# The Frontenac Arch Road Ecology Project - Highway 2 road mortality hotspot identification

*2017-2018 Final Report*

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Prepared by:
John Urquhart, Josh Jones, Ryan Danby, Monique Aarts and Cameron Smith

On behalf of:
Algonquin to Adirondacks Collaborative
1 Jessie St, Lansdowne, ON K0E 1L0
info@a2acollaborative.org

For:
Ontario Ministry of Natural Resources and Forestry

# Contents

# Introduction

Roads are a major threat to wildlife because they destroy habitat, cause direct mortality due to wildlife vehicle collisions, cause indirect mortality through land, water and air pollution, and reduce or eliminate the ability of species to move among habitat patches. There are three highways between Gananoque and Brockville that block animals from following a major continental movement corridor that extends from the Canadian Shield, south down the Frontenac Arch across the St. Lawrence River over the Thousand Islands. This report catalogues the seriousness of that blockage, and initiates a discussion on what can be done to mitigate the problem. Its primary focus, for which funding was obtained, is on species at risk, but in the course of pursuing that focus, it considered all vertebrates that tried to cross the highways and were killed. The data from this report will be used to map pathway habitat on both sides of the highways, extending roughly 25 kilometres to the north, and southward to the American side of the St. Lawrence River. It will provide the basis for a second report that will present comprehensive recommendations on highway mitigation. In the meantime this report contains some initial recommendations concerning mortality hotspots, highway signage, and roadside maintenance.

Humans continue to alter the landscape at unprecedented rates and scales. This level of impact makes it extremely difficult for most animals to adapt quickly enough, i.e. they have not evolved to avoid impacts or make use of the new anthropogenic ecosystems (Dickson and Brier 2002, Fahrig and Rytwinski 2009). As a result, landscape ecologists, conservation biologists and environmental planners are focusing their efforts and creating resilient landscapes. Resilient landscapes have large core protected areas with diverse habitats that are connected by narrower habitat corridors. This ensures habitat availability and the ability of wildlife to move between core areas in response to environmental changes (Ament et. al. 2014). Ensuring landscape resilience is particularly important in the face of a warming climate that will change entire ecosystems and require many species to migrate to more suitable habitat (Nunez et. al. 2013).

In eastern North America, the Great Lakes present a major barrier to movement. For most species, these lakes are a complete barrier. As a result, movement of terrestrial fauna is concentrated on land masses at the edges of these lakes (Roch 2015, Carr et. al. 2007). East of the Great Lakes, the St. Lawrence River presents a smaller barrier that substantially increases in width, and barrier strength as it flows east of Quebec City. Most of the landscape between Kingston (the eastern end of Lake Ontario) and Quebec City is heavily modified within 10-50 km of either side of the St. Lawrence River for residential development and agriculture. The main exception to this is the Frontenac Arch – a narrow, southern projection of the Canadian Shield that extends across the St. Lawrence into upstate New York (Figure 1). The Canadian portion of the Arch was designated a World Biosphere Reserve in 2002, in part due to its relatively intact landscape and high species diversity. In turn, the Arch is part of the Algonquin-to-Adirondack (A2A) conservation corridor, a broad region linking Algonquin Provincial Park in Canada to Adirondack State Park in the United States.

The Frontenac Arch has shallow soils that are unsuitable for most conventional agriculture and is situated just east of Lake Ontario. As a result, substantial natural habitat remains. This draws movement of animals from the west, trying to get around Lake Ontario. It also draws animals from the east that are unable or unwilling to travel through urban, rural and agricultural landscapes. As a result, this area is the most

## Study site

Phase 1 of this project was led by Parks Canada and involved conducting bicycle surveys on the Thousand Islands Parkway three times each week throughout the active season. Reptile and amphibian species were the primary targets but all vertebrate species were recorded. Phase 2 of the project was led by Algonquin to Adirondacks Collaborative, Queen’s University and the Ontario Road Ecology Group. This project involved walking the shoulders of Highway 401 in both directions as many times as feasible in 2014 and 2015. Phase 3 is the portion of the project that was conducted during the funding period. This phase added Blazing Star Environmental as a partner and focused on the third of the three parallel highways through the study area – Highway 2. A combination of bicycle, and slow moving vehicle surveys were conducted 3 times a week throughout the active seasons of 2016 and 2017.

Surveys were conducted on the Thousand Islands Parkway in Phase 1 and along Highway 401 in Phase 2 and Phase 3 (Figure 2). The 401 surveys were conducted in a compressed time frame so that all portions of this stretch of Highway would have directly comparable mortality levels that would improve the accuracy of our hotspot analysis. This data will improve the final recommendations of the mitigation measures across all three highways.

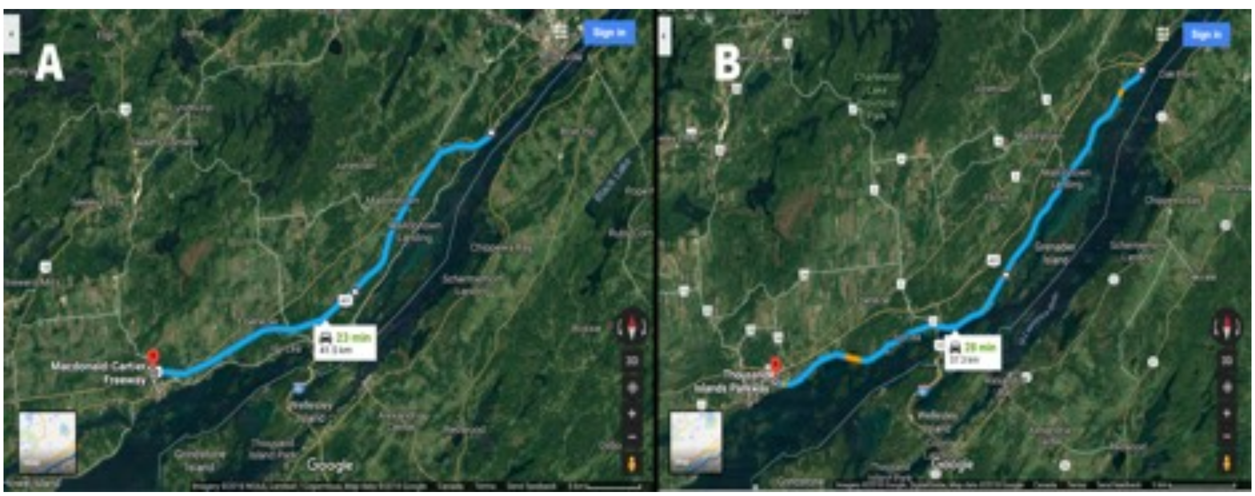


**Figure 2:** Location of road mortality surveys conducted on Highway 401 (A) and the Thousand Islands Parkway (B). This data has been incorporated into the landscape analysis.

Phase 3 road mortality surveys were completed along a 38 km long segment of Highway 2 (Figure 3). This road segment stretches from the carpool lot in front of the Shorelines Casino (44.3403, -76.1403) eastward to where Highway 401 crosses under Highway 2 at exit 687 (44.5308, -75.7682).

