A Guide to Road Ecology in Ontario

Ontario Road Ecology Group
www.torontozoo.com/conservation

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PREFACE

Road Ecology is the study of the interaction between road networks and the natural environment. The field examines and addresses the effects of roads on wildlife populations and investigates how roads influence ecological processes. Road ecology is an emerging science that is gaining momentum as citizens and transportation planners strive to achieve efficient road networks that work in harmony with and conserve the natural environment.

This guide is a resource for students, citizens, government and non-government agencies. It is a tool that 1) raises awareness about the threats of roads to biodiversity in Ontario and 2) provides solutions for mitigating these threats. The focus is on wildlife/road interactions and local road ecology projects are provided as examples. This dynamic document is intended to present the latest in road ecology initiatives and inspire sustainable road practices.


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Opposite © Janine Holman.

INTRODUCTION : ROADS IN SOUTHERN ONTARIO

Roads are gateways to development and when a road is built, housing and industrialization soon follow. The pressure of urban encroachment on wildlife populations is becoming more intense. In only 60 years the major roads of southern Ontario have increased from 7,133 km to 35,637 km (Fenech *et al*. 2000; Figure 1). Today, no point in the region is more than 1.5 km from a road (Gunson 2010).

In addition to having the greatest density of people and roads, southern Ontario also has the greatest biodiversity in the province (Figure 2). There are 203 *Species at Risk (SAR) found in Ontario and many of these are negatively affected by roads (see Appendix).

Natural cover and habitat are shrinking in southern Ontario. The trend will continue as it is estimated that the population of the Greater Golden Horseshoe area alone will increase by over 3 million residents over the next 20 years (Growth Plan for the Greater Golden Horseshoe 2006). To accommodate this growth and address existing highway congestion, the Ministry of Transportation of Ontario (MTO) has proposed road expansion projects and maintenance work that will enhance motorist safety and efficiency on provincial highways (Southern Highways Program 2008 to 2012; Figure 3). A portion of these projects may take place in identified greenspaces such as the Oak Ridges Moraine, Greenbelt and Niagara Escarpment.

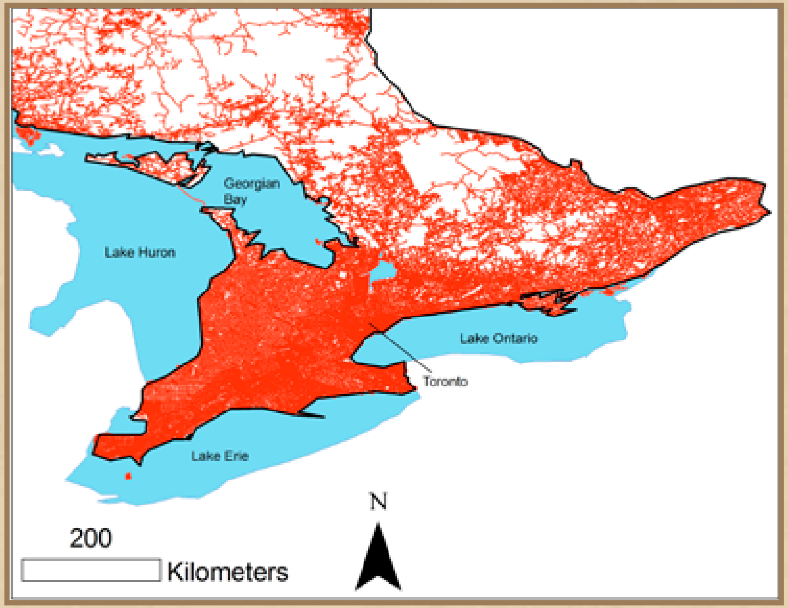
Conservation of resources including the land, the environment and biodiversity is essential for communities to prosper and endure. We are entering a new era of technology, understanding and imagination. As a society, we must acknowledge the consequences of development and resource consumption and proceed responsibly. Only by protecting our water sources, wetlands, woodlots, biodiversity and agricultural land will we thrive socially and economically.

Opposite © Mandy Karch.

Quick Fact :

*Species at Risk (SAR) are any naturally-occurring plant or animal in danger of extinction or of disappearing from the province. Once classified as "at risk", they are added to the Species at Risk in Ontario (SARO) List (Ontario Ministry of Natural Resources 2009). Milksnake (Below), *Lampropeltis triangulum*, (OMNR Status: Special Concern).
© Mandy Karch.

Figure 1 : Road density (red lines) in southern Ontario (source: Eco-Kare International).



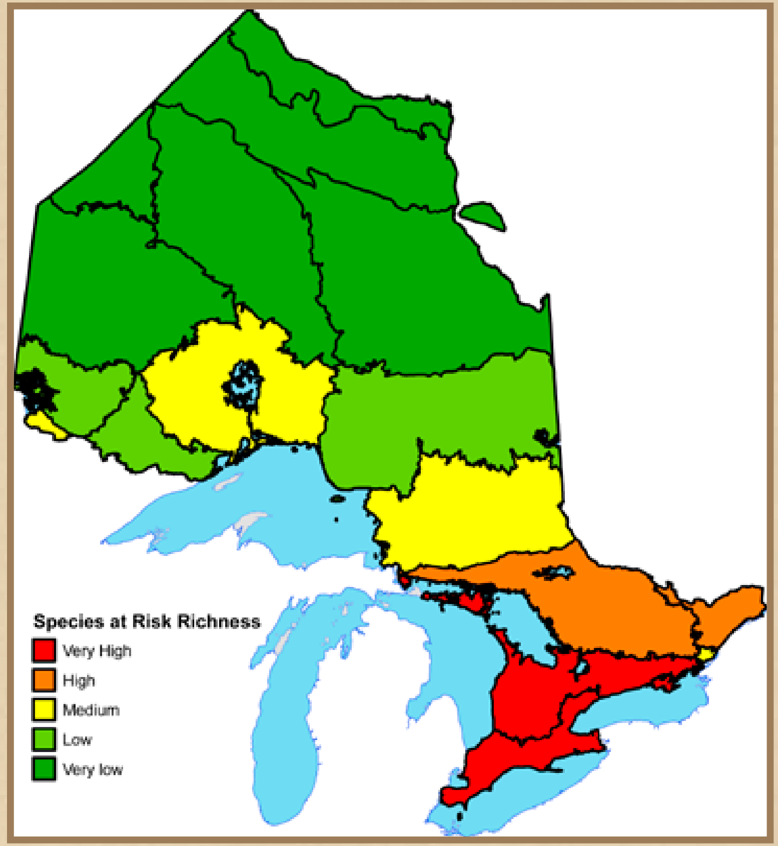
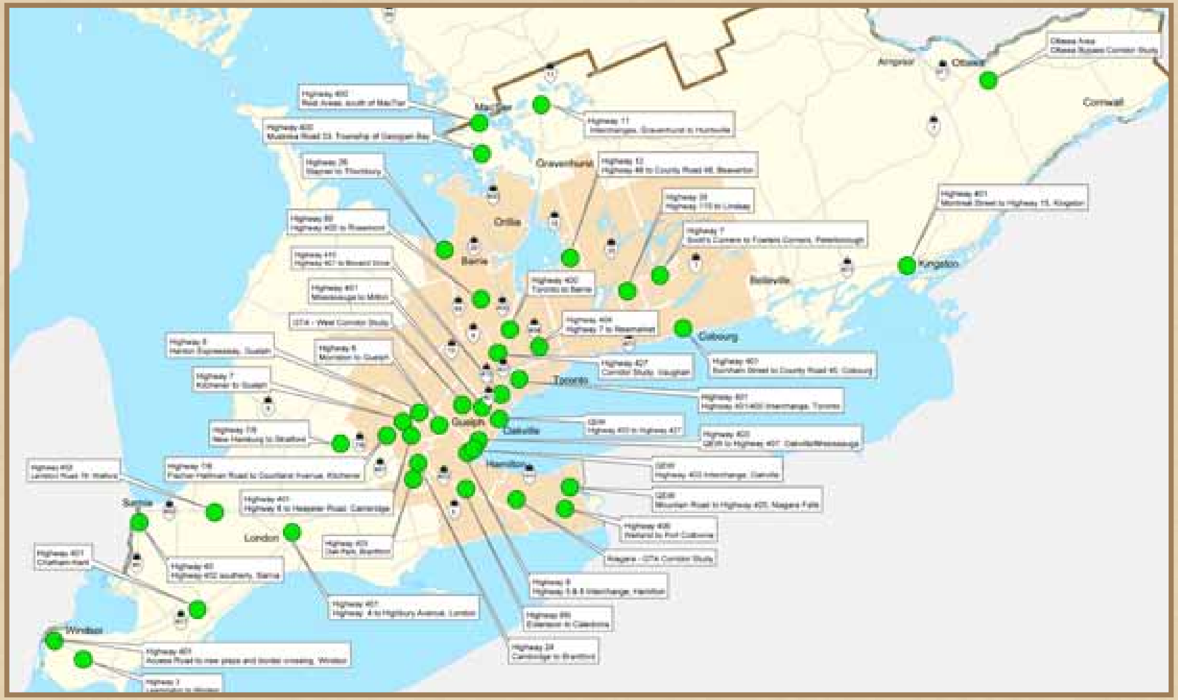


Figure 2 : Species at Risk (SAR) richness in Ontario (source: Project WILDSPACE™).

INTRODUCTION

Figure 3 : Provincial Highways Construction Program - Planning for the Future (source: Southern Highways Program 2008-2012).



Quick Fact :

Roads are a major threat to the persistence of the loggerhead shrike, *Lanius ludovicianus*, (OMNR Status: Endangered). Habitat loss and fragmentation and road kill are some of the hazards that threaten this species. Habitat degradation is another as roads facilitate the spread of invasive plant species that displace optimal shrike habitat. Road salt, noise and light pollution also degrade habitat and negatively affect this endangered species. © Ken Ardill.

THREATS OF ROADS TO WILDLIFE AND THE ENVIRONMENT

Roads pose risks to wildlife that include direct mortality, habitat loss, habitat fragmentation and habitat degradation.

