ROYAL BOTANICAL GARDENS
www.rbg.ca

Turtles of Royal Botanical Gardens Site Specific Recovery Plan

Kathryn Harrison
Tys Theÿsmeÿer
Natural Lands Department
Royal Botanical Gardens
4/11/2014

Please forward any questions about this report to:
Head of Conservation
Royal Botanical Gardens
P.O. Box 399
Hamilton, ON L8N 3H8

Cover photo: Radio-tagged male Blanding's Turtle basking in Grindstone Oxbow.

Recommended Citation:

Harrison, K and T. Theÿsmeÿer. 2014. Turtles of Royal Botanical Gardens Site Specific Recovery Plan. Internal Report No. 2014-01. Royal Botanical Gardens. Hamilton, Ontario.

Preface:

Turtle recovery is a natural and important direction for Royal Botanical Gardens (RBG) to pursue. RBG's mandate is "to sustain and promote a botanical garden and cultural attraction with natural lands in the areas of horticulture, conservation, science and education." The RBG Act of 1989 states one of the Gardens' roles is to "protect specific environments and flora and fauna that are of special value as parental stocks or may be in danger of extinction". In Royal Botanical Gardens' Multi-Year Business Plan 2012-2014, protecting native Species at Risk (Action 5) is listed as a Strategic Business Priority under Leadership in Environmental Stewardship (Priority 4).

The importance of maintaining biological diversity has been recognized world-wide by the Convention on Biological Diversity in 1993, which led to Federal and Provincial initiatives to protect Species at Risk (SAR). RBG took this opportunity to align its work with these initiatives in 2007 by creating a Species at Risk program dedicated towards benefiting the many rare species that occur at RBG. Turtles are a group that has been targeted by the SAR program and many other conservation initiatives world-wide, due to the declines that have been observed in most species within this group (Frazer, 2000).

Turtles are a priority group for RBG as the nature sanctuaries contain two of the largest coastal marshes remaining on western Lake Ontario. These wetlands, Cootes Paradise Marsh and Grindstone Marsh have a combined area of 380 ha and are the subject of an ongoing ecosystem based habitat recovery program. This environmental restoration is further complimented by the Hamilton Harbour Remedial Action Plan.

Turtles are a visible and charismatic part of our nature sanctuaries that can inspire visitors to become stewards of the environment and improve overall visitor experience; in addition, they have ecological values including seed dispersal, vegetation management, control of insect and snail populations, keeping waters cleaner through scavenging, and keeping populations healthy by preying on weak and sick individuals (Van Dijk, 2010).

RBG has a long history of habitat protection and restoration activities, both terrestrial and aquatic. These activities continue to provide benefits to turtles, among many other species, through improving overall ecosystem health. Working towards turtle recovery complements and expands upon these efforts.

Document Description:

This document summarizes background knowledge and identifies knowledge gaps. It outlines information about threats and mitigation that will be used to direct turtle recovery work at RBG. Approximately 2,500 hours of field survey work was completed between 2007 and 2012, including visual surveys, mark-recapture studies, tracking of radio-tagged turtles (day and night), nest protection and work with volunteers. This document incorporates information from federal and provincial Recovery Strategies and other sources and applies it to site specific issues.

Recommendations and an action plan are included, which will be pursued by RBG pending relevant approvals, compatibility with broader RBG strategies, funding, and support from outside organizations and the public.

The production of the Turtles of RBG Site Specific Recovery Plan was supported by OMNR Stewardship Fund but has been written independently. This report was prepared by the RBG's SAR Biologist and Head of Natural Lands.

SAR biologist, Kathryn Harrison, has an honours degree in Biology and graduate certificate in Ecosystem Restoration. She has three years of experience at RBG leading projects to assess, monitor, and restore habitat for turtles. Tys Theÿsmeÿer, Head of Natural Lands, has 20 years of experience working in the Natural Lands at RBG where much of his work has focused on the restoration of RBG's coastal marshes, for which he has authored numerous reports and papers. He has led the Natural Lands department since 2008.

A public open house was held in January 2013 and the input from participants has been incorporated into this document. Before this report is finalized, a draft version will be sent to stakeholders, experts, partners, and interested parties for review and comment.

Acknowledgements:

There are many people who have supported protection and recovery of turtle populations at RBG over the years since the SAR program was initiated. Without their help the scope of this important program would not be possible. This includes Ben Porchuk, Head of Conservation at the SAR program's inception, and Tys Theÿsmeÿer who took over as Head from 2008 to present. Karla Spence-Diermair led the program for the first three years, spear-heading radio-telemetry and mark-recapture studies that provided invaluable information on habitat-use and demographics. Dr. David Galbraith, Head of Science, has extensive knowledge of Snapping Turtles and kindly provided input and advice on many occasions. Over the years there have been various RBG staff, interns, and students that have contributed to various projects (Jennifer Bowman, Lindsay Burtenshaw, Andrea Court, Cara Daw, David d'Entremont, Melissa Fuller, Garret Gautier, Laura Gil, Felicia Radassao, Dave Reddick, Nigel Ward, Sarah Watts, Kirsten Silvera, Chris Stewart, Hillary Williamson and many more).

The volunteer group Dundas Turtlewatch, founded by Joanna Chapman, has worked closely with RBG, reducing road mortality and providing data on road mortality locations. RBG also appreciates the excellent support from volunteers who have assisted with planting aquatic vegetation (Bay Area Restoration Council), restricting access to special protection areas (McMaster Outdoors Club, Earth Rangers), installing the temporary road barrier along Cootes Dr., radio-telemetry surveys (Paul Smith), and analyzing data from the open house (Lauren Schmuck). The Stewards of Cootes Watershed and annual Great Canadian Shoreline Clean-up volunteers have also contributed substantially to removing litter and thereby improving marsh habitat.

The SAR program has been fortunate to receive generous support in the form of project funding from the Arcelor-Mittal-Dofasco, EJLB Foundation, Environment Canada Habitat Stewardship Fund, Hamilton-Wentworth Stewardship Council, Malloch Foundation, John and Pat McCutcheon Foundation, McLean Foundation, Meighen Foundation, Ministry of Culture, Ministry of Natural Resources Species at Risk Stewardship Fund, Natural Resources Canada, and Trillium Foundation.

There are many individuals who have been involved in the study and protection of turtles at RBG prior to the formation of a formal SAR program and many experts that have generously provided their time and knowledge to support the program over the years. We are thankful for support received from members of organizations including the Toronto Zoo, Kawartha Turtle Trauma Center, Ministry of Natural Resources, Canadian Wildlife Services, Scales Nature Park, Upper Thames River Conservation Authority, and the group formerly known as OMSTARRT. Thank you to those who helped to review this document. For the sake of brevity individuals will not be mentioned specifically; however, RBG would like to acknowledge and thank anyone and everyone who has contributed to our cause.

RECOMMENDATION AND APPROVAL STATEMENT

This report has been reviewed and approved by:

_____

Mark Runciman, CEO of Royal Botanical Gardens

_____

Ian Brisbin, Chair of the Board of RBG

EXECUTIVE SUMMARY

Royal Botanical Gardens' is a not-for-profit organization that owns almost 900 ha of land in Burlington and Hamilton Ontario including two large coastal marshes, ravine slopes, tablelands, escarpment and formal garden areas. RBG has identified recovery of Species at Risk as one of its objectives, and this document identifies goals for achieving turtle recovery.

Four native turtle species currently have reproducing populations at Royal Botanical Gardens (RBG): Blanding's Turtle (*Emydoidea blandingii*), Northern Map Turtle (*Graptemys geographica*), Snapping Turtle (*Chelydra serpentina*), and Midland Painted Turtle (*Chrysemys picta marginata*). Two species have previous records but are now thought to be extirpated: Eastern Musk Turtle (*Sternotherus odoratus*), and Eastern Spiny Softshell (*Apalone spinifera spinifera*). The Wood Turtle (*Glyptemys insculpta*) occurs regionally in habitats similar to those of RBG and may have occurred at RBG historically. Recent surveys have been conducted at RBG from 2007 to 2012 using basking, trapping, nesting, and radio-telemetry in order to assess habitat use, population status, and site specific threats. Painted turtles represent slightly more than half of the estimated 1500 turtles currently resident at RBG. Populations of three species are thought to be in decline, with the trend in the Midland Painted Turtle population requiring further assessment. The Blanding's turtle population is near extirpation but contains at least three reproducing female turtles.

Three of the four species with reproducing populations, are listed on the federal Species at Risk Act (SARA) and the provincial Endangered Species Act (ESA). Northern Map and Snapping Turtles are listed as Special Concern, while Blanding's Turtle is listed as Threatened and is also listed globally as Endangered (IUCN Red List). They and their habitats are also afforded varying degrees of protection through the Fish and Wildlife Act, Provincial Policy Statement, CITES, and RBG by-law.

Turtles are highly susceptible to negative human impacts for a variety of reasons:
- Short active season and high nest failure due to cool temperatures in Ontario
- Low adult recruitment due to delayed age at maturity and slow life history
- No apparent density-dependent responses

Turtles have persisted at RBG while many wetland resident species have not. Their long-life span is likely the key to their continued existence at RBG despite the extensive habitat degradation and fragmentation that has occurred. The nesting behaviour which takes them upland in May and June to sunny exposed slopes and plateaus provides a distinct challenge given the degree of human development immediately adjacent to the wetlands.

Turtle declines are related to a long list of issues that can be broadly grouped into the following:
1. Habitat loss, alteration, fragmentation and degradation,
2. Impairment of reproductive success, and
3. Direct mortality

Future turtle recovery may be limited by several factors:
- Genetic isolation of the from other populations,
- Climate Change,
- Bioaccumulation of contaminants.

Threats Facing Turtles of RBG

Habitat loss, alteration, fragmentation and degradation due to:

- Infilling & development adjacent to wetlands (loss of nest habitat, roads in movement corridors)
- Channel alteration of Spencer Creek: Creation of the Desjardins Canal
- Water level regulation and dredging
- Invasive emergent plants: Reed Manna Grass (*Glyceria maxima*) and Common Reed (*Phragmites australis*)
- Common Carp (*Cyprinus carpio*)
- Pollution (nutrients, chemical)
- Invasive upland plants covering nest sites

Direct mortality due to:

- Road mortality (particularly nesting females)
- Illegal collection and hunting (pet trade, consumption)
- Persecution and fishing by-catch
- Ingesting or getting caught in litter (especially fishing hooks/gear and tires)
- Motorized boat collisions
- Garden and lawn maintenance activities (mowing, tilling, etc.)
- Introduced pathogens and competition from exotic turtle species

Impairment of reproductive success due to:

- Urban sponsored predators depredating most nests (i.e. raccoons)
- Disturbance and harassment while nesting
- Accidental nest destruction during garden maintenance and other soil alterations
- Male biased sex ratio
- Bioaccumulation of contaminants

Future Concerns

Regional isolation and small population sizes due to barriers (roads, housing developments, etc.) to movements between the nearest adjacent populations can also threaten the long-term sustainability of a population by limiting genetic flow and the ability to cope with unstable habitats. The effect of contaminant accumulation is also unknown for the future viability of the various species. In addition, a variety of habitat characterization projects have yet to be completed, detailed under research needs section. Climate change has implications that will require further monitoring to assess potential threats including a potential decrease in habitat stability, alteration in temperature-dependent sex determination, and creating conditions that favour introduced species (i.e. Red-eared Sliders *Trachemys scripta elegans*).

Current Recovery Initiatives

RBG has been engaged in several projects to benefits turtles and overall ecosystem health. These include marsh restoration, road-kill mitigation, special protection areas, litter clean-ups, a buoy system in Carrolls Bay, and various site-specific projects to improve reproductive success.

Strategies to Address Threats

Improve habitat quality

- Continue with onsite marsh restoration program (carp exclusion, strategic plantings).
- Support initiatives to recover inflowing water to meet provincial guidelines for aquatic life.
- Undertake invasive plant removal of Reed Manna Grass (*Glyceria maxima*) and Common Reed (*Phragmites australis*) impairing turtle habitat.
- Restore nest habitat north of West Pond, along King St. E./Desjardin Canal, and on the western shore of Carrolls Bay.
- Undertake localized nest habitat improvements (invasive plant removal, soil amendments, etc.) Focal areas: Cootes Dr., the 'Lodge' on Plains Rd. W., and behind Hydro One on Olympic Dr.
- Create suitable nest habitat in or near adjacent parks.

Reduce adult mortality

- Implementation of projects to address road mortality hotspots by creating safe corridors using permanent crossing structures, guide fences, signage and/or road closures in identified areas of high mortality. Focal areas: Cootes Dr., intersection of Olympic and King St. E., Old Guelph Rd.
- Request a speed limit reduction on Cootes Dr. to match regular urban municipal roads (60km/hr).
- Solicit increased enforcement of poaching & littering laws by appropriate authorities. Each nesting season update enforcement officers on known poaching areas (Desjardin Canal, Valley Inn).
- Ensure visitors are aware of by-laws and encourage them to report violations.
- Prohibit fishing within RBG nature sanctuaries.
- Continue to restrict motorized boat access with buoy system and RBG bylaws in Carrolls Bay.
- Create a restricted water access area at the back of Westdale Inlet to remove the risk of poaching and the regular disturbance occurring as a result of the adjacent Princess Point canoe launch.
- Highlight turtle nesting and emergence seasons to turf mower operators.

Increase recruitment rates

- Nest protection – a target of 30 or more nests/year, with a focus on Blanding's Turtle.
- Tag and track Blanding's Turtle females during nesting movements and improve nest success.
- Undertake incubation for nests in high risk locations (i.e. mulch piles, garden beds, roadsides).
- Ensure nesting turtles are adequately protected in RBG garden areas.
- Relocate the Olympic Park community garden off RBG property.
- Reduce the raccoon population by minimizing accessible garbage, promoting raccoon predators and discouraging on site release of nuisance wildlife captured off site.
- Consider population augmentation and reintroductions once threats are sufficiently mitigated.
- Develop institutional policies related to staff interactions with turtles and nests and integrated them into each department's operational practices.

Education and stewardship

- Lead and participate in garbage cleanups and support garbage clean-ups.
- Establish a volunteer group to monitor the garden areas for nests during nesting season.
- Encourage Olympic Dr. community garden owners and operators to manage the garden in a way that compliments turtle nesting.
- Establish a turtle conservation page on the RBG website.
- Provide information to local landowners on turtles and on what to do if they are on your property.
- Encourage projects on adjacent properties that will reduce mortality and increase nest success. Focal areas: McMaster Campus, Spencer Creek, and King St. E.
- Continue to support Dundas Turtlewatch.
- Deliver RBG education/camp programming on turtles and Species at Risk.

