COSEWIC
Assessment and Status Report

on the

Northern Map Turtle
Graptemys geographica

in Canada

SPECIAL CONCERN
2002

COSEWIC
COMMITTEE ON THE STATUS OF
ENDANGERED WILDLIFE IN
CANADA

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AU CANADA

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COSEWIC
Assessment Summary

Assessment Summary – May 2002

Common name
Northern map turtle

Scientific name
Graptemys geographica

Status
Special Concern

Reason for designation
There have been no quantitative or long-term studies of this species in Canada and, therefore, there is little evidence of recent range contraction or local extirpation of the species. However, the long-lived life history with delayed age of maturity and numerous potential threats to this species and habitat suggest a significant susceptibility to population decline. This species should be the focus of monitoring of populations to identify demographic trends and establish some estimates of population size.

Occurrence
Ontario and Quebec

Status history
Designated Special Concern in May 2002. Assessment based on a new status report.

COSEWIC
Executive Summary

Northern Map Turtle
Graptemys geographica

Species information

The Northern Map Turtle (*Graptemys geographica*) is a sexually dimorphic, highly aquatic turtle. The carapace is olive to brownish in colour 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 geographical map, which gave rise to the turtle's common and scientific names.

Distribution

This species is found in North America, throughout the eastern United States, as well as in southeastern Ontario and southwestern Quebec. The Canadian map turtle population is distributed throughout the Great Lakes-St. Lawrence basin, from Lake St. Clair, Ontario, east to Montreal, Quebec. The map turtle's distribution coincides with the most densely populated and industrialized areas of Ontario and Quebec.

Habitat and biology

The Northern Map Turtle inhabits rivers and lakeshores where it basks on emergent rocks and fallen trees throughout the spring and summer. In winter, the turtles hibernate on the bottom of deep, slow-moving sections of river. It is a gregarious and wary species, and difficult to approach, as the disturbance of one member will result in the rapid dispersion of all members of a congregated basking group. Molluscs make up the majority of the map turtle's diet, though males and juveniles are known to feed on insects. In Canada, female map turtles lay a maximum of one clutch of 10-16 eggs per year, but clutch success rate is unknown. Although habitat requirements and some aspects of behaviour are well-known for this species, our knowledge of its life history is quite limited.

Population sizes and trends

There are no ongoing programs to monitor populations of the Northern Map Turtle in Canada. Point estimates made along the Ottawa River estimate that in localized areas there are between 15 and 35 turtles per kilometer of shoreline. From sightings

recorded in the OHS database, it appears as though the largest and most persistent Great Lakes populations are at Long Point and Rondeau Provincial Park, and that the largest and most persistent inland river populations are along the Thames and the Grand Rivers.

Limiting factors and threats

The majority of the Canadian range of the Northern Map Turtle is located within the most densely populated region of the country. Human interference through shoreline development and recreational boat use may prevent the turtle from using suitable areas of habitat along major waterways. The control of waterways, particularly through damming, must also have a negative impact on the turtles by submerging nest sites and altering habitat. The increase in international wildlife trading is yet another threat to this turtle because of its superficial resemblance to other highly desirable turtles (false and Mississippi map turtles, cooters, sliders and painted turtles).

Existing protection or other status designations

The Northern Map Turtle is protected from hunting, trapping, captivity and trade in Ontario by the 1997 Fish and Wildlife Conservation Act. In Quebec, the turtle is now ranked S2 (threatened). Its nests are protected from disturbance, destruction or alteration by the Loi sur la Conservation et la Mise en Valeur de la Faune, and the collecting, keeping and selling of individuals is prohibited by the Animals in Captivity Regulation. *G. geographica* is protected in the United States in at least 9 states.

Summary of status report

Sizes and trends of Canadian map turtle populations are poorly known, as are mortality rate, reproductive success, and age structure. Without this information, it is impossible to determine quantitatively whether the turtle's numbers are increasing or declining, or how susceptible the turtle is to human encroachment. This species should be the focus of monitoring of populations that are under human influence to quantify demographic trends. Given the late maturity and long-lived life history of this species, it is vulnerable to chronic increase in adult mortality rates. In addition, this species is losing habitat to shoreline development, and subjected to other declines in habitat quality from increased recreational use of shorelines, lakes, rivers and islands which have important habitat for map turtles. Mortality rates are increased by collisions with motorboats and road traffic. Survivorship of eggs and hatchlings has likely decreased with increased rates of predation of nests by raccoons and insects. In addition, declines in the turtles' molluscan prey and accumulation of contaminants in these prey species may be having detrimental effects on Northern Map Turtles.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) determines the national status of wild species, subspecies, varieties, and nationally significant populations that are considered to be at risk in Canada. Designations are made on all native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fish, lepidopterans, molluscs, vascular plants, lichens, and mosses.

COSEWIC MEMBERSHIP

COSEWIC comprises representatives from each provincial and territorial government wildlife agency, four federal agencies (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biosystematic Partnership), three nonjurisdictional members and the co-chairs of the species specialist groups. The committee meets to consider status reports on candidate species.

DEFINITIONS

Species	Any indigenous species, subspecies, variety, or geographically defined population of wild fauna and flora.
Extinct (X)	A species that no longer exists.
Extirpated (XT)	A species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A species facing imminent extirpation or extinction.
Threatened (T)	A species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A species of special concern because of characteristics that make it particularly sensitive to human activities or natural events.
Not at Risk (NAR)**	A species that has been evaluated and found to be not at risk.
Data Deficient (DD)***	A species for which there is insufficient scientific information to support status designation.

* 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.

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.

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

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in Canada

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2002

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SPECIES INFORMATION

> "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*) 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). The Northern Map Turtle is a distinctly wary species, a trait which is commented on by all who have studied this turtle and which makes the species difficult to study except from a distance.

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 naming 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], and the evolutionary relationships within *Graptemys* are continuously debated (Lamb et al., 1994). The debate concerns the relationship between *Malaclemys* (terrapins) and *Graptemys*. Wood (1977) believes that *Graptemys* is a polyphyletic group, having arisen from *Malaclemys*. His hypothesis is based on geology and the degree of tolerance to salinity that the two genera exhibit. Dobie (1982) believes *Graptemys* to be a distinctive group clearly separable from *Malaclemys* on the basis of osteological and external features, though he does concede that *Malaclemys* is undoubtedly more closely related to *Graptemys* than it is to any other extant genus. The most recent study on the evolution of *Graptemys* is genetically based, and hypothesizes that a *Graptemys/Malaclemys* ancestor arose from a *Trachemys*-like (slider) turtle during the Middle Miocene and that *Malaclemys* and *Graptemys* diverged by the late Miocene. 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).

Description

The carapace is olive to brownish in colour with a reticulate pattern of light yellow lines that fade as the turtle matures. The carapace is oval, elongate, and low, with a low medial keel, and the posterior marginal scutes range from roughly serrated (Froom, 1971), to somewhat denticulate (Babcock, 1971), 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, 1971). 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 of the *Graptemys* species 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 a 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, comparatively larger hind feet, greater retention of juvenile keel and colouration, and a more angular rear margin of the carapace (Carr, 1952). Vogt (1980) proposes several advantages to this sexual dimorphism: 1. It allows for intraspecific partitioning of food resources. Males feed on small, energy-rich insect larvae and molluscs, whereas adult females are omnivores that feed on both invertebrates and vegetation. 2. Small size may allow males to put their energy into searching for females, precopulatory display and sperm production, rather than into growth. 3. Reproductive maturity is reached at a smaller size in males, allowing for a lower minimum age of reproduction. For females, the larger the female, the greater number of eggs she produces in a single clutch. Larger size may also afford females greater protection from avian and mammalian predators when they venture ashore to nest (Vogt, 1980).

Study in Canada

The first published records of Northern Map Turtle in Canada were from Logier (1925) and Patch (1925) who reported sightings at Point Pelee, Ontario in 1920, and Norway Bay, Quebec, in 1922, respectively. From that time until the early 1980s the only reports of the turtle were of a distributional nature, recorded in local and national herpetology checklists. The one exception is a paper written about the blood physiology of *Graptemys geographica* in Ontario (Semple et al., 1969). Gordon and MacCulloch (1980) were the first to publish a paper on the ecology of the Northern Map Turtle in Canada. Their paper describes habitat preferences and population structure of the Lac des Deux Montagnes population in Quebec. The research on this population was continued in the Master's Thesis of Flaherty (1982), a student at McGill University under the supervision of Roger Bider.