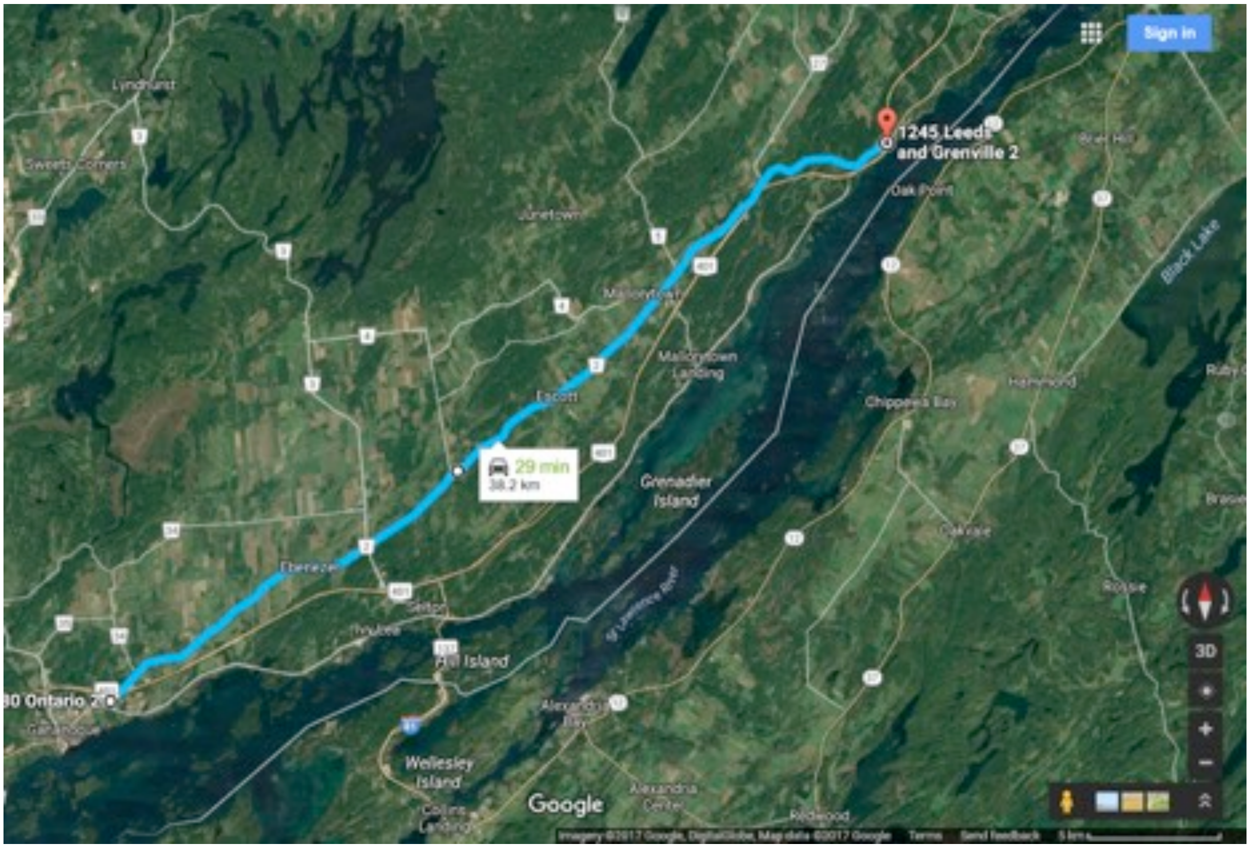


**Figure 3:** Location of road mortality surveys conducted on Highway 2 from June 2017 – November 2018

# Methods

## Survey protocol

The stretch of Highway 2 from Gananoque (from east side of Hwy 2 bridge over the 401) to the west side of the Highway 2 bridge over Highway 401 (a few kilometres west of Brockville) was surveyed by bicycle or car two-three times per week from mid-June to early-November 2016 and from mid-April to late October 2017. Where possible, surveys during April and October were conducted in weather conditions that were favourable for movement, or the following morning, to maximize the likelihood of locating wildlife during the surveys. Surveys on were conducted by cycling or driving at speeds under 30 km/hour for the entire length of the transect. Both sides of the road and 5 m into the ditch were scanned for any signs of wildlife.

Surveys were also conducted on Highway 401. In 2016, surveys focused on getting additional data from the hotspots identified in Phase 2 of the project. In 2017, surveys focused on monitoring the entire study area in as short a timeframe as possible to get results that were comparable across the study site.

Field equipment for the surveys included:

- Plastic tub with air holes drilled in top (to transport injured animals)
- Safety vest
- GPS units
- Digital camera
- Nitrile gloves
- Leather work gloves
- Clip board or field book, pencil and data cards
- Clear plastic bag (to protect data cards in rainy weather)
- Ziploc bags or Tupperware to protect collected specimens for future ID
- Masking tape and permanent marker to label specimen containers
- Towels
- Measuring tape and ruler
- Hand sanitizer
- Thermometer
- Binoculars
- First aid kit
- Emergency contact information
- Herpetofauna ID cards

The following safety equipment was worn always:

- High visibility safety vest (important for Highway 401)
- Bicycle helmet for Highway 2, hard hat for Highway 401
- Bicycle light with charged batteries (Highway 2)
- Nitrile glove (when handling roadkill)
- Close-toed shoes

At the beginning and end of every survey air temperature, wind conditions (Beaufort scale), precipitation and visibility were recorded.

For each wildlife observation (all vertebrates and SAR invertebrates) the following was recorded:

1. Finest taxonomic classification possible (species, genus, etc.)
2. Accurate location using handheld GPS receiver (latitude and longitude)
3. Location on road (pavement, shoulder, mowed shoulder or ditch)
4. Direction of traffic (animal is on north or south side of road)
5. Health (alive, dead or injured)
6. State of decay (dry, rot, bloat, fresh)
7. Any demographics possible (age class, sex, reproductive state, etc.)
8. Take photos (for all SAR and for specimens where ID is unsure)
9. Record general habitat characteristics

When SAR animals were observed, it was ensured that note taking was especially thorough and complete.

The following additional information was collected once along Highway 2 during the field season:

- Location of all driveways, roads, ATV trails and other entrances to Highway 2 that form intersections were assessed using DRAPE (Digital Rastor Acquisition Project for the East*)* imagery.

Surveys were completed in pairs. Surveyors could split up (unless on Highway 401) but had to be able to contact each other via phone or radio during the survey. Surveyors had to be prepared for all weather conditions, were not allowed to listen to music and had to always check traffic in both directions before entering any roadway. Surveyors did not handle amphibians after applying chemicals to hands (e.g. sunscreen, hand sanitizer, etc.). Injured animals were to be brought to one of local vet or animal hospitals (contact information was provided to surveyors).

On Highway 401, the Ministry of Transportation and the construction contractor was to be notified 48 hours prior to conducting surveys. A copy of the MTO Encroachment permit was carried and adhered to while surveying on Highway 401. Surveyors walked against traffic and never entered the roadway. Surveyors received safety protocol training prior to entering the field. Surveyors provided signed waivers and emergency contact information and reviewed Ontario Traffic Manual (book 7) before entering the field.

## Hotspot modelling

Hotspot modeling was used to identify the locations along the highway where road mortality is most significant.

All data was compiled into Microsoft Excel 2013. Data was then imported into ArcGIS (version 10.5), mapped and subdivided. The data was subdivided by taxonomy (e.g. reptile, bird, Blanding's Turtle, etc.), year and age class (e.g. hatchling, juvenile, etc.).

A kernel density analysis (KDA) was performed on each subset of the data and on the entire dataset to generate a continuous grid to illustrate spatial variation in wildlife road mortality for each taxa group. KDA measures the density of points that surround an individual raster cell. It begins with a raster cell, the dimensions of which are determined by the user. Then, each point within the analysis is fitted with a circular surface whose value is equal to the 'weight' of the point. In this study, the 'weight' was the number of individuals recorded at the point's location. Each point is also assigned an area equal to the search radius. A measurement is then made by counting all the circular point surfaces that overlap with the raster output cell. This process is reiterated for every cell in the final raster.

Before each KDA could be run, a 50 m buffer of the linear shapefile of each highway was created. Each buffer was used to constrain the density analyses to the expanse of the road. The output raster cell size for the kernel density analysis was 25 m and the search radius was defined at 500 m, to be large enough to capture many of the data points in an area but also small enough that the points included can be considered related to one another.

