COSEWIC
Assessment and Status Report

on the

Blanding's Turtle
Emydoidea blandingii

Nova Scotia population
Great Lakes/St. Lawrence population

in Canada

ENDANGERED
2016

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

COSEWIC status reports are working documents used in assigning the status of wildlife species suspected of being at risk. This report may be cited as follows:

COSEWIC. 2016. COSEWIC assessment and status report on the Blanding's Turtle *Emydoidea blandingii*, Nova Scotia population and Great Lakes/St. Lawrence population, in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xix + 110 pp. (http://www.registrelep-sararegistry.gc.ca/default.asp?lang=en&n=24F7211B-1).

Previous report(s):

COSEWIC 2005. COSEWIC assessment and update status report on the Blanding's Turtle *Emydoidea blandingii* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. viii + 40 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

Herman, T.B., T.D. Power and B.R. Eaton. 1993. COSEWIC status report on the Blanding's Turtle *Emydoidea blandingii* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 32 pp.

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Également disponible en français sous le titre Évaluation et Rapport de situation du COSEPAC sur la Tortue mouchetée (*Emydoidea blandingii*), population de la Nouvelle-Écosse et population des Grands Lacs et du Saint-Laurent, au Canada.

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Blanding's Turtle —Photo by Scott Gillingwater.

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COSEWIC
Assessment Summary

Assessment Summary – November 2016

Common name
Blanding's Turtle - Nova Scotia population

Scientific name
Emydoidea blandingii

Status
Endangered

Reason for designation
The current population size is < 500 mature individuals. The three main subpopulations are genetically distinct from each other and from other populations in Québec, Ontario, and the United States. Although the largest subpopulation occurs in a protected area, its numbers are still declining, possibly still showing the effects of historical mortality that took place 30-60 years ago. The other subpopulations are susceptible to increasing habitat degradation from forestry activities, recreation, water-level manipulation, and cottage development. Two subpopulations are very small (< 5 adults) and may not be viable. Threats across the range include increased pressure from predators, mortality from on- and off-road vehicles, vulnerability to collection, potential impacts of exotic predatory fishes, and the effects of climate change.

Occurrence
Nova Scotia

Status history
Designated Threatened in April 1993. Status re-examined and designated Endangered in May 2005 and November 2016.

Assessment Summary – November 2016

Common name
Blanding's Turtle - Great Lakes / St. Lawrence population

Scientific name
Emydoidea blandingii

Status
Endangered

Reason for designation
This population, although widespread, is declining because of several observed, inferred, and projected threats. The most serious threats include: road and rail mortality; illegal collection for the pet, food and traditional medicine trades; habitat loss due to invasive European Common Reed; development and wetland alterations; and, increasing numbers of predators. Quantitative analyses estimate that the total number of mature individuals in this population has declined > 60% over the last three generations (due to large-scale wetland drainage after European arrival) and will decline 50% over the next three generations because of road mortality alone.

Occurrence
Ontario, Quebec

Status history
Designated Threatened in May 2005. Status re-examined and designated Endangered in November 2016.

COSEWIC
Executive Summary

Blanding's Turtle
Emydoidea blandingii

Nova Scotia population
Great Lakes/St. Lawrence population

Wildlife Species Description and Significance

The Blanding's Turtle, *Emydoidea blandingii*, is the only representative of the genus *Emydoidea*. It is a medium-sized freshwater turtle with a characteristic bright yellow throat and a highly domed black shell with yellowish spots and flecks. It has one of the smallest global ranges compared to most other North American turtles and only ~20% of its global range occurs in Canada.

Distribution

In its Canadian range, the Great Lakes/St. Lawrence population of the Blanding's Turtle occurs primarily in southern Ontario (with isolated reports as far north as Timmins) and southern Québec (with isolated reports occurring as far north as the Abitibi-Témiscamingue region and as far east as the Capitale-Nationale region in Québec). The much smaller Nova Scotia population occurs in the southern portion of the province and represents the most isolated population within the species' range.

In the United States, the Blanding's Turtle occurs in the northeastern states, and is mainly concentrated around the Great Lakes; however, it occurs as far west as Nebraska and South Dakota and there are small isolated populations along the Atlantic seaboard in New York, Massachusetts, New Hampshire and Maine.

Habitat

In Nova Scotia, Blanding's Turtles tend to prefer darkly-coloured water, indicative of relatively higher secondary productivity. In the Great Lakes/St. Lawrence population, however, Blanding's Turtles are often observed using clear water eutrophic wetlands. Blanding's Turtles have strong site fidelity but may use several connected water bodies throughout the active season. Turtles of all ages occur primarily in shallow water habitats. Females nest in a variety of substrates including sand, organic soil, gravel, cobblestone, and soil-filled crevices of rock outcrops. Adults and juveniles overwinter in a variety of water bodies that maintain pools averaging about 1 m in depth; however, hatchling turtles have been observed hibernating terrestrially during their first winter. Reported mean home ranges generally fall between 10-60 ha (maximum 382 ha) or 1000-2500 m (maximum 7000 m); however, most studies likely underestimate Blanding's Turtle home range size because few have utilized GPS loggers to track daily movements throughout one or more entire active seasons.

Biology

The Blanding's Turtle is an exceptionally long-lived and late-maturing species, even for a turtle. Blanding's Turtles mature between 14-25 years of age and can continue to reproduce successfully until at least 75 years old. Mature females produce one clutch of eggs every 1-3 years and female fecundity and reproductive frequency are positively correlated with age. Females carry out long-distance nesting migrations and can make overland movements of >10 km. The Blanding's Turtle's ability to make long-distance movements facilitates gene flow among wetlands and may substantially increase reproductive success. The mean generation time for Canadian Blanding's Turtles is ~40 years.

Population Sizes and Trends

Across the North American range, Blanding's Turtles mainly occur in small, isolated subpopulations that maintain a few dozen to approximately 100 turtles. In Canada, most monitored subpopulations appear to maintain fewer than 150 adults, with none exceeding 1000.

The size of the Blanding's Turtle Great Lakes/St. Lawrence population is impossible to estimate accurately, given that very few mark-recapture studies have been conducted throughout the region, but is believed to harbour < 50,000 adults. It is estimated that over the last three generations > 60% of the population was lost due to large-scale wetland drainage after European arrival, and a further decline of > 50% is projected over the next three generations based on observed trends for monitored subpopulations and road mortality models. The long-term mark-recapture program in Québec has found fewer than 200 adults to date; although no trends have been confirmed for this subpopulation, it has likely also declined due to historical wetland loss and ongoing anthropogenic threats.

The total number of mature individuals in the Blanding's Turtle, Nova Scotia population is believed to be < 500. The longest studied subpopulations show very late maturity (20-25 years) and great longevity (> 70 years). Without management intervention, models predict that the Nova Scotia population faces a high extinction risk despite occurring in a protected area.

Threats and Limiting Factors

This species faces numerous threats, the most serious of which include: (i) road/rail mortality and associated road effects; (ii) habitat loss due to the invasive European Reed, various types of development and wetland modifications; (iii) illegal collection for the pet, food and traditional medicine trades; and (iv) increased mortality of individuals and nests from subsidized predators. Additional potential threats include: mortality from aggregate, forestry, energy production and recreational activities; wetland pollution; climate change and the introduction of other invasive species. The most serious threats to Blanding's Turtle subpopulations are those that result in the mortality or loss of adults.

The main limiting factors for this species are its slow life-history (extreme longevity, very late age of maturity, low annual reproductive output, low juvenile recruitment, and a dependency on high annual adult survival) and short, cool summers at the northern periphery of the range, which reduce turtle reproductive frequency and nest success. These limiting factors make the Blanding's Turtle highly vulnerable to even small increases (< 5%) in annual adult mortality. Because the Blanding's Turtle matures much later than other Canadian turtles, its vulnerability to decline is exacerbated compared to other turtle species. Therefore, population stability and persistence are critically dependent on high adult survivorship.

Protection, Status and Ranks

In 2016, COSEWIC designated the Nova Scotia population and the Great Lakes/St. Lawrence population as Endangered. The Blanding's Turtle is legally protected under the federal *Species at Risk Act, 2002* (S.C. 2002, c. 29), the Ontario *Endangered Species Act, 2007* (S.O. 2007, c. 6), the Ontario *Fish and Wildlife Conservation Act, 1997* (S.O. 1997, c. 41), the Québec *Loi sur la conservation et la mise en valeur de la faune*, 2002 (RLRQ, c. C-61.1), and the Nova Scotia *Endangered Species Act, 2000* (1998, c. 11, s. 1). In 2013, it was listed as a 'CITES Appendix II' species and its international trade is now regulated.

Its General Status Rank in Canada, Ontario, Québec and Nova Scotia is 'At Risk'. Across all 18 jurisdictions within the North American range, the Blanding's Turtle is only considered apparently secure (S4) in one state, Nebraska, where the species has benefited from nearly a century of large-scale habitat protection. It is officially designated as Endangered or Threatened in 13 of the 18 provinces and states in which it occurs and in 2010, the IUCN up-listed the Blanding's Turtle to Endangered based on global population size reductions of ≥ 80% over the last three generations.

TECHNICAL SUMMARY - Nova Scotia population

Emydoidea blandingii

Blanding's Turtle, Nova Scotia population

Tortue mouchetée, Population de la Nouvelle-Écosse

Range of occurrence in Canada (province/territory/ocean): Nova Scotia

Demographic Information

Generation time = Age of first reproduction + 1/adult mortality (IUCN 2014 guidelines).	Mean Generation Time = 40 years (range 37-42 yrs) See 'Biology – Life Cycle and Reproduction – Longevity and Development'.
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Yes, inferred and projected in two (NS1 and NS3) of seven subpopulations that are estimated to comprise 40-55% of the total population. See 'Population Sizes and Trends – Fluctuations and Trends'.
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	An average ~ 50% decline of mature individuals in NS1 subpopulation over the next 2 generations (~84 yrs) See 'Population Sizes and Trends – Fluctuations and Trends'.
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations].	It is difficult to assess trends over the last 3 generations given that the Blanding's Turtle was only discovered in the province in 1952. However, since 1952 (~1.5 generations ago) at least 10% of the estimated number of adults have been lost from the NS1 subpopulation (representing an estimated 10-20% decline in the total female subpopulation). See 'Population Sizes and Trends – Fluctuations and Trends'.
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	An average projected ~-68% decline of mature individuals in the NS1 subpopulation over the next 100 years (2.5 generations) with no intervention. See 'Population Sizes and Trends – Fluctuations and Trends'.
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future.	Not known.
Are the causes of the decline a. clearly reversible and b. understood and c. ceased?	a. No. b. Partially. c. Although historical collection for museum specimens has ceased, several other causes of decline continue.

Are there extreme fluctuations in number of mature individuals?	No.

Extent and Occupancy Information

Estimated extent of occurrence	1354 km²
Index of area of occupancy (IAO) (Always report 2x2 grid value).	392 km² (based on 98 grids)
Is the population "severely fragmented" i.e., is >50% of its total area of occupancy in habitat patches that are (a) smaller than would be required to support a viable population, and (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a. No. b. No. It is likely that all subpopulations contain sufficient habitat to support a viable subpopulation. Genetic variation within subpopulations is likely maintained by low levels of gene flow (Toews 2004). Subpopulations are only separated by 15-32 km, distances that are within the potential travel range of individual turtles (Power 1989; Mockford *et al.* 2005).
Number of "locations" * (use plausible range to reflect uncertainty if appropriate)	3-5 locations. Over 98% of known turtles exist at 4 sites.
Is there an [observed, inferred, or projected] decline in extent of occurrence?	Unknown. No observed decline in extent of occurrence at known subpopulations but researchers are still trying to determine the full extent of the range in NS.
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	Yes, inferred and projected. Three subpopulations appear to contain only 3-8 adults, and may be unable to persist at these sites.
Is there an [observed, inferred, or projected] decline in number of subpopulations?	Yes, inferred and projected. Based on very small numbers of individuals for three subpopulations and based on PVA models that suggest at least two of the three large subpopulations are at significant risk of decline and eventual extinction. See 'Population Sizes and Trends – Fluctuations and Trends'.
Is there an [observed, inferred, or projected] decline in number of "locations"*?	Yes, projected. One site is composed of only one small subpopulation (3 mature individuals) which occurs within a different watershed than the other subpopulations.
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	Yes, observed and inferred decline in habitat area/quality at some sites because of cottage and residential development, roads, water level manipulation, forestry and agricultural practices.

* See Definitions and Abbreviations on COSEWIC website and IUCN (Feb 2014) for more information on this term.

Are there extreme fluctuations in number of subpopulations?	No.
Are there extreme fluctuations in number of "locations" ∗?	No.
Are there extreme fluctuations in extent of occurrence?	No.
Are there extreme fluctuations in index of area of occupancy?	No.

Number of Mature Individuals (in each subpopulation)

Subpopulations (give plausible ranges)	**N Mature Individuals**
Nova Scotia 1	131 (129-134)
Nova Scotia 2	79 (60-116)
Nova Scotia 3 (including BA-KB)	118 (106-139)
Nova Scotia 4* (may be part of NS2 but not included in NS2 estimate)	8
Nova Scotia 5*	3
Nova Scotia 6*	3
Nova Scotia 7**	31+
Total	373 (340-434)
* small concentration of individuals that may or may not be a part of one of the three main subpopulations (NS1-NS3) ** subpopulation just discovered in April 2016; 31 adults marked in 2 months so likely much larger.	

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	Probability of extinction was not calculated for the 100 year timeframe because individuals can live nearly that long. Probability of decline for NS1 subpopulation is 73% over 100 years and risk of extinction is 42% over 400 years (Green and McNeil 2014). Probability of decline for NS2 subpopulation is 44% over 100 years (Bourque *et al.* 2006).

∗ See Definitions and Abbreviations on COSEWIC website and IUCN (Feb 2014) for more information on this term.

Threats (actual or imminent, to populations or habitats, from highest impact to least)

Calculated overall threats impact High (high range) and High (low range). Nest predation and predation of juveniles by “subsidized” predators; On- and off-road vehicle mortality, which is likely to increase with increasing residential and cottage development and industrial practices; Habitat destruction and disturbance due to residential and cottage development, mining, forestry and agriculture, which can result in habitat fragmentation as well as the creation of sites that attract turtles for nesting (e.g., roads, trails, quarries) but put them at increased risk of mortality, collection and/or nest failure; Collection for the pet, food and traditional medicine trades; Water level alteration from damming or the removal of Beaver dams; Introduction of exotic predatory fish such as Smallmouth Bass (*Micropterus dolomieu*) and Chain Pickerel (*Esox niger)* and potentially the invasive European Reed (*Phragmites a. australis*). Climate change resulting in changes to water regimes or temperatures in an already thermally constrained environment; Pollution of wetlands. These are exacerbated by: Small population size, which increases vulnerability to genetic drift and environmental stochasticity; Long-lived life history (i.e., very late age of maturity, great longevity, low annual reproductive output, limited juvenile recruitment, dependency on high adult survival) which makes species highly vulnerable to even small (<5%) chronic increases in adult mortality. Given its extensively late maturity, Blanding’s Turtle is much more susceptible to chronic or acute additive increases in adult mortality than other Canadian turtles; Reduced hatching success due to shortened active season (low heat units for egg incubation) at the northern periphery of the range; A high sensitivity to habitat fragmentation given that subpopulation persistence requires adults to engage in long-distance inter-wetland movements, to prevent loss of genetic diversity within residence wetlands. **Was a threats calculator completed for this species and if so, by whom?** Yes. Nova Scotia recovery team members: Diane Clapp, Harold Clapp, Megan Crowley, Mark Elderkin, Colin Gray, Norm Green, Sue Green, Tom Herman, Sarah Jeremy, Shalan Joudry, Chris McCarthy, Julie McKnight, Jeffie McNeil (also status report writer), Sally O’Grady, Bradley Toms, Sarah Walton. COSEWIC Amphibians and Reptiles SSC: Jim Bogart (co-chair). Facilitator: Dave Fraser (COSEWIC). COSEWIC secretariat: Bev McBride (**see ‘Appendix 2a. Threats Calculator’**).

Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	Not applicable because the DU is endemic to Canada.
Is immigration known or possible?	No.
Would immigrants be adapted to survive in Canada?	NA
Is there sufficient habitat for immigrants in Canada?	NA

Are conditions deteriorating in Canada? [+]	NA
Are conditions for the source population deteriorating? [+]	NA
Is the Canadian population considered to be a sink? [+]	NA
Is rescue from outside populations likely?	Not applicable because the DU is endemic to Canada.

Data Sensitive Species

Is this a data sensitive species? Yes.

Status History

COSEWIC Status History: Designated Threatened in April 1993. Status re-examined and designated Endangered in May 2005 and November 2016.

Status and Reasons for Designation:

Status: Endangered	**Final Criteria:** B1ab(ii,iii,iv,v)+2ab(ii,iii,iv,v); C2a(i)
Reasons for designation: The current population size is < 500 mature individuals. The three main subpopulations are genetically distinct from each other and from other populations in Québec, Ontario, and the United States. Although the largest subpopulation occurs in a protected area, its numbers are still declining, possibly still showing the effects of historical mortality that took place 30-60 years ago. The other subpopulations are susceptible to increasing habitat degradation from forestry activities, recreation, water-level manipulation, and cottage development. Two subpopulations are very small (< 5 adults) and may not be viable. Threats across the range include increased pressure from predators, mortality from on- and off-road vehicles, vulnerability to collection, potential impacts of exotic predatory fishes, and the effects of climate change.	

Applicability of Criteria

Criterion A: May meet Endangered A3 (c) and A4 (c) based on models that project a reduction of > 50% of mature individuals within 100 years. Continued recovery efforts may, however, reduce the expected decline.
Criterion B: Meets Endangered B1 (EOO is 1,354 km² (<5,000) and B2 (IAO is 392 km² (<500) and (a) 5 locations and (b) continuing decline in index of area of occupancy (ii) (inferred and projected), area/quality of habitat (iii) (observed and inferred), number of subpopulations (inferred and projected) and locations (projected) (iv), and number of mature individuals (v) (inferred and projected).
Criterion C: Meets C (<2,500 individuals) and Endangered C2a(i) – no subpopulation contains more than 250 mature individuals.
Criterion D: Not applicable.
Criterion E: Not completed.

[+] See Table 3 (Guidelines for modifying status assessment based on rescue effect) .

TECHNICAL SUMMARY - Great Lakes / St. Lawrence population

Emydoidea blandingii

Blanding's Turtle, Great Lakes / St. Lawrence population

Tortue mouchetée, Population des Grands Lacs et du Saint-Laurent

Range of occurrence in Canada (province/territory/ocean): Ontario, Quebec

Demographic Information

Generation time = Age of first reproduction + 1/adult mortality (IUCN 2014 guidelines).	Mean Generation Time = 40 years (range 37-42 yrs). See 'Biology – Life Cycle and Reproduction – Longevity and Development'.
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Yes, observed, inferred and projected. Observed and inferred declines for monitored subpopulations in Ontario of 50-95% over the last 10-30 years (< 1 generation) and high annual adult road mortality rates of 6-23% (see Table 2). See below for projected declines.
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations].	> 40% projected decline within 2 generations (~80 years) based on observed and inferred declines for monitored subpopulations in Ontario of 50-95% over the last 10-30 years (< 1 generation) and high annual adult road mortality rates of 6-23% (see Table 2 and Appendix 3).
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations].	Estimated > 60% decline over the last 3 generations due to large-scale wetland loss (see 'Habitat Trends' and Appendix 1), and high annual adult road mortality rates of 6-23% (see Table 2).
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	Projected > 50% decline over the next 3 generations (~120 years) based on observed declines for monitored subpopulations in Ontario of 50-95% over the last 10-30 years (< 1 generation) and high annual adult road mortality rates of 6-23% (see Table 2 and Appendix 3).
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future.	Estimated > 60% decline over the 3 generation period between the mid-1800s to mid-1900s when > 70% of pre-settlement wetlands were drained (**see** 'Habitat Trends' and Appendix 1).
Are the causes of the decline a. clearly reversible and b. understood and c. ceased?	a. No. b. Partially. c. No.
Are there extreme fluctuations in number of mature individuals?	No.

Extent and Occupancy Information

Estimated extent of occurrence	> 400,000 km² if isolated sightings are included but almost the entire population occurs within ~222,000 km²
Index of area of occupancy (IAO) (Always report 2x2 grid value).	> 9900 km² (based on 2475 grids)
Is the population "severely fragmented" i.e., is >50% of its total area of occupancy in habitat patches that are (a) smaller than would be required to support a viable population, and (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a. Unlikely that > 50% of total area of occupancy meets this criterion. b. Unknown if > 50% of total area of occupancy meets this criterion. If the southwestern Ontario population were considered separately, it would meet these criteria.
Number of "locations" * (use plausible range to reflect uncertainty if appropriate)	Likely 50 - 100.
Is there an [observed, inferred, or projected] decline in extent of occurrence?	No.
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	Yes, inferred. Few to no individuals have been found over the last few years at some sites where the species was once commonly observed as recently as the 1990s to early 2000s (see Table 2).
Is there an [observed, inferred, or projected] decline in number of subpopulations?	Yes, projected. At some monitored sites, observations or capture rates have declined by 50-95% in <1 generation and high annual losses of adults have been reported from across the Ontario range (see Table 2). Two Ontario subpopulations have experienced mass mortality events (see 'Biology - Mortality').
Is there an [observed, inferred, or projected] decline in number of "locations"*?	Yes, inferred and projected decline based on the high degree of habitat loss and development in areas south of the Canadian Shield.

* See Definitions and Abbreviations on COSEWIC website and IUCN (Feb 2014) for more information on this term.

Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	Yes, observed, inferred and projected (see 'Threats and Limiting Factors'). Several road, residential, wind energy and mining developments are currently occurring or proposed within Blanding's Turtle habitat throughout the Ontario range. they do not curb the overall loss of tens to hundreds of hectares of habitat per development project. A net loss of habitat is continuing even with the protections afforded by the ESA (see 'Protection, Status and Ranks – Legal Protection and Status – Ontario). The invasive European Reed is projected to cause a 11-70% decline in Blanding's Turtle habitat across the GLSL range over the next three generations. Climate change is expected to greatly reduce the amount of suitable habitat for Blanding's Turtles in southwestern Ontario by 2080.
Are there extreme fluctuations in number of subpopulations?	No.
Are there extreme fluctuations in number of "locations" *?	No.
Are there extreme fluctuations in extent of occurrence?	No.
Are there extreme fluctuations in index of area of occupancy?	No.

Number of Mature Individuals (in each subpopulation)

Subpopulations	N Mature Individuals
Southwestern Ontario 1	~ 690 Schnabel Method (modified closed-capture model)
Southwestern Ontario 2	818 (based on an estimated 341 adult females (± 214) and an average sex ratio of 1.4 M:1 F). Jolly-Seber method in program JOLLY.
Southwestern Ontario 3	~ 138 Lincoln Index
Southwestern Ontario 4	82 adults found*
Southwestern Ontario 5	5 adults found*
Southeastern Ontario 1	26 adults found*
Southeastern Ontario 2	99 (95% CI: 89-124)
Southeastern Ontario 3	114 (95% CI: 103-136)
Southeastern Ontario 4	85 (95% CI: 53-206) Schnabel Method (modified closed-capture model)

* See Definitions and Abbreviations on COSEWIC website and IUCN (Feb 2014) for more information on this term.

Southcentral Ontario 1	41 (95% CI: 39-50)
Southcentral Ontario 2	19 adults found*
Southcentral Ontario 3	~ 57 Lincoln Peterson
Southcentral Ontario 4	102 adults found*
Outaouais region, Québec	188 adults found*
# of estimated/known adults within sampled subpopulations	< 3000
Estimated total Great Lakes/St. Lawrence adult population size†	< 50,000
* based on high sampling efforts (see Table 1) † based on average subpopulation estimates/region multiplied by number of atlas squares/region (see 'Population Sizes and Trends – Abundance').	

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	Not Done

Threats (actual or imminent, to populations or habitats, from highest impact to least)

Calculated overall threats impact Very High (high range) and High (low range).

i. Road and rail mortality and associated road effects;
ii. Habitat loss and degradation from invasive European Reed (*Phragmites a. australis*), development (including residential, cottage, road, commercial, mining and energy production) and wetland modifications (including Beaver dam removals and waterfowl habitat creation);
iii. Collection for the pet, food and traditional medicine trades;
iv. Increased predation of nests and juveniles by higher numbers of "subsidized predators";
v. Mortality of individuals from human activities and intrusions (including agricultural, forestry, energy production and mining activities; boat and ATV collisions);
vi. Pollution of wetlands (from agriculture, mining and forestry); and
vii. Predicted habitat loss due to climate change.

These are exacerbated by:

- Small subpopulation sizes, which increases vulnerability to genetic drift and environmental stochasticity;
- Long-lived life history (i.e., very late age of maturity, great longevity, low annual reproductive output, limited juvenile recruitment, dependency on high adult survival) which makes the species highly vulnerable to even small (<5%) chronic increases in adult mortality. Given its extensively late maturity, Blanding's Turtle is much more susceptible to chronic increases in adult mortality than other Canadian turtles;
- Reduced hatching success due to shortened active season (low heat units for egg incubation) at the northern periphery of the range;
- A high sensitivity to habitat fragmentation given that subpopulation persistence requires adults to engage in long-distance inter-wetland movements, to prevent loss of genetic diversity within residence wetlands.

Was a threats calculator completed for this species and if so, by whom?
Yes. Status report authors: Teresa Piraino, Jeffie McNeil; MMFP QC: Yohann Dubois, Daniel Toussaint;

OMNR: Graham Cameron, Joe Crowley (also AR SSC), Colin Jones; CWS QR: Gabrielle Fortin; COSEWIC Amphibians and Reptiles SSC: Jim Bogart (co-chair), Ron Brooks, Jackie Litzgus, Dennis Murray; Other experts: Scott Gillingwater, Christina Davy; Facilitator: Dave Fraser (COSEWIC); COSEWIC secretariat: Bev McBride (See 'Appendix 2b. Threats Calculator').

Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	S2-S3 in all adjacent U.S.A. states (see Table 3).
Is immigration known or possible?	Immigration is not known but there may be very limited potential for some immigration to occur (see Rescue Effect).
Would immigrants be adapted to survive in Canada?	Yes.
Is there sufficient habitat for immigrants in Canada?	Not in southwestern Ontario but perhaps in southcentral and southeastern Ontario and Québec.
Are conditions deteriorating in Canada? [+]	Yes.
Are conditions for the source population deteriorating? [+]	Likely.
Is the Canadian population considered to be a sink? [+]	Unknown.
Is rescue from outside populations likely?	Highly unlikely **(see Rescue Effect)**.

Data Sensitive Species

Is this a data sensitive species? Yes.

Status History

COSEWIC Status History: Designated Threatened in May 2005. Status re-examined and designated Endangered in November 2016.

Status and Reasons for Designation:

Status: Endangered	**Final Criteria:** A2bcde+3cde+4bcde
Reasons for designation: This population, although widespread, is declining because of several observed, inferred, and projected threats. The most serious threats include: road and rail mortality; illegal collection for the pet, food and traditional medicine trades; habitat loss due to invasive European Common Reed; development and wetland alterations; and, increasing numbers of predators. Quantitative analyses estimate that the total number of mature individuals in this population has declined > 60% over the last three generations (due to large-scale wetland drainage after European arrival) and will decline 50% over the next three generations because of road mortality alone.	

Applicability of Criteria

[+] See Table 3 (Guidelines for modifying status assessment based on rescue effect).

Criterion A: Meets Endangered A2bcde based on loss of 60% of habitat over last 3 generations plus observed and inferred decline for monitored subpopulations in ON, and Endangered A3cde based on a continued decline (observed and inferred) in the past and projected into the future for 100 years (< 3 generations). Decline is estimated to be > 50% based on direct observation (a) and decline in the quality of habitat (c), exploitation (d) and the effects of invasive European Common Reed (e). Also meets Endangered A4bcde based on combined rationales for A2 and A3.
Criterion B: Does not meet criteria: Both EOO (400,000 km²) and IAO (9,900 km²) are above criteria and there are 50 to 100 locations.
Criterion C: Does not meet criteria for Endangered. Meets Threatened C2a(i) – no subpopulation estimated to contain > 1000 individuals.
Criterion D: Does not meet criteria.
Criterion E: Not done.

PREFACE

Research and stewardship activities have continued for the Nova Scotia population since the 2005 COSEWIC assessment, resulting in increased knowledge of distribution, population size, genetic structure, age-specific survivorship and habitat use. Ongoing research activities focus on searching for new subpopulations, identifying seasonal habitat sites and monitoring known subpopulations. Recovery activities include the continuation of an annual nest protection program, the release of headstarted turtles and the engagement of local volunteers and landowners. Since the last status assessment, four new subpopulations of Blanding's Turtles have been identified and six parcels of habitat have been protected by the Nova Scotia Nature Trust (Porter pers. comm. 2014). One parcel of habitat has been purchased by the Province of Nova Scotia; it and several additional areas of important habitat on provincial crown lands are being considered for protection under the provincial protected areas program (Province of Nova Scotia 2013). The federal Recovery Strategy for Blanding's Turtle, Nova Scotia population was published in 2012 (Parks Canada 2012) and a draft Action Plan is currently being developed. The Recovery Strategy partially identified critical habitat for the species.