Direct Mortality : Wildlife/Vehicle Collisions (WVC's)

Probably the most important impact of roads on wildlife populations is the direct mortality of animals as they are hit and killed by vehicles on roads in wildlife/vehicle collisions (WVC's). Mortality directly reduces wildlife population sizes. Since small populations are more vulnerable to extinction than are large populations, population reduction from road mortality causes an increase in the chance of population extinction. Many of the Species at Risk whose populations are affected by roads (see Appendix) are slow-moving animals, such as reptiles and amphibians that do not readily avoid roads or vehicles (Fahrig and Rytwinski 2009). These species can experience extremely high mortality rates due to roads. Large predator species, which are wide-ranging and have low natural densities, are also highly susceptible to the effects of road mortality on their populations; even a small number of WVC's can endanger populations of such species (Table 1).

Transportation agencies tend to think of WVC's as those involving large animals such as deer, because these are the WVC's that are reported to the police. However, these represent only a tiny fraction of all WVC's. For example, in Ontario, there are between 14,000 and 15,000 reported WVC's each year, almost all of which involve collisions with large herbivores – deer and moose. In contrast, there were over 24,000 vertebrate collisions including reptiles and amphibians on a 31 km stretch of road on the Thousand Islands Parkway in only a 5 month study period (Eberhardt 2008).

WVC's involving deer and moose jeopardize motorist safety, and millions of dollars are spent on these collisions every year in medical costs, vehicular repairs, insurance, road clean-up, road repair, time spent off work and extra time spent in transportation on routes closed or slowed down due to the accidents. As a result of the danger and cost, there is public support to mitigate these WVC's. However, measures aimed specifically at keeping deer and moose off roads may do little to mitigate the effects of roads on wildlife conservation, because these species' populations are not the most affected by road mortality. In fact, populations of deer and moose appear to be quite resilient to the effects of road mortality (Munro 2009). Fencing designed to keep deer and moose off roads is unlikely to prevent mortality of most species vulnerable to road mortality effects. Mitigation needs to be aimed at the species whose populations are most affected by road mortality, such as reptiles, amphibians, and mammalian carnivores. If roads occur or must be built through wildlife habitat, the first and most important objective for mitigating road effects and conserving wildlife should be to keep such animals off the roads.

Table 1 : Characteristics that make a species susceptible to the threats of roads (from Forman *et al*. 2003).

	Effects of Roads		
Characteristics Making a Species Vulnerable to Road Effects	Road Mortality	Habitat Loss	Reduced Connectivity
Attraction to Roadside Habitat	x		
Inability to Avoid Oncoming Cars	x		
High Intrinsic Mobility	x		
Habitat Generalist	x		
Multiple Resource Needs	x		x
Large Area Requirements/Low Density	x	x	x
Low Reproductive Rate	x	x	x
Behavioural Avoidance of Roads			x

Quick Fact :

The American badger, *Taxidea taxus*, is an endangered species (OMNR Status). The dense road network that runs through the heart of Ontario's badger range and the propensity of this species to nest along roads increases the risk of wildlife/vehicle collisions.
© Phillipe Verkerk.

CASE STUDY

Species at Risk Road Kill – MacTier area south of Parry Sound, Ontario

The twinning of Highway 69 (Highway 400 north extension) south of Parry Sound bisected prime Massasauga rattlesnake and eastern hog-nosed snake territory (both species are classified as threatened by the OMNR; Figure 4). Although mitigation measures were exercised during construction and planned into the road design (e.g. exclusion fencing to keep snakes off the road), snake mortality has been an issue for this highway project.

Figure 4a (Right) and 4b (Below) : Massasauga rattlesnake, *Sistrurus catenatus*; eastern hog-nosed snake, *Heterodon platirhinos*. © Mandy Karch.

Habitat Loss

Road construction consumes terrestrial and aquatic habitat resulting in :

i. Reduced population sizes leading to increased likelihood of population extinction (smaller populations are more likely to go extinct than larger populations)

ii. Limited habitat availability to accommodate species range expansions in response to climate change

iii. Smaller individual home ranges causing chronic stress, reduced individual fitness and compromised population viability

iv. Environmental disturbances to *Natural Heritage Systems (NHS's) (i.e. habitat loss within NHS's disrupts wildlife populations, hydrological processes and ecological processes such as successional native plant growth)

CASE STUDY

Natural Heritage System - Brampton, Ontario

When a road is constructed, development often follows. Roads and development within a NHS interfere with ecological processes and threaten population persistence. For example, in 2001 the loss of the 8 hectare Mimico Marsh at Bramalea Road and Bovaird Drive in Brampton likely resulted in changes to surrounding water quality, flow and level as well as the loss of seven wetland dependent wildlife species in the watershed (Turning Over a New Leaf: The Etobicoke and Mimico Creeks Watersheds Report Card 2006).

To improve the health of this NHS and to attain natural cover targets set for the year 2025, the Toronto and Region Conservation Authority (TRCA) reported that over 1,500 hectares of natural cover (forest and wetland) had to be created in the Etobicoke and Mimico Creeks watersheds (TRCA 2007; Table 2).

Table 2 : Natural cover targets of the Etobicoke and Mimico Creeks Watersheds (source: Turning Over a New Leaf: The Etobicoke and Mimico Creeks Watersheds Report Card 2006).

Watershed	2006 Natural Cover (Forest and Wetland)	2025 Natural Cover Target	Hectares of Created Habitat Required to Meet 2025 Target
Etobicoke Creek	5.47%	11%	1230
Mimico Creek	2.36%	8%	443

Quick Fact :

A ***Natural Heritage System (NHS)** is a system made up of natural heritage features and areas, linked by natural corridors which are necessary to maintain biological and geological diversity, natural functions, viable populations of indigenous species, and ecosystems. These systems can include lands that have been restored and areas with the potential to be restored to a natural state (Section 6 of the Provincial Policy Statement 2005).

Habitat Fragmentation/Connectivity

Fragmentation is the degree to which natural habitat, once continuous, is divided into remnant isolated patches. Excessive fragmentation of the landscape by roads can alter wildlife movements and lead to increased wildlife/vehicle collisions (WVC's) as animals need to traverse more and more roads to access resources.

Connectivity, from a wildlife perspective, is the ability for an individual to move through the landscape unimpeded by natural or human landscape features. Roads are one of the most prominent human features that create barriers to wildlife movement and thereby decrease connectivity.

Roads that bisect and fragment habitat result in :

i. Denied access to resources (e.g. habitat and mates)

ii. Loss of genetic and species diversity
   a. Disrupted or reduced gene flow (i.e. reduced genetic variability, inbreeding)
   b. Wildlife/vehicle collisions (WVC's)

Each of these results may cause reduced populations which increases the risk of extinction.

CASE STUDY

Snake Mortality Observation – Bruce Peninsula, Ontario

Over a 3 month period between August and October 2009, naturalists Glenn Reed and Theresa McKenzie counted 23 live and over 250 dead snakes on roads in the Northern Bruce Peninsula Township. Mortality appeared consistent on road segments bisecting suitable snake habitat. Among the dead were 6 Massasauga rattlesnakes (OMNR status: Threatened), 9 milk and 6 ribbon snakes (OMNR status: Special Concern). There were also garter, Dekay's, ring-necked, red-bellied, smooth green, northern water snakes and a female snake containing 30 fetal young among the road-killed specimens (Figure 5). The volume of mortality in this region and the loss of Species at Risk suggest that these snake populations would benefit from mitigation measures.

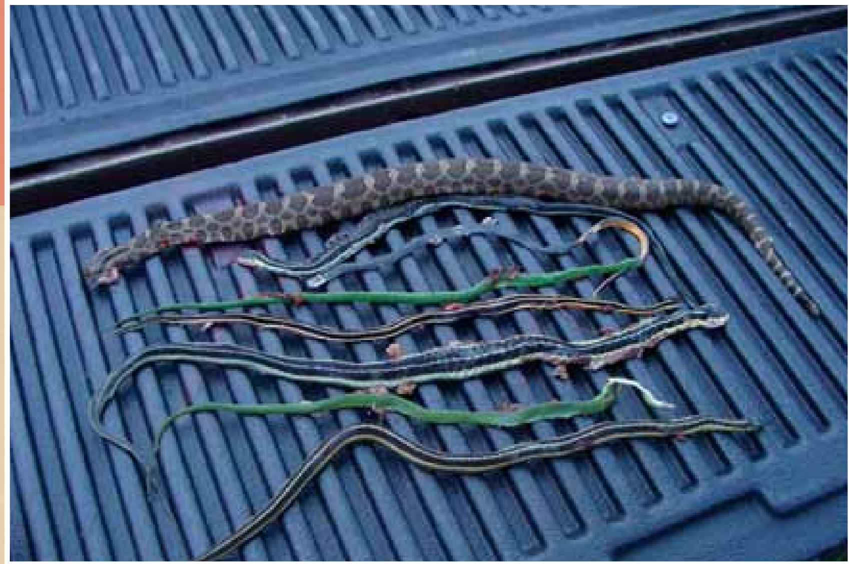


Figure 5 : Road kill snakes from the Bruce Peninsula, autumn 2009. © Glenn Reed.