The following data groupings were used to create kernel density maps; All Turtles, All Turtles Excluding Hatchlings (EH), Snapping Turtles, Snapping Turtle EH, Snakes 2016, Snakes 2017, Snakes Both Years, Milksnakes and Eastern Ribbonsnakes (see Figures below). Groupings and analyses at the species level were preferred when the amount of data was sufficient for a meaningful analysis (for our purposes it was data points >20), as is the case with Snapping Turtles, Milksnakes and Ribbonsnakes. When data at the species level was limited (<20), such as the Blanding's Turtle and Grey Ratsnake, broader groupings (e.g. snakes, turtles, etc.) were used to examine general trends that can be applied to these species instead of a species-specific analysis.

As the names imply, the groupings 'All Turtles' and 'All Snakes' contain all the data points from these classifications: 'All Turtles' encompasses Snapping Turtles, Blanding's Turtles, Midland Painted Turtles, Northern Map Turtles and turtles that were unidentifiable. Similarly, 'All Snakes' contains all the observations of every snake species observed, as well as those snakes whose species was unidentifiable.

## Landscape analysis

Data is available from similar wildlife road mortality surveys conducted on the Thousand Islands Parkway from 2008-2011, as well as from surveys conducted on Highway #401 in 2014 and 2015 (see Garrah et. al. 2015 and Danby et. al. 2016, respectively, for details). Although some wildlife mortality mitigation efforts can be implemented on any one of the roadways without considering data from the other two roadways, there is also a benefit in considering the three roadways collectively. For instance, there may be some areas whose importance is scale-dependent; that is, they may not appear as the most important hotspots on any one single roadway, but when data from all roadways are considered together they may emerge as a priority hotspot. Similarly, there may be areas on each roadway that align geographically with each other and this relationship may make habitat restoration and roadside mitigation easier to facilitate in some areas due to economies of scale. Finally, knowing the habitat context of all hotspots is critical for identifying and designing appropriate mitigation efforts and this is not evident without a broader, landscape-scale examination. This is especially true for large and costly mitigation infrastructure such as overpasses or underpasses. Now that a comprehensive set of wildlife mortality data is available from all three of the roadways we are beginning the process of integrating these data into such an analysis.
KDA was used to model road mortality data along the three roadways as a density surface. Circuitscape, a software package based on algorithms borrowed from electronic circuit theory was used to illustrate landscape current density as modelled for the Frontenac Arch and surrounding areas by Koen et. al. (2014).

Density surfaces were mapped in relation to natural habitat cover in the region. These data were obtained from the OMNRF's "Sustaining What We Value" database for Ecoregion 6E10, hereafter "6E10 database" (OMNRF 2011).

The density surfaces were mapped in relation to the preferred natural heritage system (Scenario #10) identified by OMNRF in *Sustaining What We Value*. This process identified an optimum natural heritage system (including core areas and corridors) for ecoregion 6E-10 using the software package Marxan. Inputs included a variety of spatial data including landcover, existing protected areas, species at risk habitat, hydrological features, and Circuitscape current density.

The density surfaces were mapped in relation to the cumulative score assigned to natural areas in the Algonquin to Adirondack connectivity mapping exercise (Hensen and Tellier 2014). This exercise built on the progress achieved in OMNRF's *Sustaining What We Value* and expanded it to include areas of upstate New York. The cumulative score characterizes the value of core areas and habitat linkages in a natural heritage system, with higher values indicative of areas having a higher value based on landscape-level attributes such as size, configuration, and connectivity.

# Results

**Deliverable: A detailed plan to mitigate road mortality and restore connectivity for SAR reptiles throughout the region is developed and shared widely**

This deliverable is addressed by all sections of the results and the plan of action described in the recommendations section.

## Road mortality surveys

Surveys of vertebrate road mortality for phase 3 were conducted in the 2016 and 2017 active seasons on Hwy 2 and Hwy 401.

### 2016

The field season began later than the originally planned date of May 1 because of the time that was required to hire and train field staff and acquire the necessary equipment after the funding was announced.

*Highway 2*
From June 16 – November 9, surveys were conducted 2-3 times per week for a total of 52 surveys of the entire study area. This totaled approximately 1900 km of surveys. In 2016, 18 surveys were completed by bicycle and 34 were completed by car (Table 1).

*Highway 401*
From September 27 – November 4, 9 days were spent conducting road mortality surveys on Highway 401. These surveys were focused on the road mortality hotspots identified in the two-year study completed in winter 2016.

### 2017

*Highway 2*

From April 8 – October 27, surveys were conducted 2-3 times per week for a total of 82 surveys of the entire study area. This totaled approximately 3000 km of surveys. In 2016, 28 surveys were completed by bicycle and 54 were completed by car (Table 1).

*Highway 401*

Road mortality surveys were also conducted on Highway 401. This effort involved surveying the entire stretch in as short a period as possible. Several crews of surveyors completed all but the eastern most 4 km in a four-day period (June 19 – 22) the remaining segment was surveyed the following week. This provides data that is comparable along the entire study area (i.e. does not vary with season) which is crucial for our analysis.

**Table 1.** Road surveys conducted on Highway 2 from 2016-2017.

| Year | Bicycle | Car | Total | Date range |
|---|---|---|---|---|
| 2016 | 18 | 34 | 52 | Mid-June to early Nov |
| 2017 | 28 | 54 | 82 | Mid-April to late Oct |

## SAR Observations

### Highway 2

In 2016 and 2017, 271 observations of seven SAR were recorded on Highway 2 (Table 2). There were significantly more observations in 2017. This was expected because surveys began in early April 2017, compared to mid-June 2016.

**Table 2:** SAR observed on Highway 2 during road mortality surveys in 2016 and 2017.

| Highway 2 | | | |
|---|---|---|---|
| **Species** | **2016** | **2017** | **Total** |
| **Barn Swallow** | 2 | 3 | **5** |
| **Blanding's Turtle** | 1 | 7 | **8** |
| **Eastern Ribbonsnake** | 16 | 17 | **33** |
| **Gray Ratsnake** | 2 | 0 | **2** |
| **Milksnake** | 33 | 29 | **62** |
| **Monarch** | 2 | 22 | **24** |
| **Snapping Turtle** | 50 | 87 | **128** |
| **Total** | **106** | **165** | **271** |

### Highway 401

In 2016 and 2017, 143 observations of seven SAR were recorded on Highway 401 (Table 3). There were significantly more observations in 2017.  In 2016, two surveys were conducted in the fall of the main hotspots identified in the final report on phase 2 (Danby et. al. 2016). In 2017, a single pass of the entire study area was conducted in the third week of June to target a high movement period and gather comparable data along the highway. A significant number of snapping turtles (93) were observed in 2017.

**Table 3:** SAR observed on Highway 401 during road mortality surveys in 2016 and 2017.

| **Highway 401** | | | |
|---|---|---|---|
| **Species** | **2016** | **2017** | **Total** |
| **Barn Swallow** | 0 | 0 | **0** |
| **Blanding's Turtle** | 2 | 8 | **10** |
| **Eastern Ribbonsnake** | 1 | 1 | **2** |
| **Gray Ratsnake** | 0 | 0 | **0** |
| **Milksnake** | 2 | 5 | **7** |
| **Monarch** | 3 | 13 | **16** |
| **Northern Map Turtle** | 0 | 2 | **2** |
| **Snapping Turtle** | 13 | 93 | **106** |
| **Total** | **21** | **122** | **143** |

## Non-SAR Observations

While there is not a specific deliverable associated with species that are not at risk, substantial data was collected for all vertebrate species. In total, 6971 of 7242 observations on Highway 2 and 936 of 1079 observations on Highway 401 were either non-SAR or unidentifiable. The large number of unidentified remains suggests that the true mortality of SAR has been underestimated. A high proportion (over 60%) of these observations are anurans (frogs and toads).

