# COSEWIC
# Assessment and Status Report

on the

# Northern Map Turtle
## *Graptemys geographica*

**in Canada**

**SPECIAL CONCERN**
**2012**


**COSEWIC**
Committee on the Status
of Endangered Wildlife
in Canada

**COSEPAC**
Comité sur la situation
des espèces en péril
au Canada

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# COSEWIC
# Assessment Summary

**Assessment Summary – November 2012**

**Common name**
Northern Map Turtle

**Scientific name**
*Graptemys geographica*

**Status**
Special Concern

**Reason for designation**
There have been no quantitative, long-term studies of this species in Canada and, therefore, there is limited evidence of recent declines, range contraction or local extirpation of the species. However, the species' long-lived life history with delayed age of maturity and the potential threats to its habitat suggest that it is susceptible to population decline. Significant threats include direct mortality from collisions with motor boats and from commercial fisheries bycatch. Loss and degradation of shoreline habitat is another threat because this wary turtle is readily disturbed by human activity and boating, and shoreline developments interfere with the species' basking and nesting behaviour. Unnaturally high predation of nests by mammalian predators, especially raccoons, is another threat. If not ameliorated, these threats combined with the species' life history will cause the species to become Threatened in Canada.

**Occurrence**
Ontario, Quebec

**Status history**
Designated Special Concern in May 2002. Status re-examined and confirmed in November 2012.

COSEWIC
Executive Summary

# Northern Map Turtle
*Graptemys geographica*

## Wildlife Species Description and Significance

The Northern Map Turtle (*Graptemys geographica*) is highly aquatic. The carapace is olive to brown with a reticulate pattern of light yellow lines that fade as the turtle matures. When first described, the markings on its carapace were thought to resemble a contour map, which gave rise to the turtle's common and scientific names. Adults show extreme sexual size dimorphism with females being much larger than males. There are no recognized subspecies, despite an extensive range, and this is the only *Graptemys* species to occur within Canada.

## Distribution

Northern Map Turtles are widely distributed throughout the eastern United States, southern Ontario, and southwestern Québec. The Canadian map turtle population occurs throughout the Great Lakes-St. Lawrence basin, from Lake St. Clair, Ontario, east to Montréal, Québec. The map turtle's distribution coincides with the most densely populated and industrialized areas of Ontario and Québec. Approximately 10% of its global range is within Canada.

## Habitat

The Northern Map Turtle inhabits rivers and lakes where it basks on emergent rocks, banks, logs, and fallen trees throughout the active season. This species displays a preference for shallow, soft-bottomed aquatic habitats with exposed objects for basking near natural shorelines. In winter, the turtles typically hibernate on the bottom of deep, slow-moving sections of rivers or lakes.

## Biology

The Northern Map Turtle is gregarious and wary, and thus difficult to approach. The diet is comprised of benthic invertebrates and although both sexes feed primarily upon molluscs, adult females, being larger, can consume larger prey items than either males or juveniles. In Canada, female map turtles do not become sexually mature until at least age 12, and may lay 1-2 clutches a season with an average of 10-15 eggs per clutch. Sex of the embryos is temperature-dependent, and eggs begin hatching in late summer or early fall. Hatchlings may spend their first winter in the nest before emerging the following spring. Canadian map turtles typically hibernate communally for approximately 5-6 months of the year. The hibernaculum must be highly oxygenated as this species is anoxia-intolerant. Northern Map Turtles display fidelity to both hibernacula and nest sites.

### Population Sizes and Trends

There are few baseline data on population sizes or trends for the Northern Map Turtle in Canada, making it impossible to quantify either measure for the total Canadian population. However, recent short-term studies have provided preliminary estimates of abundance of a few local populations. Extrapolations of local numbers to the entire range of the species indicate at least several thousand mature animals, but because these extrapolations are based on small areas with exceptional densities, the total abundance estimate calculated in this manner would probably be inflated and highly imprecise. Several observed threats are believed to be contributing to significant declines across this species' Canadian range.

### Threats and Limiting Factors

The life-history strategy of turtles (low juvenile recruitment, late maturity, long lifespan, and high adult survivorship) makes them susceptible to population decline when subjected to increases in annual adult mortality rates as small as 1-3%. With population persistence critically dependent on high rates of adult survival, the most serious threats to the Northern Map Turtle are human-related activities that increase adult mortality. Human interference through shoreline development and recreational activities may prevent individuals from using suitable areas of habitat along major waterways. Furthermore, there is strong evidence that many Northern Map Turtle populations are subject to injury and mortality from recreational boat use, and that these collisions are sufficient to extirpate populations when occurring at rates typical of many recreational lakes and rivers. Control of waterways, particularly through damming and lock systems, also has a negative impact on this species by submerging nest sites, altering habitat, and creating impediments to movement. Road mortality also presents a serious threat to some map turtle populations living near roads. Commercial fisheries bycatch poses another serious local threat to map turtles, and one population was documented losing 5.5% of captured individuals in a season solely to drowning in fishing nets. The increase in international wildlife trade of turtles may also threaten this species. Lastly, any pollution or siltation of water bodies that reduces the distribution or abundance of molluscs would be detrimental to map turtle populations given the map turtle's dietary specialization.

## Protection, Status, and Ranks

The Northern Map Turtle was designated 'Special Concern' by COSEWIC in 2002 and is listed as such both nationally and in Ontario. It is considered a 'specially protected species' under the OMNR *Fish and Wildlife Conservation Act* (1997), which proscribes hunting, trapping, keeping in captivity, and trading Northern Map Turtles without a licence or permit. As a species of Special Concern, map turtle habitat should be protected under the Provincial Policy Statement of the *Ontario Planning Act* (R.S.O. 1990, c.P.13). Furthermore, the map turtle receives protection by law where it resides in national parks and wildlife areas, provincial parks, and conservation areas. In Québec, the map turtle is listed as Vulnerable under the provincial *Loi sur les espèces menacées ou vulnérables* (R.S.Q., c. E-12.01) and receives protection under the provincial *Loi sur la conservation et la mise en valeur de la faune* (2002) (R.S.Q., c. C-61.1). This Act also protects map turtle nests from disturbance, destruction or alteration and keeping or selling of individuals is prohibited by the *Règlement sur les animaux en captivité*. Habitat of the map turtle in Québec is also protected under the *Loi sur la qualit*é *de l'environnement*. It is ranked 'secure' (N5) both globally and within the US. It is ranked 'vulnerable' in Canada (N3) and S3 in Ontario and Québec. Its General Status Rank in Canada and Ontario is 'sensitive', whereas in Québec, it is 'may be at risk'.

# TECHNICAL SUMMARY

*Graptemys geographica*
Northern Map Turtle — Tortue géographique
Range of occurrence in Canada: Ontario, Québec

**Demographic Information**

| | |
|---|---|
| Using the IUCN estimator: Generation time: GT = 1/annual mortality rate + age at maturity (years). The age of maturity (12 years and rate of mortality are discussed in sections on 'Longevity and Development' and 'Mortality' respectively. Annual natural mortality rate was set slightly lower than measured rates because the natural rate is likely to be lower than rates affected by anthropogenic factors.<br><br>Therefore, GT = 1/0.05 + 12 = 32 years and 3 generations is 96 years. | 32 years |
| Is there an observed, inferred, or projected continuing decline in number of mature individuals? | Inferred and projected decline. |
| Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations] (64 years).<br><br>It is estimated that many populations experience >5% adult mortality annually, which would produce inevitable decline. | Unknown, but it is highly probable that many populations are declining. |
| Suspected percent reduction in total number of mature individuals over the last 3 generations (96 years). | Unknown, but likely substantial. |
| Suspected percent reduction in total number of mature individuals over the next 3 generations (96 years). | Unknown, but continuing reduction seems certain if threats are not addressed. |
| Suspected percent reduction in total number of mature individuals over any 3 generations period over a time period including both the past and the future. | Unknown, but likely substantial. |
| Are the causes of the decline clearly reversible and understood and ceased? | Understood but not necessarily reversible and not ceased<br>(see Threats). |
| Are there extreme fluctuations in number of mature individuals? | No |

**Extent and Occupancy Information**

| | |
|---|---|
| Estimated extent of occurrence | 414,465 km² (minimum convex polygon only including Canada's extent of jurisdiction) |
| Index of area of occupancy (IAO)<br>(Always report 2x2 grid value). | > 2000 km² |
| Is the total population severely fragmented? | Probably not |
| Number of locations* | Unknown, but likely >> 10 |
| Is there an inferred continuing decline in extent of occurrence? | Unknown |
| Is there an inferred continuing decline in index of area of occupancy? | Unknown |
| Is there an inferred continuing decline in number of populations? | Unknown |
| Is there an inferred continuing decline in number of locations*? | Unknown |

* See Definitions and Abbreviations on COSEWIC website and IUCN 2010 for more information on this term.

| | |
|---|---|
| Is there an observed continuing decline in quality of habitat? | Yes, due to dams and locks and increased boating/recreational activity and shoreline development. (see Threats) |
| Are there extreme fluctuations in number of populations? | 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 population)**

| **Population** | **N Mature Individuals** |
|---|---|
| Lake Opinicon, Rideau Canal Waterway | 652<br>Males= 335 (95% C.I.: 281-391)<br>Females= 317 (95% C.I.: 243-391) |
| Trent-Severn Waterway (section from Peterborough to Trenton) | >163 |
| Point Pelee National Park, Lake Erie | >163 |
| Rondeau Provincial Park, Lake Erie | ~300 |
| Long Point NWA, Lake Erie | >300 |
| Grand River (section from York to Paris) | >300 |
| Thames River (section from London to Delaware) | >300 |
| Ottawa River (Eastern portion of the Lac des Deux-Montagnes region) | >228 |
| Ottawa River (Western portion of the Lac des Deux-Montagnes region) | >46 |
| Ottawa River (Westmeath Provincial Park) | >181 |
| Ottawa River (Bristol region, east of Norway Bay) | >128 |
| Carroll's Bay Marsh, Royal Botanical Gardens, Lake Ontario | >188 |
| St. Lawrence Islands National Park (Grenadier Island) | >352 |
| Lost Bay, Gananoque River Waterway | >83 |
| All other populations, including those in Georgian Bay | Unknown |
| Minimum Adult Population | 3200 |
| **Total Population** | Unknown, but likely more than 10,000 adults (see 'Abundance') |

**Quantitative Analysis**

| | |
|---|---|
| Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years]. | n/a |

**Threats (actual or imminent, to populations or habitats)**

- habitat destruction/alteration: industrialization, siltation of waterways from agriculture, watershed "clean-up" that includes removal of basking structures, damming waterways, shoreline development, especially destruction of nest sites
- flooding of nests and nest sites in dammed/controlled waterways
- high rates of nest predation by "urbanized" mammalian predators
- mortality from collision with outboard motors on all motorized watercraft
- road mortality in areas where turtles nest on or crossroads
- fisheries bycatch
- commercial turtle trade
- long-lived life history, delayed age of maturity (≥ 1 2 years for females), and low juvenile recruitment make this species highly susceptible to population declines from increases in adult mortality rates as low

* See Definitions and Abbreviations on COSEWIC website and IUCN 2010 for more information on this term.

| |
|---|
| as 1-3% annually |

**Rescue Effect (immigration from outside Canada)**

| | |
|---|---|
| Status of outside population(s)? | Varies ('Critically Imperiled' to 'Secure') |
| Is immigration known or possible? | Unknown, but possible (see Rescue Effect) |
| Would immigrants be adapted to survive in Canada? | Yes |
| Is there sufficient habitat for immigrants in Canada? | Likely |
| Is rescue from outside populations likely? | Unknown, but possible |

## Status History

| |
|---|
| **COSEWIC**: Designated Special Concern in May 2002. Status re-examined and confirmed in November 2012**.** |

**Status and Reasons for Designation**

| | |
|---|---|
| **Status:**<br>Special Concern | **Alpha-numeric code:**<br>Not applicable |
| **Reasons for designation:**<br>There have been no quantitative, long-term studies of this species in Canada and, therefore, there is limited evidence of recent declines, range contraction or local extirpation of the species. However, the species' long-lived life history with delayed age of maturity and the potential threats to its habitat suggest that it is susceptible to population decline. Significant threats include direct mortality from collisions with motor boats and from commercial fisheries bycatch. Loss and degradation of shoreline habitat is another threat because this wary turtle is readily disturbed by human activity and boating, and shoreline developments interfere with the species' basking and nesting behaviour. Unnaturally high predation of nests by mammalian predators, especially raccoons, is another threat. If not ameliorated, these threats combined with the species' life history will cause the species to become Threatened in Canada. | |

**Applicability of Criteria**

| |
|---|
| **Criterion A** (Decline in Total Number of Mature Individuals):<br>Not applicable. Although this species is declining there are no data to estimate the size of this decline. |
| **Criterion B** (Small Distribution Range and Decline or Fluctuation):<br>Not applicable. The EO and IAO exceed thresholds. |
| **Criterion C** (Small and Declining Number of Mature Individuals):<br>Not applicable. Population size exceeds thresholds. |
| **Criterion D** (Very Small or Restricted Total Population):<br>Not applicable. |
| **Criterion E** (Quantitative Analysis):<br>Not applicable. |

## PREFACE

Since the previous status assessment in 2002, several short- and medium-term field studies have been conducted on this species in Ontario and Québec. Preliminary data suggest that population numbers are higher than thought at the time of the previous assessment; however, these higher estimates are clearly a result of increased sampling efforts rather than actual recruitment into populations. In fact, despite these higher estimates, it still appears highly likely that populations are declining due to several observed and quantified threats, the most serious of which include: boat mortality, habitat loss and degradation, fisheries bycatch, and reduced nest success due to flooding by dams and greater numbers of mammalian nest predators. Historical data that would provide conclusive evidence of decline, stability, or growth of Northern Map Turtle populations over the past three generations (~96 years) are lacking. Research over the last 10 years has produced a better understanding of the Northern Map Turtle's Canadian distribution, abundance, movement patterns, habitat use and preferences, population demographics, nest success, and physiology. Studies focused on mortality from collisions with motor boats and from commercial fishing bycatch indicate that these activities have been responsible for past and continuing declines.

## 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
**(2012**)

| | |
|---|---|
| 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 Canada / Environnement Canada
Canadian Wildlife Service / Service canadien de la faune
Canada

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

# COSEWIC Status Report

on the

# Northern Map Turtle
*Graptemys geographica*

**in Canada**

2012

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# WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

"In the summer of the year 1816, I discovered in a marsh, on the borders of Lake Erie, a tortoise, which I have reason to believe is a nondescript…The stripes and markings on the disk, presenting the appearance of a geographical map, gave rise to the trivial name which I have bestowed on this tortoise." (LeSueur 1817)

## Name and Classification

The Northern Map Turtle, *Graptemys geographica* (Boundy *et al*. 2008) was first noted on the shores of Lake Erie in 1816 (Le Sueur 1817). Its name arises from the markings on its carapace which resemble the contour lines of a map (Graptos = inscribed or painted; geo = earth; graphic = line drawing) (Froom 1971; Johnson 1989). Other synonyms for this species include the French common names tortue géographique and graptémyde géographique (Desroches and Rodrigue 2004), as well as the previously used English name, Common Map Turtle (Boundy *et al*. 2008), which has not been officially used since 2001.

Comprising 12 species, *Graptemys* is the most speciose genus in the family Emydidae (Order: Testudines) and ranks among the more speciose of all turtle genera. The name of *Graptemys geographica* has changed many times [*Testudo geographica* (Le Sueur 1817), *Emys geographica* (Say 1825), *Terrapene geographica* (Bonaparte 1830), *Emys megacephala* (Holbrook 1844), *Emys labyrintha* (Dumeril 1851), *Graptemys geographica* (Agassiz 1857), *Clemmys geographica* (Strauch 1862), *Malacoclemmys geographica* (Cope 1875), *Malacoclemmys geographicus* (Davis and Rice 1883); recorded in McCoy and Vogt 1990]. The distinct *Graptemys geographica* lineage had formed by 6-8 million years ago (Lamb *et al*. 1994). No subspecies have been described (McCoy and Vogt 1990).