This early research prompted questions about the status of the species in Quebec. Sarazzin et al. (1983) considered the Northern Map Turtle to be potentially threatened in Quebec. In 1992, the Northern Map Turtle was put on the list of species potentially vulnerable or threatened in Quebec (Beaulieu, 1992). In the 1990s, several reports were written, again on the distribution and abundance of *Graptemys geographica* in Quebec (Daigle, 1992), with the extension of studies into Norway Bay on the Ottawa

River (Chabot et al., 1993), the Ottawa River between Hull and Rapides des Joachims (Daigle et al., 1994), the St. Lawrence River (St. Lawrence Centre, 1996), and the St. Lawrence Lowlands (Daigle and Lepage, 1997). A status report has recently been published by the Ministry of the Environment and Wildlife of Quebec (Bonin, 1998).

There is a conspicuous lack of research on the Northern Map Turtle in Ontario despite, or perhaps because of, its wide range. A detailed account of the species is given in the Hamilton Herpetofaunal Atlas (Lamond, 1994), but this account is not based on any new research. Little attention is usually paid to supposedly northern species, including the effects of management practices geared towards rarer species. The biological status of these "common" species tends to be overlooked until problems become glaringly apparent (Dodd Jr. and Franz, 1993). The Ontario Herpetofaunal Summary (OHS) (Oldham, 1997) details all recorded sightings of the Northern Map Turtle in Ontario, as far back as the turtle's earliest record in 1922. The OHS and the Atlas of Amphibians and Reptiles of Quebec (Bider and Matte, 1994) allow for detailed range descriptions of this (and other) species.

DISTRIBUTION

Global range

The Northern Map Turtle has a fairly extensive range throughout the northeastern United States (Figure 1). 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; Carr, 1952; McCoy and Vogt, 1990).

Canadian range

The physiography and climate of eastern Canada are varied and strongly influence the abundance and distribution of reptiles and amphibians (Bleakney, 1958). The St. Lawrence Lowlands, where the majority of range of the Canadian map turtle population is found, are warmer than the mountainous country to the north and south which presumably impose a temperature barrier on the map turtle's distribution. In southern Quebec, turtles are also limited by the foothills of the Canadian Shield and the low temperatures north of the St. Lawrence River, and in eastern Quebec they are limited by the increasing salinity of the St. Lawrence River (Bleakney, 1958).

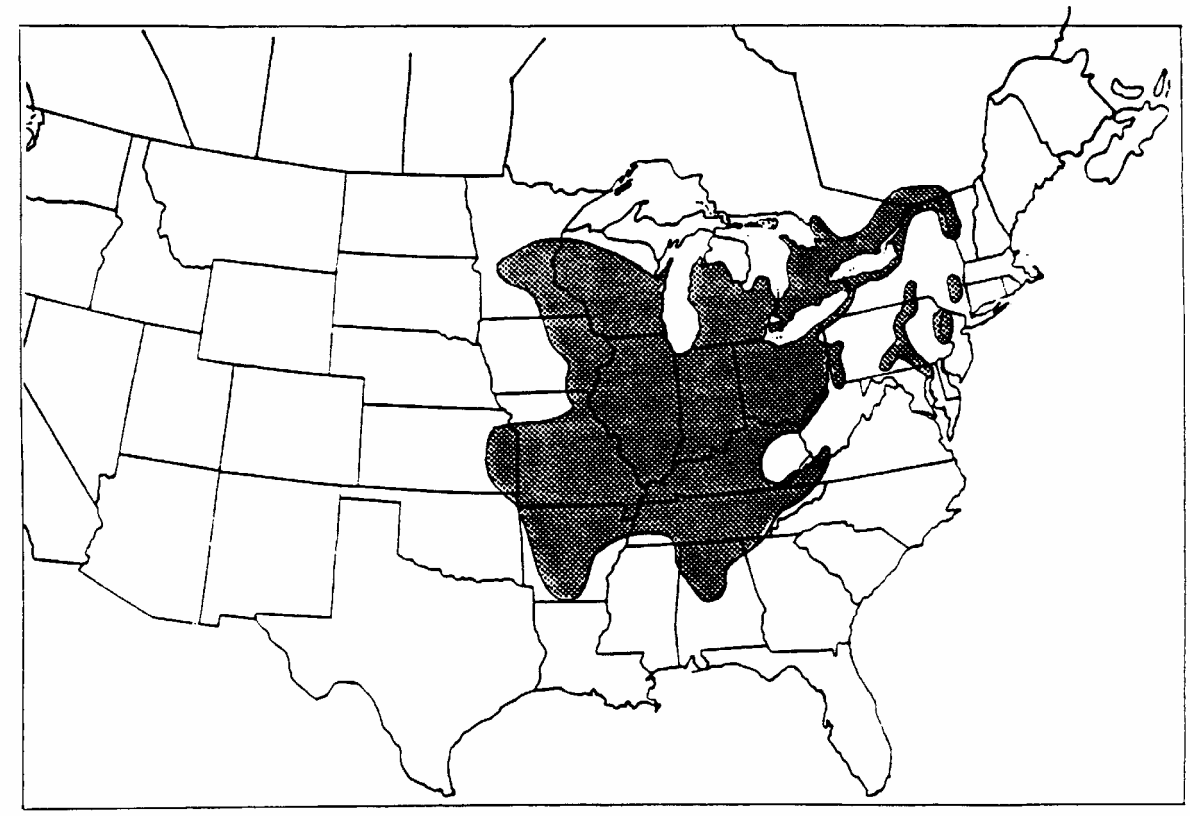

Figure 1. Distribution of the Northern Map Turtle (*Graptemys geographica*) in North America (Ernst et al., 1994).

Bleakney's (1958) account of the distribution of eastern Canadian reptiles and amphibians also proposes how the Northern Map Turtle arrived in Canada. He 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 and tributary valleys, into the Great Lakes, and through the St. Lawrence River system.

The Canadian range of the Northern Map Turtle is limited to southern Ontario (Figure 2) and to southwestern Quebec (Figure 3), and this range represents the northern limit of the species. No contraction of the range of the Northern Map Turtle in Canada has been documented, although it is likely that local populations in urban areas may have been extirpated. The lack of any short- or long-term population studies makes it difficult to assess the population trends over the years. The data within the OHS database suggest that 16% of all districts since 1985 have not had map turtle observations in areas where they were previously found; however 16% of districts have observations since 1985 in districts where they were previously unrecorded. It is unlikely that the species dispersed into these areas, but more likely that they were always there and not recorded.