Collecting data on non-SAR is beneficial for several reasons. First, the small number of SAR observations limits our ability to conduct complex statistical analyses. By adding the non-SAR observations, the sample size is larger and allows improved modelling for the target SAR. Second, it allows the project to benefit a much broader range of species.

## Hotspot modelling

**Deliverables: The model for road mortality hotspots is improved to the point of being more broadly applicable to other regions of Ontario**

### Highway 2

The variation in kernel density estimates is indicative of the relative variation in wildlife road mortality along Hwy 2. However, it is challenging to interpret the absolute values assigned in the maps because they are calculated on a 1000x1000 m basis, but then assigned to a linear feature only 100m wide. Therefore, strict interpretation should be avoided in favour of relative comparisons.

Figure 4a-d shows road mortality hotspots on Highway 2 for all turtles and snapping turtles, with and without hatchlings included in the dataset. The emergence of 'new' hotspots when turtle hatchlings are omitted from the analysis is likely due to the skewing-power of hatchling observations. Since many were found in a small area, they can skew the representation of hotspots. To protect adults, focusing on the hotspot maps that exclude hatchlings will be more appropriate. The Blanding's Turtle points were indicated on the "All Turtle" figures as there was insufficient data to determine hotspots for this species (Figure 4a, b).

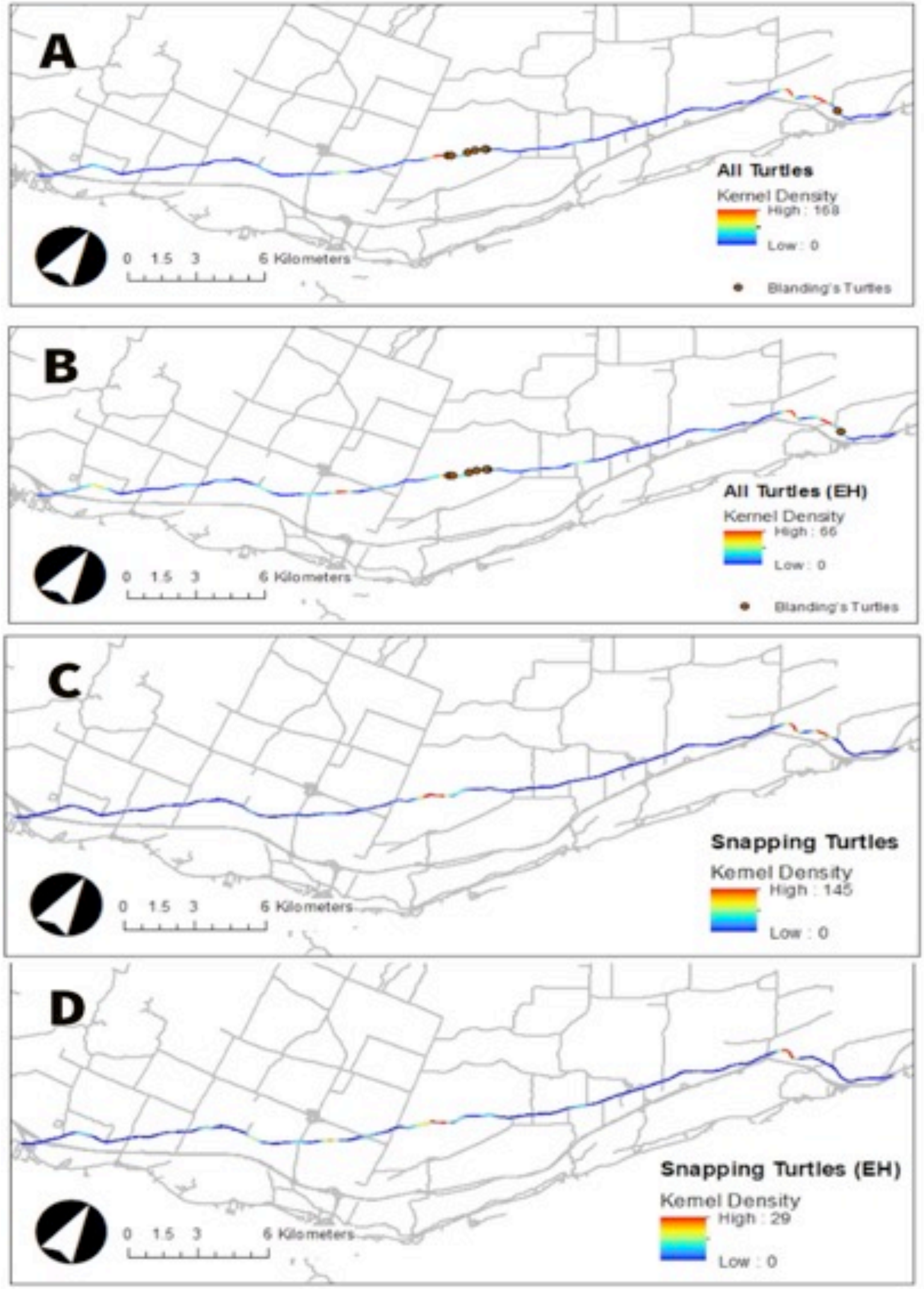
A
All Turtles
Kernel Density
High : 168
Low : 0
Blanding's Turtles
0 1.5 3 6 Kilometers
B
All Turtles (EH)
Kernel Density
High : 66
Low : 0
Blanding's Turtles
0 1.5 3 6 Kilometers
C
Snapping Turtles
Kernel Density
High : 145
Low : 0
0 1.5 3 6 Kilometers
D
Snapping Turtles (EH)
Kernel Density
High : 29
Low : 0
0 1.5 3 6 Kilometers

**Figure 4:** Maps showing kernel density of road mortality observations on Highway 2 for all turtles (A), turtles excluding hatchlings (B), snapping turtles (C) and snapping turtles excluding hatchlings (D). EH = excluding hatchlings.

Figure 5a-c shows road mortality hotspots on Highway 2 for all snake species, Eastern Ribbonsnake and Milksnake included in the dataset. The high number of hotspots for Milksnakes is likely a result of the low number of Milksnakes that were observed and used in the analyses. With only 66 observations from both years used in the analysis, the location of each individual Milksnake had a relatively high weight (compared to other analyses done with larger datasets). Milksnakes occurred throughout the landscape, with some areas having moderately higher rates of mortality than others. Eastern Ribbonsnakes also had a small sample size (39 individuals) but there were relatively few hotspots. This indicates that Eastern Ribbonsnakes cross the road in specific locations, usually near wetlands.

The Gray Ratsnake points were indicated on the "All Snakes" figure as there was insufficient data to determine hotspots for this species (Figure 5a). In addition, neither observation occurred at a snake hotspot.