Since the last status assessment, much research has been conducted on the Blanding's Turtle, Great Lakes/St. Lawrence population. This research has included radio-telemetry of adults, hatchlings and headstarted juveniles; subpopulation monitoring at 13 sites in Ontario and two in Québec (with 2-21 years of sampling efforts conducted at each site); a province-wide genetic study in Ontario and large search efforts in Québec. All of this research has greatly increased our knowledge of distribution, habitat requirements, home range sizes, demography, local abundances, and threats to Blanding's Turtles. Despite large sampling efforts, most monitored subpopulations appear to maintain low numbers of Blanding's Turtles, even in areas that have abundant habitat and high densities of other wetland turtle species. Most importantly, long-term population monitoring efforts across Ontario have revealed large declines and high annual mortality rates of adults, even within protected areas, and there are many sites where the species used to be commonly observed but is no longer or rarely seen. Habitat loss is continuing across the region due to invasive species, various types of development and wetland alterations. A proposed federal Recovery Strategy for the Great Lakes/St. Lawrence population was posted for review in March 2016 (Environment Canada 2016) and a recovery strategy has been posted under the Ontario *Endangered Species Act* (ESA) (http://files.ontario.ca/environment-and-energy/species-at-risk/286973.pdf).

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS
(2016)

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

Environment and Climate Change Canada
Canadian Wildlife Service

Environnement et Changement climatique Canada
Service canadien de la faune

Canada

The Canadian Wildlife Service, Environment and Climate Change Canada, provides full administrative and financial support to the COSEWIC Secretariat.

COSEWIC Status Report

on the

Blanding's Turtle
Emydoidea blandingii

Nova Scotia population
Great Lakes/St. Lawrence population

in Canada

2016

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Blanding's Turtle (*Emydoidea blandingii*) was originally named and described by Holbrook (1838) as a member of the genus *Cistuda* based on morphological characteristics resembling the European Pond Turtle, *Emys orbicularis* (then *Cistuda europea*), and the Eastern Box Turtle, *Terrapene carolina* (then *Cistuda carolina*). Blanding's Turtle was then grouped in the genus *Emys* with *E. orbicularis* based on morphological similarities such as unkeeled carapaces, kinetic shells, and colouration (Feldman and Parham 2002). It remained as such until separated into the genus *Emydoidea* as the sole member (McCoy 1973). Some taxonomists have recommended that the genus *Emydoidea* be reclassified within *Emys* (Feldman and Parham 2002; Spinks and Shaffer 2005) based on morphological and ecological traits as described by Loveridge and Williams (1957), thus eliminating the genus *Emydoidea*. Crother (2012) recommended that both the genus *Emydoidea* and the polyphyletic genus *Emys* be maintained for the sake of current stability and in consideration of monotypic genera as being valuable for providing phylogenetic information.

Morphological Description

Adults

Relative to other North American freshwater turtles, Blanding's Turtles are of medium size with a smooth domed carapace (upper shell) that is black with yellowish spots and flecks (see Cover Photo). The bright yellow chin and throat are this species' most characteristic features. The scales and skin are black and yellow. The neck is long and the mouth curves upward in the form of a smile (Figure 1). The plastron exhibits an anterior hinge and a dark rectangular blotch on the outer edge of each scute (Figure 2), although entirely dark plastrons are sometimes observed. Male Blanding's Turtles have a moderately concave plastron and a vent that extends beyond the posterior edge of the carapace; males also tend to have a dark upper beak. Female Blanding's Turtles have a flatter plastron, a shorter and narrower tail, a vent that does not extend past the posterior edge of the carapace and an upper beak streaked with yellow.

Figure 1. Adult Blanding's Turtle, front view. Photo by Scott Gillingwater.

Figure 2. Adult female Blanding's Turtle, ventral view. Photo by Scott Gillingwater.

Reported carapace lengths (CL) of Canadian Blanding's Turtle adults range from 12.6 cm to 26.7 cm, with southwestern Ontario subpopulations averaging smaller sizes than those reported in Québec, southcentral Ontario and Nova Scotia (mean CL 20 cm, 24 cm, 23 cm and 21 cm respectively) (Gillingwater and Brooks 2001; Gillingwater and Piraino 2004; Gillingwater 2009; Caverhill *et al.* 2011; St-Hilaire *et al.* 2013; Nova Scotia Blanding's Turtle Database 2014; Québec Turtle Recovery Team unpub. data; Edge unpub. data; Gillingwater unpub. data; Paterson unpub. data). In Nova Scotia, adult size varies significantly among at least two of the subpopulations (McNeil 2002) and sexual size dimorphism is evident, with adult males tending to be larger than adult females (McNeil 2002; Caverhill 2003; Lefebvre *et al.* 2011).

Hatchlings

Reported hatchling Blanding's Turtle sizes range from 24 mm to 40 mm CL (Standing *et al*. 2000; Gillingwater and Brooks 2001; Riley *et al.* 2012; Nova Scotia Blanding's Turtle Database 2014) and 6 to 12 g in weight (Gillingwater and Brooks 2001). The carapace of hatchlings is often plain brown-grey with faint spots or streaks; however, some individuals may display a more obvious pattern (Figure 3). The tail is approximately one-half to two-thirds the length of the carapace and is proportionally much longer than that of the adult. The plastron is characterized by a central greyish spot. The throat and chin are creamy yellow. The pattern of spots and streaks on the carapace typically begins to develop around 8-10 months (McNeil pers. obs.) and the plastral hinge does not become fully functional until approximately 5 years of age (at ~100 mm CL; Gillingwater unpub. data).

Figure 3. Well-patterned hatchling Blanding's Turtle. Photo by Scott Gillingwater.

Population Spatial Structure and Variability

In Ontario, a recent study (Davy *et al.* 2014) was carried out to investigate the level of population structure and genetic diversity among subpopulations given that atlas data for this species have revealed a discontinuous distribution across the province. The study amplified samples at four microsatellite loci developed for Blanding's Turtle and 13 loci developed for Bog Turtle *Glyptemys muhlenbergii* that cross-amplified with Blanding's Turtle. Overall, 97 individuals were genotyped from eight geographically disjunct Ontario subpopulations spread approximately 150-500 km apart. The study revealed a minimum of two genetically distinct populations and four subpopulations in Ontario (Lake Erie/Golden Horseshoe and Georgian Bay/Eastern Ontario) with assignment tests identifying individuals to area of origin with high accuracy (69-79%). The results also suggested that the Ontario Blanding's Turtle subpopulation is not immediately threatened by loss of genetic diversity given that levels of genetic variation (e.g., heterozygosity, allelic diversity) were comparable to those reported for other turtle populations. The authors did suggest, however, that long generation times may have slowed the loss of genetic variation in Blanding's Turtle across the study area, which in turn may be further exacerbated by significant habitat fragmentation and continuing population decline (Davy *et al.* 2014). No genetic analyses have been conducted for the Québec subpopulation.

Blanding's Turtles were only recently (1952) discovered to exist in Nova Scotia (Bleakney 1958). The Nova Scotia population is restricted to a few watersheds in southwest Nova Scotia and is geographically isolated from the rest of the species' range (Herman *et al.*1995). Genetic studies indicate that this population has diverged significantly from other populations in the species' range (Mockford *et al.* 1999). Despite its small size and isolation, the Nova Scotia population contains a relatively high degree of genetic variation (Mockford *et al.* 1999). Within the Nova Scotia population, three main subpopulations have been identified which are genetically distinguishable. The estimates of gene flow are very low (1.8 – 5.8 individuals per generation), despite proximity (15-25 km) of the three subpopulation centres (Mockford *et al.* 1999, 2005). Mockford *et al.* (2005) reported that microsatellite analysis of five loci resulted in F_{st} values of 0.042-0.124 ($p<0.05$) in pairwise comparisons between the subpopulations. Analysis suggests that this population structure likely pre-dates European influence on the landscape and there is no evidence of a recent population bottleneck (Mockford *et al.* 2005). Genetic variation is likely maintained by small but significant migration of individuals among these subpopulations (Toews 2004); however, genetic structuring is evident within one subpopulation between streams separated by as little as 5 km (Toews 2004; Mockford *et al.* 2005). A seemingly sizable subpopulation was discovered in 2016 (NS7); its relationship to the other three main subpopulations is not yet known.

Designatable Units

There are two designatable units (DUs) that meet the criteria for discreteness and significance. The Canadian population of Blanding's Turtles is divided into two geographically separated units and exists in two different faunal provinces. The first unit is the Nova Scotia population, in the Appalachian/Atlantic Coast Terrestrial Amphibian and

Reptile Faunal Province as well as in the Atlantic Ecological Area, and occurs at the northeastern periphery of the species' range. This unit is separated from the rest of the range by several hundred kilometres. Because of its isolation, there is no reasonable likelihood of dispersal from other populations in Canada or the U.S.A. The Nova Scotia population has significantly diverged genetically from the tested populations in the main range (Mockford *et al*. 1999; Rubin *et al*. 2001) and may be an evolutionarily significant unit at the subspecies or species level (Mockford *et al.* 2007). The second Canadian designatable unit occurs in the Great Lakes/St. Lawrence Terrestrial Amphibian and Reptile Faunal Province, and in the Great Lakes Plains Ecological Area. It exists within Ontario and Québec.

Special Significance

The Blanding's Turtle is of biological significance because it is one of the longest-lived freshwater turtles (Congdon *et al.* 1993, 2001; Rubin *et al.* 2001), with a lifespan exceeding 83 years (University of Michigan News May 25, 2016). Thus, the Blanding's Turtle has been used in models of conservation and demography (Congdon *et al*. 1993), and to test competing hypotheses on why and how organisms age (Congdon *et al.* 2001). It is also the only living representative of the genus *Emydoidea* and has one of the smallest global ranges compared to most other North American turtles. It has been proposed that the Nova Scotia population be recognized as an evolutionarily significant unit because of its isolation and potential for continued genetic divergence from the species' main range (Mockford *et al.* 2007). This turtle is at risk across its global range (NatureServe 2014) and as such, has been widely adopted as a "poster" species for conservation research. To its detriment, the Blanding's Turtle has become an increasingly popular species in the pet, food and traditional medicine trades.

DISTRIBUTION

Global Range

The global range of the Blanding's Turtle's is centred in and around the Great Lakes Basin (Figure 4), with approximately 20% of the range contained within Canada. In the United States, the species' range extends from Nebraska and South Dakota, eastward through Iowa, Minnesota, Missouri, Wisconsin, Illinois, Indiana, Michigan, Ohio, and Pennsylvania. There are also small subpopulations in New York, Massachusetts, New Hampshire and Maine.

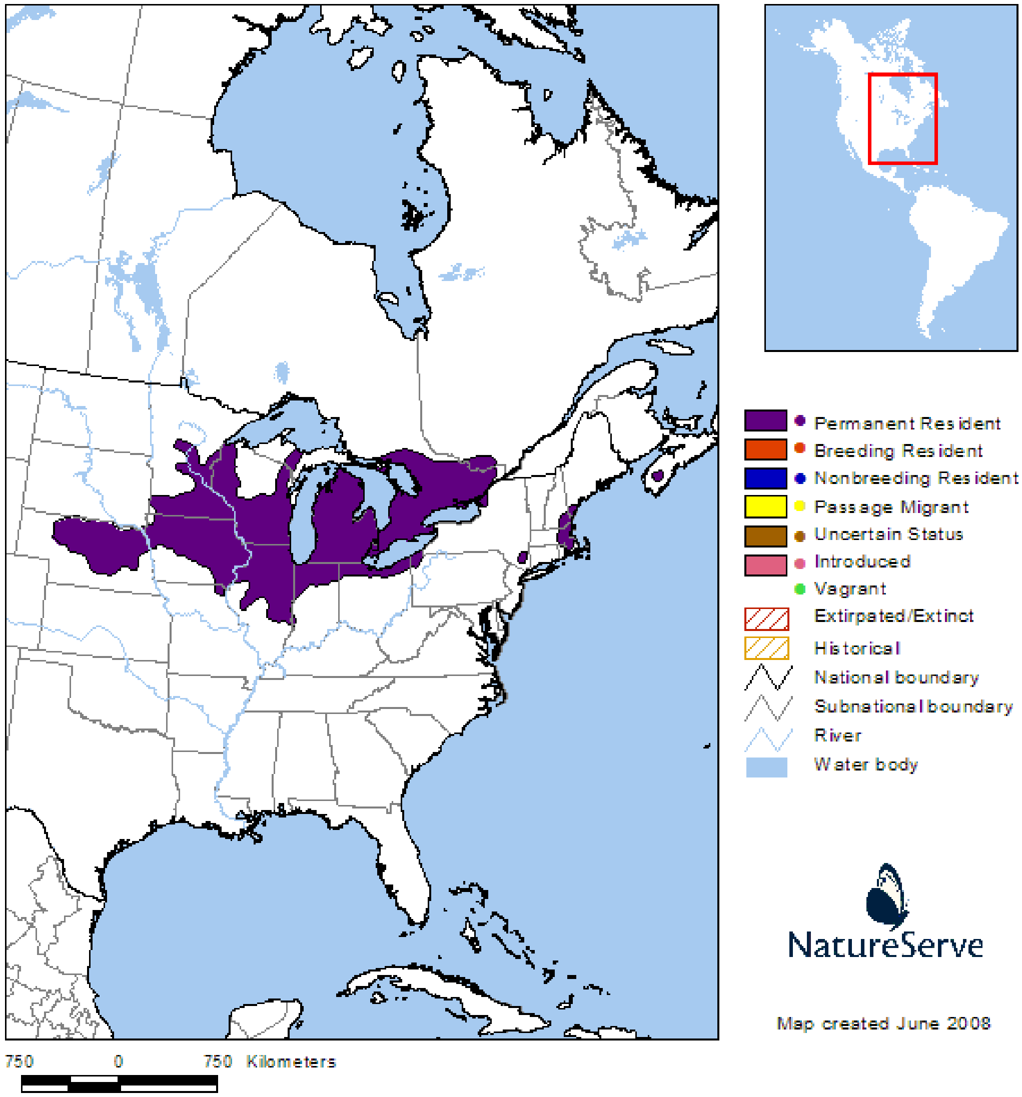

Figure 4. Blanding's Turtle distribution in North America.

Canadian Range

In Canada, the Blanding's Turtle is primarily found within the southern portions of Ontario, Québec and Nova Scotia (Atlas des Amphibians et des Reptiles du Québec (AARQ); Ontario Reptile and Amphibian Atlas (ORAA); Nova Scotia Blanding's Turtle Database).

In Ontario, Blanding's Turtle mainly occurs from extreme southwestern Ontario, east to Ottawa and northwest to Sault-St. Marie; however, a handful of isolated records occur as far north as Timmins district (OMNRF Timmins District pers. comm. 2014). The Ontario distribution is not continuous and there are large portions of the province with few to no records, including the area from north of Sudbury to Timmins; the area from Grey and Bruce counties south to Waterloo County and east to Lake Simcoe; extreme southeastern Ontario; and the areas west and south of Algonquin Provincial Park. Interestingly, models predicted these zones as maintaining lower habitat suitability for Blanding's Turtle (Millar and Blouin-Demers 2012); thus, low numbers of records in these zones may reflect low abundances rather than inadequate survey efforts.

In Québec, the main subpopulation occurs within the Outaouais region; however, individuals have also been reported from the Abitibi-Témiscamingue region, the Montérégie region and the Capitale-Nationale region (Bernier 2014).

In Nova Scotia, the majority of the known turtles occur in three main subpopulations on two watersheds. Three additional small concentrations of individuals (3-8 adults), which may or may not be part of one of the three main subpopulations, were confirmed in 2012, including one on a previously undocumented watershed. A forth subpopulation was discovered in spring 2016; its size and extent are not yet known. Additional undiscovered populations may occur in the province and anecdotal sightings have been reported from several areas (McNeil 2002; Herman *et al.* 2003; Nova Scotia Blanding's Turtle Database 2014), though most have not been verified through images or specimens. A few photo-verified sightings of single individuals outside the known range have been documented but follow-up surveys have failed to find additional turtles. It is unknown if Blanding's Turtles inhabit these areas or if these were isolated sightings of vagrants, possibly moved there by people.

Extent of Occurrence and Area of Occupancy

The extent of occurrence (EOO) for this species within the Great Lakes/St. Lawrence population is 405,273 km². Although this estimate suggests that the EOO has increased by ~331,000 km² since the 2005 status report, this is not representative of the actual level of increase in EOO, but rather, partly due to differences in calculation methods. EOO was previously calculated by removing areas of unsuitable habitat; however, the present method of EOO estimation is based on a minimum convex polygon around all known, inferred or projected sites of present occurrence of the species, with areas outside Canada's jurisdiction removed; therefore, the previous and new estimates cannot be compared (Wu pers. comm. 2014). Recalculation of the 2005 EOO according to the new guidelines, provides an estimate of ~282,170 km², so the actual increase in EOO from 2005 is ~123,103 km². This increase in EOO since 2005 is largely the result of a handful of isolated sightings in northern Ontario and Québec as well as the Capitale-Nationale region of Québec, that greatly extended the polygon. If these isolated sightings were removed, it would reveal that the bulk of the Great Lakes/St. Lawrence population lies within an area of ~222,000 km² (i.e., approximately half the size of the current estimated EOO). In 2005, the index of area occupancy (IAO) for the Great Lakes/St. Lawrence population was estimated at 9852 km² (based on 2463 ‘2 km x 2 km’ grids) and is currently estimated at > 9900 km^2 (based on 2475 grids); so there has been very little change in IAO since 2005. If the isolated sightings to the far north and east are removed from the estimate, the IAO decreases to > 9880 km^2 (based on 2470 grids).

The EOO of the Nova Scotia population is ~1354 km^2 and the IAO is 392 km^2 (based on 98 ‘2 km x 2 km’ grids). These calculations include the area encompassing the seven subpopulations and concentrations, but do not include unconfirmed sightings or confirmed isolated sightings of single individuals for which follow up studies failed to detect additional individuals. Critical habitat has been identified for the Nova Scotia subpopulations (Parks Canada 2012). Identified critical habitat encompasses the known geographic limit of each subpopulation and includes the known seasonal habitats used by all life stages as well as aquatic and terrestrial areas that connect these habitats (Parks Canada 2012). Within critical habitat, high use areas have been identified that include the specific seasonal sites occupied by Blanding’s Turtles, excluding travel routes. These high-use polygons comprise 57 km^2, which can be considered the minimum biological area of occupancy for the Nova Scotia population. Critical habitat identified in the recovery strategy does not include the subpopulation discovered in 2016 (NS7) or the smaller concentrations discovered in 2012 (NS4, NS5, NS6). Critical habitat in these areas will be included in the species’ action plan currently in development.

Search Effort

This section describes the qualitative (i.e., distributional) search effort used to locate Blanding’s Turtles at potential sites (new or historical) in order to aid in determining the species’ Canadian range. For a discussion of sampling efforts and methods used to estimate sizes and demography of known subpopulations **see Population Sizes and Trends – Sampling Effort and Methods and Table 1.**

Much of what we know about the distribution of Blanding’s Turtle across Canada has been collected over the last 30 years by the following volunteer reporting programs: the Ontario Herpetofaunal Summary (since 1984); the Atlas des amphibiens et reptiles du Québec (since 1988); the Toronto Zoo’s Ontario Turtle Tally Program (since 2003); the Ontario Reptile and Amphibian Atlas (since 2009); and the Nova Scotia Blanding’s Turtle Database (since 1996).

Table 1. Blanding's Turtle Demographics and Subpopulation Sampling Efforts from Across the Canadian Range.

Subpopulation	Size of Study Site	Male : Female Ratio & Adult : Juvenile Ratio	Adult Population Estimate OR # of Adults Found	Density (adults/ha)	Study Period (# of seasons)	Sampling Effort	Survey Methods	Sources
SW Ontario 1	3300 ha	1M : 1.2F 20.6A : 1J	690 Schnabel Method (modified closed-capture model)	0.21	9 seasons (2000-2001; 2008-2014)	>650 person-days	Hand/dip net captures while conducting visual surveys in wetlands and nesting areas	Gillingwater and Brooks 2001; Davy unpub. data
SW Ontario 2	607 ha	1.35M : 1F 9.4A : 1J	818 based on an estimated 341 ±214 adult females (Jolly-Seber method in program JOLLY using model A and mark-recapture data from 2003-2006) and an average sex ratio of 1.4M:1F.	1.35	21 seasons (1973; 1979; 1980; 1982; 1992-1994; 2003-2016)	>680 person-days; ~500 trap days	Hand/dip net captures while conducting visual surveys in wetlands and nesting areas; hoop net traps	Weller 1973; Hubbs 1979; Purves 1980; Ashenden 1983; Saumure 1995; Gillingwater and Piraino 2004, 2007; Piraino and Gillingwater 2005, 2006; Gillingwater 2009, 2013; Enneson 2009
SW Ontario 3	800 ha	1M : 3.2F 10A : 1J	138 Lincoln Index where N=MC/R (using data from 2010-2011)	0.17	5 seasons (2010-2014)	1317 person-hours; 2200 trap days	Hand/dip net captures while conducting radio-telemetry surveys, road mortality surveys and visual surveys in wetlands and nesting areas; hoop net traps	Caverhill *et al*. 2011; Toronto Zoo unpub. data
SW Ontario 4	1500 ha	1M : 2.32F 14.5A : 1J	82 found	~	2 seasons (2001-2002)	>200 person-days; 2280 trap days	Hand/dip net captures while conducting visual surveys in wetlands and nesting areas; basking, hoop net and live traps	Browne and Hecnar 2007
SW Ontario 5	68 ha	1M : 1F 6A : 1J	5 found (this # is considered representative of the total adult population size due to the large sampling efforts)	~	10 seasons (2005-2014)	1855 person-hours	??	Toronto Zoo unpub. data
SE Ontario 1	3724 ha	?M : ?F 5.2A : 1J	26 found	~	3 seasons (2012-2014)	>27 trap days (2013); >4500 trap hours (2014)	Hand/dip net captures while conducting radio-telemetry surveys and visual surveys in wetlands; hoop net traps	Carstairs 2014, unpub. data
SE Ontario 2	690 ha	1M : 2F 4.3A : 1J	99 (95% CI: 89-124)	0.14	4 seasons (2010-2013)	5300 person-hours; 2360 trap days	Hand/dip net captures while conducting radio-telemetry surveys, road mortality surveys and visual surveys in wetlands; hoop net traps	Dillon Consulting Ltd. 2014

Subpopulation	Size of Study Site	Male : Female Ratio & Adult : Juvenile Ratio	Adult Population Estimate OR # of Adults Found	Density (adults/ha)	Study Period (# of seasons)	Sampling Effort	Survey Methods	Sources
SE Ontario 3	900 ha	1.3M : 1F 30.3A : 1J	114 (95% CI: 103-136) Closed capture model in MARK	0.13	3 seasons (2007-2009)	Wetlands surveyed every day from April-Sept every season. Hoop traps were also set all season.	Hand/dip net captures while conducting radio-telemetry surveys and visuals surveys in wetlands; hoop net traps	Millar 2009, unpub. data; Millar and Blouin-Demers 2012
SE Ontario 4	238 ha	1M : 1F ?A : ?J	85 (95% CI: 53-206) Schnabel Method (modified closed-capture model)	0.36	5 seasons (2010-2014)	~68 person- days ~54 trap days	Hand/dip net captures while conducting visual surveys in wetlands; hoop net and basking traps	Middleton 2014; Ontario Nature unpub. data
SC Ontario 1	340 ha	0.6M : 1F 6.3A : 1J	41 (95% CI: 39-50)	0.12	5 seasons (2006-2008; 2009-2010)	Wetlands surveyed several days between April-May every season. Nightly nest site patrols from 7-11pm for 3-4 weeks/season. Several incidental captures during telemetry and at communal hibernacula.	Hand/dip net captures while conducting visual surveys in wetlands and nesting areas	Edge et al. 2009, 2010, unpub. data; Paterson *et al*. 2014, unpub. data
SC Ontario 2	1,100 ha	1.4M : 1F 9.5A : 1J	19 found	~	2 seasons (2011-2012)	150 person-hours; 210 trap days	Hand/dip net captures while conducting radio-telemetry surveys and visual surveys in wetlands; hoop net traps	Markle and Chow-Fraser 2014, unpub. data
SC Ontario 3	90 ha	1M : 1.2F 5.9A : 1J	57 Lincoln Peterson N=n1*n2/m2	0.63	2 seasons (2013-2014)	134 person-hours (2013); 1128 person-hours (2014)	Hand/dip net captures while conducting visual surveys in wetlands	Sheppard 2013, 2014, unpub. data
SC Ontario 4	250,000 ha	1M : 2.1F 13A : 1J	102 found	~	2 seasons (2013-2014)	?? hours (2013) >2500 hours (2014)	Hand/dip net captures while conducting radio-telemetry surveys, road mortality surveys and visual surveys in wetlands	Scales Nature Park unpub. data
Québec	>60,000 ha	1M : 1.1F 4.9A : 1J	188 found	~	6 seasons (1996-1997; 2009-2011; 2013)	1500 person-hours; >2600 trap days	Hand/dip net captures while conducting radio-telemetry surveys and visual surveys in wetlands; fyke net and crab pot traps	NCC 2007; Dubois 2009; Fortin and Dubois 2010; Dubois *et al.* 2011, 2012, unpub. data; Bernier 2013, unpub. data; St.-Hilaire *et al.* 2013.
Nova Scotia 1	942 ha	1.2M : 1F 1.5A : 1J (wild juveniles only) 1A : 2.2J (incl. all released headstarts)	131 (129-134) Jolly Seber (using data from 1987-2013 excluding 1990-1991)	0.14	46 seasons (Primarily 1971-72; 1977-79; 1987-88; 1992-2016)	5212 trap nights (>3300 field hours); ~2100 person-hrs visual surveys; > 10000 hrs nesting surveys; ~4000 hrs radio-telemetry	Hand captures while conducting radio-telemetry and visual surveys in wetlands and nesting areas; hoop net traps	Power 1989; Green and McNeil 2014; Nova Scotia Blanding's Turtle Database 2014

Subpopulation	Size of Study Site	Male : Female Ratio & Adult : Juvenile Ratio	Adult Population Estimate OR # of Adults Found	Density (adults/ha)	Study Period (# of seasons)	Sampling Effort	Survey Methods	Sources
Nova Scotia 2	260 ha	1M: 1.1F 1.7A: 1J	79 (60-116) Schnabel (using data from 1997-2002)	0.30	21 seasons (1995-2016)	>2400 trap nights (>500 hrs field effort); > 300 hrs person-hours visual surveys; 1000 hrs radio-telemetry; >3500 hrs nesting surveys	Hand/dip net captures while conducting radio-telemetry and visual surveys in wetlands and nesting areas; hoop net traps	McNeil 2002; Nova Scotia Blanding's Turtle Database 2014
Nova Scotia 3	877 ha	1M : 1F 1.5A : 1J	118 (106-139)	0.13	19 seasons (1997-2015)	6892 trap nights (2172 field hours); 1254 hrs radio-telemetry; 296 hrs visual surveys; >3000 hrs nesting surveys	Hand/dip net captures while conducting radio-telemetry and visual surveys in wetlands and nesting areas; hoop net traps	Nova Scotia Blanding's Turtle Database 2014
Nova Scotia 4	58 ha	1M : 2F 2.2A : 1J	8 found	0.16	4 seasons (2012-2015)	200 trap nights (105 hrs field effort); 325 hrs radio-telemetry; >116 hrs visual surveys; 67 hrs nesting surveys	Hand/dip net captures while conducting radio-telemetry and visual surveys in wetlands and nesting areas; hoop net traps	Nova Scotia Blanding's Turtle Database 2014
Nova Scotia 5	37 ha	2M : 1F 3A : 0J	3 found	0.08	2 seasons (2004-2005)	246 trap nights (77 field hours); 1.7 hrs visual surveys	Hoop net traps	Nova Scotia Blanding's Turtle Database 2014
Nova Scotia 6	66 ha	2M : 1F 3A : 1J	3 found	0.05	3 seasons (2007-2009)	590 trap nights (318 field hours); 79.5 hrs visual surveys; 122 hrs radio-telemetry; 4 hrs nesting surveys	Hand/dip net captures while conducting radio-telemetry and visual surveys in wetlands and nesting areas; hoop net traps	Nova Scotia Blanding's Turtle Database 2014
Nova Scotia 7	306 ha* *full extent not yet known	0.6M:1F (No J yet found)	31 found	0.10	1 season (2016)	>600 hrs tracking and visual surveys	Hand/dip net captures while conducting radio-telemetry and visual surveys in wetlands and nesting areas	Nova Scotia Blanding's Turtle Database 2014

It is difficult to know how many targeted searches for new or historical Blanding's Turtle sites have been conducted in Ontario because these efforts are not coordinated. In the early 2000s, limited searches (~140 person-hours across 10 sites) were conducted at some of the best remnant wetlands in southwestern Ontario's Oxford, Middlesex and Perth counties (Gillingwater and Piraino 2002; Gillingwater unpub. data); only two specimens were found at two different Middlesex sites, each of which were fragmented and surrounded by agriculture. Herpetofaunal surveys in the Niagara region between 2006-2008 confirmed the presence of Blanding's Turtles at only four of 11 historical sites (Yagi *et al.* 2009). Although extensive herpetofaunal surveys were conducted throughout the Bruce Peninsula from 2007-2014, no Blanding's Turtles were observed despite the availability of suitable habitat in the region, and it seems likely that isolated reports in the region are of released individuals (Environment Canada 2014). It is not known if targeted searches for additional sites in northern Ontario have been conducted since the isolated reports in the region began in 2007. It seems that most searches for this species in Ontario are often associated with sampling efforts at known sites (primarily within protected areas) as part of turtle research studies. **See Population Sizes and Trends – Abundance and Table 1** for more information on the findings of these studies.