- Improve RBG entrances and boundaries to control access and communicate to visitors they are in a nature sanctuary (priority locations include, Valley Inn and Desjardin Canal and Spencer Creek.
- Educate the public about the dangers of releasing pet turtles; provide other options for an unwanted turtle, and things to consider before taking on a turtle as a pet.

Data management
- Improve the database for turtle monitoring and research at RBG.
- Add website record reporting abilities for members of the public.
- Standardize monitoring & marking protocols as per provincial guidelines as they are provided.
- Ensure all research conducted at RBG is authorized by a permit and a copy of the results is received upon completion of the study.
- Ensure that a copy of all available studies and relevant raw data (past, present, and future) are documented in RBG's library/archives.

Collaborate with outside organizations
- Collaborate with adjacent landowners to improve habitat connectivity.
- Participate in and stay informed of turtle conservation and research initiatives.
- Collaborate and share information with institutions with similar goals.
- Foster relationships with researchers promoting opportunities to study turtles at RBG.
- Encourage upstream initiatives by Hamilton Harbour Remedial Action Plan (HHRAP) partners to reduce water pollution and sedimentation.
- Continue to inform the Lake Ontario & St. Lawrence River Regulation water regulation study team.
- Provide access and field support to studies of chemical contaminants & impacts on turtles of RBG.
- Encourage initiatives to reduce chemical inputs into the natural lands & remediate where possible.

Management of non-native turtle species:
- When encountered non-native turtles should be removed from the wild.

Monitoring
- Update turtle population status information on a five-year basis for the overall group and annually for Blanding's Turtle.
- Undertake nest surveys and protection and establish index locations at Laking Garden and the Community Garden on Olympic Dr.
- Support and coordinate with volunteers to maintain up-to-date information on roadkill turtles.
- Monitor Red-eared Slider populations and keep up-to-date on related research to assess the level of threat that they pose through competition.

Based on the above strategies a recommended action plan and target completion dates are set out at the end of this document. The action plan is broken down into habitat improvement, monitoring and management, outreach, policy, data collection and management, and enforcement.

Research Needs

- Effects of environmental contaminants during hibernation (ammonia in areas of sewage runoff).
- Northern Map Turtle hibernation site identification.
- Turtle movement between sanctuaries and outside of RBG boundaries.
- Potential population sizes if recovered and population dynamics.
- Health, accumulated contaminants, and genetic studies (blood sample collection and analyses).
- Effects of pollutants (reproductive).
- Status of groundwater quality at hibernation sites.
- Blanding's Turtle Nest site identification.

Table of Contents

List of Figures

List of Tables

List of Photographs

Turtle Site Specific Recovery Plan Goals

The goals for recovery of turtle species at RBG are outlined by the following targets:

1. Mitigate threats to the long-term survival of turtles of RBG.

2. Recover populations to sustainable levels that are reflective of available habitat and historic population sizes (as is deemed appropriate by future research).

Property Overview

Royal Botanical Gardens' is a not-for-profit organization with the mission to promote the public's understanding of the relationship between the plant world, society and the environment.

Royal Botanical Garden's nature sanctuaries span 779 ha of natural land including Lake Ontario coastal marsh, interior Carolinian forest, and talus slopes of the Niagara Escarpment (Figure 1). An additional 99 ha of cultivated gardens and other properties is owned and operated by RBG as the biggest public visitor attraction between Toronto and Niagara.

RBGs' natural lands are recognized as important habitat through several significant designations:

- UNESCO World Heritage Site
- Important Area for Reptiles and Amphibians (IMPARA)
- Nationally Important Bird Area (IBA)
- Class 1 and 2 wetlands
- Area of Natural and Scientific Interest (ANSI; Figure 2)
- Environmentally Sensitive Area (ESA; Figure 2)

The wetlands of RBG are the largest remaining coastal wetlands on the western side of Lake Ontario. These areas are divided into two nature sanctuaries that flow out into Hamilton Harbour: Cootes Paradise Marsh, to the West; and Grindstone Marsh to the East. The combined area of the two marshes is 380 ha with the 330 ha protected as RBG nature sanctuaries, and most of the remaining lands owned by Hamilton Conservation Authority. Very small localized areas are owned by Hydro One and McMaster University.

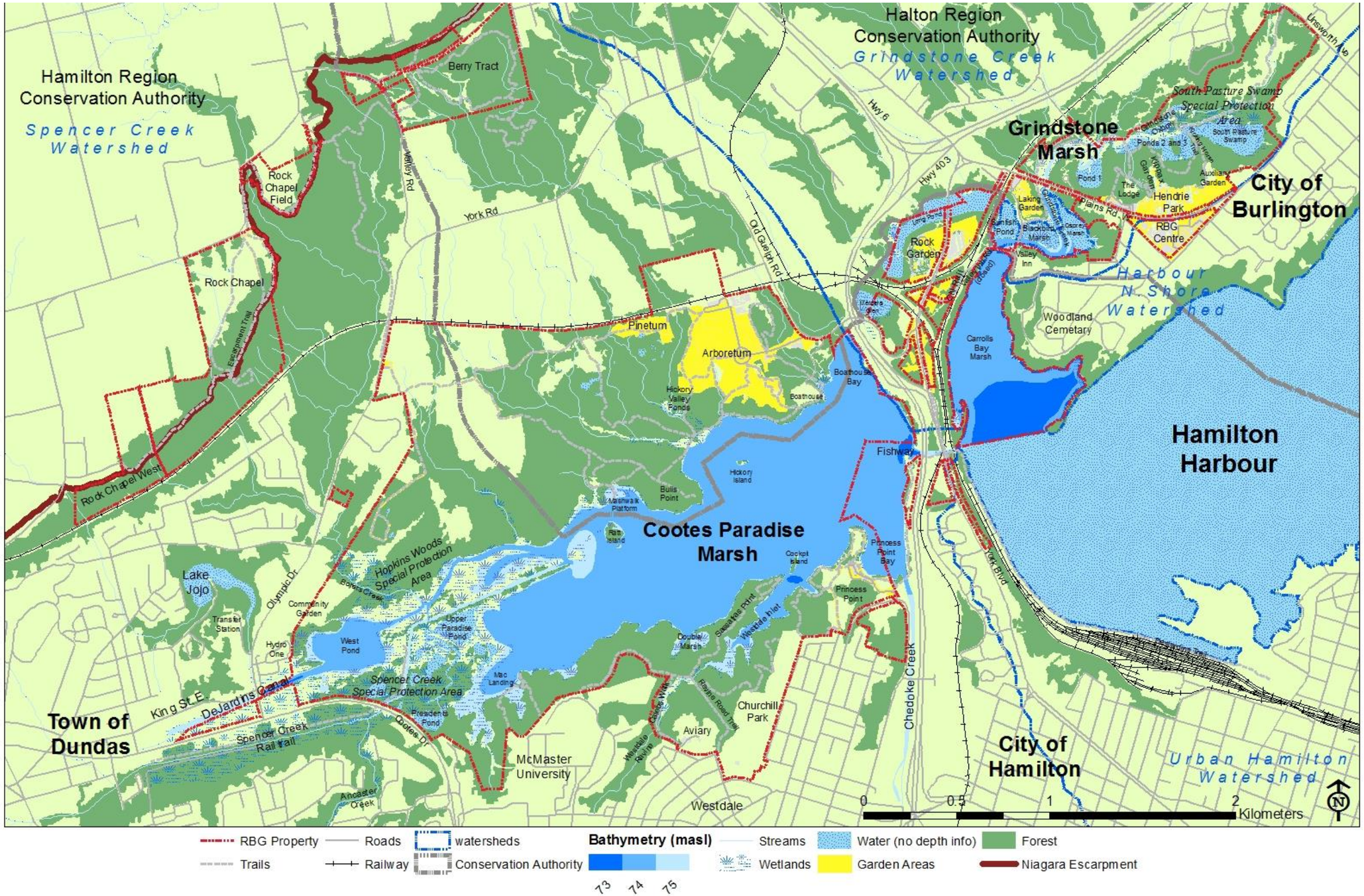


Figure 1. Overview map of Royal Botanical Gardens

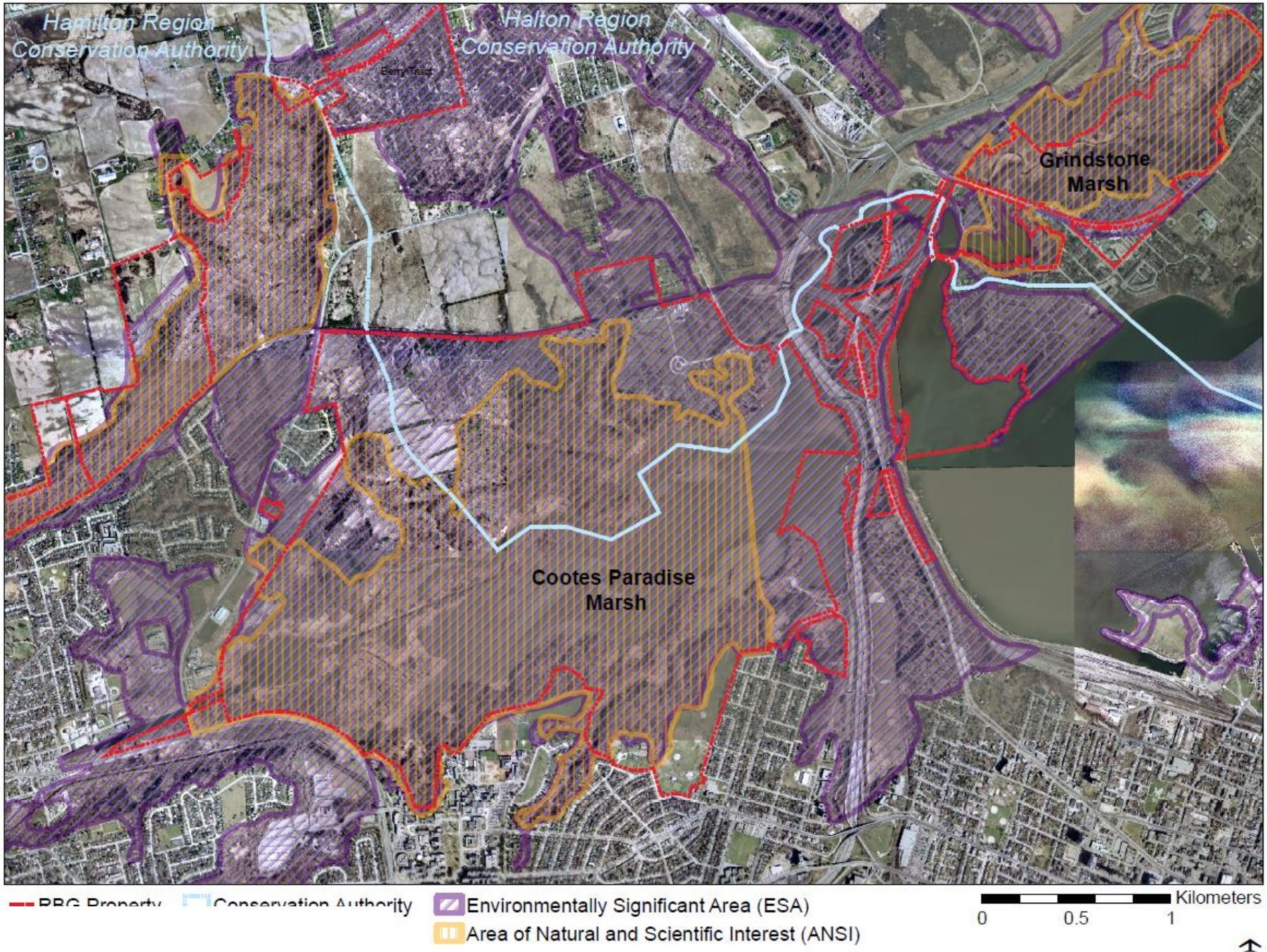


Figure 2. ESA and ANSI designated areas.

Figure 2. ESA and ANSI designated areas.

Cootes Paradise Marsh

Cootes Paradise Marsh is located west of the Hwy 403 and Burlington, north of the City of Hamilton, and east of the Town of Dundas. The 3 km long, 320 ha wetland is the receiving body for 15 different tributaries, the largest being Spencer Creek. Cootes Paradise wetland is a complex mixture of open water, ponds, lowlands and inlets. The vegetation currently consists of patches of submergent aquatics (mainly pondweeds *Potamogeton* spp.) in the large open water area, emergent and meadow marsh in the floodplains (mainly cattails *Typha* spp.), smaller areas of dense floating leaved aquatic marsh, and a few sections of swamp (Daw, 2011). Seasonally the Lake Ontario water cycle (average fluctuation 70 cm) floods and dries vast areas of the wetland (Theÿsmeÿer, 2003). Three large floodplain pond areas retain water independent of this fluctuation. The wetland is surrounded by forested ravine slopes and tablelands, dominated mainly by oak and maple. Upland areas with open canopies (suitable for turtle nesting) include cultivated gardens, lawns, and regenerating old fields.

The total watershed area of Cootes Paradise Marsh is 290 km^2. Main tributaries are Spencer Creek, Chedoke Creek, and Borers Creek. Other water input to the marsh include twelve smaller creeks with headwaters below the escarpment, three road drains, and many areas fed by natural springs. Major groundwater sources are from the south shore in Westdale Inlet and Mac Landing. In addition, the Dundas Wastewater Treatment Plant and four Combined Sewer Overflows enter the marsh.

The wetland was historically subjected to extreme human alterations and existed in a highly degraded state for many decades. Its status in 1990 was a wetland with essentially no submergent or emergent aquatic vegetation, the water was turbid and highly enriched (hypereutrophic), and two invasive species dominated the wetland Common Carp (*Cyprinus carpio*) and Reed Manna Grass (*Glyceria maxima*). This represented a habitat loss of 230 of the 320 ha wetland (Epp, 2012). Currently its recovery is critical part of the Hamilton Harbour Remedial Action Plan (HHRAP) and has been ongoing since 1996 with multiple projects completed and underway.