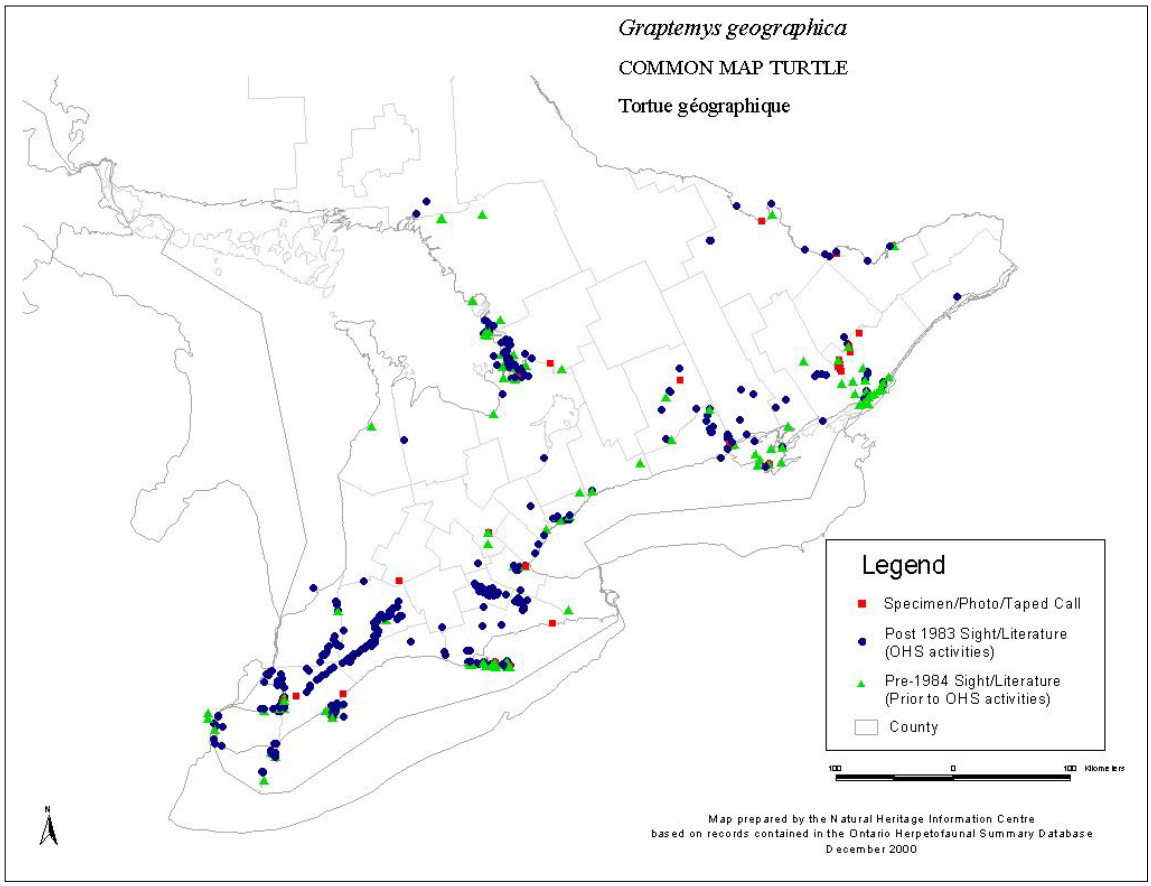

Figure 2. Distribution of the Northern Map Turtle (*Graptemys geographica*) in Ontario. This map is a draft prepared by the Natural Heritage Information Centre (1998) based on records contained in the Ontario Herpetofaunal Summary database.

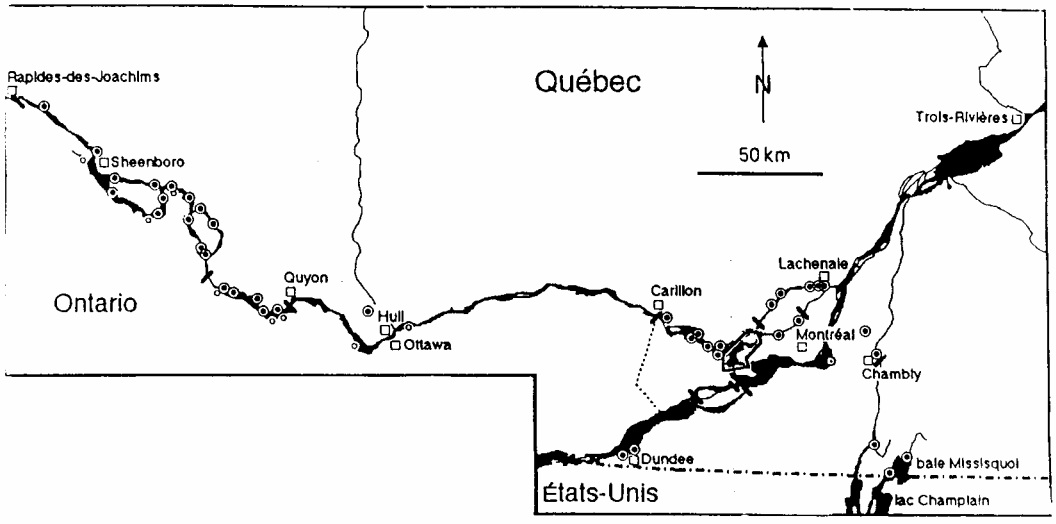

Figure 3. Distribution of the Northern Map Turtle (*Graptemys geographica*) in Quebec (Bonin, 1998).

In Ontario, the Northern Map Turtle is scattered along the shorelines of Georgian Bay (as far north as the southern Sudbury district), Lake St. Clair (western limit), the Detroit River, Lake Erie and Lake Ontario. It is found inland along major rivers such as the Thames, Ausable, Sydenham, Grand, and Ottawa (as far west as Deep River), and in some of the larger lakes along the southern edge of the Canadian Shield (Rideau Lakes system) (Cook, 1981; Froom, 1971; Lamond, 1994; Bonin, pers. comm.).

Since the early 1980s, the status of the map turtle in Quebec has been under examination, as its range was thought to be limited to Norway Bay west of Ottawa, and the Lac des Deux Montagnes at the eastern end of the Ottawa River. The map turtle has since been found along the Ottawa River between Deep River and Montreal, in the southern end of Lac St. François on the St. Lawrence River, and in Baie Missisquoi of Lake Champlain (Gordon and MacCulloch, 1980; Flaherty, 1982; Daigle et al., 1994; Daigle and Lepage, 1997).

HABITAT

General

The Northern Map Turtle is almost exclusively aquatic, leaving the water only to bask and to lay eggs. It inhabits both lakes and rivers (Froom, 1971), preferring slow moving currents, muddy bottoms, and abundant aquatic vegetation (Anderson, 1965; Behler and King, 1979; DeGraff, 1983). The habitat must contain suitable basking sites, such as rocks and deadheads, with an unobstructed view from which a turtle can drop immediately into the water if startled (Logier, 1939; Froom, 1971; Cook, 1981). In the spring, when water levels are high, summer basking sites are usually submerged, therefore the turtles tend to bask along the shore. As the water level falls, preferred basking sites are offshore and adjacent to deep water. Sites should be exposed to the sun for at least part of the day (Gordon and MacCulloch, 1980). Nesting occurs in soft sand or soil and at a distance from the water, perhaps to protect the nests from flooding (Gordon and MacCulloch, 1980; DeGraff, 1983). Northern Map Turtles hibernate for about five months in Canada, and tend to remain active in deeper hollows under the ice (see Biology - Hibernation). The river bottom at the hibernating site tends to be typical of the river in general, with patches of sand and gravel (Graham and Graham, 1992).

Specific

1. Ottawa River Habitat

The Ottawa River is generally a slow-flowing river, enlarging in some places to form lakes and reservoirs (dammed) of several hundred hectares. There are numerous islands and bays which are usually marshy habitats with abundant emergent vegetation, as well as rocky environments with little vegetation but with numerous basking sites (Daigle, 1992; Daigle et al., 1994).

Norway Bay, about 40 km west of Ottawa, consists of a group of small islands and a contoured shore. The riverbed is often shallow, with a bottom substrate of mud and rock. The presence of supports in the water such as tree trunks, logs and rocks, as well as sites providing shelter from the waves, are two important habitat characteristics (Chabot et al., 1993). The majority of turtles studied by Chabot et al. (1993) were found on emerging supports.

The Lac des Deux Montagnes is situated at the southeast end of the Ottawa River, before its junction with the St. Lawrence River. The map turtle population of the eastern basin of this lake has been extensively studied. All the bays of this lake are shallow, with clay or sand bottoms and fairly extensive submergent and emergent vegetation. Numerous basking sites are provided by fallen trees and exposed rocks. The shoreline consists mostly of rocks and stones of varying sizes embedded in sandy clay (Gordon and MacCulloch, 1980). Flaherty and Bider (1984) found that the physical structure of the habitat was not the key stimulus for habitat selection, as not all potential basking and nesting sites were used equally and there was an apparent clumping of turtles in the bays of the lake. Sites tend to be separate from shore, and stationary with an easterly orientation. Used sites were significantly longer, farther from land, farther from aquatic and terrestrial vegetation, and were in deeper water than unused sites (Flaherty, 1982; Flaherty and Bider, 1984).

2. St. Lawrence River Habitat

The only section of the St. Lawrence River where *G. geographica* is found is in the Fluvial Section, which extends from the Cornwall area, west of the Quebec border to Lake St. Pierre. The Fluvial Section is characterized by a fairly wide flood plain, allowing for considerable development of shoreline wetlands. This section of the river is freshwater and unaffected by tides. The shoreline sediment of Lac St. Francois is mainly sand-silt, whereas around Montreal it is a mix of silt-clay, gravel, and sand. The banks of the Fluvial Section have frequently been altered by roads, walls, dikes, breakwaters or dams built to meet urban, industrial or agricultural needs, which have altered the dynamic equilibrium of the shoreline (see Limiting Factors) (St. Lawrence Centre, 1996).

3. Great Lakes Shoreline Habitat

The shorelines along which the Northern Map Turtle is found usually have a considerable amount of wetland and beach (Table 3).

4. United States Habitat

Pluto and Bellis (1988) found that most turtles in Pennsylvania basked on logs and rocks about 22 m from the nearest shore, in deep, slow areas of a river. However, research in Kansas revealed quite a different use of habitat (Fuselier and Edds, 1994). *G. geographica* were found exclusively in shady creeks and streams over rock and gravel substrata, as opposed to rivers with sandy bottoms. The species in Kansas inhabited sites with bare shoreline, and was not found in areas with high amounts of emergent or submerged vegetation.

