rabbits, raccoons, groundhog, porcupines and one fisher (Photo 17);
- Birds on-top of the structure include sandhill cranes, blue jays, wild turkeys, and one common yellow-throat (Photo 16);
- Bobcats have not been documented on the overpass since construction was completed, though prior to construction, a bobcat was observed on the structure on one occasion.
- Lynx have been detected on the structure three times in 2017 and 2018 (Photo 19);
- Elk have not been detected on the structure but this is because the overpass is not located within their home range (McGeachy 2014); Elk have used the wildlife overpasses in Banff National Park on numerous occasions (Clevenger & Barrueto 2014).

Conclusions:

- Yes, wildlife overpasses out-perform other underpass structures for terrestrial passage of birds and small- mid- and large-sized mammals and this is facilitated by the abundance of vegetation on-top of the structure.

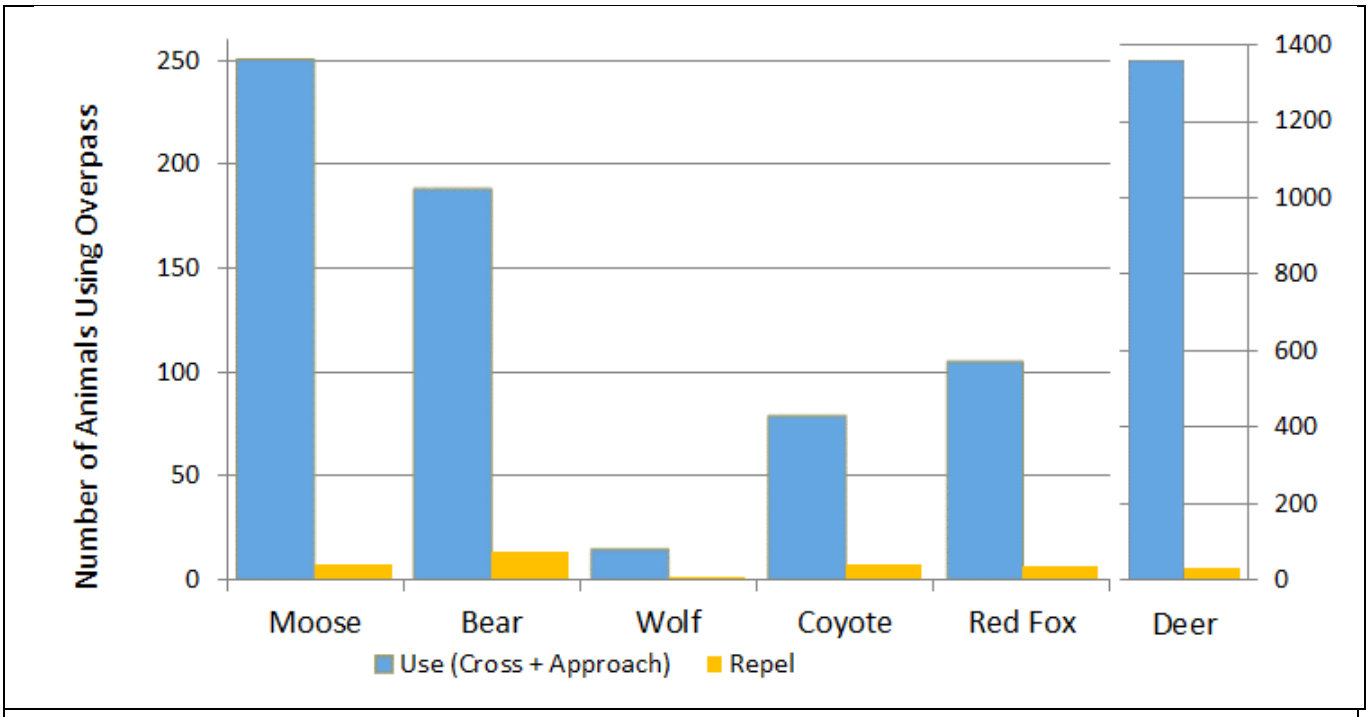


Figure 3: Summary of large and mid-size animal use at wildlife overpass

Photo 9: Burwash overpass both lanes

Photo 10: Burwash overpass NB lanes

Photo 11: Debris pile on-top of overpass

Photo 12: Grass meadow on-top of overpass

Photo 13: Wolf approaching west side of overpass

Photo 14: Moose browsing on vegetation on east side

Photo 15: Wild turkey crossing overpass

Photo 16: Sandhill crane family on overpass

Photo 17: Porcupine using overpass

Photo 18: Two bucks dueling ontop of overpass

Photo 19: Lynx using overpass in 2018

Photo 20: Juvenile moose approaching overpass

Photo 21: Black bear on hind legs looking across overpass

Photo 22: Black bear repelling from overpass in 2019

5.3 Do Wildlife Underpasses Work?

5.3.1 Burwash 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 (Photo 23; Photo 24).

Monitoring methods:

- Two cameras at each entrance and one camera in middle of structure;
- Snow-tracking completed approximately 8 times in each of eight winter seasons from 2011 to 2019;
- Monitoring summarized for data collected after mitigation was finished between July 1st 2012 to September 13th 2019.

Results:

- Moose have used the underpass the most (71 times), followed by deer (54), coyote (31), red fox (30), wolves (18), black bear (12) and one lynx (Figure 4);
- Larger coyotes that are possibly Wolves were documented using the structure in 2019 (Photo 27);
- Moose and deer repelled from the underpass the most crossing the structure 73% and 68% of the time respectively; Bears only repelled one time (Photo 31; Photo 32).

Conclusions:

- The high frequency of moose use indicates the Burwash underpass is located well for these animals;
- More animals may use this structure if vegetation is planted in the median and at the entrances to create a more 'natural' experience for ungulates to graze and browse.