Habitat Degradation

Roads negatively affect land, water and air quality due to :

i. Pollution

  a. Vehicle debris and particulate matter
  b. Combustion engine emissions
  c. De-icing agents (e.g. salt, wind shield wiper fluids, etc.)
  d. Dust leading to siltation and sedimentation of aquatic habitats
  e. Motorist litter
  f. Fertilizers, insecticides, larvicides
  g. Light and noise pollution and road vibrations that may disturb wildlife behaviours such as :
    - Mating
    - Nesting
    - Migration
    - Foraging success
    - Predation risk

ii. Run off (Rain water becomes storm water requiring treatment as it picks up sediment and debris while accumulating on non-porous road surfaces. The accumulated precipitation rushes into nearby water bodies where it destroys riparian zones and bottom substrate composition and hinders wildlife movements.)

iii. Roadside vegetation cutting/removal

  a. Attracts wildlife to the roadside
  b. Breaks established plant community rootwebs
  c. Eliminates habitat
  d. Facilitates the proliferation and spread of invasive species (e.g. the common reed, *Phragmites australis*)
  e. Depletes soil nutrient levels
  f. Promotes erosion
  g. Promotes the accumulation of run off

CASE STUDY

Proliferation of Invasive Species - Ontario

Roads disturb natural ecosystems and facilitate the spread of invasive plant species (Gelbard and Belnap 2003). Monocultures of the invasive, European variety of common reed *Phragmites australis* have invaded roadside ditches in Ontario (Figure 6). *Phragmites* out-competes native plants because it spreads quickly and is tolerant of the salty roadside conditions. Proliferation is facilitated as seeds readily disperse down road corridors on the wind and once established grow underground stems that give rise to new plants. The most common spread of *Phragmites* is via root fragments carried on road maintenance equipment from one area to the next.

Figure 6 : A road side monoculture of the invasive common reed, *Phragmites australis*. © Mandy Karch.

Citizens have a role to play in in reducing the negative effects of roads on the environment.

ROAD ECOLOGY : A CITIZEN'S GUIDE

How to Conserve the Environment and Avoid a Wildlife/Vehicle Collision (WVC)

1. Don't Litter
   - Garbage pollutes wildlife habitat
   - Food items attract wildlife to the road

2. Participate in Community Roadside Litter Clean Ups

3. Reduce Wildlife/Vehicle Collisions and Engine Emissions
   - Limit driving
   - Avoid driving at dawn and dusk when most WVC's occur
   - Plan efficient routes
   - Take alternate modes of transportation: walk, bicycle, public transit
   - Carpool
   - Drive fuel efficient/hybrid/electric vehicles
   - Maintain your vehicle (adhere to Ontario's mandatory vehicle emissions inspection and maintenance Drive Clean program)

4. Reduce Water Contamination
   - Maintain your vehicle, check for fluid leaks
   - Limit use of wind shield wiper fluids
   - Don't pour chemicals down roadside storm water catch basins (http://www.yellowfishroad.org)

5. Avoid Disturbing Wildlife
   - Limit honking the horn and loud music while driving through wildlife habitat
   - Leave rocks and native vegetation in place (i.e. don't build roadside rock sculptures)

6. Drive Cautiously
    - Obey speed limits and wildlife crossing signs
    - Use proper lighting to increase visibility (especially at night)
    - Pay attention, don't be distracted by the radio and electronic devices

7. Participate in Organized Native Vegetation Plantings
    - (e.g. http://conservation.gardenontario.org)

8. Participate in Organized Removal of Invasive Plant Species
    - (e.g. http://www.torontozoo.com/Conservation/invasive.asp?pg=garlic)

9. Move Wildlife
    - When it is SAFE, move slow moving wildlife (e.g. turtles and snakes) off the road

10. Get Involved!
    - Attend Public Information Centres (PICs) regarding local road projects (For a list, go to Ontario's Environmental Registry: http://www.ebr.gov.on.ca)
    - Become a citizen scientist and monitor/report wildlife/road interactions
    - Inform the local government about areas of road mortality
    - Report wildlife sightings near or on roads to the Ontario Road Ecology Group (http://www.wildlifeonroads.org)

CASE STUDY

Reducing Vehicle Emission with Ontario's Drive Clean Program - Ontario

Ontario's Drive Clean program reduced light duty vehicle emissions (e.g. hydrocarbons and nitrogen oxide(s)) by an estimated 225,000 tonnes between 1999 and 2007. In the same time period emissions of carbon monoxide and carbon dioxide (a greenhouse gas) were also reduced by over 2.1 million and 232,000 tonnes respectively. As well in 2007, the Heavy Duty Diesel Vehicle program was responsible for reducing emissions of particulate matter by 254 tonnes. Without Drive Clean, smog causing pollutants would have been 33% higher in 2007 alone in the Drive Clean program area. The Drive Clean program is responsible for eliminating tens of thousands of tonnes of pollutants from the environment every year. Driving clean through proper vehicle maintenance can save on fuel consumption and prolong the life of your vehicle.

Refer to the Drive Clean website, http://www.driveclean.com for details on when a vehicle is required to get a Drive Clean test.

ONTARIO'S DRIVE CLEAN*

Suggested Link :

www.wildlifeonroads.org.

Amphibian Road Mortality Hotspot - Guelph, Ontario

After observing mass mortality of amphibians (an estimated 1000 frogs and toads) on Laird Road (near the Hwy 6 junction) in September 2008, concerned citizens of Guelph predicted a similar occurrence on a warm, wet September night in 2009. The dedicated volunteers went to the site to assist in the seasonal migration across the road. Their efforts resulted in the safe crossing of some individuals; however there were still over 200 dead amphibians and 1 garter snake that were recovered that evening (Figure 7). The City was presented with the data and temporarily closed the road to vehicular traffic the following night.

To prevent future mass mortalities on Laird Road, the City of Guelph is planning to erect silt fencing and construct culverts to facilitate safe wildlife crossings.

Figure 7 (Above) : Remains of over 200 amphibians (leopard frog, *Lithobates pipiens*, green frog, *Lithobates clamitans*, wood frog, *Lithobates sylvatica*, gray treefrog, *Hyla versicolor*, spring peeper, *Pseudacris crucifer*, toads, *Anaxyrus americanus* and a garter snake, *Thamnophis sirtalis*) recovered from Laird Road, Guelph, Ontario between 19:30 and 21:30, September 21, 2009, Guelph, Ontario. © Judy Martin.

Habitat Loss Due to Makeshift Roadside Rock Sculptures

While constructing a rock sculpture (Figure 8), may seem like a friendly gesture, the general public participating in this practice along roadsides has resulted in habitat disturbance and loss for many native species including salamanders, skinks, and aquatic organisms such as mudpuppies, sculpins and native crayfish. Restore wildlife habitat by dismantling roadside sculptures and placing the rocks back in the scars of the sites they initially came from.

Figure 8 (Right) : Example of a roadside rock sculpture disturbing habitat for local wildlife. © Mandy Karch.

Ministry of Transportation: Watch for Wildlife

Motorist behaviour influences the risk of wildlife/vehicle collisions (WVC's). Drivers can reduce the risk of WVC's with large animals such as deer, moose and bear by following the Ministry of Transportation of Ontario's (MTO) recommendations:

1. Watch
   - Scan the road ahead from shoulder to shoulder. When you see wildlife beside the road, slow down and pass carefully as they may suddenly bolt onto the road.
   - Watch for the yellow wildlife warning signs that indicate an area of increased risk. Slow down when traveling through these areas.
   - Use high beams at night where possible and watch for glowing eyes of animals.
2. Steer
   - Stay in control. Watch your speed and take extra precautions when driving at night as visibility is greatly reduced. Slowing down will give you that extra second to respond. If you focus on a target, you are more likely to collide with it. Look where you want to travel, do not focus on what you are trying to avoid.
3. Brake
   - Brake firmly if an animal is standing on, or crossing the road. Never assume the animal will move out of your way.
4. Stop
   - Stop as safely as possible if wildlife is crossing the road. Remember, if one animal crosses the road, others may follow.

Suggested Link :

www.mto.gov.on.ca/english/safety/wildlife.shtml

Peak Timing of Wildlife/Vehicle Collisions

While a wildlife/vehicle collision (WVC) can occur at any time, there may be peaks due to patterns in wildlife movement and traffic volume. For example, in Algonquin Provincial Park, May and June are the peak months for collisions with moose and deer (Table 3).

Table 3 : Summary of total reported road-kill statistics in the Algonquin District (1985-2009; source: Huner and Laderoute, 2010).

	Moose	Deer	Bear	Owl	Hawk	Wolf	**Total**
January	12	5	-	1	-	1	19
February	4	0	-	2	-	-	6
March	7	3	-	2	-	-	12
April	14	7	-	2	1	-	24
May	47	19	-	-	1	-	67
June	66	26	1	-	-	1	94
July	31	13	5	-	-	1	50
August	32	8	7	1	2	1	51
September	15	11	2	-	1	-	29
October	14	14	2	-	2	1	33
November	15	9	-	-	-	1	25
December	14	7	-	-	-	-	21
Total	271	122	17	8	7	6	431

Reptiles and amphibians are at risk throughout their active season (April to October; Table 4).

Table 4 : Peak months when reptiles and amphibians are at risk of road mortality.

April/May	June/July	August/September	October
Animals are emerging from their overwintering sites and moving into their active wetlands to feed, grow and reproduce	Reptiles are crossing the road in search of suitable nesting sites	Hatchlings are emerging and animals are moving through the landscape	Animals are moving back into their overwintering sites

How to Safely Move Wildlife Off the Road

When helping wildlife off the road use good judgment. Ensure your safety and the safety of other motorists is secure before attempting to move the animal. If the situation is unsafe, call a local wildlife handler or shelter for assistance.

Some wildlife species (e.g. reptiles) use roads for behaviours such as basking or nesting. Most reptiles and amphibians are easy to handle, but if in doubt, use a shovel or stick to gently encourage animals off the road. Handling snapping turtles is not recommended since they may attempt to bite in defence. Holding a snapping turtle by the tail may damage the vertebrae and dropping a turtle may be fatal, so to avoid harm to yourself and the turtle, move the turtle by gently nudging the back end of the shell with a stick or transport the turtle using a blanket or shovel or encourage the turtle to snap onto a large stick and then gently drag the turtle off the road (Figure 9). Always move a turtle in the <u>same</u> direction it was traveling. If the direction is unclear (i.e. the animal is moving parallel to the road) choose the side with the better habitat (e.g. wetland).

When moving amphibians, ensure you do not have sunscreen, insect repellent or anti-bacterial cleanser on your hands. These chemicals are an irritant to the delicate skin of an amphibian, but be sure to always wash your hands after handling any wildlife.

Figure 9a, 9b, 9c and 9d (Right and Opposite) : Suggested methods of moving a snapping turtle, *Chelydra serpentina*, off the road.
© Toronto Zoo Adopt-A-Pond Programme.