Age/size class differences in habitat use

Research conducted in Pennsylvania by Pluto and Bellis (1986) suggested that juvenile and adult map turtles use different microhabitats. Large turtles (carapace length greater than 125 mm) were found more often in the deep slow areas of a river, basking an average of 22 m from the nearest bank. These large turtles have the greatest ability to maintain locomotion and orientation in fast currents and are able to dive for longer times than juveniles. Therefore, adults generally have a greater facility for occupying deeper/faster water. By contrast, small turtles (carapace length less than 66.5 mm) frequent shallow, slow areas close to shore. Pluto and Bellis (1986) hypothesized that by inhabiting these areas, juveniles require much less swimming effort to breathe and feed. Additionally, this use of habitat may involve a trade-off between the risks from terrestrial and aquatic predation. In deeper water, small turtles would be more susceptible to predation by large fish, but remaining on shore would increase the risk of terrestrial predation. The escape behaviour of small turtles was one of attempted concealment under or between small rocks and logs rather than by flight to deeper water (Pluto and Bellis, 1986).

The predation risks for larger turtles seem to increase as the distance from the shore decreases (Pluto & Bellis, 1986). Large individuals avoided shallow, near shore areas and avoided basking on or near shore, except when mid-stream basking sites were submerged during high water periods. The escape behaviour of large turtles was to swim into deeper water; only rarely would they attempt concealment along the shore.

Trends and protection

The Northern Map Turtle's habitat is destroyed by urbanization, industrialization and agriculture (Gibbons, 1997). Turtles, generally, can take advantage of other habitats in a region, but habitat specialists such as map turtles may not be able to tolerate habitat alteration and may be replaced by a more tolerant species. Turtles that live near the latitudinal extremes of their distribution may be even more at risk (Pritchard, 1997). For example, in Norway Bay, there was a complete disappearance of map turtles from sites where they were regularly found following the removal of trees and logs on which they basked. Although these features were being removed as part of a river clean-up project, there was a resulting negative impact on turtle habitat (Chabot et al., 1993). Chabot et al. (1993) suggested that features be replaced by platforms or logs, and recommended that the region's habitat be protected by the Government of Quebec. At present, however, the only region in Quebec that affords protection to habitat used by this species is the National Wildlife Area at St. Francis (Bonin, pers. comm.) (Table 3). In 1994, the Great Lakes 2000 Cleanup Fund requirements were defined for implementing habitat rehabilitation projects including non-game species such as reptiles. This cleanup fund supposedly maintains logs for basking and soft pond bottoms for hibernating, and includes 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).

Though many populations of map turtles are found in areas that are already protected (Table 3), these populations are still subject to high human impact from recreational activities. 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).

It is difficult to determine the effects of human impacts on turtle populations for which we have no historical information. For example, the construction of dams must have affected *Graptemys* populations throughout their range, but the extent is unknown due to a lack of information about the populations prior to construction (Gibbons, 1997). From a management perspective, pre-impact surveys and long-term data sets would facilitate the implementation habitat protection strategies.

BIOLOGY

Reproduction

The reproductive season of the Northern Map Turtle begins while the turtles are still congregated in hibernacula (i.e. between October and April). At this time, courtship and mating occur (Anderson, 1965; Vogt, 1980), with males identifying conspecific females through visual and olfactory cues. After initial cloacal contact with a female, a male may attempt to mount the female, or may swim to her head, make snout-to-snout contact, and bob his head rapidly in the vertical plane. To mount the female, the male hooks the tip of his tail around that of the female to maintain balance and pulls her cloaca into position to allow intromission. Coitus lasts 15 seconds to 4 hours (Vogt, 1980). After leaving the hibernacula in April, females move toward nesting beaches and spend 6 weeks basking and applying shell to ovarian follicles. The higher the temperature in April and May, the higher the metabolic rate of the turtles; thus the shell may be laid around the eggs more rapidly, allowing the clutch to be laid earlier (Vogt, 1980). This temperature effect may explain why some southern populations of the Northern Map Turtle nest earlier than more northern ones. For example, in Illinois and Indiana, nesting begins in May or very early June (Cahn, 1937; Newman, 1906), whereas in Wisconsin egg laying occurs from late June to mid-July (Vogt, 1980). All nesting observations from the Ontario Herpetofaunal Summary (Oldham, 1997) occurred between June 10th and July 24th.

Newman (1906) noted that nesting females never had a carapace length less than 19 cm. In the Lac des Deux Montagnes population, Gordon and MacCulloch (1980) estimated carapace length at sexual maturity to be 17.5 cm for females and 7.5 cm for males. Females may wander considerable distances inland in search of well-drained, sunlit sites (Johnson, 1982), or sites with soft-ploughed soil or clear dry sand (Carr, 1952). The absence of vegetation and shade permit maximum solar radiation to heat the substrate and to incubate the eggs (Vogt and Bull, 1984).

The nest itself is a symmetrical, flask-shaped cavity with two layers of eggs placed in the expanded portion, and the last two or three eggs left in the narrow neck. Loose dirt is scraped into and over the hole, and the surface is smoothed by dragging the plastron over it. There are usually 10-16 eggs in a clutch (Carr, 1952), which hatches in late August or early September (Froom, 1971). Delayed emergence of hatchlings may occur within nests laid later in the season. These hatchlings overwinter and emerge in late May or June in the following year (Cahn, 1952; Behler and King, 1979). There is no evidence of delayed emergence in Canadian populations, though it has been documented in the northern United States (Gibbons and Nelson, 1978). Southern turtles also lay more than one clutch (up to three), whereas northern females are restricted to one clutch per season (White and Moll, 1991).

Physiology

1. Thermoregulation

The Northern Map Turtle thermoregulates by basking in the spring and summer, and hibernating under the ice during the winter months. When basking, this turtle will dive into water to a depth of up to 6 m where the water temperature may be up to 20º C less than that on the basking platform. This requires considerable physiological adjustments to temperature fluctuations (Semple et al., 1969). Semple et al. (1969) studied the Northern Map Turtle in Ontario and reported that the turtles' body temperatures range from 3º C under the winter ice to 30º C in certain summer locations, and that their blood physiology varies seasonally. They also found that plasma volumes in *G. geographica* relative to body weight are large in comparison with many other turtle species, and that plasma was sequestered in certain areas of the vascular bed of the cold animal. This sequestration of fluid from the peripheral regions (skin, shell) to the core areas (heart, lungs) reduces heat loss from the core (Semple et al., 1969). In another experiment, temperatures ranging from 10-40º C caused a lag in core temperature change behind change in rectal and ambient temperatures, and no turtle subjected to core temperatures over 35°C survived (Akers and Damm, 1963).

Unlike other turtles, this species does not become completely torpid, but remains mobile on the bottom of the river or lake. Metabolic rate is higher than that reported for other hibernating emydids and is 2-3 times higher in male than in female map turtles (Graham and Graham, 1992). As a turtle cools, its heart rate slows with decreasing temperature from 20-21 beats/minute at 20º C to 5-6 beats/minute at 5º C (Akers and Damm, 1963; Semple et al., 1969).

2. Temperature-dependant sex determination

Temperature-dependent sex determination occurs in *Graptemys* during the middle third of development, with males developing at a constant incubation temperature of 25º C, and females at 30.5º C (Bull and Vogt, 1979). Bull et al. (1982b) suggested that at intermediate temperatures, there might be a genetic disposition towards one sex. 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). 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 variation in sex ratio may result entirely from changes in the environment, potentially leading to a bias in the population hatchling sex ratio, unless females changed their nesting sites (Vogt and Bull, 1984). Threshold temperatures did not differ as expected between northern and southern populations (2-4º C daily mean difference during nesting season), and there was not an obvious female-biased sex ratio. This is likely because different nesting behaviours compensated for the climatic differences (Bull et al., 1982a).

Feeding

The Northern Map Turtle is a carnivore specializing on molluscs, although it may occasionally eat other food items. Diet differs within the species; the females with their larger, crushing jaws break open clams (unionids) and large snails (Logier, 1939), whereas males and juveniles eat insects, crayfish, and smaller molluscs (Behler and King, 1979; Vogt, 1981). Although *G. geographica* may feed on aquatic plants (Carr, 1952; Froom, 1971), Vogt (1981) stated that vegetation is taken accidentally along with other food. *G. geographica* dive underwater for up to 6 minutes and move along the vegetation looking for snails, and turning over small rocks to consume the snails or clams found underneath (Vogt, 1981). Map turtles feed using two different methods: the first involves capturing the mollusc when the foot and gills are well out of the shell, biting off the soft parts, and leaving the hard shell; in the second method, the hard shell is crushed between the jaws and the broken pieces of the shell are extricated by using the claws of the front feet (Newman, 1906). Food is always swallowed underwater (Froom, 1976).