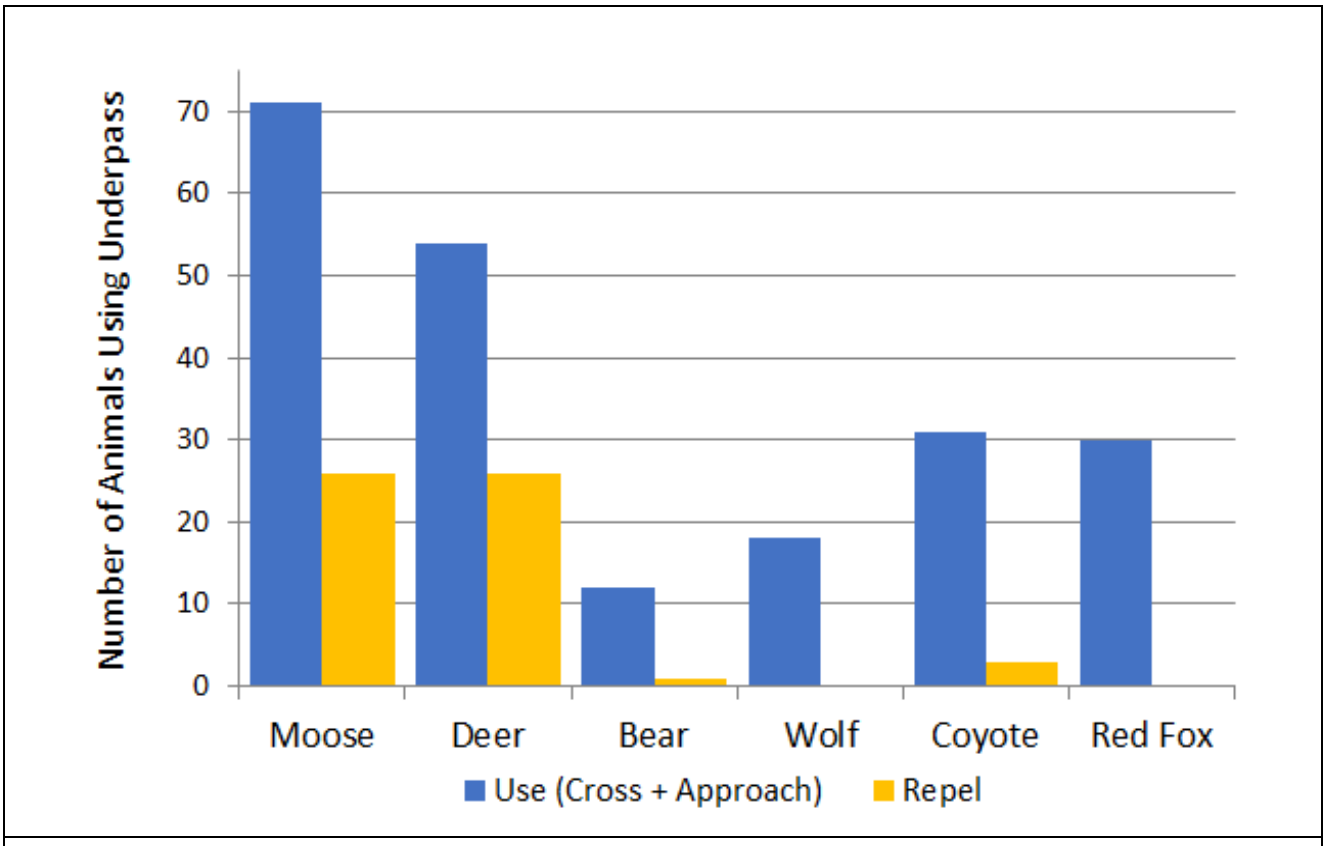


Figure 4:Summary of large and mid-size animal use at Burwash underpass

Photo 23:Burwash underpass entrance with wing-walls before fencing in June 2012

Photo 24: Burwash underpass showing open median and fencing abutting entrance

Photo 25:Doe and three juveniles in middle of Burwash underpass

Photo 26: Fox with kill approaching underpass

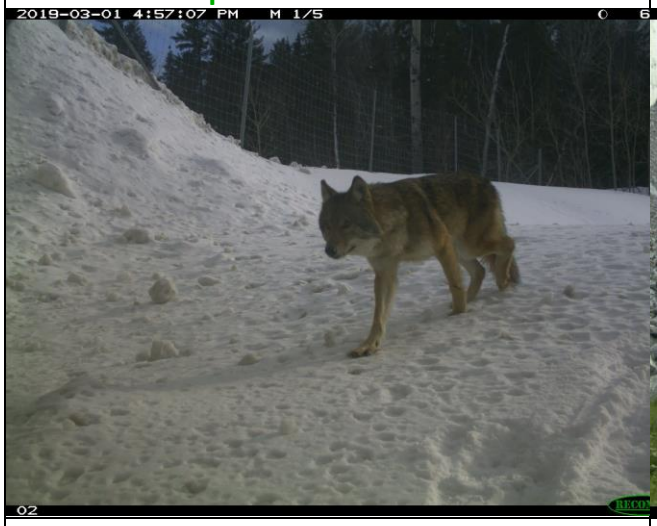


Photo 27: Coyote/wolf using underpass in 2019

Photo 28: Two younger moose entering underpass

Photo 29: Bear entering underpass

Photo 30: Cow and young in middle of underpass

Photo 31: Deer repelling from underpass

Photo 32: Moose turning around at underpass

5.3.2 Reptile Tunnels

Structure Type: Two 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 and there is an open median; wing-walls at each entrance to structure; water flow and pooling in spring and tapering off in late summer; any standing water freezes in tunnels in winter (Photo 33; Photo 34).

Monitoring methods:

- Tunnels were designed and located for Blanding's Turtles (*Emydoidea blandingii*), a species that is Threatened in Ontario;
- One to two cameras at each entrance of three tunnels;
- Snow-tracking completed approximately 8 times annually in the winter months;
- Cameras placed approximately 1 m high or on-top of structure to target large animals;
- Camera and snow-tracking monitoring period from January 2015 to September 2019;
- Concurrent monitoring for reptiles at structures using time lapse from 2015 to 2019;
- For comparison to other nearby crossing structures these structures were also monitored for large and mid-sized animals use.

Results (Figure 5):

- Tunnels are providing some connectivity for large animals; surprisingly six moose, eight deer, 11 bear, and two wolves have used the tunnel over 54 months (4.5) years of monitoring (Figure 5);
- Coyote regularly use the structures (64 times) followed by fox (29 times);
- Coyote passages has greatly increased in 2018 and 2019 and coyotes have used reptile tunnel 1 second to the wildlife overpass;
- Overall large animals that approached the structure used it 81% of the time, moose passage rates were lowest at 43%, followed by black bear at 65% and surprisingly deer passage rates (89%) were relatively high at 89% (Photo 35, Photo 36, Photo 37, Photo 38);
- Lynx have used the reptile tunnels four times in 2018, and 2019 (Photo 39);
- Frequency of ungulate use at these three smaller underpasses is lower than at the adjacent Burwash underpass structure, but the higher passage rates by deer at the reptile tunnels is noteworthy;
- A diversity of terrestrial and aquatic animals were captured using the reptile tunnels that includes weasels, river otter, beaver, mink; reptiles include the Blanding's turtle, snapping turtle and painted turtle (Eco-Kare International, in prep) and birds that includes the American bittern, great-blue heron, geese and ducks (Photo 40; Photo 41).

Conclusions:

- Smaller aquatic animals are using these structures the most because they are located where the highway bisects aquatic wetland habitat;
- Large animals don't regularly use the structures likely because they are located in wetland habitat, however, surprisingly deer are more likely to pass through the structure more-so than the adjacent larger Burwash Underpass;
- Over-sized underpass structure for reptiles have an additional benefit of providing connectivity for a diversity of large and smaller animals contributing to a multi-species strategy.

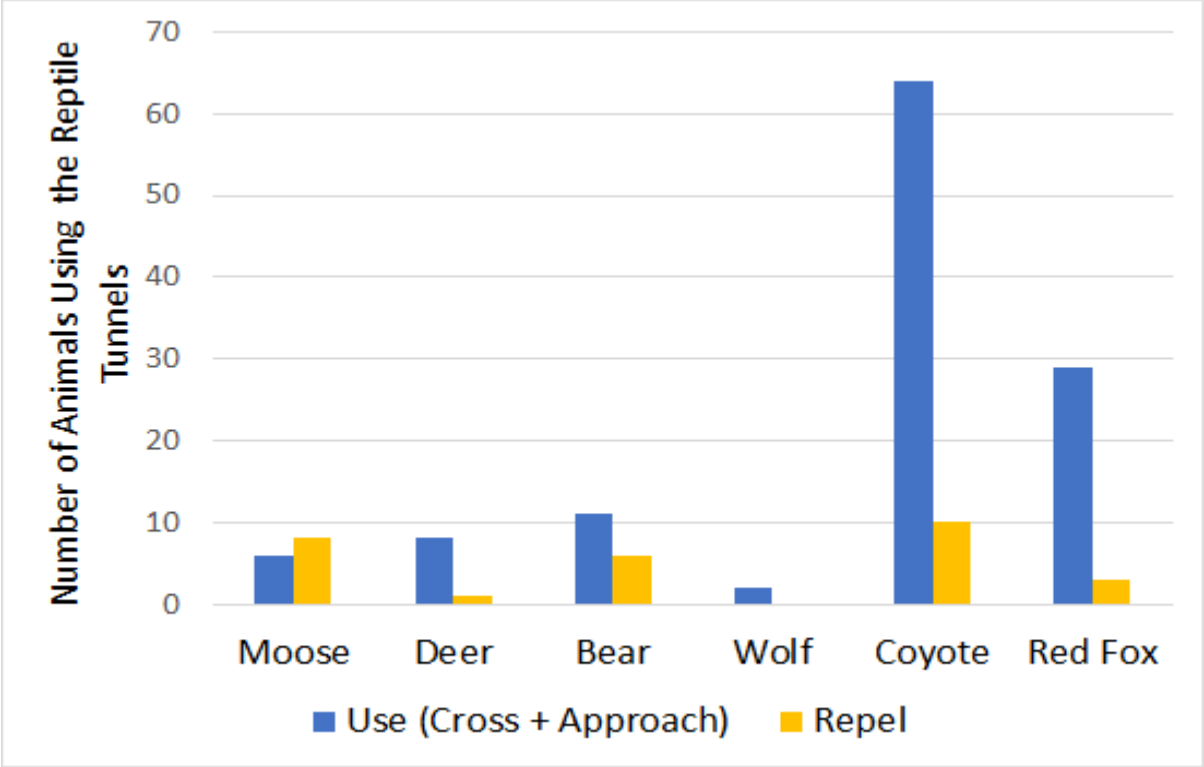


Figure 5: Summary of large- and mid-size animal use at the three reptile tunnels combined

Photo 33: Reptile tunnel with water pooled and aquatic vegetation in median

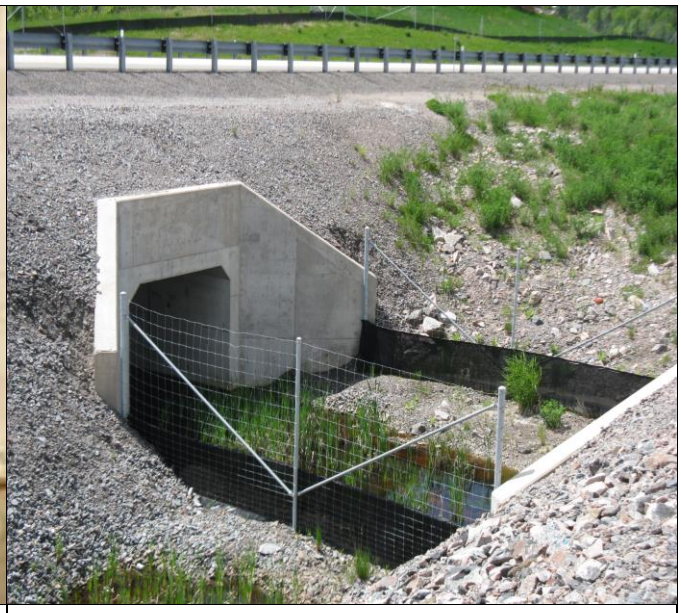


Photo 34: Open-median with fencing at reptile tunnel

Photo 35: Moose approaching reptile tunnel

Photo 36: Deer approaching reptile tunnel

Photo 37: Black bear using reptile tunnel in August 2019

Photo 38: Wolf using reptile tunnel in February 2019

Photo 39: First lynx passage through reptile tunnel 1; the same lynx crossed through the adjacent reptile tunnel 3 days later

Photo 40: American bittern approaching reptile tunnel

Photo 41: Mink with rabbit in reptile tunnel

5.3.4 Healey Underpass

Structure Type: Two twinned concrete structures under the NB and SB lanes; each structure is 4 m wide x 4 m high x 24.1 m long and there is an open median; wing-walls at each entrance to structure; paved trail in middle for All-Terrain Vehicles (ATV), and snowmobile use (Photo 42, Photo 43, Photo 44).