## Morphological Description

The carapace is olive to brownish with a reticulate pattern of light yellow lines that often fade as the turtle matures. The carapace is oval, elongate, and low, with a shallow medial keel, and the posterior marginal scutes range from roughly serrated (Froom 1971), to somewhat denticulate (Babcock 1919), to not strongly serrated (McCoy and Vogt 1990). In young turtles, the carapace is more strongly keeled and deeply notched posteriorly and laterally. The plastron is light yellow to cream, usually unmarked, but sometimes with a pattern of concentric dark rings on the bridges (McCoy and Vogt 1990), or a central blotch (Babcock 1919). The undersides of the marginal scutes are light with concentric dark markings centred forward of each suture (Logier 1939). The head, neck, and limbs are a dark, olive green with longitudinal, greenish-yellow stripes, and a roughly triangular spot lies behind each eye, separated from the orbit by two or three stripes (McCoy and Vogt 1990). All *Graptemys* species, particularly the females, are characterized by a broad head with strong, broad crushing surfaces in the jaws (Anderson 1965), which are exaggerated in molluscivorous populations (McCoy and Vogt 1990). Northern Map Turtles exhibit marked sexual dimorphism. The female carapace may exceed 25 cm in length, whereas the male carapace length is on average 14 cm (Froom 1971). Males average only 20% of the mass of females (Vogt 1980). Males have a smaller head, much thicker and longer tail, relatively larger hind feet, greater retention of juvenile keel and colouration, and a more angular rear margin of the carapace (Carr 1952). See Figures 1 and 2.

### Population Spatial Structure and Variability

The movements of Northern Map Turtles living along rivers and waterways are restricted by locks and dams, and it has been speculated that locks and dams may create genetic structure across such infrastructure. However, recent observations suggest that although locks and dams present formidable barriers to movement, they are not impermeable to this species. For example, on the Trent-Severn Waterway, three marked females and a male were found in different lock sections than where they were originally captured, and a lockmaster confirmed seeing a radiotagged female floating within a lock (Bennett *et al*. 2010). Furthermore, even very large dams like that on the Thames River in London, Ontario, do not necessarily present impassable obstacles for map turtles. For instance, an adult gravid female managed to scale the Fanshawe Dam's large steep embankment, representing approximately a 30-m climb over large rip rap pieces and crevices (Gillingwater pers. comm. 2011).

Genetic analyses confirm some gene flow between populations fragmented by locks and dams. A study along the Trent-Severn Waterway found no significant linkage disequilibrium between map turtles on either side of a barrier, and allelic richness or heterozygosity was not affected by apparent fragmentation related to dams and locks (Bennett *et al*. 2010). Furthermore, the number of barriers between sites did not correlate with genetic differentiation. Currently, the best model to explain the genetic structure of Northern Map Turtles on the waterway is that of a single, panmictic population. However, this does not negate the possibility of detecting genetic distinction in the future once more generations have passed, particularly as evidence suggests that these structures do restrict movements of adult females (Bennett *et al*. 2010).

An unpublished genetic study investigated the characterization of seven different populations in Canada (Lake Champlain, various regions along the Ottawa River including Pembroke, Finlay Islands, Bristol, Fitzroy Harbour, and Petrie Island, as well as rivière des Mille-Iles near Montreal) (Tessier and LaPointe 2009). Preliminary analyses suggested that most of these populations were genetically distinct from one another. The sample from Lake Champlain was most different, followed by that from Mille-Iles. The populations located along the Ottawa River were more similar to each other, but still distinguishable. The Lake Champlain population showed the greatest genetic distinction from the Thousand Islands population ($F_{ST}$ = 0.128, $R_{ST}$ = 0.554). However, the authors commented in their report that lack of funds made the genetic analysis incomplete and kept sample sizes small. Perhaps, the most that can be said is that there appears to be significant $F_{ST}$ and $R_{ST}$ variation among populations separated by dams and locks, but the significance of these variations to genetic structure of the species requires more research. For example, given the long generation time, do measures of rate of genetic exchange based on $F_{ST}$ values presented in the report reflect past or present rates?

**Designatable Units**

Thus far, there is no definitive evidence that Northern Map Turtle populations in Canada have significant genetic structure. Although a preliminary study by Tessier and Lapointe (2009) suggests that Northern Map Turtle populations in the Ottawa River and Lake Champlain may be genetically distinct from one another, further investigation is necessary to assess the relevance of genetic structure to potential designatable units. For example, this species displays low levels of genetic variation, which is unusual given its extensive range and suggests a recent (Holocene) northward expansion (Ernst and Lovich 2009).

Additionally, although some populations appear naturally disjunct (occurring in different river systems) or occupy different eco-regions (Great Lakes/St. Lawrence Faunal Province or Carolinian Faunal Province), there is no evidence of local adaptation or significant differences in population trends or factors affecting them. Therefore, there is no current evidence to warrant more than one status designation for this species in Canada.

**Special Significance**

The Northern Map Turtle has the widest distribution of all *Graptemys* species, and it is the only member of the genus to occur in the Atlantic drainages of North America (Ernst and Lovich 2009). Approximately 10% of the global range is in Canada (Seburn 2007).

The Northern Map Turtle is highly molluscivorous (Ernst and Lovich 2009) and some populations consume large amounts of invasive Zebra and Quagga Mussels (*Dreissena* spp.) and Asian Clams (*Corbicula fluminea;* Lindeman 2006b; Bulté and Blouin-Demers 2008; Richards-Dimitrie and Seigel 2010).

The Northern Map Turtle also has some interesting morphological traits. For instance, it displays extreme sexual dimorphism with adult females attaining approximately double the carapace length and up to 10 times the mass of adult males (Bulté and Blouin-Demers 2008; Ernst and Lovich 2009) (Figure 1). This size dimorphism has led to tests of several interesting ecological and evolutionary hypotheses (Bulte *et al.* 2008 a,b; Bulte and Blouin-Demers 2009; 2010a). In addition, embryo sex is temperature-dependent and hatchlings are adapted to overwinter in the nest before emerging the following spring (Ernst and Lovich 2009). This species is anoxia-intolerant and overwintering in the nest by hatchlings may have evolved as an adaptation to avoid aquatic hibernacula that may become anoxic (Reese *et al*. 2001).

No ATK was available for this species.

Figure 1. Adult Male (top) and Female (bottom) Northern Map Turtles. Photo by: Scott Gillingwater.

Figure 2. Adult Female Northern Map Turtle. Photo by Scott Gillingwater.

## DISTRIBUTION

### Global Range

The Northern Map Turtle has a fairly extensive range throughout the northeastern United States (Figure 3). Its range extends westward through the Great Lakes Drainage to Wisconsin, and the Mississippi Drainage from central Minnesota south to northern Louisiana and west to eastern Oklahoma and Kansas. It is found throughout the Tennessee River Drainage, in streams above the Fall Line in the Tombigbee River Drainage of Alabama, and in the Ohio Drainage from West Virginia to Illinois. Isolated populations occur in the Susquehanna Drainage in Pennsylvania (eastern range limit) and Maryland, the Delaware River from the mouth northward to Sussex County, New Jersey and the lower Hudson River, New York (Patch 1925; Logier 1939; McCoy and Vogt 1990). Its range extends northward into Canada.

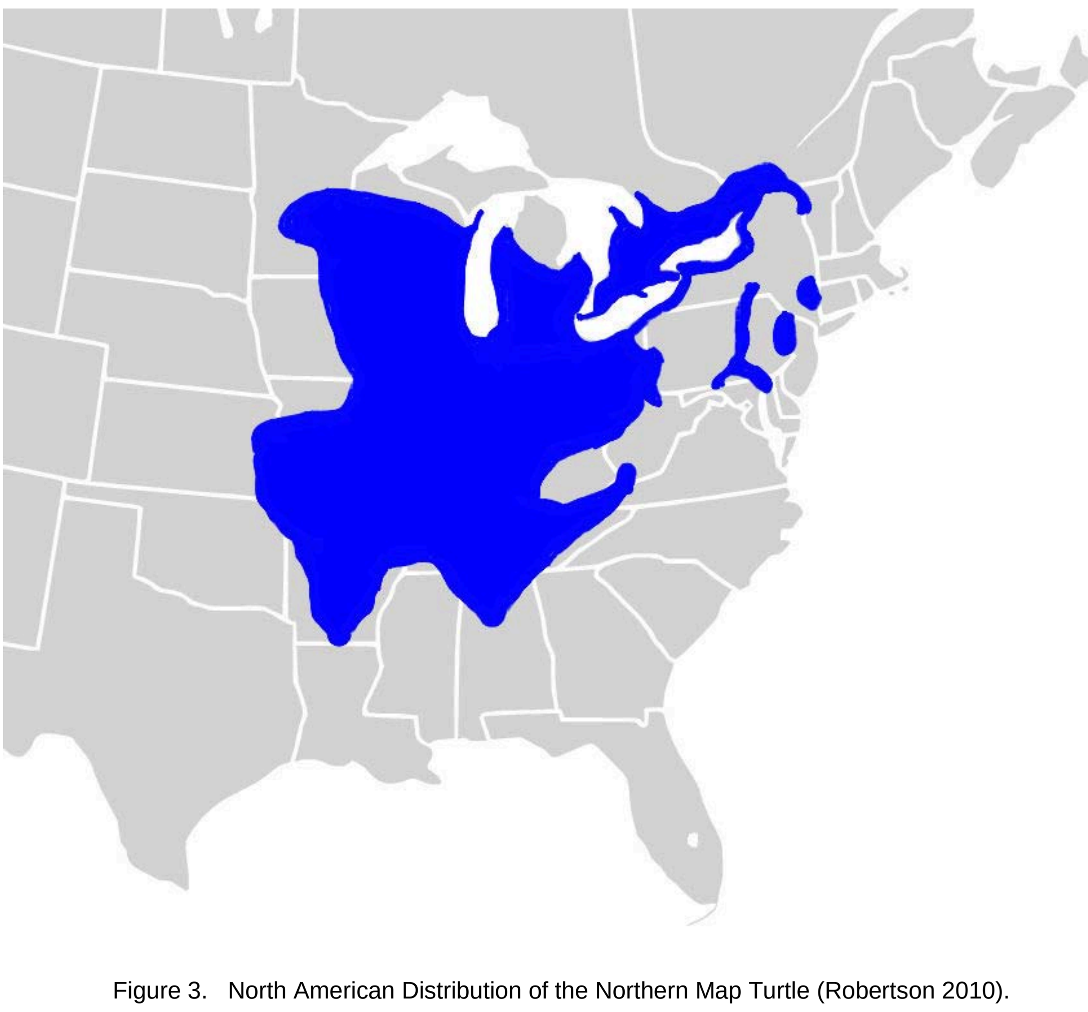
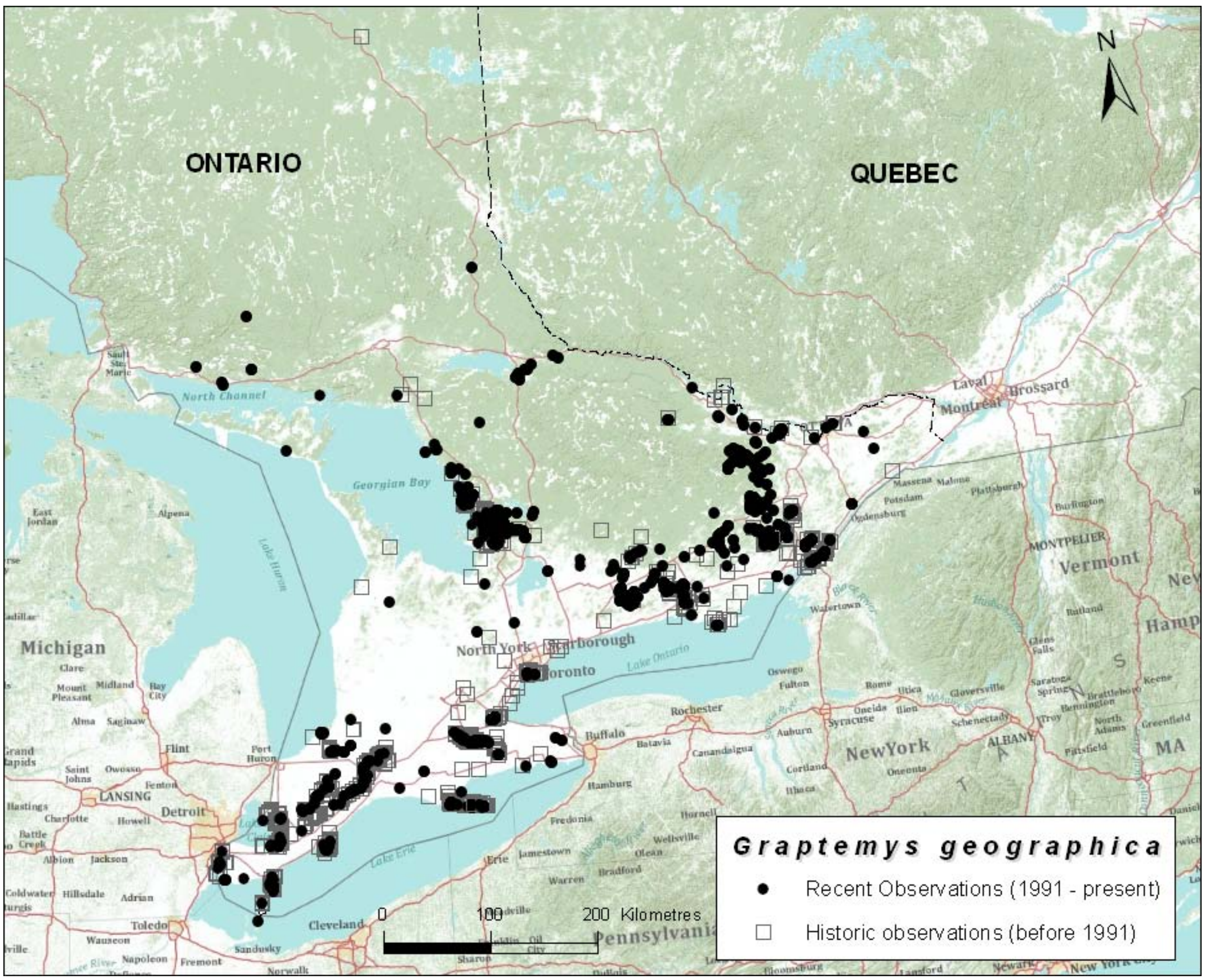


Figure 3. North American Distribution of the Northern Map Turtle (Robertson 2010).

## Canadian Range

The Canadian range of the Northern Map Turtle is limited to central and southern Ontario (Figure 4) and to southwestern Québec (Figure 5), and represents the northern limit of the species' distribution. The physiography and climate of eastern Canada are varied and strongly influence the abundance and distribution of reptiles and amphibians (Bleakney 1958). The majority of the Canadian map turtle population is found within the St. Lawrence Lowlands, which are bounded by mountainous country to the north and south. In southern Québec, turtles are also limited by cooler temperatures in the foothills of the Canadian Shield and in eastern Québec they are limited by the increasing salinity of the St. Lawrence River (Bleakney 1958).




Note: Comments from J.Trottier (MNR Sault Ste. Marie District) suggest that observations north of Lake Huron's North Channel are likely misidentifications. Thus, the northernmost observation at Cochrane is also likely a misidentification.

Figure 4. Distribution of Northern Map Turtle in Ontario (Jenny Wu, Environment Canada 2012).