In the Ottawa River, males begin to feed in May, shortly after ice breakup, and females in June, after the completion of nesting. When the females begin to feed, male turtles tend to disperse, which indicates that there may be competition for food at this point (Flaherty, 1982).

In the Great Lakes region, the invasion of zebra mussels (*Dreissena polymorpha*) has greatly altered the composition and structure of macroinvertebrate communities, particularly unionid populations. In the upper St. Lawrence River, Lake St. Clair and Lake Erie, native unionids have suffered extirpation where zebra mussels occur in high densities (Nalepa, 1994; Schloesser and Nalepa, 1994; Serrouya et al., 1995; Ricciardi et al., 1996). This decline in unionids, which are the prime food source for the Northern Map Turtle, could have a long-term effect on the turtle populations (Mitchell, 1994). Map turtles in the affected regions will consume zebra mussels only when more profitable prey items are scarce. In the upper St. Lawrence River, Lake Champlain, the lower Great Lakes, and the upper Mississippi River basin, populations of map turtles and zebra mussels are sympatric (Serrouya et al., 1995).

Growth and survivorship

There has been little research on age structure and growth rates of the Northern Map Turtle and none on age-specific survivorship and mortality rate. Age at maturity is unknown for Canadian populations and poorly known in U.S. populations. Ernst et al. (1994) suggest that female map turtles in Wisconsin do not mature until at least 10-12 years. It is likely that in Canada age of maturity of females is at least 12 years. It is difficult to study the age structure and growth rates of these populations because of the elusiveness of juveniles and adult females (Gordon and MacCulloch, 1980; Chabot et al., 1993). Gordon and MacCulloch (1980) estimated that juveniles under two years comprise approximately 8% of the Lac des Deux Montagnes population. It is generally agreed that map turtle populations are male-biased (Ernst et al., 1994). This may be a behavioural bias, as females were more difficult to capture (Chabot et al., 1993), or a result of temperature-dependent sex determination (Gordon and MacCulloch, 1980).

Growth rates in the Northern Map Turtle have been studied in the Lac des Deux Montagnes (juveniles) and in Indiana. In the Lac des Deux Montagnes population, Gordon and MacCulloch (1980) proposed that males were larger than females at hatching, but grew more slowly as juveniles. Males and females in Iverson's (1988) Indiana population had nearly the same growth rate during their first two years; thereafter, females grew significantly faster than males.

Hibernation

An extensive study of hibernation in the Northern Map Turtle was completed in Vermont by Graham and Graham (1992). The majority of turtles congregated by late fall in a 6.7 m oval depression of the river bottom, located about 10 m from the south bank, in the deepest spot in the lower section of the study river. Deep slow areas were the prime hibernating sites, as deep water is less likely to freeze to the bottom, to be exposed during an extreme dry period, or to be scoured by shifting late winter ice (Pluto and Bellis, 1988). The bottom at the hibernating site was typical of the river as a whole, with patches of sand and gravel. The current 1 m below the surface was 0.1 m/s, but practically nil on the bottom. At approximately 2º C, the turtles congregated in the hollow. Decreasing water temperature may have stimulated the turtles to begin fall movements towards hibernacula (Pluto and Bellis, 1988).

Hibernation is communal, with females and males piling on top of each other. Graham and Graham (1992) noted intersexual activity differences, in that males were much more active than females throughout winter. This may be attributed to their higher metabolic rates which serve to delay the onset of greater torpidity. Many females lay motionless beside, under, or on top of submerged rock and logs, while others were stationary on open sand/gravel substrates (Graham and Graham, 1992). Hatchlings and small juveniles do not seem to be a part of the hibernating congregation. It is unknown where they spend the winter, although young turtles frequently bask late into November, becoming immobilized by the cold and left on the shores after the ice has formed (Newman, 1906). Northern Map Turtles emerge from hibernation in late March

or early April and immediately start basking (Newman, 1906; Lamond, 1994). Increasing water temperature and the search for nesting sites may prompt movements away from hibernacula (Pluto and Bellis, 1988).

Behaviour

The Northern Map Turtle is an extremely wary species, diving immediately into the water when startled. Although turtles are fairly easily captured after emergence from hibernation, within a week it is difficult to get within 50 feet of them, and they must be observed from a distance or caught in traps (Newman, 1906; Gordon and MacCulloch, 1980; Daigle et al., 1994). When threatened, they are not usually aggressive, biting only when hard pressed. If attacked, a turtle will retreat into its shell with the head carried far back between the shoulders, the neck drawn in, the legs folded between the inner parts of the projecting free edges of the carapace, and the tail turned in laterally (Babcock, 1971).

G. geographica is a gregarious basker, and may form several layers of up to 30 turtles (Froom, 1971, Daigle et al., 1994). The advantage of this group basking is that it provides good all-round visibility. All will topple into the water at the slightest unaccustomed movement or sound, even from several hundred feet away, or from the splashing of one individual into the water (Froom, 1971). There appears to be a hierarchy at the basking site. Larger turtles knocked medium turtles off the site, and usually blocked juvenile access to the site by basking right above the water line. Smaller individuals were repeatedly observed surfacing at a blocked site and then swimming away to a nearby unoccupied site to bask (Pluto and Bellis, 1986).

Movement and migration

Lotic environments undergo seasonal changes in water current, depth and substrate. These fluctuations may result in seasonal migrations of local species to more accommodating habitats (Pluto and Bellis, 1988). Pluto and Bellis (1988) studied the seasonal movements of Northern Map Turtles in a Pennsylvania River extensively and found two types of annual movement patterns. The first pattern, shown by males only, consisted of late spring or summer movements from deep, slow areas to upstream or downstream locations. At these sites, a two-month summer home range was established, and was returned to yearly. In August or September, the males returned to the deep, slow area. It is unclear why males should move upstream or downstream from the deep, slow area to other habitats. The turtles are not likely in search of mates, as few females are found in summer, and no reports of summer mating are known. In the second pattern, males and females confined all their annual movements to a relatively small area, usually in the vicinity of the major basking sites. The range length (distance between the two most extreme captures of an individual) of males per year averaged 2114.8m, which was significantly greater than the 1210.7 m per female per year (Pluto and Bellis, 1988).

The Lac des Deux Montagnes population in Quebec had quite different movement patterns than the population studied in Pennsylvania. Females had a significantly larger home range than did males (67.83 ha vs. 32.33 ha), moved significantly more often, and travelled greater mean distances (12.5 km vs. 3.77 km) (Gordon and MacCulloch, 1980; Flaherty, 1982). Considerable overlap of male and female home ranges was observed (Flaherty, 1982). The number of turtles seen in the lake's bays increased after hibernation until a peak was reached in mid-May. Females remained in these bays until nesting occurred in mid-June. Movement also occurred in males of the Lac des Deux Montagnes population, although not to the same extent as in females, of a less directed nature. These male and female movement patterns were reversed from the patterns observed in Pennsylvania. There, the turtles dispersed after nesting occurred in early July; females more than males. By the end of August, turtles reappeared in the bays and tended to remain there until freeze-up occurred. If feeding by turtles was limited during the spring, the relatively high densities of turtles during the pre-nesting period were tolerated, but post-nesting dispersal was potentially necessary to alleviate the pressure on available food resources. (Gordon and MacCulloch, 1980).

Flaherty's (1982) research in this population found that the movements of males were fairly evenly distributed over time, whereas female movement increased slowly until it peaked in July. Females maintained a high activity level until September, but exhibited their longest movements during the summer period, which coincided with the completion of nesting. Movement toward the hibernaculum was observed during the late summer and over-wintering periods (22 Aug-29 Sept) (Flaherty, 1982).

These case studies emphasize the variations in movement patterns of this species. Movements are generally related to the search for basking sites, food and nesting sites, as well as the search for mates and for overwintering areas.

POPULATION SIZES AND TRENDS

Ongoing population monitoring of the Northern Map Turtle in Canada is non-existant. Point estimates of population sizes have only been made for populations along the Ottawa River. The population of map turtles in Lac des Deux Montagnes was estimated at 351 map turtles in 1980, or 15 turtles/km of shoreline (Gordon and MacCulloch, 1980). Chabot et al. (1993) estimated 350 turtles in Norway Bay, or 32.4-38.2 turtles/km of shoreline. Daigle et al. (1994) estimated a total of over 1000 turtles in the Ottawa River from Lac des Deux Montagnes to Deep River. Daigle and Lepage (1997) estimate that 1191 turtles have been inventoried along the St. Lawrence and its tributaries (Table 1).