Monitoring methods:

- Two cameras at each entrance of the tunnel and one in the middle of the structure (Photo 45);
- Cameras placed approximately 1 m high on wing-wall at entrances, covered in snow in winter from snow plows;
- Monitoring began on November 2016 when fencing abutted the structure; all three cameras were stolen on August 2018 likely because of increased human use in the tunnels;

Results:

- Healey underpass is primarily providing connectivity for deer (35 passages) and is rarely used by moose, likely because population abundance for Moose is lower in this area (Figure 6);
- The underpass was rarely used by moose (Photo 46), black bear, coyotes, and red fox;
- Overall, during consistent monitoring periods animals used this structure less than the Burwash underpass and this was primarily due to lack of moose use;
- Surprisingly, sandhill cranes used the Healey underpass regularly on 17 occasions (Photo 47);
- Passage rates are higher for Deer (92%) when compared to Burwash underpass (68%) even though there is ATV (152 occurrences in 2017) and snowmobile (537 occurrences in 2017) use at Healey underpass (Photo 48; Photo 49),

Conclusions:

- Of all the underpass tunnels, Healey underpass is preforming the best for Deer passage and this may because of vegetation that is adjacent to the east approach;
- Longer-term monitoring is required to correlate human use with animal use; in 2017 there were 537 snowmobiles and 152 ATVs;
- Animal use was only monitored for a little less than two years; and Deer appear to be responding to the structure well.

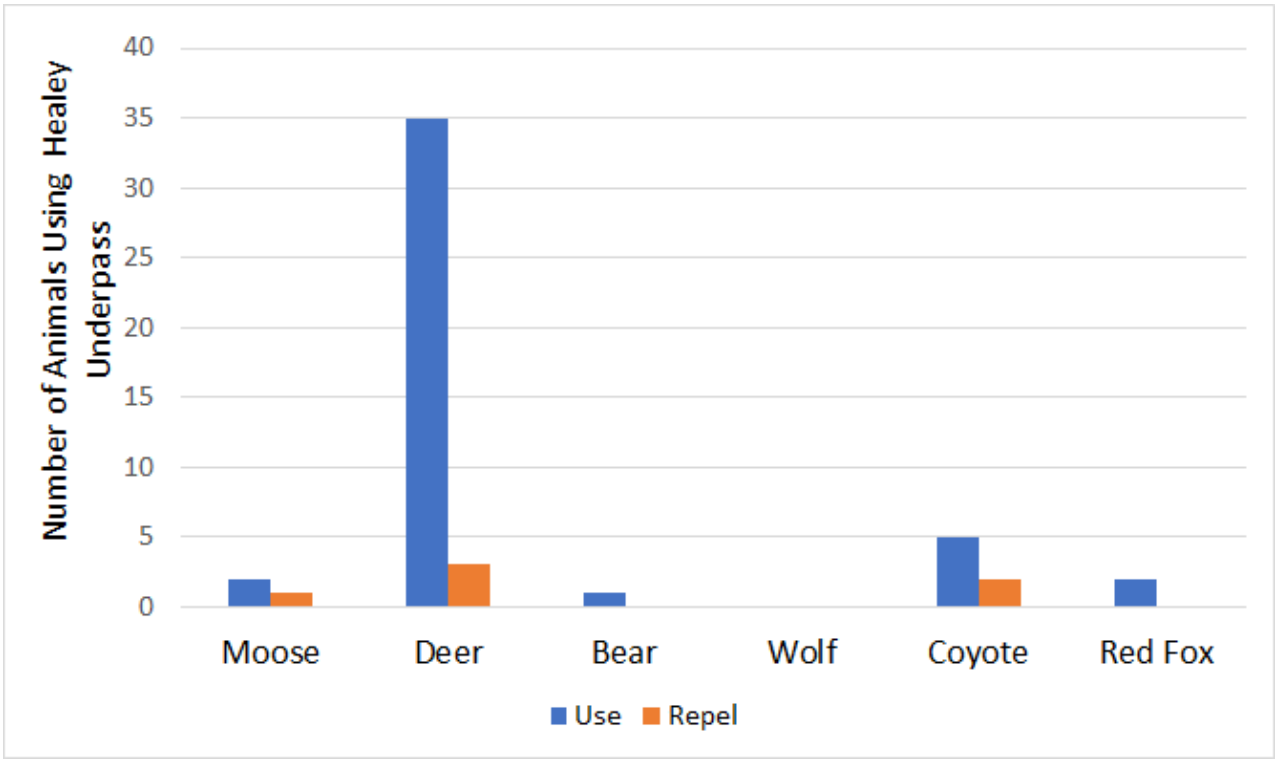


Figure 6: Summary of large- and mid-sized animal use at Healey underpass

Photo 42: Healey underpass with 4 m wide road running through structure

Photo 43: Healey underpass East entrance from top

Photo 44: Attaching reptile fence to large animal fence along Healey in November 2016

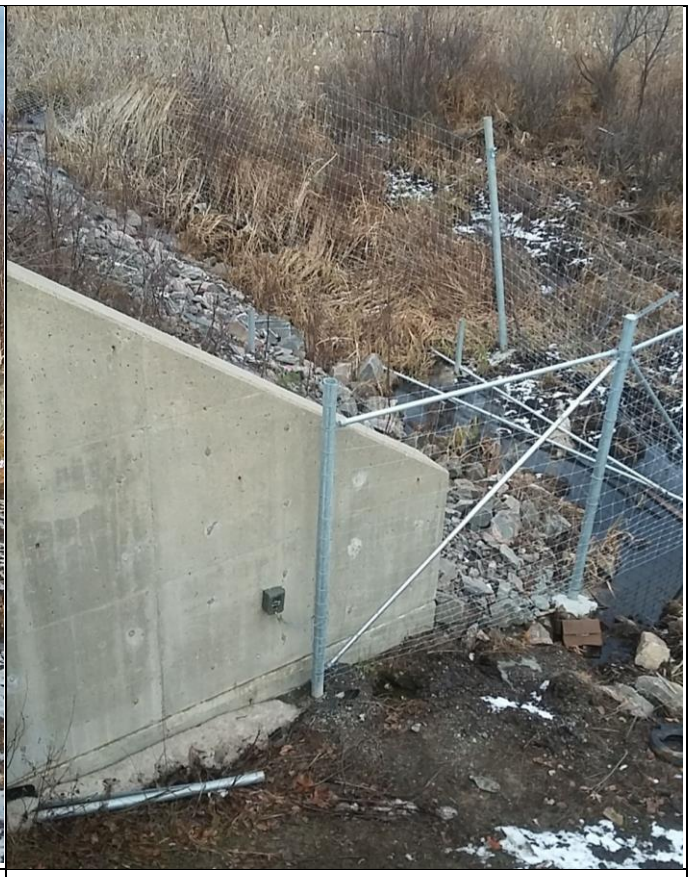


Photo 45: Camera monitoring animals entering structure at Healey underpass

Photo 46: Moose exiting Healey underpass in July 2018

Photo 47: Sandhill Cranes entering Healey underpass

Photo 48: Grooming the trail under Healey underpass for snowmobile use

Photo 49: Snowmobile using trail at Healey underpass

5.4 Do Bridge Pathways Work?

5.4.1 Lovering Creek Bridge

Structure Type: Two metre granular pathway constructed on north side of river gorge under highway bridge; connected to rugged, rocky trails along the creek (Photo 50; Photo 51).

Monitoring methods:

- Two cameras at each entrance and one camera on trail approaching east side of wildlife pathway or ledge;
- Cameras do not necessarily capture all wildlife passage under structure, wildlife may cross out-of-sight from cameras and cross closer to the creek;
- Snow-tracking completed approximately 8 times in each of eight winter seasons from 2011 to 2019;
- Monitoring summarized for data collected after mitigation was finished between July 1st 2012 to September 13th 2019.

Results:

- Animal use along the wildlife ledge increased as animal size decreased (Figure 7);
- Moose used the structure the least (2 times), followed by 7 deer, 16 bear, 19 wolves, 26 coyote, and 51 red fox (Photo 52; Photo 53; Photo 54; Photo 55; Photo 56; Photo 57).