Helping injured wildlife off the road requires more equipment, especially if you intend to transport the animal to a shelter for medical assistance. If moving an animal is feasible, wearing gloves pick the animal up in a towel and gently place it in a towel-lined box. If an animal cannot be transported, delineate the area with pylons or flares to alert other motorists to proceed around the area with caution. Good items to include in a vehicle emergency kit to deal with wildlife on the road are :

- Ventilated box/animal carrier
- Towel, blanket, or pillow case
- Gloves (rubber and thick work gloves)
- Protective eye wear
- Sticks/shovel
- Board to use as a stretcher
- Flares/pylons
- Pool liner or rubber mat to handle porcupines

Moving dead wildlife off the road is a good way to deter future road mortality. Dead wildlife may attract their mate, young or scavengers to the road.

APPLIED ROAD ECOLOGY SOLUTIONS

Although roads pose threats to the environment and biodiversity, there are solutions to mitigate these threats.

Minimizing the Effects of Roads on the Environment and Biodiversity

Ideally no more roads would be built, and some existing roads, particularly those bisecting natural areas, would be removed. However, as long as road construction projects are being planned, responsible design and best practices must be implemented for the ecological impacts of these roads to be minimized. Recommended design elements should; 1) maintain habitat connectivity and keep animals off the road; 2) improve driver awareness and visibility; and 3) minimize habitat degradation and disturbance of wildlife behaviour. Early conversation is critical among transportation planners and ecologists to facilitate the design process.

1. Maintain habitat connectivity and keep animals off the road
    a. Build fewer roads
    b. Route selection:
        - Road alignment (minimize bisecting habitat and avoid natural wildlife crossing areas such as valleys)
        - Bundle roads where multiple transportation corridors are deemed necessary and minimize the amount of land between road features such as by-passes (Figures 10 and 11)
    c. Reduce road width (fewer lanes facilitate successful wildlife crossings)
    d. Median design
        - Open post and rail design maintains habitat connectivity, but allows wildlife access to roads
        - Solid concrete medians prevent wildlife crossings of half the road, but fragment the habitat and potentially trap animals on the road increasing the likelihood of a collision
    e. Road closures (temporary road segment closures during peak wildlife movements (e.g. amphibian migrations) in areas where alternate routes are available)
    f. Noise reduction walls (solid barriers that prevent wildlife crossings and mitigate noise pollution)

Opposite © Matt Aresco.

g. Exclusion fencing (note: design elements must target specific species (consider: barrier height, amount buried under ground and mesh size) and account for issues such as maintenance, particularly winter snow removal)
h. Ecopassages (provide wildlife passage over or under roads)
i. Grading (raised road sections discourage wildlife from crossing – adding a lip further deters wildlife from climbing onto and crossing roads, Figure 12)
j. Raised roads (i.e. extended bridges that enable wildlife to cross under the road)
k. Roadside drainage (i.e. prevent the formation of salt puddles/licks that attract wildlife)

2. Improve driver awareness and visibility
    a. Wildlife crossing signs (install in areas with suitable wildlife habitat)
    b. Curvature (i.e. bends in the road reduce driver visibility and reaction time)
    c. Elevation (i.e. hills and valleys in the road reduce driver visibility and reaction time)
    d. Lighting (adequate illumination with covers that direct light down to reduce light pollution)

3. Minimize habitat degradation and disturbances to wildlife
    a. Vegetation : 1) limit mowing and herbicide and insecticide treatments to protect biodiversity (e.g. conserve pollinator habitat); 2) plant native vegetation following road construction to reduce the spread of invasive plant species; 3) remove and control invasive plant species populations; and 4) clean construction equipment between projects to eliminate the spread of invasive plant species
    b. Run off : 1) keep sewage covers clear of debris; 2) de-compact roadside soil to facilitate absorption of precipitation; and 3) manage stormwater in the drainage system with 'leaky' pipes that allow seepage back into the ground
    c. Water quality (see Fisheries Act) : 1) control siltation and sedimentation with silt fencing, filter clothes and sand bags; and 2) install run-controls such as large, concrete culverts to protect the riparian edge
    d. Protect, restore and create habitat
    e. Surface road material: choose materials that reduce noise and vibrations to minimize disturbing surrounding wildlife

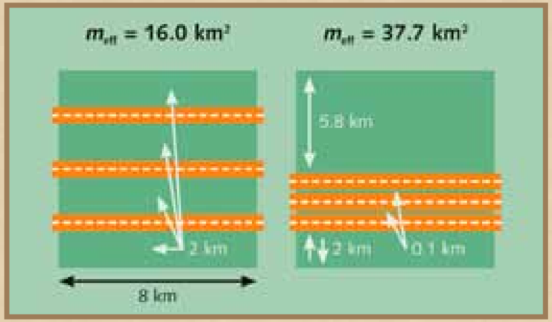


Figure 10 : Bundling transport routes (right) conserves habitat and limits fragmentation leading to a higher m_{eff} (effective mesh size: measure of the size of the "meshes" (i.e. remaining, unfragmented areas of landscape) that remain in the network of transport infrastructure and urban areas) value © Jaeger *et al.* 2007.

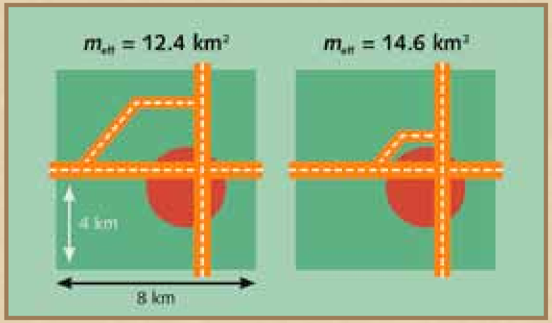


Figure 11 : When road features such as by-passes are built closer to settlements, more habitat is conserved resulting in a higher m_{eff} value. © Jaeger *et al.* 2007.

Figure 12 : A raised section of road outfitted with lipped-wall and ecopassage. © Matt Aresco.

Road Closure – Rondeau Provincial Park, Ontario

Located south of Chatham on the shores of Lake Erie, Rondeau Provincial Park protects many rare habitats. To help prevent wildlife/vehicle collisions within the Park, posted speed limits are 40km/hr year round and seasonally, selected roads are closed to vehicular traffic to allow safe passage for turtles and snakes. Park staff monitor wildlife on the road to: determine closure times; assist wildlife off the road during the busy summer season when the road is open to cars; and educate Park visitors about road ecology.

The Friends of Rondeau Provincial Park (http://www.rondeauprovincialpark.ca) support public outreach and education by selling 'brake for snakes' and 'brake for turtles' t-shirts (Figure 13) in the Visitor Centre.

Figure 13 : 'Brake for Snakes' T-shirts alert motorists to the risk of running over snakes and raises public awareness about road ecology.
© Friends of Rondeau Provincial Park.

Quick Fact :

Native plant species and agricultural crops are threatened by the disappearance of pollinators (mostly insects and birds). In an effort to preserve the diversity of native plant species in Ontario, the Ontario Horticultural Association has developed 'Roadsides' a conservation initiative that aims to restore pollinator habitat along road corridors. © Mandy Karch

CASE STUDY

Restoring Landscape Connectivity by Creating Habitat- Regional Municipality of York, Ontario

Avoiding habitat destruction is a primary objective when choosing a road alignment. If however, the chosen road alignment affects habitat, as little as possible should be destroyed, and the lost habitat should be re-created nearby.

Between 1998 and 2002 the development of the Bayview Avenue Extension between Stouffville Road and Bloomington Road passed through the environmentally sensitive landscape of the Oak Ridges Moraine. The alignment affected or resulted in the removal of four wetland pockets as well as the west edge of Forester Marsh. Some of the wetland impacts occurred on Toronto and Region Conservation Authority (TRCA) land. In recognition of these impacts, the Region of York commissioned Ecoplans Limited to develop a wetland creation concept in cooperation with TRCA staff. The result was the implementation of the Wetland Habitat Creation Project (Figure 14) on TRCA lands and on land near Lake St. George, situated well away from the new roadway. The Wetland Habitat Creation Project created an outdoor scientific laboratory and outdoor education resource that TRCA staff use for conservation programming. Wetland development and wildlife use in the restored area have been very encouraging (Gartshore *et al.* 2006).

Figure 14 : The plan for the Bayview Avenue Extension wetland habitat creation project. Three wetland plots were created for research purposes. The far left wetland is salvaged (excavated and lined with wetland substrates salvaged from the wetland zones removed by the construction of the road), the middle wetland is untreated (excavated but received no subsequent treatment) and the far right wetland is planted (excavated and planted with nursery stock).
© Ecoplans Limited.

Exclusion Fencing

Fencing is vital to preventing wildlife crossings. Without fencing, most wildlife crossing structures (i.e. ecopassages) would go unused (Clevenger *et al*. 2001). Dodd *et al*. (2004) found that the total number of species using a culvert ecopassage increased from 28 to 42 with the addition of a barrier wall to guide wildlife to the opening and that overall road mortality declined by 93.5%.

Fencing requirements vary depending on landscape and target species. Fences that prevent road access to large mammals such as deer differ from fences that prevent reptiles and amphibians from crossing the road. Fence material, installation, maintenance and cost will all vary depending on what the fence is intended to protect, how much is needed and the installation terrain.

Environmental Considerations of Fence Installation

Adding a fence disturbs the natural environment. To mitigate the hazards:

- Identify sensitive habitat within the work area
- Determine the disturbance level of the work and necessary mitigation measures
- Consider what additional fence features are necessary
- Budget and schedule for maintenance and repairs (removal of vegetation/fallen trees, holes in the fence, soil stabilization, etc.)
- Practice eco-friendly construction (minimize destruction to surrounding habitat during construction, use non-toxic building materials)

Risk of Predation at Fence Lines

Fencing raises the concern of predation as wildlife may become concentrated at the fence line. It has not however been substantiated that ecopassages and fences aggregate animals and render them more vulnerable to predation (Little 2003). Aresco (2005) found that 1% of turtles behind drift fences were preyed upon. Although this represents a loss in the population, without the drift fence, 98% of the turtles would have been killed while attempting to cross the road.
To reduce the threat of predation at ecopassages or along fences, there needs to be suitable cover to conceal wildlife movements. Follow up monitoring is also important to determine if the structures effectively protect the target species.