In Québec, searches for new subpopulations have been conducted within the Abitibi-Témiscamingue and Montérégie regions where isolated records were reported (Bernier 2014). Follow-up search effort in the Montérégie region included a total of 338 person-hours and 852 fyke net trap days between 2011 and 2013; one individual was observed (Rouleau and Giguère 2012; Rouleau and Bourgeois 2014). Search efforts led by two Anishinabe Bands and in collaboration with the provincial government in the Abitibi-Témiscamingue region, were conducted based on non-redundant historical and recent observations. Search efforts were carried out with 14,514 baited hoop net hours and 252 basking trap hours during 2013 and 2014 (Lapointe and Fournier 2014; Déry 2014, 2015); no Blanding's Turtles were captured. Additionally, extensive basking surveys as well as 6,744 hours of ATK informed targeted surveys using baited hoop nets at various localities in the region were also conducted by the First Nation Bands. Although other turtle species were captured (Snapping and Painted turtles), no Blanding's Turtles were captured or observed (Déry 2014, 2015). Most searches for this species in Québec are associated with sampling efforts for research studies on the main subpopulation in the Outaouais region. The area of occupancy for the Outaouais region subpopulation is extended with each new study (Fortin pers. comm. 2016). **See Population Sizes and Trends – Abundance and Table 1** for more information on the findings of these studies.

Search effort in Nova Scotia is coordinated by the Nova Scotia Blanding's Turtle Recovery Team. From 1996 to 2016, 7870 trap nights and > 850 hours of visual survey effort have gone into the search for new subpopulations. Trapping efforts included 95 waterbodies (lakes, streams or segments of rivers) on 13 watersheds (Nova Scotia Blanding's Turtle Database 2014). Through these efforts, combined with public sighting reports, ~150 Blanding's Turtles were captured, with three new subpopulations (**see Population Sizes and Trends – Sampling Effort and Methods**) and three smaller concentrations discovered outside the main study area. Despite 200 to > 700 trap nights over 2-4 years, only 3-8 adults have been found within the areas surrounding the three concentrations (NS4-NS6; Nova Scotia Blanding's Turtle Database 2014; **see Population Sizes and Trends – Sampling Effort and Methods**). The three adults in the NS6 concentration all appear to be older individuals and it is not known if recruitment is occurring in this area. The presence of a juvenile (approximately age 13) in the NS5 concentration suggests at least some recruitment in this area. The newest subpopulation (NS7) was discovered in 2016; > 600 hours of visual survey effort at this site have thus far found 31 adults (Nova Scotia Blanding's Turtle Database 2014). Despite ongoing efforts, only a very small proportion of the potential habitats in Nova Scotia have been surveyed.

HABITAT

Habitat Requirements

The Blanding's Turtle is a largely aquatic turtle that occurs in a variety of habitats including swamps, bogs, fens, marshes, marshy meadows, lakes, ponds, Beaver-regulated wetland complexes, slow flowing creeks, river sloughs, human-made channels and coastal areas of lake bays (Power *et al.* 1994; Herman *et al.* 1995; Gillingwater and Brooks 2001; Gillingwater and Piraino 2004; 2007; Ernst and Lovich 2009; Edge *et al.* 2010; Dubois *et al.* 2012). In the Great Lakes/St. Lawrence population, the most preferred habitats are wetlands that are eutrophic, with shallow water (typically < 100cm, range 0-200cm), an organic substrate, a high density of aquatic vegetation and slow to no flow (Herman *et al.* 1995; Gillingwater and Piraino 2004; 2007; Ernst and Lovich 2009; Edge *et al.* 2010; Duclos and Fink 2013; St-Hilaire *et al.* 2013). Swamp, pond, marsh, lake, fen and bog habitats are significantly preferred over lotic or ephemeral habitats (Edge *et al.* 2010). In Nova Scotia, Blanding's Turtles are often associated with acidic streams having peaty soils and tannin-rich waters as these areas maintain higher secondary productivity than clear waters in this region (Power *et al.* 1994; Bourque 2006).

Upland forest is a strong predictor for the presence of Blanding's Turtle in a landscape (Quesnelle *et al.* 2013). Upland habitat is extensively used as a travel corridor (Edge *et al.* 2010) and for hatchling dispersal to overwintering sites (Paterson *et al.* 2012). Wet forest, vernal pools, Beaver ponds and shallow-water wetlands, are also often used by Blanding's Turtles when travelling between residence wetlands and during nesting forays (Edge *et al.* 2010; Markle and Chow-Fraser 2014). Vernal pools and ephemeral wetlands are important foraging sites for Blanding's Turtles during spring as they provide rich sources of amphibian and insect eggs and larvae (Beaudry *et al.* 2009). Blanding's Turtle habitat suitability is positively correlated with air temperature and wetland area and negatively correlated with cropland area (Millar and Blouin-Demers 2012).

Adult Blanding's Turtles make extensive inter- and intra-wetland movements (Rubin *et al*. 2001; Edge *et al.* 2010; Seburn 2010; Christensen 2013; Markle and Chow-Fraser 2014) and may travel > 2000 m between wetlands (Edge *et al.* 2010), using multiple bodies of water throughout the active season (mean 5; range 1-20) (Beaudry *et al.* 2009; Edge *et al.* 2010). Despite these seasonal movements, Blanding's Turtles have strong site fidelity (McNeil 2002; Herman *et al.* 2003; Markle and Chow-Fraser 2014) and spend the majority of the season within a single residence wetland (Congdon *et al.* 2011; Christensen and Chow-Fraser 2014; Markle and Chow-Fraser 2014). Individuals only utilize a few residence wetlands over their lifetime and may spend decades in a specific locality (Congdon *et al.* 2011). Juvenile Blanding's Turtles use the same water bodies as adults (McMaster and Herman 2000; Paterson *et al.* 2012; Gillingwater unpub. data) where they are typically found in areas of dense aquatic vegetation (McMaster and Herman 2000; McNeil 2002; Caverhill 2003; Gillingwater unpub. data). Hatchlings use a variety of terrestrial and wetland habitats upon emergence from the nest (Standing *et al.* 1997; McNeil *et al.* 2000; Camaclang 2007) and have been most commonly found on or in forest leaf litter, grass, *Sphagnum* sp., water or buried under the soil (Camaclang 2007). Hatchlings may extensively use open upland habitats during dispersal from nests to overwintering sites (Paterson *et al.* 2012).

Home Range

In Canada, mean home range areas (based on minimum convex polygon (MCP) or equivalent minimum polygon method) generally fall between 10 - 60 ha (range 0.2-382 ha) and mean home range lengths generally fall between 1000 - 2500 m (range 37-7000 m; McNeil 2002; Caverhill 2003; Edge *et al.* 2010; Kydd 2010; Caverhill *et al.* 2011; Millar and Blouin-Demers 2011; Dubois *et al.* 2012; Fortin *et al.* 2012; Lefebvre *et al.* 2012; St-Hilaire *et al.* 2013; Christensen 2013; Baxter-Gilbert 2014; Christensen and Chow-Fraser 2014; Dillon Consulting 2014; Woods 2014; Markle and Chow-Fraser 2014b, unpub. data; Cameron unpub. data; Edge unpub. data; OMNRF Timmins District unpub. data; Riley *et al.* unpub. data; Rouse unpub. data; Scales Nature Park unpub. data).

Several studies have found that movement data which exclude long-distance nesting migrations, or which are obtained solely from non-daily radio-tracking regimes and/or over a single or partial active season, greatly underestimate the home range size and habitat requirements for this highly mobile species (Power 1989; McNeil *et al.* 2000; Herman *et al.* 2003; Caverhill *et al.* 2011; Congdon *et al.* 2011; Christensen 2013; Christensen and Chow-Fraser 2014; Markle and Chow-Fraser 2014b; Millar and Blouin-Demers 2011; Woods 2014). The use of GPS loggers, especially over more than one season, seems to be the most accurate method for estimating Blanding's Turtle home range size (Christensen and Chow-Fraser 2014; Markle and Chow-Fraser 2014b).

Hibernation Habitat

Adult and juvenile Blanding's Turtles overwinter in permanent or temporary waterbodies, including bogs, fens, forest and shrub swamps, marshes, graminoid shallow meadow marshes, streams, shorelines of lakes and ponds, and flooded borrow pits or roadside ditches (Power 1989; McNeil 2002; Caverhill 2003; Hartwig 2004; Penny 2004; Edge *et al.* 2009, 2010; Newton and Herman 2009; Seburn 2010; Caverhill *et al.* 2011; Dubois *et al.* 2012; Paterson *et al.* 2012; Carstairs 2014; Dillon Consulting 2014; Woods 2014; Nova Scotia Blanding's Turtle Database 2014; Markle and Chow-Fraser 2014b; Gillingwater unpub. data; Rouse unpub. data). Reported winter water depths at hibernation sites vary from 0 to >100 cm (Edge *et al.* 2009; Newton and Herman 2009; Thiel and Wilder

2010; St-Hilaire *et al.* 2013) and hibernation sites often occur within the same areas used for summer activity (Joyal *et al.* 2001; Seburn 2010; Dubois *et al.* 2012; Christensen 2013; Dillon Consulting 2014; Markle and Chow-Fraser 2014). Hatchlings choose both aquatic and terrestrial sites for hibernation and may successfully overwinter within the nest cavity (Paterson *et al.* 2012; Nova Scotia Blanding's Turtle Database 2014). Blanding's Turtles may hibernate singly (Seburn 2010; Gillingwater unpub. data; Markle unpub. data) or communally (McNeil 2002; Caverhill 2003; Herman *et al.* 2003; St-Hilaire 2003; Edge *et al.* 2009; Newton and Herman 2009; Paterson *et al.* 2012; St-Hilaire *et al.* 2013; Gillingwater unpub. data; Markle unpub. data) with up to 16 individuals observed in a single hibernaculum (Herman *et al.* 2003). This species often shows fidelity to hibernation areas (Herman *et al.* 2003; Edge *et al.* 2009; Newton and Herman 2009; Dubois *et al.* 2012).

Nesting Habitat

Suitable nesting habitat occurs in sun-exposed areas with low vegetation cover and loose soils. Blanding's Turtles are known to nest in a variety of habitats including sand beaches and dunes, soil-filled crevices in rock outcrops, Muskrat lodges, Canada Goose mounds, wetland berms, gardens, yards, agricultural fields, pastures, railway embankments, gravel pits, as well as sand or gravel roads, road shoulders and trails (Gillingwater and Brooks 2001; Gillingwater and Piraino 2004; Caverhill 2006; 2007; Congdon *et al.* 2008; Ernst and Lovich 2009; Beaudry *et al.* 2010; Caverhill *et al.* 2011; Markle and Chow-Fraser 2014; Woods 2014; Gillingwater unpub. data; NHIC data). Females in Nova Scotia often also utilize cobble lakeshore beaches (Standing *et al.* 1999). Nearly 50% of nesting sites for the Nova Scotia population (Caverhill 2006; Nova Scotia Blanding's Turtle Database 2014) and ~90% of nesting sites for the Québec subpopulation (Dubois *et al.* 2012) occur in human-altered landscapes.

Females often show fidelity to nesting areas; however, nests may be laid up to 2 km from the previous nesting site (McNeil 2002; Congdon *et al.* 2008; Dubois *et al.* 2012). Females may travel up to 7500 m prior to nesting (mean ~1000-2000 m; Standing *et al.* 1999; St-Hilaire 2003; Congdon *et al.* 2008; Edge *et al.* 2010; Millar and Blouin-Demers 2011; Caverhill *et al.* 2011; Dubois *et al.* 2012; Christensen and Chow-Fraser 2014; Markle and Chow-Fraser 2014a, 2014b; Nova Scotia Blanding's Turtle Database 2014). Reported mean distances between nesting sites and nearest wetland habitats were 100-242 m (range 10 to > 1000 m); however, nests may be laid up to 2580 m from the female's residence wetland (Beaudry *et al.* 2010; Congdon *et al.* 2008; 2011; Dubois *et al.* 2012; Paterson *et al.* 2012; Équipe de rétablissement des tortues du Québec unpub. data). Females may make large overland movements of 2.5 to > 10 km during the nesting season (Power 1989; Nova Scotia Blanding's Turtle Database 2014). In areas where nesting habitat is limited, several females may aggregate at the few sites that are available (Davy unpub. data; Gillingwater unpub. data).

Habitat Trends

This section only discusses historical landscape changes and associated impacts to habitat; for a discussion of current and projected future habitat trends see 'Threats and Limiting Factors'.

Prior to European settlement (ca. 1800), there were ~2 million ha of wetland in southern Ontario (25% of the total area) but by 2002, approximately 1.4 million ha or 72% of pre-settlement wetlands ≥ 10 ha in size were lost (Ducks Unlimited 2010) (resulting in an estimated > 60% decline for the Blanding's Turtle, Great Lakes/St. Lawrence population; **see Appendix 1**). This is a very conservative estimate of wetland loss in southern Ontario given that wetlands < 10 ha were not considered in the analysis (Ducks Unlimited 2010). Most counties experienced losses of 45 - 85%; however, some experienced losses as high 89 - 98% (i.e., Essex, Kent, Lambton, Middlesex, Perth and Russell; Ducks Unlimited 2010); these are the same counties with few to no Blanding's Turtle records. Forestry, agriculture, urban fields and the development of roads and hydro corridors have accounted for 94% of this wetland loss (Ducks Unlimited 2010). Since 1951, coastal wetlands in southern Georgian Bay have undergone losses of 16 - 68% in some regions (Severn Sound Remedial Action Plan 1993b) due to shoreline modification, road construction and residential and marina development (Severn Sound Remedial Action Plan, 1993a). From the 1980s to early 2000s, habitat losses were observed at 17 Lake Huron coastal wetlands, and > 50% of coastal wetlands along Georgian Bay and the Bruce Peninsula have been affected due to agriculture and cottage development (Environment Canada and OMNRF 2003). In southern Ontario, the average wetland loss from 1982 to 2002 was estimated at 0.17% annually; however, this estimate is extremely conservative given that only wetlands ≥ 10 ha were considered in the calculation (Ducks Unlimited 2010). Coastal wetland habitat along Lake Erie was also incrementally lost throughout the 1990s because of cottage and marina development, and is expected to continue into the future (Petrie 1998).

Habitat suitability mapping for Blanding's Turtle in Ontario has revealed a sharp divide between northern and southern subpopulations, with southern cohorts seemingly facing a much higher extinction risk due to higher rates of habitat loss and fragmentation in this part of the range (Millar and Blouin-Demers 2012).

Little information exists on historical wetland loss in the Outaouais region of Québec; however, wetland loss along the Ontario side of the Ottawa River in that region ranged from 65-100% (Ducks Unlimited 2010). Furthermore, a review of Google Earth aerial imagery reveals that ~50% of the area that overlaps with the current known range of the Blanding's Turtle in that region has been converted to agriculture.

Similarly, there is little information on the amount of historical wetland loss in the southwest region of Nova Scotia. Despite this, a review of Google Earth aerial imagery reveals that there has been a significant amount of logging outside protected areas throughout the province which has likely resulted in loss of Blanding's Turtle habitat. The two principal changes in habitat in Nova Scotia since European colonization have been increased fragmentation of forests and alteration of water flow regimes (primarily for power generation; Herman *et al*. 2003).

BIOLOGY

Since the last status assessment, more research has been conducted on Blanding's Turtles in Ontario and Québec, and study of the Nova Scotia population has remained ongoing. These studies have greatly increased our knowledge of Blanding's Turtle biology in terms of breeding behaviours; annual movements; reproductive success; population demographics; hibernation behaviours and conditions; and the survivorship of adults, juveniles and hatchlings.

Life Cycle and Reproduction

<u>Annual Life Cycle</u>

Blanding's Turtles emerge from hibernation sites in the early spring shortly after ice melt begins (McMaster and Herman 2000; McNeil 2002; Gillingwater unpub. data). In Canada, mating activity often occurs when turtles are congregated at hibernacula (McNeil 2002; Dubois *et al.* 2012) but has been observed in every season (Power 1989; Gillingwater and Brooks 2001; McNeil 2002; Newton and Herman 2009; Dubois *et al.* 2012). During early spring (pre-nesting period), males may move from residence wetlands into ephemeral habitats (Christensen 2013; Markle and Chow-Fraser 2014). Prior to nesting, gravid females may spend several days in terrestrial areas (Congdon *et al.* 2000) or up to a few days or weeks in aquatic "staging areas" within close proximity to nesting habitat (Congdon *et al.* 2008; Christensen and Chow-Fraser 2014; Markle and Chow-Fraser 2014). Round-trip nesting migrations may take nearly a month to complete (Markle and Chow-Fraser 2014b). The nesting period begins as early as late May and continues through to early July, peaking in early to mid-June (Standing *et al.* 1999; Gillingwater and Brooks 2001; Millar and Blouin-Demers 2011; Christensen 2013; Nova Scotia Blanding's Turtle Database 2014; Équipe de rétablissement des tortues du Québec unpub. data; Gillingwater unpub. data). Hatchlings emerge from early August to late October (incubation days = 56 - 133; Standing *et al.* 1999; Herman *et al*. 2003; Gillingwater and Piraino 2004; Caverhill *et al.* 2011; Riley *et al.* 2011, 2012; Nova Scotia Blanding's Turtle Database 2014; Gillingwater unpub. data). Some individuals may become dormant for a few days or weeks during the summer period, remaining inactive either within wetlands or buried terrestrially beneath forest litter or dead cattails (Dubois *et al.* 2012; Woods 2014). In Canada, adults typically move to hibernation sites between late August to early November (Hartwig 2004; Edge *et al.* 2009; Newton and Herman 2009; Seburn 2010; Caverhill *et al.* 2011; Markle and Chow-Fraser 2014). Hatchlings in southcentral Ontario enter hibernacula between mid-September to mid-October (Paterson *et al.* 2011, 2012).

Reproductive Ecology

Blanding's Turtles are polygamous and individuals may mate more than once with one or multiple partners within and among years (Dubois *et al.* 2012; McGuire *et al.* 2013, 2015; Anthonysamy *et al*. 2014). Females have the ability to store sperm and clutches may have multiple sires (Patterson 2007; McGuire *et al.* 2013, 2015; Anthonysamy *et al*. 2014). Mating attempts are often unsuccessful and reproductive success among males within a subpopulation may be strongly skewed (Anthonysamy *et al*. 2014). Over an eight year study, the mean number of offspring sired per male was 11 (SD=9, range=1-40, N=32; McGuire *et al.* 2015). Clutch size, egg size, multiple paternity and female reproductive frequency are positively correlated to age (Congdon *et al*. 1983, 2001, 2008; McGuire *et al.* 2015) and older females have a higher probability of mating with non-resident males; making older females particularly important for maintaining genetic connectivity between wetlands (McGuire *et al.* 2013). The Blanding's Turtle's ability to make extensive movements facilitates gene flow among wetlands and may substantially increase reproductive success; small subpopulations are able to maintain genetic diversity through long-distance sojourns and nesting forays that bring increased mating opportunities with non-residence individuals and allow hatchlings to disperse to wetlands other than their parents' residences (McGuire *et al.* 2013). Therefore, population persistence is dependent on habitat connectivity which facilitates these long-distance movements between wetlands (McGuire *et al.* 2013, 2015).

Blanding's Turtle has a highly iteroparous reproductive strategy, having multiple reproductive cycles over the course of a lifetime. At maturity, one clutch of eggs is produced at a frequency of once every 1 - 3 years (Congdon *et al.* 1983). Across the range, reported mean clutch size falls between 6 - 13 eggs (range 1 - 25 eggs; Standing *et al.* 1999; Gillingwater and Brooks 2001; McNeil 2002; Caverhill 2006; Congdon *et al.* 2008; Caverhill *et al.* 2011; Riley *et al.* 2012; Nova Scotia Blanding's Turtle Database 2014). In Nova Scotia, clutch size differs among the subpopulations (Herman *et al*. 2004). Predation on Blanding's Turtle eggs is often extremely high (**see Threats and Limiting Factors – Subsidized Predators**). Nest monitoring studies in Ontario and Nova Scotia reported a 59% to 68% mean hatch success of eggs protected with caging to prevent mammalian predation (Gillingwater and Brooks 2001; Nova Scotia Blanding's Turtle Database 2014). Although sarcophagid fly larvae often predate live hatchlings before they can successfully emerge from the nest, the larvae largely consume rotting eggs (Gillingwater and Brooks 2001) and have no significant impact on hatching success (Bolton *et al.* 2008).

Hybridization

Intergeneric hybridization has been observed in rare cases, both in the wild and in captivity, between Blanding's Turtle and Wood Turtle (*Glyptemys insculpta*) where their ranges overlap within Ontario and the U.S.A. (Harding and Davis 1999; Knudson pers. comm. 2004). Viable hybrid offspring are produced (Harding and Davis 1999).

Longevity and Development

Blanding's Turtles can live in excess of 83 years (University of Michigan News May 25, 2016) and are one of the latest maturing species of freshwater turtles. Annual rates of growth are greatest in the first year and decrease steadily until sexual maturity; once maturity is attained, the rate of growth declines drastically (Congdon *et al.* 2008). Sexual maturity has been estimated to occur between 14-26 years of age, with individuals at more northerly latitudes reaching maturity later (Congdon and van Loben Sels 1991, 1993; Congdon *et al.* 2001; McNeil 2002; Herman *et al.* 2003; Nova Scotia Blanding's Turtle Database 2014; McGuire *et al.* 2015). The minimum Straight Carapace Length (SCL) recorded for nesting females was 15.8 cm in southwestern Ontario (MacCulloch and Weller 1987; Gillingwater unpub. data) and 18 cm in Nova Scotia (Nova Scotia Blanding's Turtle Database 2014).

The mean generation time for Canadian Blanding's Turtles is estimated to be 40 years (range 37-42 years), based on an age of maturity at 20-25 years (Congdon *et al.* 2001; Herman *et al.* 2003), a mean annual adult survivorship of 0.94 (calculated from mean estimates reported from Congdon *et al.* 2008, 0.94; Dillon Consulting 2014, 0.89; Green and McNeil 2014, 0.98) and using the equation [Generation time = Age of first reproduction + 1/adult mortality] (IUCN 2014).

Population Structure and Demographics

Some Canadian studies have reported female biased sex ratios while others have reported male biased sex ratios or ratios of 1:1 (Table 1). The reported adult to juvenile ratios for Canadian subpopulations range from approximately 1.5 to 30 adults for every juvenile; studies that sampled using traps versus those that sampled using hand captures have both reported high ratios of adults to juveniles (Table 1).

Feeding and Diet

Blanding's Turtles are omnivorous. Their diet includes aquatic and terrestrial invertebrates, aquatic vegetation, crayfish, bivalves, fish and fish eggs, carrion, frogs, toads and tadpoles (Ernst and Lovich 2009; Gillingwater unpub. data; Herman unpub. data). Feeding typically takes place under water (Harding 1997).

Mortality

Reported sources of natural mortality for adult Blanding's Turtles include predation by mammals, disease, and overwintering deaths resulting from harsh environmental conditions (Gillingwater and Brooks 2001; Parks Canada 2012; Nova Scotia Blanding's Turtle Database 2014; Woods 2014; Davy unpub. data; Gillingwater unpub. data). One southwestern Ontario study reported 2-12 dead individuals per spring resulting from natural mortality factors (or 0.25 to 1.5% of the estimated subpopulation size; Gillingwater unpub. data); this would be a significant underestimate of annual adult mortality given that surveys were only conducted in April and May and that several areas of the wetland were not accessible for researchers to survey. It is suspected that other subpopulations throughout the range experience similar mortality rates due to natural factors. **See Threats and Limiting Factors for more information on anthropogenic sources of mortality**.

Instances of mass mortality for this species have been reported from Ontario. In the early 1990s, dozens of Blanding's Turtles were observed washed up on shore at a protected southwestern Ontario site in early spring and were suspected winter kills (McCracken pers. comm. 2014). More recently, 52 dead Blanding's Turtles (9 juveniles and 43 adults) were found between May to June of 2013 within a protected area in southcentral Ontario (Sheppard 2014a). This mass mortality event appears to have removed almost half of the breeding population (Litzgus pers. comm. 2016) and is believed to have been caused by increased predator access into the wetland because of unseasonal drought conditions (Sheppard 2014a). In small subpopulations, such unexpected stochastic events could have a devastating effect.

Annual survivorship estimates for adults range from 0.89 - 0.98 (Congdon *et al.* 1993; Herman *et al.* 2004; Enneson 2009; Dillon Consulting 2014; Green and McNeil 2014). Most recent average annual survivorship estimates for juveniles in one subpopulation in Nova Scotia were calculated as follows: 0.90 for large individuals (10-18.5 cm CL), 0.73 for small individuals (5 - 9.99 cm CL) and 0.09 for hatchlings (Green and McNeil 2014). The observed morality rate for 2 to 3 year old headstarted (N=22) and wild-caught (N=5) juveniles averaged 30% for individuals tracked over three years (range 0 - 80% annually; Carstairs 2014). No differences in mortality rates have been observed between headstarted and wild-caught individuals (Arsenault 2011; Carstairs 2014). Of 48 radio-tracked hatchlings from southcentral Ontario, a minimum of 42% survived until winter; of the remainder, 16% were found depredated, 2% were found desiccated, 2% were found dead on road and 38% had an unknown fate because of signal loss (Paterson *et al.* 2012). Hatchlings that were more likely to survive were smaller in size, emerged from nests later (thereby having a reduced exposure period to predators) and spent less time in open uplands (Paterson *et al.* 2014).

Physiology and Adaptability

Thermoregulation and Thermal Tolerance

Blanding's Turtle has one of the lowest critical thermal maxima, compared to other North American Emydid turtles, at an upper maximum of 39.5°C (Hutchinson *et al.* 1966). The mean preferred temperature is 22.5°C for males and 24.8°C for females (Nutting and Graham 1993). The fitness of ectotherms is tightly linked to thermoregulation, as all physiological processes are temperature dependent (Millar *et al.* 2012); basking increases energy gain and optimizes metabolism, digestion, growth and egg development (Avery *et al.* 1993; Sarkar *et al.* 1996; Koper and Brooks 2000; Steyermark and Spotila 2001; Carrière *et al.* 2008; Dubois *et al.* 2009; Millar and Blouin-Demers 2011; Millar *et al.* 2012). Basking may be particularly important at northern latitudes where the active season is short and reproductive output is constrained by cooler temperatures (Rollinson and Brooks 2007). A study in southeastern Ontario found that environmental temperatures were rarely within the optimal body temperature range for this species, so turtles had to actively thermoregulate during the early and late portions of the active season (Millar *et al.* 2012). Alternatively, the Blanding’s Turtle may aestivate during the summer when temperatures are too high (**see Biology – Annual Life Cycle**). The thermal tolerance range for egg incubation is 22-32°C; this high thermal requirement results in high nest failure rates in the northern portion of the species’ range (Ewert and Nelson 1991).

Temperature-dependent Sex Determination

This species displays temperature-dependent sex determination (TSD); males are produced when the eggs are incubated at or below 28°C and females are produced at temperatures above 30°C (Ewert and Nelson 1991).

Hibernation

A study of hibernation conditions for Blanding’s Turtles in southcentral Ontario found that individuals selected sites that were thermally stable, with water temperatures close to 0°C, and that body temperatures were 1 - 3°C colder than water temperatures at haphazard stations (Edge *et al.* 2009). Across both years of study, ice cover prevented access to atmospheric oxygen for > 101 to > 136 days and individuals chose to hibernate in wetlands with ubiquitously low levels of dissolved oxygen (Edge *et al.* 2009), supporting the hypothesis that this species is anoxia-tolerant (Ultsch 2006). In Nova Scotia, median winter water temperatures of selected overwintering sites ranged from 0.8°C to 8.6°C; although most sites formed ice cover each winter, one warm site remained ice-free (Newton and Herman 2009; Nova Scotia Blanding’s Turtle Database 2014). Reported levels of dissolved oxygen at hibernacula fall between 0.8 - 11.3mg/L (Edge *et al.* 2009; Newton and Herman 2009; St-Hilaire *et al.* 2013).