Conclusions:

- Smaller animals are able to navigate the steep rocky bedrock slopes to reach the wildlife ledge and be captured on the cameras;
- Canid use (red fox, coyote and wolves) was steady between 10 and 17 animals per year from 2015-2019 and peaked in 2018 and 2019 when larger canids, likely wolves began using the structure;
- Although the frequency of animals on the pathway is likely under-estimated due to camera placement and positioning, animals (with the exception of moose) are willing to use the ledge;
- Wildlife pathways along waterways may be improved with wider, level pathways, e.g. Murdock River crossing and are a cost-effective approach for creating safe wildlife passage on highways.

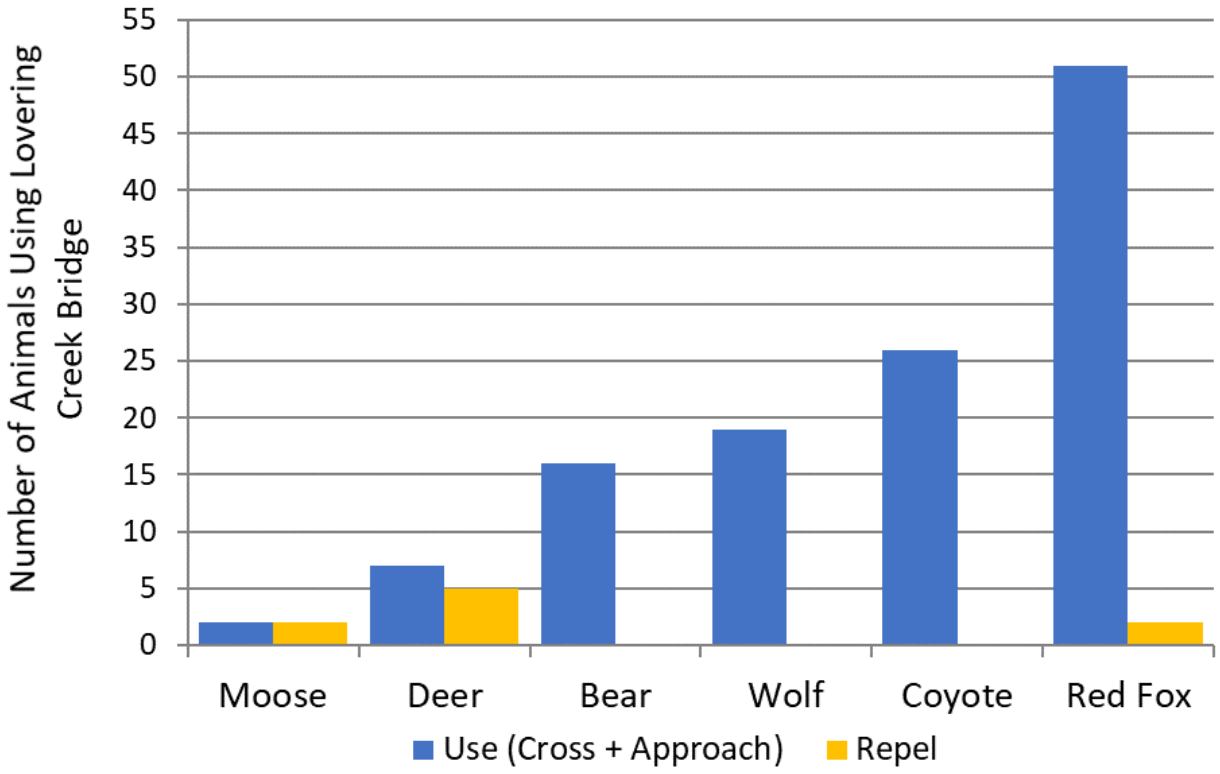


Figure 7: Summary of large and mid-size animal use at Lovering Creek bridge pathway

Photo 50: Walking up to Lovering Creek wildlife pathway on east side (top); looking from south side at wildlife ledge (bottom)

Photo 51: Close-up of 2 m wildlife pathway in median of Lovering Creek bridge

Photo 52: Male moose approaching wildlife pathway from east side

Photo 53: Several deer approaching wildlife pathway from east side

Photo 54: Coyote approaching wildlife pathway from west side

Photo 55: Red fox entering onto wildlife pathway at east side

Photo 56: Black bear exiting wildlife pathway on west side

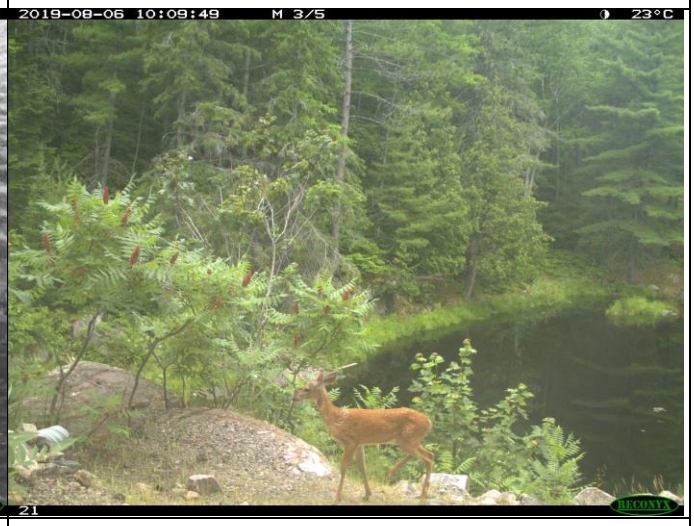


Photo 57: Deer approaching wildlife pathway on east side

5.4.2 Murdock River Bridge

Structure Type: Two open bridges with open median spanning the Murdock River gorge; Eight metre wide granular wildlife pathway follows moderate terrain of the river on the north and south side (Photo 58; Photo 59).

Monitoring methods:

- Four cameras at each of the four northeast, southeast, southwest, and northwest bridge abutments along wildlife pathway (Photo 60);
- Animals able to move out-of-sight of the camera field-of-view to cross structure;
- Monitoring conducted from January 13th 2016 to September 13th 2016.

Results (Photo 58 to Photo 65):

- Moose (2 times), deer (4 times), coyote (2 times) and red fox (1 time) have used the structure in the first 9 months of monitoring (Figure 8; Photo 62; Photo 64; Photo 65; Photo 66; Photo 67);
- Wolves were found crossing the structure in January 2017 (Photo 63);
- There were fewer large animal passages at the structure than other nearby structures likely because animals are able to circumvent the cameras
- None of the animals captured on cameras, have noticeably repelled.

Conclusions:

- Wildlife are willing to use Murdock River crossing and longer-term monitoring with additional cameras would likely show an increased frequency of wildlife passage;
- Wildlife fencing should be extended from Murdock River crossing at least 200 m at the NB, SB, EB, and WB abutments which may improve wildlife abundance along the pathways.

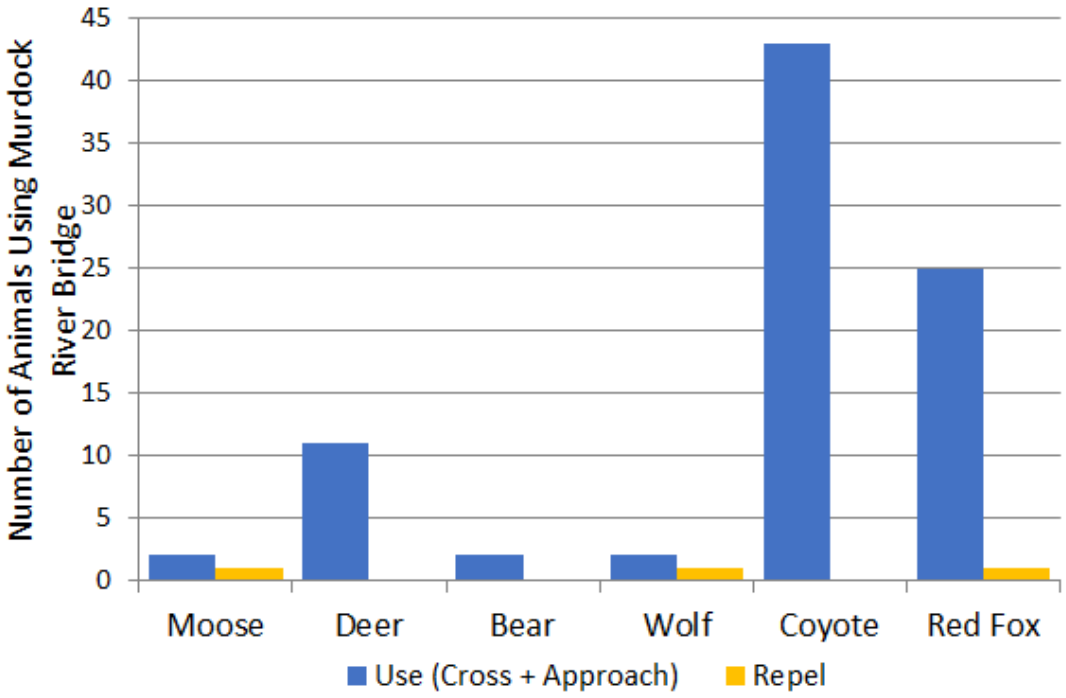


Figure 8: Summary of large and mid-size animal use at Murdock River bridge pathway