Infilling has occurred in multiple locations, but most notably along the eastern shore in the Chedoke Creek/Princess Point area where 20 ha was filled as a landfill. In the early 1800's the now abandoned Desjardin Canal was dredged through the middle of the wetland to provide a direct shipping route to Dundas from Lake Ontario. This also connected the wetland to the Lake Ontario water cycle. In 1952 the original marsh outlet of Cootes Paradise through Grindstone Marsh into Lake Ontario was severed by infilling to enable construction of the CN Rail across Cootes Paradise's eastern shore. The course of this outflow can be seen in the now isolated ponds: Mercer's Glen and Long Pond (Figure 3).

In addition to the rail lines, roads also bisect the wetland. Cootes Dr., Olympic Dr., and King St. E. run through the floodplain of Spencer Creek at the west end of the wetland. Spencer Creek and its tributaries provide connections to upstream natural areas such as the Hamilton Conservation Authority's Dundas Valley Conservation Area. Highway 403, Old Guelph Rd. and the Waterfront Trail cross the eastern end.

The main body of the marsh contains both highly degraded and high-quality habitat areas. Chedoke Creek drains the urbanized watershed to the south into Princess Point Bay. This creek is largely ditched. A large closed landfill exists in the river mouth of Chedoke (~20 ha.). Highway 403 and two combined sewage overflows (CSO) occur along its course. In contrast, Westdale Inlet, located just west of Chedoke is sheltered by Princess Point and Sassafras Point. While formerly degraded and fed by a CSO, the 750 m long inlet is now fed by a healthy spring creek and has been restored to one of the most pristine parts of the wetland. It contains clear water and a dense cattail and White-Water lily shallow marsh. Mac Landing is a similar spring fed inlet but lacks deeper areas and seasonally is reduced to a damp floodplain.

Photograph 1. Aerial image of Cootes Paradise Marsh and surrounding area (Photo by Dr. D. Galbraith, 2012).

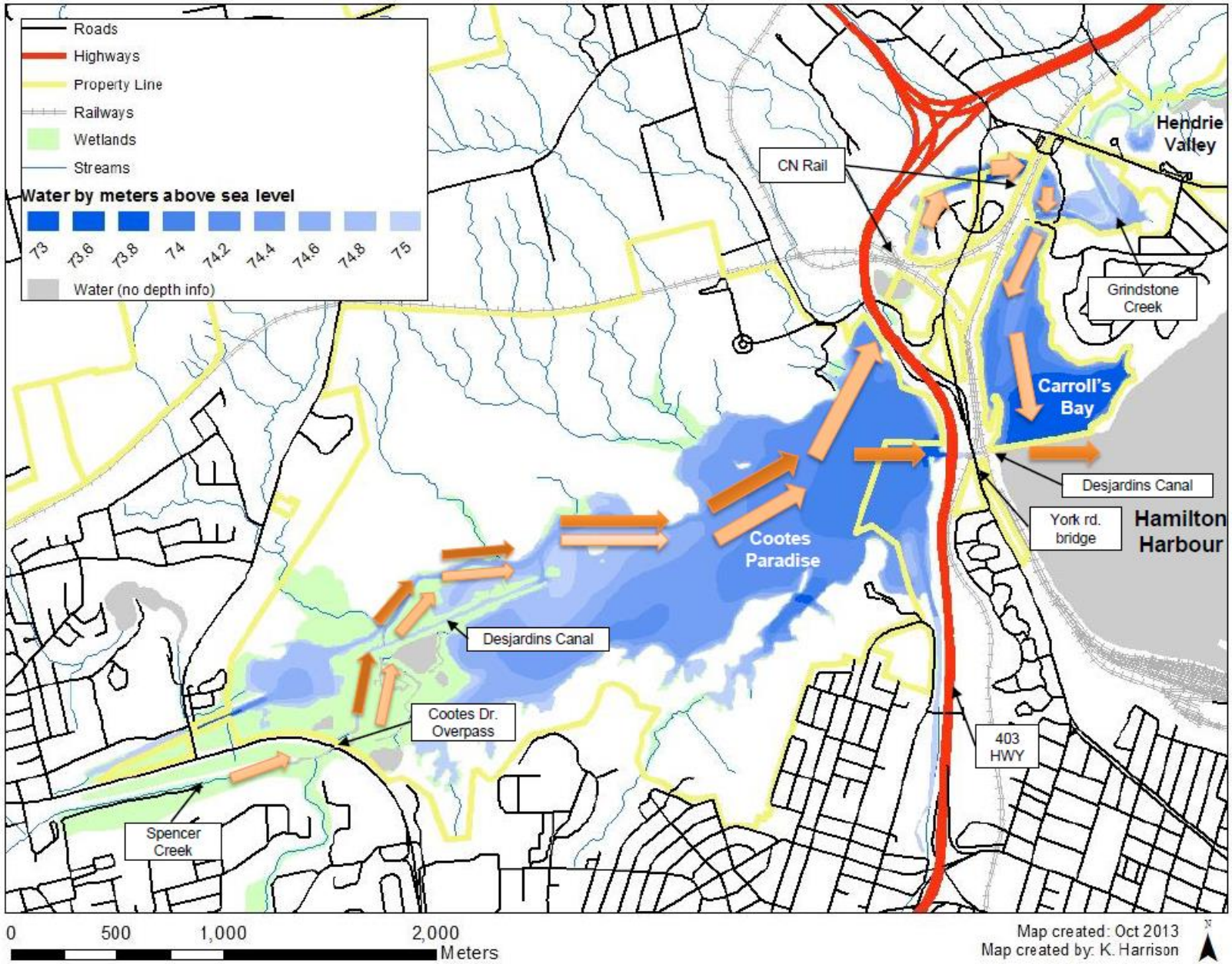


Figure 3. Past and current flow of Spencer Creek showing barriers to passage as a result of built infrastructure. Light arrows represent the former outflow and dark arrows represent the current outflow.

Grindstone Marsh

Located in Hendrie Valley Nature Sanctuary, Grindstone Marsh is a 60 ha wetland complex consisting of the lower portion of Grindstone Creek, a series of floodplain ponds and inlets, and Carrolls Bay Marsh. The wetland enters Hamilton Harbour at the northwest corner separated partially from the harbour by a low beach peninsula called Carrolls Point. Carroll's Bay was once mostly vegetated with a defined channel. Today vegetation is restricted to small pockets where the shape of the shoreline provides shelter from wind and wave action.

Moving upstream along Grindstone Creek, there is a series of floodplain ponds that were recreated by RBG between 1999 and 2001 through construction of artificial berms that restored the natural creek channel and reduce the amount of Common Carp. These ponds are now predominantly White-Water Lily (*Nymphaea odorata*) and pondweed shallow aquatic systems with the surrounding floodplain area composed of diverse vegetative communities including cattail marsh, dogwood thicket, and willow swamp (Reddick, 2012). The slopes of the valley are forested, but most of the tablelands have been developed, including subdivisions, graveyards, and RBG gardens.

Grindstone Creek (watershed 90 km^2) is the main tributary of the wetland; however, numerous springs and five smaller tributaries also flow into the marsh. A noted decline in habitat quality has occurred in this system in recent decades. The Waterdown Wastewater Treatment Plant discharged into Grindstone Creek negatively impacting it and its surrounding habitats up until it was rerouted in 2011. Currently the primary sources of water quality impairment are developed tablelands that generate sediment and erosion during heavy rain events and the re-suspension of sediment by Common Carp. Interpretation of 1995 aerial imagery of Grindstone Marsh indicates that emergent and meadow marsh vegetation occupied less than half (46%; or 10.6 ha) of the potential area (23.3 ha) for this vegetation type based on bathymetry (Court and Reddick, 2014).

Carrolls Bay Marsh and Long Pond, two of the larger waterbodies in this system, are highly degraded habitats and as such are included in the Hamilton Harbour Remedial Action Plan (HHRAP). The land surrounding Carrolls Bay has been heavily altered. A major rail line runs along the west shore of Carrolls Bay Marsh. Valley Inn Road divides Inner Carrolls Bay from Grindstone Creek, although it was reduced to a service road and active transportation route in 2009. Spring Gardens Rd. crosses the wetland area over Grindstone Creek, then between Sunfish Pond and Blackbird Marsh, providing access to the Laking Garden.

Photograph 2. Aerial view of Grindstone Marsh from west of South Pasture Swamp (Photo by Dr. D. Galbraith, 2012).

Photograph 3. Aerial view of Grindstone Marsh taken from north of the marsh (Photo by Dr. D. Galbraith, 2012).

Turtle Populations at RBG

Currently the population estimate for RBG's native turtles is 1,500, representing four species, with two species recently extirpated or incidental. Most of these turtles are found in the Grindstone Marsh system. The Midland Painted Turtle represents almost two thirds of all turtles. Populations of all species are thought to be lower than potential/ historical populations. The predominance of turtles in the smaller Grindstone Marsh vs Cootes Paradise Marsh reflects the state of the two wetlands over the past 50 years. In areas with degraded habitat most turtle activity has been reduced to the woody debris along the shorelines.

Five of the seven native species of turtles that historically were found in the area still occur at RBG (i.e. observed within the last 10 years), while two species are extirpated (Table 1). Reports from the 1920s to the 1980s recorded six native turtle species, they did not observe Wood Turtle, and one non-native, the Red-eared Slider (*Trachemys scripta elegans*) (Bishop, 1985; Lamond, 1994; Warren, 1950). All but one of the native species has been listed as a Species at Risk both provincially and federally. Various non-native pet release turtles are periodically found, the most common is the Red-eared Slider.

Table 1. Native turtle species of RBG.

Species (common name)	Scientific Name	Status (Provincial & Federal)	RBG Status
Midland Painted Turtle	*Chrysemys picta marginata*	Not at Risk	Abundant (~965)
Northern Map Turtle	*Graptemys geographica*	Special Concern	Common (~350)
Snapping Turtle	*Chelydra serpentina*	Special Concern	Common (~222)**
Blanding's Turtle	*Emydoidea blandingii*	Threatened	Rare (~25)
Eastern Musk Turtle/ Stinkpot	*Sternotherus odoratus*	Threatened	Incidental (~1)
Eastern Spiny Softshell	*Apalone spinifera spinifera*	Threatened	Extirpated
Wood Turtle	*Glyptemys Insculpta*	Threatened	Extirpated*

*No historical records of this species; however based on habitat and regional occurrence it is considered likely to have occurred at RBG in the past.
**There is a higher degree of error associated with this estimate due to small sample size.

The status of each turtle species has been outlined in the following section based on our current knowledge. A population estimate has been provided of each species for Cootes Paradise and Grindstone Marsh. Mark-recapture surveys were conducted in targeted areas from 2008-2012 (Table 2). Specific trapping methods have been outlined in the referenced reports. The population estimates are based on a combination of mark-recapture data and where that is not available rough estimates were calculated based on other observations recorded from 2007-2012 (i.e. basking, nesting, incidental). The estimates vary in confidence and method of calculation due to the limitations of the data available. Estimates based on small sample sizes or basking/nesting ratio comparisons should not be considered definitive.

Table 2. Summary of mark-recapture efforts conducted from 2008-2012.

Year	Trapping Days (Mark-Recapture)	Focal Area	Traps	Reference
2008	63	South Pasture Swamp	3 basking, 7 hoop	Spence Diermair, 2009
2008	152	Carroll's Bay	3 basking, 7 hoop	Spence Diermair, 2009
2009	162	Carroll's Bay	3 basking, 6 hoop	Spence Diermair, 2010
2010	144	Carroll's Bay	3 basking, 6 hoop	Harrison, 2011a
2011	198	Cootes Paradise Marsh	3 basking, 6 hoop	Harrison, 2012
2012	410	Cootes Paradise Marsh	3 basking, 15 hoop	Harrison, 2013

The RBG range of each species has been illustrated in maps (Figures 9, 10, 13, 14, 17, 18, 23, 24) showing all recorded observations with coordinate data (2007-2012). This data includes surveys of basking (annual), trapping (Carrolls Bay, 2007-2010; Cootes Paradise, 2011-2012), radio-telemetry (2009-2012), nesting (2007-2012), road mortality (2008-2012), and incidental observations (2007-2012) (Spence-Diermair, 2008, 2009, 2010; Harrison, 2011a, 2012, 2013).
The species most commonly observed in both trapping and basking surveys is the Midland Painted Turtle, followed by Northern Map Turtle (Figure 4 and 5). Snapping Turtles are the third most abundant in basking and trapping surveys and have a greater representation in the number of turtles trapped than in basking surveys. They are by far the species most frequently observed nesting (Figure 6). Many of the 'unidentifiable' nests were likely also Snapping Turtles based on size. Nests were not excavated to confirm the presence of eggs; therefore, this is a measure of nesting activity not actual reproduction.

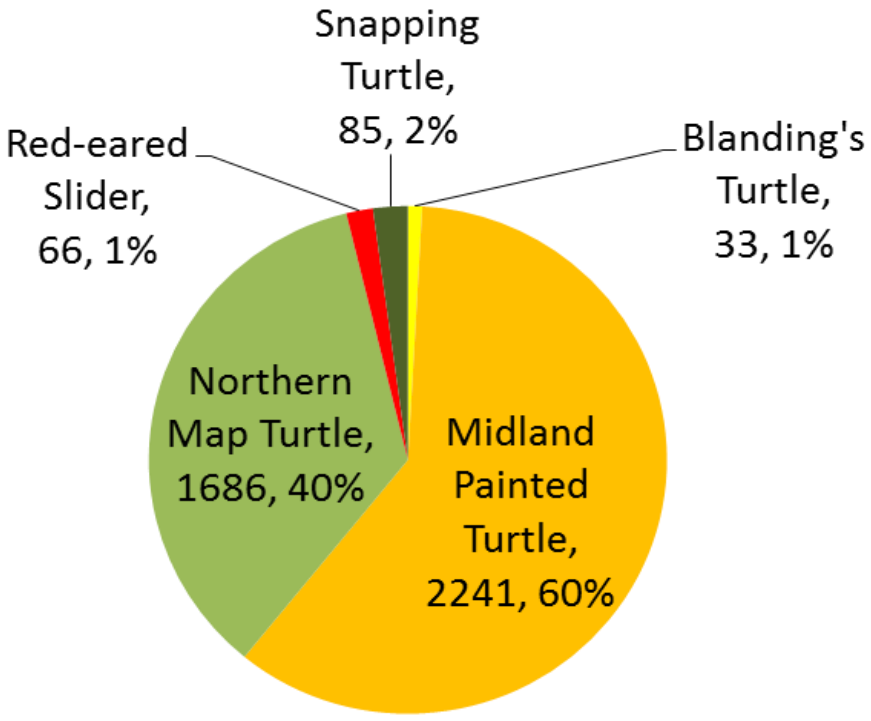


Figure 4 (above). Basking observations at RBG by species 2007-2012. Midland Painted Turtle and Northern Map Turtle represent the majority of all records.