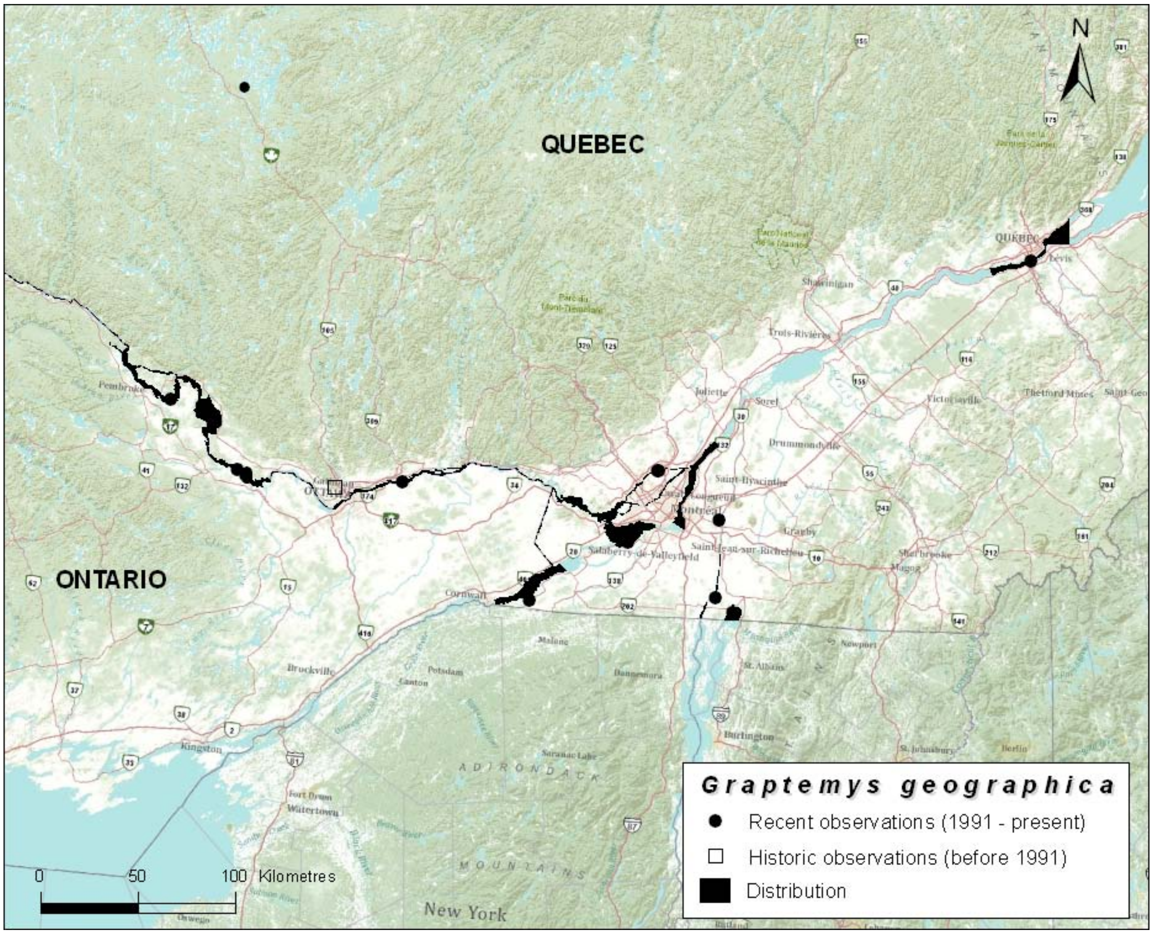


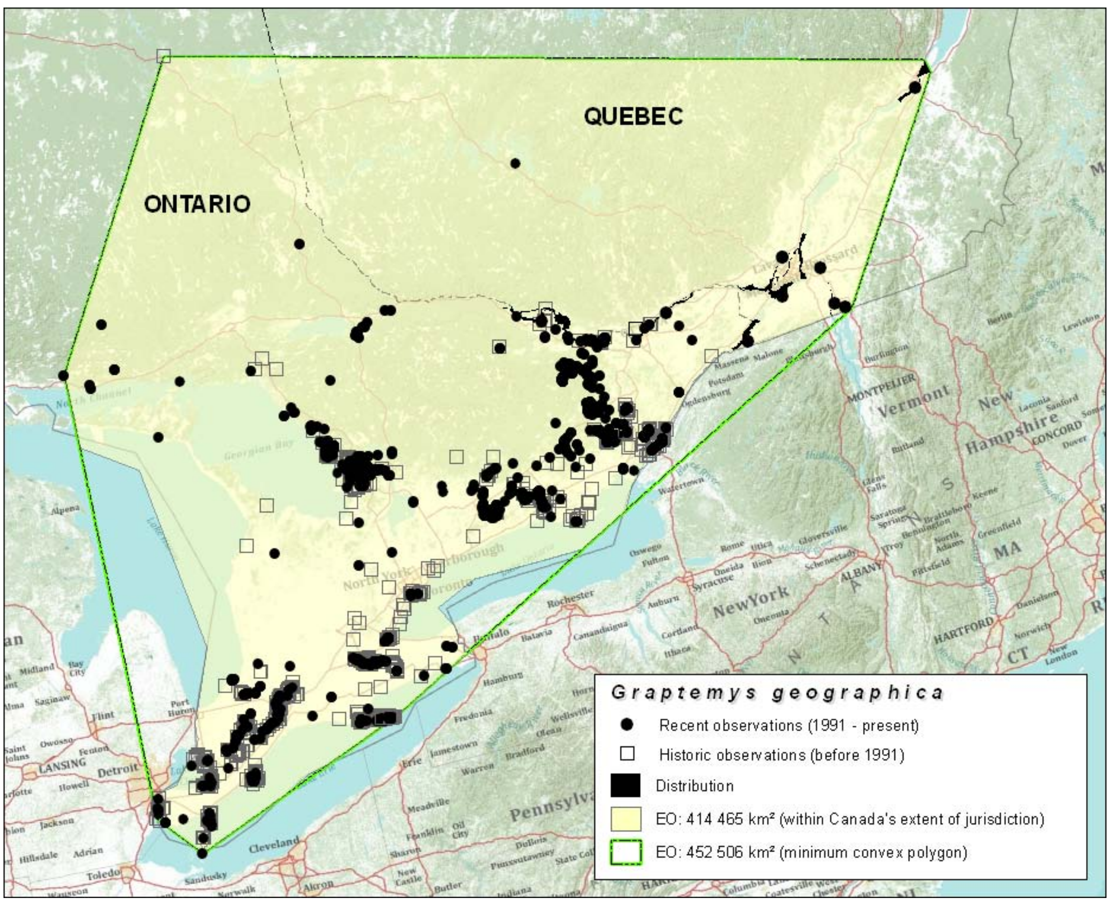

Figure 5. Distribution of Northern Map Turtle in Quebec (Jenny Wu, Environment Canada 2012).

Bleakney (1958) considers the present species' distribution to be a result of postglacial immigrations from refugia outside the margins of ice sheets. One of the main avenues of dispersal would have been from the south through the Mississippi River and tributary valleys, into the Great Lakes, and through the St. Lawrence River system.

In southwestern Ontario, the Northern Map Turtle occurs along the shorelines of Lake St. Clair, Lake Erie, and Lake Ontario. It also occurs in all major tributaries of the Lower Great Lakes, including the Ausable, Detroit, Grand, Sydenham, and Thames rivers. In southeastern and central Ontario, this species appears to be widely distributed throughout the lakes, rivers, and waterways of the Canadian Shield. This distribution includes eastern Georgian Bay; the French, Wanapitei, Mattawa, Ottawa, and St. Lawrence rivers; the Gananoque, Rideau Canal, and Trent-Severn waterways; and a multitude of lakes such as Lake Simcoe, Lake Couchiching, Lake Muskoka, the Kawartha Lakes, Trout Lake in North Bay, and the lakes of Frontenac Provincial Park (Froom 1971; Cook 1981; Lamond 1994; Cebek *et al*. 2005; Barrett Beehler 2007; Bulté and Blouin-Demers 2008; Bennett *et al*. 2009, OMNR (Brownell pers. comm. 2012).

In Québec, the map turtle can be found along the St. Lawrence River between Ile-d'Orléans and Lac St-François; in the Richelieu River east of Montréal from Basin of Chambly south to Baie Mississquoi of Lake Champlain; and along the Ottawa River from Montréal to Deep River. The principal populations occur in the Ottawa River, at Lac des Deux-Montagnes (near Montréal) and in the Bristol region (near Norway Bay west of Gatineau). Smaller populations exist in the Basin of Chambly, the Richelieu River, and in Lac St-François (Gordon and MacCulloch 1980; Flaherty 1982; Daigle *et al*. 1994; Daigle and Lepage 1997; Bernier and Rouleau 2010; Toussaint pers. comm. 2010; CDPNQ 2011).

The extent of occurrence (EO) for this species within Canada's extent of jurisdiction is 414,465 km². This estimate was calculated by minimum convex polygon encompassing all historical and recent observations with areas outside of Canada's jurisdiction removed (Figure 6).




Note: Comments from J.Trottier (MNR Sault Ste. Marie District) suggest that observations north of Lake Huron's North Channel are likely misidentifications. Thus, the northernmost observation at Cochrane is also likely a misidentification. Removal of these 6 locations would greatly reduce the EO for this species.

Figure 6. Extent of occurrence (EO) of the Northern Map Turtle in Canada. Calculated using a minimum convex polygon encompassing all historical and recent observations within Canada's extent of jurisdiction (Jenny Wu, Environment Canada 2012).

The index of area of occupancy (IAO) was calculated by summing the area under 2 $km^2$ x 2 $km^2$ grids overlain on both historical and recent Northern Map Turtle sightings in Canada. This produced an IAO estimate of greater than 2000 $km^2$ (Figure 7).

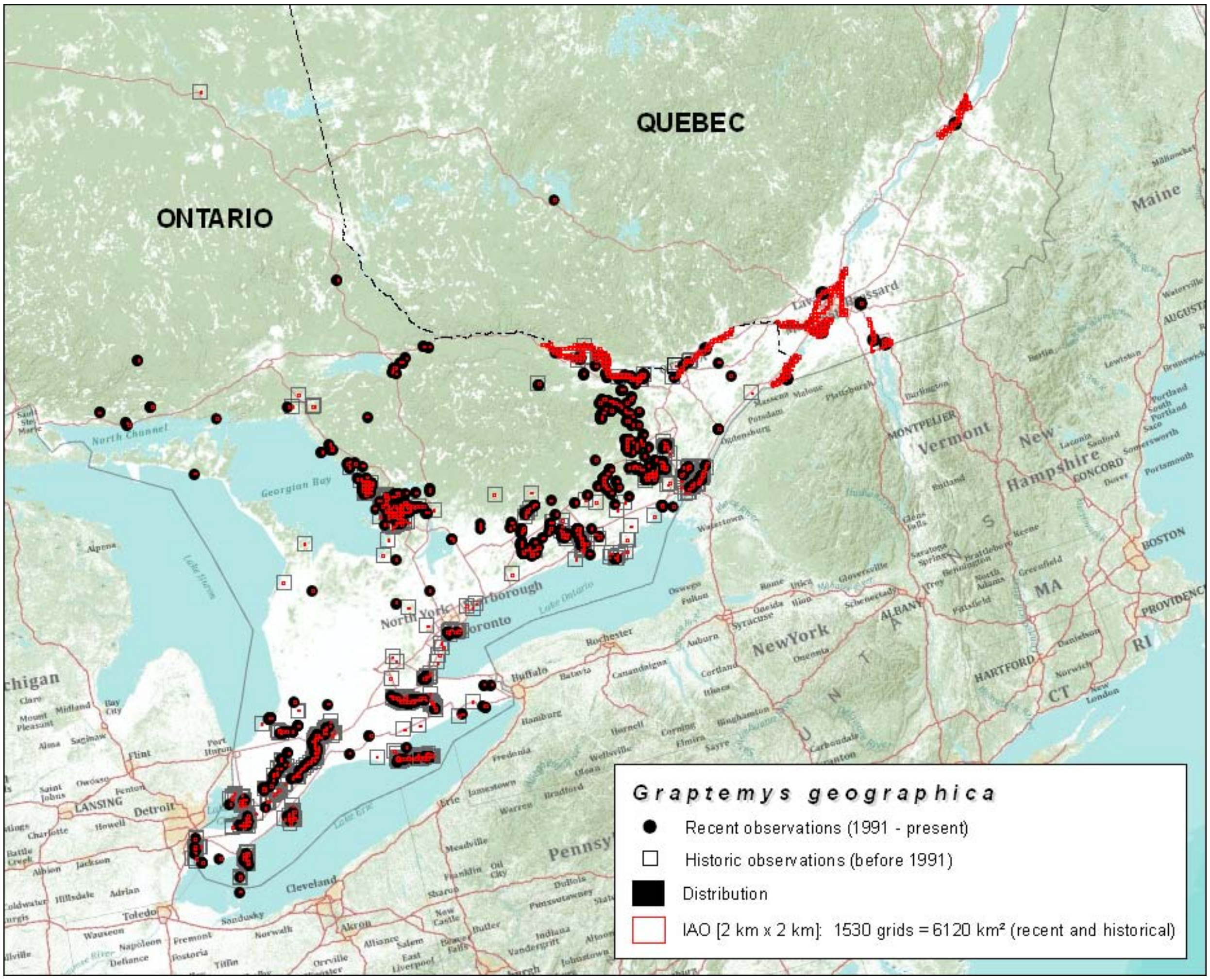



Figure 7. Index of area of occupancy (IAO) of the Northern Map Turtle in Canada. Calculated using historical and recent sightings within a 2 x 2 km grid (Jenny Wu, Environment Canada 2012).

## Search Effort

The first published record of the Northern Map Turtle in Canada was from Garnier (1881) who mentioned "*Malacoclemmys geographica*" in his list of Ontario reptiles. A few decades later, Logier (1925) and Patch (1925) reported sightings at Point Pelee, Ontario in 1920, and Norway Bay, Québec, in 1922, respectively. Since the early 1980s, several studies and presence/absence surveys have also been conducted in Ontario and Québec. In particular, the volunteer reporting programs known as the Ontario Herpetofaunal Summary Atlas, the Ontario Reptile and Amphibian Atlas, and the Atlas des amphibiens et reptiles du Québec have provided much of what we know regarding the distribution of this species in Canada. See Table 1 for a summary of search effort.

**Table 1. Search effort: Presence/absence surveys for the Northern Map Turtle in Canada.**

| Time Frame | Area Searched | Method | Targeted Survey? | Person Hours/ Trap Days | # of Map Turtles Observed | Source |
|---|---|---|---|---|---|---|
| 2003 | Ausable River --> ~30% of watercourse surveyed | Visual surveys by canoe or walking | YES | ? | 5 | NHIC, unpub. data 2003 |
| June 2-Sept 2, 2004 | Ausable River --> 75 km (including Hay Swamp, Thedford Bog, Old Ausable Channel, some spots up and downstream of Exeter, and Cassidy Rd. to Hwy 6/7) | Visual surveys by canoe, by walking, and spot surveys | YES | 19 days 172.25 person hours | 14 confirmed 48 possible | Stewart 2004 |
| 2010-2011 | French River | Visual surveys | NO | n/a | 30-40 | Cobb pers. comm. 2012 |
| 2009 and 2010 | Grand River--> Dunnville Marshes | Visual surveys by canoe | YES | ? | 0 | Zamitt pers. comm. 2011 |
| 2009-2010 | Grand River--> Downstream of Brantford | Visual surveys by canoe and from road | NO | 3 days | -In 2009, 65 by canoe and 32 by road survey<br>-In 2010, 69 by canoe survey | Beck pers. comm. 2011 |
| 1992, 1999 | Ottawa River--> 12.7km stretch east of Norway Bay (near Bristol) | Visual surveys by motorboat | YES | 14 days | Average of 54.1 individuals per day | Chabot *et al*. 1993 |
| 1992 | Ottawa River--> Hull to Quyon | Visual surveys | YES | ? | 198 Total (7 btwn RDJ to Downey Bay, 52 at Fraser Island, 54 at lac des Chats, and 85 near Norway Bay) | Daigle *et al.* 1994 |