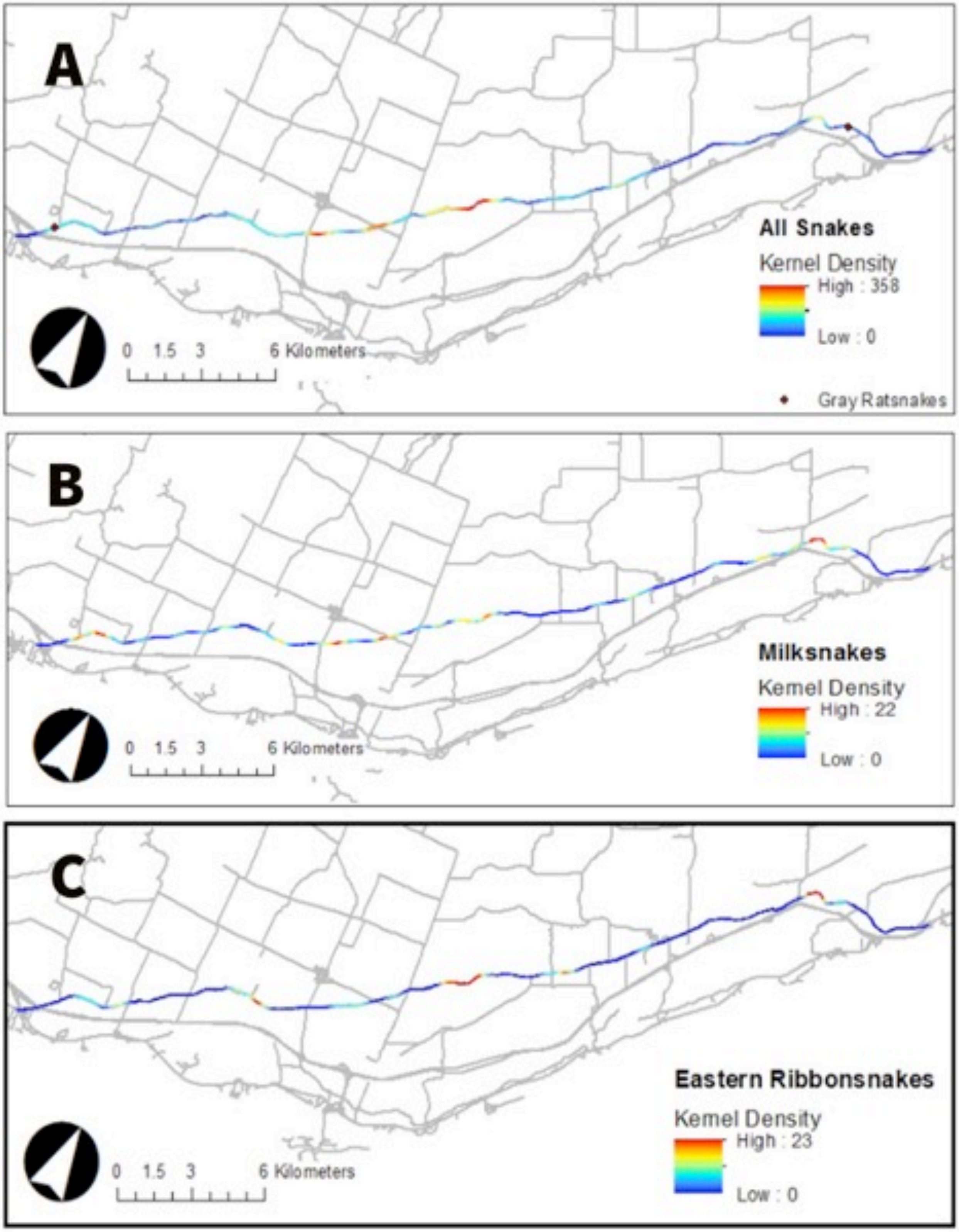


**Figure 5:** Maps showing kernel density of road mortality observations on Highway 2 for all snakes (A), milksnakes (B), and eastern ribbonsnakes (C).

Maps showing kernel density of road mortality observations on Highway 2 for snakes in 2016 (A), snakes in 2017 (B) and snakes in both years (C).

Overall, two main hotspots emerged from this analysis. Hotspot 1 occurred in the middle of the highway's extent (Figure 6a). This is an area where the road is bounded by wetland on either side with little in the way of obstacles or inclines. This hotspot lies within a corridor of natural habitat stretching from Charleston Lake to the St. Lawrence River and is a priority for maintaining connectivity.

Hotspot B occurs near the eastern end of our study area, where the highway crosses a wetland (Figure 6b). Visibility is poor when approaching this area from the west as there is a sharp bend in the road. The road does not lie level with the wetland, as the previous hotspot did, instead it is raised some 3-4 meters by fill.

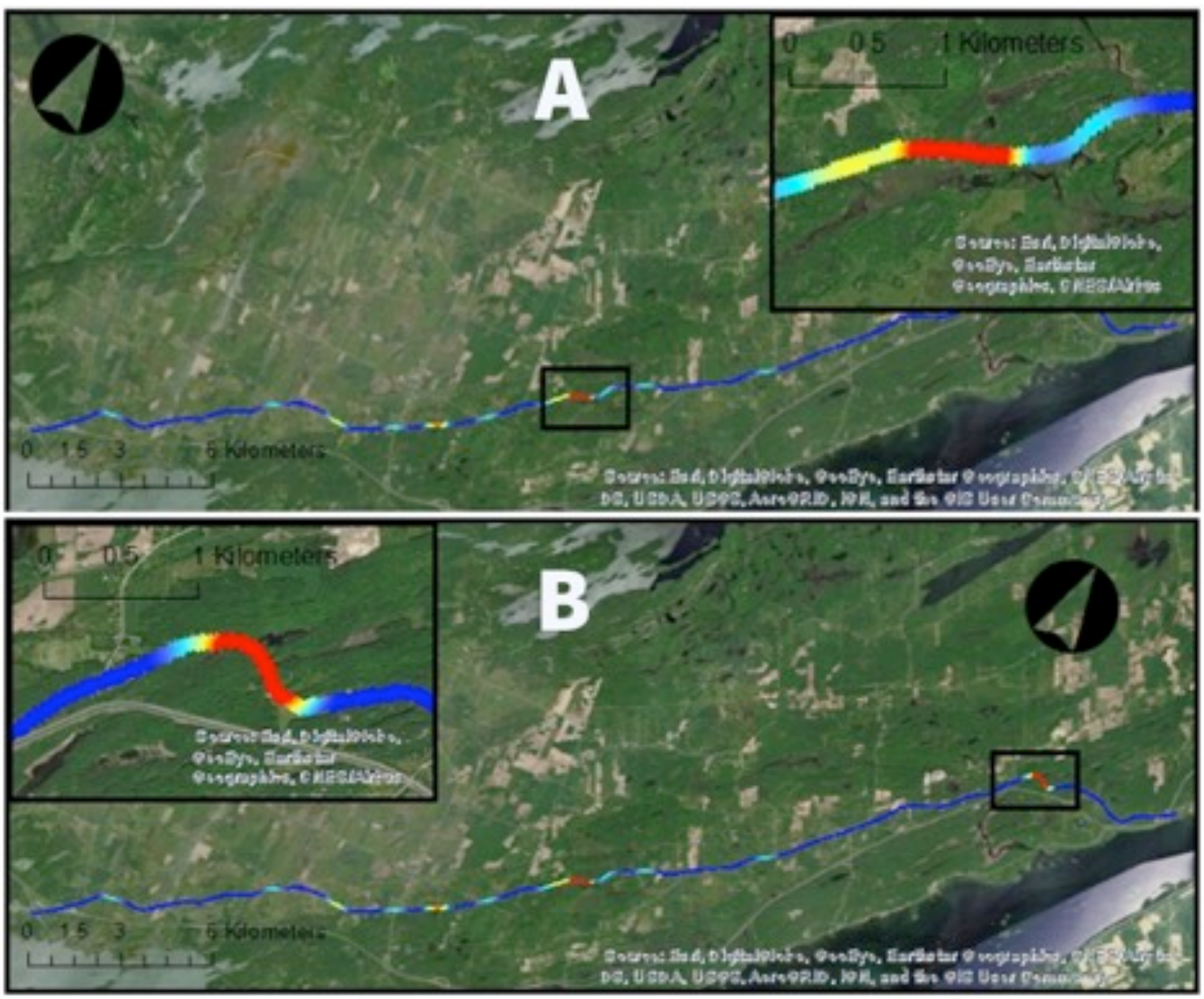


**Figure 6.** The two main hotspots that emerged from Highway 2 hotspot modelling.

## Landscape analysis

Figures 7, 8, 9, and 10 present results from some of the preliminary stages of this landscape-scale analysis. Each of the figures presents road mortality data along the three roadways as a density surface modelled using KDA. The data have not yet been standardized across the three roadways and so remain unitless at this point and suitable only for visual identification of hotspots. Further, they are based on the locations of all vertebrate mortality locations but excluding frogs, which are so abundant that they overwhelm the analysis. Subsequent density modeling will account for these differences among roadways and taxa.