Table 1. Quebec counties in which the Northern Map Turtle (*Graptemys geographica*) has been observed. Data are taken from the Atlas of Amphibians an Reptiles in Quebec (1997). Information from published papers or government documents is not included in the Atlas, and therefore is not in this table.

	1	2	3*	4	5*	6	7*	8	9	10*	11*	12	13*
1980			X				X						X
1981													
1982													
1983				X									
1984													
1985												X	
1986													
1987													
1988							X						X
1989		X					X						
1990							X			X			
1991													
1992										X			
1993					X				X				
1994	X					X	X	X	X			X	X
1995		X									X		X
1996		X					X						X

(X=sighting; *=sightings in 1960s and/or 70s).

1=Argenteuil, 2=Chambly, 3=Deux Montagnes, 4=Gatineau, 5=Huntingdon, 6=Iberville, 7=Île de Montréal, 8=L'Assomption, 9=Missisquoi, 10=Pontiac, 11=Shefford, 12=Terrebonne, 13=Vaudreuil

There are few data to estimate population sizes from Ontario. However, for the purposes of establishing an estimate of relative population sizes, the total number of turtles seen per year in a population will be considered to be representative of the actual population size. The largest and most persistent Great Lakes populations seem to be at Long Point and Rondeau Provincial Park (Figure 4), and the largest and most persistent inland river populations occur along the Thames and the Grand Rivers (Figure 5). A rough estimate from Rondeau Provincial Park suggests that there may be 200-400 adults in the Bay and its tributaries (S. Gillingwater, pers. comm.). This estimate is based partly on an intense study of turtle nesting patterns in Rondeau Park in 2000-2001 (Gillingwater and Brooks, 2002). Lower numbers occur at Pelee National Park, and there may be a trend toward an older age distribution possibly foreshadowing a decline (Browne and Hecnar, 2002).

Northern Map Turtle populations vary in abundance throughout their North American range (Table 2). 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; Logier and Toner, 1961). Records of rare or extirpated populations in Ontario are from the Metropolitan Toronto area including the Rouge Valley (Johnson, 1982), and the Hamilton area (J. Lamond, 1994; J. Bonin, pers. comm.). In 1993, the map turtle was considered vulnerable along the Lake Ontario waterfront from Burlington to Trenton (Brownwell, 1993), but there are still small numbers in the area around Cootes Paradise (K. Barrett, pers. comm., 2002).

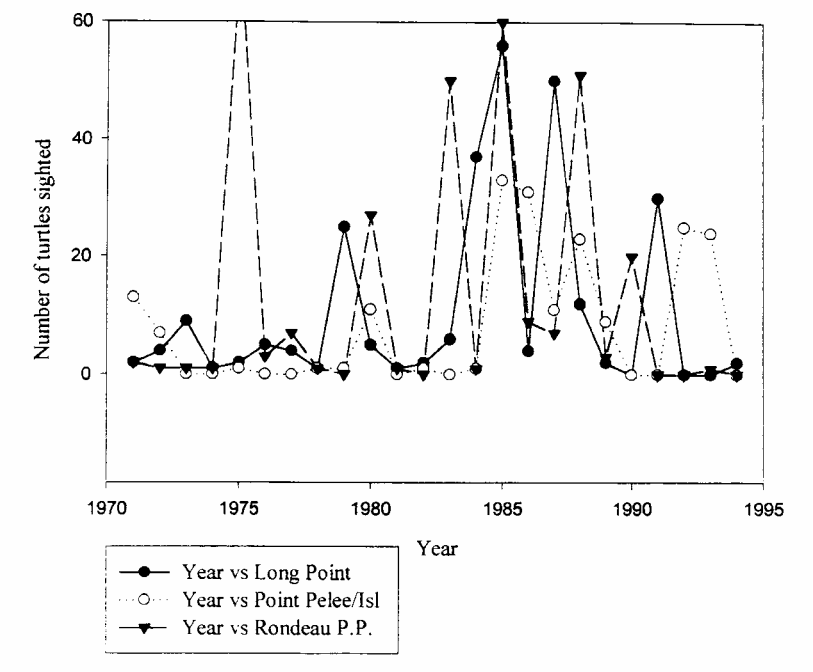

Figure 4. Total number of turtles (*G. geographica*) sighted per year in three park regions along Lake Erie's Canadian shoreline. Data are taken from the Ontario Herpetofaunal Summary (Oldham, 1997). Sampling effort was not controlled amoung years or sites.

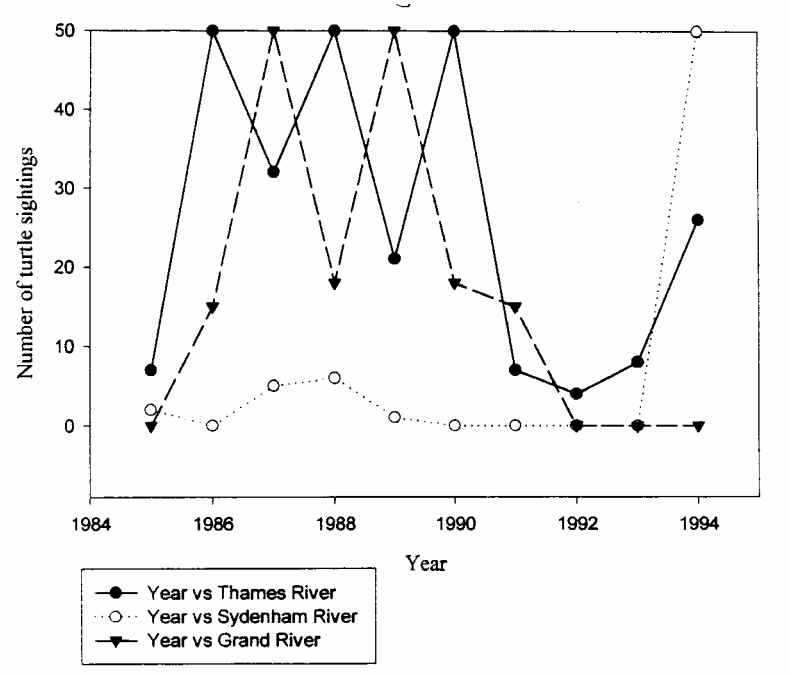

Figure 5. Total number of turtles (*G. geographica*) sighted per year along the river systems in southern Ontario. Data are taken from the Ontario Herpetofaunal Summary (Oldham, 1997). Sampling effort was not controlled amoung years or sites.

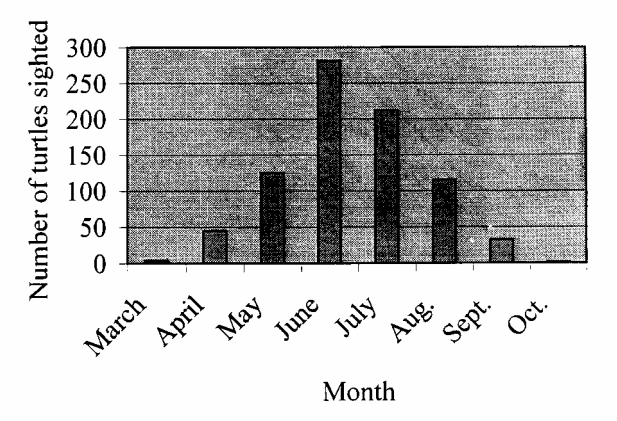

Figure 6. Monthly variations in total number of Northern Map Turtles seen over a year. Source: Ontario Herpetofaunal Summary records over a period of 72 years.

Table 2. Global, National, and Provincial/State Rankings of the Northern Map Turtle. (Source: Eastern Regional Office of the Nature Conservancy, 1997. Natural Heritage Central Databases).