Photo 58: Animal tracks under bridge in winter

Photo 59: Graded granular pathway for wildlife crossing at Murdock River bridge, northbound lanes

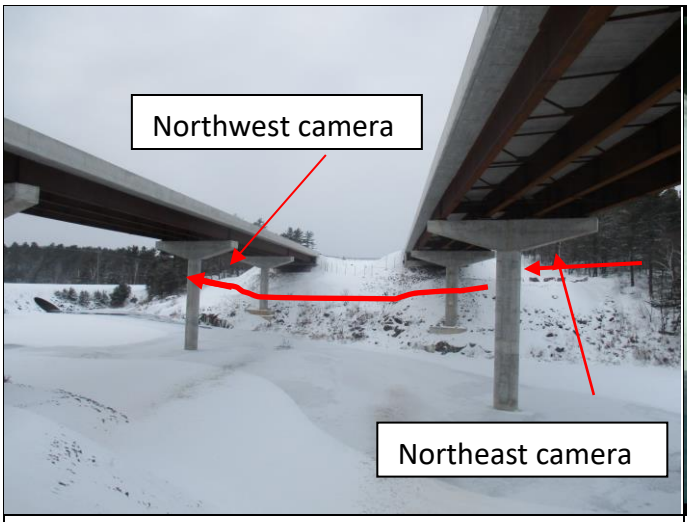


Photo 60: Animal movement path on north side shown with red arrow

Photo 61: Data acquisition moving away from northwest camera (later stolen) that was placed on a tree

Photo 62: Deer approaching northeast side of path

Photo 63: Wolf crossing at southeast side

Photo 64: Moose exiting northwest side of path

Photo 65: Coyote crossing at southwest side

Photo 66: Black bear moving along south side of Murdock River pathway

Photo 67: Red Fox moving past camera placed on southwest bridge pillar at Murdock River bridge

5.5 What Structure do Wildlife Prefer?

Monitoring methods:

- Wildlife 'use' is defined as an approach: an animal that enters into/onto or exits out of/away from an underpass or overpass respectively and a confirmed cross or passage where an animal is captured entering and exiting from the structure;
- A 'repel' is when an animal enters into/onto a structure and immediately turns around with no apparent reason as seen by the camera; animals that look at the camera or come onto the overpass to feed are not included as a repel;
- Passage rate index is [use/(use + repel)];
- This index was used to compare what structure large- and mid-sized animals preferred to use to cross under or over the highway;
- Post construction data from July 1st, 2012 to September 13th, 2019.

Results (Figure 9; Table 3)

- At all of the crossing structures, repels were generally low (6%) for large- to mid-sized animals;
- Higher passage rates were observed at the more open structures such as the overpass, and bridge pathways (>90%) than at the structurally enclosed underpasses (>79%);
- Canids, black bears and deer had the highest passage rates (>90%), followed by moose (88%);
- Repels occurred more often than expected when adult female deer and moose travelled with juveniles than without juveniles at both the Burwash underpass and overpass;
- Generally, ungulates (moose and white-tailed deer) quickly habituate to using the overpass and do not repel from the structure, while at the Burwash underpass, passage rates varied over the seven-year period and peaked in 2018/2019 (Figure 9).

Conclusions:

- Wildlife overpasses and large open-span bridges (Photo 70) are the optimal crossing structure type for providing safe passage for all large and small animals due to the increased openness;
- The wildlife overpass has the highest frequency of animal crossings than other structures because of the 'natural' open conditions and vegetation helps to absorb noise and provide food resources for ungulates (Photo 68);
- Structurally enclosed box structures are likely used less because of traffic vibrations overtop of the structure and minimal vegetative growth inside and adjacent to the structure (Photo 69; Photo 71);

- Fewer large- to mid-sized terrestrial animals likely cross at the reptile tunnels because of the presence of water in warm weather and ice in cold weather, not necessarily because of the smaller size as compared to the Burwash underpass.

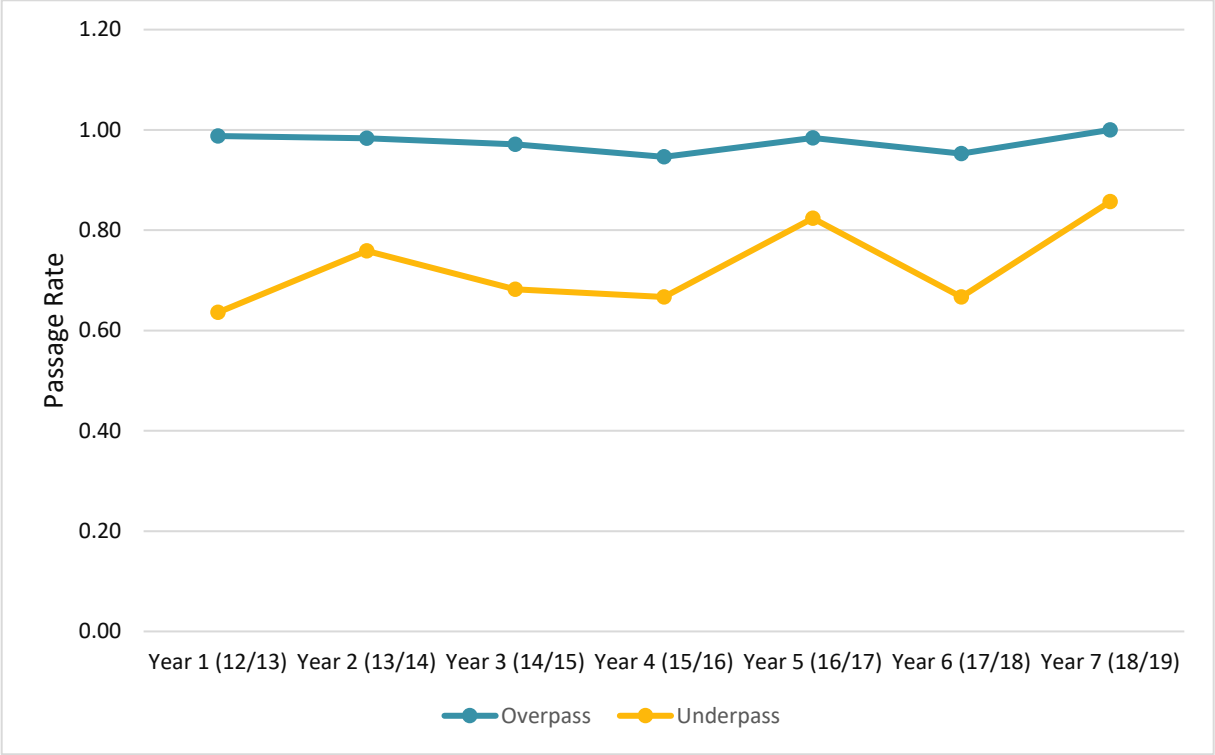


Figure 9: Passage rate comparison for moose and deer on the overpass and Burwash underpass over the seven-year post-monitoring period (above)

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

Structure	OR (height*width)/ length	Moose	Deer	Bear	Wolf	Coyote	Red Fox	Total
Overpass	NA	0.97	0.99	0.94	0.94	0.92	0.95	0.96
Burwash Underpass	(5 x 5)/14=1.79 (open median)	0.73	0.68	0.92	1.00	0.91	1.00	0.79
Lovering Creek bridge	NA	0.50	0.58	1.00	1.00	1.00	0.96	0.93
All Reptile Tunnel (3)	(2.8 x 3.3)/24=0.39 (open median)	0.43	0.89	0.65	NA	0.86	0.91	0.81
Murdock River bridge	NA	0.67	1.00	1.00	0.67	1.00	0.96	0.97
Healey Underpass	(4 x 4)/16=1.00 (open median)	0.67	0.92	1.00	1.00	0.71	1.00	0.86
Total		**0.88**	**0.96**	**0.92**	**0.97**	**0.92**	**0.95**	**0.94**