| Time Frame | Area Searched | Method | Targeted Survey? | Person Hours/ Trap Days | # of Map Turtles Observed | Source |
|---|---|---|---|---|---|---|
| 1993-2010 | Ottawa River --> at CFB Petawawa (including mouth of Petawawa River, Chalk Bay, and Sturgeon Lake) | Visual surveys by boat and walking along shoreline | NO (general SAR surveys) | ? | ~150 | Richard 2011 |
| Aug-Sept 2000 | Ottawa River--> Upstream of Lac des Deux Montagnes to Fitzroy Harbour | Visual surveys | YES | 125h | 38 | MRNF unpub. data 2010 |
| Summer 2000 | Ottawa River--> Hull to Papineauville | Visual surveys | YES | ? | 12 | MRNF unpub. data 2010 |
| 2010 (early May, late June, Sept) | Ottawa River--> Lac des Deux Montagnes (at Oka National Park) | Visual surveys | YES | ? | 0 | Bernier and Rouleau 2010 |
| 2011 | Ottawa River--> Claredon sector | Visual surveys | NO | ? | 105 (including 55 observed in the baie à Armstrong and 21 in the baie Indian) | Toussaint and Caron 2012 |
| 2011 | Ottawa River--> Parc national de Plaisance including rivière de la Petite Nation just outside park limits | Visual surveys by kayak | YES | ? | 2 (1 inside park limits, 1 outside park limits in rivière de la Petite Nation) | Vallières 2011 |
| 2004 and 2007 | St. Clair NWA and Bear Creek Marsh | Visual surveys by walking | YES | 9 days | -1 in SCNWA<br>- 48 and 38 in BCM in 2004 & 2007 respectively | Gillingwater and Piraino 2004; Gillingwater and Piraino 2007. |
| 2004-2005 | St. Lawrence River--> Lake St. Francis NWA and Akwesasne Indian Reserve | Visual surveys by canoe, hoop net trapping | NO (not target species) | 158 hours and 59 trap days | 10 | Giguere 2006 |
| Between 2003-2006 | St. Lawrence River --> Rivière-des-Prairies | Visual surveys | YES | ? | 0 | Tessier and Lapointe 2009 |
| Between 2003-2006 | St. Lawrence River--> Ile-des-Soeurs | Visual surveys | YES | ? | 0 | Tessier and Lapointe 2009 |
| Between 2003-2006 | St. Lawrence River --> Rapids of Lachine | Visual surveys | YES | ? | 0 | Tessier and Lapointe 2009 |
| 2005 | St. Lawrence River --> Grandes Battures Tailhandier | Visual surveys | YES | ? | ~8 nests | Tessier and Lapointe 2009 |
| 2008 | St. Lawrence River --> Grandes Battures Tailhandier | Visual surveys | YES | ? | 0 | Giguere, pers. comm.,2011 |

| Time Frame | Area Searched | Method | Targeted Survey? | Person Hours/ Trap Days | # of Map Turtles Observed | Source |
|---|---|---|---|---|---|---|
| 2003 | Sydenham River --> ~30% of watercourse surveyed | Visual surveys by canoe or walking | YES | ? | 11 | NHIC unpub. data |
| 2003-2011 | Sydenham River--> East Branch, | Visual surveys by canoe | YES | ~100 person hours | 175 (sum of max number observed per stretch across all years) | SCRCA unpub. data |
| 1994-2012 | Thames River --> Middle Branch, downstream of London | Visual surveys by canoe<br>-incidental surveys during Spiny Softshell research | NO | Hundreds of hours | -hundreds observed over the years<br>-regularly occurring | Gillingwater pers. comm. 2012 |
| 2005 | Trent-Severn Waterway<br>-visual surveys occurred along 296km (77%) of waterway<br>-trapping occurred along 100km (26%) | Visual surveys and basking traps | YES | 248 trap days | 257 occurrences<br>-found at 30 of 31 historic NHIC EOs | Cebek *et al*. 2005 |
| 2012 | Wanapitei River | Visual Surveys | NO | n/a | 18 | Cobb pers. comm. 2012 |

Note: this list does not include surveys that were not transmitted to the author by various organizations, despite requests for this information.

# HABITAT

## Habitat Requirements

The Northern Map Turtle occupies rivers, lakes, streams, and creeks that are well-oxygenated (Ernst and Lovich 2009). The habitat must also contain suitable basking sites (such as rocks, exposed banks, and logs) that are adjacent to deep water and provide an unobstructed view (Logier 1939; Froom 1971; Gordon and MacCulloch 1980; Cook 1981; Daigle 1992; Chabot *et al*. 1993; Daigle *et al*. 1994; Bernier and Rouleau 2010).

Radio-telemetry studies in St. Lawrence Islands National Park revealed that macro-habitat selection by Northern Map Turtles was non-random as there was a significant preference for home ranges with undeveloped shoreline areas and shallow waters < 1 m deep (Carrière *et al*. 2009). At Lac des Deux-Montagnes on the Ottawa River, > 95% of all visual and radio-telemetry observations occurred in water < 2.5 m deep (average 1.7 ± 0.8 m) and < 200 m (average 43 ± 57 m) from shore, and all visual observations of turtles basking on banks reported that the turtles occurred within 1 m of the water (Bernier and Rouleau 2010).

Preferred nesting sites are characterized by soft sand or soil and full sunshine (Nagle *et al.* 2004), and nests are typically deposited within 35 m of the water (Gillingwater and Brooks 2001; Gillingwater and Piraino 2004; Barrett Beehler 2007; Bernier and Rouleau 2010; Rouleau and Bernier 2011). However, females may wander considerable distances inland in search of nesting locations despite the fact that suitable areas occur in proximity to the home lake or river (Johnson 1982; Gillingwater and Piraino 2004). Nesting habitat can include sand beaches and dunes (Gillingwater and Brooks 2001; Gillingwater and Piraino 2004), gravel piers and old quarries (Bernier and Rouleau 2010; Rouleau and Bernier 2011), sand bars and cattle pastures along rivers (Gillingwater pers. comm. 2011), gardens (Harrison 2011), cottage laneways (Barrett-Beehler 2007; Laverty pers. comm. 2012), and rock outcrops with thin soil deposits (Barrett-Beehler 2007; Litzgus pers. comm. 2012). Although Northern Map Turtles use a wide range of egg-laying sites there are no studies that test for differential success of nests among substrates, and in many cases females may use sites because they have no other "choice". In general, nest sites are in the open with long exposure to sunlight, but beyond that, how and why a female selects a site is still unknown, and the effect of nesting substrate on survival and quality of hatchlings is unknown (see Nagle *et al.* 2004).

Northern Map Turtles hibernate on the lake or river bottom typically in deeper hollows under the ice. In Canada, recorded depths of hibernacula (n=25) range from 1.5 - 6.5 m (average 3.6 m, maximum 11.3 m, minimum < 0.30 m) (Carrière et al. 2006; Bernier and Rouleau 2010, Rouleau and Bernier 2011; Harrison 2011).

1. Lake Habitat

On Lake Erie and Lake Ontario, this species occurs in areas that maintain marsh habitats and undeveloped shorelines (Gillingwater and Brooks 2001; Gillingwater and Piraino 2004; Tran *et al*. 2007; Harrison 2011). At the Ottawa National Wildlife Refuge in Ohio, radio-telemetry revealed that map turtles were utilizing marsh habitats 41-44% of the time and all observations occurred in water < 1.2 m deep (Tran *et al*. 2007). At Carroll's Bay Marsh in Lake Ontario's Hamilton Harbour, tracked turtles were mainly found within 10 m of the shoreline (Harrison 2011).

In eastern and central Ontario, this species occurs along the eastern shore of Georgian Bay and in the lakes and lake-river systems of the Canadian Shield. Habitat for these Shield populations consists of areas with rocky open shorelines, rocky shoals and islands, and rock or muck substrates (Laverty pers. comm. 2012).

2. River Habitat

The Northern Map Turtle inhabits small to major rivers with slow to moderate flows. The low-flow volume-discharge of Canadian watercourses where map turtles occur, range from < 500 $m^3/s$ (e.g., Thames River) to > 4000 $m^3/s$ (e.g., Saint Lawrence River; ORHDC 2005). Map turtles on the Thames River appear to be concentrated in areas maintaining moderate flow and turbidity (0.30-0.75 m/s and 9.4-13.2 Jackson Turbidity

Units; Thames River Ecosystem Recovery Team 2003), with fewer sightings occurring from areas with slow flow and high turbidity (from Kent Bridge to the mouth is considerably flat and highly turbid [69.5 Jackson Turbidity Units]; Thames River Ecosystem Recovery Team 2003). On the Ottawa River, map turtle concentrations appear to be lower in areas where the water is less transparent and the level of human activity is higher (Toussaint pers. comm. 2011). However, this species also occurs along the east branch of the Sydenham River where waters are sluggish and quite heavy with suspended material (Burke pers. comm. 2011).

In Canada, substrate in areas of use is variable and includes: fractured bedrock (Ottawa River: Norway Bay; Chabot *et al.* 1993), clay or sand (Ottawa River: Lac des Deux-Montagnes; Gordon and MacCulloch 1980), clay-mud or gravel (Sydenham River; MacDonald pers. comm. 2011), organic muck (Grand River: Dunnville Marshes; Zammit pers. comm. 2011), and gravel-cobble-rock mixture (Grand and Thames River; Gillingwater pers. comm. 2011; Zammit pers. comm. 2011). Reported pH values for some Canadian rivers where map turtles occur range from slightly alkaline along the St. Lawrence River (Ramesh 1989) and Ottawa River (upstream of Fitzroy Harbour; ORHDC 2005) to highly alkaline (8.0-8.5) along the Thames River (Thames River Ecosystem Recovery Team 2003).

Canadian studies on map turtle movements in rivers reveal that the mean aquatic home range area (i.e., the Minimum Convex Polygon that encompasses all known locations, minus the terrestrial portions) is 120-347 ha for adult males, 160-1347 ha for adult females, and 160-1037 ha for juvenile females (Carrière *et al*. 2009; Bernier and Rouleau 2010).

Home range length (i.e., the shortest straight-line distance by water between the two most separated location points) ranges from 2.2-24 km for adult females (Tessier and Lapointe 2009; Rouleau and Bernier 2011), 3.5-7.8 km for adult males (Rouleau and Bernier 2011), and 2.6-9.5 km for immature females (Rouleau and Bernier 2011).

The Complex Linear Home Range (i.e., the minimum-length centreline-based tree that spans all observed location points of the individual) calculated for twelve radiotracked adults on the rivière-des-Mille-Iles ranged from 1349-4164 m for males (n=6) and 2418-4402 m for females (n=6) (Ouellette and Cardille 2011).

Along the Trent-Severn Waterway, adult females within fragmented habitats had significantly smaller average home-range lengths (1.53 ± 0.31 km) than adult females within non-fragmented large reaches (8.51 ± 1.59 km), suggesting that control structures were restricting movements (Bennett *et al*. 2010).

**Habitat Trends**

Northern Map Turtle habitat is altered by urbanization, industrialization, recreational development, river control devices, contamination of waterways and siltation from agriculture (Gibbons 1997). For example, in Norway Bay along the Ottawa

River in Québec, an urban river cleanup reduced map turtle habitat quality by removing trees and logs which were regularly used by map turtles for basking (Chabot *et al*. 1993). Subsequently, in 1994, the Great Lakes 2000 Cleanup Fund requirements were defined to include habitat rehabilitation and maintenance (i.e., logs or platforms for basking and soft pond bottoms for hibernating) for non-game species such as reptiles and included areas where the Northern Map Turtle has been found (Rondeau Bay, Hamilton Harbour, Metro Toronto, St. Lawrence River, Detroit River, Long Point Bay) (Dunn 1995). Map turtles within Lac des Deux-Montagnes have responded well to the addition of artificial basking and nesting sites (Gordon and MacCulloch 1980; Flaherty 1982; Bernier and Rouleau 2010).

Though many populations of map turtles are found in protected areas (Table 5), these and other populations are still subject to high human impact. For instance, protected and non-protected areas along the Great Lakes shorelines and the St. Lawrence Seaway are at risk from heavy industrial pollution, agricultural runoff, and toxic spills from passing ships (Gillespie *et al*. 1991). Water quality studies conducted in the Thames River reveal that phosphorus and bacteria levels are well above the provincial guidelines and that nitrate levels have significantly increased over the last several decades (Thames River Ecosystem Recovery Team 2003); the same likely holds true for the Grand, Sydenham, and Ausable rivers which also pass through agriculturally dominated landscapes.

The construction of dams must have detrimentally affected *Graptemys* populations throughout their range, but the extent is unknown (Gibbons 1997). However, it is known that habitats of certain map turtle populations, on the Thames and Ottawa rivers and the Trent-Severn Waterway, are altered by such structures (See **'Threats and Limiting Factors-** Dams and Other Water Management Structures'). Furthermore, dams and locks in Canadian waterways fragment populations (See **'Population Spatial Structure and Variability**'), alter population demographics due to changes in nesting habitat (See **'Fluctuations and Trends'**) and greatly limit the movements of individuals (See **'Dispersal and Migration'**). There are currently two proposed waterpower projects for the French and Wanapitei rivers where a number of Northern Map Turtles were recently recorded (Brownell pers. comm. 2012).

## BIOLOGY

Most of the information provided in the **'Life Cycle and Reproduction'** section has been gathered recently from Canadian populations at Lake Opinicon (Rideau Canal Waterway), the St. Lawrence Islands National Park (St. Lawrence River), Lac des Deux-Montagnes (Ottawa River), and Lake Erie at Rondeau Provincial Park, Long Point National Wildlife Area, and Carroll's Bay Marsh. Other short-term studies from Canada as well as studies from Indiana, Vermont, Maryland, and Wisconsin also contribute to our biological knowledge of this species. However, most of what we know regarding Northern Map Turtle physiology and adaptability comes from the study of U.S. populations.

## Life Cycle and Reproduction

Breeding Habits and Reproductive Schedule

In Canada, nesting begins in early to mid-June (Gillingwater and Brooks 2001; Gillingwater and Piraino 2004; Browne and Hecnar 2007). Twelve radio-tracked gravid females at St. Lawrence Islands National Park were all confirmed to double-clutch in a season, with each one displaying nest-site fidelity (Carrière *et al*. 2006). Hatchlings begin emerging in early August (Gillingwater and Brooks 2001) or may overwinter in the nest and emerge from May to July of the following year (Behler and King 1979; Gillingwater and Brooks 2001; Baker *et al*. 2003; Gillingwater and Piraino 2004; Nagle *et al*. 2004) even as far north as Renfrew County (Kruschenske pers. comm. 2011).

Fecundity and Reproductive Success

There have been few studies on fecundity and reproductive success of the Northern Map Turtle in Canada. Clutch size ranges from three (Ryan and Lindeman 2007) to 22 (Gillingwater and Brooks 2001) with an average of 10-16 eggs (Carr 1952; Gillingwater and Brooks 2001). Bulté *et al*. (2008b) found that female reproductive output is positively correlated with body size, with larger females producing larger offspring. Thus, given that adult female size is significantly reduced in fragmented habitats compared to control areas (Bennett *et al*. 2009), it is possible that habitat fragmentation may lead to reduced reproductive output. Bulté *et al*. (2008b) found that female reproductive output is positively correlated with relative head width. Females with wider heads have greater bite force capacity and better energy acquisition due to consumption of larger prey, and they produce larger offspring.

A 2-year study at Rondeau Provincial Park (Gillingwater and Brooks 2001) investigated hatching success of 241 Northern Map Turtle nests. Of these, 75% were depredated by mammals. Of the remaining eggs (n=1364) protected on site with caging, 33% produced live young that emerged successfully from the nest, 33% did not hatch because they were infertile or contained dead undeveloped embryos, 8% were stolen or destroyed by vandals, and the remaining 26% produced hatched young that were eaten by Sarcophagid fly larvae while still in the nest chamber (See **'Interspecific Interactions'** and **'Threats'** for more information regarding Sarcophagid and mammalian depredation of nests).

Longevity and Development

To study age structure and growth rates of Northern Map Turtles one must follow known-age individuals for many years. A Northern Map Turtle at the Brookfield Zoo lived 18 years, and individuals in the wild have been to known to live more than 20 years (Ernst and Lovich 2009). The generation time of the Northern Map Turtle in Canada is estimated at 32 years based on recent estimates of age at maturity and annual survival (94% Bulte *et al*. 2010) of female adults (see **Technical Summary**).

Growth models based on more than 2000 captures from Lake Opinicon estimated age at maturity to be 12 years for females and 4 years for males (Bulté and Blouin-Demers 2009). The minimum measurement recorded for a gravid female is 175 mm CL, and the estimated size at maturity for males is 75 mm CL (Gordon and MacCulloch 1980). Along the Trent-Severn Waterway, the estimated growth rates of males and juveniles were significantly greater in control areas versus areas severely fragmented by locks. Furthermore, turtles found within control sites were significantly larger than those within fragmented habitats (Bennett *et al*. 2009).