Dispersal and Migration

The recognized separation distances (i.e., distances over which individuals would not normally travel and which are based on typical movements or home ranges for the species) between Blanding’s Turtle subpopulations are: (i) 10 km in areas of continuous undeveloped aquatic or aquatic/terrestrial habitats; (ii) 5 km in areas of continuous undeveloped upland terrestrial habitats; and (iii) 2 km in areas with a mosaic of upland terrestrial habitat and development (NatureServe 2014).

According to IUCN (2014) "a taxon can be considered severely fragmented if most (>50%) of its total area of occupancy is in habitat patches that are (i) smaller than would be required to support a viable population and (ii) separated from other habitat patches by a large distance". Given this definition and the estimated dispersal distances of this species, neither the Great Lakes/St. Lawrence population nor the Nova Scotia population appears to meet the criteria for severe fragmentation given that the majority of the area of occupancy in both populations occurs within large areas of contiguous habitat. It is likely that subpopulations in southwestern Ontario would meet the criteria for severe fragmentation if they were considered in isolation from the rest of the Great Lakes/St. Lawrence population, given the lack of habitat remaining in that portion of the province.

Interspecific Interactions

Known mammalian predators of turtles and turtle nests across Canada include American Mink (*Neovison vison*), Black Bear (*Ursus americanus*), Coyote (*Canis latrans*), Raccoon (*Procyon lotor*), Red Fox (*Vulpes vulpes*), River Otter (*Lontra canadensis*), Striped Skunk (*Mephitis mephitis*), Virginia Opossum (*Didelphis virginiana*) and Short-tailed Shrew (*Blarina brevicauda*) (Brooks *et al.* 1991b; Standing and Herman 2000; Browne and Hecnar 2007; Ernst and Lovich 2009; Davy unpub. data; Gillingwater unpub. data). Other potential small mammal predators of Blanding's Turtle nests in Canada include chipmunks, voles and moles (Congdon *et al.* 2000). Raccoons and foxes, in particular, are the primary predators of nests (Congdon *et al.* 2008). Because of their small size, hatchling and small juvenile turtles are also susceptible to predation by American Kestrel (*Falco sparverius*), crows, Eastern Chipmunk (*Tamias striatus*), Northern Short-tailed Shrew, Red Squirrel (*Tamaisciurus hudsonicus*), fish, frogs, snakes and wading birds (Camaclang 2007; Ernst and Lovich 2009; Paterson *et al.* 2012, 2014; Green pers. comm. 2014).

Throughout the Canadian range, Blanding's Turtles are often associated with Beaver-influenced wetlands (Herman *et al.* 2003; Millar 2009; Dubois *et al.* 2012; Bernier 2013; Duclos and Fink 2013; Markle and Chow-Fraser 2014; OMNRF Timmins District unpub. data). The Blanding's Turtle is also positively associated with Muskrat (Kiviat 1978b; Gillingwater 2013). Muskrat lodges and mounds provide turtle hibernation, nesting and basking habitat while the cleared aquatic channels created by Muskrats provide movement corridors for turtles (Kiviat 1978b; Gillingwater 2013). Beaver lodges and channels likely also provide nesting, basking and movement opportunities. Therefore, the removal of these mammals from wetlands is likely to have a negative impact on Blanding's Turtles, through eliminating the important habitat features that these aquatic mammals create for turtles (Kiviat 1978b; Gillingwater 2013). Furthermore, the removal of Beaver dams also poses a threat to Blanding's Turtles (see Threats and Limiting Factors – Natural System Modifications). See Biology – Reproductive Ecology' for discussion of nest parasitism by fly larvae. See Biology – Feeding and Diet for a list of Blanding's Turtle prey species.

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

Although the known Blanding's Turtle subpopulations in Québec and Nova Scotia have been thoroughly sampled, relatively few mark-recapture studies have been conducted for known Blanding's Turtle subpopulations in Ontario.

In southwestern Ontario, 2 - 21 years of sampling efforts have been conducted for five subpopulations and are ongoing for two. In southeastern Ontario, 2 - 5 years of sampling efforts have been conducted for five subpopulations. In southcentral Ontario, 2 - 5 years of sampling efforts have been conducted for three subpopulations. In the Outaouais region of Québec, where the main subpopulation in the province occurs, nine years of sampling efforts have been conducted since 1996 and are ongoing. In Nova Scotia, 1 - 46 years of sampling efforts have been conducted for seven subpopulations/concentrations and are ongoing. **See Table 1 for a summary of sampling effort and methods for various subpopulations across the Canadian range**.

Abundance

It is difficult to estimate the abundance of Blanding's Turtles in the Great Lakes/St. Lawrence population, as there has been very little research on abundance or subpopulation trends throughout Ontario, where the majority of the population occurs. Although two southwestern Ontario subpopulations are estimated to maintain ~700 - 800 adults each (based on sampling efforts of > 650 person-days at each site), large sampling efforts for six other subpopulations across the Great Lakes/St. Lawrence region yielded low subpopulation estimates of 41 - 138 adults (based on > 2200 trap days and/or 1000-5300 person-hours at each site) (Table 1). Even subpopulations that occur in protected areas with suitable habitat and large abundances of other sympatric turtle species seem to maintain small numbers of Blanding's Turtles. For example, five seasons of sampling efforts at a protected southeastern Ontario site (~68 person days and ~54 trap days of effort) provided a Blanding's Turtle subpopulation estimate of 85 (the recapture rate was 75%); however, Eastern Musk Turtle (*Sternotherus odoratus*), Midland Painted Turtle (*Chrysemys picta marginata*) and Snapping Turtle estimates were much higher (1403, 1343 and 684, respectively) despite the same survey efforts for these species (Middleton 2014). North of Sudbury, the species appears to only occur very rarely; indeed, only five records are known for all of northern Ontario and only one individual was observed across a three-year radio-tracking study in Timmins district (OMNRF Timmins District unpub. data). Based on evidence from all sampling efforts across the Great Lakes/St. Lawrence range, it appears that most subpopulations are small (< 150 adults) and occur at low densities, especially at more northerly latitudes (**see Appendix 1 and Table 1**). If the number of Blanding's Turtle atlas squares from the ORAA are used as a proxy for subpopulations (which seems reasonable given that each atlas square represents a 10 km^2 x 10 km^2 area and that the largest recognized separation distance between Blanding's Turtle subpopulations is 10 km; see 'Dispersal and Migration') then a rough estimate of total population size could be achieved by multiplying the number of ORAA squares within each ecoregion by the average subpopulation size in each ecoregion (SC=49, SW=72 and SE=99). If the two southwestern Ontario subpopulations with atypically large sizes are considered in the total population size but excluded as outliers from the average subpopulation size estimate for the Lake Erie/Lake Ontario ecoregion, and depending on whether historic ORAA squares are excluded or included in the calculation (396 to 643 squares), a very crude estimate for the Great Lakes/St. Lawrence population (including the ~200 currently known adults from Québec) is approximately 25,000-45,000 adults.

The total number of mature individuals in Nova Scotia is not known but is believed to be < 500 based on currently known subpopulations, each of which is unlikely to exceed 200 adults. The current estimate for the NS1 subpopulation is 131 (95% CI: 129 - 134) and is based on mark-recapture data from 1987-2013, excluding 1990-1991 (Green and McNeil 2014). The NS2 subpopulation is estimated to contain 79 adults (95% CI: 60-116), based on mark-recapture data from 1997 to 2002 (McNeil 2002). An estimate for the NS3 subpopulation as a whole has not yet been calculated; however, an estimate of 88 individuals (95% CI: 79-102) was calculated for the BA-KB concentration within the subpopulation (Lefebvre *et al.* 2012). This estimate includes individuals of all age classes (Lefebvre 2009). In Lefebvre's analysis, 58% of the individuals encountered were mature adults (40 of 69 turtles); assuming this ratio remains constant, this would result in an adjusted estimate of 51 adults (46-60) in the concentration. The concentration represents approximately 43% of the total marked turtles in the entire subpopulation. Extrapolation of the estimate for the concentration across the entire NS3 subpopulation would yield an estimate of approximately 118 (106-139) mature individuals, though differences in habitat and survey effort are not taken into account using this method. Initial analysis from two studies using limited sample sizes (n= 23 & 21 nests) and a small number of microsatellite loci (n= 5 & 3) have indicated that the Nova Scotia population may have a low number of males that are successfully reproducing and lower incidence of multiple-sired clutches than reported elsewhere (Beckett 2006; Patterson 2007). If this is true, it would mean that the effective population (Ne) size may be considerably lower than the actual population size (Parks Canada 2012). The NS7 subpopulation was discovered in April 2016; 31 adult turtles were found in the first two months of sampling, suggesting this could be a sizable subpopulation. **See Table 1 for a summary of sampling effort and adult population estimates for various subpopulations across the Canadian range.**

Fluctuations and Trends

The estimated decline in the total number of mature individuals for the Great Lakes/St. Lawrence population over the last three generations is > 60% due to large-scale wetland loss after European arrival (see Appendix 1). It is inferred that most pre-settlement Blanding's Turtles lived in the Lake Erie/Lake Ontario ecoregion (based on higher densities of individuals reported from monitored subpopulations there; Appendix 1); as most of the wetlands in southern Ontario were lost, an increasing proportion of the remaining Blanding's Turtles were found in more northerly, less productive ecoregions (Appendix 1). Because wetland loss has been most severe in southern Ontario, where subpopulation densities were inferred to be higher, the decline in overall abundance has likely been steeper than the rate of wetland conversion (Appendix 1). Given that the Québec subpopulation occurs in a predominantly agricultural landscape, it is inferred that the subpopulation there also experienced historical decline after European settlement (**see Habitat Trends**).

High levels of continuing decline for the Great Lakes/St. Lawrence population are inferred and projected based on observed trends from monitored Ontario subpopulations (no current trends have yet been identified for subpopulations in Québec; Bernier 2014). For instance, large declines in Blanding's Turtle numbers have been observed at six protected areas in Ontario (based on extensive survey efforts and/or anecdotal evidence from expert naturalists), with up to 50-95% declines reported at some sites over the last 10 - 30 years (< 1 generation; Table 2, specifically sites SW Ontario2, SW Ontario4; SW Ontario6, SW Ontario7, SC Ontario3, SE Ontario6). Large declines are also inferred and projected for subpopulations across Ontario based on observed high levels of annual road mortality (6-23% of estimated subpopulation sizes), or worse, a lack of road kill observations in recent years at sites that were once road mortality hotspots for this species into the early 2000s (Table 2, specifically sites SW Ontario2, SW Ontario3, SE Ontario1, SC Ontario4, SC Ontario5, SC Ontario6). Road mortality models based on the lowest road kill rate[1] (estimated from four monitored subpopulations along major roadways in Ontario) and the highest estimated total population size of 45,000 adults, project that the Blanding's Turtle, Great Lakes/St. Lawrence population will decline by 40% in the next 80 years (i.e., 2 generations) and by 50% in the next 117 years (i.e., < 3 generations; Appendix 3). Therefore, based on these conservative models (i.e., 40-50% declines over 2-3 generations respectively, due to road mortality alone) and the observed/inferred trends and high levels of annual adult road mortality reported from monitored sites (i.e., 50-95% declines in < 1 generation and high annual adult road mortality rates of 6-23% of estimated subpopulation sizes), the projected decline of the Great Lakes/St. Lawrence population is > 40% over the next 2 generations and > 50% over the next 3 generations (Table 2 and Appendix 3).

Table 2. Summary of Subpopulation Trends and Threats Across the Canadian Range.
LEGEND: O = Observed; I = Inferred; P = Projected; † = *Phragmites a. australis*; ‡ = Not-native fish and *Phragmites a. australis*

Location	Subpopulation Trend	Main Observed, Inferred and Projected Threats									
		Road / Rail Mortality	Poaching	Invasive Species	Subsidized Predators	Development	Wetland Drainage and/or Alterations	Aggregate Activities	Forestry Activities	Agricultural Activities	Recreational Activities
SW Ontario 1	Inferred decline resulting from large-scale habitat degradation from invasive European Reed, heavy nest predation from subsidized predators, easy access for poachers and observed boating injuries (Gillingwater and Brooks 2001; Ontario Parks unpub. data; Davy unpub. data).	I	I	O	O					I	O

[1] The lowest road kill rate was chosen to compensate for the fact that road kill rates are likely lower on smaller roads. This provides a conservative estimate of Blanding's Turtle annual road mortality and projected decline.

Location	Subpopulation Trend	Main Observed, Inferred and Projected Threats									
		Road / Rail Mortality	Poaching	Invasive Species	Subsidized Predators	Development	Wetland Drainage and/or Alterations	Aggregate Activities	Forestry Activities	Agricultural Activities	Recreational Activities
SW Ontario 2	Observed and projected decline. 1) ~85% decline in CPUE -- In the late 1980s, three 1-day visual surveys, with binoculars from the edge of the wetland, found 102 to 130 Blanding's Turtles per survey (~6 person-hours/survey; NHIC data; McCracken pers. comm. 2014). In comparison, intensive spring surveys at this site from 2003 to 2006 (~70-120 person-days/per spring spent wading through the wetlands on foot) only found a maximum of 31 individuals/survey (~15 person-hours per survey; Gillingwater unpub. data). Between 2003 and 2013, the average number of spring captures/day fell from 14 to 2 despite similar amounts of person effort between the years (Gillingwater 2013, unpub. data). 2) ~95% decline in # of nesting females -- In 1982, 257 adult female Blanding's Turtles were captured on the main nesting beach over 22 days between June 7-29 (Ashenden 1983) while only 14 females were located during a 20 day nesting survey along the same nesting beach between late May to early July 2012 (one was road-killed; Gillingwater 2013). 3) Between 2003-2014, 64 dead adults were found (Gillingwater unpub. data). This represents ~8% of the estimated adult population size. This is a gross underestimate of actual adult loss during that time, since surveys were only conducted during spring rather than across an entire active season. 4) Models predict: (i) a 7% annual loss of adult females due to all causes; (ii) a loss of 123 adult females in 50 years; and (iii) the extirpation of all adult females (~46% of the estimated subpopulation size) in <150 years (i.e., <4 generations; Enneson 2009).	O	O	O	O		O			O	O
SW Ontario 3	Inferred decline. 8 DOR adults were incidentally observed by a passerby on April 16, 2008. This represents a ~6% loss of the estimated adult subpopulation size over the first couple weeks of one active season (Caverhill *et al.* 2011; Toronto Zoo unpub. data).	O	I	O	I		I			O	
SW Ontario 4	Observed decline. Blanding's Turtle was once considered abundant at this site in the early 1900s (Patch 1919) but now only persists in small numbers. CPUE fell from 0.054 to 0.010 and a significant shift to a larger and presumably older age structure was observed over 30 years between the early 1970s to early 2000s (Rivard and Smith 1973a,b; Browne and Hecnar 2007).	I	I	O	O					I	I

Location	Subpopulation Trend	Main Observed, Inferred and Projected Threats									
		Road / Rail Mortality	**Poaching**	**Invasive Species**	**Subsidized Predators**	**Development**	**Wetland Drainage and/or Alterations**	**Aggregate Activities**	**Forestry Activities**	**Agricultural Activities**	**Recreational Activities**
SW Ontario 5	Subpopulation is considered functionally extinct. Only 5 adults found in over 1855 person-hours of survey effort. Headstarting efforts and wetland rehabilitation activities have begun (Toronto Zoo unpub. data)	I	I	O	O						I
SW Ontario 6	Observed decline. Incidental observations since the mid-1990s have declined >50% of the long-term average recorded over the previous 30 years (Mackenzie *et al.* 2014). A mass mortality event occurred in the early 1990s where dozens of individuals were observed washed up on shore (McCracken pers. comm. 2014). Between 1999-2006, invasive *Phragmites* rapidly spread through this site at ~34-48% annually (Badzinski *et al*. 2008).		I	O	O		O				O
SW Ontario 7	Observed decline. BLTU was once commonly observed in the Park as recently as the late 1990s; however, only 1 was found during 5 years of targeted turtle surveys (~2000 person-hours) during the early 2000s (Davy unpub. data; Mackenzie pers. comm. 2014).	I	I	O	O		O			I	I
SW Ontario 8	Inferred decline. Only found in 4 of 11 historical sites during targeted surveys in the Niagara region conducted from 2006 to 2008 (Yagi *et al.* 2009).	I	I	O	O		I			I	I
SW Ontario 9	Inferred decline. Since 1994, there have been very few reported sightings of the Blanding's Turtle in the counties of Elgin, Middlesex and Oxford (NHIC data). In the early 2000s, surveys at some of the best remnant wetlands in Middlesex, Oxford and Perth (~140 person-hours across 10 sites) only found 2 individuals at 2 different sites in Middlesex; both sites were fragmented and surrounded by agriculture (Gillingwater and Piraino 2002).	O	I	O	O	O	I			O	I
SE Ontario 1	Inferred decline due to large numbers of road kills in the region annually. Large search efforts at this protected site have found very few adults. Eggs from road-killed females are incubated and the young are headstarted and released at the site (Carstairs 2014, unpub. data). 103 DOR individuals observed over 100 km of highways in the region between 2011-2014. This is a very conservative estimate given that road mortality survey effort was only 1-29 days annually (Davy unpub. data; Seburn *et al*. 2014).	O	I	P[†]						I	
SE Ontario 2	Inferred decline due to surrounding roads, railway, agricultural and urban development. Average annual adult survivorship estimated at 0.89 (Dillon Consulting Ltd. 2014).	O	I	P[†]	O	O	I			O	

Location	Subpopulation Trend	Main Observed, Inferred and Projected Threats									
		Road / Rail Mortality	Poaching	Invasive Species	Subsidized Predators	Development	Wetland Drainage and/or Alterations	Aggregate Activities	Forestry Activities	Agricultural Activities	Recreational Activities
SE Ontario 3	No trends identified (Millar and Blouin-Demers 2012).		I	P†	I						I
SE Ontario 4	No trends identified (Middleton 2014).	O	I	P†	I	O					O
SE Ontario 5	Inferred decline. According to several expert naturalists familiar with the Park, BLTU densities were much higher ~10 years ago (i.e., mid-2000s; Boyle pers. comm. 2014).	O	I	P†	I						I
SC Ontario 1	No trends identified. Very few Blanding's Turtles occur in the Park so it is difficult to assess trends (Brooks pers. comm. 2014).	O		P†					O		I
SC Ontario 2	No trends identified (Markle and Chow-Fraser 2014).		I	P†	I	O					I
SC Ontario 3	Inferred decline due to mass mortality event with > 50 adults lost in 2013 (Sheppard unpub. data 2014); this is believed to represent nearly 50% of the breeding population (Litzgus pers. comm. 2016).	I	I	P†		P				I	I
SC Ontario 4	Inferred decline due to large numbers of road kills in the region annually. Between 2013-2014, 15% of Blanding's Turtle records (N=123) during surveys in the region were of individuals found dead on roads and railways (N=19; including two juveniles; Scales Nature Park unpub. data).	O	I	P†	I					I	I
SC Ontario 5	Inferred decline due to high road mortality. Between 2012-2014, 112 DOR adults and juveniles were recorded for one subpopulation along a highway with at least 23 DOR adults in 2014 alone (Morin *et al.* unpub. data; Riley *et al.* unpub. data). If this subpopulation hypothetically maintained 100-300 adults (larger than the avg subpopulation size), then 8-23% of adults were lost over 1 year.	O	I	P†		O		O	O		
SC Ontario 6	Inferred decline. There used to be 3 major road mortality hotspots for BLTU in the Pembroke district up until ~5 years ago. Since 2012, no nesting females have been observed and as of 2014, no road kills have been reported at these hotspots, suggesting that these subpopulations may now be functionally extirpated (Kruschenske pers. comm. 2014; NHIC data).	O	I	P†		O		I	O		

Location	Subpopulation Trend	Main Observed, Inferred and Projected Threats									
		Road / Rail Mortality	**Poaching**	**Invasive Species**	**Subsidized Predators**	**Development**	**Wetland Drainage and/or Alterations**	**Aggregate Activities**	**Forestry Activities**	**Agricultural Activities**	**Recreational Activities**
Québec: Outaouais region	Inferred decline due to historical habitat loss for agriculture and projected decline due to continuing threats, especially continued habitat loss from increased dismantling of Beaver dams in the region (NCC 2007; Dubois 2009; Fortin and Dubois 2010; Dubois *et al.* 2011, 2012, unpub. data; Bernier 2013, unpub. data; St.-Hilaire *et al.* 2013).	O	I	P[†]	I		O	O		O	O
Nova Scotia 1	Inferred and projected decline. Historic museum collection may have reduced the adult female abundance by 10-20%. Without management intervention, this subpopulation faces a 42% risk of extinction over 400 years and an average 68% risk of decline over 100 years (Green and McNeil 2014).	O	I	P[‡]	O						O
Nova Scotia 2	Projected decline. This subpopulation faces a 44% risk of decline over 100 years (Bourque *et al.* 2006).	I	I	P[‡]	O	I		O	O		O
Nova Scotia 3	This subpopulation has a relatively high proportion of juvenile and young adults, a positive sign for recruitment (Caverhill 2006; Lefebvre 2012).	O	I	P[‡]	O	I		O	O	O	O
Nova Scotia 4	No trends identified. May be an extension of the ML subpopulation.	O	I	P[‡]	I	I		O	O		
Nova Scotia 5	No trends identified but only 3 adults found.			P[‡]							
Nova Scotia 6	No trends identified but only 3 adults found.		I	P[‡]							
Nova Scotia 7	No trends identified. Subpopulation only discovered in April 2016; 31 adults found as of August 1st, 2016.	I							O		O

It is difficult to discuss historical trends for the Nova Scotia population over the last three generations given that the species was only discovered in the province in the 1950s; however, adult female abundance in the NS1 subpopulation may have been reduced by 10-20% from the 1950s to 1980s due to collection for museum specimens (> 10) and road mortality (at least 3). Though this mortality occurred 30 - 60 years ago, this represents slightly more than one generation, likely insufficient time for population recovery, especially because annual adult recruitment and natural mortality in turtle populations are often nearly balanced (e.g., Shoemaker *et al.* 2013). The most recent Population Viability Analysis (PVA) model projects that, without any management intervention, the NS1 subpopulation faces a 42% risk of extinction over 400 years (i.e., 10 generations) and an average decline of 68% over 100 years. Extinction rates were not calculated for the 100-year time frame as they were considered meaningless in a population where individuals are capable of living nearly that long. While this and previous model results appear sobering, it is not known if the predicted trends reflect knowledge gaps in survivorship and abundance parameters, violations of the model's key assumptions or true population trends (Green and McNeil 2014). The NS Blanding's Turtle Recovery Team recommends caution in the use and interpretation of these models particularly given the apparent high adult survivorship in this population (Herman pers. comm. 2015). Recovery efforts for the NS1 subpopulation have included an annual nest protection program which has resulted in the release of over 1800 hatchlings since 1992 (Standing *et al.* 2000; Parks Canada 2012) and a headstarting program which has resulted in the release of 212 captive-reared 1- to 2-year-old juveniles since 2002 (Penny 2004; Arsenault 2011; Nova Scotia Blanding's Turtle Database 2014). These large-scale recovery efforts have the potential to affect future population trends for the NS1 subpopulation. An initial unpublished PVA model developed for the NS2 subpopulation in Nova Scotia indicated a 44% risk of decline over 100 years (Bourque *et al.* 2006). Genetic analysis using Bayesian statistics suggest that the magnitude and direction of gene flow among Nova Scotia subpopulations may have shifted (1 - 3 generations) from trends seen over the long term. The NS2 subpopulation appears to have shifted from being a net exporter to being a net importer of genes (Howes *et al*. 2009). The reason for this is unclear. Population trends may have been influenced by the installation of a power dam in 1943 (McNeil 2002). There are few data on population trends in the NS3 subpopulation in Nova Scotia; however, it has a relatively high proportion of juvenile and young adult turtles, a positive sign for recruitment (Caverhill 2006; Lefebvre *et al.* 2012). Little is known about the three small concentrations (NS4-NS6), though current data suggest they may not be viable since they are composed of very few individuals (< 10 adults at each site). The NS7 subpopulation was only discovered in 2016, so trends are not yet known.

Rescue Effect

Rescue effect for the Great Lakes/St. Lawrence population from U.S.A. subpopulations is highly unlikely. Although there are some narrower sections of the Detroit, St. Clair, St. Mary's and St. Lawrence Rivers where Ontario borders Michigan and New York, there is no evidence that turtles are crossing over in these regions and it is doubtful that this species, which is not known to be a strong swimmer, could successfully cross deep open waters of large waterways with heavy boat traffic; or at least not in numbers large enough to provide rescue. Rescue from outside Canada is not possible for the Nova Scotia population given that the province is geographically isolated by the surrounding Atlantic Ocean.

THREATS AND LIMITING FACTORS

The main threats to the Blanding's Turtle include: road/rail mortality and associated road effects; habitat loss from invasive European Reed; increased mortality of individuals and nests from subsidized predators; illegal collection for the pet, food and traditional medicine trades; and habitat loss from various types of development and wetland modifications. Additional potential threats include mortality of individuals from agricultural and recreational activities; forestry and energy production; climate change; wetland pollution and the introduction of other invasive plant and animal species, especially predatory fish. **See Appendix 2 – Threats Calculator** for details regarding the predicted scope and severity of each threat for each population. The most serious threats to Blanding's Turtle subpopulations are those which decrease the number of adults or significantly limit movement opportunities between residence wetlands. Therefore, population stability and persistence are critically dependent on high adult survivorship and habitat connectivity.

As with other turtles in Canada, one of the main limiting factors for this species is its slow life-history (extreme longevity, late age of maturity, low juvenile recruitment and a dependency on high annual adult survival). This life history strategy makes turtles highly vulnerable to extinction due to even small increases (<5%) in annual mortality of adults (Congdon *et al.* 1993). The needed recovery time for turtle subpopulations to rebound from periods of increased adult mortality is expected to be lengthy (Congdon *et al.* 1994) due to late maturity and low recruitment; this has been corroborated by some studies that reported no evidence of recovery even 16-35 years later (Brooks *et al.* 1991b; Pitt and Nickerson 2012; Howey and Dinkelacker 2013; Keevil *et al.* 2015 *in prep.*). However, this vulnerability to increased adult mortality would be exacerbated for Blanding's Turtle given its excessively late age of maturity and low reproductive frequency, thus making it much more susceptible to chronic increases in mortality compared to other Canadian turtles.

The other main limiting factor for Canadian turtles is the short, cool summer at the northern periphery of the range which reduces reproductive potential and nest success (Brooks *et al.* 1991a). Turtle embryo development rates are strongly correlated with ambient temperatures; if temperatures are too low, the embryos will not complete development (Obbard and Brooks 1981b). Furthermore, hatchlings exposed to low temperatures during the incubation period exhibit poor growth and viability (Brooks *et al.* 1991a). Egg and hatchling survival are poorest for subpopulations at the more northerly latitudes in Canada (Brooks *et al.* 1991a) and thus recruitment in these areas is exceptionally low. Alternatively, its narrow thermal tolerance range (see 'Physiology and Adaptability – Thermoregulation'), makes it more sensitive to the effects of climate change at the southern periphery of its Canadian range compared to other turtle species (King and Niiro 2013; **see Threats – Climate Change**).

Another potential limiting factor for this species is that subpopulation persistence seems to hinge on the propensity of adults to make long-distance movements which maintain genetic diversity within residence wetlands (McGuire *et al.* 2013; see 'Biology – Reproductive Ecology'). This makes the Blanding's Turtle particularly vulnerable to decline due to habitat loss and fragmentation, and increases the risk of collection and mortality along transportation corridors during extensive overland journeys.

Lastly, because Blanding's Turtles may aggregate together during certain times of the year, including at wintering, spring basking and nesting sites (**see Habitat – Habitat Requirements and Biology – Life Cycle and Reproduction**), Blanding's Turtles are particularly vulnerable to collectors, localized increases in predation, habitat disturbance or climate-related events (Parks Canada 2012), as several individuals could be lost at once.

Roads and Railways

<u>Overall Threat Impact: GLSL = High; NS = Low-Medium</u>

Because Blanding's Turtles travel large distances over land, they are particularly susceptible to being struck and killed crossing roads and railways. Turtles (and snakes) in particular, are often intentionally targeted by drivers (Ashley *et al.* 2007; Gillingwater pers. comm. 2016; Piraino pers. obs.; McNeil pers. obs.). One road mortality study at a known Blanding's Turtle site in southern Ontario found that ~2.7% of drivers purposely aimed for reptile decoys on the road and that these targeted efforts occurred at a rate of approximately every 15 minutes (Ashley *et al.* 2007). Given that adult female turtles nest along road shoulders and cross roads more often than males or juveniles during the nesting season, they are at a greater risk of road mortality (Gibbs and Steen 2005; Steen *et al.* 2006; Walston *et al.* 2015), which may lead to male-biased sex ratios for subpopulations adjacent to roadways (Saumure 1995; Gibbs and Steen 2005; Piraino and Gillingwater 2006; Steen *et al.* 2006). Nesting along roadways also increases the mortality risk for hatchlings, many of which are observed dead on roads annually during spring or fall emergence (Parks Canada 2012; Baxter-Gilbert *et al.* 2013; Gillingwater 2013, unpub. data; Nova Scotia Blanding's Turtle Database 2014; NHIC data), and roadside nests are sometimes destroyed by graders (which has been observed at one site; Edge unpub. data). Blanding's Turtles may also hibernate in flooded roadside ditches or borrow pits along forest access roads (Riley *et al.* unpub. data; Rouse unpub. data; Steinberg pers. comm. 2014), which puts them at increased risk of mortality from encounters with vehicles and heavy machinery. The impacts of roads and railways on wildlife not only include direct mortality from vehicle collisions but also barriers to movement as well as the loss, degradation and fragmentation of habitat (Proulx *et al.* 2014). Furthermore, because Blanding's Turtles cross roads significantly less than expected than if they moved randomly in relation to roads (Proulx *et al.* 2014) and because extensive movements by Blanding's Turtle adults are important for maintaining gene flow between residence wetlands (McGuire *et al.* 2013), reduced connectivity between wetlands may decrease genetic diversity of subpopulations in fragmented landscapes (McGuire *et al.* 2013; Proulx *et al.* 2014).