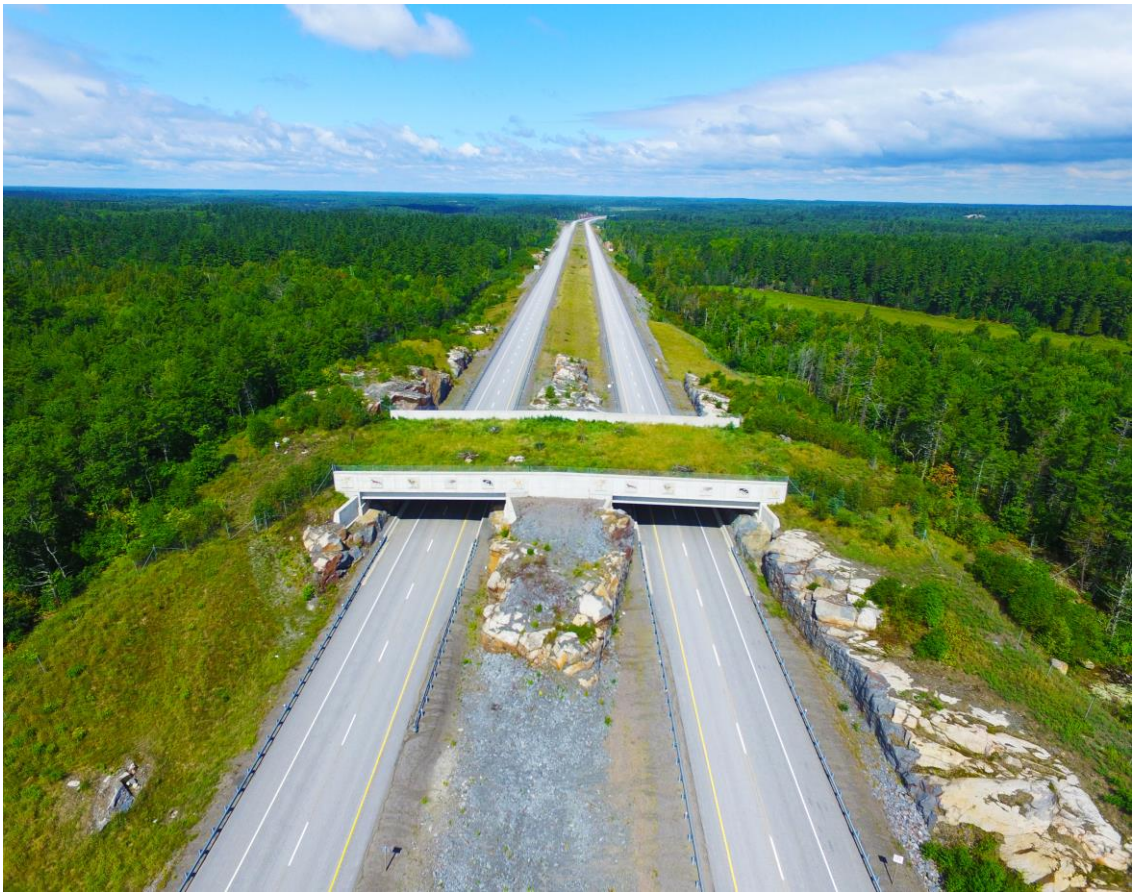


Photo 68: Burwash widlife overpass top view and adjacent forest

Photo 69: Aerial view of Burwash underpass before the highway was opened

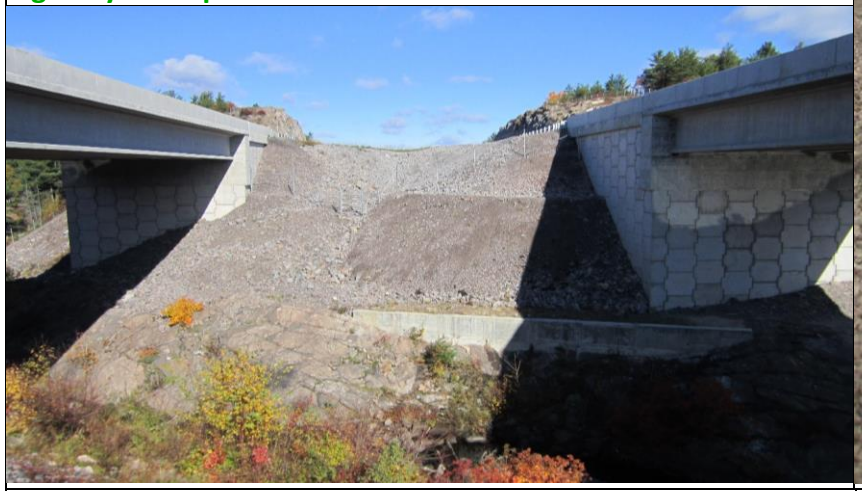


Photo 70: Highway 69 wildlife ledge/pathway on north side of Lovering Creek bridge

Photo 71: Reptile tunnel being installed into new highway construction

5.6 Are there Seasonal Patterns of Wildlife Use on the Overpass?

Methods and Result (Photo 72; Photo 73; Photo 74; Photo 75; Photo 76; Photo 77; Photo 78; Photo 79):

- Seasons were defined as summer (June, July, August; Photo 75); fall (September, October, November; Photo 73); winter (December, January, February; Photo 74; Photo 76; Photo 79); and spring (March, April, May; Photo 78) for deer, moose, black bear and canids (wolves, coyotes, and red fox) that used the overpass;
- Year 1 is defined from Sep-2012 to Aug-2013; Year 2 from Sep-2013 to Aug-2014; Year 3 from Sep-2014 to Aug-2015 and Year 4 from Sep 2015 to Aug 2016, etc., up to Year 7 from Sep 2018 to Aug 2019;
- Black bear, moose, and canid (red fox, coyotes and wolves) use of the overpass remained stable over the seven-year monitoring period (Figure 10);
- Deer use of the overpass greatly declined over the seven-year monitoring period and this was correlated to abundance as measured by annual deer harvest/hunter in the corresponding Wildlife Management Unit;
- Deer and black bears used the overpass the most in the summer (Photo 75) followed by the fall season;
- Moose use was noticeably higher in the spring months (Photo 78);
- Canids used the overpass equally in all seasons.

Conclusions:

- There are species-specific temporal changes of animal use of crossing structures and this is evident annually and seasonally;
  - A decline in deer use is attributed to changes in deer abundance and not due because deer were unwilling to use the structure over time;
  - Moose have salt-deficient winter diets and likely use the overpass more in the spring to acquire salt from road-side ditches and aquatic vegetation.

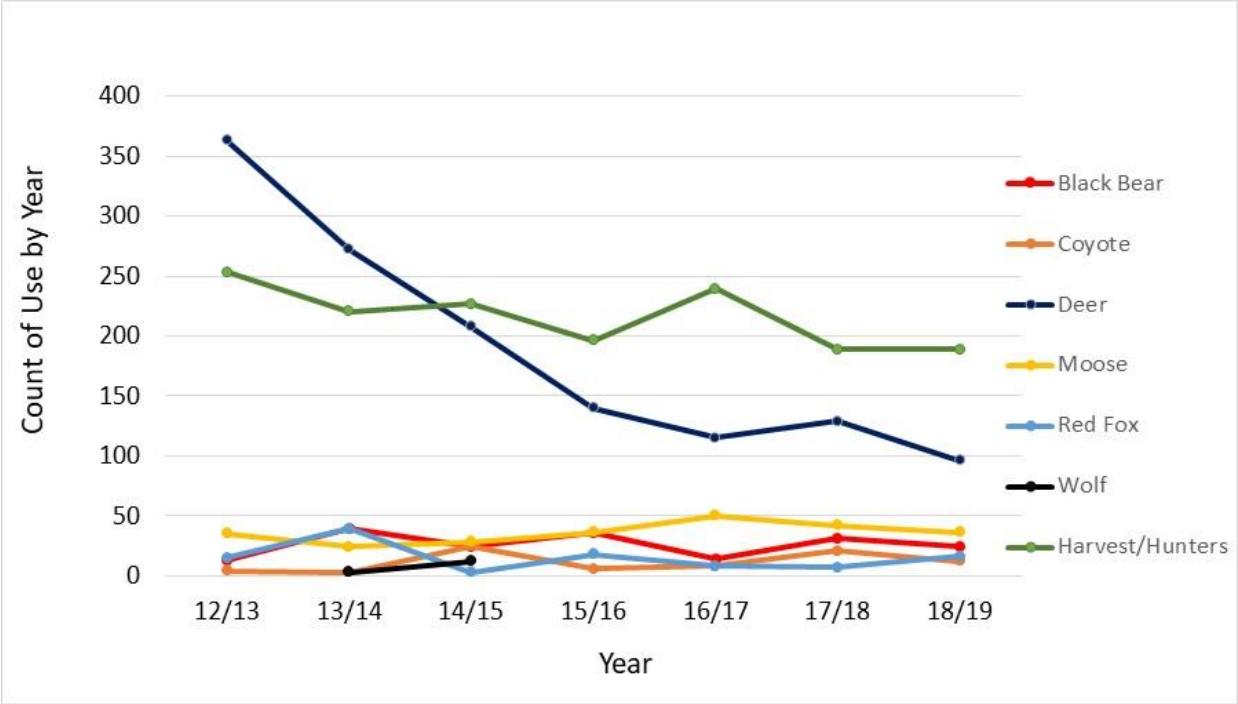


Figure 10: Summary of annual use of overpass for all large- and mid-sized animals over the seven year monitoring period. Deer use is correlated to the annual hunter harvest over the same time period.