Population Structure and Demographics

Some studies report that Northern Map Turtle populations are male-biased (Gordon and MacCulloch 1980; Vogt 1980; Pluto and Bellis 1986; Chabot *et al*. 1993; DonnerWright *et al*. 1999; Conner *et al*. 2005), whereas other studies report female-biased populations (Gillingwater and Brooks 2001; Gillingwater and Piraino 2004; Gillingwater and Piraino 2005; Barrett Beehler 2007; Browne and Hecnar 2007; Carrière 2007; Tran *et al*. 2007; Bernier and Rouleau 2010; Harrison 2011; Rouleau and Bernier 2011). Differences in population sex ratios may be illusory due to sampling bias (Ream and Ream 1966) caused by behavioural differences between sexes (Pluto and Bellis 1986; Chabot *et al*. 1993), or ratios may actually be biased from, for example, the interaction between nesting habitat and temperature-dependent sex determination (Bull and Vogt 1979; Gordon and MacCulloch 1980; Bennett *et al*. 2009).

A study on the Trent-Severn Waterway found that sex ratios within fragmented habitats were significantly female-biased, whereas those in controls were only slightly male-biased, suggesting that habitat alterations such as increases in mowed areas and roads may increase nest temperatures and lead to female-biased sex ratios (Bennett *et al*. 2009). The study also revealed that fragmented populations were composed of a much larger percentage of juvenile turtles than were control populations. Possible explanations are that adult females funnel energy resources towards reproduction after habitat disturbance or that nest predator numbers have been reduced by road mortality in altered habitats (Bennett *et al*. 2009).

Feeding and Diet

The Northern Map Turtle's diet largely consists of molluscs (snails and bivalves), but also includes crayfish and aquatic insect larvae (dipterans, trichopterans, and ephemeropterans) (Logier 1939; Lagler 1943; Moll 1977; Behler and King 1979; Vogt 1981; Lindeman 2006a; Bulté and Blouin-Demers 2008; Richards-Dimitrie and Seigel 2010). Studies reveal intersexual differences in diet composition in that females primarily consume larger molluscs, whereas males and juveniles primarily feed upon aquatic insects, crayfish, and smaller molluscs (Logier 1939; Behler and King 1979; Vogt 1981; Lindeman 2006a; Bulté and Blouin-Demers 2008; Richards-Dimitrie and Seigel 2010).

In the Great Lakes region, native unionids suffered near extirpation where invasive

Zebra Mussels (*Dreissena polymorpha*) occurred in high densities (Nalepa 1994; Schloesser and Nalepa 1994; Serrouya *et al*. 1995; Ricciardi *et al*. 1996; McGoldrich 2009). A recent study in the Hudson River revealed that some native unionids have since stabilized or even recovered since the invasion of the Zebra Mussel, suggesting that native and non-native unionids may be able to co-exist in North America as they do in Europe (Strayer and Malcolm 2007). Thus, initial concerns over whether native unionid declines could have a negative effect on the molluscivorous Northern Map Turtle (Mitchell 1994) appear to be unsupported. Rather, evidence suggests that Zebra Mussels and Asian Clams may have positively affected Northern Map Turtles by providing a new and abundant food source (Lindeman 2006a; Bulté and Blouin-Demers 2008; Richards-Dimitrie and Seigel 2010).

Based on studies in Pennsylvania and Maryland, a dietary shift towards non-native prey does not appear to be a result of reduced availability of native prey species (Lindeman 2006a; Richards-Dimitre and Seigel 2010). On the contrary, adult female map turtles at some localities have been shown to eschew a diversified diet of native species in favour of a diet composed nearly exclusively of non-native molluscs (Shively and Vidrine 1984; Porter 1990; Lindeman 2006b). However, this phenomenon likely occurs only in areas with a superabundance of the alien species (Lindeman 2006a).

In Lake Opinicon on the Rideau Canal Waterway, Zebra Mussels are approximately 100 times more abundant than viviparid snails and support 25-33% of the standing crop biomass of the map turtle population. Furthermore, it has been estimated that map turtles from this lake consume 3200 kg of Zebra Mussels annually (95% by females) and that this invasive mollusc constitutes 0-14% of male and 4-36% of female diets (Bulté and Blouin-Demers 2008).

Annual Movements

Seasonal changes in water current and depth, vegetation, substrate, and sun exposure may result in seasonal migrations to more accommodating basking habitats (Gordon and MacCulloch 1980; Pluto and Bellis 1988; Laverty pers. comm. 2012; Urquhart pers. comm. 2012). At Lac des Deux-Montagnes, turtles tend to bask along the shore during spring; however, as water levels fall during summer, preferred basking sites are offshore and adjacent to deep water (Gordon and MacCulloch 1980).

After leaving hibernacula in early spring, females move toward basking sites along nesting beaches where they remain for approximately 6 weeks until post-nesting (Gordon and MacCulloch 1980; Vogt 1980; Urquhart pers. comm. 2012). In Canada, map turtles move back towards hibernacula between late August and October (Flaherty 1982; Carrière *et al*. 2006; Bernier and Rouleau 2010; Rouleau and Bernier 2011).

Hibernation

Northern Map Turtles may hibernate communally (Graham and Graham 1992; Carrière *et al*. 2006) or singly (Harrison 2011) and adult females often show fidelity to the same hibernaculum in successive years (Graham *et al*. 2000). At Lac des Deux-Montagnes, eight radio-tagged map turtles hibernated within an average of 220 m (range 17-423) of their previous year's hibernation site (Rouleau and Bernier 2011). Hatchlings and small juveniles have not been reported within hibernating congregations and it is still unknown where they spend the winter. At the Central Canal in Indiana, more than 70% of hibernating turtles were found within woodland-bordered areas of the canal and avoided areas with disturbance (Ryan *et al*. 2008).

<u>Mortality</u>

Natural predation presents one source of mortality for the Northern Map Turtle. Along the Trent Severn Waterway, over two field seasons, 13% of captured map turtles had injuries from predation attempts (Bennett pers. comm. 2012). A 2-year study at Rondeau Provincial Park, found 16 depredated map turtles (13%) (Gillingwater and Brooks 2001). Adult females are at greater risk of predation while wandering on land looking to nest. Within an interior dune nesting area at the Long Point National Wildlife Area, researchers found the carcasses of approximately 40 adult females over 7 years and witnessed five female map turtles being attacked and killed by Mink (*Mustela vison*) and Raccoon (*Procyon lotor*) (Gillingwater and Piraino 2004).

Disease and illness are also sources of mortality for map turtles. For example, during 4 years of general surveys at Rondeau Provincial Park, approximately 30 dying turtles were found resting on beaches; they were lethargic, emaciated, had 'shell rot' and died within 5 days of being found in this condition. Botulism may have been the cause of death as the disease was affecting other wildlife in the area during that time (Gillingwater pers. comm. 2011). Similarly, on the Trent Severn Waterway, map turtles were occasionally found lethargic, emaciated, and with gurgling respiration; a necropsy of one that died revealed the cause of death as chronic pneumonia (Bennett *et al*. 2012). At Lac des Deux-Montagnes, 4% of all map turtles captured displayed symptoms of respiratory system infection (Rouleau and Bernier 2011).

Other sources of mortality for map turtles include anthropogenic causes such as boat collisions, road mortality, and fisheries bycatch (see **'Threats and Limiting Factors'**). Models based on data from over 2000 captures at Lake Opinicon produced the following mortality rate estimates for various demographic classes (this includes both natural and anthropogenic sources of mortality): 35% for 2-4 year old juveniles of undetermined sex; 26% for 4-11 year old juvenile females; 19% for adult males; and 6% for adult females (Bulté *et al*. 2010). Presumably, natural rates of mortality would be less (see **Technical Summary**).

## Physiology and Adaptability

<u>Thermoregulation and Basking Behaviour</u>

Studies on Canadian map turtles reveal that the preferred body temperature range for adult males is wide (19-30ºC), suggesting that shifting between diverse aquatic and terrestrial habitats for thermoregulatory purposes is costly (Ben-Ezra *et al*. 2008). However, map turtles obtain a definite thermal benefit from aerial basking (Bulté and Blouin-Demers 2010a). Even during the warmest summer months on Lake Opinicon, aerial basking resulted in body temperature gains of 10ºC above the water surface temperature (Bulté and Blouin-Demers 2010a), and it increased metabolized energy intake by 17-30% (Bulté and Blouin-Demers 2010b).

In Ontario, map turtles have been seen basking on ice in the very early spring and can be observed basking well into November (Kruschenske pers. comm. 2012; Beck pers. comm. 2012). During the summer months, map turtles often opt to bask at the surface of the water amongst mats of aquatic vegetation (Gillingwater and Brooks 2001; Gillingwater and Piraino 2004; Peterman and Ryan 2009; Bulté *et al*. 2010; Urquhart pers. comm. 2012). At Lake Opinicon, females increased aquatic basking behaviour post-nesting, which put them at higher risk of being struck by powerboats due to greater boat traffic later in summer (Bulté *et al*. 2010; See **'Threats and Limiting Factors'**).

<u>Hibernation</u>

During hibernation, the Northern Map Turtle meets its $O_2$ needs through aquatic respiration (Ultsch *et al*. 2000). Given that this species is relatively anoxia-intolerant and requires high environmental oxygen tension to endure prolonged cold submergence, it seems that a high $PO_2$ is a required hibernaculum microhabitat feature to ensure winter survival (Crocker *et al*. 2000).

Overall, hatchling map turtles display a poor tolerance to freezing (Baker *et al.* 2003; Dinkelacker *et al*. 2005; Costanzo *et al*. 2006; Storey 2006). In soils lacking moisture, hatchlings froze at an average temperature of -10.2ºC and they were highly susceptible to innoculative freezing in substrates that retained 16% moisture content (Baker *et al*. 2003)

<u>Temperature-dependent sex determination</u>

Sex determination in *Graptemys* is temperature-dependent, with males developing at a constant incubation temperature of 25º C, and females at a temperature of 30º C or higher (Bull and Vogt 1979). A variety of factors interact to determine the sex ratio: maternal behaviour in choosing a nest site, the zygote's response to temperature in becoming male or female, and the environmental effects of the temperature of the nesting area (Bull *et al*. 1982a). In Wisconsin, nests that produced females were located in open sand, whereas nests that produced males were associated with vegetation at the edge of a beach. This dependence of sex ratio upon the environment indicates that changes in sex ratio may result from changes in the environment, potentially leading to a bias in the population hatchling sex ratio, unless females change their nesting sites (Vogt and Bull 1984). (See 'Biology - Population Structure and Demographics' above for further discussion regarding changes in environmental temperatures). Threshold temperatures did not differ as expected between northern and southern populations despite 2-4º C daily mean difference in ambient temperatures during nesting season, and there was no correlation between mean ambient temperatures and sex ratio. This lack of effect may result from different nesting behaviour that compensates for the climatic differences (Bull *et al*. 1982a) or from undefined effects of natural temperature fluctuations.

### Dispersal and Migration

A study comparing the spatial ecology of map turtles in lentic versus lotic environments found differences in movement patterns and habitat use among populations. In particular, at Lake Opinicon there were no significant differences in movement patterns or home range size between reproductive classes, and there was no significant interaction between month and reproductive class. The mean daily distance (i.e., the shortest aquatic straight-line distance between relocations) travelled by adult females in this lentic environment was 149 m. In contrast, within the St. Lawrence Islands National Park, adult females moved larger distances, had larger home ranges, and moved more during June than did adult males and juvenile females. The mean daily distance travelled by adult females in this lotic environment was 315 m. Suitable nesting habitat is lacking within the park, and females have been observed to travel up to 5 km in search for such areas, which may explain the greater movement patterns observed within the lotic environment (Carrière *et al*. 2009).

Bernier and Rouleau (2010, 2011) found that tracked turtles generally moved along the banks within shallow water areas and typically remained on either the south or north shore all season; however, two adult females were noted crossing great stretches (> 1090 m) of deep water between land. Employees at the locks of Sainte-Anne-de-Bellevue reported map turtles within the locks (Bernier and Rouleau 2010); however, the accuracy of these identifications remains unknown.

Map turtles on the Trent Severn Waterway were confirmed to cross through locks; however, the locks still restricted overall movement (Bennett *et al*. 2010). In particular, adult females within areas severely fragmented by locks and dams had significantly smaller average daily movements (i.e., the shortest aquatic straight-line distance between relocations) than adult females from areas of continuous habitat (76.1 +/- 10.2 m/day versus 277.6 +/- 50 m/day respectively).

## Interspecific Interactions

The diet of the Northern Map Turtle is largely comprised of molluscs and other benthic invertebrates. Prey items include: snails (*Amnicola integra*, *A. limnosa*, *A. lustrica*, *A. walkeri*, *Bythinia tentaculata*, *Campeloma sp*., *Elimia potosiensis*, *Goniobasis livescens*, *Gyraulus parvus*, *Helisoma antrosa*, *H. campanulata*, *H. trivolvis*, *Lioplax subcarinata*, *Lymnaea calascopium*, *L. palustris*, *Physa gyrina*, *P. sayii*, *Planorbula armigera*, *Valvata bicarinata*, *V. tricarinata*, *Viviparus georgianus*), native and non-native mussels (*Anodonata grandis*, *Corbicula fluminea*, *Corbicula maniliensis*, *Dreissena polymorpha*, *Lampsilis siliquoidea*, *Pisidium abditum*, *Sphaerium* sp., *Strophitus rugosus*), crayfish (*Cambarus* sp., *Orconectes immunis*, *O. propinquus*, *O. rusticus*, *O. variabilis*), caddisfly larvae (Heliocopsychidae, Leptoceridae, Limnephilidae), mayfly nymphs (Ephemeroptera, *Stenonema* sp.), damselfly nymphs (Zygoptera), beetles (Hydrophilidae, Scolytidae, Scarabaeidae), robber and stone flies (Asilidae, Plecoptera), midges (Nematocera), and water mites (Hydracarina) (Bulte *et al*. 2008a; Ernst and Lovich 2009; Richards-Demitrie and Seigel 2010).

Observed predators of adult and juvenile Northern Map Turtles in Canada include Mink, Raccoon, Red Fox (*Vulpes vulpes*), and Coyote (*Canis latrans*), but hatchlings and young-of-year turtles can also be taken by large fish, Green Frogs (*Lithobates clamitans*), and American Bullfrogs (*Lithobates catesbeianus*), as well as gulls, terns, herons, and Snapping Turtles (*Chelydra serpentina*) (Gillingwater pers. comm. 2011).

Nests of many species of both freshwater and marine turtles are often infested by larvae of several species of Dipteran flesh flies of the Sarcophagidae (Bolton *et al*. 2008 and references therein). Nests of Northern Map Turtles in Rondeau Provincial Park are frequently infested by these larvae which feed on both eggs and hatchlings and it appeared that these larvae were a threat by reducing nest success via predation (Gillingwater and Brooks 2001). However, Bolton *et al.* (2008) demonstrated using nests of Spiny Softshells (*Apalone spinifera*) in both Rondeau Provincial Park and in Long Point National Wildlife Area that the larvae largely fed on infertile eggs or dead embryos and hatchlings and were opportunistic scavengers rather than active predators. There was no statistical difference in hatching success between infested and noninfested nests. Subsequent analysis of the 2-year study at Rondeau Provincial Park found that, despite large differences in the number of Northern Map Turtle nests affected by fly larvae between the first and second season (16% vs. 68% respectively), the percent of nest success remained very similar between the years (35% vs. 31% respectively) (Gillingwater and Brooks 2001). Thus, fly larvae do not seem to pose any threat to map turtle populations. These data suggest that the larvae are largely scavengers of dead or severely compromised turtle embryos and hatchlings, and although they may sometimes depredate apparently healthy pipping or hatched young, this mortality has no significant impact on measures of hatching success (Bolton *et al*. 2008).

Other known nest predators in Canada include Raccoon, Red Fox, Striped Skunk (*Mephitis mephitis*), and Coyote (Gillingwater pers. comm. 2011). (See **'Threats - Urban Encroachment'**).

## POPULATION SIZES AND TRENDS

### Sampling Effort and Methods

Various methods of sampling map turtle populations have been employed and include: basking traps, hoop traps, folding live traps, dip net captures from a boat, hand captures while swimming, snorkeling, or walking along water bodies, and visual surveys of basking individuals. See Table 2 for a summary of sampling efforts for various populations.