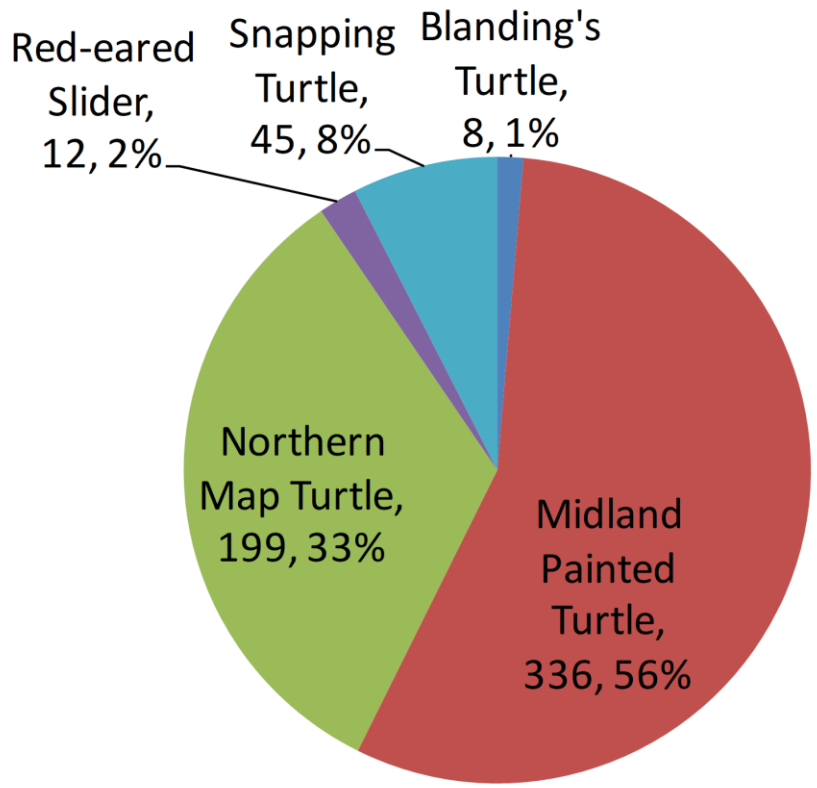


Figure 5 (top right). Trapping observations at RBG by species 2007-2012.

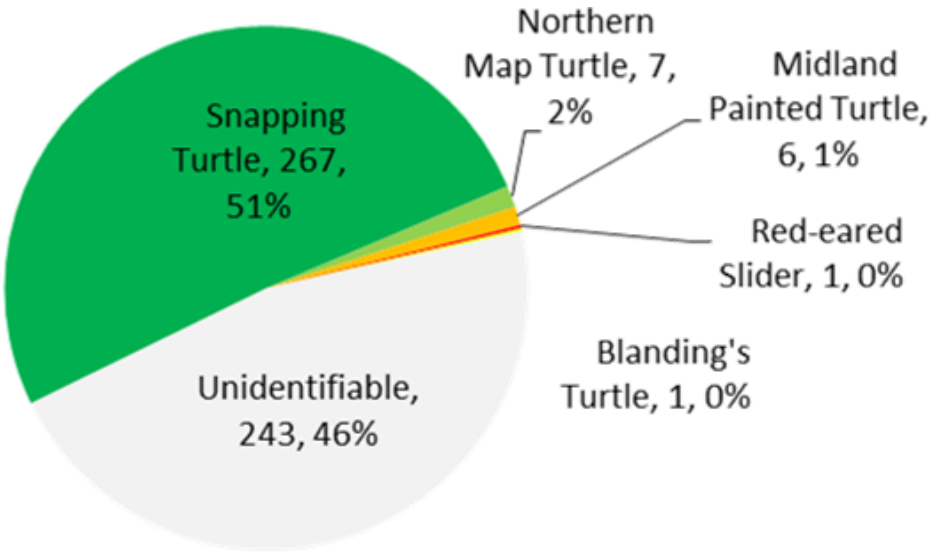


Figure 6 (bottom right). Nesting observations at RBG by species 2007-2012.

Midland Painted Turtle *Chrysemys picta marginata*

2013 Status

Global*: Least Concern	RBG Populations
Federal**: Not at Risk	• Cootes Paradise Marsh:~425
Provincial***: Not at Risk	• Grindstone Marsh:~540

Photograph 4. Midland Painted Turtle caught in Westdale Inlet.

Painted Turtles are the only species of turtle in North American that naturally spans from one side of the continent to the other (Ernst and Lovich, 2009). They are divided into four sub-species. The sub-species that occurs at RBG is the Midland Painted Turtle. In Ontario they are abundant and widespread (S5), occurring roughly south of the Canadian Shield in the Great-Lakes St. Lawrence Climatic Region (Ontario Nature, 2013). Midland Painted Turtles are currently considered stable. The Midland Painted Turtle is not currently listed as at risk; however, it is noteworthy that a closely related sub-species, the Western Painted Turtle *Chrysemys picta bellii,* has two populations in BC on the Pacific Coast and in the Intermountain-Rocky Mountain region that are listed as Endangered and Special Concern respectively.

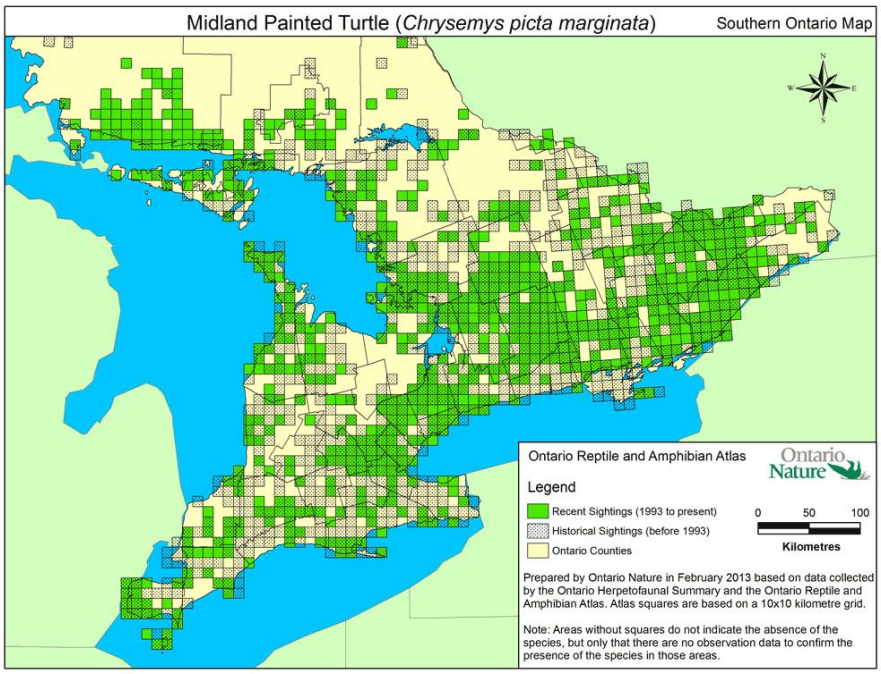


Figure 7. Ontario Midland Painted Turtle occurrences (Ontario Nature, 2013).

*Global Status = IUCN Redlist
**Federal Status = COSEWIC & SARA
***Provincial Status = COSSARO & ESA

RBG Population:
Cootes Paradise Marsh: ~425 turtles* Grindstone Marsh: ~540 turtles**

Midland Painted Turtles occur throughout RBG's wetlands (Figures 9 and 10), with largest numbers observed basking in Presidents Pond and South Pasture Swamp in the spring as they emerge from hibernation. A very small number are caught at the Fishway migrating between the two wetland areas (2007-2012 N=3). Turtles of all ages are observed; however, trapping methods do not frequently capture smaller turtles (Figure 8). Mark-recapture studies indicate that the population is male biased (207:60 or 3.45:1). Radio-telemetry studies were conducted in 2012, monitoring movements of five Painted turtles in Cootes Paradise during their active season (May-Nov). Turtles remained relatively localized to where they were initially caught (max distance between observations = 0.6 km). Nests have been located up to 200 meters from the wetland edge (Figure 9).

In Cootes Paradise Marsh the most successful trapping locations were West Pond, Marshwalk, and Westdale Inlet. They are also observed in the ponds along the former course of Spencer Creek and Upper Paradise Pond. Boathouse Bay contains several driftwood tree branches where turtles bask. Less frequent observations have been recorded at Mac Landing and Double Marsh. One or two turtles are seen annually in the constructed Hickory Valley ponds and one has been observed in the Pinetum irrigation pond. Less information is available about the nesting habits of Midland Painted Turtles in Cootes Paradise. Nesting adults and juveniles are frequently observed moving along Cootes Dr., King St. E., and Olympic Dr. in Dundas. Painted Turtles are also observed regularly on land at the Boathouse during nesting season.

In Grindstone Marsh basking surveys show the highest populations of Painted Turtles in South Pasture Swamp and Ponds 2/3, although they can be easily found throughout any of the floodplain ponds. Almost none are found in Carrolls Bay and only a few have been seen in Long Pond. Evidence of nesting in Hendrie Valley is limited. Painted Turtles have been observed nesting in the lawn and garden beds at Laking and Hendrie Park Gardens.

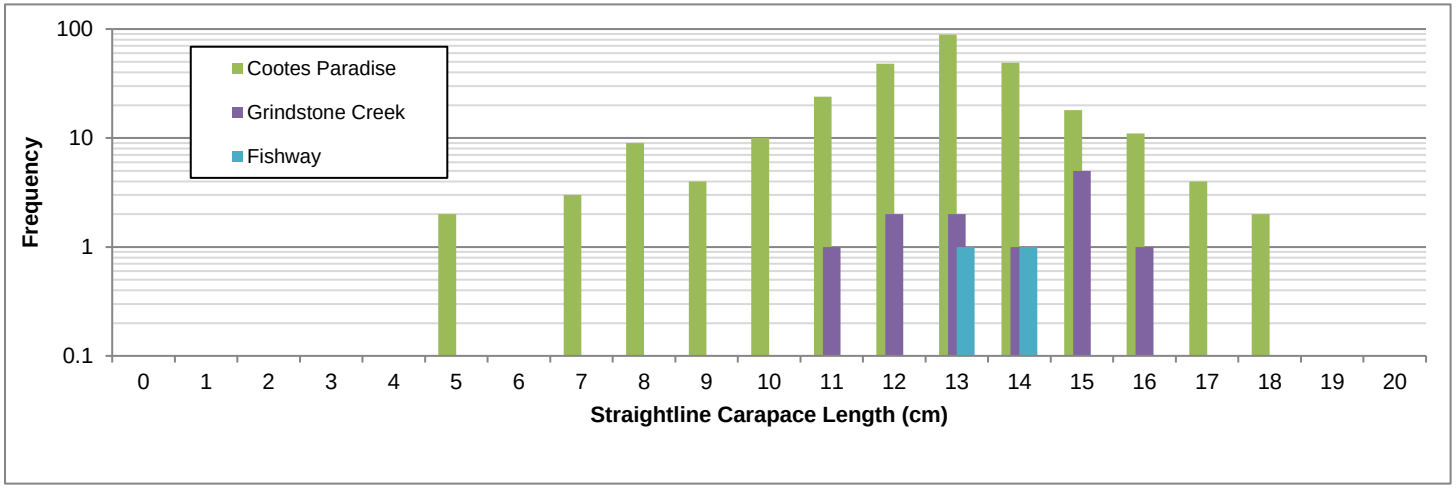


Figure 8. Size distribution of Midland Painted Turtles measured from 2007-2012 during mark-recapture studies and Fishway operation. Frequency is displayed on a logarithmic scale (N=288)

Northern Map Turtle Graptemys geographica

2013 Status

Global*: Least Concern	RBG Populations
Federal**: Special Concern	• Cootes Paradise Marsh:~51
Provincial***: Special Concern	• Grindstone Marsh:~299+

Photograph 5. Northern Map Turtles sunning on a basking trap in Carrolls Bay.

Northern Map Turtle occurs throughout most of the eastern United States and reaches its northern extent in the southern parts of Ontario and Quebec (COSEWIC, 2012). Substantial populations of Northern Map Turtles can be found in waterways where mollusks are abundant (Ernst & Lovich, 2009). This species typically inhabits rivers and lakeshores.

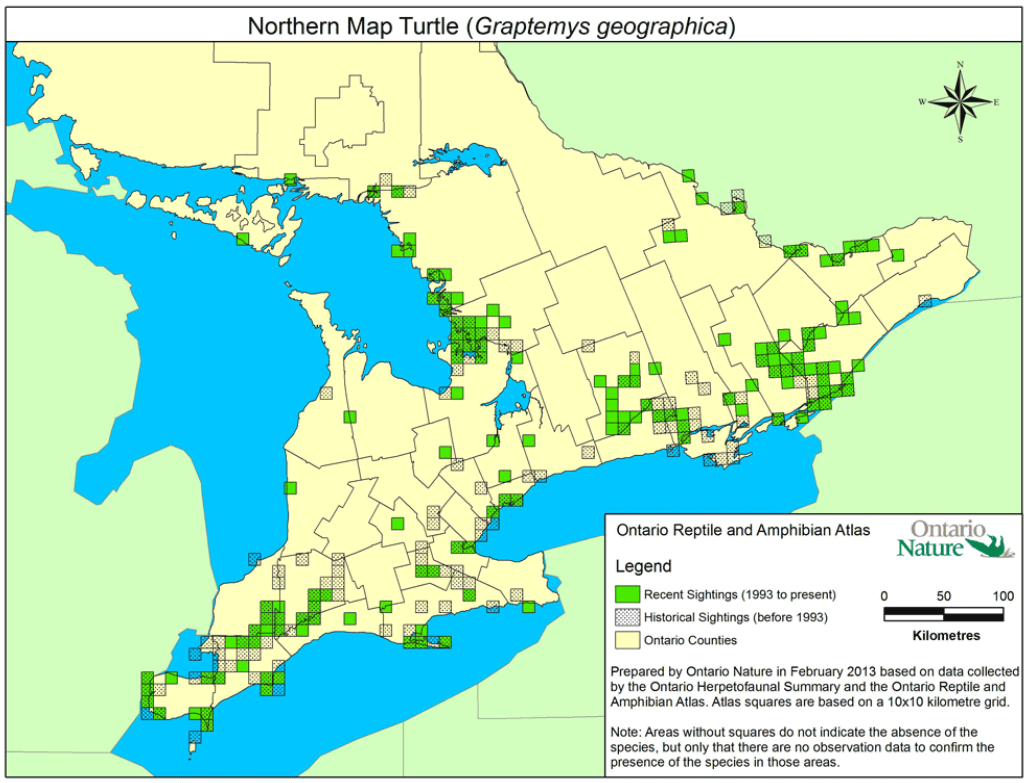


Figure 9. Ontario Nature map of Northern Map Turtle occurrences (Ontario Nature, 2013).