Though there are few documented incidents of road mortality in Nova Scotia, road mortality is still considered a significant and increasing threat and is identified as a high level of concern in the Recovery Strategy (Parks Canada 2012). There have been six documented incidents of road mortality of adults in Nova Scotia and > 15 documented mortalities of juveniles and hatchlings (Nova Scotia Blanding's Turtle Database 2014); additional mortalities may have gone undetected. Because some of the subpopulations in Nova Scotia are very small (i.e., < 10 adults), even a slight increase in the adult mortality rate can have an impact on their viability. Many adults and older juveniles are known to regularly cross roads during their movements to and from nesting and overwintering sites. It is likely that the annual nest protection program has helped lower mortality on roads as volunteers often move or direct traffic around turtles at risk.

In Québec, there is a high density of roads in the Ottawa Valley (up to 2.9 km of road/km²; Duclos and Fink 2013) which present a significant threat to this population. Several road-killed Blanding's Turtles have been found in the area (Desroches and Picard 2005; Dubois *et al.* 2012; St-Hilaire *et al.* 2013). Of 72 sites in the Outaouais region, the road mortality risk rate for a Blanding's Turtle crossing the road was considered high at 37 sites (51%), moderate at 27 sites (38%), low at 7 sites (10%) and null at one site (1%) based on the distance separating the wetland perimeter and the closest road (Dubois 2009).

In southern Ontario the number of major roads has greatly increased over the past 40 years (Fenech *et al.* 2001) and is continuing. An average of ~900 km of forest roads are constructed in Ontario annually (Ontario MNRF 2014a) and several large-scale road development/improvement projects have been recently completed or are currently underway within confirmed Blanding's Turtle habitats in Kemptville, Parry Sound, Pembroke and Sudbury districts. Between 2010-2016, there were four ESA Overall Benefit permit applications (three approved and one proposed) for road developments within Blanding's Turtle habitat; each project has proposed installing ecopassages as the primary method to compensate for the loss of habitat (Government of Ontario 2016). Several other recent or ongoing large-scale road development projects do not appear on the Ontario Environmental Registry, meaning that they did not require an Overall Benefit Permit to proceed. This suggests that the type of ESA approval for these road developments was a Regulatory Exemption; since Blanding's Turtle habitat only became protected under the ESA in 2013, road infrastructure projects could apply for Regulatory Exemption if they were approved to a certain stage by January 2015 (Ontario MNRF 2013b) **See Protection, Status and Ranks – Legal Protection and Status – Ontario** for an explanation of the various types of ESA approvals and associated requirements for species protection.

Although the majority of Blanding's Turtle road mortality records in Ontario have been reported from major roadways, many observations have also been reported from Provincial Park roads, rural county roads, gravel forestry access roads and even ATV trails (NHIC data). Once logging roads and gravel county roads are also considered, there may be few Blanding's Turtle subpopulations in southern Ontario that do not occur within 10 km of a road. Within Parry Sound district, the level of Blanding's Turtle road mortality is considered high; most individuals are killed on larger paved roads, some on smaller cottage roads and a few on forest access roads (Rouse pers. comm. 2015). Public use of most forest access roads in this region is not regulated and therefore the level of road mortality risk on public access logging roads is likely similar to that of cottage roads. Furthermore, a large portion of the females in Parry Sound district nest on roads and the rate of new roads being built in the region is high (Rouse pers. comm. 2015). Similarly, within Pembroke district, several to dozens of new forestry access roads are created annually; these logging roads attract nesting females and continue to add new population sinks (Kruschenske pers. comm. 2014). Railway mortality is also a threat for this species, with several observations of live and dead individuals on railway tracks reported from across the Great Lakes/St. Lawrence population, including the Outaouais region of Québec and the Ontario counties of Muskoka, Parry Sound, Ottawa, Simcoe and Sudbury (Dubois *et al.* 2012; Dillon Consulting 2014; Keevil pers. comm. 2014; Marks pers. comm. 2014; Mills pers. comm. 2014; Woods 2014; Scales Nature Park unpub. data; NHIC data). Based on estimated road kill rates of 0.2-0.3 turtles/km from standardized surveys along four major roadways across Ontario, it is estimated that ~265 to 400 Blanding's Turtles (> 15 cm PL) are killed on roads annually in the province (Appendix 3).

Invasive Species

<u>Overall Threat Impact: GLSL = Medium-High; NS = Low-High</u>

European Reed is an invasive plant that can rapidly displace natural vegetation communities with dense mono-cultural stands (attaining heights of >5m, densities of >95% and expansion rates of ~10 cm/day (Wilcox *et al.* 2003; Jodoin *et al.* 2008; Gilbert 2012). Although turtles may occasionally use the flooded edges of European Reed stands when they initially occur as small pockets within larger habitat mosaics, once the stands become extensive impenetrable monocultures (which is usually inevitable given that it is a highly competitive and aggressive plant; Wilcox *et al.* 2003; Gilbert 2012), the wetland habitat becomes unsuitable for turtles (Gillingwater 2009; 2013). Indeed, surveys within dense European Reed stands have found few to no turtles within them compared to open wetland areas surveyed with similar effort (Davy unpub. data; Gillingwater 2009; 2013). The height and density of European Reed stands limits turtle basking and movement opportunities (Misfud 2013; Gillingwater 2009; 2013; Markle unpub. data) Individuals have even been observed stuck and/or dead within dense stands (Mackenzie *et al.* 2014; Davy unpub. data; Markle unpub. data). Loss of nesting habitat is another issue; European Reed can invade a nesting site over the course of a few weeks, resulting in lowered hatching success due to spreading roots or reduced incubation temperatures from shading (Bolton and Brooks 2010). Greater vegetation cover also increases hatchling overwintering mortality by limiting snow accumulation which is needed to insulate the nest against winter temperatures (Weisrock and Janzen 1999). Pervasive lowered incubation temperatures resulting from shading also threaten to skew population sex ratios for TSD species such as Blanding's Turtles (Janzen 1993; Janzen and Morjan 2001). Dense stands of dead European Reed also present a mortality risk due to fire hazard (Gilbert 2012).

European Reed has been rapidly spreading throughout southeastern Canada since the 1990s and was reported in central Ontario (the Canadian stronghold for Blanding's Turtle) by 2010. By 2030 it is expected to substantially increase its distribution throughout all of southern Canada (Catling and Mitrow 2011; Figure 5), and will overlap entirely with the Canadian range of Blanding's Turtle. Since the mid-2000s, there have been large alterations to Blanding's Turtle habitats at some sites within southwestern Ontario and observations of turtles at a couple of these sites have declined substantially in recent years (MacKenzie *et al.* 2014; Gillingwater unpub. data). Rates of spread at these sites between 1999-2006 were estimated at 34-48% annually (Badzinski *et al.* 2008) and this has likely only increased since then given the rapid alterations observed over the last seven years alone (Gillingwater unpub. data). One of these southwestern Ontario sites is largely isolated (mostly surrounded by water, with little human intrusion and at least 10 km away from the nearest road) and thus, it seems that even relatively undisturbed areas are prone to invasion. Furthermore, there is no open wetland habitat type that is immune to invasion by European Reed (Gilbert pers. comm. 2013). The continuing expansion of roads and extensive logging activities throughout central Ontario will likely facilitate the spread of European Reed through the region. Based on all this information, it is anticipated that Blanding's Turtle habitat in Ontario may decline by 11% - 70%, over the next 120 years (i.e., three generations) due to the continued spread of invasive European Reed (**see Appendix 2b. Threats Calculator**). Although European Reed is present in the Outaouais and Montérégie regions of Québec it has not yet posed a threat to Blanding's Turtle habitat (Giguère pers. comm. 2014; Toussaint pers. comm. 2014). Similarly, although European Reed was first documented in Nova Scotia in the early 1900s (Catling and Mitrow 2011), researchers have not yet observed this invasive plant within or near Blanding's Turtle habitat in the province (Nova Scotia Blanding's Turtle Database 2014). Invasive European Reed is, however, predicted to spread throughout all of southern Canada by 2030 (Catling and Mitrow 2011); thus habitat losses in both Québec and Nova Scotia are anticipated in the near future. Other invasive species known to occur in Blanding's Turtle habitat within the Great Lakes/St. Lawrence region include Reed Canary Grass (*Phalaris a. arundinacea*), Rough Mannagrass (*Glycerian maxima*), Common Carp (*Cyprinus carpio*) and Red-Eared Slider (*Trachemys scripta elegans*). In Nova Scotia, other invasive species which are expanding their distribution include predatory fish such as Smallmouth Bass (*Micropterus dolomieu*) and Chain Pickerel (*Esox niger;* Parks Canada 2012). While the level of threat for each of these additional invasive species on Blanding's Turtle subpopulations is not known, they have the potential to affect habitat quality, food availability and may also pose a predatory threat to turtle hatchlings.

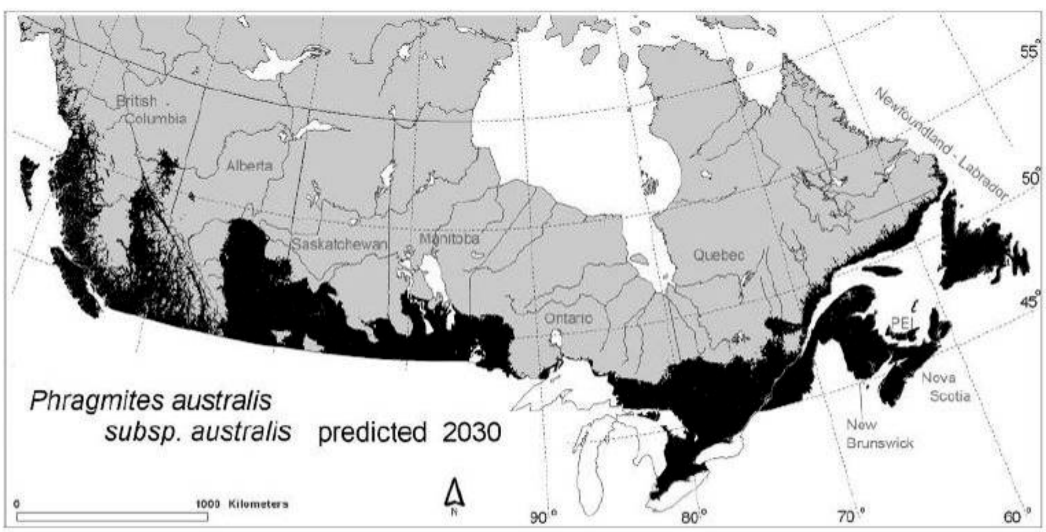

Figure 5. Minimal predicted distribution of invasive *Phragmites a. australis* by 2030 (Catling and Mitrow 2011).

Subsidized Predators

Overall Threat Impact: GLSL = Medium; NS = Medium

In human-dominated landscapes, subsidized predators (i.e., those that occur in higher abundances resulting from increased food resources from human sources; Garrott *et al.* 1993; Mitchell and Klemens 2000) can cause unnaturally high predation rates of turtles at all life stages (**see BIOLOGY – Mortality**). Reported predator-related injury rates for monitored Blanding's Turtle subpopulations range from 17% - 31% (Kofron and Schreiber 1985; Gillingwater and Brooks 2001; Dubois *et al.* 2012; Gillingwater unpub. data). Abnormally high levels of predators on the landscape can also result in much higher predation rates on nests and hatchlings. Studies in southwestern Ontario have reported 55-100% mammalian predation rates of nests that were not protected with caging (Saumure 1995; Gillingwater and Brooks 2001; Browne 2003; Gillingwater 2013). Limited juvenile recruitment, due to elevated predation rates, has been considered the likely cause of a shift to a larger size and presumably older age structure of one Blanding's Turtle subpopulation in southwestern Ontario (Browne and Hecnar 2007). Although the level of this threat in Ontario is likely highest in the heavily developed areas south of the Canadian Shield, increasing cottage and road development are expected to expand the scope of this threat to subpopulations in some areas on the Shield (**see Appendix 2b. Threats Calculator)**. In Nova Scotia, predation on unprotected nests and hatchlings can be very high in human-dominated landscapes (Herman *et al.* 1995) and nests along lakeshores and roadsides appear to have higher predation rates than inland nests that occur away from areas of high disturbance (McNeil pers. obs.; Herman pers. comm. 2015). An annual nest protection program has been implemented in these areas to counter the high predation rates (Standing *et al.* 2000). Graham (in Congdon *et al.* 2008) found that mammal trapping/removal to protect turtle nests required considerable effort and yielded poor results and that nest caging was a much more effective means of improving hatchling recruitment.

Pet, Food and Traditional Medicine Trades

Overall Threat Impact: GLSL = Medium; NS = Low-Medium

Recent evidence indicates that Canadian Blanding's Turtles are being illegally harvested to supply the Asian food and traditional medicine trades both in Canada and abroad (Miller pers. comm. 2014). Reptiles are a prime target in the illegal wildlife trade and there are black market brokers in Ontario that are smuggling rare turtles both into and out of the country on a regular basis (Miller pers. comm. 2014). Demand for turtle products is expected to rise in Ontario as the number of cultural consumers and practitioners of Traditional Asian Medicine continue to grow (Miller pers. comm. 2014). There is also demand for Blanding's Turtles in the pet trade. In 2012, Reptiles Magazine advocated the Blanding's Turtle as one of the best species for collectors to keep in captivity due to its "engaging and interesting" character (CITES 2013). As species become rarer and difficult to obtain, the market value increases and they also become more sought after in the black market (CITES 2013; Miller pers. comm. 2014). In 2007, a Wallaceburg man was arrested along with two Toronto practitioners for possessing 26 live Blanding's Turtles and one Spotted Turtle from a southwestern Ontario subpopulation (Chatham Daily News September 11, 2008). In August 2014, a Windsor man was arrested at the Detroit-Windsor border with 51 turtles in his pants; just a few weeks later he was detained after his Toronto courier attempted to fly out of Detroit Metro Airport with 970 turtles hidden in his luggage (the shipment consisted of 700 Diamondback Terrapins (*Malaclemys terrapin*) as well as Blanding's Turtles and Wood Turtles that were destined for Chinese pet and food markets (The Detroit News September 26, 2014). Federal agents discovered that this one trafficker peddled thousands of turtles over many years (The Detroit News September 26, 2014); in April 2016, he received an unprecedented sentence of 5 years in federal prison (The Globe and Mail April 12, 2016).

In addition to commercial collection for the pet trade, local community members often take wild individuals as personal pets or move them to "better" areas such as rural/cottage properties far removed from the turtle's place of origin (CITES 2013; Gillingwater pers. comm. 2014; Marks pers. comm. 2014; Woods 2014; McNeil pers. obs.). Likewise, there are reports of increased non-commercial collection of turtles from within protected natural areas in the U.S.A. (Lovich 1987; Garber and Burger 1995; Graham 1995). From conversations with local citizens in Nova Scotia, it appears that temporary removal of turtles for children's pets is relatively commonplace and tends to occur opportunistically (McNeil pers. obs.). These turtles are often returned to the wild though not necessarily to their place of origin. One Blanding's Turtle was found on an island, many kilometres from its home range (Nova Scotia Blanding's Turtle Database 2014), and a Blanding's Turtle was photographed on the Haines Road in Southwest Yukon (Bruce Bennett, pers. comm. 2016). Blanding's Turtle localities in Nova Scotia are widely known among community members and are described in literature and media sources, which could put them at risk of directed collection in the future. The magnitude of these occurrences and their relative effects on subpopulations across the range is not known. The removal of turtles from the wild is equivalent to mortality from a population viability perspective. Removal of adults decreases the number of sexually mature individuals available for reproduction and may reduce the reproductive success of the remaining adults. Since females are often targeted for collection, this may skew sex ratios and stability of subpopulations (Congdon *et al.* 2008).

Residential and Commercial Development

Overall Threat Impact: GLSL = Medium; NS = Low

Besides direct removal of wetland habitat, development can also lead to habitat fragmentation and degradation of remaining habitat (**see Threats and Limiting Factors – Roads and Railways** for discussion of associated habitat fragmentation effects). Blanding's Turtles extensively use upland forests (**see Habitat**) and the removal of forest habitat makes the landscape less suitable for Blanding's Turtles (Quesnelle *et al.* 2013). Movement of Blanding's Turtles through developed areas increases the risk of vehicle collisions, predation and harm from machinery or other anthropogenic hazards (Findlay and Bourdages 2000; Gibbs and Shriver 2002; Steen and Gibbs 2004; Aresco 2005; Ryan *et al.* 2008; McGuire *et al.* 2013). Furthermore, disturbed areas often attract Blanding's Turtles (and other turtles) in search of nesting habitat (see **Habitat – Habitat Requirements – Nesting Habitat**), but nesting in these areas likely creates an ecological trap because it exposes females and hatchlings to the anthropogenic hazards mentioned above. Congdon *et al.* (2011) suggest that terrestrial protection zones of 450 m around all wetlands (residence and temporary) and 2000 m around residence wetlands are necessary to protect 100% of Blanding's Turtles nests and adults, respectively; however, habitat protection at this scale is rarely implementable as mitigation for development (see **Legal Protection and Status – Ontario** for a discussion of habitat protection requirements under the provincial *Endangered Species Act*).

By the early 2000s southern Georgian Bay was noted as the fastest developing area in Ontario (Watters 2003) with high density developments commonly replacing low density, non-intensive land use areas (MacKinnon *et al.* 2005). Shoreline cottage development is currently resulting in habitat loss in the region (Enneson and Litzgus 2009; Brooks pers. comm. 2014) and within confirmed Blanding's Turtle habitat (Government of Ontario 2016). In the Sudbury district, there is at least one subpopulation that occurs within an active housing development surrounded by lands also proposed for development (Woods 2014). In Kemptville district, habitat continues to be threatened by residential and other land development and in 2014 alone, there were several proposed developments within Blanding's Turtle General Habitat (Thompson pers. comm. 2014). Between 2010-2014, there were several ESA approvals for developments within Blanding's Turtle habitat which did not require a permit to proceed, including 11 Regulatory Exemption Registrations and three Agreements (these numbers include both development and road infrastructure projects; **see Protection, Status and Ranks – Legal Protection and Status – Ontario** for explanation of the various types of ESA approvals and associated requirements for species protection). Because Blanding's Turtle habitat only became protected under the ESA in 2013, development projects could receive Regulatory Exemption if they were approved to a certain stage by January 2015 (Ontario MNRF 2013b). Thus it is assumed that there were additional Exemption Registrations in 2015 for development projects affecting Blanding's Turtle; however, this number was not obtained in time for inclusion in this report. Between 2015 - 2016, there were three ESA Overall Benefit Permit applications for proposed residential developments within Blanding's Turtle habitat; there will be a net loss of ~20-124 ha of habitat per project and the primary proposed compensation measures include installing fencing, reducing road mortality and enhancing remaining habitat through riparian restoration or creating nesting and overwintering microhabitats (Government of Ontario 2016).

In Québec, the majority of Blanding's Turtle habitat occurs within protected areas and agricultural zones where the threat of residential and commercial development is low (Dubois pers. comm. 2014; Giguère pers. comm. 2014). In Nova Scotia, two subpopulations occur in working landscapes that are affected by residential and cottage development (McNeil 2002; Caverhill 2003; Lefebvre 2009).

Natural System Modifications

Overall Threat Impact: GLSL = Low-Medium; NS = Unknown

Dredging of wetlands, especially during the hibernation period, presents a mortality risk for turtles. At a protected wetland in southwestern Ontario, researchers observed seven dead adult Blanding's Turtles in early spring partially buried in sediment that had been dredged during the winter; many others were likely completely buried out of view (Gillingwater and Piraino 2004). Since at least 2009 and continuing into 2016, large-scale dredging has occurred within adjacent protected areas to create waterfowl habitat and has resulted in the loss of confirmed Blanding's Turtle habitat; shallow wet meadows with abundant vegetation were replaced with deep, open-water, sand-bottomed ponds devoid of cover and foraging opportunities (Gillingwater pers. comm. 2016). Another threat is the use of aquatic weed mowers to clear boat channels; this has resulted in injury and mortality to turtles in coastal wetlands where Blanding's Turtle is known to occur (Bolton pers. comm. 2015). Wetland dredging, aquatic vegetation mowing and waterfowl habitat creation likely occur within many wildlife management areas and could potentially be a significant source of mortality for Blanding's Turtles.

Beaver dam trimming or removal during the winter also presents a mortality risk for Blanding's Turtles. In 2010, the "trimming" of a dam within an Ontario Provincial Park resulted in accidental destruction of the dam and an immediate water level drop of 2 m. Overwintering habitat was completely destroyed, many dead turtles were located and there was no mitigation to deal with the impact (Davy unpub. data). Blanding's Turtles are often associated with Beaver-influenced wetlands across their range and thus, Beaver dam removal during the winter has the potential to impact this species throughout its range. In the Outaouais region of Québec, dismantling of Beaver dams was observed to be a significant threat to the population; many dams were dismantled at the end of November 2010 which resulted in a significant loss of Blanding's Turtle habitat and likely mortality given the timing of the removals (Dubois *et al.* 2012). Many citizens in this region have expressed desires to remove Beaver dams from their properties (Dubois *et al.* 2012) and since 2006, citizens within certain Regional County Municipalities (RCM) of Québec have been obliged to dismantle dams that may represent a threat to human safety (Duclos and Fink 2013).

In Nova Scotia, water level manipulation resulting from the installation of dams and/or the removal of beaver dams has been identified as a significant threat (McNeil 2002; Mockford *et al.* 2005; Parks Canada 2012). In addition to increased mortality risk to overwintering turtles, changes to water levels could increase nest flooding events and result in sub-optimal moisture retention in eggs, affecting hatching success and hatchling fitness (Packard 1999; Standing *et al.* 2000; Parks Canada 2012). Blanding's Turtle eggs are not highly susceptible to drought or drowning (Packard *et al.* 1982); however, prolonged flooding can lead to nest failure. In lakeshore sites in Nova Scotia, nest flooding occurs frequently and in 2003, all lakeshore nests in one subpopulation were lost as a result of late summer flooding (Nova Scotia Blanding's Turtle Database 2014). Since this time, researchers have attempted to move nests at risk of imminent flooding to higher ground along the lakeshore. Furthermore, changes in water flow regimes may impede seasonal movements and affect the turtles' ability to nest, feed, and access overwintering sites (Herman *et al.* 2003).

Logging and Wood Harvesting

<u>Overall Threat Impact: GLSL = Low; NS = Low</u>

In Ontario, Blanding's Turtles are known to occur extensively throughout Crown forests where forest management activities are conducted (Environment Canada 2014; Crowley pers. comm. 2015); at least half of the Blanding's Turtle Ontario range (i.e., the entire Georgian Bay ecoregion and northern Ontario) overlaps with the Area of the Undertaking (AOU), where forest management on Crown land takes place. Forestry operations can cause direct mortality of turtles due to being crushed by logging equipment and can also cause destruction of vernal pool and hibernation habitat (Natural Heritage and Endangered Species Program 2007). Therefore, many specific guidelines have been implemented into the Stand and Site Guide under the Ontario *Crown Forest Sustainability Act* (S.O. 1994, c. 25) to better protect Blanding's Turtles from forestry operations. For instance, heavy equipment is not permitted within suitable winter habitat (in any season), within 300 m of suitable summer habitat during the nesting season (June 1-30), within 150 m of suitable summer habitat during other periods of the active season when Blanding's Turtles are terrestrial (i.e., May 1-30, July 1-15 and Sept 1-30), or within 30 m of suitable summer habitat during the rest of the active season when Blanding's Turtles are less terrestrial (i.e., April 15-30, July 15-Aug 31, Oct 1-15; Ontario MNRF 2016). There is still a risk of encounters with vehicles and heavy machinery during long-distance terrestrial forays away from wetlands. Furthermore, because these restrictions are only applied to the 1 km 'area of concern' (AOC) surrounding suitable habitat within 2 km of a known occurrence or recent (< 20 years) "reliable sighting" (Ontario MNRF 2016), it is possible that some unknown or unconfirmed subpopulations do not receive any protections from forestry operations. Furthermore, forestry ditch cleaning operations are permitted in October (Ontario MNRF 2016) and this could harm turtles hibernating in flooded ditches. In addition to direct mortality that may result from heavy equipment operations, logging roads can result in road mortality and are considered the primary forestry-related threat to the species (**see Threats and Limiting Factors – Roads and Railways**). To mitigate against this threat, the Stand and Site Guide requires driver awareness training and the development of a strategy to reduce traffic speeds and volume on logging roads, and within the 1 km AOC, it prevents construction of new roads within 30 m of nesting sites or suitable summer habitat, unless using techniques that will avoid road mortality (Ontario MNRF 2016). Therefore, the Stand and Site Guide provides several important mitigation measures to protect Blanding's Turtle and thus, it is assumed that the 'Overall Threat Impact' from forestry operations is 'Low' for the Great Lakes/St. Lawrence population despite widespread overlap of Blanding's Turtles within provincial Crown forests where large-scale logging activities occur. However, there is no evidence to prove or disprove whether implementation of these mitigation measures has significantly reduced the level of threat to Blanding's Turtle from forestry operations.

Forestry is not a threat for the Québec subpopulation because Blanding's Turtle habitat in the province is situated within protected areas or agricultural landscapes (Dubois pers. comm. 2014; Giguère pers. comm. 2014). In Nova Scotia, three subpopulations are surrounded by provincial Crown and private lands where land use activities include forestry (Caverhill 2003; Mockford *et al.* 2005; Lefebvre *et al.* 2012).

Energy Production and Mining

Overall Threat Impact: GLSL = Unknown; NS = Low

Besides direct loss of habitat from mining developments due to wetland drainage and land conversion, the operation of heavy machinery within Blanding's Turtle habitat increases the risk of injury and mortality of individuals. In addition, roads associated with mines and energy developments increase the risk for road mortality and other road related impacts (**see Threats and Limiting Factors – Roads and Railways**). Furthermore, pollution from mines has been confirmed in some Blanding's Turtle habitats and may be a potential source of mortality, decreased fitness, and reduced nesting success (**see Threats and Limiting Factors – Pollution**). Evidence of Blanding's Turtles using mining areas has been reported from across the Canadian range. In Nova Scotia, individuals have been observed nesting in mine tailings and using mining ponds as habitat (Caverhill 2006) and one subpopulation occurs in a landscape where gravel mining currently occurs (Caverhill 2003; Mockford *et al.* 2005; Lefebvre *et al.* 2012). Furthermore, existing mineral extraction rights threaten to delay protection of several areas containing critical habitat for Blanding's Turtles in Nova Scotia, including a vital overwintering site (The Province of Nova Scotia 2013). In Québec, some radio-tracked Blanding's Turtles reportedly crossed through quarries during overland movements and 32% of nests were laid in quarries (Dubois *et al.* 2012). In Ontario, the home range of a radio-tracked Blanding's Turtle had a large overlap with an active gold mine (OMNRF Timmins District unpub. data) and individuals have been observed using gravel pit ponds as habitat (Schueler pers. comm. 2015).

In Ontario, there are a multitude of active mining claims (Ministry of Northern Development and Mines 2014), 29 active gold and base metal mines (Ontario Mining Association 2014) and hundreds of active pits and quarries (Ontario MNRF 2012) that occur within the range of Blanding's Turtle. Between 2013 - 2016, there were three ESA Overall Benefit permit applications for mining developments (one approved and two proposed) within Blanding's Turtle habitat (Ontario Government 2016). Each will result in a net loss of habitat (16-23 ha habitat removals for two projects and an unspecified amount for a third project on 472 ha of Crown land); however, one proponent granted a 259 ha conservation easement and this will increase the amount of protected habitat for Blanding's Turtle (Ontario Government 2016). Other compensatory measures for these habitat removals include installing fencing, ecopassages, and enhancing remaining habitat by installing a wetland outlet or nesting microhabitat and basking structures (Government of Ontario 2016).