**Table 2. Sampling efforts, methods, and abundance estimates for various populations.**

| Population | Sampling Period | Sampling Method | Sampling Effort | #Marked/ #Recaptured | Population Estimate | Estimation Method | Sampling Uncertainty |
|---|---|---|---|---|---|---|---|
| Carroll's Bay (Harrison, 2011) | 2008-2010 | Basking Traps, Hoop Traps, Dip Nets, Basking Surveys | -780 hoop trap days<br>-390 basking trap days | -126 marked.<br>-12 recapture events.<br>-max observed during single basking survey was 252 | 300 (250-450) | Modified Lincoln-Peterson | Low recapture rates |
| Grand River -- Paris to York (Beck pers. comm. 2012) | 2009-2012 | Visual Surveys by canoe and hiking along river | 13 inventory days | 0 | >300 *estimate of mature individuals | Rough estimate based on 4 years of visual observations during reptile surveys | No mark-recapture effort. |
| Lake Opinicon on the Rideau Canal Waterway (Bulte *et al*., 2010) | 2003-2008 | Basking Traps, Dip Nets, and Hand Captures while swimming | ? | 898 marked.<br>>2000 capture events. | 1529 (95% CI= 1487-1662) *estimate of mature individuals | Jolly-Seber Model using the software CAPTURE | |
| Long Point NWA (Gillingwater pers. comm. 2011) | 1996-1999, 2003-2004 | Hand Captures and Basking Surveys | ~400 person hours dedicated to reptile mark-recapture surveys | -39 marked.<br>-4 recapture events. | >300 *estimate of mature individuals | Rough estimate based on 5 years of visual observations during reptile surveys | Low recapture rates. Most captures were of adult females. Insufficient mark-recapture data to produce a reliable pop. estimate. |
| Lost Bay on the Gananoque River Waterway (Barrett Beehler, 2007) | 2007 | Basking traps and Basking Surveys | -204 basking trap days | 112 marked.<br>23 recaptured | >112 | Based on minimum number of individuals known from population | Insufficient mark-recapture data to produce a reliable pop. estimate. |

| Population | Sampling Period | Sampling Method | Sampling Effort | #Marked/ #Recaptured | Population Estimate | Estimation Method | Sampling Uncertainty |
|---|---|---|---|---|---|---|---|
| Ottawa River--Bristol Region of Norway Bay (Chabot et al., 1993; MRNF, unpub. data, 2010) | June-July 1992 and May to Sept 1999 | Dip net captures by boat and resightings of numbered individuals by binoculars | -37 inventory days | -In 1992, 86 turtles marked -in 1999, 67 turtles marked -only 2 turtles recaptured in 1999 | -In 1992, estimate was 350 individuals -In 1999, estimate was 731 individuals -Density of 36 - 58 turtles/km | -In 1992, 'Adjusted Petersen, 'Schumacher and Eschmeyer', 'Schnabel', and 'Modified Schnabel' -In 1999, Adjusted Petersen | Low number of captures produced large confidence intervals. Unlikely that the pop. doubled in 7 years. However, data reveal a very strong density of turtles in this sector. This is believed to be the largest map turtle pop. in Quebec. |
| Ottawa River and mouth of Petawawa River at Canadian Forces Base Petawawa | 2006-2009 | Basking traps and hand captures | -2006--> 55 basking trap days | -2006- 2007--> 17 turtles were marked and 6 were recaptured | >17 | Based on minimum number of individuals known from population | Insufficient mark-recapture data to produce a reliable pop. estimate. |
| Ottawa River--Lac des Deux Montagnes (Mazerolle and Dubois, in prep) | May to June 2009 | Basking Traps, Hoop Traps, Hand Captures, Basking Surveys | -332 basking trap days -95 hoop trap days -20 working days invested in mark/recapture -80 hours of visual observations | -297 marked -63 recaptured | 728 (95% CI= 612-888) *estimate of total individuals | Average of estimates derived from 5 closed population CMR models | |
| Ottawa River--Westmeath Provincial Park (Kruschenske, pers. comm., 2011) | 2003-2004 | Basking Traps | -48 days | 221 marked. 18 recaptured | 496 (95% CI= 412-622) *estimate of total individuals | Schnabel | Low recapture rates |
| Point Pelee National Park (Browne, 2003) | 2001-2002 | Basking Traps, Hoop Traps, Folding Wire Cage Traps, Hand Captures, Dip Nets | -93 basking trap days in 2001 -245 hoop trap days in 2001 -3237 trap days in 2001-2002 | 172 marked. | >172 | Based on minimum number of individuals known from population | Jolly-Seber Model 241.3 ha (area used by map turtles in the park) X 0.7 ind/ha produced an underestimate of 169 turtles because Lake Erie was not included in the population model |
| Rondeau Provincial Park (Gillingwater pers. comm. 2011) | 2000-2001 | Hand Captures, Nest Surveys, and Basking Surveys | ~1500 person hours dedicated to reptile mark-recapture surveys | -119 marked. -4 recapture events. -max # of nests in a season was 243 | ~300 | Rough estimate based on the number of nests found within a season and assuming a 1:1 ratio of males to females. | Low recapture rates. Most captures were of adult females. |
| St. Lawrence Islands National Park (Millar, 2009; Bulte *et al.,* 2010) | 2005-2009 | Basking Traps, Dip Nets, and Hand Captures while swimming | ? | 500 marked. 1134 capture events. | 649 ± 25 (95% CI= 608-706) *estimate of mature individuals | POPAN formulation of Jolly-Seber Model in program MARK | |

| Population | Sampling Period | Sampling Method | Sampling Effort | #Marked/ #Recaptured | Population Estimate | Estimation Method | Sampling Uncertainty |
|---|---|---|---|---|---|---|---|
| Thames River -- London to Delaware | 1994-2012 | Visual Surveys by canoe | Hundreds of hours | 0 | >300 *estimate of mature individuals | Rough estimate based on 18 years of visual observations during reptile surveys | No mark-recapture effort. |
| The Massasauga Provincial Park (Laverty, 2010) | 2008-2009 | Dip Netting from a boat and Dip Net or Hand Captures while swimming | 2008- CPUE ranged from 0 to 0.12<br>2009- CPUE ranged from 0 to 0.4 | -86 marked<br>-42 recapture events | >86 | Based on minimum number of individuals known from population | |
| Trent-Severn Waterway -- Trenton to Peterborough (Bennett *et al.,* 2009) | May-August 2007-2008 | Basking Traps, Dip Nets, and Hand Captures while swimming | ? | 310 marked. 5 recaptured. | >310<br>Density Estimate 22-243 turtles/km. | Based on minimum number of individuals known from population | Very low recapture rates and high SEs produced large population size estimates that may not accurately estimate the actual population size. However, the pop. size and density appears to be large on the TSW. |
| TOTAL INDIVIDUALS MARKED | | | | 3050 | | | |
| MINIMUM ESTIMATE OF INDIVIDUALS IN CANADA | | | | | ~6000 | | |
| MAXIMUM ESTIMATE OF INDIVIDUALS IN CANADA | | | | | Unknown; likely >20000 | | |

## Abundance

The total number of Northern Map Turtles in Canada is unknown. However, this total is certainly greater than 10,000 adults based upon recent sampling results from some locations.

Despite the relatively small size of Lake Opinicon (788 ha) on the Rideau Canal Waterway, over 2000 captures occurred between the years 2003-2008. Overall, nearly 900 individuals have been marked at this site and the population is estimated at approximately 1529 turtles (95% CI = 1487-1662) (Bulté *et al*. 2010). With 12 other lakes of similar or larger size along this waterway it seems likely that at least some of these other waterbodies hold similar map turtle abundances. Thus the waterway as a whole maintains at least a few thousand map turtles.

At St. Lawrence Islands National Park, over 1000 capture events occurred between the years 2005-2009. Overall, 500 individuals have been marked within a 2890-ha area surrounding Grenadier Island and the population at this site is estimated at 629 (95% CI= 597-661) individuals (Millar 2009). Along the Ottawa River, more recent surveys (Bernier and Rouleau 2010; Toussaint pers. comm. 2011) suggest that the populations at Bristol near Norway Bay and at Lac des Deux-Montagnes are approximately 730 individuals each. In addition, another study on the Ottawa River at Westmeath Provincial Park estimated 496 (95% CI= 412-622) individuals in this area alone (Kruschenske pers. comm. 2011). These studies reveal that the original estimates of approximately 1000 individuals each in the Ottawa and St. Lawrence River were too low given that new estimates suggest that at least 500-1000 individuals occur at each study site along these rivers.

An estimated 300 (95% CI= 250-450) individuals remain within Lake Ontario's Hamilton Harbour in the coastal marshes of the Royal Botanical Gardens' nature sanctuary (Harrison 2011). The population at Rondeau Provincial Park along Lake Erie is also estimated at approximately 300 individuals (based on numbers of nests found within a season and assuming a 1:1 ratio of adult males to females; Gillingwater pers. comm. 2011). Populations at the Long Point National Wildlife Area and the Thames (Gillingwater pers. comm. 2011) and Grand rivers (Beck pers. comm. 2012) likely maintain >300 adult map turtles each. Sampling efforts at other locales in Canada provide insufficient data for reliable population estimates. The Georgian Bay population may be quite large (Brownell pers. comm. 2012), but claims of thousands of map turtles in the Georgian Bay region are not supported by published or quantitative data. See Table 2 for a summary of population estimates for various regions.

### Fluctuations and Trends

In 1958, the species was considered common in eastern Ontario (Bleakney 1958), and was reported as being locally common in southwestern Ontario as early as 1928 (Brown 1928; Logier 1931; Toner 1936). The lack of any long-term population studies makes it difficult to assess large-scale population trends directly; however, population sizes are unlikely to fluctuate given the slow rate of reproduction.

No contraction of the range of the Northern Map Turtle in Canada has been documented; however, in 1993, this species was deemed vulnerable along the Lake Ontario waterfront from Burlington to Trenton (Brownell 1993). At Lost Bay on the Gananoque River Waterway, anecdotal evidence from local cottagers suggests a decline in the number of map turtles there, as many more used to be observed basking on rocks in the past (Barrett Beehler 2007; Urquhart pers. comm. 2012).

According to the Natural Heritage Information Centre's (NHIC) Biodiversity Explorer, 51 of 86 Element Occurrences for the Northern Map Turtle in Ontario are considered historical (OMNR 2010). Furthermore, data from Ontario Nature's Ontario Reptile and Amphibian Atlas reveal that 53% of historical occurrences (n=166) have not had map turtle observations since 1985 despite this being an easily observed turtle, whereas 47% of occurrences continue to have observations until the present. In addition, 98 new 10 X10 km districts (37% of all 264 known occurrences) have been reported since 1991 (Ontario Nature 2012), with over 50 of these new locations being identified in 2009-2010 alone (Crowley pers. comm. 2012). However, it is unlikely that the species dispersed into these areas, but more likely that they were always there and not recorded. Furthermore, it is probable that some "historical" sites still maintain map turtles but have just not had any reported observations or survey efforts over the last 20 years.

Surveys conducted along the Trent-Severn Waterway (TSW) in 2005 found map turtles in 30 of 31 NHIC historical EOs indicating persistence within this waterway (Cebek *et al*. 2005). Other recent research in the TSW reveals a trend toward decreased body sizes, greater female bias, and younger age distributions for populations within fragmented habitats (Bennett *et al*. 2009). (See **'Biology'**).

At Point Pelee National Park, there appears to be a trend toward an older age distribution, which may foreshadow a population decline (Browne and Hecnar 2002, 2007). Although map turtle captures at Point Pelee were 40 times greater in 2001-2002 than in a previous study 30 years earlier (Rivard and Smith 1973), this apparent increase in abundance is probably the result of capture methodology given that the 1970s study did not use basking traps, the sampling method which produced over 80% of captures in 2001-2002 (Browne and Hecnar 2007).

In Québec, the largest populations seem to be along the Ottawa River at Lac des Deux Montagnes near Montréal and at the Bristol region of Norway Bay. Each of these sites is currently estimated to have ~730 individuals (all ages), which is double the previous estimates of 350 individuals at each site (Gordon and MacCulloch 1980; Chabot *et al*.1993). Again, these apparent increases likely represent different sampling methods rather than added recruitment into the populations (Bernier and Rouleau 2010; Toussaint pers. comm. 2011; Mazerolle and Dubois in prep.). The Bristol population is currently believed to be the largest in Québec, and does not seem to be in decline (Toussaint pers. comm. 2011). Furthermore, another location upstream of Norway Bay, in the l'Ile aux Allumettes region, appears to have a similar number of map turtles as the Bristol site (Toussaint pers. comm. 2011). Surveys in lac des Deux-Montagnes in 1982 and in 2009 found no evident signs of a decrease (Gauthier pers. comm. 2012).

Currently, there are no baseline data from which to draw definitive quantitative conclusions regarding overall population trends in Canada. However, it is inferred that many Canadian map turtle populations are in decline due to a multitude of anthropogenic threats that increase adult mortality (see **'Threats and Limiting Factors'**).

### Rescue Effect

Northern Map Turtle populations in southwestern Ontario and Québec are relatively close to northeastern United States' populations and potential crossing areas include the Detroit and Richelieu rivers as well as lakes Erie and St. Clair. Anecdotal evidence of immigration exists where an isolated population on the lower Hudson River in New York is believed to have arrived after the construction of canals linking the river to the Great Lakes (Ernst and Lovich 2009).

According to NatureServe (2011) the status of neighbouring Northern Map Turtle populations in the U.S. ranges from 'Vulnerable' (S3) in New York and Vermont, to 'Apparently Secure' (S4) in Pennsylvania, to 'Secure' (S5) in Michigan. The population in Ohio has not been ranked.

Given that there is anecdotal evidence of immigration, that some bordering states have secure populations, and that the Northern Map Turtle has the ability to disperse up to at least 24 km within a season (Tessier and Lapointe 2009; See **'Dispersal and Migration'**), the movement of individuals across international boundaries is possible. Rescue, however, would only be possible if the threats responsible for the original population's decline had been addressed and eliminated.

## THREATS AND LIMITING FACTORS

There are numerous potential threats to map turtles in Canada, but there are few quantitative assessments of these threats. Significant threats include boat mortality, commercial fisheries bycatch, water management structures such as dams and locks, shoreline development, and unnaturally high levels of nest predation by mammals. Road mortality is a threat in some local situations, but a minor threat overall. Additional considerations include the commercial (food and pet) trades in turtles, and climate change. Given the slow life histories of turtles, they are highly susceptible to decline with even slight increases (1-3%) in adult mortality (Doroff and Keith 1990; Brooks *et al*. 1991; Congdon *et al*. 1993; Gibbs and Shriver 2002). An example of the major and long lasting impact of increased adult mortality was described recently in a long-term study of a Missouri population of Northern Map Turtles (Pitt and Nickerson 2012). This population was studied from 1969-1980 then revisited in 2004. The population declined from 1969-1980 largely from harvesting, and by 2004 showed no evidence of rebound despite cessation of harvesting. Ongoing threats to the population included lack of basking sites, increased recreational use of the habitat and degraded water quality (Pitt and Nickerson 2012).

Although the Northern Map Turtle is widespread, and seemingly locally numerous given their high visibility, perceptions of abundance need to be considered in light of our "shifting baseline", where each succeeding human generation perceives the current level of species' abundance as the new norm, sometimes obscuring the reality that historical numbers may actually have been much greater (Roberts 2007). Indeed, some authors suggest that freshwater turtle abundances today often only represent a small fraction of historical abundances (Iverson 1982; Congdon and Gibbons 1986).

A new school of conservation thought stresses the importance of protecting common species *before* they become rare due to their disproportional influence in shaping macroecological patterns (Gaston and Fuller 2008). Evidence suggests that even small declines in common species can result in large losses of individuals and biomass, and in disruptions to the integrity of entire ecosystems (Gaston and Fuller 2008). Furthermore, history is replete with instances of anthropogenic stresses having led to once common species becoming threatened or even extinct (Gaston and Fuller 2008). Thus, conservationists need to identify common species that are undergoing marked declines before their numbers collapse to perilous levels (Gaston and Fuller 2008). This is especially true of freshwater turtles given their poor ability to rebound from such population declines (e.g., Brooks *et al*. 1991; Congdon *et al*. 1993; Pitt and Nickerson 2012).Therefore, although the Northern Map Turtle is still apparently abundant in some areas, its long-lived life history with delayed age of maturity and numerous potential threats to both the species and its habitat suggest historical and ongoing population declines.