Country	Province/ State	Rank	Date of Designation	Additional Designation	Comments
Global		G5	96-10-05		
Canada		N4			
	Ontario	S4	88-10-24		
	Quebec	S1	89-01-26	SDMV	
United States		N5			
	Alabama	S5	91-09-20		
	Georgia	S1	87-10-23	R	rare
	Iowa	S4	94-05-24		
	Indiana	S4	87-04-21		
	Kansas	S2	91-07-30	T	threatened
	Kentucky	S4S5	90-10-10		
	Maryland	S1	86-10-01	E*	endangered/limited area only
	Michigan	S5	92-06-24		
	New Jersey	S3	84-08	U	undetermined
	New York	S4	83-11-17	U	unprotected
	Oklahoma	S1	95-01-05	P	statewide closed season
	Pennsylvania	S3	84-03		
	Virginia	S2S3	93-12-15		
	Vermont	S3	92-11-15	SC	special concern
	Wisconsin	S5	86-05-29		

The map turtle has recently been the focus of research in Quebec. Bleakney (1958) considered it to be rare in the St. Lawrence Lowlands and southeastern Quebec. Inventories since the 1980's have resulted in the identification of several important populations, especially along the Ottawa River, indicating that the turtle is more

widespread than previously thought (Daigle and Lepage, 1997). Despite the discovery of these populations, the species is on the list to be designated threatened or special concern in Quebec (Bonin, pers. comm.).

Table 3. Map Turtle sightings in Protected Areas in Ontario.

District	Sightings in or near protected areas	Shoreline habitat information	Human encroachment
Brantford	Brant CA	-	-
Durham	Kendall PP	-	-
	Big Bend CA	-	-
Essex	Holiday Beach CA	-	-
	Ruscom Shores CA (ESA)	Sand beach, wetland	Marina, rip rap
	Tremblay Beach CA	-	-
	Pelee Island (ANSI, ESA)	Sand beach, fringing wetlands	Residential, marinas, rip rap
	Point Pelee NP (ANSI,RAMSAR)	Sand barrier, lagoon	High use recreational beaches
Frontenac	Frontenac PP	-	-
Halton	Royal Botanical Gardens	-	-
Haldimand-Norfolk	Long Point PP (ANSI, NWA,RAMSAR, World Biosphere Reserve (UNESCO))	Broad wetland, sand beach, lagoon, dunes	One recreational beach
	Big Creek Marsh (ANSI,NWA,ESA)	Broad wetland	-
Hamilton-Wentworth	Royal Botanical Gardens	-	-
Kent	Cootes Paradise (ANSI)	Mixed beach	Rip rap, large urban area
	Lake St. Clair(NWA)	Fringing wetlands	High recreational use, residential
	Rondeau PP (ANSI)	Broad wetland, mixed beach, dunes	High use beaches, boat launches, residential
Leeds and Grenville	Charleston Lake PP	-	-
Lambton	St. Lawrence Islands	-	-
	Walpole Island (ESA)	Fringing wetlands	Some recreational use
	Kettle Point (ESA)	Wetlands, sand beach, dunes	Rip rap, boat launches
	Rock Glen CA	-	-
Lanark	Murphy's Point PP	-	-
Middlesex	Big Bend CA	-	-
	Fanshawe CA	-	-
Muskoka	Georgian Bay Islands NP	Bedrock bluff, fringing wetlands, low vegetated banks	Recreational and some residential
Northumberland	Presqu'ile PP (ANSI)	Broad wetland, low vegetated banks	Boat launches
	Ferris PP	-	-
	Crowebridge CA	-	-
Ottawa-Carleton	Fitzroy Harbour PP	-	-
Prince Edward County	Sandbanks PP (ANSI)	Sand beach, dunes	High use recreational beach, boat launches, residential
	Outlet Beach	Sand beach, dunes	High use recreational beach
Dundee*	Lac St. François (NWA,RAMSAR)	Wetlands	Recreational (cottages) nearby

Table 4. Factors leading to the mortality of the Northern Map Turtle (*G. geographica*) in Ontario. Data are taken from the Ontario Herpetofaunal Summary (Oldham, 1997).

Area	Number (F= female)	Cause	Date
Brantford	1 F + eggs	Dead on road	June 2, 1991
Tilbury	1	Dead on road	June 7, 1987
Desert Lake	2 F	Dead on road	Aug. 1988
Norfolk	2	Dead on road	June 8, 1985
Long Point	1	Eaten by raccoon	June 3, 1987
Long Point	150+	Dead in dried up pond	July 3, 1977
Long Point	1	Dead on beach-possibly hit by boat prop	Aug. 28, 1988
Long Point	2	Shells collected from bald eagle nest	June 8, 1989
Bay of Quinte	2	?	July 1979
Rondeau	1	?	Dec. 21, 1981
Rondeau	1	Dead on road	July 5, 1986
Rondeau	1 F + eggs	Dead on road	June 25, 1966
Salmon River	1	Dead on road	July 27, 1988
Centreville	1	Dead on creek edge	July 27, 1988
Ivy Lea	1 F	Dead on road	June 24, 1973
Thames River	1	Dead on road	April 30, 1987
Georgian Bay Islands N.P.	1 F	Dead on road	July 15, 1989
12 O'clock Point	1 F	Dead on road	Aug. 11, 1987
Cambellford	1	Dead on road	Aug. 14, 1987
Sandbanks	1	Killed with axe	July 12, 1987

LIMITING FACTORS AND THREATS

There are numerous potential threats to map turtles in Canada, but there are few quantitative assessments of these threats. Northern Map Turtles are at their northern limit of distribution so it is almost certain that like other Canadian turtle species, map turtles have exceptionally delayed age of maturity, probably not reproducing until at least 12 years of age. Certainly too, they experience a high rate of nest failure because of relatively cool incubation temperatures compared to more southern populations (Holt, 2000; Flaherty, 1982; Galbraith et al., 1997). In addition, map turtles may be exceptionally vulnerable to attacks on their eggs by a sarcophagid fly (Metasarcophaga: *Tripanurga importuna* [Walker]) (S. Marshal, pers. comm.). In Rondeau Provincial Park, 100% of map turtles were invaded by maggots of this fly in 2001 (Gillingwater and Brooks, 2002). The maggots kill embryos and hatchlings.

Trade

The expanding international wildlife trade has contributed significantly to the decline of many turtle and tortoise populations in the wild (Luiff, 1997). Turtles are not generally recognized as charismatic species in need of protection, and thus little

attention is paid to their trapping and trading (Galbraith et al., 1997). Although *G. geographica* is not a popular species in the wildlife trade (Carr, 1952; Anderson, 1965), its resemblance to several other species (false and Mississippi map turtles (*Graptemys* species), painted turtles, cooters, and sliders) (Conant and Collins, 1991) used for food and pets may put it at risk. From 1989 to 1993, total U.S. exports of *Graptemys* species increased from 673/year to 37 233/year, and the value of a single turtle almost tripled (Anon, 1996a). This huge increase in trade combined with the difficulty of distinguishing between the different species has led to a proposal to place all *Graptemys* species on CITES Appendix II. Appendix II includes species that, while not presently threatened with extinction, may become so unless the trade is strictly controlled. It also lists species that must be regulated in order for trade of other currently or potentially threatened species to be brought under effective control (e.g. because of difficulty in distinguishing specimens of currently or potentially threatened species from those of other species) (U.S. Fish and Wildlife Service, 1996). Very little is known about the impact of international commercial trade on *Graptemys* populations, but the increasing numbers of turtles that are exported, combined with low clutch sizes and low reproductive frequencies, are cause for concern.

Urban encroachment

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). Lac des Deux Montagnes shoreline has a marked increase in recreational use (boating and swimming) during July and August. As of 1996, there were 82 marinas and wharves in the Fluvial Section of the St. Lawrence River (St. Lawrence Centre, 1996). The disturbance caused by these activities, coupled with the wary nature of these turtles, may result in the exclusion of the turtles from potentially useable habitat. At the time of Gordon and MacCulloch's (1980) research on this population, there were plans to develop more bays in this lake for intense recreational use. The specific bays targeted for more development were used by 50% of the turtles and contained potential nesting habitat. If recreation use does adversely affect map turtles, Gordon and MacCulloch (1980) predicted that this population would be seriously affected within 15 years.

Development of any type along shorelines and riverbanks may destroy important habitat, because turtles nest and bask along sandy areas close to water. Females would be forced to travel farther to find suitable nesting sites, putting them at risk from vehicles and even raccoons, which increase in numbers near urban areas (Anon, 1996). Even in relatively protected and undeveloped areas such as Lake Opinicon in the Queen's University Biological Station area, cottage development on shorelines, especially on islands, destroys nesting areas, and increased traffic leads to more road kills of nesting females (G. Blouin-Demers, S. Holt, M. Gross; pers. comm., 2002). The construction of dams could affect map turtles in several ways. Female *Graptemys* exhibit nest fidelity, and water levels that are artificially raised would flood and destroy

nesting sites (Flaherty, 1982). The number of egg laying sites is reduced through diminished wave action and spring flooding, which would allow vegetation to invade the sandy shores. The elimination of rapids would reduce the amount of dissolved oxygen in the water (see Biology-Hibernation) (St. Lawrence Centre, 1996). It is estimated that between 1945 and 1988, 3240 ha of aquatic habitat in the Fluvial Section have been altered by backfilling, drainage, encroachment, and changes in flow (St. Lawrence Centre, 1996). All of these problems will also reduce the molluscan prey of the turtles.