Photo 72: Winter landscape on Burwash overpass

Photo 73: October fall colours on overpass

Photo 74: Two moose exiting overpass in winter

Photo 75: Deer grazing in meadow in summer

Photo 76: Red fox leaving tracks on overpass

Photo 77: Young moose in June on overpass

Photo 78: Young moose in spring thaw

Photo 79: Wolf on overpass on Christmas eve

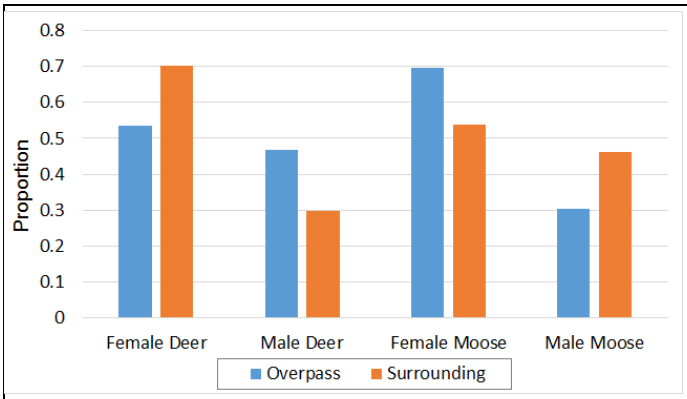
5.7 Are there sex- and age- related wildlife patterns of use

Methods & Results (Figure 11; Photo 80 to Photo 83):

- Only the Burwash underpass and overpass were evaluated;
- The number of times a juvenile moose (calf) or deer (fawn) were observed on the overpass was summarized;
- Adult female deer often travelled on the overpass with young fawns (80 occasions) (Photo 82);
- Additionally, adult female moose often travelled with their calves (28 occasions);
- Sex of ungulates (deer and moose) was defined for the fall and summer months when antlers are clearly visible (male) (Photo 80), or not (female) (Photo 81) in the photos;
- 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) from July 1st, 2012 to July 20th, 2015;
- Significantly more male deer and fewer female deer were observed on the overpass than were observed in surrounding areas;
- There were no sex-related differences for deer and moose that used the underpass.

Conclusions:

- Offspring that use the overpass at an early age will likely use the crossing structures throughout their life-time and therefore the number of repels should decrease over time as the local deer population habituates to the crossing structures;
- More male deer likely use the overpass, primarily in summer and fall months, because males are moving to find mates in the fall and generally move larger distances than females.



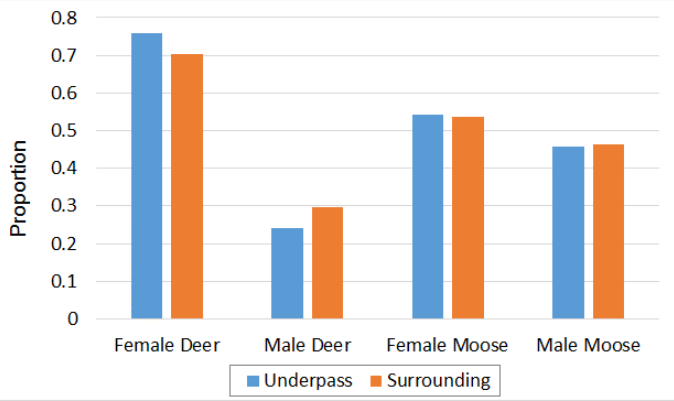


Figure 11: Proportion of female and male deer at overpass and underpass

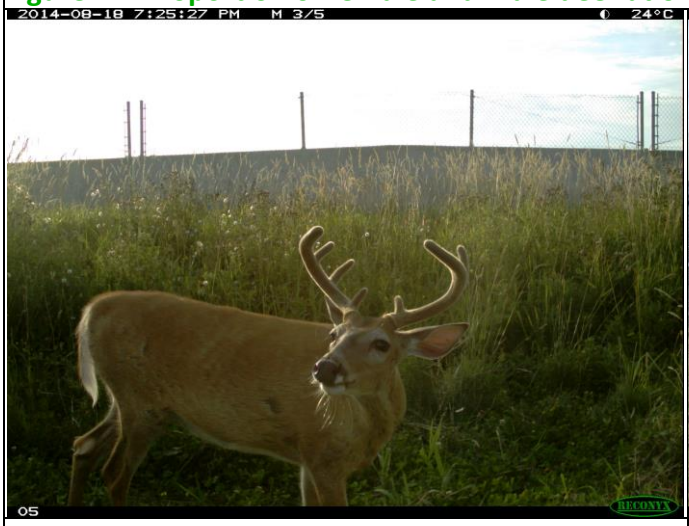


Photo 80: Male deer grazing on overpass in August

Photo 81: Cow moose entering underpass.

Photo 82: Doe and fawn using overpass in winter

Photo 83: Adult female with doe on access road

6 Do one–way gates work?

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); some are placed in-line with fence, and other set-back with fence forming a V pattern to funnel animals to gate (Photo 84; Photo 85).

Methods:

- Six to 15 one-way gates were monitored during the study period. Gates also monitored with snow tracking surveys approximately 8 times a winter season;
- Post construction data from September 1st, 2011 to July 20th, 2015;
- All animal records were defined as animal moving safe-side to road-side (not as intended) and moving road-side to safe-side (as intended);

Results (Figure 12; Photo 84 to Photo 91):

- On Highway 69, there were 26 passages through the one-way gates road-side to safe-side as intended;
- 100% of all four deer passages were as intended (Photo 91), and 76% of all 13 Bears captured moving through gates were as intended (Photo 88);
- 0% (2 total), 75% (4 total), and 50% (18 total), lynx, coyote and fox passages respectively were as intended;
- Small mammals (rabbits, racoons, 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 (road-side to safe-side) but can 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 designed in a V formation with adjacent exclusion fence will facilitate movement of animals towards gates and not past gates;
- Prongs designed closer together with no gaps may deter wrong-way passage by bears, and other mid-size animals;
- Measures such as jump-outs designed effectively are recommended for future mitigation projects.

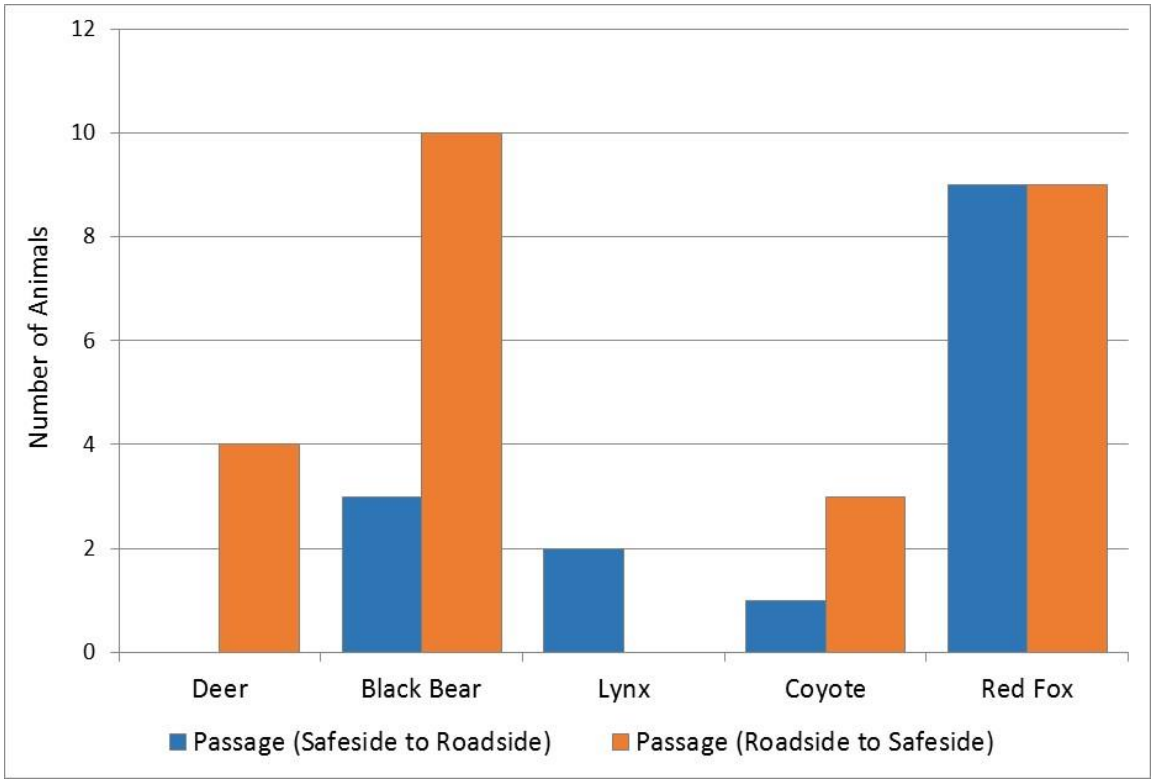


Figure 12: Number of animal passage through one-way gate

Photo 84: One-way gate in-line with fence

Photo 85: Gate set-back from fence in V-design

Photo 86: Bear exploring one-way gate

Photo 87: Lynx using one-way gate not as intended safe-side to road-side

Photo 88: Bear using gate as intended

Photo 89: Deer using gate set-back from fence

Photo 90:Moose approaching gate road-side

Photo 91: Deer using gate road-side to safe-side

7 Do Ungulate Guards Work?

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 (Photo 92; Photo 93). Two guards located at Murdock River road, south of Highway 637, and at Burwash road, north of Highway 637 (Figure 1).