Boat Mortality

Boat collisions are a major cause of injuries and mortality for map turtle populations in lakes and rivers with heavy boat traffic. Just as road mortality is a serious threat to many turtles and snakes, boat traffic is a significant and growing threat to map turtles. Like road mortality, the impact of collisions with boats was originally recognized largely from anecdotal accounts, and without knowledge of the vulnerability of map turtles to increased mortality and injury from boats, this problem has been underestimated until quite recently. In shallow bays at Long Point along Lake Erie, many map turtles have boat propeller injuries to their carapaces (Beck pers. comm. 2011; Gillingwater pers. comm. 2011). At Lost Bay on the Gananoque Waterway, several map turtles have been observed with boat propeller injuries, and boat strikes seem to be a significant threat to this population (Urquhart pers. comm. 2012). Captured map turtles at the eastern sector of Lac des Deux-Montagnes (5.1 % of n=297) and the Trent-Severn Waterway (18.0 % of n=312) had injuries consistent with being struck by a boat propeller (Bernier and Rouleau 2010; Bennett pers. comm. 2012).

More quantitative assessments of boat impacts come from research on marked map turtles from Lake Opinicon and St. Lawrence Islands National Park. Researchers found obvious scars from boat propellers (3.8% and 8.3% respectively of captured individuals), and it is likely that many turtles are killed annually in these areas by such collisions (Bulté *et al*. 2010; Carrière and Blouin-Demers 2010). The prevalence of propeller injuries was two to nine times higher in adult females than in adult males and juvenile females as a result of demographic differences in patterns of movement, habitat use, and aquatic basking. Population viability analyses conducted on these populations concluded that even low boat mortality rates of adult females, i.e., a risk of mortality greater than 10% when hit by a boat, led to a high probability of extirpation of the population. For example, if only one adult female is killed by a boat every 3 years the probability of extinction over 500 years is 63% for the Lake Opinicon population and 99% for the St. Lawrence Islands National Park population (Bulté *et al*. 2010).

Given that many map turtle populations in Canada occur in large water bodies (e.g., the Great Lakes, the Ottawa and St. Lawrence Rivers, the Rideau Canal and Trent-Severn Waterways) with moderate to heavy motorized boat traffic, the scope of this threat is likely “large”, with much (31-70%) of the total population being affected within 10 years if circumstances are not improved (COSEWIC 2010).

Fisheries Bycatch

Commercial fishing traps present another potentially serious mortality risk for Northern Map Turtles. At Thompson's Bay in the St. Lawrence River, 16 individuals (representing 5.5% of total captures in one season) were found drowned in traps within less than a week (Carrière *et al*. 2006). This bay is highly frequented by map turtles, especially gravid females, and 30% of all captures occurred at this location. The findings of this study led the Ontario Ministry of Natural Resources to enforce removal of traps from this bay by May 1st of each year (before the movement of map turtles into the area). No map turtle bycatch mortalities were noted during the succeeding year.

A recent study in two lakes in the Rideau Canal Waterway (Larocque *et al*. 2012a) found that 93 – 100% of non-fish bycatch consisted of four different species of turtles (*G. geographica, Sternotherus odoratus, Chrysemys picta,* and *Chelydra serpentina*). Modifying fyke nets using floats to create air spaces effectively reduced turtle bycatch mortality without significantly affecting fish catch rates or composition; however, turtle mortality was still severe (33% died) in nets tended infrequently (every 2-6 days). Frequent tending (every 8-48 h) of nets was effective in reducing turtle mortality, as there were no fatalities in either floated or submerged nets that were monitored at this frequency (Larocque *et al*. 2012b). Furthermore, regulations restricting commercial fishing to the fall would be beneficial, as this restriction does not appear to reduce fish catches, yet greatly reduces the incidence of turtle captures (Larocque *et al*. 2012b). The addition of escape chutes and/or excluder devices have also been found to effectively reduce freshwater turtle bycatch by 77% - 100% (Lowry *et al*. 2005; Larocque *et al.* 2012c). The life history of turtles renders them unable to cope with harvest pressure and populations can be decimated quickly (Raby *et al*. 2011). For instance, Dorcas *et al*. (2007) found that age and sex-ratio of a Diamondback Terrapin (*Malaclemys terrapin*) population in South Carolina was greatly altered by trapping bycatch, because selective mortality of smaller individuals resulted in a female-biased population with an older distribution. Furthermore, Diamond-back Terrapin populations have reportedly declined across their range as a result of drowning in commercial traps (Seigel and Gibbons 1995).

The Great Lakes represent one of the largest freshwater commercial fisheries in the world (Raby *et al*. 2011); however, the extent of commercial fishing along the various rivers and waterways that map turtles inhabit in Ontario and Québec is unknown. The potential threat of bycatch mortality for Northern Map Turtle populations living in commercial fishing zones is serious and deserves further investigation.

<u>Shoreline Development and Recreational Activities</u>

The majority of the Canadian range of the Northern Map Turtle is located within the most densely populated region of the country, in particular the most heavily used waterways and lakes. This turtle is therefore regularly subjected to the effects of human interference by way of recreation and development (Gordon and MacCulloch 1980; St. Lawrence Centre 1996). Shoreline development and increased human recreational activity pose real threats to Northern Map Turtle populations, as research demonstrates that map turtles show a significant preference for habitats with natural shorelines (Carrière and Blouin-Demers 2010), and that their abundance declines in areas with urban development and human activity (Rizkalla and Swihart 2006; Ryan et *a*l. 2008; Tessier and Lapointe 2009; Toussaint pers. comm. 2011). Map turtle declines are also associated with deadwood removal (Moll 1980; Chabot *et al*. 1993; Lindeman 1999).

Currently, cottage development in the Thousand Islands and Land o'Lakes regions of eastern Ontario is ubiquitous. At St. Lawrence Islands National Park, several cottages have recently been built along Thompson's Bay, a once quiet and natural area where 30% of map turtle captures occurred in one major study in 2005-2007 (Carrière 2008); the effects of this development on the local map turtle population have yet to be determined. At Lake Opinicon, cottage development on shorelines, especially on islands, has destroyed nesting areas, and increased traffic has led to more road and boat kills of nesting females (Blouin-Demers pers. comm. 2002). In the Parry Sound district, impacts to shoreline habitat are mostly by cottagers who “clean” shorelines by removing or changing natural structures, such as vegetation, sunken logs and rock outcrops, used by map turtles for basking and shelter (McDonnell pers. comm. 2012).

On the Ottawa River, increased boating activity and the development of an immense public beach on Petrie Island have led to a decline in map turtle observations and captures in the surrounding bays and channels (Tessier and Lapointe 2009). Map turtles inhabiting the area around St-Joseph Island are highly disturbed during basking by passing boats and a proposed housing development threatens to worsen the situation (Tessier and Lapointe 2009). At Knox Landing in the Bristol region, following the removal of woody debris from the banks and bay by a private company, observations of basking map turtles decreased (Chabot *et al*. 1993). At Fitzroy Harbour (located just outside of Fitzroy Provincial Park), a campsite on the principal nesting beach has affected map turtle activity in the area (Tessier and Lapointe 2009). There has been a constant increase in residential and recreational development along the shores of the Ottawa River (Bernier and Rouleau 2010; Toussaint pers comm. 2012) and this change almost certainly poses a threat to map turtles in the area. Furthermore, 26 intrusions into a no-boating zone at Cape-Saint-Jacques Nature Park were noted over 84 days of observations (Rouleau and Bernier 2011). Waterfront development is also an issue in the area near Westmeath Provincial Park and nesting beaches are affected by associated increases in vehicle and ATV activity (Kruschenske pers. comm. 2011).

Unnaturally High Numbers of Mammalian Nest Predators

Another limiting factor related to urban encroachment is a large increase in Raccoon populations in human modified and surrounding habitats (Garrott *et al*. 1993). At Point Pelee National Park (PPNP), 63-100% of turtle nests were lost to Raccoon predation (Browne 2003). Phillips and Murray (2005) found that density of Raccoons was four times higher in PPNP than the overall average for rural Ontario and that Raccoons were the primary predators of turtle nests within the park (Phillips 2008). Increased nest mortality in disturbed habitat was due primarily to greater Raccoon densities overall rather than foraging efforts targeted toward turtle nests (Phillips 2008). Research suggests that heavy predation of nests by Raccoons has limited juvenile recruitment and led to an older age distribution for turtle species inhabiting PPNP (Browne 2003).

Mammalian predators (mostly Raccoon and Coyote) have been observed to take 100% of known turtle nests at Rondeau Provincial Park, Long Point National Wildlife Area, and the Thames River in years where nest protection measures were not carried out (Gillingwater pers. comm. 2011). At the Royal Botanical Gardens (RBG), Raccoon populations are high due to urban surroundings and the release of many captured and "pet" Raccoons onto the property by community members and pest removal companies. An estimated 17-40% of known nests of various turtle species within the RBG reserve were taken by predators annually between 2008 and 2011 (Harrison pers. comm. 2012). At Lac des Deux-Montagnes, the rate of nest predation was estimated between 55 -95%, and nesting sites near human-modified landscapes were under greater predation pressure from Raccoons (Bernier and Rouleau 2010).

Dams and Other Water Management Structures

Construction of dams presents a serious threat to map turtles in several ways. In Iowa, Northern Map Turtles were intolerant of river modifications such as dams and channelization (Vandewalle and Christiansen 1996). Female map turtles exhibit nest fidelity, and water levels that are artificially raised could flood and destroy traditional nesting sites (Flaherty 1982). Contemporary water flow management practices likely place turtle nests at greater risk of flooding due to the artificial elevation of water levels to accommodate recreational activities during summer (Tucker *et al*. 1997). Flow regulation also reduces the availability of sandbars and beaches, and map turtle declines have been noted in the Missouri River due to loss of such habitats (Johnson 1992).

Evidence of dams altering Northern Map Turtle habitat in Canada has been documented. For instance, in Québec, large dams at Rapides-des-Joachims and Fitzroy Harbour on the Ottawa River regularly cause water level fluctuations and flood map turtle basking and nesting sites (Tessier and Lapointe 2009; Kruschenske pers. comm. 2011). In Ontario, the Thames River Fanshawe Dam reduces the scouring effect associated with heavy spring flow (loss of scouring reduces the availability of turtle nesting beaches), and increases the occurrence of sustained high water levels after summer storm events (which causes turtle nesting beaches downstream of the dam to be flooded for up to several days during incubation periods). Spiny Softshell nests located downstream of the Fanshawe dam experienced increases in embryo mortality during periods of sustained flooding (Gillingwater unpub. data), and it is likely that this effect would be worse for map turtles given that the eggs of this species are soft-shelled (and presumably more permeable than the hard-shelled eggs of the Spiny Softshell), and that map turtle hatchlings regularly overwinter in the nest chamber.

In addition to altering nesting and basking habitat suitability, dams also alter natural movements and turtles may be obliged to cross overland to bypass these structures making them vulnerable to depredation and road mortality. Dams may also eliminate rapids thereby reducing dissolved oxygen in the water (St. Lawrence Centre 1996), which could detrimentally affect the suitability of hibernation sites as this anoxia-intolerant species requires highly oxygenated hibernacula to survive winter (See **'Biology-**Hibernation**'**). Dams could also change the temperature and depth requirements of hibernation sites and cause earlier ice-off dates which may lead to premature emergence from hibernation (Brownell pers. comm. 2012). Furthermore, given this species' preference for shallow water areas (See **'Habitat'**) and a dietary preference for benthic invertebrates (See **'Biology-** Feeding and Diet**'**), dams could greatly reduce the quality of foraging habitat and food availability as a result of changes in sedimentation and increased water depths (Brownell pers. comm. 2012). As yet, there have been no studies investigating the effects on map turtle hibernation sites located downstream of dams.

Waterway locks also seem to pose a mortality risk for Northern Map Turtles. For instance, Bennett *et al*. (2010) noted that an adult female turtle they observed passing through a lock on the Trent-Severn Waterway, had an injury on her shell that was consistent with being crushed against something solid such as a lock gate or a boat hull. Map turtles on the Ottawa River must also cross through locks to reach certain areas (Bernier and Rouleau 2010). An average of 8,500 boats and 5,000 boats passed through the locks at Sainte-Anne-de-Bellevue and Carillon respectively between 2002 and 2010 (Rouleau and Bernier 2011). However, the extent of this threat to map turtle populations inhabiting the river is unknown.

Water treatment facilities also pose a mortality risk to map turtles. Along the Trent-Severn Waterway, six map turtles (2 % of captures) became trapped in a water treatment well in 2005-2006 after they entered an intake chute in a reservoir; rescued turtles had sloughing skin and one turtle died (Bennett pers. comm. 2012).

Trade

The expanding international wildlife trade has contributed significantly to the decline of many turtle and tortoise populations in the wild (Luiff 1997). The superficial resemblance *of Graptemys geographica* to several other turtle species (False (*Graptemys pseudogeographica*) and Mississippi Map Turtles (*Graptemys kohnii*), painted turtles, cooters, and sliders; Conant and Collins 1991) widely valued for food and pets may put it at risk of collection. The majority of map turtles exported from the U.S.A. are not defined by species but rather, are defined as "map turtles" in general; however, declared exports of "map turtles" are likely a mixture of common species including the Northern Map Turtle (Senneke 2006). In 1989, total declared U.S.A. exports of *Graptemys* species was 673 individuals and the value of a single turtle almost tripled from 1989 to 1993 (Anon 1996). By the early 2000s, the total annual number of U.S.A. *Graptemys* exports increased by more than 250 times with 511,520 individuals declared between 2003 and 2005, of which 10,365 (2.02%) were wild-caught (Senneke 2006). During this same 3-year period, 3,672 Northern Map Turtles (0.73% wild-caught) were also declared at U.S.A. customs for export (Senneke 2006).

Although illegal to do so, Northern Map Turtles have been listed for sale on *Kijiji.ca* in Ontario (Gillingwater pers. comm. 2011). According to investigations of tips to the Natural Resources Violations Reporting Program, nine indigenous wild-caught Northern Map Turtles were offered for sale online from 2010 to 2012 in Ontario (Miller pers. comm. 2012). Map turtle species are highly sought in the pet trade, and thus, large numbers are being smuggled into Canada to meet the demand (Miller pers. comm. 2012).

Road Mortality

Although road traffic is a source of mortality for the Northern Map Turtle, the extent to which it presents a significant threat to this species is currently unknown. According to the OHS database, the impact of road mortality seems to be much lower for this species than for several other Canadian turtle species (Oldham pers. comm. 2012). Nevertheless, many populations of large-bodied pond turtles in densely human populated areas, such as the Great Lakes region, may be losing >5% of individuals annually to road mortality (Gibbs and Shriver 2002). Therefore, this mortality factor may pose a threat to some map turtle populations because map turtles in Canada mostly occur in road-dense southern Ontario and Québec, where the number of major roads has greatly increased in the past 40 years (Fenech *et al*. 2001).

Gibbs and Shriver (2002) estimate that Northern Map Turtle populations are susceptible to population declines where road and traffic thresholds exceed 2 km of roads/km$^2$ with traffic volumes of >200 vehicles/lane/day. The Long Point Causeway, which borders the Big Creek National Wildlife Area along Lake Erie, greatly exceeds this threshold with an average daily vehicle flow of >2200 between April and October with increases of 400% during the July holiday weekend (Ashley *et al*. 2007). Although a survey conducted along a 3.6-km stretch of this road bordering the wetland only found 25 road-killed map turtles of various age classes over 4 years (Ashley and Robinson 1996), this number could possibly represent up to a 2% annual loss if the population maintains approximately 300 individuals (See **'Population Sizes and Trends -- Abundance'**). Furthermore, this number might be much higher except that the map turtle population seems to be concentrated more towards the tip of Long Point rather than within the bay which lies adjacent to the causeway (Gillingwater pers. comm. 2011). Researchers from this study reported that 2.7% of drivers utilizing the causeway were observed to intentionally hit reptile decoys placed on the centre line of the highway (Ashley *et al*. 2007). Since 2006, the Long Point Causeway Improvement Project Committee has initiated a development process to install wildlife culverts at this location over the next few years. In the meantime, wildlife barrier fencing has been installed and has subsequently reduced Species-At-Risk reptile mortality by 62% over the last 3 years (Long Point World Biosphere Reserve Foundation 2010).