CASE STUDY

Highway 24 - Brantford, Ontario

In spring 2008 naturalist Don Scallen reported 8 dead Blanding's turtles (OMNR Status: Threatened) on Highway 24 at the Mount Pleasant Creek crossing just south of Brantford (Figure 15). In response to this report the MTO, in collaboration with the Toronto Zoo, installed temporary exclusion fencing in late summer to direct turtles and other small animals to an existing culvert (Figure 16). In February 2010, the MTO installed permanent turtle fencing and preliminary findings by Toronto Zoo monitoring suggest that turtles are using the crossing to safely access wetland habitat on either side of the road.

Figure 15 (Below) : Blanding's turtles, *Emydoidea blandingii*, killed while crossing Highway 24 to access wetlands to feed and reproduce. © Don Scallen.

Figure 16a and 16b (Right) : Silt fencing installed along Highway 24 to direct wildlife to the safe passage through the culvert under the road. © MTO.

CASE STUDY

Highway 10 – Caledon, Ontario

In June 2000, 8 dead turtles (7 snapping turtles and 1 painted turtle) and 1 live painted turtle were observed on Highway 10 near the Orangeville Wetland Complex. June is a peak mortality month as turtles leave their wetlands in search of suitable nesting habitat and get killed by vehicle collisions.

To help conserve the Orangeville Wetland Complex turtle populations, MTO finalized mitigation designs in April 2007 and in late 2009 installed expanded metal anti-glare screen/mesh barrier fencing and a 40 metre corrugated steel pipe culvert with sandy substrate to facilitate safe turtle crossings (Figure 17). The entryway of the culvert was designed to let light in and encourage wildlife crossings and a fine sandy/granular substrate was placed at either end of the culvert to create potential turtle nesting habitat. The nesting habitat was installed to encourage nesting away from the highway shoulder and the fence was installed to keep the hatchlings and adult turtles off the highway during nesting/migration. A two year monitoring program of the mitigation measures is scheduled to begin in summer 2010.

Figure 17 : Installation of a steel culvert and barrier fencing to facilitate turtle movements across Highway 10 near Orangeville. © MTO.

Ecopassages

Wildlife fencing and specific road design elements (please read above) can be implemented to keep animals off the road and therefore reduce road mortality. However, in many situations it will be important for animals to be able to get to the other side of the road to access resources. In these cases, along with fencing, ecopassages can be installed. Ecopassages provide linkages for wildlife movements over or under roads. In the past, road design features such as bridges and viaducts have inadvertently served to improve habitat connectivity and facilitate wildlife crossings. While effective in some locations, 'accidental' road mitigation is not sufficient. Effective road mitigation requires well researched, planned and placed structures that target conservation and protection of wildlife and habitat. Ecopassage design and placement differ depending on the target species. An ecopassage is only effective if wildlife use it. Designing ecopassages to be attractive to the target species requires careful consideration of the dimensions, lighting, substrate and the noise and moisture levels of the structure. Fencing is required along with ecopassages, to keep the animals from trying to cross the road itself and direct them to the passage.

There are two types of ecopassages :
a) Overpasses and b) Underpasses.

a) Overpasses :

An overpass connects the landscape by facilitating wildlife movement over a road (Figure 18). Overpasses target large mammals and help reduce WVC mortality (Clevenger 2007).

Figure 18 : One of two wildlife overpasses in Banff National Park, Alberta. © Eco-Kare International.

Overpasses – Sudbury, Ontario

MTO has commenced construction on a wildlife overpass on Highway 69 near the Highway 637 (Kilarney Road) junction south of Sudbury (Figure 19). The overpass will accommodate elk, deer, moose and bear.

Figure 19 : Conceptual rendition of the Highway 69 overpass MTO plans to build for large mammal passage. © MTO.

b) Underpasses:

An underpass connects the landscape by facilitating wildlife movement under a road. Underpasses may be small in width and height (e.g. a pipe, tunnel or drainage culvert) or large (e.g. bridges, viaducts or large box culverts). Bridges and viaducts maintain habitat connectivity and landscape features including streams and waterways for fish passage. Small culverts provide drainage zones beneath roads and wildlife is naturally drawn to crossing at these sites. Culverts may be up-graded to ecopassages with a few added design elements suited to attract the target species. Fencing is required along with underpasses to keep the animals from entering the road itself and to direct them towards the underpass. The following are examples of different types of underpasses.

i) Culverts

- Typical highway design feature intended to drain water
- Round or elliptical in cross section
- Made of metal, cement or plastic
- Facilitate small wildlife crossings when designed and located properly in the landscape

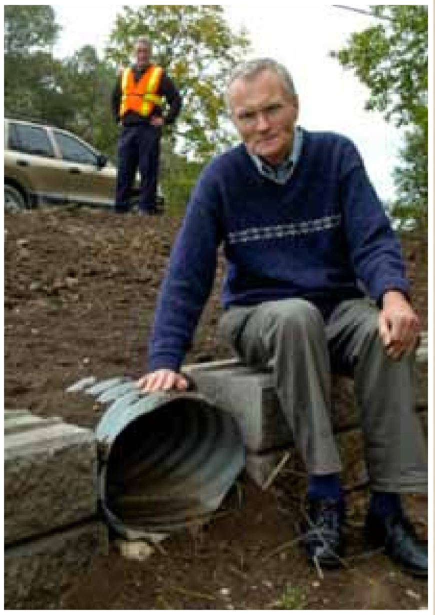
Quick Fact :

Road mortality is a significant threat to Ontario's turtles. Turtles have evolved with very low adult mortality. Population persistence is dependent on maintaining this life history trait. Even a small number of reproductive adults, particularly females, removed from the population (e.g. killed by cars), can drive the population to extinction.
© Mandy Karch.

Culvert Installation - Waterloo, Ontario

In summer 2009, the Region of Waterloo directed a portion of their Environmental Stewardship Fund towards the installation of a dry culvert underneath a segment of Blair Road (Figure 20) where road-killed reptiles and amphibians had been documented. Initially, the only road work to be done in the area was resurfacing and select up-grades, but city staff identified an opportunity to re-establish habitat connectivity and facilitate wildlife crossings.

Figure 20 : Region of Waterloo Manager of Environmental Planning, Chris Gosselin and project manager, John Lee (background) with the ecopassage installed under Blair Road.
© The Waterloo Region Record.



ii) Box Culverts

- Larger interior space compared to round culverts of comparable size (Figure 21)
- Accommodate passage for larger wildlife

Figure 21 : Box culvert with fencing for multi-species usage. © Tony Clevenger.

iii) Multi-Plate Arches

- Large, bottomless structures that run under road
- Accommodate passage for large wildlife

iv) Open-Span Bridges

- Improve habitat connectivity by spanning natural drainage sites
- Accommodate passage of wildlife of all sizes
- Attract wildlife (situated in natural crossing areas, light and open)

v) Bridge Extensions

- Lengthen the ends of a bridge farther beyond the drainage area
- Easily incorporated into existing bridges
- Maintain landscape connectivity and terrestrial/aquatic ecosystem functioning
- Accommodate passage of wildlife of all sizes
- Attract wildlife (situated in natural crossing areas, light and open)

Open Span Bridge - Regional Municipality of York, Ontario

In 2002 a 4.5 km extension of Bayview Avenue from Stouffville Road north to Bloomington Road was opened to public traffic. The segment of road crossed the Oak Ridges Moraine, an environmentally sensitive landscape that has been designated for permanent protection under the Greenbelt Plan 2005. In order to minimize and mitigate the effects of the road on the natural environment, wetland habitat was created and ecopassages were included in the road design. An 81 metre 3 span bridge, two corrugated steel pipe (CSP) culverts for amphibian crossings and five additional wildlife ecopassages (designs based on Ecoplans Limited 2002) with funneling walls were installed to improve habitat connectivity and reduce the occurrence of WVC's (Figure 22). Ecopassage monitoring in 2006 and 2007 revealed that small mammals, amphibians, and reptiles all used the mitigation measures (Ecoplans 2006a,b; 2007).

Figure 22a and 22b (Below) : Span bridge (left) and culvert with fencing (right) along Bayview Avenue to help conserve the landscape and wildlife of the Oak Ridges Moraine. © Ecoplans Limited.

Tips for Successful & Effective Ecopassages

Ecopassages are ineffective without measures such as fencing or raised road designs that keep animals off the road. Therefore, they should only be installed along with such measures.

Ecopassage placement and design are crucial in order to maximize efficacy. Wildlife may require an adjustment period before ecopassages are an accepted feature of the landscape. The following tips provide guidelines to creating successful ecopassages.

1. The location of wildlife crossing structures is the first consideration and should only be decided after collecting field data specific to the area. Ideally, crossing structures should be placed where animals naturally approach the road. Likely crossing areas may be vegetated, occur within a valley, along streams or rivers, or in areas where the number of lanes is reduced. A suitable location will optimize the use of the ecopassage.

2. The approach to a wildlife crossing structure will determine whether or not it is used. More animals will enter and successfully cross ecopassages that fit into the surrounding habitat; the more natural an ecopassage appears, the more effective it will be. Vegetative cover provides security and attracts wildlife by sheltering the noise and light pollution generated by the road. This is particularly relevant to existing culverts that may have only been placed for hydrology purposes, but may double as wildlife crossings with a few easy upgrades. Cement approaches, mounds of debris/road-fill material, poles and signs should be avoided near ecopassages in order to maintain a more natural appearance.

3. The line of sight is a very important ecopassage feature. Wildlife should be able to see suitable habitat on the other side of the structure. Ecopassages that obliterate the view, exit into unsuitable habitat, drop or are dark are less likely to be used.

4. The internal environment of the ecopassage is critical. Lighting, moisture and ground cover must all be appropriate for the target species. Mimicking the environment outside the crossing as best as possible will result in a more effective ecopassage.