Global Status = IUCN Redlist
Federal Status = COSEWIC & SARA
Provincial Status = COSSARO & ESA

RBG Population Status

Cootes Paradise Marsh: 51 turtles* Grindstone Marsh: 299+ turtles**

Northern Map Turtles are typically observed basking on logs in or near deeper open water. Turtles of all ages are observed, although it is rare to see hatchlings (Figure 9). The population is male biased (M:F ratio = 95:53 or 1.79:1). They are observed infrequently on land during nesting season (est. 1-2/year are observed). It is unknown how much movement occurs between Cootes Paradise and Grindstone Marsh; however, Map Turtles are regularly observed at the Fishway basking and caught in the baskets (2007-2012 catch N=30). In early spring they are observed in Carrolls Bay and Westdale Inlet suggesting overwintering habitat is located nearby. Radio-telemetry studies found turtles travelled up to a kilometer within the wetlands. Nesting turtles have been located up to 83 m from the wetland, and a roadkill turtle was reported during nesting season, roughly 120m away from the nearest wetland.

Cootes Paradise Marsh Map Turtles are concentrated in Westdale Inlet, but are also found basking in Princess Point Bay, Boathouse Bay, and West Pond. Despite observations of map turtles at the Fishway, radio-telemetry studies in Carrolls Bay (2009) and Cootes Paradise (2012) observed no movement from one side of the Fishway to the other. This may be related to problems with interference from Highway 403 and Fishway. No map turtles trapped in 2012 in Cootes Paradise (N=18) showed signs of being marked in previous studies of Carrolls Bay (2008-2010, N=147).

Carrolls Bay Marsh is the largest portion of Grindstone Marsh (~30 ha.) and by far the most populated area for Map Turtles of RBG properties. These turtles have been observed upstream of Carrolls Bay in Grindstone Creek, Sunfish Pond, and Osprey Marsh. They have been found nesting in Laking Garden, at the Valley Inn parking lot, up the western slope of Carrolls Bay and Sunfish Pond near the CN Rail, and at 'The Lodge' (an RBG fenced storage area upslope from Osprey Marsh). Two adult female Northern Map Turtles have been found as roadkill in 2011 and 2012 along Plains Rd. W. west of Hendrie Park.

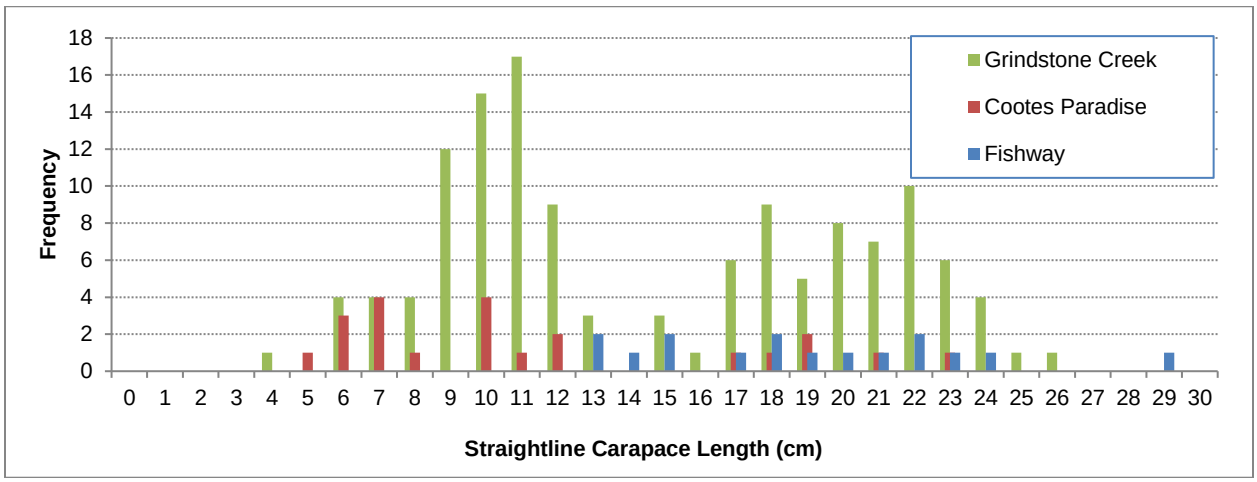


Figure 10. Size distribution of Northern Map Turtles captured during mark-recapture studies and Fishway operation from 2007-2012 (N=168). Note that there are two peaks caused by the size dimorphism between male and female map turtles.

* Estimate based on 2012 mark-recapture study using an adapted Lincoln-Peterson Equation (Harrison, 2013). President's and Upper Paradise Ponds were not sampled.
** Estimate based on 2009-2010 mark-recapture study of Carrolls Bay using an adapted Lincoln-Peterson Equation (Harrison, 2011a). Additional map turtles occur in Sunfish Pond and Grindstone Creek; however, there appears to be movement of turtles from these areas into Carrolls Bay so some of these turtles may have been captured in Carroll's Bay studies.

Snapping Turtle *Chelydra serpentina*

2013 Status

Global*: Least Concern	RBG Populations
Federal**: Special Concern	• Cootes Paradise Marsh:~126
Provincial***: Special Concern	• Grindstone Marsh: ~96?

Photograph 6. Snapping Turtle caught in Double Marsh during 2012 mark-recapture studies.

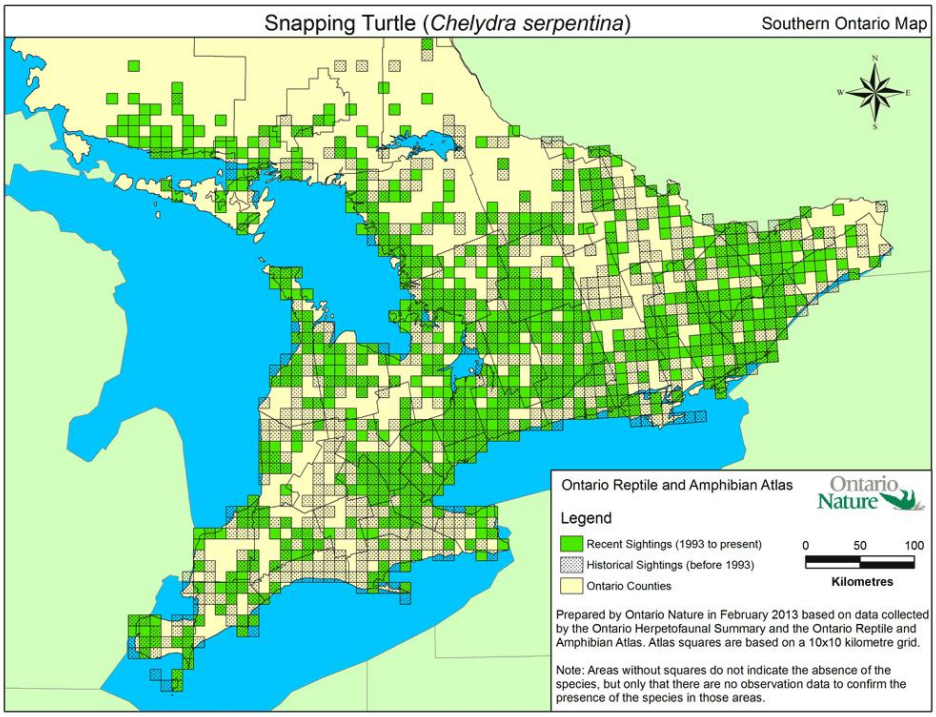


Figure 11. Ontario Snapping Turtle occurrences (Ontario Nature, 2013).

The Snapping Turtle is a Great Lakes health indicator species with regular ongoing monitoring throughout the lakes. The Snapping Turtle is a widespread species occurring in North America through the central and eastern United States. In Canada the species occurs east of Alberta and for the most part south of the top of Lake Superior (Ernst & Lovich, 2009).

Global Status = IUCN Redlist
Federal Status = COSEWIC & SARA
Provincial Status = COSSARO & ESA

RBG Population Status:
Cootes Paradise Marsh: ~126 turtles* Grindstone Marsh: Insufficient data** (~96)

At RBG Snapping Turtles have been monitoring for decades, with most studies focused in West Pond and based around contaminant monitoring. Most turtles found are either adult turtles or hatchlings. They are observed most frequently during nesting season or basking at the surface of floodplain ponds in the spring and fall. They are occasionally caught at the Fishway, indicating some migration between areas. Hibernation occurs in the floodplain ponds, and the lower ends of the small tributaries. Radio-telemetry studies found that the turtles stayed relatively localized over the summer; with the maximum distance between observations of only 0.29 km. Nests have been located up to 280m from the wetland (Churchill Park).

In Cootes Paradise Marsh the most observations of Snapping Turtles in water are in President`s Pond and West Pond. Westdale inlet also hosts several sightings. Cootes Paradise nesting activity (nests and turtles on land) is most concentrated at the Community Garden, along Spencer Creek and the Desjardin Canal, and on the Hydro 1 property, and is impacted by roads. Roadkill monitoring in recent years averaged 9 adult mortalities per year at the west end, contributing to population decline. Nests have also been recorded near Bull`s & Sassafras Points, the islands, Ravine Road Trail, and Churchill Park (Figure 17, 18, 26). All nesting sites have high predation rates, with the Hickory Island and Cockpit Island nests difficult to access/ protect.

Grindstone Marsh Snapping turtles are observed throughout the system (Figure 18), rarely in Carrolls Bay, and frequently in South Pasture Swamp (19 adult turtles were observed basking in one early spring survey). Snapping Turtles are seen nesting most frequently in the Laking Garden, Hendrie Park (Kippax and Auxiliary Gardens), on Kicking Horse Trail, and along the western side of Sunfish Pond. These areas are relatively protected from road impacts. In Hendrie Park turtle nests are also regularly observed in mulch and soil piles. Nest protection has been undertaken throughout these areas, but nests laid along Kicking Horse trail are subject to compaction from hiker and vehicle use on this access road. Standard nest protection is difficult along this trail as a result of the compacted soils. Nest protection is ineffective in loose mediums such as mulch as predators dig under wire mesh.

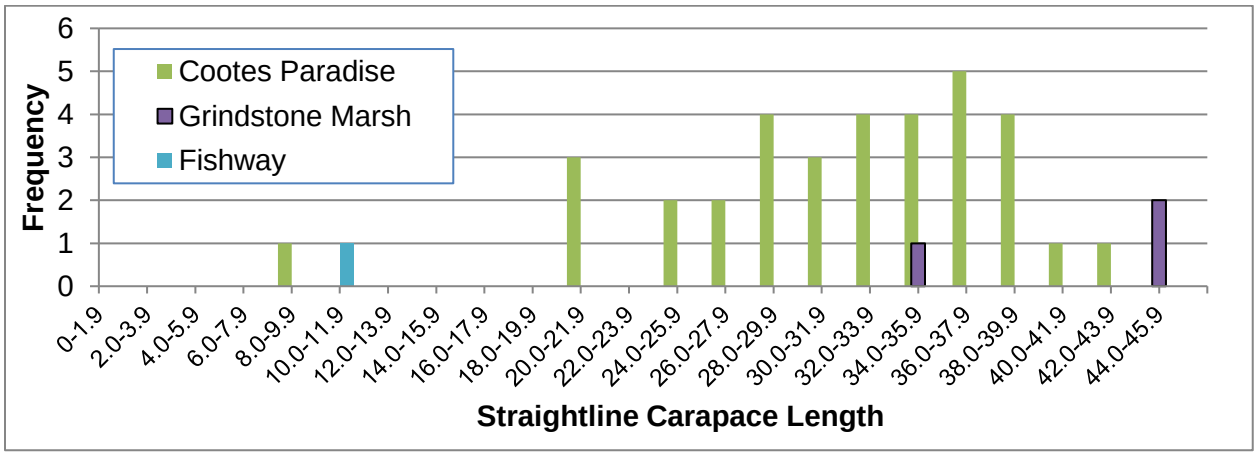


Figure 12. Size distribution of Snapping Turtles captured during mark-recapture studies and Fishway operation from 2007-2012 (N=38).

* Calculated based on 2012 mark-recapture study using an adapted Lincoln-Peterson Equation (N=22; S=+/- 31.94) (Harrison, K., 2013); Sample includes only one recapture.
** Using the overall number of observations from 2007-2012 in Grindstone Marsh/Cootes Paradise (excluding radio-telemetry) a rough estimate of 96 Snapping Turtles can be calculated. It should be noted that this estimate has a high degree of error associated with it due to variations in sampling effort and differences in land management between areas.

In 1990 and 1991, radio-telemetry was used to study movements of 23 Snapping Turtles trapped in or near West Pond (Pettit et al., 1995). This study showed Snapping Turtles moving into Lake Jojo (Sleepy Hollow), up Borers Creek, into Mac Landing, and up Spencer Creek (Figures 19 and 20). Some of the range maps that were created are not included in the paper, but those that were published show no movement east of Double Marsh. Females were found to have larger home ranges than males and the maximum distance travelled from the nesting site (Community Garden) was just over 2km. Wintering sites included in West Pond, Desjardins Canal, Borers Creek, Double Marsh, and Spencer Creek.