Although very few road-killed map turtles have been reported from Rondeau Provincial Park (two over a 2-year study; Gillingwater and Brooks 2001), Point Pelee National Park (0.036% annually over 16 years; Browne 2003), and from Fanshawe Conservation Area on the Thames River (one over 10 years; Gillingwater pers. comm. 2011), it is important to bear in mind that these are protected areas with reduced traffic, controls on road access and speed, and barriers to road access. In a study of parameters that influence road mortality of several taxa in southwest Ontario, posted road speed limit was the dominant positive predictor of roadkill, followed by maximum daily temperature and habitat diversity, and distance from wetlands was the major negative predictor (Farmer and Brooks 2012). For turtles, adult females are especially vulnerable to road mortality as they are more likely to be found crossing roads than are males or juveniles, and they often nest along road shoulders (Gibbs and Steen 2005; Steen *et al.* 2006; Szerlag 2006); this may be why several aquatic freshwater turtle populations near roads or in road-dense areas report significantly male-biased sex ratios (Aresco 2005; Steen and Gibbs 2004; Gibbs and Steen 2005; Steen *et al*. 2006).

Most turtle populations within road-dense southwestern Ontario likely experience a loss of individuals annually to road mortality although the extent and impact of these losses are unknown. Given the low tolerance of most freshwater turtle species to adult mortality (Brooks *et al*. 1991; Doroff & Keith 1990; Congdon *et al.* 1993, 1994; Gibbs and Shriver 2002), in conjunction with the documented evidence of road-related adult loss from some populations in Canada, it logically follows that populations within regions of high road activity have experienced some levels of decline. In the context of the extensive length of three generations for map turtles, there has been a huge increase in density and traffic speed and volume implying that impacts of road mortality have undoubtedly also increased during the past century and will continue to increase in the future as road intrusion increases. The significance of these impacts is currently unknown.

<u>Climate Change</u>

The sex of developing map turtle embryos is dependent on environmental temperatures within the nest chamber (See **'Physiology and Adaptability-** Temperature-Dependent Sex-Determination**'**) and thus, climate change has the potential to greatly alter the structure of map turtle populations. In particular, because higher temperatures produce female embryos, populations have the potential to become female-biased as climate becomes warmer. Increased nest site temperatures within altered habitats along the Trent-Severn Waterway are suggested to explain the observed female-bias in the populations there (Bennett *et al*. 2009; See **'Biology -** Population Structure and Demographics**'** and **'Fluctuations and Trends'**). Given this correlation of significant female-bias within populations subject to warmer nest site temperatures, climate change could present a serious threat to the viability of map turtle populations in the future.

## PROTECTION, STATUS, AND RANKS

### Legal Protection and Status

In Canada, the Northern Map Turtle was designated as a species of ‘Special Concern’ by the Committee on the Status of Endangered Wildlife in Canada in 2002 (COSEWIC 2002). It is classified as 'Special Concern' both federally and in Ontario, and as 'Vulnerable' in Québec according the *Loi sur les espèces menacées ou vulnérables du Québec (Act respecting threatened or vulnerable species).* According to the Ontario *Endangered Species Act* (ESA 2007), the Québec *Loi sur les espèces menacées ou vulnérables* (1989)*,* and the federal *Species at Risk Act* (SARA 2002) a management plan must be developed for the recovery of this species (see also Table 3).

**Table 3. Implemented recovery actions in Canada.**

| | | Ausable River | Gananoque River Waterway (Lost Bay) | Grand River (York to Paris) | Lake Erie (Point Pelee NP) | Lake Erie (Rondeau PP) | Lake Erie (Long Point NWA) | Lake Huron (The Massasauga PP) | Lake Ontario (Carroll's Bay Marsh, RBG) | Lake Opinicon (Rideau Canal Waterway) | Lake St. Clair (SCNWA, Bear Creek Marsh) | Ottawa River (Deep River to Lac des Deux-Montagnes) | St. Lawrence River (SLINP) | Sydenham River | Thames River (London to Delaware) | Trent-Severn Waterway (Peterborough to Trenton) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Conservation | Habitat Improvement | | | | | | | | X | | | X | | | | |
| Conservation | Habitat Protection | | | | | | | | | | | X | | | | |
| Conservation | Nest Protection | | | | X | X | | | X | | | | | | | |
| Conservation | Public Education | | | | | X | | X | X | | | X | | | X | X |
| Inventory | Mark-recapture surveys | | X | | X | X | X | X | X | X | | X | X | | | X |
| Inventory | Population Estimates | | | | X | | | | X | X | | X | X | | | |

| | | Ausable River | Gananoque River Waterway (Lost Bay) | Grand River (York to Paris) | Lake Erie (Point Pelee NP) | Lake Erie (Rondeau PP) | Lake Erie (Long Point NWA) | Lake Huron (The Massasauga PP) | Lake Ontario (Carroll's Bay Marsh, RBG) | Lake Opinicon (Rideau Canal Waterway) | Lake St. Clair (SCNWA, Bear Creek Marsh) | Ottawa River (Deep River to Lac des Deux-Montagnes) | St. Lawrence River (SLINP) | Sydenham River | Thames River (London to Delaware) | Trent-Severn Waterway (Peterborough to Trenton) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Inventory | Presence/ Absence surveys | X | | X | | | | | | | X | X | | X | X | X |
| Monitoring | Water Quality | X | | X | | | | X | | | | | | X | X | |
| Monitoring | Benthic Invertebrates | X | | X | | | | | | | | | | X | X | |
| Research | Biology and Behaviour | | X | | | X | X | | X | X | | X | X | | | X |
| Research | Demographics | | | | X | X | | | X | X | | X | X | | | X |
| Research | Genetic Profiling | | | | | | | | | | | X | | | | X |
| Research | Habitat Use/Needs | X | X | X | X | X | X | X | X | X | | X | X | X | X | X |
| Research | Mortality | | | | X | X | X | | | X | | X | X | | | X |
| Research | Movement/ Home Range | | | | | | | | X | X | | X | X | | | X |
| Research | Nest Success | | | | X | X | | | | | | | | | | |
| Research | Population Threats | | | X | X | X | X | | X | X | | X | X | | | X |

The Northern Map Turtle is protected from hunting, trapping, captivity and trade under Ontario's *Fish and Wildlife Conservation Act* (1997) and its habitat receives a degree of protection under the Provincial Policy Statement of the *Ontario Planning Act* (R.S.O. 1990, c.P.13). Map turtle populations occurring in Provincial and National Parks or Wildlife Areas also receive protection under the *Provincial Parks and Conservation Reserves Act,* the *Canada National Parks Act*, and the *Canada Wildlife Act*. In Québec, the Northern Map Turtle is listed as Vulnerable under the *Loi sur les espèces menacées ou vulnérables* (R.S.Q., c. E-12.01) and thus it receives protection under the provincial *Loi sur la conservation et la mise en valeur de la faune* (R.S.Q., c. C-61.1) (*Act respecting the conservation and development of wildlife*). This Act prohibits the collecting, keeping, buying, and selling of individuals and protects its nests from disturbance, destruction or alteration. In 2010, all *Graptemys* spp. were listed as Appendix III by the Convention on the International Trade of Endangered Species (CITES), which means that, although not endangered, international trade in live specimens, parts, or products is monitored and requires valid permits.

## Non-Legal Status and Ranks

The global Northern Map Turtle population is ranked G5 ('secure'; last reviewed in 2005) and is estimated at 100,000 to 1,000,000 individuals (NatureServe 2011). At the national level, the U.S. population is ranked N5 ('secure') (NatureServe 2011), and the Canadian population recently (2011) had its rank changed from N4 to N3 ('vulnerable') (Anions pers. comm. 2011). Out of the 24 U.S. states in which this species occurs, it is ranked 'vulnerable' (S3) in four states, 'imperiled' (S2) in two states, and 'critically imperiled' (S1) in three states. At the provincial level this species is ranked 'vulnerable' (S3) in Ontario (NatureServe 2011) and 'imperiled' (S3) in Québec (Gauthier pers. comm. 2012). See Table 4.

**Table 4. Non-legal ranks of the Northern Map Turtle.**

| Global | G5 | Iowa | S4 | North Carolina | SNR |
|---|---|---|---|---|---|
| United States | N5 | Kansas | S2 | Ohio | SNR |
| Canada | N4 | Kentucky | S4 | Oklahoma | S1 |
| Québec | S2 | Maryland | S1 | Pennsylvania | S4 |
| Ontario | S3 | Michigan | S5 | Tennessee | S5 |
| Alabama | S3 | Minnesota | SNR | Vermont | S3 |
| Arkansas | S4 | Mississippi | SNR | Virginia | S3 |
| Georgia | S1 | Missouri | S5 | West Virginia | S2 |
| Illinois | S4 | New Jersey | SNA | Wisconsin | S5 |
| Indiana | S4 | New York | S3 | | |

(Nature Serve, 2011)

**Table 5. Northern Map Turtle occurrences in protected areas in Canada.**

| Conservation Areas | Location | Prov-ince | Governing Authority | Other designations |
|---|---|---|---|---|
| Big Bend | Thames River | ON | Lower Thames Valley CA | |
| Brant | Grand River | ON | Grand River CA | |
| Cedar Creek | Lake Erie | ON | Essex Region CA | |
| Crowe Bridge | Crowe River | ON | Crowe Valley CA | |
| Fanshawe | Thames River | ON | Upper Thames River CA | |
| Hillman Marsh | Lake Erie | ON | Essex Region CA | |
| Holiday Beach | Lake Erie | ON | Essex Region CA | |
| Minesing Wetlands | Nottawasaga River | ON | Nottawasaga Valley CA | ANSI, RAMSAR |
| Rock Glen | Ausable River | ON | Ausable Bayfield CA | |
| Ruscom Shores | Lake St. Clair | ON | Essex Region CA | ESA |
| Selwyn | Kawartha Lakes, Canadian Shield | ON | Otonabee Region Conservation Authority | |
| Stoney Point | Lake St. Clair | ON | Essex Region CA | |
| Tremblay Beach | Lake St. Clair | ON | Essex Region CA | |
| **National Parks** | | | | |
| Georgian Bay Islands | Lake Huron | ON | Parks Canada | |
| Point Pelee | Lake Erie | ON | Parks Canada | ANSI, RAMSAR |
| St. Lawrence Islands | St. Lawrence River | ON | Parks Canada | |
| **National Wildlife Areas** | | | | |
| Big Creek Marsh | Lake Erie | ON | Canadian Wildlife Service | ANSI, ESA |
| Lac Saint-François | St. Lawrence River | QC | Canadian Wildlife Service | RAMSAR |
| Long Point | Lake Erie | ON | Canadian Wildlife Service | ANSI, RAMSAR, World Biosphere Reserve |
| St. Clair | Lake St. Clair | ON | Canadian Wildlife Service | RAMSAR, IBA |
| **Provincial Nature Reserves** | | | | |
| O'Donnell Point | Lake Huron | ON | Ontario Parks | |
| **Provincial Parks** | | | | |
| Awenda | Lake Huron | ON | Ontario Parks | |
| Bonnechere | Canadian Shield | ON | Ontario Parks | |
| Charleston Lake | Gananoque River Basin, Canadian Shield | ON | Ontario Parks | |
| Ferris | Trent River | ON | Ontario Parks | |
| Fitzroy | Ottawa River | ON | Ontario Parks | |
| French River and French River Waterway | Lake Huron | ON | Ontario Parks | |

| Conservation Areas | Location | Prov-ince | Governing Authority | Other designations |
|---|---|---|---|---|
| Frontenac | Cataraqui River Basin, Canadian Shield | ON | Ontario Parks | |
| Killbear | Lake Huron | ON | Ontario Parks | |
| Komoka | Thames River | ON | Ontario Parks | |
| Long Point | Lake Erie | ON | Ontario Parks | |
| Murphy's Point | Rideau Canal Waterway | ON | Ontario Parks | |
| Parc national de Plaisance | Ottawa River | QC | Parcs Québec | |
| Presqu'ile | Lake Ontario | ON | Ontario Parks | ANSI |
| Puzzle Lake | Canadian Shield | ON | Ontario Parks | |
| Rondeau | Lake Erie | ON | Ontario Parks | ANSI |
| Sandbanks | Lake Ontario | ON | Ontario Parks | ANSI |
| Six Mile Lake | Lake Huron | ON | Ontario Parks | |
| Turkey Point | Lake Erie | ON | Ontario Parks | |
| The Massasauga | Lake Huron | ON | Ontario Parks | |
| Wasaga Beach | Lake Huron | ON | Ontario Parks | |
| Westmeath | Ottawa River | ON | Ontario Parks | |
| **Other** | | | | |
| Big Sandy Bay Management Area | Lake Ontario | ON | OMNR | ANSI |
| Carroll's Bay Marsh Nature Sanctuary | Lake Ontario | ON | Royal Botanical Gardens | ANSI, IMPARA |
| Cootes Paradise Wildlife Sanctuary | Lake Ontario | ON | Royal Botanical Gardens | ANSI, ESA, IBA, IMPARA |
| Canadian Forces Base Petawawa | Ottawa and Petawawa River | ON | Canadian Department of National Defence | |
| Finlay Islands Ecological Reserve | Ottawa River | QC | Government of Québec | |
| Kettle Point | Lake Huron | ON | Kettle Point First Nation | ESA |
| Lighthouse Point Provincial Nature Reserve | Pelee Island, Lake Erie | ON | Ontario Parks | |
| Lost Bay Nature Reserve | Gananoque Waterway | ON | Ontario Nature, Kingston Field Naturalists | |
| Murray Marsh Natural Habitat Area | Trent River Watershed | ON | Lower Trent CA, OMNR | PSW |
| Pelee Island | Lake Erie | ON | Township of Pelee Island | ANSI, ESA |
| Refuge faunique de la rivière des Milles-îles | Rivière des Milles-îles | QC | Government of Québec | |
| Walpole Island | Lake St. Clair | ON | Walpole Island First Nation | ESA |

The Northern Map Turtle's General Status Rank in Canada and Ontario is 3 or 'sensitive' (uplisted from 'secure' in 2000), meaning it requires attention and protection to prevent it from becoming at risk. Its General Status Rank in Québec is 2 or 'may be at risk', meaning that it may be at risk of extirpation or extinction and thus requires a detailed risk assessment (Wild Species 2010).

## Habitat Protection and Ownership

In Canada, the Northern Map Turtle occurs within a multitude of provincial and national parks, in addition to several conservation and wildlife areas (See Table 5). This species also occurs at the Rideau Canal and Trent-Severn Waterway National Historic Sites, with recent evidence suggesting it also likely occurs within the Sainte-Anne-de-Bellevue National Historic Site (Bernier and Rouleau 2010). It is considered abundant at the Canadian Forces Base in Petawawa (Richard 2011) and there has been one confirmed sighting at the Trenton Base (Nernberg pers. comm. 2011). In 2009, there was a confirmed sighting in Algonquin Provincial Park although the species does not occur there regularly (Steinberg pers. comm. 2011). This species also occurs on several First Nations reserves including Walpole Island, Akwesasne, Kanesatake, Six Nations of the Grand River, and the Chippewas, Munsee/Delaware, Moravian, and Oneida Nations of the Thames River, to name a few.

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Teresa Piraino is a freelance ecologist with over 12 years of experience conducting research on at-risk reptiles, forest birds, and flying squirrels throughout southern and central Ontario. Her work has been in association with a variety of organizations including The Upper Thames River Conservation Authority, the Ontario Ministry of Natural Resources, York University, Guelph University, the Canadian Forest Service, the Canadian Wildlife Service, MMM Group, Ecoplans Consulting, and M.K. Ince and Associates. Over the years, she has gained in-depth field experience with many of Ontario's reptiles, including the Northern Map, Spiny Softshell, Blanding's, Spotted, Midland Painted, and Snapping Turtle as well as the Queensnake, Eastern Foxsnake, and Eastern Hog-nosed Snake to name a few. Teresa earned an Honour's Bachelor degree in Environmental Anthropology/Political Ecology from the University of Western Ontario and recently co-authored an OMNR stewardship guide for landowners entitled 'A Landmanager's Guide To Conserving Habitat for Forest Birds in Southern Ontario'.