5. Multiple crossing structures should be constructed at a known hotspot to provide connectivity to accommodate all species present and their behavioural needs. For example, small, slow moving animals may require numerous ecopassages in close proximity to conserve energy and minimize vulnerability to predation. Clevenger *et al.* (2001) recommends placing underpasses every 150-300m to accommodate small mammals, reptiles and amphibians. An inadequate number of crossing structures within an animal's home range has been identified as a cause of low ecopassage usage (Ruediger 2001).

6. Maintenance of ecopassages is critical for optimal functioning. Low maintenance options are preferable and more economical, but once an ecopassage is installed it should be monitored for and cleared of obstructions. Vegetation, silt and refuse blockages will deter or impede wildlife movement and render the structure ineffective.

Wildlife Crossing Signs

- Raise awareness and alert motorists that wildlife may be crossing the road (Figure 23)
- May be interactive (a motion sensor mechanism that illuminates only when wildlife is present - best suited to low traffic volume roads and only effective with larger wildlife)
- May be placed seasonally or indicate when the hazard is present
- Data must support the need/type of signage in any given area

Figure 23 (Right) : Examples of wildlife crossing signs used by transportation agencies to alert motorists of the risk of wildlife on the road. © Toronto Zoo Adopt-A-Pond Programme, MTO.

To order a turtle crossing sign go to: http://www.torontozoo.co/adoptapond/turtleCrossing.asp

CASE STUDY

Electronic Signs - Norfolk County, Ontario

The Long Point Causeway Improvement Project (LPCIP) uses an electronic sign (Figure 24) to alert motorists to watch for wildlife on the road. The Long Point Causeway is a 3.6 km stretch of road built in 1927 that links the Long Point Peninsula on Lake Erie with mainland Ontario (Figure 25). Traffic along the causeway is responsible for up to 10,000 wildlife road mortalities in a five month period each year. Amphibians such as the leopard frog constitute most of the road kill and several Species at Risk (SAR) reptiles such as the Blanding's turtle, spotted turtle and eastern foxsnake are also killed along the causeway. The Long Point Causeway represents an important research, conservation and management site in Ontario. While signs do raise awareness at Long Point, Ecoplans (2008) recommends incorporating more effective mitigation measures such as exclusion fencing and specially-designed culverts (ecopassages) to help wildlife move safely through the landscape. To learn more about the LPCIP go to: http://longpointcauseway.com.

Figure 24. Temporary electronic sign warning motorists of wildlife on the Long Point Causeway. © LPCIP.

Figure 25 (Right) : Map of Long Point showing the Causeway (red line) location. © Scott Gillingwater.

ROAD ECOLOGY RESEARCH

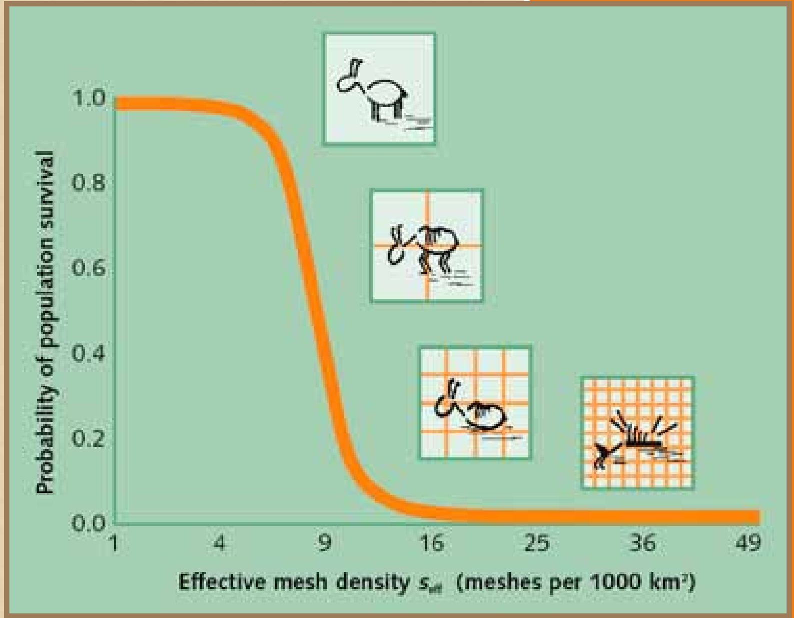
The rate of road development exceeds our understanding of the effects on the environment and biodiversity.

Road construction and repair is on-going. The rate of road development exceeds our understanding of the effects on the environment and biodiversity. Research is necessary to study and predict these effects and to provide guidance and recommendations on how to minimize the negative effects.

Wildlife Population Road Mortality Thresholds

Ecological research has demonstrated that there are thresholds of total traffic in a landscape for the persistence of animal populations (Figure 26) that, when reached, can drastically reduce the probability of survival of the population. These thresholds depend on the placement of roads in the landscape and the traffic volume.

Figure 26 (Right) : Example of the landscape fragmentation threshold, based on traffic volume, for the survival of a given wildlife population. © Jaeger and Holderegger 2005.



Prioritizing Road Mitigation in Ontario with Connectivity Modeling

Mitigation locations should be selected based on habitat availability. Basing the mitigation site on wildlife sightings (alive or dead) alone may be problematic as previous road mortality may be responsible for current diminished wildlife observations. Mitigation in areas with suitable habitat in the absence of wildlife sightings may lead to a re-colonization, range expansion and an established population where it was once wiped out.

Transportation planners can predict where accumulating road density will have the greatest effect on the local ecology and prioritize mitigation by using Geographic Information System (GIS) and fragmentation indices.

Opposite © Mandy Karch.

Geographic Information System (GIS)

GIS is a tool that may be applied to analyse and display road ecology issues. By merging geographically referenced information and wildlife population data, a GIS model may be developed to 1) predict hotspots (i.e. areas where wildlife mortality is high (i.e. WVC's) and roads act as barriers to habitat connectivity (i.e. impede movement through the landscape)) and 2) prioritize mitigation sites (i.e. rank hotspots; Figure 27). Progressive development of the model (i.e. refining the model based on systematic data collection) will result in greater predictive ability and species-specific applications that will enable conservation authorities, municipalities and transportation planners to identify which existing road mortality hotspots require urgent mitigation to protect wildlife populations.

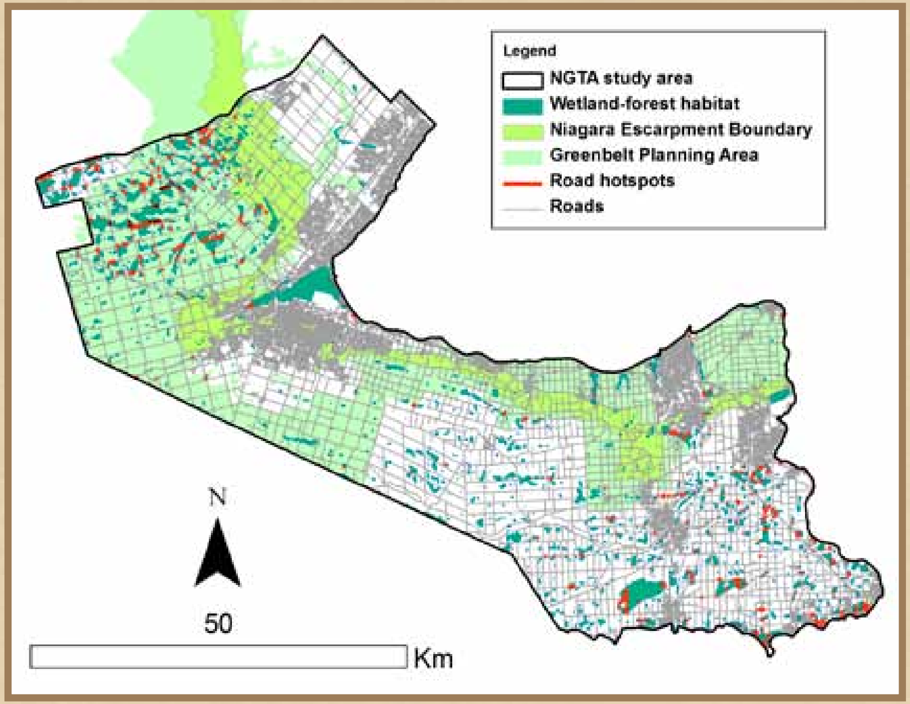


Figure 27 : Example of a GIS hotspot output map for the Niagara-GTA corridor, a potential site for road development.
© Eco-Kare International.

Tips for Applying a GIS Model as a Mitigation Tool Across Ontario

1) Identify and prioritize key locations where connectivity needs to be restored

2) Produce maps at a scale reasonable for planning, e.g. by municipality or by watershed

3) Overlay species at risk presence/absence data, perform road-kill surveys, etc. to determine what, how many and when species road-mortality is occurring at each prioritized location

4) Design an appropriate mitigation strategy, e.g. wildlife crossing signs, ecopassages, etc. at each of these locations

5) Set-up an implementation strategy with each municipality to integrate these mitigation measures in their planning and road upgrade projects

GIS Application – Pickering, Ontario

In 2009, a GIS model was used to provide guidance and consultation for the 407 East Individual Environmental Assessment (IEA; 2009). The model identified potential hotspots that would require mitigation to improve habitat connectivity and facilitate wildlife crossings if road construction where to proceed (Figure 28).

Figure 28a and 28b (Right) : GIS maps illustrating wildlife connectivity hotspots along the proposed extensions of Highway 407. © Eco-Kare International.

Fragmentation Indices

Armed with fragmentation indices, transportation planners may be better able to limit urban sprawl and predict the effects road construction will have on local biodiversity and ecological processes (Figure 29a). A technique used to quantitatively measure the degree of landscape fragmentation is the effective mesh size (m_{eff}) (Jaeger *et al.* 2008). This metric expresses the probability that two points chosen randomly in a region are connected. The more barriers that fragment a landscape the less likely an individual will be able to access resources such as food, water, shelter and mates and the lower the m_{eff} value (Figures 29b and 29c).