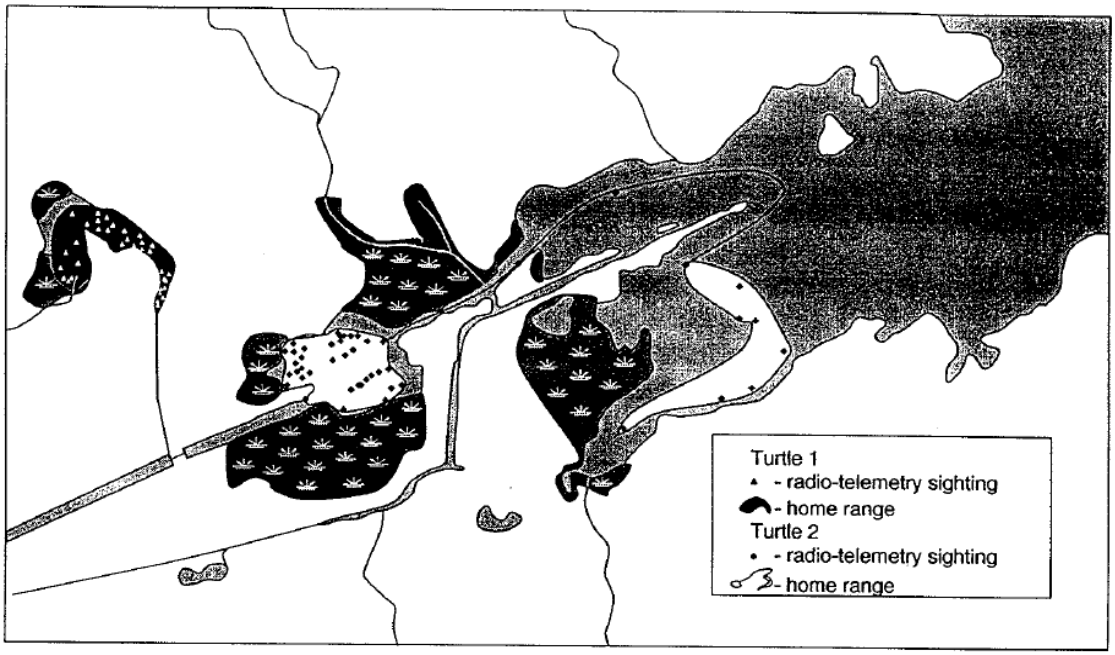


Figure 13. Home ranges of two female Snapping Turtles in Cootes Paradise and Lake Jojo (Pettit et al., 1995).

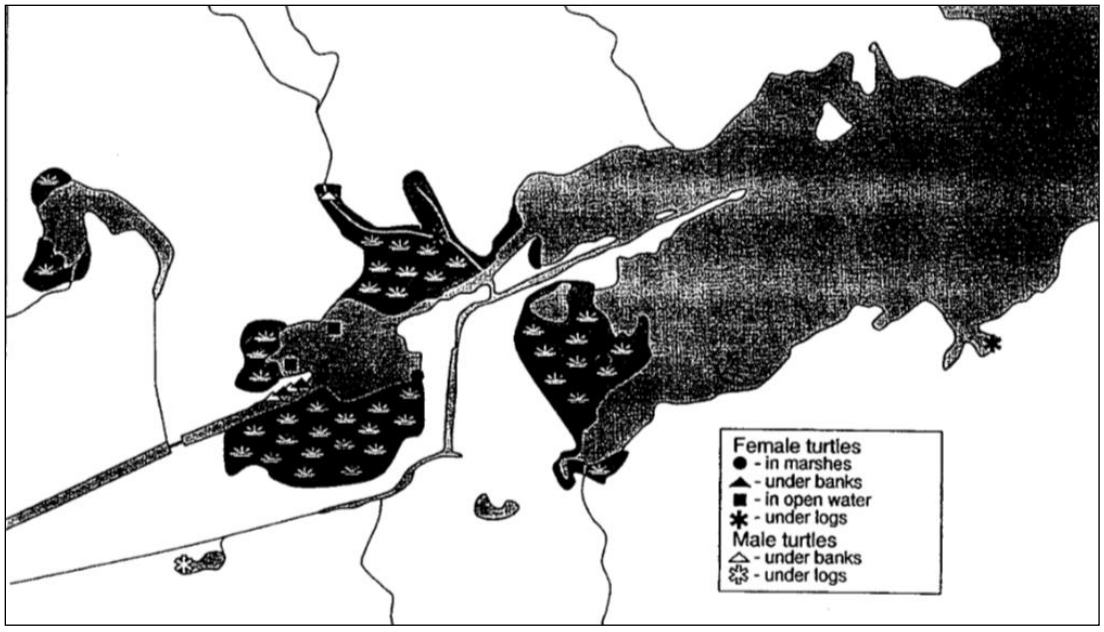


Figure 14. Wintering sites of 15 Snapping Turtles based on a radio-telemetry study of turtles trapped in or near West Pond conducted in 1990 and 1991 (Pettit et al., 1995).

Blanding's Turtle Emydoidea blandingii

2013 Status

Global*: Endangered	RBG Populations
Federal**: Threatened	• Cootes Paradise Marsh:<5
Provincial***: Threatened	• Grindstone Marsh:~20

Photograph 7. Juvenile Blanding's Turtle caught in Grindstone Oxbow in 2011.

The Blanding's Turtle occurs in and around the Great Lakes Basin, with 20% of the species' range occurring in Canada (COSEWIC, 2005). It moves more terrestrially than other species found at RBG. The Canadian part of its range is concentrated in southern and south-central Ontario, extending into the extreme south-western corner of Quebec. A disjunct population occurs in two watersheds in Nova Scotia.

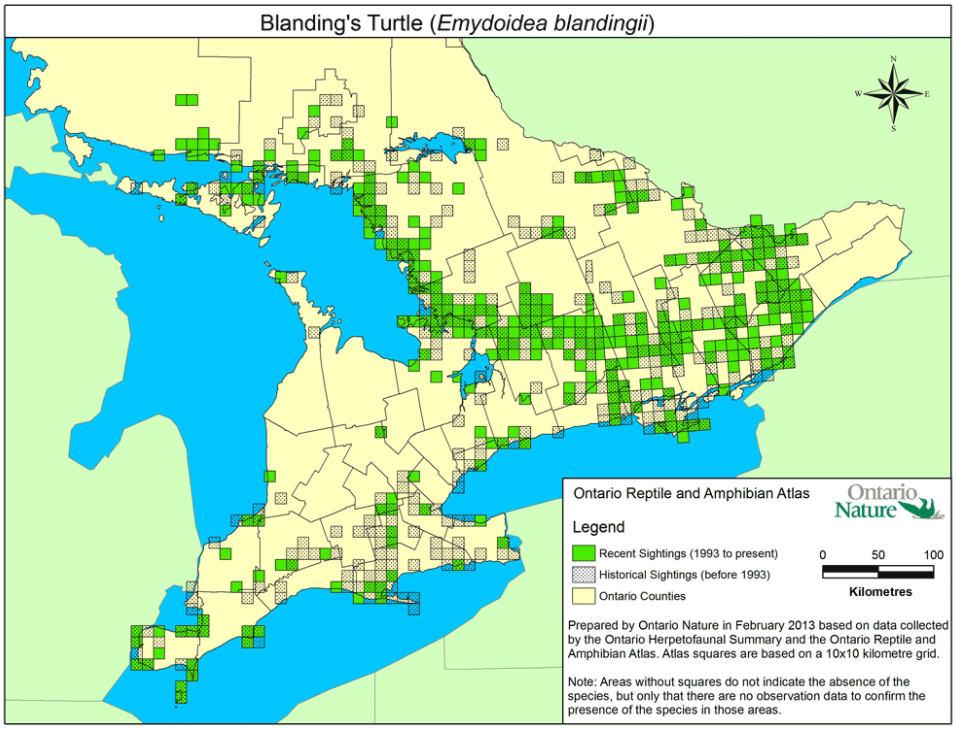


Figure 15. Ontario Nature map of Blanding's Turtle occurrences (Ontario Nature, 2013).

Global Status = IUCN Redlist
Federal Status = COSEWIC & SARA
Provincial Status = COSSARO & ESA

RBG Population Status:
Cootes Paradise Marsh :< 5 turtles* Grindstone Marsh: 20 turtles**

Blanding's Turtles are found in the floodplain ponds and meadow marsh areas of both wetland systems. Most turtles that have been observed are adults, with a couple more males than females (M:F = 5:3). Based on spring basking and radio-telemetry surveys hibernation sites are located in floodplain ponds that tend to be spring fed (President's Pond, Westdale Inlet, South Pasture Swamp, and Grindstone Oxbow). Radio telemetry work has been completed in recent years with one Cootes Paradise adult male (2009-2010) moving east, from the most western part of the marsh, across and out of the marsh and was last observed in 2010 crossing a road that passes under the 403. It is suspected because of this ranging behaviour that the Cootes Paradise and Grindstone Marsh populations were once a single population connected via the former outflow of Spencer Creek in the north east corner to Sunfish Pond via Mercer's Glen and Long Pond.

The Cootes Paradise Marsh population is extremely small, with no evidence of reproduction or female turtles observed in recent years. At least two large turtles are annually observed basking in the spring in Presidents Pond and Spencer Creek Floodplain (2007-2012). There are spring reports from Westdale Inlet, and a few summer observations throughout the marsh. A roadkill individual was recorded on Cootes Dr. in 1999 (Pomfret, 2003).

The Grindstone Marsh population is small but successful reproduction has been observed, including females, juveniles, and hatchlings (Harrison, 2012). Hibernation appears to be almost totally in South Pasture Swamp and Grindstone Oxbow. In the years (2007-2012) a minimum of 16 different Blanding's Turtles have been observed in floodplain pond areas (in some cases observations were unable to be uniquely identified). Marked turtles include 3 known females, 3 known males, one unsexed adult, one juvenile (SCL= 10.1cm - 2010), and eight hatchlings. Additional basking turtles have been observed but could not be captured. With RBG assistance, the nest of a radio-tagged female hatched successfully in 2012 in an adjacent subdivision outside the boundaries of RBG. The nest was protected, and emerging hatchlings were relocated to the marsh. No observations have occurred in Carrolls Bay or Long Pond. Three separate individuals have been found dead (some not recently dead) in the past 5 years within the valley, including one a radio tagged individual.

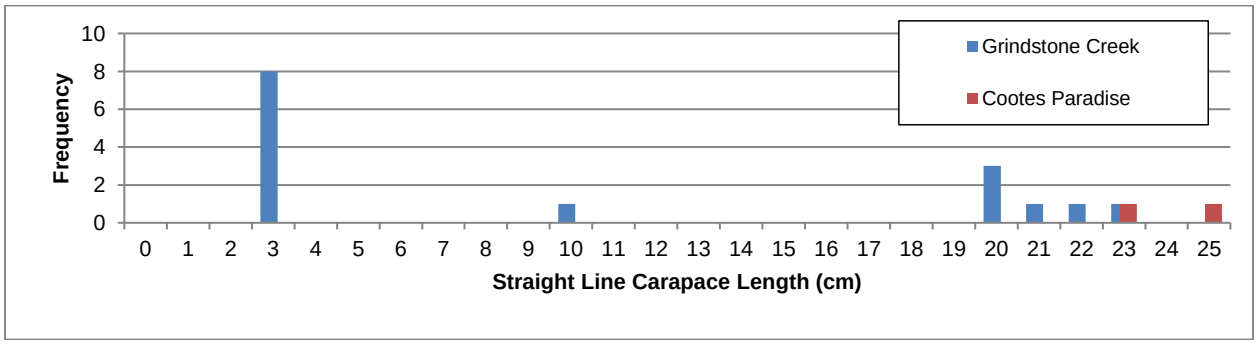


Figure 16. Size distribution of Blanding's Turtles of Royal Botanical Gardens measured between 2007 and 2012 (N=17).

* Two Blanding's have been observed basking in Cootes Paradise in 2012 during the same survey, indicating that the population is a minimum of 2.

** a minimum of 16 different turtles were observed in the marsh between 2007-2012. Additional sightings support the assumption that some untagged turtles remain in Hendrie Valley.

Other Native Species

The remaining three native Ontario species that have been recorded at RBG are not thought to have reproducing populations and are all potentially extirpated (Table 3).

Table 3. Native Ontario turtle species observed at RBG that are not thought to currently have reproducing populations.

Species (common name)	Scientific Name	Most Recent RBG Occurrences	RBG Status
Eastern Musk Turtle/Stinkpot	Sternotherus odoratus	2009 - A single turtle was trapped at the Fishway. 2003 - single turtle was trapped at the Fishway	Incidental
Eastern Spiny Softshell	Apalone spinifera spinifera	1984 (Bishop, 1985) – More recent records were recently identified as a non-native sub-species of the Spiny Softshell (a likely pet release).	Extirpated
Wood Turtle	Glyptemys insculpta	The only record of Wood Turtle from Cootes Paradise is considered to likely be an escaped pet (Lamond, 1994)	Extirpated (?)

Non-native species

Four non-native turtle species have been observed at RBG since 2007:

- Red-eared Slider (*Trachemys scripta elegans*) – estimated population ~17 turtles*
- Ouachita Map Turtle (*Graptemys ouachitensi*s)
- Striped Mud Turtle (*Kinosternon baurii*)
- Texas Spiny Softshell (*Apalone spinifera emoryi*)

The Red-eared Slider is the only of the non-native turtles that occurs on a regular basis and frequently enough to generate a population estimate. Following a low water/cold winter numerous shells of the species have been observed on the shores of Cootes Paradise. This species has been observed nesting at RBG on several occasions. Red-eared Sliders are most often observed near public access points or roads, with the source of these turtles thought to be release of unwanted pet turtles. These areas include Princess Point, West Pond, and President's Pond in Cootes Paradise, and Sunfish Pond and Carrolls Bay in Grindstone Marsh.

*Estimated by applying the ratio of [Midland Painted Turtles observed basking in 2011-2012:mark-recapture estimate calculated for the same years = 0.63] to Red-eared slider basking data from 2007-2012. The average number of Red-eared Sliders observed basking annually from 2007-2012 was 11.

Evidence of Decline

Based on the observations of RBG staff over the years there is evidence that turtle species at RBG are at risk of becoming locally extirpated with two species already lost to the area and a third, the Blanding's Turtle near extirpation. A good indication of this is the massive extent of local habitat loss that occurred historically (discussed in threats section pg. 48).

There have been a few population studies conducted at RBG in the past. Two studies from the 80s used mark-recapture estimates in West Pond to estimate Snapping Turtle populations (Galbraith, 1988; Bishop, 1985). Both had population estimates near or above 600 turtles and trapped over 200 Snapping Turtles in a two-year period using a single trap net. In the study conducted in 2011 and 2012 for all of Cootes Paradise (with a focus on West Pond), using more traps (6 and 15 hoop nets in 2011 and 2012 respectively), over as many or more trapping days (mainly in spring and early summer) only 37 Snapping Turtles were caught (Harrison, 2012). The recent population estimate was calculated to be 126 although it has a high degree of error due to small sample size. Further study and analyses are needed to evaluate differences in methods, and improve sample size; however, at present it appears that the Snapping Turtle population is showing evidence of decline over the past few decades.