Methods:

- Monitoring at two sites with one camera intermittingly from Oct 8th, 2013, to July 2015;
- All animal records were defined as an animal crossing, or repelling from the gate.

Results (Photo 92 to Photo 99):

- Twenty-six animals were documented crossing, repelling or jumping over (e.g. deer; Photo 94) the guards;
- 14 red fox, 1 deer, 2 wolves, 2 coyotes, 1 black bear (Photo 96), and 1 lynx (Photo 98) walked across the guard (81% of interactions);
- The guards successfully repelled 1 deer, 2 wolves (Photo 95), and 2 coyotes (19% of interactions);
- One elk crossed the guard but it's legs fell through the bars (Photo 97);
- Moose have not been detected at the guards.

Conclusions:

- More animals were able to breach the gates than were repelled (as intended);
- There is a safety concern with the gates for elk falling through and deer jumping over;
- Research on proven and effective designs used elsewhere is recommended and retro-fits to design should be implemented.

Photo 92: Ungulate guard at Murdock road

Photo 93: Width of bars ontop of guard

Photo 94: Deer jumping over ungulate guard

Photo 95: Wolf turning away from guard

Photo 96: Bear crossing/breaching guard

Photo 97: Elk falling between bars

Photo 98: Lynx crossing guard

Photo 99: Wolf crossing guard

8 Are Exclusion Fencing and Crossing Structures Working on Highway 69?

8.1 How Often are Wildlife Observed on the Road-side of the Fence?

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

Methods:

- Six to 15 one-way gates were monitored during the study period;
- Gates also monitored with snow-tracking surveys approximately 8 times a winter season from September 1st, 2011 to July 20th, 2015;
- A breach of the fencing system was defined in three ways: an animal observed road-side of the fence, an animal travelling around a fence-end towards the highway, and an animal that went through a one-way gate the wrong way;
- Only one observation was counted for multiple individuals that were observed more than once on each day.

Results (Photo 100 to Photo 105):

- Deer breached the fence system 39 times (e.g. Photo 103) and the majority of the breaches were near fence-ends (Photo 105) or gaps: 51% 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 two times and coyote two times;

Conclusions:

- Of the large animals the fencing system works most effectively at excluding moose from the mitigated section of highway;
- Black bears are able to go through one-way gates both ways, and can easily go under or climb over the fence;
- Deer are able to navigate 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 would reduce the occurrence of animals moving around the northerly fence-end;

- A fence-end retro-fit such as an inward fence extension at the Highway 637 interchange or an electro-mat system at the highway interchange could improve fence breaches at the southerly fence-end.

Photo 100: Moose on the road-side of fence

Photo 101: Deer on the safe-side of fence near Highway 637 interchange

Photo 102: Black bear on road-side of fence

Photo 103: 3 deer walking road-side of fence near Trout Lake road

Photo 104: Elk on safe-side of fence

Photo 105: 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 exclusion fencing was installed.

Methods:

- The Ontario Provincial Police compile WVC data for vehicle accidents greater than $1,000 in property damage and this data is then geo-referenced by the Ministry of Transportation (2003 to 2015);
- The research team also collected WVC information when carcasses were found on the highway from September 2011 to September 2019;
- These data above were evaluated to assess whether fencing and crossing structures reduced the number of WVC before and after fencing.

Results (Photo 106-Photo 107):

- Overall, there was a 74% reduction in black bear, moose and deer collisions after fencing and crossing structures were functional (2003-2018; Table 4, MTO unpublished data);
- A species-specific evaluation shows that deer and moose collisions were reduced by 78%, while black bear decreased by 17% (Table 4, MTO unpublished data);
- Before the exclusion fence was complete the research team found 1 ungulate, 1 moose, 1 elk, 1 wolf, and 2 deer in the Burwash mitigated section before exclusion fence was complete (2011-2012; 6 WVC per year);
- After the exclusion fence was complete the research team found 5 black bears, and 2 deer in the fenced Burwash area (2012-2019; 1.2 WVC per year).
- The two deer collisions were likely associated with the Killarney fence-end at the Highway 69 and 637 interchange;
- Overall, the research team found fewer WVC occurrence along the Burwash mitigated section, however this was not the case for black bears (Table 4).

Conclusions:

- Overall, the fencing and crossing structures are working to reduce WVCs for large animals on Highway 69;
- A species-specific evaluation shows that the mitigation works best for moose, moderately effective for deer, and less so for black bears;

- Retro-fits of the exclusion fence to improve effectiveness could include a buried apron along its length, top wires angled inwards to deter climbing, and additional fencing to exclude bears from using one-way gates the wrong way;
- Fence-end retro-fits such as large boulders, rip rap, 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 2018 before and after large animal exclusion fencing was installed

Before Fencing				
Year	**Moose**	**Deer**	**Black bear**	**Total**
2003	7	3	1	11
2004	6	3	1	10
2005	12	3	0	15
2006	2	3	0	5
2007	0	3	0	3
2008	7	3	0	10
2009	4	2	2	8
2010	4	3	2	9
2011	3	1	1	5
2012	5	1	1	7
Average	**5**	**2.5**	**0.8**	**8.3**
After Fencing				
2013	0	0	1	1
2014	1	1	1	3
2015	1	0	1	2
2016	1	2	0	3
2017	2	2	0	3
2018	0	0	1	1
Average	**0.8**	**0.83**	**0.67**	**2.17**
Change	**83% decrease**	**67% decrease**	**17% decrease**	**74% decrease**
Data Source: Ministry of Transportation				

Photo 106: Bear road-side of wildlife fencing

Photo 107: Wolf killed on highway 69

9 Conclusions

- All structure types combined provide a cost-effective, multi-species strategy that optimizes safe passages and connectivity for wildlife along the Highway 69 corridor;
- The more wildlife crossing opportunities, the less likely animals will move along the fence and breach the fence to access the highway;
- Wildlife movement integrated into riparian bridge structures are essential because drainages are often used as wildlife corridors;
- Vegetation at structure entrances and in medians, such as that naturally occurring at the reptile tunnels, should be integrated into all underpass structure design;
- Long-term monitoring showed an increase use of wildlife passages by the faunal community, primarily the Canada lynx and younger ungulates; deer use decreased and this was correlated to hunter/harvest data which is often used as an index of population abundance;
- There was a 74% decrease in wildlife-vehicle collisions with large animals along the Burwash mitigated sections, and this can be further improved by closing exclusion fence gaps, extending the fence southerly and northerly, closing one-way gates, burying the fence bottom, and reducing the probability of wildlife access onto Highway 69 at the Killarney fence end interchange.

10 References

Beyer HL, Ung R, Murray DL, Fortin M-J. 2013. Functional responses, seasonal variation and thresholds in behavioural responses of moose to road density. Journal of Applied Ecology **50**:286–294.

Chruszcz B, Clevenger AP, Gunson KE, Gibeau ML. 2003. Relationships among grizzly bears, highways, and habitat in the Banff-Bow Valley, Alberta, Canada. Canadian Journal of Zoology **81**:1378–1391.

Clevenger AP, Barrueto M, editors. 2014. Trans-Canada highway wildlife and monitoring research. Part B: Research. Final report prepared for Parks Canada Agency, Radium Hot Springs, British Columbia. 314 pp.

Cserkész T, Ottlecz B, Cserkész-Nagy Á, Farkas J. 2013. Interchange as the main factor determining wildlife–vehicle collision hotspots on the fenced highways: spatial analysis and applications. European Journal of Wildlife Research **59**:587–597.

Eco-Kare International. 2014. Monitoring effectiveness of large mammal mitigation measures: Highway 69 between Sudbury and Parry Sound, Final report submitted to the Ministry of Transportation, Northeastern Region, North Bay, Ontario, 92 pages.

McGeachy D. 2014. Population distribution and seasonal resource selection by elk (Cervus elaphus) in Central Ontario. MSc in Biology from Laurentian University, Sudbury, Ontario.

Ministry of Transportation. 2010. Provincial Highways Traffic Volumes 2010 (AADT Only). King's Highways / Secondary Highways / Tertiary Roads. Ministry of Transportation, Highway Standards Branch, Traffic Office.

Appendix A Acronyms

AADTV	Annual Average Daily Traffic Volume
MTO	Ministry of Transportation
NER	Northeastern Region
OPP	Ontario Provincial Police
OR	Openness Ratio
OW gate	One-way Gate
ROW	Right-of-Way
UP	Underpass
WVC	Wildlife-Vehicle Collision(s)