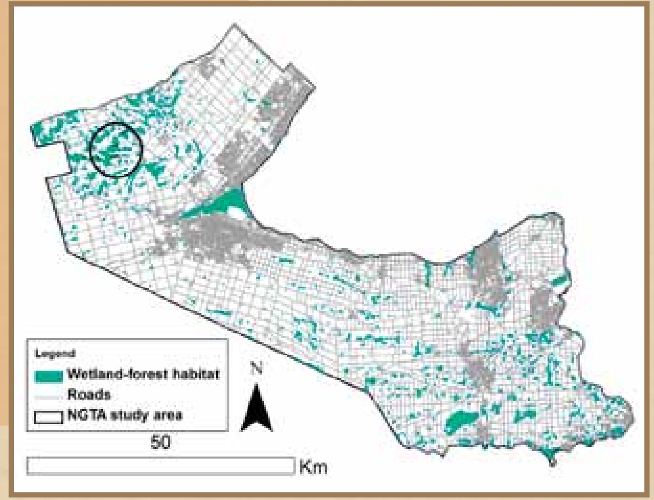
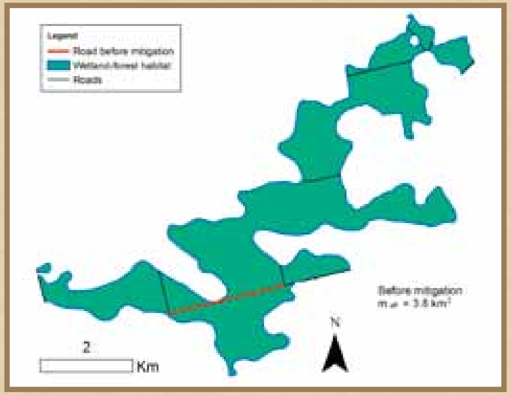
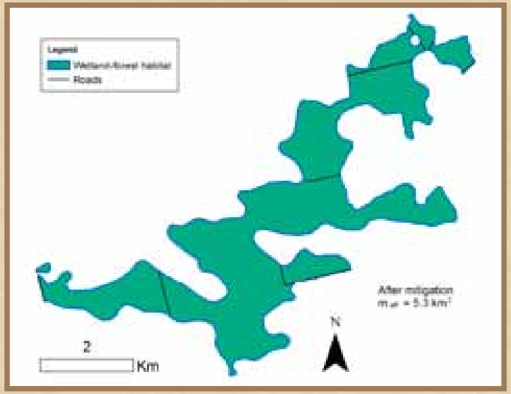


Figure 29a, 29b and 29c : Maps of the Niagara-GTA corridor illustrating fragmentation indices. © Eco-Kare International.





CASE STUDY

Determining a Technically Preferred Route (TPR) – Greater Golden Horseshoe, Ontario

Southern Ontario's 400 series highways are expanding to accommodate the increased traffic volumes expected in the Greater Golden Horseshoe (GGH) over the next 20 years. Proposed roads are currently under review in an Environmental Assessment Study (EAS) for the GTA-west corridor; Brantford to Cambridge corridor; and the Niagara-GTA corridor (Figure 30). These corridors bisect provincially protected green spaces; Ontario's Greenbelt and Niagara Escarpment, a world biosphere reserve site. Connectivity modeling should be used in these areas to ensure that the damage to the environment from the road development is minimized.

Figure 30 : Overview of study areas proposed for transportation corridors in the Greater Golden Horseshoe. © Eco-Kare International.

Ontario Road Ecology Group

www.torontozoo.com/conservation

THE ONTARIO ROAD ECOLOGY GROUP

Protecting biodiversity from the threats of roads.

The Ontario Road Ecology Group (OREG – est. 2009) raises awareness about the threats of roads to biodiversity in Ontario and researches and applies solutions. OREG operates out of the Toronto Zoo where in 2005 the 'International Symposia and Workshops on Conservation of the Massasauga Rattlesnake, Sistrurus catenatus' highlighted the obstacles that roads pose to the conservation of this provincially threatened species and other wildlife populations. Two years later in 2007, the Toronto Zoo hosted the internationally attended 'Ontario Roads and Ecopassages Forum'. The success of that meeting prompted the establishment of OREG as well as the 2008 'Ontario Road Ecology Stewardship Symposium and Habitat Connectivity Workshop' held at the Toronto Zoo.

OREG is an umbrella organization made up of a diverse membership that includes government and non-government agencies dedicated to resolving road ecology issues. As a champion for biodiversity that is at risk of being negatively affected by roads, OREG strives to:

1. Promote the science of road ecology in Ontario.

2. Contribute to the development of policy and legislation in areas of road ecology to aid transportation planning agencies design more ecologically-sustainable transportation networks.

3. Facilitate partnerships among individuals and groups who strive to research and resolve road ecology questions in Ontario.

4. Promote and provide responsible decision-making criteria for the development of mitigation techniques and technologies that minimize the threats of roads to biodiversity in Ontario.

5. Provide resources through a forum of data, statistical methods and scientific literature exchange relating to the analyses of the interaction of roads and biodiversity.

6. Provide outreach and education to Ontarians and encourages stewardship within and among communities to raise awareness about the ecological effects of roads.

Through outreach and education OREG raises awareness and informs the public how the individual, motorist and government can take responsibility to ensure that roads are more ecological.

OREG actively participates in:

- Community Events (presentations, displays, brochures)
- University Lectures
- Public Attractions (e.g. Road Ecology Display in the Conservation Connection Centre at the Toronto Zoo)
- Local, national and international conferences

On-line resources available through OREG's webpage provide up to date road ecology news and information.

Get Involved!

The public is a vital source of data. Only through public participation can an area as vast as Ontario be monitored. The data OREG collects are used province-wide to study road ecology issues and contribute to the conservation of wildlife including Species at Risk (SAR; see Appendix).
This unique database accepts all accounts of wildlife alive or dead near or on roads and is accessible through the Toronto Zoo website.

Report wildlife sightings to: **www.wildlifeonroads.org**

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5) Eastern Rat Snake Recovery Team

6) Loggerhead Shrike Recovery Team

7) Walpole Island Recovery Team

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ADDITIONAL ROAD ECOLOGY RESOURCES

Algonquin to Adirondacks Conservation Association (A2A)
Tel : 613-659-4824
www.a2alink.org

Biodiversity Centre for Wildlife Studies
Tel: 250-47-0465
www.wildlifebc.org/index.php?pageid=71

Bishop Mills Natural History Centre
Tel: 613-258-3107
http://pinicola.ca

Corridor Designs
http://corridordesign.org

Critter Crossings
www.fhwa.dot.gov/environment/wildlifecrossings/main.htm

Geomatics and Landscape Ecology Research Laboratory, Carleton University
Tel: 613-520-2600 Ext. 3856
http://www.glel.carleton.ca

Griffith University
http://www.griffith.edu.au/__data/assets/pdf_file/0007/170656/Applied-road-ecology-flier.pdf

International Conference on Ecology and Transportation
Tel: 919-515-8620
http://www.icoet.net/

Ontario Road Ecology Group
Tel: 416-393-6365
http://www.wildlifeonroads.org

Road Ecology Research Group
http://www.bees.unsw.edu.au/school/staff/croft/roadgroup.html

Safe Passage
http://www.carnivoresafepassage.org/

SHIFT Ontario
http://shiftontario.org/

Sustainable Urban Development Association
Tel: 416-400-0553
http://www.suda.ca

The Lake Jackson Ecopassage
http://www.lakejacksonturtles.org/

The Litzsinger Road Ecology Center, St. Louis
Tel: 314-918-9143
www.litzsinger.org

The Road Ecology Center at the University of California, Davis, California
Tel: 530-752-3608
http://www.roadecology.ucdavis.edu

University of Massachusetts Amherst
http://www.streamcontinuity.org/index.htm

Utah State University
http://www.wildlifeandroads.org/

Western Transportation Institute
Tel: 406-994-6114
http://www.wti.montana.edu

Wildlife Collision Prevention Program
Tel : 250-828-2551
www.wildlifeaccidents.ca/default.aspx

Table A1 : Glossary of Terms

OMNR Status		Definition
EXP	Extirpated	A species that no longer exists in the wild in Ontario but still occurs elsewhere.
END	Endangered	A species facing imminent extinction or extirpation in Ontario which is a candidate for regulation under Ontario's ESA.
THR	Threatened	A species that is at risk of becoming endangered in Ontario if limiting factors are not reversed.
SC	Special Concern (formerly Vulnerable)	A species with characteristics that make it sensitive to human activities or natural events.