Figure 7 presents the density surfaces in relation to landscape current density as modelled for the Frontenac Arch and surrounding areas by Koen et al. (2014). The final map is a current density map with each cell representing the probability of use by moving animals, and tested against fishers (*Martes pennanti*) and reptiles. Higher values indicate areas with high probability of landscape-scale animal movement.

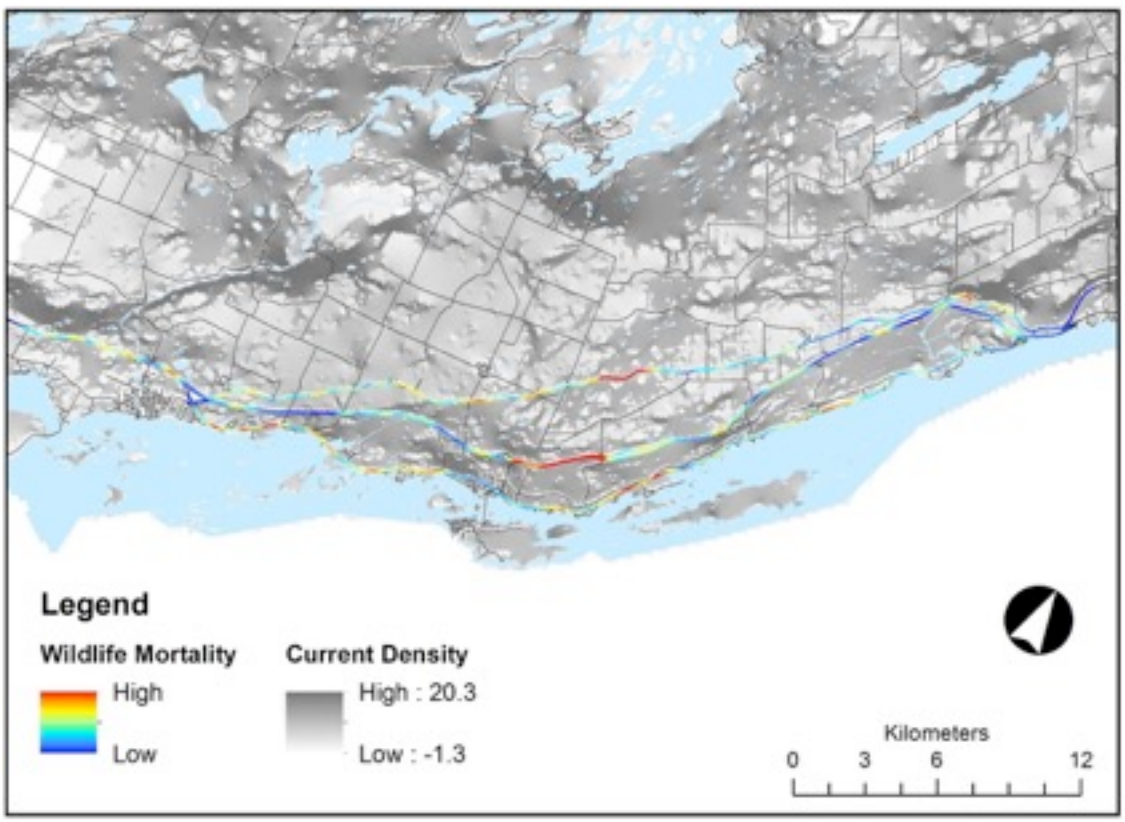


**Figure 7.** Density surfaces in relation to landscape current density as modelled for the Frontenac Arch and surrounding areas.

Figure 8 presents the density surfaces in relation to natural habitat cover in the region. The Natural Cover classification segregates the landscape into upland and lowland forest, open wetland, and open natural areas (grasslands, etc.). The location of these areas on the landscape thereby coincides with areas that are likely to provide the most suitable habitats for the species of concern in relation to wildlife road mortality.

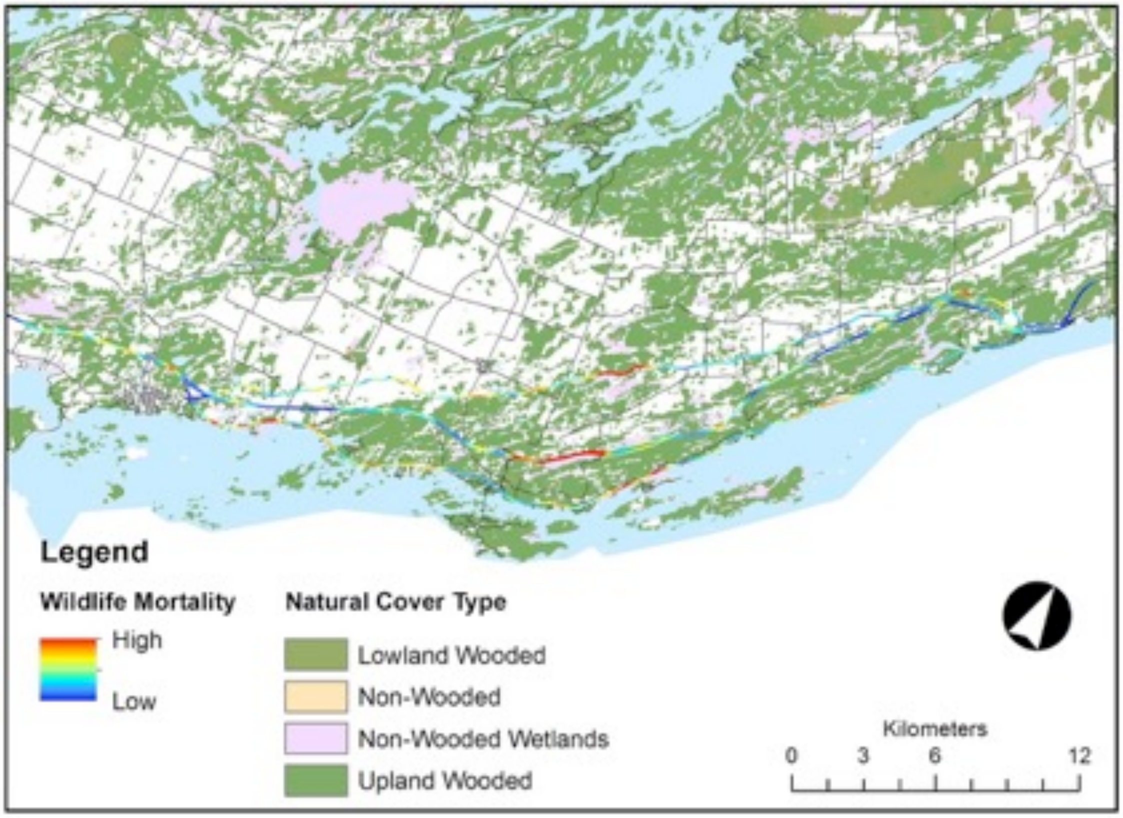


**Figure 8.** Density surfaces in relation to natural habitat cover in the region.

Figure 9 presents the density surfaces in relation to the preferred natural heritage system (Scenario #10) identified by OMNRF in Sustaining What We Value.