In southwestern Ontario, between 2011 - 2016 there were five Renewable Energy Approvals (REA) for wind energy projects to be built within Blanding's Turtle habitat (Government of Ontario 2016). Only one of these five projects required an ESA Overall Benefit Permit to obtain a REA (Government of Ontario 2016). Each of these REAs has been appealed based on "serious and irreversible harm to Blanding's Turtle" due to the potential for increased road mortality risk and increased predator/poacher access into habitat from constructing/upgrading access roads, as well as the potential for increased nest predation (because turtles may begin to nest in easily accessible areas such as access roads, crane pads and turbine bases). The Environmental Review Tribunal (ERT) upheld two wind energy approvals (for insufficient evidence of potential harm to Blanding's Turtle or for raising the issue too late in the proceedings to permit the appeal based on potential harm to Blanding's Turtle; Government of Ontario 2016). Two other wind energy projects are still under appeal while approval for a fifth wind farm was decisively revoked in June 2016 after four years of appeals (Government of Ontario 2016; The Toronto Star June 6, 2016); the ERT concluded that the potential threats to Blanding's Turtle from this proposed 324 ha wind farm could not be effectively mitigated (Aware Simcoe July 5, 2013). This decision could potentially influence the outcome of the two remaining wind energy projects under appeal. A 14-year study of a Desert Tortoise (*Gopherus agassizii*) subpopulation at a large wind energy facility in California found evidence that wind energy activities and construction contributed directly to habitat destruction and mortality of tortoises but that the subpopulation seemed stable overall with no significant differences in mortality, density, growth, maturity, demography or nesting ecology when compared to other subpopulations in more natural areas; however, these results were only correlative because the study was not a Before-After-Control-Impact (BACI) study with comparative pre-construction data on the subpopulation to establish a cause and effect relationship (Lovich *et al.* 2011; Ennen *et al.* 2012). Impacts to freshwater turtles from wind energy developments have not been studied and thus it is uncertain whether wind farms would cause serious harm to Blanding's Turtle or its habitat.

Human Intrusions and Disturbance

<u>Overall Threat Impact: GLSL = Low; NS = Low</u>

At two southwestern Ontario lakeshore sites, dead and live Blanding's Turtles have been observed with boat propeller strikes to the carapace (Gillingwater and Brooks 2001; Davy unpub. data; Gillingwater unpub. data) with approximately 10% of captures at one site displaying carapacial scarring indicative of propeller strikes (Davy unpub. data). It is likely that boat mortality also presents a threat for other subpopulations where recreational boating is common. The extent of this threat in Nova Scotia is not known but one turtle is believed to have died as a result of motor boat impact (Nova Scotia Blanding's Turtle Database 2014).

Throughout their Canadian range, Blanding's Turtles are known to move along, cross or nest on active all-terrain vehicle (ATV) or bicycle trails and in old quarries used by ATVs (Dubois *et al.* 2012; Nova Scotia Blanding's Turtle Database 2014; Gillingwater unpub. data; NHIC data). This presents a mortality risk to individuals and potential for damage to nests and habitat. Live and dead individuals have been reported on active ATV trails in Ontario (NHIC data). In the Sudbury district, ATVs and 4x4 trucks frequently drive through shallow aquatic ditches or flooded trail ruts used by juveniles and adults, and over nesting sites along a railway embankment; it is suspected that females in this subpopulation may also nest on or in close proximity to a bicycle path, putting the hatchlings at risk of bicycle mortality (Woods 2014). In Nova Scotia, several nests have been disturbed or destroyed by ATV and dirt bike users who frequent the old quarries (Nova Scotia Blanding's Turtle Database 2014) and off-road vehicle mortality is considered a significant and increasing threat that has been identified as a high level of concern in the Recovery Strategy (Parks Canada 2012).

Agriculture

Overall Threat Impact: GLSL = Low; NS = Negligible

Large-scale wetland conversion for agriculture occurred in the Great Lakes/St. Lawrence region from the early 1800s to the mid-1900s (**see Habitat Trends**); therefore, although agricultural expansion is incrementally continuing, it is not anticipated to cause large declines in Blanding's Turtle habitat over the next 10 years. However, agricultural operations and machinery still pose a mortality risk to individuals, nests and hatchlings given that Blanding's Turtles are often observed crossing through or nesting in farm fields and even using flooded fields as staging areas prior to nesting (Caverhill 2003; Mockford *et al.* 2005; Dubois *et al.* 2012; Lefebvre *et al.* 2012; Dillon Consulting 2014; Environment Canada 2014). Indeed, there are records of adults that have been killed by farm machinery (NHIC data). Christmas tree farming adjacent to one of the Nova Scotia subpopulations may lead to habitat fragmentation, and vehicles operating on the farms may pose a mortality risk to turtles, especially adult females that are attracted to these areas for nesting (Caverhill 2006; Appendix 2a. Threats Calculator). Agricultural runoff can also degrade wetlands through pollution and sedimentation (**see Threats and Limiting Factors – Pollution**).

Climate Change

Overall Threat Impact: GLSL = Unknown; NS = Low

A recent study investigating climate change-induced distributional shifts for Great Lakes region reptiles reported that Blanding's Turtle appears to be highly sensitive to climate change (King and Niiro 2013), potentially due to its low critical thermal maxima (Hutchinson *et al.* 1966). The study used ecological niche modelling to characterize the association between climatic variables and current species' distributions. Current distributions were well predicted by the models and this information was then used to project future areas of high climatic suitability. For Blanding's Turtle, seven climatic variables were incorporated into the models (Annual Mean Temperature, Mean Diurnal Range, Isothermality, Temperature Seasonality, Annual Precipitation, Precipitation of Wettest Month, Precipitation of Driest Month). To quantify change in climatic suitability based on these variables, (i) the known Blanding's Turtle localities were compared against the area exceeding the threshold values for high climatic suitability and (ii) the size of the area satisfying a given threshold value was compared to the size of the geographic background to allow for increases in the size of the area deemed climatically suitable. Models based on high versus moderate greenhouse gas emissions scenarios predicted that by the year 2050, only 25-50% of current known Blanding's Turtle localities across the range would still be climatically suitable and that this number would fall below 25% by the year 2080. Under the 'high emissions' scenario, most of the currently occupied area within Ontario was predicted to provide low climatic suitability for this species by 2080, with extreme southwestern Ontario providing zero suitability. Even under the more conservative 'moderate emissions' scenario, most of southwestern Ontario was still predicted to become an area of low suitability by 2080. Given that the landscape in southwestern Ontario is highly fragmented, it will not be possible for individuals to migrate north with warming temperatures and translocation efforts may be necessary to preserve them.

Sustained low water levels have already been reported in the coastal wetlands of Lake Erie and Lake Huron since the late 1990s and early 2000s respectively (Great Lakes Wetlands 2011; Mackenzie *et al.* 2014). A further 1 m water level drop within the Great Lakes is predicted to occur by 2036, threatening the existence of these dynamic coastal habitats and the species that utilize them (Great Lakes Wetlands 2011).

Pollution

Overall Threat Impact: GLSL = Unknown; NS = Unknown

The effects of pollution on Blanding's Turtles have not been studied and are poorly understood; however, studies on the sympatric Snapping Turtle (a species that shares many of the same habitats and dietary habits with Blanding's Turtle) reported reduced hatching success and increased deformity rates due to high concentrations of contaminants such as PCBs and organochlorines (Bishop *et al.* 1991, 1998; de Solla *et al.* 2008). Furthermore, several studies on North American freshwater turtles have reported declines or absences of turtles from areas with degraded water quality and high levels of urban, industrial and agricultural pollutants (Moll and Moll 2004), suggesting that heavy pollution may result in mortality and/or habitats becoming unsuitable.

Lake Erie in southwestern Ontario receives the bulk of its water input from the St. Clair, Detroit, Sydenham, Thames and Grand Rivers, all of which lie within the most heavily utilized agricultural landscape in Canada, resulting in a significant influx of pesticide residues and nutrient loading from both animal and plant agriculture (Environment Canada and United States Environmental Protection Agency 2008; Lake Erie LaMP 2011; UTRCA 2012; International Joint Commission 2014). Chemical contamination is likely also pronounced within inland wetlands in the heavily urbanized and agricultural landscapes of southwestern Ontario and southwestern Québec. In the Sudbury district of Ontario, logging and mining have carried sulphuric acid and heavy metals into local waterways used by Blanding's Turtles; four of five tributaries are treated mine effluent or are contaminated by surface drainage, and one section of a creek bed was heavily contaminated with creosote until it was removed in 2007 (Woods 2014). Gold mines and associated mine tailings in

Ontario and Nova Scotia pose the risk of water and soil contamination within Blanding's Turtle habitats. Studies along tributaries of the St. Lawrence River found heavy metals in Snapping Turtle eggs, including mercury in all samples (Bonin *et al.* 1995; Bishop *et al.* 1998). Wetlands in Nova Scotia, including those with Blanding's Turtles, have unusually high mercury content resulting from atmospheric deposition interacting with the geology of the area (Sicliano *et al.* 2003); high mercury levels have been documented in the Common Loon (*Gavia immer*) in this area (Sicliano *et al.* 2003). Other potential sources of pollution in Nova Scotia include a fish hatchery and Christmas tree farms in areas adjacent to Blanding's Turtle habitat (**see Appendix 2a. Threats Calculator**).

Number of Locations

The term 'location' defines a geographically or ecologically distinct area in which a single threatening event can rapidly affect all individuals of the taxon present. The size of the location depends on the area covered by the threatening event and may include part of one or many subpopulations. Where a taxon is affected by more than one threatening event, location should be defined by considering the most serious plausible threat (IUCN 2014).

It is very difficult to determine a precise number of locations since threats to Blanding's Turtles are many and can occur at a variety of spatial scales. However, if we consider a watershed as the base scale at which a single threatening event (e.g., the creation of a major highway or a very harsh winter) could lead to local extinction, the number of Blanding's Turtle locations is likely 50-100 in Ontario, 2-5 in Québec and 3-5 in Nova Scotia.

PROTECTION, STATUS AND RANKS

Legal Protection and Status

Canada

In Canada, the Great Lakes/St. Lawrence population is designated as Threatened and the Nova Scotia population is designated as Endangered; both populations receive protection under Schedule 1 of the federal *Species at Risk Act, 2002* (S.C. 2002, c. 29) which makes it an offence to kill, harm, harass or capture this species or to destroy its residences on federal lands. A SARA-compliant Proposed Recovery Strategy for the Great Lakes/St. Lawrence population (Environment Canada 2016) was posted on the SARA website for public review on March 29, 2016; it identifies areas of critical habitat and recovery actions for this species (Environment Canada 2016). In Nova Scotia, a SARA-compliant Recovery Strategy is already in place (Parks Canada 2012) and a draft action plan is in development. Critical habitat has been identified for the known subpopulations, with the exception of the newly discovered NS4 and NS7 subpopulations and a recently documented extension to the NS1 subpopulation (Parks Canada 2012; Nova Scotia Blanding's Turtle Database 2014). Critical habitat in the NS1 subpopulation occurs on federal lands; seasonal special management practices are implemented at these sites to reduce risks to the turtles (Parks Canada 2010). A number of recovery actions are ongoing in the Nova Scotia population and include habitat protection, an annual nest protection program, a headstarting program, road signage, stewardship and awareness programs (Caverhill 2006; Parks Canada 2012).

<u>Ontario</u>

In Ontario, the Blanding's Turtle is listed as Threatened under the *Endangered Species Act*, 2007 (S.O. 2007, c.6) (ESA). As a Threatened species, it is illegal to kill, harm, harass, capture, collect, transport, possess, buy, sell or trade a Blanding's Turtle. In 2013, Blanding's Turtle received general habitat protection under the ESA and the Ontario Ministry of Natural Resources and Forestry published a General Habitat Description (Ontario MNRF 2013a) to provide guidance on the identification of Blanding's Turtle habitat and implementation of ESA habitat protection for this species. The General Habitat Description identifies the habitat of this species as suitable wetlands within 2 km of an occurrence (as long as these wetlands are not separated by distances greater than 500 m), as well as a 250 m buffer around these wetlands. In order to develop within protected species' habitat developers must obtain an ESA approval (i.e., a 'Permit', 'Agreement' or 'Regulatory Exemption'). All types of ESA approvals require implementation of mitigation measures (Ex. timing windows to avoid sensitive periods or temporary fencing around construction zones) to reduce adverse effects on the species that will be impacted (Ontario MNRF 2014b). Overall Benefit Permits go a step further in requiring the developer to perform an activity that will either increase the number of individuals, distribution, population viability or habitat quality/quantity for the species (i.e., provide an "overall benefit"); the conditions of the permit also require impact and effectiveness monitoring as well as scheduled reporting to the MNRF to show compliance (Ontario MNRF 2014b, 2014c). The Regulatory Exemptions (Ontario Regulation 242/08) adopted in 2013 are applicable to several types of industries and developments; MNRF oversight is greatly reduced and proponents are responsible for determining eligibility and interpreting the rules outlined on the MNRF website (Ontario MNRF 2014b). These regulatory changes to the ESA are currently being challenged in court (Ontario Nature 2015). Blanding's Turtle habitat is also afforded protections under the Provincial Policy Statement of the Ontario *Planning Act, 1990* (R.S.O. 1990, c. P.13) and the species is listed as a Specially Protected reptile under the Ontario *Fish and Wildlife Conservation Act, 1997* (S.O. 1997, c. 41). The Stand and Site Guide under the *Crown Forest Sustainability Act* (S.O. 1994, c. 25) also provides timing windows and other conditions for minimizing risks to Blanding's Turtles and their habitat during forestry operations (**see Threats – Logging and Wood Harvesting**).

<u>Québec</u>

In Québec, the Blanding's Turtle is listed as Threatened under the *Loi sur les espèces menacées ou vulnérables, 1989* (RLRQ, c. E-12.01) (LEMV) (*Act Respecting Threatened or Vulnerable Species;* CQLR, c. E-12.01. As a Threatened species, it receives protection under the *Loi sur la conservation et la mise en valeur de la faune, 2002* (RLRQ, c. C-61.1) (LCMVF) (*Act Respecting the Conservation and Development of Wildlife*; CQLR , c. C-61-

1). Under article 26 of the LCMVF, it is illegal to disturb, destroy, or damage the eggs or nest of an animal. It is illegal to capture, hunt, and/or keep in captivity any species of turtle that is native to Québec. The aquatic habitat of turtles in Québec is also indirectly protected by Article 128.6 of the LCMVF. Because this turtle is primarily an aquatic species, its habitat is generally protected under the *Loi sur la qualité de l'environnement* (RLRQ, c. Q-2) (*Environment Quality Act*) (CQLR, C. Q-2) and more specifically under the *Politique de protection des rives, du littoral et des plaines inondables* (RLRQ, c. Q-2, a. 2.1) (*Protections Policy for Lakeshores, Riverbanks, Littoral Zones and Floodplains*) (CQLR, c. Q-2, a. 2.1).

Nova Scotia

In Nova Scotia, the Blanding's Turtle was designated as Endangered by the province in 2000 and receives protection under the provincial *Endangered Species Act* (NSESA 1998, c. 11, s. 1), which prohibits killing, injuring, disturbing, buying selling and trading listed species and destroying or disturbing their dwelling places. The Act also contains provisions for the minister to designate core habitat and set regulations within that habitat. There are several additional legislative tools which may afford protection to turtles or their habitat including: *Provincial Parks Act*, *Crown Lands Act*, *Wildlife Act*, *Environment Act*, *Forests Act*, *Special Places Protection Act*, *Nova Scotia Wetland Conservation Policy* and *Wilderness Areas Protection Act*.

U.S.A.

In the U.S.A., the Blanding's Turtle is considered a Candidate for Listing (Category 2) under the federal *Endangered Species Act* (Congdon *et al.* 2008); however, it is protected to varying degrees under state regulations in all states in which it occurs (CITES 2013).

International

In March 2013, the Convention on the International Trade in Endangered Species (CITES) included Blanding's Turtle in Appendix II; its international trade is now regulated (CITES 2013).

Non-Legal Status and Ranks

COSEWIC designated the Nova Scotia population as Threatened in 1993 and up-listed it to Endangered upon status reassessment in 2005. At that time, COSEWIC also designated the Great Lakes/St. Lawrence population as Threatened (no status prior to 2005). The General Status Rank of Blanding's Turtle in Canada was changed from 'Secure' in 2000, to 'May be at risk' in 2005', then to 'At Risk' in 2010 (Wild Species 2010). Conservation Status Ranks for this species are: 'Critically Imperilled' (S1) in Nova Scotia and Québec, and 'Vulnerable' in Ontario (S3) and Canada (N3; NatureServe 2014). Interestingly, the Blanding's Turtle is listed as 'Apparently Secure' in the U.S.A. (N4) and across the global range (G4) despite the fact that it is listed at some level of peril (i.e., S1 to S3) in 14 of 15 states where it occurs; within 13 of these states, Blanding's Turtle is considered a 'Species of Greatest Conservation Need' (**see Table 3 for a complete list of**

Conservation Status Ranks). It is only considered 'Secure' (S4) in one of the 18 North American jurisdictions in which it occurs; Nebraska maintains an exceptionally large subpopulation of >130,000 adults within a large wildlife refuge (~29,000 ha) that has been protected for nearly a century (U.S. Fish and Wildlife Service 2014). The population size in Nebraska reflects historical abundances that are characteristic of undisturbed subpopulations of turtles; a situation which is now becoming extremely rare. Other subpopulations across the species' range are often small and localized, maintaining a few dozen to a hundred turtles (Congdon *et al.* 2008; van Dijk and Rhodin 2013; this report). In 2010, the IUCN Red List status of Blanding's Turtle was up-listed from 'Lower Risk (near threatened)' to 'Endangered' based on criteria 'A2cde+4ce', meaning that there is evidence of extensive decline for most subpopulations and a slow rate of potential recovery (van Dijk and Rhodin 2013); according to this assessment, the Blanding's Turtle has undergone a global population reduction ≥80% over the last three generations.

Table 3. Blanding's Turtle Protection, Status and Ranks.

Jurisdiction	Status	Conservation Rank
Global	Endangered (IUCN)	G4
Countries		
Canada	Threatened (Great Lakes/St. Lawrence); Endangered (Nova Scotia)	N3
United States	Candidate for Listing (Category 2)	N4
Provinces		
Ontario	Threatened	S3
Nova Scotia	Endangered	S1
Québec	Threatened	S1
States		
Illinois	Endangered; SGCN	S3
Indiana	Endangered; SGCN	S2
Iowa	Threatened; SGCN	S3
Maine	Endangered; SGCN	S2
Massachusetts	Threatened; SGCN	S2
Michigan	Protected; SGCN	S3
Minnesota	Threatened; SGCN	S2
Missouri	Endangered; SGCN	S1
Nebraska	Protected; SGCN	S4
New Hampshire	Endangered; SGCN	S1
New York	Threatened; SGCN	S2S3
Ohio	Protected	S2
Pennsylvania	Protected; SGCN	S1

Jurisdiction	Status	Conservation Rank
South Dakota	SGCN	S1
Wisconsin	Threatened; SGCN	S3S4

Sources: CITES 2013; NatureServe 2014

Legend:
G = Global Rank; N = National Rank; S = State or Provincial Rank;
1 = Critically Imperiled; 2 = Imperiled; 3 = Vulnerable; 4 = Apparently Secure; 5 = Secure
SGCN = State designation of Species of Greatest Conservation Need

Habitat Protection and Ownership

In Ontario, the Blanding's Turtle occurs in at least 119 protected areas including 53 Provincial/National Parks, 34 Conservation Areas, eight Provincial/National Wildlife Areas, six Nature Reserves, five DND properties, five First Nations Reserves, three Sanctuaries, two National Historic Sites, one Game Reserve, one Wildlife Reserve and one Wildlife Management Area. Overall, there are >1,000,000 ha of protected lands in Ontario where Blanding's Turtles occur at least within certain portions of those lands.

In Québec, approximately 21,000 ha of Blanding's Turtle habitat is protected within provincial, federal and conservation agency owned lands, including one Regional Park, one National Wildlife Area and one First Nations Reserve (Bernier pers. comm. 2014; Environment Canada 2014).

In Nova Scotia, the NS1 subpopulation is located primarily within the boundaries of a protected area, with the exception of a recently documented extension maintaining a small concentration of turtles (Parks Canada 2012; Nova Scotia Blanding's Turtle Database 2014). The NS2 and NS3 subpopulations occur in a mix of private and provincial Crown lands (McNeil 2002; Caverhill 2006; Lefebvre 2009). Between 2008 and 2013, the Nova Scotia Nature Trust formally protected an additional six habitats for these subpopulations totalling 103 ha (Porter pers. comm. 2014). In 2003, a substantial portion of critical habitat (102 ha) was protected by the local forestry company that owned it. This habitat has since been purchased by the Province of Nova Scotia. Several large tracts of provincial crown land containing Blanding's Turtle habitat, including the piece purchased from the forestry company, were proposed for protection under the province's obligation to protect at least 12% of provincial lands by 2015 (The Province of Nova Scotia 2013). As of December 29, 2015, the tract that includes some land around NS4 was formally designated. The tracts around the larger subpopulations, NS2 and NS3, are listed as pending, subject to addressing mineral rights. If successful, the designation of these protected areas will significantly increase the proportion of Blanding's Turtle habitat that is protected in Nova Scotia, including areas that maintain some of the most significant overwintering and summering sites.

The ability for these Canadian protected areas to serve as refugia for Blanding's Turtle is questionable since high road densities and large numbers of recreational visitors to many of these areas result in an increased threat of road mortality and poaching (**see Threats**

and Limiting Factors). Indeed, most of the documented threats and observed declines discussed throughout this report were recorded from within protected areas. Crowley and Brooks (2005) found that the average road density of Provincial Parks within the distribution of Ontario's reptiles was nearly double the provincial average, which may cause these areas to act as regional population sinks rather than safe havens. Phillips and Murray (2005) found that density of subsidized predators was four times higher in a southwestern Ontario protected Park than the overall average for rural Ontario. Most subpopulations of Blanding's Turtles that have been studied occur within protected areas; however, there is strong evidence that Blanding's Turtles at several protected sites across the Canadian range are declining due to various threats (see **Threats and Limiting Factors and Fluctuations and Trends**).

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BIOGRAPHICAL SUMMARY OF REPORT WRITER(S)

Teresa Piraino is an ecological consultant with MMM Group Limited (a WSP Company) in Kitchener, Ontario. She has 17 years of field experience conducting Species At Risk research and wildlife surveys throughout Ontario. Over the years she has gained in-depth field research experience with many of Ontario's reptiles, including the Blanding's, Spotted, Spiny Softshell, Northern Map, Snapping and Midland Painted Turtles, as well as the Eastern Foxsnake, Eastern Hog-nosed Snake and Queensnake. Teresa sits as an advisor to the Ontario Turtle Conservation Group and has authored the COSEWIC Spotted Turtle (2015) and Northern Map Turtle (2012) Update Status Reports. She is also a co-author for the upcoming IUCN Chelonian Research Monographs: Spotted Turtle Species Account (in prep.).

Jeffie McNeil is the Species at Risk Biologist and Research Coordinator at the Mersey Tobeatic Research Institute. She is a co-chair of the Nova Scotia Blanding's Turtle Recovery Team and has 20 years of field experience with the species. Jeffie graduated with an M.Sc. in biology from Acadia University in 2002 with a thesis focusing on Blanding's Turtle ecology in Nova Scotia. She was the lead author for the Blanding's Turtle (Nova Scotia population) Recovery Strategy (2012), the Eastern Ribbonsnake (Atlantic population) Recovery Strategy (2008), the Nova Scotia Action Plan for Mainland Moose (2007), and the COSEWIC Update Status Report for Eastern Ribbonsnake (2012).

Appendix 1. The Decline in Relative Abundance of Blanding's Turtles (*Emydoidea blandingii*) in Ontario Attributable to Historic Wetland Conversion

A report in support of the COSEWIC Update Status Report and Status Assessment in progress.

AU: Matthew G. Keevil

Submitted to Teresa Piraino

16 September 2015.

Purpose and scope

The purpose of this analysis is to provide an estimate of the relative decline of Blanding's Turtles across Ontario caused by habitat loss over three intervals between ~1800 and 2002. Proportional declines are calculated as wetland loss across ecoregions weighted by density estimates obtained from available mark-recapture data sets within each region. Other causes of abundance decline such as fragmentation by roads, upland habitat loss, and subsidized predation, which collectively cause declines or extirpation within habitats, were not considered.

Methods

The provincial scale proportional change in abundance due to habitat loss was calculated from the following equation which quantifies density-weighted habitat loss:

$$\left(D^C Q_t^C\left(1-\frac{H_t^C}{H_{t-1}^C}\right)+D^S Q_t^S\left(1-\frac{H_t^S}{H_{t-1}^S}\right)+D^G Q_t^G\left(1-\frac{H_t^G}{H_{t-1}^G}\right)\right)\left(D^C Q_t^C+D^S Q_t^S+D^G Q_t^G\right)^{-1}$$

Where D^R is mean density estimated from study sites in ecoregion *R*, Q_t^R is the quantity of habitat in ecoregion *R* at time *t*, and $\frac{H_t^R}{H_{t-1}^R}$ is the ratio of habitat area in *R* at times *t* and $t-1$. *R* represents one of three ecoregions: Lake Erie-Lake Ontario (Ecoregion 7E), Lake Simcoe-Rideau (6E), and Georgian Bay (5E) (OMNRF 2007). This model breaks the Ontario distribution of Blanding's Turtles into three regions in order to accommodate available data on ecoregional differences in population density, historical wetland loss, and total wetland area. Spatial analyses were performed using ArcGIS 9.3.

Range Extent of Blanding's Turtles in Ontario

The range extent of Blanding's Turtles was digitized based on records reported in the Ontario Reptile and Amphibian Atlas (Ontario Nature 2015). Blanding's Turtles are distributed across much of southern and central Ontario except for Bruce and Grey counties and parts of southeastern Ontario. A limitation of these distributional data is that historic range extent may be underestimated if Blanding's Turtles were extirpated before records were collected. All subsequent analyses are based on spatial data clipped to the Blanding's Turtle range extent. A proportion of the northwestern limit of the Blanding's Turtle distribution extended into the Lake Temagami Ecoregion (4E) and this was merged into the Georgian Bay Ecoregion for this analysis.

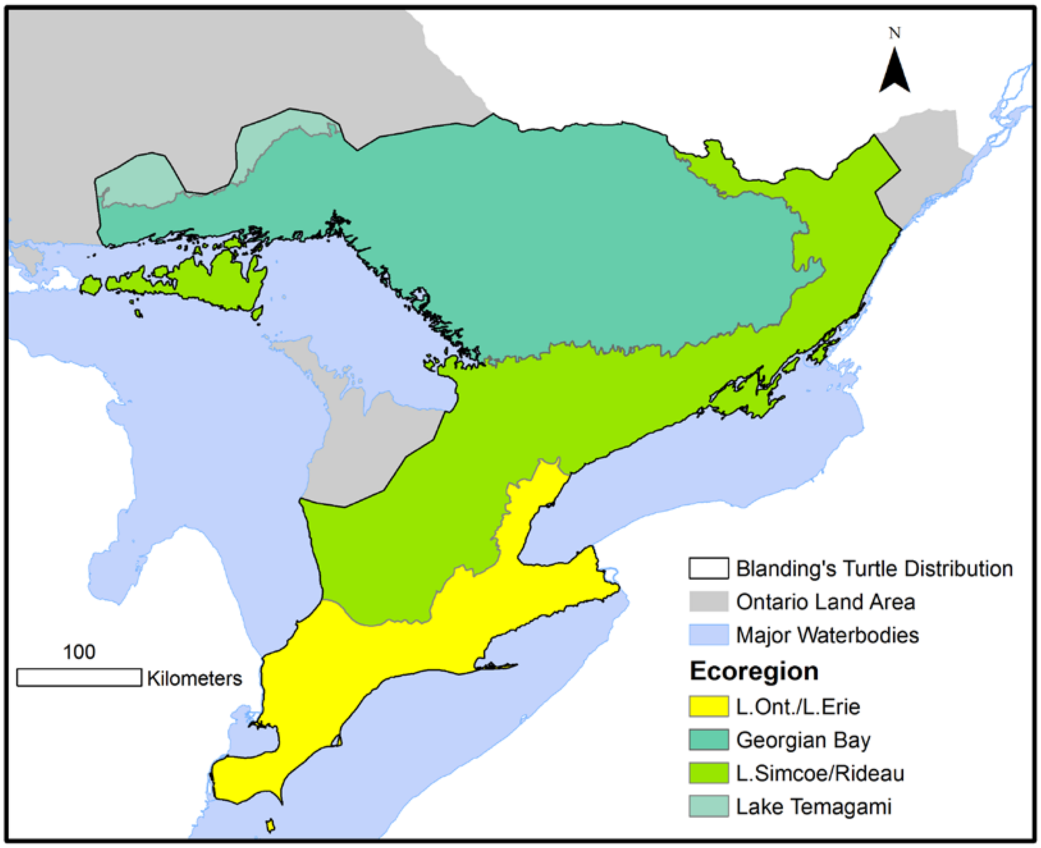

Figure 1. Ecoregions (OMNRF 2007) clipped to the distribution of Blanding's Turtles in Ontario digitized from Ontario Reptile and Amphibian Atlas records (Ontario Nature 2015).