Despite pollution clean-up projects in the Great Lakes, there are still localized areas of contamination (Anon, 1996). The Great Lakes are the largest source of pesticides, and contribute to 40% of the pollutant loading of the St. Lawrence River. Cornwall, Massena, and Montreal produce heavy industrial discharges, and the Ottawa River contributes pollution from its pulp and paper industry (Bonin et al., 1995). The shorelines of Lac St. François are highly contaminated by PCBs, and the Lac des Deux Montagnes is considered to be a potential deposition and accumulation zone for contaminated sediment (St. Lawrence Centre, 1996). Studies of the effects of St. Lawrence River contaminants on snapping turtles (*Chelydra serpentina*) found that males with high concentrations of organochlorines in their testes may have reduced offspring viability (Hebert et al., 1993). Contaminants are assimilated by primary producers and are transferred to higher trophic levels as lower trophic levels are consumed (Hebert et al., 1993). For map turtles, the consumption of unionid molluscs would result in accumulation of heavy metals, organochlorines, and polycyclic aromatic hydrocarbons. Unfortunately, zebra mussels, which have overtaken unionid populations and are also eaten by map turtles, may contain contaminant levels, particularly of mercury, that are several times higher than those found in native unionid populations (Serrouya et al., 1995). Also, in recent years (2000-2001), about 30 dead adult map turtles have been found in Rondeau Provincial Park; the cause of death is unknown (Gillingwater, pers. comm., 2002). Raccoons (*Procyon lotor*) kill map turtles of all sizes, including of course a large proportion of eggs laid (Gillingwater and Brooks, 2002).

Early life stages are often the most susceptible to the toxic effects of environmental contaminants. Because contaminant levels in adult turtles increase with age and size, there might be a relationship between maternal age/size and egg viability. Eggs laid by older/larger turtles would receive the greatest toxic burden and might have the least developmental success (Hebert et al., 1993). However, none of these concerns can be confirmed or rejected, as there have been no studies on this species.

EXISTING PROTECTION OR OTHER STATUS

In Ontario, native species of amphibians and reptiles are protected by law in national and provincial parks, and in conservation areas. Under the Ontario Ministry of Natural Resources (OMNR) Fish and Wildlife Conservation Act (1997), the Northern Map Turtle is a specially protected species. It is protected from hunting, trapping, captivity and trade, except under the authority of a license and/or in accordance with ministry regulations.

The Northern Map Turtle in Quebec has no legal status under the province's conservation and development of wildlife act (Loi sur la Conservation et la Mise en Valeur de la Faune, C-61.1) though it is considered susceptible. Its nests are protected from disturbance, destruction or alteration (R.S.Q., chapter C-61.1, article 26). The collecting, keeping and selling of individuals is prohibited by the Animals in Captivity Regulation (Pierre Aquin, pers. comm.). The St. Lawrence Centre (1996) has given the map turtle priority status. As of 2002, the species is listed as S2 in Quebec (Natureserve 2002).

In 1996, the United States Fish and Wildlife Service put forth a proposal to CITES to place *G. geographica* (and 11 other species in the genus) on Appendix II, due to its resemblance to other *Graptemys* species that are intensively collected in the United States. Two of these species, *G. pseudogeographica* and *G. ouachitensis*, are listed as threatened under the Endangered Species Act. *G. nigrinoda* is endangered in Mississippi and *G. barbouri* is considered vulnerable to extirpation in Florida (Anon, 1996). The CITES proposal was rejected (Gray, 1997). In 2002, *G. geographica* was listed as S1 in 3 states, S2 in 3 states, S3 in 4 states and S4 or S5 in 8 states (Natureserve 2002). Most jurisdictions with S1, S2 or S3 rankings are on the periphery of the species' range.

SUMMARY OF STATUS REPORT

Historic data that would provide conclusive evidence of population decline, stability or growth of the Northern Map Turtle are lacking. There are significant gaps in our knowledge regarding growth rates, mortality rates, demographics (including age at maturity, longevity), reproductive success, and reproductive potential. To assess completely this species' status, such information would have to be collected. Additionally, pre- and post-impact studies would have to be undertaken to determine the effects of habitat alteration (i.e. through the building of dams). The effects of contaminants on map turtle ontogeny and reproductive success are important to examine in light of the presence of zebra mussels in the turtles' diet. Long-term monitoring, either specific to this species or as part of a broader program encompassing all basking turtle species, might answer many of these questions. Recent surveys have set benchmarks to monitor the populations in the future (see Bonin, 1998).

Several threats may be causing significant problems for the Northern Map Turtle in Canada. These are: (a) insect egg predators, (b) loss of shoreline nesting and basking habitat; (c) dams in major rivers affecting water levels and habitat for the turtles' molluscan prey, (d) declines in unionid mussels and accumulation of contaminants in these prey species, (e) effects of cool temperatures on nest success, (f) road kill, (g) long-lived life history strategy.

Although there is no direct evidence of recent range contraction or local extirpation of the Northern Map Turtle, the extensive limiting factors, long-lived life history with delayed age of maturity and potential threats to this species and its habitat suggest a

susceptibility to population decline. This species should be the focus of monitoring in populations under human influence to identify demographic trends. I recommend that the Northern Map Turtle (*Graptemys geographica*) be designated Special Concern.

TECHNICAL SUMMARY

Graptemys geographica
Northern Map Turtle — Tortue geographique
Ontario, Quebec

Extent and Area information	
• *extent of occurrence (EO)(km²)*	~200,000km^2
• *specify trend (decline, stable, increasing, unknown)*	Probably declining
• *are there extreme fluctuations in EO (> 1 order of magnitude)?*	No
• *area of occupancy (AO) (km²)*	Unknown
• *specify trend (decline, stable, increasing, unknown)*	Probably declining
• *are there extreme fluctuations in AO (> 1 order magnitude)?*	No
• *number of extant locations*	Unknown
• *specify trend in # locations (decline, stable, increasing, unknown)*	Probably declining
• *are there extreme fluctuations in # locations (>1 order of magnitude)?*	No
• *habitat trend: specify declining, stable, increasing or unknown trend in area, extent or quality of habitat*	Declining area, extent and quality of habitat
Population information	
• *generation time (average age of parents in the population) (indicate years, months, days, etc.)*	>20 years
• *number of mature individuals (capable of reproduction) in the Canadian population (or, specify a range of plausible values)*	Unknown
• *total population trend: specify declining, stable, increasing or unknown trend in number of mature individuals*	Probably declining
• *if decline, % decline over the last/next 10 years or 3 generations, whichever is greater (or specify if for shorter time period)*	--
• *are there extreme fluctuations in number of mature individuals (> 1 order of magnitude)?*	--
• *is the total population severely fragmented (most individuals found within small and relatively isolated (geographically or otherwise) populations between which there is little exchange, i.e., ≤ 1 successful migrant / year)?*	Probably not
• *list each population and the number of mature individuals in each*	Rondeau Bay ~200 Ottawa River ~1000 St. Lawrence ~1000
• *specify trend in number of populations (decline, stable, increasing, unknown)*	Unknown
• *are there extreme fluctuations in number of populations (>1 order of magnitude)?*	No
Threats (actual or imminent threats to populations or habitats)	
- habitat destruction/alteration: development, industrialization, siltation of waterways from agriculture, watershed “clean-up”, damming waterways, shoreline development, especially destroying nest sites - decline in food supply (molluscs) - flooding of nests and nest sites in dammed/controlled waterways - high rates of nest predation by raccoons and insects - bioaccumulation of environmental contaminants - mortality from motor vehicles when turtles cross roads to get to hibernation sites or to use roadsides to nest - long-lived life history, delayed age of maturity (> 12 y)	

Rescue Effect (immigration from an outside source)	
• *does species exist elsewhere (in Canada or outside)?*	Yes
• *status of the outside population(s)?*	Varies
• *is immigration known or possible?*	Unknown, possible
• *would immigrants be adapted to survive here?*	Yes
• *is there sufficient habitat for immigrants here?*	Unknown
Quantitative Analysis	

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