In 1985, ten Blanding's Turtles were known to occur in Cootes Paradise and four in Grindstone Marsh (Hendrie Valley) (Bishop, 1985). More recent surveys (2007-2012) show slightly fewer adult turtles, but in different locations (Grindstone Marsh = 8, Cootes Paradise = 2).

Northern Map and Midland Painted Turtles at RBG were not estimated using trapping surveys prior to 2007. Bishop (1986) described Midland Painted Turtles as most common and in a similar distribution to present. Northern Map Turtles were listed as common in Grindstone Creek, Carrolls Bay, and Westdale Inlet, and uncommon in West Pond. The population is thought to be significantly smaller than 20 years ago.

Life History

The individual life history characteristics of each turtle species occurring at RBG vary but have several areas of overlap (Table 4; Ernst and Lovich, 2009). In general, they are long-lived and take many years to reach maturity. They nest in the spring on land, in open areas with loose soils that are exposed to the sun. There is no parental care for the offspring. The eggs incubate in the nest for two to four months before hatching. Hatchlings either emerge in the fall or over-winter in the nest and emerge in the spring. Most species lay from three to twenty eggs in the nest; however, twenty is at the lower end of the number of eggs a Snapping Turtle typically lays.

During the winter turtles hibernate, usually in soft substrates at the bottom of a water body though other habitats may be used. Studies of Northern Map Turtles in other locations have located group hibernacula of greater than 100 turtles in river pools. This has not been observed at RBG, though data on over-wintering habitats of Northern Map turtles is limited.

* Two Blanding's have been observed basking in Cootes Paradise in 2012 during the same survey, indicating that the population is a minimum of 2.

** a minimum of 16 different turtles were observed in the marsh between 2007-2012. Additional sightings support the assumption that some untagged turtles remain in Hendrie Valley.

Photograph 8. Common Snapping Turtle hatchlings found in the Community Garden and released into West Pond in late summer of 2012.

* Two Blanding's have been observed basking in Cootes Paradise in 2012 during the same survey, indicating that the population is a minimum of 2.

** a minimum of 16 different turtles were observed in the marsh between 2007-2012. Additional sightings support the assumption that some untagged turtles remain in Hendrie Valley.

	Midland Painted Turtle	Northern Map Turtle	Snapping Turtle	Blanding's Turtle
Diet	omnivore generalist "in the broadest sense"	Specialized carnivore; feeds primarily on mollusks	Omnivore "essentially consuming anything it can fit into its jaws"	chiefly carnivorous; leeches, snails, slugs, bivalves, millipedes, small crustaceans, crayfish, etc.
Maturity	Females: 6-10 years Males: 2-4 years (6 max)	Females: 14 years Males: unknown	Females 17-19 years Males est. 6yrs	Females 14-20 years Males: unknown
Life Span	30-40 years (61 max)	Maximum: >20 years	Average: 40 years (Adult females) Maximum: >50 years*	Maximum: >77 years
General Habitat	Slow moving shallow water with soft bottoms, aquatic vegetation, and abundant basking sites	Rivers and lakes; abundant basking sites preferred	Slow-moving waterways with mud/sand bottom, aquatic vegetation, submerged woody debris	productive eutrophic habitats; soft, firm organic bottom; abundant aquatic vegetation
Over-wintering Habitat	soft bottom of water body, lodges, over-hanging dirt banks, floodplain woods/pastures; up to 0.95 m deep in water usually < 2m	Group hibernacula (can be >100 individuals); deep, cold, highly oxygenated river pools	buried in substrate (small streams or marshes) or beside logs/stumps near shore	Near summer habitat; partially buried in shallow or deep water with organic substrate; can be on land under wet leaves; Good freezing tolerance
Nesting Habitat	loamy/sandy soil in open areas	soft soil/sand and full sun; disturbed sites along highways	open to sun; loose sand, loam, veg. debris, sawdust, beaver/muskrat lodge, roadsides, railways, earthen dams	well-drained sandy loam or sand; grasslands, road berms, pastures, yards, driveways
Nesting Time	June and July	late May to mid-July	Mid June - August	late May to early July
Incubation Time (days)	70 (62-80)	N/A	75-95 (55 - 125)	85 (65-110)
Emergence	late April and May (occasionally in the fall)	mid Aug to Sept or early April to early June; low tolerance to freezing	mid Aug to early Oct; overwintering in the nest rarely successful	mid Aug to early Oct; overwintering in the nest rarely successful
Number of eggs	3-17	9 - 17 (20)	25-45 (max 109)	3 - 22

Table 4.Summary of life history traits of Native Turtles of RBG as described by Ernst and Lovich (2009).

* >100 years reported in more recent literature (R. Brooks, unpublished data, in COSEWIC 2008)

Hibernation Areas

Turtle observations between November and April were mapped to give a general overview of probable over-wintering habitat (Figure 25). This map suggests key areas include Spencer Creek floodplain, Westdale Inlet, the shoreline of Carrolls Bay, and the upper Grindstone Marsh ponds.

Different species have considerably different over-wintering requirements. Snapping Turtles in Ontario have been found to winter in small streams that flow all winter, under/beside submerged logs within 5m of the shoreline, and in marsh areas in deep mud or beneath vegetation mats (Brown and Brooks, 1994). Survival rates are higher under normoxic conditions, but Snapping Turtles are known to over-winter successfully in mud under anoxic conditions (Ernst and Lovich, 2009). Due to this variability in environments for Snapping Turtle hibernation, suitable habitat is relatively ubiquitous near shores and in marsh/soft bottom areas. The preference for areas with flowing water and better survival under normoxic conditions, indicate that small creeks and spring fed areas, such as Borers Creek, Westdale Inlet, and South Pasture Swamp, provide better over-wintering habitats than other areas. A previous radio-telemetry study showed West Pond, Borers Creek, Double Marsh, Spencer Creek and Lake Jojo as over-wintering habitat for Snapping Turtles (Pettit et al., 1995; Figure 20).

Midland Painted Turtles tend to choose a well oxygenated hibernaculum in habitats that such as soft bottomed waterbodies, muskrat/beaver lodges, undercut banks, and even floodplain woods or pastures (Ernst and Lovich, 2009). The water depth can be up to 2m and they bury themselves as deep as 0.95m (Ernst and Lovich, 2009). They can be anoxia tolerant but tend not to move and as a result, low water in winter can cause mortality if substrate temperatures drop below freezing (Ernst and Lovich, 2009). Ideal conditions exist in the upper ponds of Grindstone Marsh, inner Westdale Inlet, and Spencer Creek Floodplain, although many other areas are also suitable.

Blanding's Turtles have been observed over-wintering in the deepest parts of ponds and creeks with organic substrates, under ice in shallow water (mean=0.9m), and even on land under wet leaves (Ernst and Lovich, 2009). At RBG radio-telemetry in winter months showed turtles over-wintering in President's Pond, Grindstone Oxbow, and South Pasture Swamp.

In contrast to other species, Northern Map turtles hibernate on the exposed bottom of deep, cold depressions in river channels with highly oxygenated water (Ernst and Lovich, 2009). They are also known to hibernate in groups (Ernst and Lovich, 2009). At RBG, the most suitable conditions are plunge pools along the lower stretch of Grindstone Creek. Outer Carrolls Bay is less ideal as it is a more open and active area. Additionally, issues with contamination in the harbour compromise the integrity of this habitat (HHRAP, 2002). In Cootes Paradise the largest grouping of Map turtles in the early spring is in Westdale Inlet, where Westdale Creek may be providing enough oxygenated water to sustain Map Turtles over the winter. Alternatively, the turtles may be migrating into Grindstone Creek, or up one of the tributaries, with admittedly sub-optimal conditions, that feed Cootes Paradise such as Spencer Creek or the Desjardins Canal.

Water levels in most of the wetlands fluctuate as a result of their connection to Lake Ontario. This can result in seasonal loss of water in much of the wetland areas during the fall/winter hibernation period, which could have implications on over-wintering survival. On average Lake Ontario water level declines 19cm during the hibernation period, which has not changed significantly as a result of Lake water level regulation (Theÿsmeÿer, 2003). In extreme cases such as 1998, water levels declined about 50cm leaving the main body of the wetlands without water (Theÿsmeÿer, 2003). During these types of extremes, hibernation sites associated with spring fed floodplain ponds may provide higher chances of survival by providing a more stable environment and water level regime. Maintaining the quality of the groundwater is of ongoing interest in these areas.

Nesting Areas

Critical to nesting are features such as open sun exposed ground, elevation above the water table, and relatively loose or granular soil. Morning sun exposure on open ground is a key factor, and as such south, and south west facing slopes are critical nesting sites. As a result, principle nesting areas are found on the north side of the wetlands. Some degree of upstream migration has been observed by turtles moving towards nest sites.

In and around RBG, turtle nesting occurs in almost any available area that has the needed sun exposure, open soils, and is located near the wetlands (Figures 26 and 27). Areas in Cootes Paradise Marsh with higher concentrations of nests are located in upstream areas on northern shores, and include the Community Garden on Olympic Dr., the parking area and roadsides on King St. E. at Olympic, openings along the Spencer Creek Rail Trail, and along the road on Cootes Dr. In Hendrie Valley the most used sites are Laking Garden, Kicking Horse Trail, Kippax Garden, and mulch/soil piles near the Auxiliary Garden. These areas are characterized as tilled garden soils or sand/gravel trails and roadsides, exposed to the sun and they are typically at heights of land (excluding Kicking Horse trail).

Nesting in the natural areas is limited as most of the shorelines are forested with large trees. Collapsing shoreline areas, islands, larger access trails, Princess Point, and the Boathouse area represent the only opportunities. Despite the concentration of turtles in Westdale Inlet and Princess Point Bay, very few have been recorded nesting at the open sunny areas of Princess Point, and the most consistent reports are of the non-native Red eared Slider.

Photograph 9. Blanding's Turtle nesting in subdivision adjacent to RBG wetlands.

Threats to Freshwater Turtles Overview

An extensive body of work has been completed to assess the status of turtles and the factors that are leading to their declines worldwide. The following highlights the work as it pertains to freshwater turtles in Ontario.

Globally: The International Union for Conservation of Nature (IUCN) Red List of Threatened Species has listed 59% of all turtle species (Order Testudines) as "Threatened", meaning that they have a high to extremely high risk of becoming extinct in the wild (IUCN, 2012). A review of literature available globally identified and summarized the main threats to reptile populations as habitat loss and degradation, introduced invasive species, environmental pollution, disease, unsustainable use, and global climate change (Gibbons et al., 2000).

A Global Action Plan for Conservation of Tortoises and Freshwater Turtles: Strategy and Funding Prospectus 2002–2007 identifies the primary threat to tortoises and freshwater turtles world-wide as trade (food, traditional medicine, pet, cosmetics) (Turtle Conservation Fund, 2002). The primary threats identified for North America and Europe were development, habitat destruction and fragmentation, and pet trade collection. Other threats identified in developed countries were invasive alien species, chemical and hormonal pollution, gradual global warming (affecting temperature-dependent sex determination and habitat stability), and illnesses due to introduced pathogens.

Nationally: The federal government provides information about threats to Species at Risk through Assessment and Status Reports written by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Threats from the status reports for each of the three at risk turtles that have reproducing populations at RBG and for a closely related sub-species of Painted Turtle listed as at risk in BC are summarized below. The Canadian Amphibian and Reptile Conservation Network (CARCNET) lists habitat destruction, traffic mortality, predators, contaminants, pet trade, introduced species, and persecution as major threats to reptiles in Canada (CARCNET, 2012).

Threats as identified by COSEWIC assessment and status reports:

Blanding's Turtle (COSEWIC, 2005)

Threats are identified as nest predation, cool summer temperatures resulting in nest failure, flooding of nests, development in and around wetlands, roads (especially for nesting females and hatchling turtles), and pet trade. Throughout its range Blanding's Turtle populations are divided by natural and man-made barriers. When these barriers are roadways, which they often are, road mortality occurs, especially that of nesting females. It is also noted that the removal of a few reproducing individuals from the population, which occurs through road mortality or collection, is a severe risk to the survival of this long-lived species.

The COSEWIC report mentioned depredation by sarchophagid fly larvae as a threat. In 2006, a study on sarchophagid larvae in Northern Map Turtle nests was published showing that the larvae that were present in the nest were unlikely to have been the cause of nest failure (Raymond et al., 2006).

Northern Map Turtle (COSEWIC, 2012)

* Two Blanding's have been observed basking in Cootes Paradise in 2012 during the same survey, indicating that the population is a minimum of 2.

** a minimum of 16 different turtles were observed in the marsh between 2007-2012. Additional sightings support the assumption that some untagged turtles remain in Hendrie Valley.

Several potential and confirmed threats are identified for the species, but it is noted that few had been quantified at the time. These threats include delayed age at maturity, high nest failure due to cool temperatures, trade, and urban encroachment. Sarchophagid fly larvae are again noted as having invaded the nest, as mentioned above this may not have been the cause of nest failure.

Snapping Turtle (COSEWIC, 2008)
This turtle may still be considered abundant, but its life history makes it susceptible to human-related threats and even minor increases in adult mortality can have significant impacts on the long-term sustainability of a population. Females are especially vulnerable to roads during nesting season, with recent studies showing signs that populations near roads are becoming male-biased (Ernst & Lovich, 2009). Snapping turtles in Ontario like many other turtle species are constrained by a slow life history, short active season, low rates of recruitment, late maturity, and lack of any apparent density-dependent responses. These traits make Snapping Turtles vulnerable to anthropogenic stressors. The combination of Ontario's cool climate, high human densities, and a large extent of habitat alteration has led to randomly determined mortality events and chronic increases in mortality rates of both juveniles and adults. Anthropogenic threats include road mortality, mortality from ingesting fishing hooks/gear, intentional killing, unnaturally high rates of nest predation, decreases in reproductive success due to environmental contamination, urban development, and boat traffic. The persistence of populations depends on high adult survivorship, meaning that the greatest limitations to the Snapping Turtle's persistence in Canada are any events that increase adult mortality.