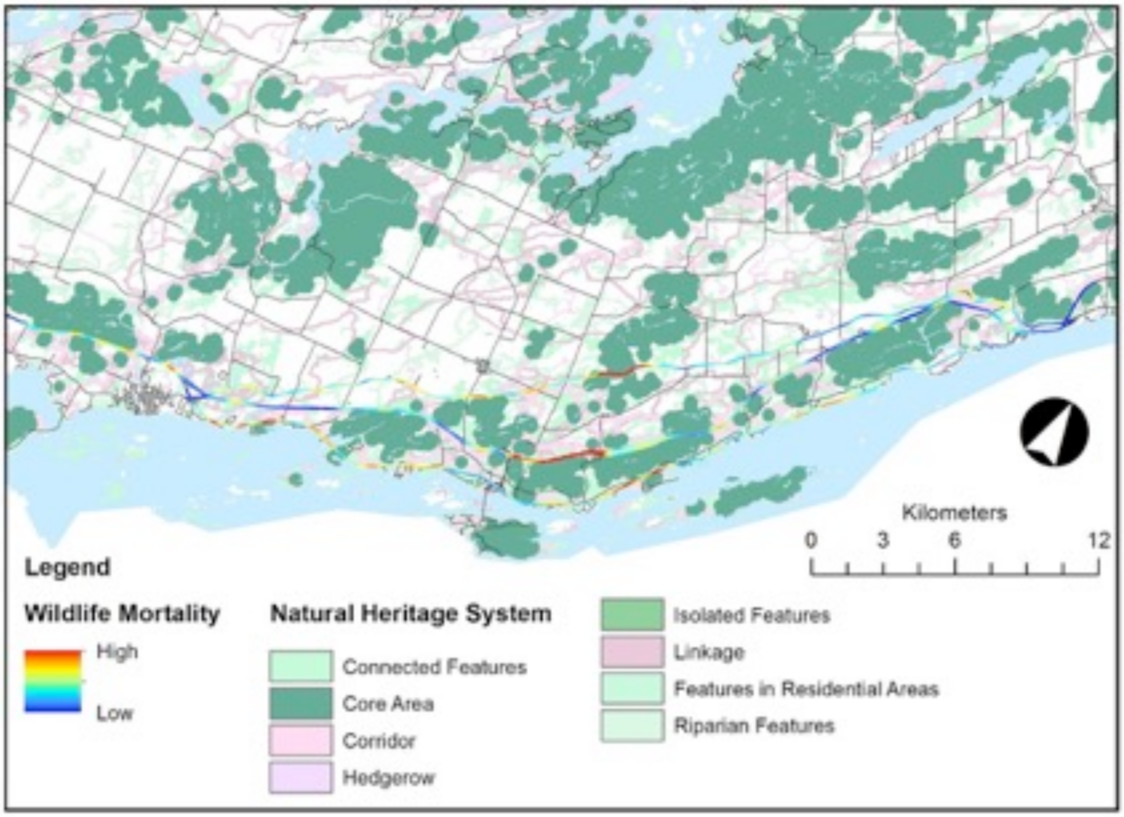


**Figure 9.** Density surfaces in relation to the preferred natural heritage system (Scenario #10) identified by OMNRF in Sustaining What We Value.

Figure 10 presents the density surfaces in relation to the cumulative score assigned to natural areas in the Algonquin to Adirondack connectivity mapping exercise (Hensen and Tellier 2014). This exercise built on the progress achieved in OMNRF's *Sustaining What We Value* and expanded it to include areas of upstate New York. The cumulative score characterizes the value of core areas and habitat linkages in a natural heritage system, with higher values indicative of areas having a higher value based on landscape-level attributes such as size, configuration, and connectivity.

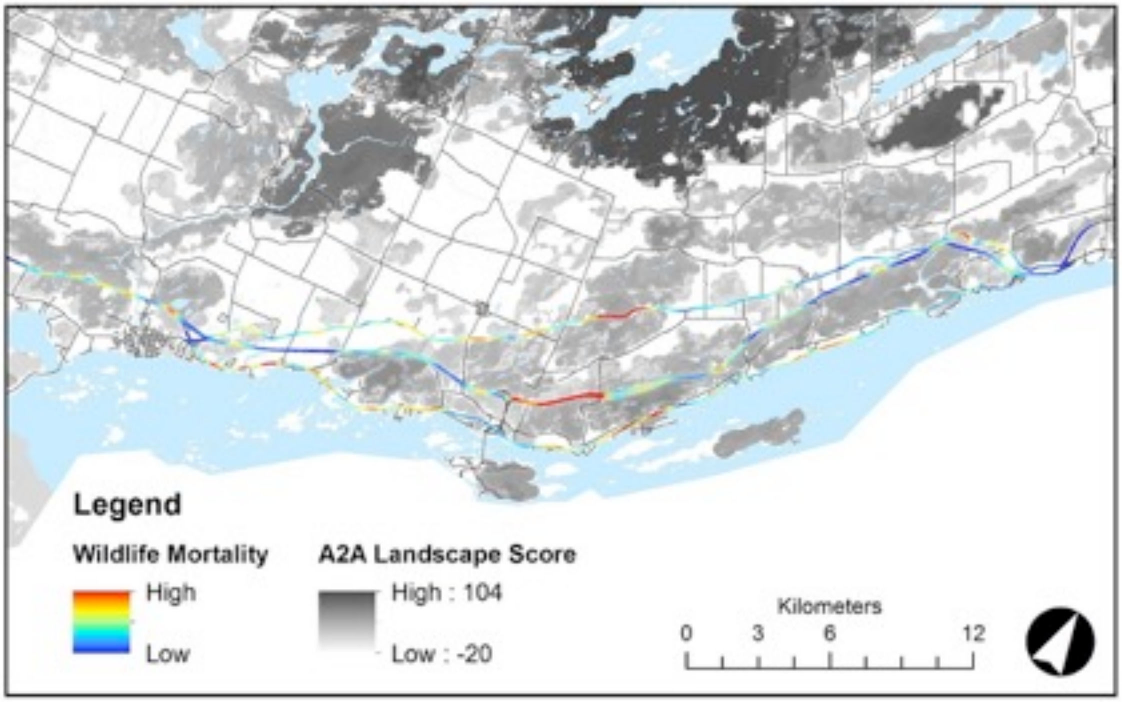


**Figure 10.** Density surfaces in relation to the cumulative score assigned to natural areas in the Algonquin to Adirondack connectivity mapping exercise

Initial examination of the four maps suggests that there are areas of hotspot mortality which align with landscape features, particularly an area of higher landscape connectivity which extends northwards from the St. Lawrence River to Charleston Lake; crossing Highway #2 at the location of the major hotspot identified in this report. However, this is still in its preliminary stages and more detailed analysis is forthcoming.

## Outreach completed

**Deliverable: At least 100 individuals receive outreach about this project in the area of impact**

We exceeded our outreach goals for this project. We were able to reach ~1,540 people through presentations, workshops and manned booths (Table 4).

**Table 4:** Summary of outreach conducted from April 1, 2017 to March 31, 2018. '*' indicates a conservative estimate of the number of attendees

| Outreach | Presenter | Audience | Attendees | Date |
|---|---|---|---|---|
| Research Day Presentation | Joshua Jones | Classmates, faculty and staff | 32 | 2017-04-25 |
| Talk on road ecology and connectivity in the region | Joshua Jones | Class of undergraduate students | 37 | 2017-09-30 |
| Class Lecture | Ryan Danby | Students in Environmental Science, Biology, and Geography at Queen's University | 96 | 2017-10-19 |
| Quebec Road Ecology Conference | Ryan Danby, Mandy Karch | Road Ecologists, Government planners, consultants and other practitioners and researchers | 250 | 2017-10-25 |
| University of Ontario Institute of Technology | Mandy Karch | Teacher Candidates | 25 | 2018-01-26 |
| Radio Interview; CJBQ Belleville ("Newsmaker Sunday"; 10min guest interview) | Ryan Danby | General public | 1,000* | 2018-02-11 |
| Public Presentation | Ryan Danby | Quinte Field Naturalists | 70 | 2018-02-26 |
| Final recommendations discussion | John Urquhart, Cameron Smith | MTO | 10* | 2018-03-26 |
| Final recommendations discussion | John Urquhart, Cameron Smith | St. Lawrence Parks Commission | 10* | 2018-03-26 |
| Final recommendations discussion | John Urquhart, Cameron Smith | United Counties of Leeds and Grenville | 10* | 2018-03-27 |
| | | **Total** | **1,540*** | |

**Deliverable: At least 2000 people learn about this project through newsletters and other media**

We were able to reach an additional 27,032 people through social, print and digital media (Table 5).