Estimating Wetland Conversion as an Indicator of Relative Habitat Loss (H_t/H_{t-1})

Wetland conversion has been estimated between four time periods (~1800, 1967, 1982, 2002) for geographic townships corresponding to the Mixwood Plains Ecozone (Lake Simcoe-Rideau and Lake Erie-Lake Ontario Ecoregions) and presented in the Southern Ontario Wetland Conversion Analysis Final Report (Ducks Unlimited Canada 2010). These data were used to estimate total wetland conversion within the Blanding's Turtle distribution for these two ecoregions. Township wetland conversion statistics were allocated to ecoregions based on centroid location from pre-amalgamation 1977 geographic townships (OMNRF 2013). Wetland area conversion estimates (as absolute areas) were then summed across ecoregions in over each time period. Estimates of wetland conversion were not available for most municipalities outside the Lake Simcoe-Rideau and Lake Erie-Lake Ontario ecoregions. Therefore, habitat loss in the Georgian Bay Ecoregion was not quantified in this analysis.

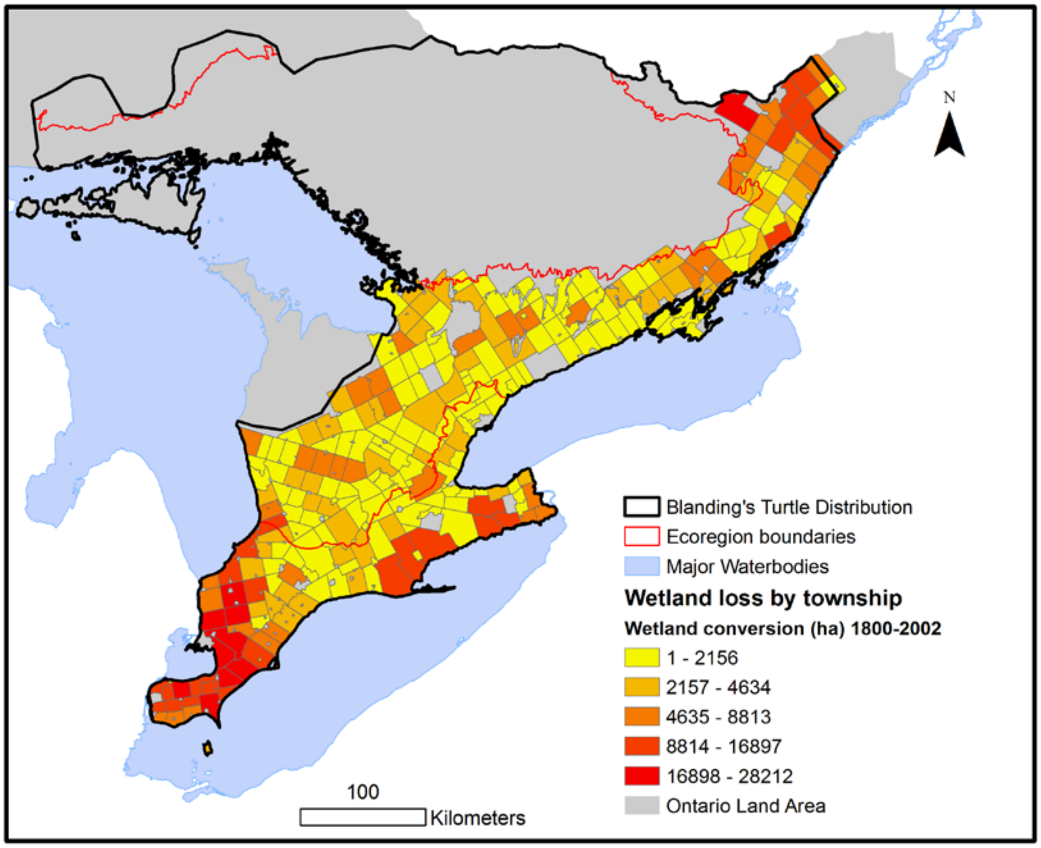

Figure 2. Wetland loss by township across the Lake Ontario/Lake Erie and Lake Simcoe/Rideau ecoregions within the range of Blanding's Turtles in Ontario from pre-settlement (~1800) to 2002. Wetland loss data from Southern Ontario Wetland Conversion Analysis Final Report (Ducks Unlimited Canada 2010).

Estimating Relative Habitat Quantity (*Q*)

Total potential habitat was quantified in order to account for relative differences between ecoregions due to differences in total land area and proportion of wetlands. These habitat area estimates are not intended to quantify the absolute amount of suitable habitat for Blanding's Turtles. Wetland area was estimated using land cover layers instead of tabulated from the Southern Ontario Wetland Conversion Analysis (Ducks Unlimited Canada 2010) because the latter was unavailable for the Georgian Bay ecoregion. Two land cover data sources were used: SOLRIS (OMNRF 2008) in southern Ontario and the Provincial Land Cover Database (Spectranalysis Inc. 2004). Where these datasets spatially overlap, SOLRIS data were used. Habitat quantity was calculated as the total area of all wetland land cover classes (Ontario Land Cover classes 15-23; SOLRIS classes 50, 55, 59, and 63) within the Blanding's Turtle range extent across each ecoregion.

Table 1. Area of wetland land cover classes within the range extent of Blanding's Turtles in Ontario broken down by ecoregion. 4086 km^2 from the Lake Temagami Ecoregion that was within the range extent of Blanding's Turtles was merged with the Georgian Bay Ecoregion before analysis.

Ecoregion	Wetland Area (km^2)			Geographic Area (km^2)
	SOLRIS	Prov. Land Cover	Total	
Simcoe/Rideau	7417	51	7468	50947
L. Erie/L. Ont.	1428	0	1428	21899
Georgian Bay	377	1685	2062	68478

Estimating Relative Population Density (*D*)

Mark-recapture abundance estimates and study area data were available from eight study sites in Ontario (Appendix 1 Table), two in the L.Erie/L. Ontario Ecoregion, five in the L. Simcoe/Rideau Ecoregion, and one in the Georgian Bay Ecoregion. Mean density estimates were 0.78, 0.29, and 0.12 adults/ha respectively. Differences in historic densities between ecoregions may have been greater than for recent densities because populations in the more productive southern parts of Ontario are also subjected to greater disturbances such as road mortality and higher levels of subsidized nest predation. This could have caused estimated historic relative abundance to be lower than true values where wetland loss has been most extensive. In turn, this would cause an underestimation of total declines.

Data Limitations:

- Great Lakes coastal wetland losses were not available in the wetland conversion analysis (Ducks Unlimited Canada 2010).
- Wetlands smaller than 10 ha were not available from the wetland conversion analysis (Ducks Unlimited Canada 2010).
- Land cover and wetland conversion data were only available up to 2002.
- Wetland conversion data is only available for the Mixedwood Plains Ecozone portion of the Ontario distribution of Blanding's Turtles.
- Density estimates are based on a small number of sites. Recent relative densities may be biased indicators of historic relative densities.

Results

Table 2. Decline in density-weighted Blanding's Turtle habitat across the range extent in Ontario. Recent wetland land cover reflects data gathered up to 2000-2002 in SOLRIS (OMNRF 2008) and The Provincial Land Cover Dataset (Spectranalysis Inc. 2004). Proportional wetland loss and density weighted declines are reported relative to the start and end of corresponding time intervals. Therefore, the loss of wetlands in the Simcoe/Rideau portion of the Blanding's Turtle range between 1967 and 2002 is 3.4% of the wetlands that remained in 1967. An assumption of no wetland loss in the Georgian Bay Ecoregion was necessary because of a lack of data on wetland conversion.

Ecoregion	Density (adults/ha)	Recent wetland land cover (ha)	Wetland loss between 2002 and:			Provincial decline in density-weighted wetlands between 2002 and:		
			1800	1967	1982	1800	1967	1982
L.Erie/L.Ont.	0.78	142800	92.1%	34.3%	26.2%	65%	13%	11%
Simcoe/Rideau	0.29	746800	58.5%	3.4%	4.5%			
Georgian Bay	0.12	206200	0.0%	0.0%	0.0%			

Table 3. Trends in the distribution of density-weighted habitat of Blanding's Turtles across ecoregions and time periods scaled as a proportion of total remaining wetlands. Data sources and assumptions are as described for Table 2.

Ecoregion	1800	1967	1982	2002
L.Erie/L.Ont.	72.2%	40.7%	37.7%	31.8%
Lake Simcoe/Rideau	26.6%	53.3%	56.1%	61.1%
Georgian Bay	1.3%	6.0%	6.2%	7.1%

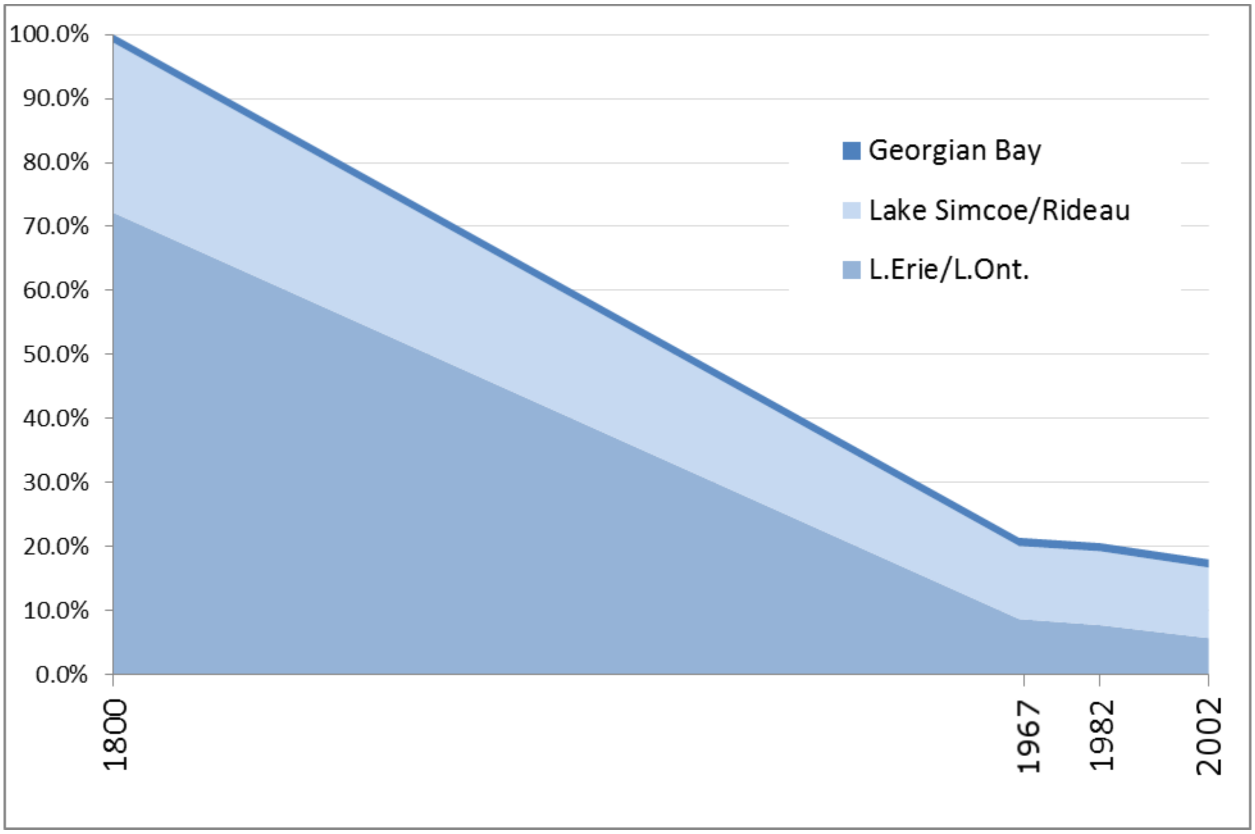

Figure 3. Stacked area plot of the estimated proportions of density-weighted Blanding's Turtle habitat in Ontario partitioned by ecoregion and plotted against year (See Tables 2, 3).

The generation time of Blanding's Turtles in Ontario has been estimated as >40 years (COSEWIC 2005). Times when habitat losses were quantified correspond to 5.05 (1800), 0.875 (1967), 0.5 (1982), and 0 (2002) generations before the most recent measurement year or 5.375, 1.2, 0.825, and 0.325 generations before present (2015). This analysis estimates a minimum decline in Blanding's Turtle abundance of 13% within the past 1.2 generations due to wetland loss in addition to unmeasured habitat losses after 2002 and probable within-habitat declines over all periods caused by road mortality, subsidized predation, poaching, upland habitat loss and other chronic threats.

A large gap in measured wetland loss occurs between the pre-settlement period and 1967. If a constant rate of wetland loss occurred during this interval is provisionally assumed and calculated separately for each ecoregion, then the proportion of density weighted habitat would have been twice as great in 1936 (~1.98 generations before present) as it was in 2002. This corresponds to a minimum 50% decline across Ontario within the last two Blanding's Turtle generations. However, an approximately constant rate of habitat loss during this interval is unlikely and therefore this extrapolation must be interpreted with extreme caution.

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Appendix 1 Table. Blanding's Turtle adult densities from mark-recapture studies in Ontario (provided by Teresa Piraino).

Subpopulation	Ecoregion	Size of Study Site (ha)	Adult Population Estimate	Density (adults/ha)	Study Period (# of seasons)	Sampling Effort	Survey Methods	Sources
SW Ontario 1	Erie/Ontario	3300	690 Schnabel Method (modified closed-capture model)	0.21	9 seasons (2000-2001; 2008-2014)	>650 person-days	Hand/dip net captures while conducting visual surveys in wetlands and nesting areas	Gillingwater and Brooks 2001; Davy unpub. data
SW Ontario 2	Erie/Ontario	607	818 based on an estimated 341 ±214 adult females (Jolly-Seber method in program JOLLY using model A and mark-recapture data from 2003-2006) and an average sex ratio of 1.4M:1F.	1.35	21 seasons (1973; 1979; 1980; 1982; 1992-1994; 2003-2016)	>680 person-days; ~500 trap days	Hand/dip net captures while conducting visual surveys in wetlands and nesting areas; hoop net traps	Weller 1973; Hubbs 1979; Purves 1980; Ashenden 1983; Saumure 1995; Gillingwater and Piraino 2004, 2007; Piraino and Gillingwater 2005, 2006; Gillingwater 2009, 2013; Enneson 2010
SW Ontario 3	Simcoe	800	138 Lincoln Index where N=MC/R (using data from 2010-2011)	0.17	5 seasons (2010-2014)	1317 person-hours; 2200 trap days	Hand/dip net captures while conducting radio-telemetry surveys, road mortality surveys and visual surveys in wetlands and nesting areas; hoop net traps	Caverhill *et al.* 2011; Toronto Zoo unpub. data
SE Ontario 2	Simcoe	690	99 (95% CI: 89-124)	0.14	4 seasons (2010-2013)	5300 person-hours; 2360 trap days	Hand/dip net captures while conducting radio-telemetry surveys, road mortality surveys and visual surveys in wetlands; hoop net traps	Dillon Consulting Ltd. 2014

Subpopulation	Ecoregion	Size of Study Site (ha)	Adult Population Estimate	Density (adults/ha)	Study Period (# of seasons)	Sampling Effort	Survey Methods	Sources
SE Ontario 3	Simcoe	900	114 (95% CI: 103-136) Closed capture model in MARK	0.13	3 seasons (2007-2009)	Wetlands surveyed every day from April-Sept every season. Hoop traps were also set all season.	Hand/dip net captures while conducting radio-telemetry surveys and visual surveys in wetlands; hoop net traps	Millar 2009, unpub. data; Millar and Blouin-Demers 2012
SE Ontario 4	Simcoe	238	85 (95% CI: 53-206) Schnabel Method (modified closed-capture model)	0.36	5 seasons (2010-2014)	~68 person-days; ~54 traps days	Hand/dip net captures while conducting visual surveys in wetlands; hoop net and basking traps	Middleton 2014; Ontario Nature unpub. data
SC Ontario 1	Georgian Bay	340	41 (95% CI: 39-50)	0.12	5 seasons (2006-2008; 2009-2010)	Wetlands surveyed several days between April-May every season. Nightly nest site patrols from 7-11pm for 3-4 weeks/season. Several incidental captures during telemetry and at communal hibernacula.	Hand/dip net captures while conducting visual surveys in wetlands and nesting areas	Edge et al. 2009, 2010, unpub. data; Paterson *et al.* 2014, unpub. data
SC Ontario 3	Simcoe	90	57 Lincoln Peterson N=n1*n2/m2	0.63	2 seasons (2013-2014)	134 person-hours (2013); ?? person-hours (2014)	Hand/dip net captures while conducting visual surveys in wetlands	Sheppard 2013, 2014, unpub. data

THREATS ASSESSMENT WORKSHEET

Species or Ecosystem Scientific Name	Blanding's Turtle, Nova Scotia population
Element ID	
Elcode	
Date (Ctrl + ";" for today's date):	27/03/2015
Assessor(s):	Nova Scotia recovery team members: Diane Clapp, Harold Clapp, Megan Crowley, Mark Elderkin, Colin Gray, Norm Green, Sue Green, Tom Herman, Sarah Jeremy, Shalan Joudry, Chris McCarthy, Julie McKnight, Jeffie McNeil (also status report author), Sally O'Grady, Bradley Toms, Sarah Walton. COSEWIC Amphibians and Reptiles SSC: Jim Bogart (co-chair). Facilitator: Dave Fraser (COSEWIC). COSEWIC secretariat: Bev McBride (notes)
References:	

Overall Threat Impact Calculation Help:

Threat Impact		**Level 1 Threat Impact Counts**	
		high range	**low range**
A	Very High	0	0
B	High	0	0
C	Medium	3	1
D	Low	3	5
Calculated Overall Threat Impact:		High	High

Threat		**Impact (calculated)**		**Scope (next 10 Yrs)**	**Severity (10 Yrs or 3 Gen.)**	**Timing**	**Comments**
1	Residential & commercial development	D	Low	Small (1-10%)	Slight (1-10%)	High (Continuing)	
1.1	Housing & urban areas		Negligible	Small (1-10%)	Negligible (<1%)	High (Continuing)	
1.2	Commercial & industrial areas						
1.3	Tourism & recreation areas	D	Low	Small (1-10%)	Slight (1-10%)	Moderate (Possibly in the short term, < 10 yrs)	Activities that may cause threats include constructing jumps for ATV users and a private landowner who intends to develop a tour operation near part of the population.
2	Agriculture & aquaculture		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	
2.1	Annual & perennial non-timber crops		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	Christmas tree farming: change to habitat and risk from motor vehicles operating on farms.
2.2	Wood & pulp plantations						
2.3	Livestock farming & ranching						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
2.4	Marine & freshwater aquaculture		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	Various activities at a provincial fish hatchery near a dam where turtles nest may pose threats including vehicle movement and adding substances to the water.
3	Energy production & mining		Unknown	Small (1-10%)	Unknown	Moderate (Possibly in the short term, < 10 yrs)	
3.1	Oil & gas drilling						
3.2	Mining & quarrying	D	Low	Small (1-10%)	Serious - Slight (1-70%)	Moderate (Possibly in the short term, < 10 yrs)	Mining rights and active surveyors in the areas used by turtles; existing quarry and gravel pits. Severity would depend on the type of habitat being affected, could be quite severe if impacted overwintering sites.
3.3	Renewable energy						
4	Transportation & service corridors	CD	Medium - Low	Large (31-70%)	Moderate - Slight (1-30%)	High (Continuing)	
4.1	Roads & railroads	CD	Medium - Low	Large (31-70%)	Moderate - Slight (1-30%)	High (Continuing)	35% of females known to cross roads. Mitigation activities to reduce road kill are assumed to be ongoing when estimating severity. More forestry roads are expected in areas used by turtles but these are temporary. Roads create nesting habitat but also increase the risk of road mortality.
4.2	Utility & service lines						
4.3	Shipping lanes						
4.4	Flight paths						
5	Biological resource use	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	
5.1	Hunting & collecting terrestrial animals	CD	Medium - Low	Large (31-70%)	Moderate - Slight (1-30%)	High - Low	Threat is from illegal collection for pets or pet trade. This can be episodic. Blanding's Turtles presently less sought after than some other species, but this could change.
5.2	Gathering terrestrial plants						
5.3	Logging & wood harvesting	D	Low	Restricted (11-30%)	Moderate (11-30%)	High (Continuing)	Mitigation is in place but there are still impacts to turtles.
5.4	Fishing & harvesting aquatic resources						Blanding's Turtles not known to be found as by-catch.
6	Human intrusions & disturbance	D	Low	Large (31-70%)	Slight (1-10%)	High (Continuing)	
6.1	Recreational activities	D	Low	Large (31-70%)	Slight (1-10%)	High (Continuing)	ATV users(on and off trails); recreational users (e.g., motor boat collisions).
6.2	War, civil unrest & military exercises						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
6.3	Work & other activities		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	Researchers: small potential for impact from trapping and attachment of tracking devices.
7	Natural system modifications		Unknown	Large (31-70%)	Unknown	Moderate (Possibly in the short term, < 10 yrs)	
7.1	Fire & fire suppression		Unknown	Unknown	Unknown	Moderate (Possibly in the short term, < 10 yrs)	May be a risk to turtles on land.
7.2	Dams & water management/use		Unknown	Large (31-70%)	Unknown	High (Continuing)	Change in water levels and conditions due to removal beaver dams (happens opportunistically but not through a program).
7.3	Other ecosystem modifications						
8	Invasive & other problematic species & genes	C	Medium	Pervasive (71-100%)	Moderate (11-30%)	High (Continuing)	
8.1	Invasive non-native/alien species	BD	High - Low	Pervasive (71-100%)	Serious - Slight (1-70%)	High - Moderate	Expansion of non-native fish species such as chain pickerel and smallmouth bass expected; these species known to eat hatchling turtles and alter species composition. The non-native Phragmites australis australis may also be a theat. It is has not been documented in Blanding's habitat in NS at present but is expected to increase across the province and its negative effects on wetlands have been well documented elsewhere (note: The native species of Phragmites, P australis spp americanus, does occur near Blanding's habitat but is not considered a threat).
8.2	Problematic native species	C	Medium	Pervasive (71-100%)	Moderate (11-30%)	High (Continuing)	Raccoons and red squirrels are both increasing due to human activity, increasing threat to eggs and hatchlings. Up to 100% of nests would be affected but nest protection has reduced this amount and is expected to continue for the next 10 years at least.
8.3	Introduced genetic material						
9	Pollution		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	
9.1	Household sewage & urban waste water						
9.2	Industrial & military effluents						
9.3	Agricultural & forestry effluents		Unknown	Small (1-10%)	Unknown	High (Continuing)	Pesticide use at Christmas tree farms.
9.4	Garbage & solid waste						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
9.5	Air-borne pollutants		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	Mercury from various sources (needs more investigation; also includes natural background levels)
9.6	Excess energy						
10	Geological events						
10.1	Volcanoes						
10.2	Earthquakes/tsunamis						
10.3	Avalanches/landslides						
11	Climate change & severe weather	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	
11.1	Habitat shifting & alteration		Not Calculated (outside assessment timeframe)	Pervasive (71-100%)	Unknown	Low (Possibly in the long term, >10 yrs)	Climate change may reduce the number of years in which ice scouring occurs. Ice scouring is needed in some but not all years to keep nesting beaches in good condition.
11.2	Droughts		Not Calculated (outside assessment timeframe)	Pervasive (71-100%)	Unknown	Low (Possibly in the long term, >10 yrs)	Models predict warmer, drier summers for Atlantic Canada.
11.3	Temperature extremes		Unknown	Pervasive (71-100%)	Unknown	Unknown	May affect sex ratio as sex determination is temperature dependent; may affect nesting success as eggs may not incubate properly. Could potentially increase overwintering mortality which would increase severity considerably.
11.4	Storms & flooding	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	Can affect nesting, wintering, and estivation sites. Interventions sometimes possible to rescue nests.

Classification of Threats adopted from IUCN-CMP, Salafsky et al. (2008).

Appendix 2b. Threats Calculator - Great Lakes/ St. Lawrence Population

THREATS ASSESSMENT WORKSHEET			
Species or Ecosystem Scientific Name	Blanding's Turtle, Great Lakes / St. Lawrence population		
Element ID		Elcode	
Date (Ctrl + ";" for today's date):	30/03/2015		
Assessor(s):	Status report authors: Teresa Piraino, Jeffie McNeil; MMFP QC: Yohann Dubois, Daniel Toussaint; OMNR: Graham Cameron, Joe Crowley (also AR SSC), Colin Jones; CWS QR: Gabrielle Fortin; COSEWIC Amphibians and Reptiles SSC: Jim Bogart (co-chair), Ron Brooks, Jackie Litzgus, Dennis Murray; Other experts: Scott Gillingwater, Christina Davy; Facilitator: Dave Fraser (COSEWIC); COSEWIC secretariat: Bev McBride (notes)		
References:			

Overall Threat Impact Calculation Help:

Threat Impact		Level 1 Threat Impact Counts: high range	Level 1 Threat Impact Counts: low range
A	Very High	0	0
B	High	2	0
C	Medium	1	3
D	Low	3	3
	Calculated Overall Threat Impact:	Very High	High