Table A2 : Ontario Species at Risk Threatened by Roads

Common Name	Population Specifications	Species At Risk in Ontario (SARO) Status
Amphibians		
Allegheny Mountain Dusky Salamander, *Desmognathus ochrophaeus*		END
Fowler's Toad, *Anaxyrus fowleri*		THR
Jefferson Salamander, *Ambystoma jeffersonianum*		THR
Reptiles		
Blanding's Turtle, *Emydoidea blandingii*		THR
Butler's Gartersnake, *Thamnophis butleri*		THR
Common Five-lined Skink, *Plestiodon fasciatus*	Southern Shield	SC
Common Five-lined Skink, *Plestiodon fasciatus*	Carolinian	END
Eastern Foxsnake, *Pantherophis gloydi*	Georgian Bay	END
Eastern Foxsnake, *Pantherophis gloydi*	Carolinian	END
Eastern Hog-nosed Snake, *Heterodon platirhinos*		THR
Eastern Ribbonsnake, *Thamnophis sauritus*		SC
Gray Ratsnake, *Pantherophis spiloides*	Frontenac axis	THR
Gray Ratsnake, *Pantherophis spiloides*	Carolinian	END
Massasauga, *Sistrurus catenatus*		THR
Milksnake, *Lampropeltis triangulum*		SC
Northern Map Turtle, *Graptemys geographica*		SC
Queen Snake, *Regina septemvittata*		THR

Common Name	Population Specifications	Species At Risk in Ontario (SARO) Status
Snapping, *Chelydra sperpentina*		SC
Spiny Softshell, *Apalone spinifera*		THR
Stinkpot, *Sternotherus odoratus*		THR
Wood Turtle, *Glyptemys insculpta*		END
Birds		
Acadian Flycatcher, *Empidonax virescens*		END
Cerulean Warbler, *Dendroica cerulea*		SC
Hooded Warbler, *Wilsonia citrina*		SC
King Rail, *Rallus elegans*		END
Least Bittern, *Ixobrychus exilis*		THR
Loggerhead Shrike, *migrans* subspecies, *Lanius ludovicianus migrans*		END
Louisiana Waterthrush, *Seiurus motacilla*		SC
Prothonotary Warbler, *Protonotaria citrea*		END
Red-headed Woodpecker, *Melanerpes erythrocephalus*		SC
Short-eared Owl, *Asio flammeus*		SC
Mammals		
American Badger, *jacksoni* subspecies, *Taxidea taxus jacksoni*		END
Woodland Vole, *Microtus pinetorum*		SC

Common Name	Population Specifications	Species At Risk in Ontario (SARO) Status
Insects		
Monarch, *Danaus plexippus*		SC
Plants		
American Chestnut, *Castanea dentata*		END
Broad Beech Fern, *Phegopteris hexagonoptera*		SC
Butternut, *Juglans cinerea*		END
Cucumber Tree, *Magnolia acuminata*		END
Deerberry, *Vaccinium stamineum*		THR
Eastern Prairie Fringed-orchid, *Platanthera leucophaea*		END
Green Dragon, *Arisaema dracontium*		SC
Red Mulberry, *Morus rubra*		END
Shumard Oak, *Quercus shumardii*		SC
White Wood Aster, *Eurybia divaricata*		THR

Road mortality and habitat destruction from road construction are key threats to reptile and amphibian conservation. Motorists can help mitigate the threats of roads by looking out for these animals while driving (particularly between May and October). The following maps (A1, A2 and A3) depict where Species at Risk reptile and amphibian populations occur and major roads overlap.

Figure A1 : Species richness of five species of turtles: Snapping, eastern spiny soft shell, stinkpot, map and Blanding's in southern Ontario.
© Eco-Kare International.
Data Source : Ontario Herpetofaunal Atlas, 10 x 10 km presence squares.

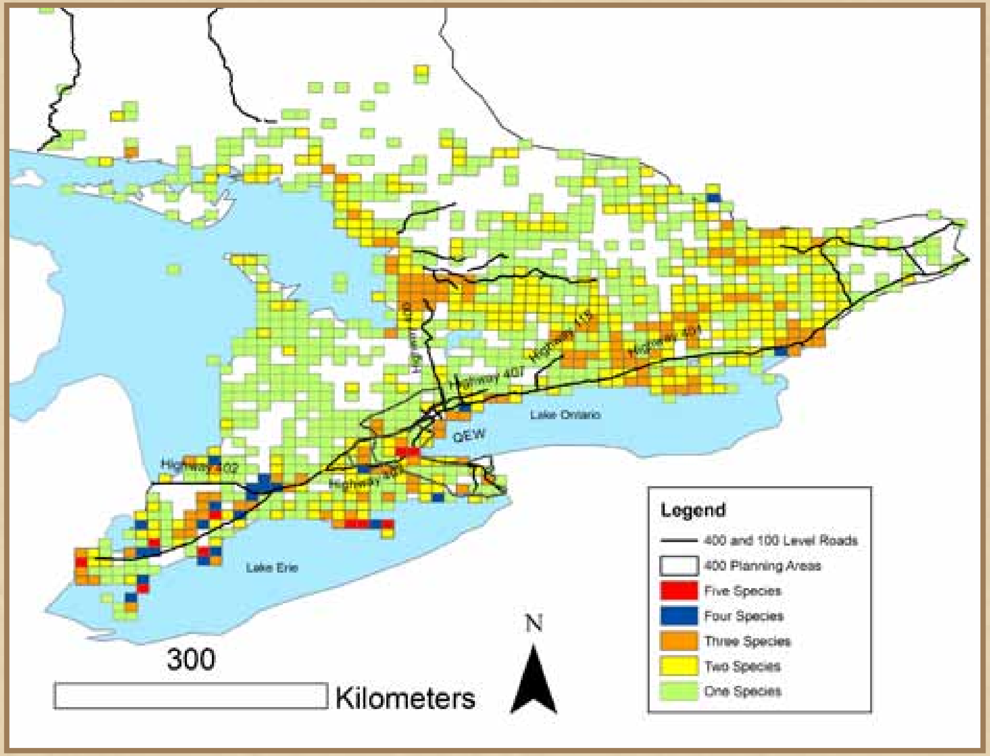


Figure A2 : Species richness of six species of snakes: Massasauga, eastern ribbon, eastern rat, eastern hog-nosed, milk and eastern fox in southern Ontario. © Eco-Kare International.
Data Source : Ontario Herpetofaunal Atlas, 10 x 10 km presence squares.

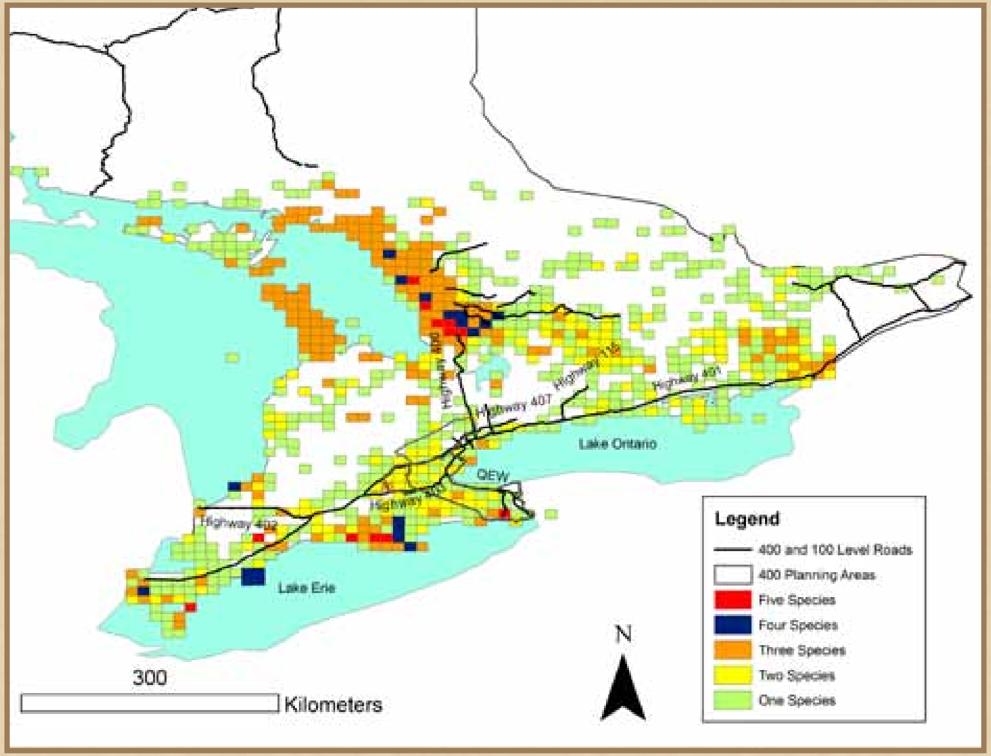
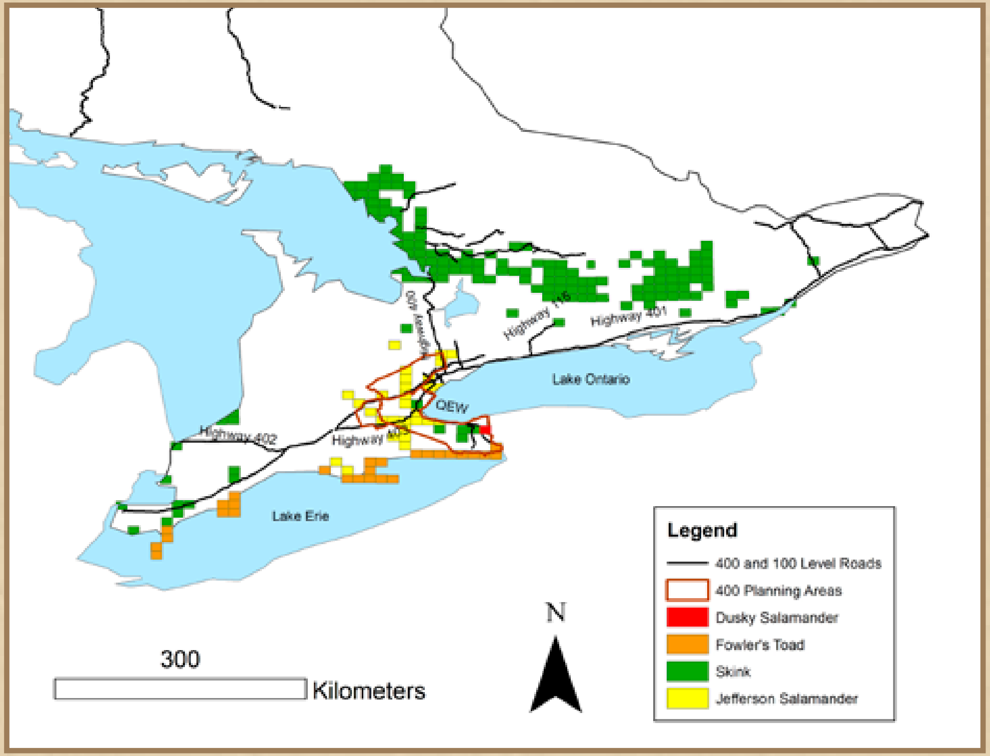


Figure A3 : Species richness of Species at Risk amphibians: Fowler's toad, northern dusky salamander and Jefferson salamander in southern Ontario, and Ontario's only lizard species: five-lined skink.
 Data Source : Ontario Herpetofaunal Atlas, 10 x 10 km presence squares.



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Thank you, OREG