**Table 5:** Summary of social, print and digital media from April 1, 2017 to March 31, 2018.

| Platform | Platform holder | # reached | Date | Content |
|---|---|---|---|---|
| Facebook | A2A | 150 | June 22, 2017 | Road ecology content |
| Website | A2A | 1,200 | ~100 visits/ month | Road ecology portal |
| Fall Newsletter | A2A | 250 | December 15, 2017 | Project article – print and digital |
| Twitter | Ryan Danby | 1,777 | 23-May-17 | Graph of turtle mortality for International Turtle Day |
| Twitter | Ryan Danby | 605 | 23-Mar-17 | Map of Frontenac Arch road ecology |
| YouTube | A2A | 5,000 | 2018-03-31 | Triple Highway Road Mortality Threat Awareness |
| Ontario Nature Magazine | Ontario Nature | 16,000 | June 2018 | lengthy feature on completing the 4-year MNRF project |
| Instagram | Brett Forsyth Photography | 2,000 | June 21-22, 2017 | Instagram story with 5-10 posts/day including photo and video |
| **Total** | | **27,032** | | |

**Deliverable: All stakeholders receive the final recommendations of how to mitigate road mortality and restore connectivity for SAR reptiles across the triple threat of Highway 2, Highway 401 and the Thousand Island Parkway**

This report will be shared with all stakeholders including MTO, MNRF, the United Counties of Leeds and Grenville, St. Lawrence Parks Commission, local land trusts, A2A's 50 collaborating partners, other ENGOS, and concerned citizens by March 31, 2018. Outreach is being scheduled in March to share the findings within this report with MTO. After meeting with MTO, presentations to share results will be scheduled for the following groups; United Counties of Leeds and Grenville and the St. Lawrence Parks Commission (Highway 2 and the Parkway, respectively), the Township of Leeds and the Thousand Islands, the Town of Gananoque, Brockville, and the Township of Front of Yonge. Partners and concerned parties who do not receive direct outreach will receive digital or print copies of the report.

# Recommendations

This report focuses primarily on the effects of Highway 2 on turtle and snake SAR mortality and population connectivity. It also considers the impacts of the triple threat of Highway 2, Highway 401 and the Thousand Islands Parkway on these species.

The recommendations within this report focus on the most pressing concerns for SAR snakes and turtles. A subsequent report, to be prepared under separate funding, will provide a larger analysis of all terrestrial fauna mortality, connectivity and existing land uses, and it will present recommendations for safe passage for all animal species, including SAR reptiles.

## Hotspot 1 mitigation

This hotspot has emerged as a crucial linkage between the shorelines of the St. Lawrence River and Charleston Lake. In addition, it is a major reptile SAR hotspot. Urgent action is needed in this location to reduce mortality while maintaining or improving the ability of reptiles to successfully cross the road. We recommend signage be erected at specific locations by May 1, 2018 (Figure 11). However, we do not recommend any major changes to this area (e.g. fencings, ecopassages, etc.) until the completion of our broader analysis later in 2018.

## Hotspot 2 mitigation

The stretch of road through this hotspot is raised ~3-4 m above the wetland water level. An ecopassage is recommended at this hotspot. The simplest way to improve connectivity and reduce mortality is to install ecopassages under the road. Fencing may not be required because of the steep embankment. Post ecopassage construction monitoring would be required to confirm. However, the type, size and number of ecopassages will be better informed by the broader analysis. As a result, we recommend waiting until this is complete before designing any ecopassages at this hotspot.

In the interim, we recommend seasonally (May 1 – October 31) decreasing the speed-limit approaching the eastbound bend to 60 km/h to allow for drivers to avoid any potential wildlife crossing the road.

## Raise public awareness

An outreach program should be initiated to communicate with the people living and working along Highway 2, and the communities that regularly travel this highway (e.g. Gananoque, Brockville, etc.). This program should focus on the potential negative impacts of roads and the actions local citizens can take to reduce these impacts. These actions include: watching for snakes and turtles while driving, avoiding hitting them, reporting observations to citizen science programs and, when safe to do so, stopping to help the animals cross the road.

In addition to reducing direct mortality, this awareness campaign would increase the number of successful crossings of Highway 2 and other roads in the region, thereby increasing connectivity across these roads.

### Install wildlife crossing signage

It is recommended that signage indicating that the area is a turtle crossing from the months of May-September be installed approximately 500 m prior to each hotspot (Gunson and Schueler 2012). This signage will raise awareness of the animals crossing and encourage drivers to watch for turtles. Locations of hotspots that would benefit from signage are shown in Figure 11.


**Figure 11.** Proposed signage placement for turtle crossings. It is suggested that signs are placed 500m before the hotspots, in both directions.

Similarly, all Eastern Ribbonsnake hotspots that do not overlap with turtle hotspots should have snake crossing signage installed 500 m prior to the hotspot (Figure 12). Because milksnake crossings are more evenly distributed, additional signage is not recommended to target this species. They will benefit from mitigations at hotspots 1 and 2 and the signage recommended for turtles and eastern ribbonsnakes.


**Figure 12.** Proposed signage placement for Ribbonsnake crossings. The hotspots highlights are those that are different in geography from turtle hotspots. It is suggested that signs are placed 500m before the hotspots, in both directions.

### Road maintenance mitigation

#### Shoulder grading

Turtles lay their eggs as early as late May on the shoulders of the road. The eggs typically hatch in late August through late September. It is recommended that grading of the shoulder substrates be conducted outside of the window when turtle eggs may be in the ground (June 1 – September 30).

#### Mowing

Mowing can cause mortality to reptiles from the tires of the mowing equipment, the blades of the mower, and by making the animals more visible to predators (e.g. hawks). Snakes are particularly susceptible to mowing related mortality (Johnson et. al. 2000, Kingsbury 2002). We recommend that mowing be conducted as infrequently as possible from May 1 – October 31. We further recommend that mower blades be set to cut 30 cm from the soil to minimize direct and indirect mortality. Mowing heights of 20 cm or lower have been shown to cause over 50% mortality to the snakes within the mowed area (Durbian 2006). Gray Ratsnakes will be more susceptible to mowing related mortality as they can climb and are more likely to be hit by mower blades regardless of the height they are set.

## Conclusion

This project was a success. We met or exceeded all deliverables. Furthermore, we have been able to leverage support to expand this project to conduct a more detailed landscape analysis of all terrestrial vertebrate species from Charleston Lake south to the St. Lawrence River and are working on expanding the scope to include the area south of the St. Lawrence River through to Adirondacks State Park. We have generated anticipation of the final results of this project amongst the land and road managers in the study area and several neighbouring provinces and states. We have also generated interest in the project among the local community and several conservation and citizen science groups that focus on road ecology and SAR issues. Actions have already been taken to reduce mortality and improve connectivity on Highway 401 and we anticipate further action as early as the 2018 season. Finally, major action (e.g. construction of major ecopassages) will be deferred until the final regional report for all vertebrates is complete to ensure resources are being most effectively allocated.

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