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1	Residential & commercial development	C	Medium	Restricted (11-30%)	Serious (31-70%)	High (Continuing)	
1.1	Housing & urban areas	C	Medium	Restricted (11-30%)	Serious (31-70%)	High (Continuing)	Urban development continues to expand in many parts of Blanding's Turtle range in Ontario and Quebec such that habitat is affected. Several residential developments have been approved or proposed within Blanding's Turtle habitat in Ontario between 2010 and 2014.
1.2	Commercial & industrial areas		Negligible	Negligible (<1%)	Serious (31-70%)	High (Continuing)	Developments of this type are less likely than housing to be made in previously pristine areas.
1.3	Tourism & recreation areas	D	Low	Small (1-10%)	Slight (1-10%)	High (Continuing)	In Quebec a park development project may take place in the next 10 years that will affect the species.
2	Agriculture & aquaculture	D	Low	Small (1-10%)	Slight (1-10%)	High (Continuing)	
2.1	Annual & perennial non-timber crops	D	Low	Restricted (11-30%)	Slight (1-10%)	High (Continuing)	Agricultural expansion expected to be negligible in next 10 years. Injury to adults and nests have been observed where turtles use agricultural lands. Use of agricultural areas known in southern Ontario and Quebec, but minimal in the Canadian Shield. Females may use flooded sections of hayfields as a staging areas for several days before nesting in the field.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
2.2	Wood & pulp plantations						
2.3	Livestock farming & ranching		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	Blanding's Turtles are known to nest on ranchlands/pasture in Quebec. In Ontario no new areas of this are expected; grazing is generally decreasing.
2.4	Marine & freshwater aquaculture						
3	Energy production & mining		Unknown	Restricted (11-30%)	Unknown	High (Continuing)	
3.1	Oil & gas drilling						
3.2	Mining & quarrying		Unknown	Restricted (11-30%)	Unknown	High (Continuing)	Hundreds of active mines, quarries and claims in or near areas used by Blanding's Turtles. While mines do not generally go directly into wetlands, they can affect water bodies by changing hydrology and causing pollution, and they can cause fragmentation of habitat (since Blanding's Turtles use multiple wetlands). Furthermore, individuals are not deterred from moving through these areas and are attracted to quarries for nesting (demonstrated by radio tracking in Ontario and Quebec). Adults, nests and hatchlings may be harmed by equipment.
3.3	Renewable energy		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	In southern Ontario several wind farm developments are approved and proposed in Blanding's Turtle habitat. Related roadways are expected to have the greatest impact, rather than the turbines themselves.
4	Transportation & service corridors	BC	High - Medium	Pervasive (71-100%)	Serious - Moderate (11-70%)	High (Continuing)	
4.1	Roads & railroads	B	High	Pervasive (71-100%)	Serious (31-70%)	High (Continuing)	Lots of evidence of mortality of adults on roads across the range. Roadkills have been recorded from major roadways, rural county roads, park roads, gravel forestry access roads and railroads. This species is known to travel several kilometers over land, thus adults likely often encounter roads/railroads even if their residence wetland does not occur along such infrastructure.
4.2	Utility & service lines		Negligible	Small (1-10%)	Negligible (<1%)	High (Continuing)	Threat is from use of heavy equipment for brush clearing and other maintenance activities.
4.3	Shipping lanes						
4.4	Flight paths						
5	Biological resource use	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
5.1	Hunting & collecting terrestrial animals	C	Medium	Pervasive (71-100%)	Moderate (11-30%)	High (Continuing)	There is increasing evidence in recent years that Canadian Blanding's Turtles are being illegally harvested to supply the Asian food and traditional medicine trade at home and abroad. This demand is expected to rise in Ontario as the number of cultural consumers continues to grow. There is also an increasing demand for Blanding's Turtles in the pet trade. Wild Blanding's Turtles from southern Ontario have been found in possession of Toronto practitioners and in 2014 several individuals were found hidden in luggage destined for Chinese pet/food black markets.
5.2	Gathering terrestrial plants						
5.3	Logging & wood harvesting	D	Low	Large (31-70%)	Slight (1-10%)	High (Continuing)	In Ontario, Blanding's Turtles are known to occur extensively throughout Crown forests where forest management activities are conducted. This species is known to use upland forest habitat extensively for travel and for vernal pool foraging, which increases the risk of encounters with heavy machinery. However, the Forestry Stand and Site Guide provides several mitigation measures to reduce the risk of impacts.
5.4	Fishing & harvesting aquatic resources		Negligible	Negligible (<1%)	Unknown	High (Continuing)	Blanding's Turtles are sometimes caught incidentally (bycatch) during legal recreational (or possibly illegal) snapping turtle hunt (Ontario), and may not always be released since there is a ready market for them.
6	Human intrusions & disturbance	D	Low	Large (31-70%)	Slight (1-10%)	High (Continuing)	
6.1	Recreational activities	D	Low	Large (31-70%)	Slight (1-10%)	High (Continuing)	Ontario: boat and propeller strikes (10% of captured individuals from a subpopulation in a protected area showed evidence of this). On L. Erie shoreline, turtles venturing further into lake in path of boats and silt and vegetation increase at shoreline. Mortality due to ATV users crushing nests.
6.2	War, civil unrest & military exercises		Negligible	Negligible (<1%)	Unknown	High (Continuing)	Military exercises and vehicles may harm individuals and nests on bases.
6.3	Work & other activities		Negligible	Restricted (11-30%)	Negligible (<1%)	High (Continuing)	Occurs in a few areas.
7	Natural system modifications		Unknown	Large (31-70%)	Unknown	Moderate (Possibly in the short term, < 10 yrs)	
7.1	Fire & fire suppression		Negligible	Negligible (<1%)	Unknown	High (Continuing)	Threat not well studied. Has been known to affect Spotted Turtles. Blanding's Turtles at two southern Ontario sites have been observed with fire-damaged shells.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
7.2	Dams & water management/use	CD	Medium - Low	Restricted - Small (1-30%)	Serious - Moderate (11-70%)	High (Continuing)	Removal of Beaver dams during hibernation poses a serious threat to hibernating individuals. An increasing concern in Quebec since citizens within Regional County Municipalities are now obliged to remove dams on private lands that may represent a threat to human safety. The Scope is likely >10% in Quebec. In Ontario, there is evidence that Beaver dams have been removed in known Blanding's Turtle habitat within provincially-managed protected areas during the hibernation period. Large areas of wetlands can be drained by the removal of a single Beaver dam.
7.3	Other ecosystem modifications	D	Low	Small (1-10%)	Serious - Moderate (11-70%)	High (Continuing)	Dredging; mostly a concern in southern Ontario. One operation during winter was known to kill at least 14 adults from a protected area. These activities likely occur in several managed areas. Some infilling of wetlands on L. Erie shore.
8	Invasive & other problematic species & genes	BC	High - Medium	Large (31-70%)	Serious - Moderate (11-70%)	High (Continuing)	
8.1	Invasive non-native/alien species	BC	High - Medium	Large (31-70%)	Serious - Moderate (11-70%)	High (Continuing)	Non-native *Phragmites* grass rapidly expanding in southern Ontario, particularly an issue near L. Erie and Huron shorelines; currently less prevalent in Canadian Shield but predicted to occur throughout southern Canada by 2030.
8.2	Problematic native species	C	Medium	Large (31-70%)	Moderate (11-30%)	High (Continuing)	An increase over "background" mortality due to native predators is assumed because of 100% nest depredation in some cases. Less pervasive in Shield but known to occur in cottage country.
8.3	Introduced genetic material						
9	Pollution		Unknown	Restricted (11-30%)	Unknown	High (Continuing)	
9.1	Household sewage & urban waste water		Unknown	Restricted (11-30%)	Unknown	High (Continuing)	Nutrient and sediment loading in SW Ontario; also affects Georgian Bay coastal populations.
9.2	Industrial & military effluents		Unknown	Small (1-10%)	Unknown	High (Continuing)	Some evidence of mercury from mining sources.
9.3	Agricultural & forestry effluents		Unknown	Restricted (11-30%)	Unknown	High (Continuing)	Mostly in agricultural areas; not expected from forestry operations.
9.4	Garbage & solid waste						
9.5	Air-borne pollutants						
9.6	Excess energy		Unknown	Unknown	Unknown	High (Continuing)	
10	Geological events						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
10.1	Volcanoes						
10.2	Earthquakes/tsunamis						
10.3	Avalanches/landslides						
11	Climate change & severe weather		Unknown	Unknown	Unknown	High (Continuing)	
11.1	Habitat shifting & alteration		Not Calculated (outside assessment timeframe)	Restricted (11-30%)	Unknown	Low (Possibly in the long term, >10 yrs)	Water levels in L. Erie and L. Huron are dropping due to warmer temps; coastal wetland habitat availability is reducing. Blanding's Turtle has a narrow thermal tolerance range and appears to be highly sensitive to climate change; 50-75% of currently suitable areas across the range are predicted to become unsuitable for Blanding's Turtle by 2050, dropping to <25% by 2080. Most of southwestern Ontario likely will not be climatically suitable for this species by 2080 and due to large-scale habitat fragmentation in the region, these subpopulations will not be able to migrate north.
11.2	Droughts		Unknown	Unknown	Unknown	High (Continuing)	Lower water levels in L. Erie and L. Huron causing drying and succession in coastal marshes. Drought is suspected as part of the cause of a mass mortality event at a provincial park when 53 of 101 marked turtles died within a short time period. Cause unknown but drought may have led to lower water levels allowing predators more access, or shallower water led turtles to freeze during winter, subsequently being scavenged.
11.3	Temperature extremes		Not Calculated (outside assessment timeframe)	Pervasive (71-100%)	Unknown	Low (Possibly in the long term, >10 yrs)	May affect sex ratio as sex determination is temperature dependent; may affect nesting success as eggs may not incubate properly.
11.4	Storms & flooding		Unknown	Unknown	Unknown	High (Continuing)	At least one nesting site in Ontario washed away by storms. Not well studied.
Classification of Threats adopted from IUCN-CMP, Salafsky et al. (2008).							

Appendix 3. Estimating the effect of road mortality on Blanding's Turtles across Ontario

A report in support of the COSEWIC Update Status Report and Status Assessment in progress

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ABSTRACT

The effect of road mortality on the Ontario Blanding's Turtle population was estimated based on documented road kill rates from standardized surveys along four roads in the province. There were 1,328.8 km of road within 1x1 km grid squares with recent observations of Blanding's Turtles. Using two different methods, the observed annual road kill rate varied from 0.2 – 0.3 Blanding's Turtles/km on surveyed roads. An estimated 265.8 – 398.6 Blanding's Turtles are killed on roads each year in Ontario based on this range of road kill rates. At the lowest kill rate, the population would decline by 50% in three generations (120 years). The population would decline by 50% in 65 years based on a starting population of 25,000 adults, or in 117 years given a starting population of 45,000 adults.

INTRODUCTION

Traffic mortality is widely acknowledged as a significant threat to turtle populations. Modelling studies predict that populations of semi-terrestrial species such as Blanding's Turtles (*Emydoidea blandingii*) likely experience road mortality rates that exceed sustainable levels in many areas with high road density (Gibbs and Shriver 2002). High adult survivorship rates are a key trait of Blanding's Turtle biology and even modest increases in adult mortality rates can lead to population declines (e.g., Congdon *et al.* 1993). In addition, road mortality may preferentially affect females who must leave wetlands to find nesting sites (Steen *et al.* 2006). Road mortality is likely a serious issue for Blanding's Turtles in Ontario, where the road network has expanded from approximately 7,000 km to over 35,000 km of paved roads from 1935-1995 (Fenech *et al.* 2001). Compounding this problem, approximately 2.7% of drivers will deliberately run over reptiles (Ashley *et al.* 2007).

Recently, a few studies in Ontario have documented rates of road mortality of turtles across a few different roads in different parts of the province. Using the data from these studies, we have endeavoured to estimate the annual number of large juvenile or adult Blanding's Turtles that are killed on the roads each year based on a low, medium and high kill rate per kilometre of road. Using these annual estimates of mortality, we estimated the effect of this level of mortality over the next three generations, or 120 years, on Blanding's Turtle population size in Ontario.

METHODS

The area of occupancy of Blanding's Turtles in Ontario was defined by using 1x1 km grid squares. A 1x1 km grid square was selected because Blanding's Turtles can easily travel 1 km or more (Joyal *et al.* 2001; Edge *et al.* 2010). Given that Blanding's Turtles can move >3 km (Grgurovic and Sievert 2005), it can be argued that a larger grid square should be selected. Blanding's Turtles do not move uniformly across the landscape, however, and selecting a larger grid size (e.g., 2x2 km) substantially increases the likelihood of including areas, and therefore roads, not within a population's typical movement patterns. Selecting a smaller grid square (e.g., 1x1 km) provides a conservative estimate of the effect of roads on Blanding's Turtles.

The Ontario Reptile and Amphibian Atlas provided us with a GIS shapefile of all Blanding's Turtle observations records partitioned into 1x1 km grid squares. We included only squares with the most recent record occurring within the last 20 years (1995 or more recently). The amount of road in each recent 1x1 km grid square was determined using the 2013 OMNR roads data from the Ontario Geospatial Data Exchange network. Seven broad classes of road types were defined: arterial, collector, freeway/highway, local, ramp, resource/recreation and service. We included all road types in the analyses.

Next we examined the road kill data from road survey studies. Because adults are more important to the viability of turtle populations than juveniles (Congdon *et al.* 1993), we only wanted to include road mortality of adults. Not all turtles killed on roads are adults, but unfortunately some dead-on-road (DOR) turtles were in poor condition and size data were not available, but turtles could be reliably assigned to either juvenile or adult age classes. We filtered out all clearly juvenile turtles (e.g., < 15 cm PL) but included all others, providing one kill rate for subadult and adult turtles combined.

Road kill rates for Blanding's Turtles were calculated using data from pre-existing surveys on the following roads:

- #7, ~80 km surveyed in 2012-2014 (Lesbarrères *et al.* 2013)
- #41, ~20 km surveyed in 2012-2014 (Lesbarrères *et al.* 2013)
- #17, ~100 km surveyed in 2014 (Seburn 2014)
- #69, ~12 km surveyed in 2012-2014 (Morin, Riley and First Nations of Georgian Bay unpublished data)

For each surveyed road section, we divided the road into 1 km sections and counted the number of dead Blanding's Turtles within each section. All sections of road with no observations of Blanding's Turtle during all years of surveys were excluded from the kill rate calculation to ensure areas without the species were not included in the analysis. For #7, #41 and #69, standardized road survey data were collected over multiple years, allowing for the determination of an average number killed each year in each 1 km section of road, for a more robust estimate of annual kill rate/km. Once a road kill rate or average road kill rate was determined for each 1 km section where Blanding's Turtles had been detected, we then calculated the median and modal road kill rates across these sections of road.

A second method was also used to calculate road kill rates for comparison purposes. For each road, the number of dead Blanding's Turtles detected was divided by the total surveyed road length to provide the number of turtles found per kilometre. Using this method includes stretches of roads with no road kill and hence reduces any bias in the first method of excluding road segments where road kill may occur but was not detected. For roads where surveys were conducted over multiple years, a kill rate was calculated for each year, along with an overall average kill rate for each road.

The road kill rates from these two methods were multiplied by the number of km of road in the 1x1 km grid squares with recent observations of Blanding's Turtles to determine the estimated number of Blanding's Turtles killed each year on Ontario. Using these estimates of annual road kill, we then calculated the estimated percentage of the Ontario population that is killed each year based on the high and low population size estimates provided in the COSEWIC report. These percentages were then used to calculate the effect on the Ontario population over three generations, or 120 years, as defined in the COSEWIC report.

Over the course of 120 years, recruitment into the adult population, as well as natural adult mortality, are significant factors. Turtle populations generally demonstrate very slow population growth rates, and recruitment and mortality are often essentially balanced (e.g., Shoemaker *et al.* 2013). We have therefore modelled the effect of annual road mortality on the Ontario Blanding's Turtle population with the assumption of a stable population (recruitment = natural mortality). Although this assumption may not be true, it allows for examining the effect of road mortality independent of other factors, and does not assume an arbitrary population growth rate. The population decline over time was modelled using a constant annual percentage road kill rate over time in the compound interest equation:

$$A = P\,(1 + r/n)^{nt}$$

Where
A = the future size of the population
P = the original size of the population
r = the annual interest, or kill rate (as a negative decimal)
n = the number of times the rate is compounded per year (once in this case)
t = the number of years

Because the kill rate is only applied once per year, the value n in the equation is equal to 1 and the equation simplifies to:

$$A = P\,(1 + r)^{t}$$

To calculate how many years it would take for the population to decline by 50% the equation was re-arranged to solve for t, setting A/P (the future population size divided by the present population size) to 0.5:

$$t = \frac{\ln (A/P)}{\ln (1 + r)}$$

RESULTS & DISCUSSION

Amount of road in Blanding's Turtle range in Ontario

A total of 2,020 1x1 km grid squares contained observations of Blanding's Turtles. Only 64% (1,283) of those squares had recent observations (1995 or more recent). This likely underestimates the number of grid squares where the species is currently present as the Blanding's Turtle can live far more than 20 years. In addition, lack of recent records in the Ontario Reptile and Amphibian Atlas does not confirm that a species is absent (Seburn and Mallon 2015). The recent grid squares contained 1,328.8 km of road. Almost 60% of roads consisted of local roads and 90% of roads were in three categories: arterial, freeway/highway and local (Table 1). Average road length within a grid square was 1.04 km. Given that over 700 grid squares were excluded because of a lack of recent records, the total length of road within the Blanding's Turtle range may have been underestimated by hundreds of kilometres.

Table 1. Amount of various road types in 1x1 km grid squares with recent records of Blanding's Turtles.

Road type	# of km	% of total km
Arterial	275.0	20.7
Collector	90.5	6.8
Freeway/highway	139.6	10.5
Local	791.9	59.6
Ramp	10.8	0.8
Resource/recreation	20.5	1.5
Service	0.5	<0.1
Total	**1,328.8**	**100**

Road kill rate – Method 1

Using the first method, the observed kill rate was determined for 66 sections of 1 km road segments along # 7, 17, 41 and 69. The annual kill rate in each section of road varied from 0.25 - 4.0 Blanding's Turtles/km (Figure 1). Determining an accurate measure of kill rates/km is difficult. Inevitably some turtles killed on roads will be missed as the road surveys did not always span the entire active season and it is known that predators can remove turtle carcasses from roads and the median persistence time of turtles may be a little as 3 days (Santos *et al.* 2011). This will underestimate some kill rates. In contrast, some roads were only surveyed for one year, which likely overlooks stretches of road where road kill does not occur annually. Along #7, for example, with four years of surveys, many stretches of road had only one Blanding's Turtle killed every four years.

The median kill rate across these roads was 0.50 turtles/km, while the modal kill rate was 0.25 turtles/km. The modal kill rate was selected for further analyses to provide a more conservative estimate of Blanding's Turtle road mortality.

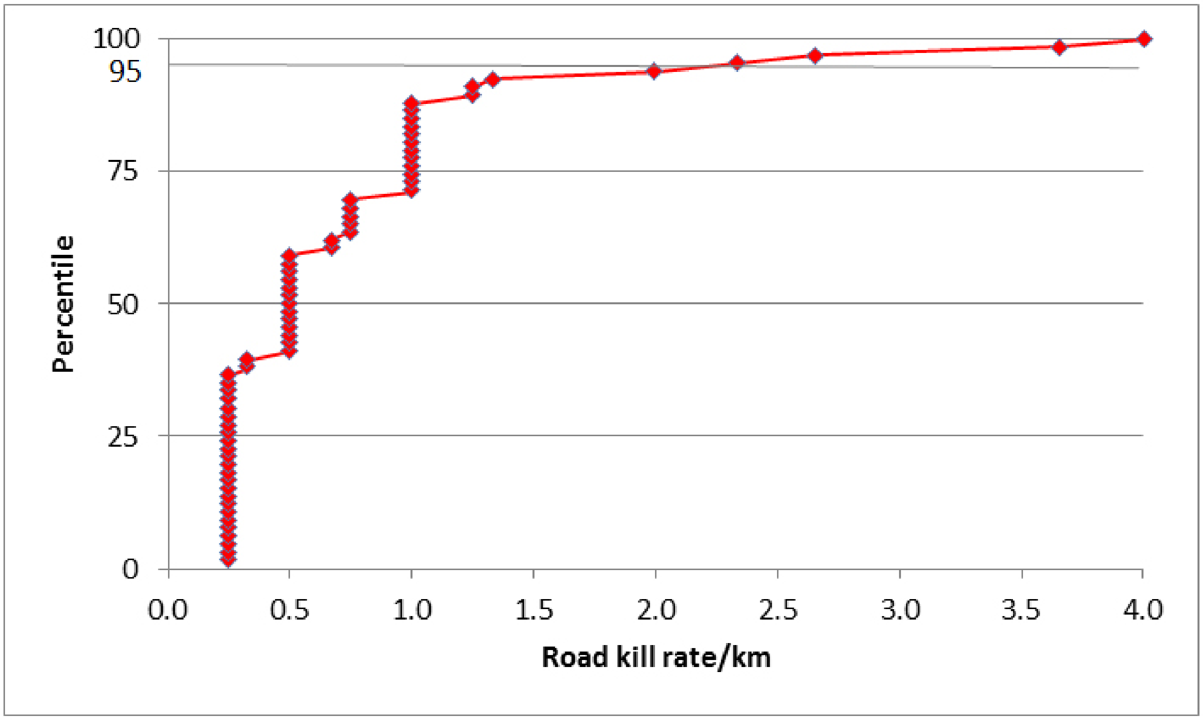

Figure 1. Observed road kill rates for adult and subadult Blanding's Turtles from systematic road surveys along four roads in Ontario expressed as percentiles.

Road kill rate – Method 2

The second method for calculating kill rates indicated that 0.07 to 1.25 turtles/km were killed across the surveyed roads (Table 2). The road kill rate along #17 is quite low, likely for two reasons. First of all, large sections of the road surveyed had no observations of Blanding's Turtles, there were no previous records of the species in these areas in the Ontario Reptile and Amphibian Atlas, and the roadside habitat appeared inappropriate. Including these large 20-30 km sections of road that likely do not have Blanding's Turtles would artificially reduce the kill rate for this road. Second of all, only eight road surveys were conducted during this study and so few surveys would undoubtedly underestimate actual levels of road kill.

In contrast, the road kill rate for #69 is quite high. This may be driven by selecting a short section of road (only 12 km) that was a known area of road kill. The road kill rates along #7 and #41 may be more meaningful as they were both determined from longer sections of road. The average road kill rates along these two roads (0.2 - 0.3 turtles/km) are quite similar to the modal kill rate determined using the first method.

Table 2. Observed road kill rates for Blanding's Turtles calculated from the total number of large juveniles or adults found dead on the road each year, divided by the number of kilometres of road surveyed.

Road	Km surveyed	# of years	Range of annual road kill rates	Mean road kill rate (if more than one yr of data)
17	100	1	0.07	N/A
7	80	4	0.175 – 0.225	0.20
41	20	4	0.15 – 0.45	0.3
69	12	3	1.08 – 1.58	1.25

Effect on population

The modal kill rate from the first method (0.25 turtles/km) and the kill rates along #7 and #41 (0.2 – 0.3 turtles/km) were used to examine the effect of road mortality on the Ontario population. Based on these three road kill rates, an estimated 265.8 to 398.6 Blanding's Turtles are killed on roads in Ontario each year (Table 3). The current draft COSEWIC report estimates that the Ontario adult Blanding's Turtle population is between 25,000 and 45,000 adults (T. Piraino personal communication). Based on a population of estimate of 25,000 adults, an estimated 1.06 – 1.59% of the population is killed each year (Table 3). Assuming a population of 45,000 adults, then an estimated 0.59 – 0.89% of the population is killed each year.

Table 3. Observed kill rates/km for Blanding's Turtles from two different methods. Total annual kill is calculated from the length of road in 1x1 km grid squares containing recent reports of Blanding's Turtles (1,328.8 km). The annual kill was then expressed as a percentage of the estimated total adult Blanding's Turtle population size in Ontario (range: 25,000 to 45,000 turtles).

Road kill rate (turtles/km)	Total annual kill	% of 25,000 population	% of 45,000 population
0.2	265.8	1.06	0.59
0.25	332.2	1.33	0.74
0.3	398.6	1.59	0.89

Assuming a current population of 25,000 Blanding's Turtles, all three road kill rates result in significant declines over the next three generations, or 120 years (Figure 2). Even taking a road kill rate of 0.2 turtles/km, the most conservative estimate, the population would decline by 50% in 65 years (Table 4).

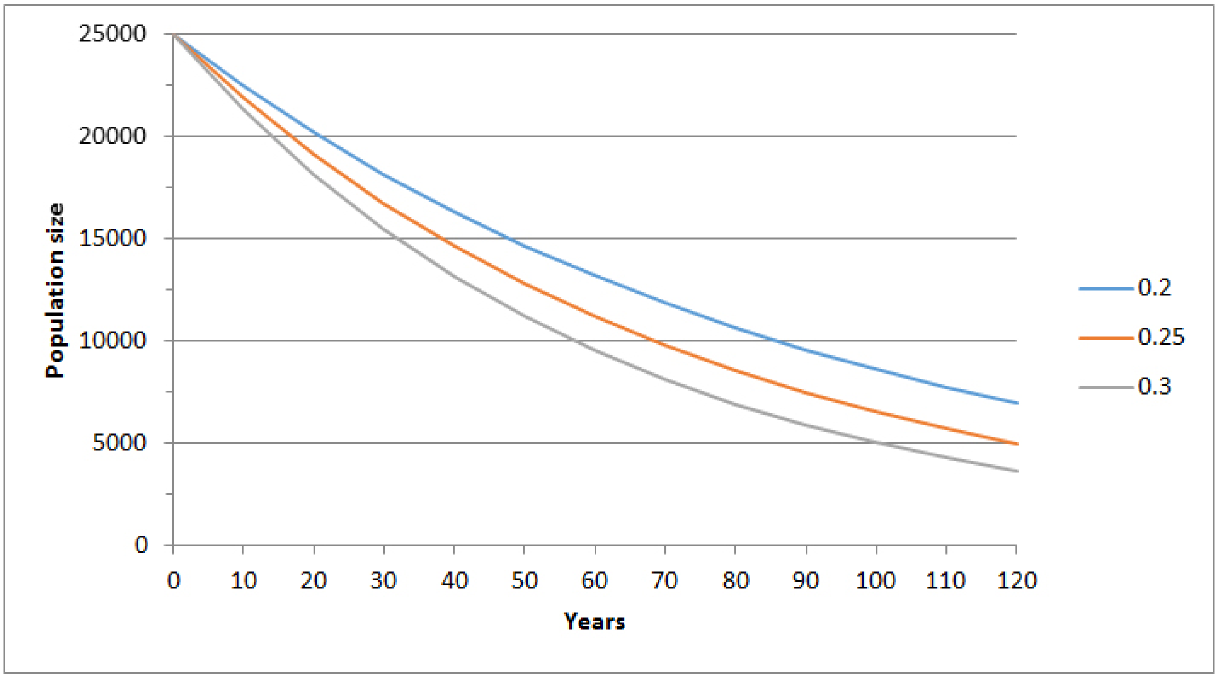

Figure 2. Estimated population decline in adult Blanding's Turtles from road kill over three generations (120 years), starting from a population of 25,000 adults and based on annual kill rates of 0.2, 0.25, and 0.3 turtles/km.

Table 4. Estimated amount of time for a 50% decline in the Ontario adult Blanding's Turtle population based on three road kill rates and two population size estimates.

Road kill rate (turtles/km)	Time to reduce population of 25,000 adults by 50% (years)	Time to reduce population of 45,000 adults by 50% (years)
0.2	65.0	117.1
0.25	51.8	93.3
0.3	43.2	77.5

Increasing the initial population size estimate to 45,000 adult Blanding's Turtles still results in a significant decline at all three road kill rates (Figure 3). The lowest road kill rate, 0.2 turtles/km, would cause the population to be reduced by 50% in 117 years, just slightly less than three generations.

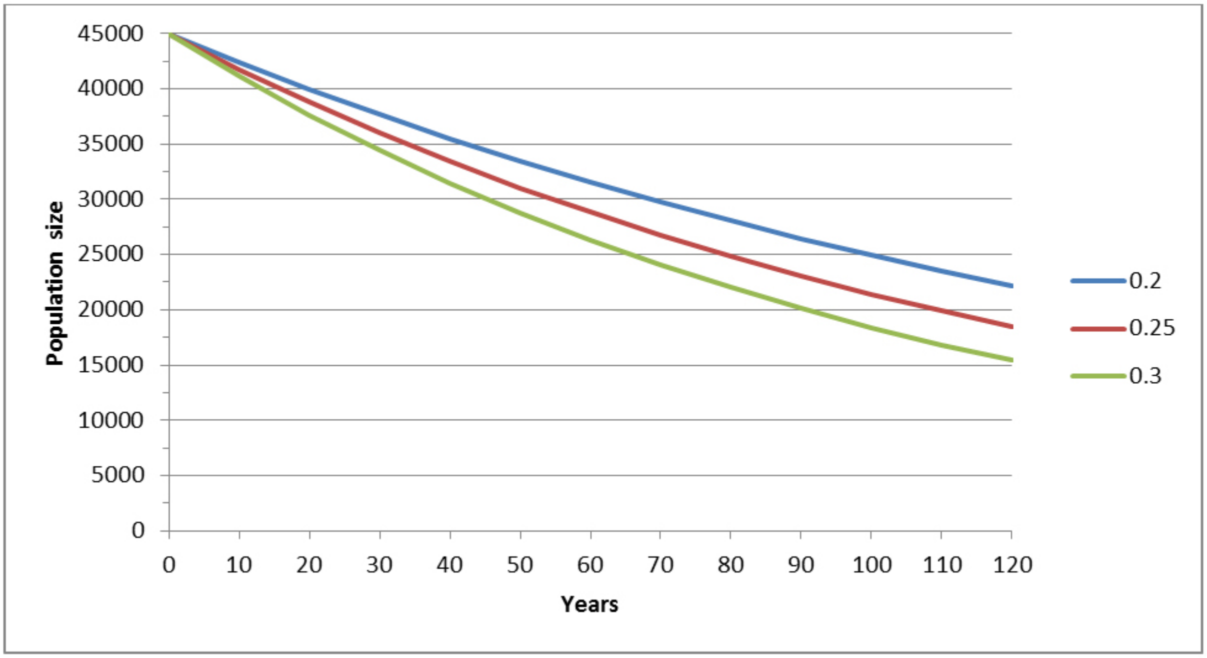

Figure 3. Estimated population decline in adult Blanding's Turtles from road kill over three generations (120 years), starting with a population of 45,000 adults and based on annual kill rates of 0.2, 0.25, and 0.3 turtles/km.

Possibly a buffer of 1 km around recent Blanding's Turtle observations has captured more roads than the turtles will likely encounter. If that is the case, our results overestimate the number of turtles killed each year. Given that Blanding's Turtle home range lengths >3 km (Grgurovic and Sievert 2005) have been documented, it seems, if anything, we have underestimated the amount of roads Blanding's Turtles will encounter.

The calculated road kill rates in this study are based on only a few roads in the province. All of these roads are major roads and may not be representative of all roads included in the provincial range of the species (see Table 1). While #7 is well known as a hotspot for turtle mortality by Ontario turtle biologists, it is noteworthy that #41 had a higher average kill rate (Table 2), despite the fact that #7 has approximately 30% higher traffic volumes than #41 (MTO 2012). Traffic volume alone does not determine the amount of road kill. Given that turtles will often become immobile when a car passes nearby (Seburn, personal observation), road mortality can result even under lower traffic volumes. We have conservatively estimated the amount of road Blanding's Turtles are exposed to as well as the road kill rates on the surveyed roads. This may compensate for the fact that road kill rates may be lower on some other roads, but we acknowledge this uncertainty.

One variable we have not included in our modelling is the growth rate of the Ontario population over time. A ten year study of Bog Turtles (*Glyptemys muhlenbergii*) found that the recruitment of new adults into the population each year approximately equalled the number of mortalities (Shoemaker *et al.* 2013). In our study, net annual adult recruitment

(recruitment – natural mortality) would have to be at least 1.06% to balance the effect of road mortality based on an estimated 25,000 adult population and the lowest road kill rate (Table 3). Although such growth rates may be possible in some areas, it seems likely that many Ontario populations demonstrate limited growth once natural mortality is included. In addition, our modelling does not take into account any increase in the amount of roads over time, or any increase in the number of vehicles on roads. For example, there were 6.9 million vehicles registered in Ontario in 2005 (NRC 2007) but this number increased to 8.2 million by 2014 (Statistics Canada 2015). In conclusion, the best evidence at hand suggests that road mortality is a widespread threat to the Blanding's Turtle and that the Ontario population will decline by more than 50% over the next three generations from this threat alone.

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