Painted Turtle (COSEWIC, 2006)
These turtles, like most, have low adult recruitment, delayed maturity, and high adult survival. Chronic added mortality of juveniles and adults pose a threat to localized populations in Western Canada. Identified threats from the Western populations that also apply to Midland Painted Turtle include roadkill (particularly gravid females during the nesting season), increased predation on dispersing turtles during drought years (or in reservoirs with low water levels), increasing depredation of nests (particularly by higher populations of raccoons), habitat loss, wetland and riparian degradation due to human activity, water pollution, habitat fragmentation, drainage of wetlands, increased predation of eggs and juveniles, introduction of exotic turtle species, and associated diseases and parasites.

Other Turtles (incidental/locally extirpated)
The primary threat to the **Eastern Musk aka Stinkpot** Turtle is habitat destruction (wetland drainage, pollution, and shoreline development). They are sensitive to drought, and abnormally high-water levels can drown eggs. Heavy motorboat traffic and intense fishing increase adult mortality rates (COSEWIC, 2002a).

Eastern Spiny Softshell is most threatened by recreational activities at nesting sites. Habitat loss was a major threat in the past, but habitat degradation is currently a bigger problem. Other identified threats are extensive bank stabilization, urban and agricultural development along shorelines, environmental contamination and sewage, destruction of eggs by fluctuating water levels, collisions with boats, and fishing (COSEWIC, 2002b).

Wood Turtle is threatened by road traffic and modern agricultural machinery, destruction of nests by recreational vehicles such as all-terrain vehicles (ATVs) and snowmobiles, lost nesting habitat and hibernacula due to watercourse bank alternations, flooding and shoreline stabilization, increased
* Two Blanding's have been observed basking in Cootes Paradise in 2012 during the same survey, indicating that the population is a minimum of 2.

** a minimum of 16 different turtles were observed in the marsh between 2007-2012. Additional sightings support the assumption that some untagged turtles remain in Hendrie Valley.

predation of nests by raccoons and possibly coyotes and other mammals, and collection for pet and food trade. As this is an upland based turtle, pollution of watercourses used by this species is one of the lesser threats. Increasing access to its habitat by people is also listed as a threat. As with several of the other turtles this species is vulnerable to any increased adult mortality due to its longevity, late sexual maturity, and very low number of juveniles being added to the population each year (COSEWIC, 2007).

* Two Blanding's have been observed basking in Cootes Paradise in 2012 during the same survey, indicating that the population is a minimum of 2.

** a minimum of 16 different turtles were observed in the marsh between 2007-2012. Additional sightings support the assumption that some untagged turtles remain in Hendrie Valley.

RBG Site Specific Threats

The threats that face turtles of RBG can be divided into three main categories:

1. Habitat loss, fragmentation, alteration, and degradation
2. Direct mortality
3. Impairment of reproductive success

In addition, global climate change and population demographics related to small and isolated populations will have an effect on the turtle populations. These issues threaten the long-term success of turtles, but there is further research required to understand the impacts they will have.

Habitat loss, alteration, fragmentation and degradation

Regionally RBG exists as a sanctuary for wildlife within one of the ten largest metropolitan areas in Canada (Statistics Canada, 2012). This has resulted in considerable habitat loss. Habitat degradation has been identified as an issue since the 1940s. Inflowing water impairment and very high Common Carp (*Cyprinus carpio*) densities led to the creation of Project Paradise, a long-term fundraising and restoration project and key project within the HHRAP, focused on the wetlands of RBG. Work initiated in 1994 and in 1997 a large-scale Fishway and carp barrier was installed at the connection between Cootes Paradise Marsh and Hamilton Harbour reducing the number of carp in the marsh.

Infilling & development near wetlands: Loss of nest habitat & roads in movement corridors

Large sections of marsh were filled or altered along transmission routes including the CN Rail line, Highway 403, Old Guelph Rd., the Desjardins Canal, Cootes Dr., Olympic Dr., the Waterfront Trail, and the road that formerly ran along the western shore of Carroll's Bay. In addition, Princess Point was formerly a landfill site and the mouth of Chedoke Creek has been filled extensively. Lands surrounding RBG, including the garden areas of RBG, have been developed and exist now as a combination of buildings, pavements, compacted trails, and manicured lawns. This can be illustrated by an overlay of distances turtles move from the marsh to nest over local roadways (Figure 28).

The filled and developed lands surrounding RBG are the areas where turtles would have historically nested and currently do nest (Figures 26 and 27). Garden beds, compost, mulch and gravel piles provide some opportunities for nesting, but there are recognized threats to nest success in each of these locations. Turtles are regularly observed nesting in newly created, artificial, and unsuitable habitats suggesting an overall lack of suitable nesting habitat. An assessment of each of the main nesting areas that have been identified and associated threats is provided in the following section.

Roadways in developed areas also create barriers to movement through road mortality and are discussed further with respect to direct mortality (pg. 59)

* Two Blanding's have been observed basking in Cootes Paradise in 2012 during the same survey, indicating that the population is a minimum of 2.

** a minimum of 16 different turtles were observed in the marsh between 2007-2012. Additional sightings support the assumption that some untagged turtles remain in Hendrie Valley.

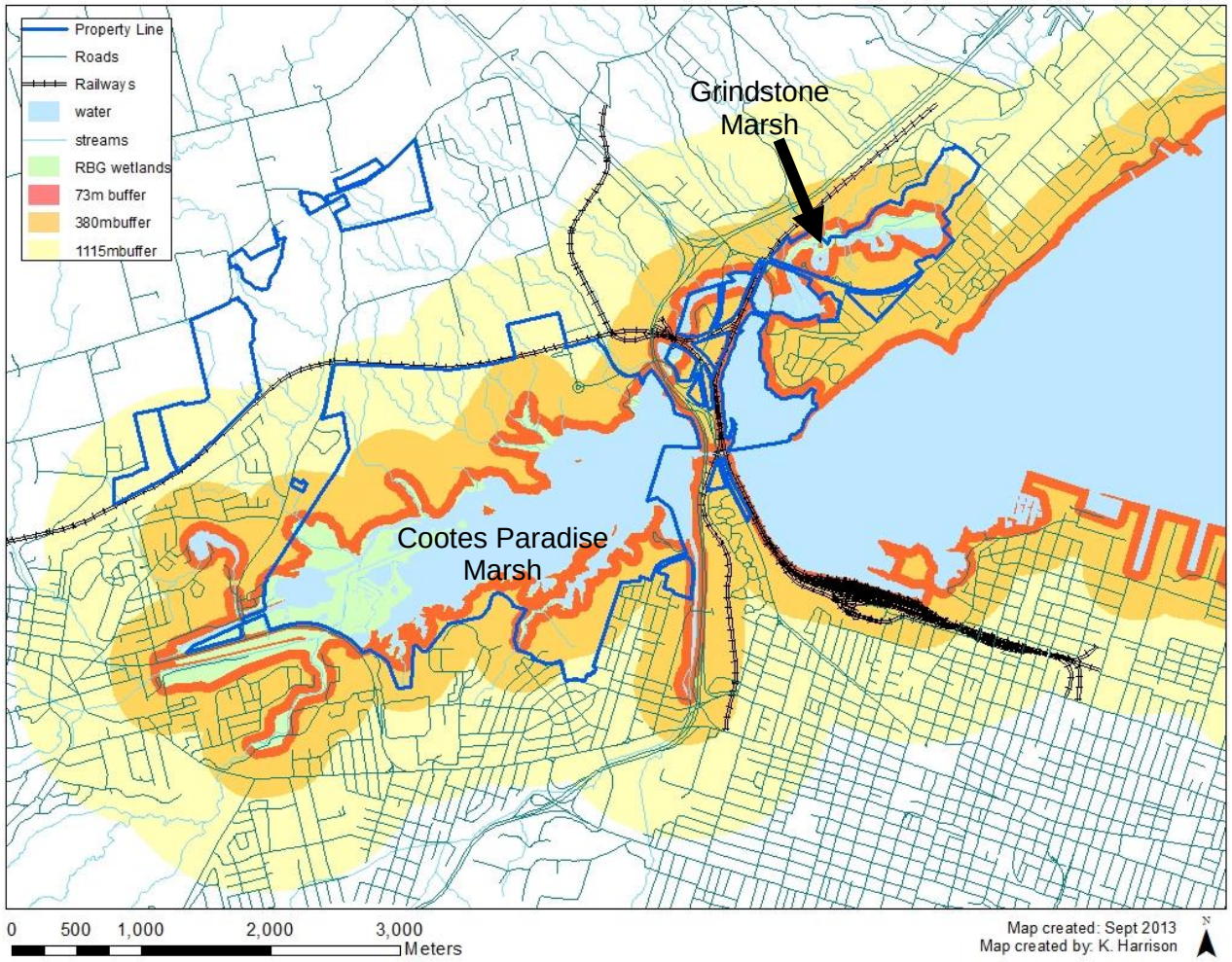


Figure 17. Buffers of 73m, 380m, and 1115m around the wetland based on Critical Function Zones from How much Habitat is Enough? (Environment Canada, 2004 & 2013). The 73m buffer represents the area where 90% of turtle nests are likely to be located (Environment Canada, 2004). The 380m buffer represents the Critical Function Zone for Blanding's nesting based on the mean distance plus standard deviation observed by Joyal et al. (2001). The 1115m buffer is based on the Blanding's maximum distance observed in a review of three studies by Semlitsch and Bodie (2003). Blanding's Turtles were chosen as the representative species because they are known to travel the greatest distances terrestrially.

* Two Blanding's have been observed basking in Cootes Paradise in 2012 during the same survey, indicating that the population is a minimum of 2.

** a minimum of 16 different turtles were observed in the marsh between 2007-2012. Additional sightings support the assumption that some untagged turtles remain in Hendrie Valley.

Turtle Nesting in Natural Areas

Peninsulas and Islands:

Sassafras Point, Cockpit Island, Hickory Island, Bull's Point, the knoll between Ponds 1 and 2, and other exposed shoreline areas have all been used for nesting and in some cases represent ideal south facing slopes. Predation rates in these areas as throughout all nesting areas around the wetlands are high. Protecting nests at these sites requires boat access and significant time investment if nest protection is to be undertaken.

Western Shoreline Carrolls Bay:

Carrolls Bay area contains one of the highest concentrations of Northern Map Turtles in the region and historically had the highest native turtle species diversity. The south facing angle of the western shoreline provides a key characteristic for nesting conditions. Nesting along the shoreline was limited from 2007-2012 by the vegetation that has established there. Almost all vegetation is non-native consisting of species such as Phragmites, Reed Manna Grass, Buckthorn, Honey Suckle and Barberry. The upper slope above the train tracks has very limited use by turtles as the tracks form a barrier to migration, although some turtles to manage to cross the tracks.

The western shoreline of Sunfish Pond existed as a forested slope up until 2006 (Photographs 11 a-d). At that time expansion of the CN Rail line resulted in reconstruction of the slope. After the reconstruction, which added a large retaining wall to prevent infilling into the wetland, turtle nesting was observed in the open soils along the shoreline & face of the retaining wall. It was necessary to plant the area between the retaining wall and the water in order to ensure soil stability and re-establish a riparian zone along that shoreline. A small area along the north-east portion of the retaining wall has been maintained as open habitat for nesting. Due to the proximity of the water table open soils in the area are quickly colonized by plants, despite an attempt to maintain open areas by adding sand-based materials. Between 2007 and 2012 prior to the beginning of turtle nesting bindweed, sumac, and tree of heaven have been removed from this site. Multiple visits throughout the summer are required to maintain open conditions. In addition, under high water conditions nests on the lower portion of this shoreline may flood.

Turtle Nesting in Artificially Created Habitats

Roadside, trail, and parking lot nesting:

The potential for collisions and soil compaction make these locations poor nesting areas. Turtles are frequently observed nesting along Cootes Dr., King St. E., Olympic Dr., Spencer Creek Trail, and at the hydro yard on Olympic Dr. In Hendrie Valley they have been observed nesting at the Lodge, along Kicking Horse Trail, and at Valley Inn. These areas are driven over by vehicles resulting in compacted soils that make it difficult to dig nests and reduce nest success. Mowing of roadsides can also result in turtle mortality in these areas. Hatchling mortality has been observed along the Spencer Creek Trail as small unseen turtles are run over by cyclists.

Adjacent Parks:

Nesting in Churchill Park Centennial Park and the edge of McMaster Campus has been observed around Cootes Paradise. The perceived threat of Snapping Turtles, disregard for maintaining a safe

* Two Blanding's have been observed basking in Cootes Paradise in 2012 during the same survey, indicating that the population is a minimum of 2.

** a minimum of 16 different turtles were observed in the marsh between 2007-2012. Additional sightings support the assumption that some untagged turtles remain in Hendrie Valley.

distance from a nesting turtle, or a lack of understanding of a turtle's natural life cycle can lead to them being disturbed or harmed. There is also the potential for turtles to be harmed by maintenance equipment park maintenance. Turtles have been collected and relocated from this location by members of the public, and there is indication that smaller turtles have been hit by grounds maintenance equipment in these areas.

Olympic Dr. Community Garden:
The community garden behind the arena on Olympic Dr. is located on the tablelands at the top of a south facing slope that leads down to West Pond. This area has been a well-known hotspot for nesting turtles for decades and has been the site of Snapping Turtle nest collection for contaminant monitoring (Judd, 1951; Bishop, 1985; Galbraith, 1988; Bishop et. al, 1991; Struger et al, 1993; Bishop et al, 1994; de Solla et al., 1998; Ashpole et al., 2003; de Solla et al., 2007; de Solla et al., 2008; Spence-Deirmair, 2009; Harrison, 2012). The location is ideally located, unlike most other nesting habitat at the back of Cootes Paradise Marsh, as turtles do not have to cross a road to reach the nesting location.

The community garden is largely located on RBG property. Nests in gardens are always at risk of being accidently disturbed or damaged by the gardening activities and it is expected that nests have been unintentionally damaged in the past. Since 2008 and for an unknown number of years prior, a section of this area, aside from nesting within the garden plots, was tilled once in spring then left fallow for turtles to nest by a community gardener. Recent changes in management practices of the community garden involved the erection of an eight-foot chain-link fence around a portion of the lands (date unknown), restricting turtle access, and temporarily terminating tilling in the part of the garden left fallow. The area outside the fence that had traditionally been tilled was rapidly invaded by dense waist high weed species, mainly cocklebur (*Xanthium strumarium)*. This represented the potential loss of a significant proportion of nesting habitat in what would be identified as the single best location for turtles of Cootes Paradise Marsh to nest. Thankfully in 2013 spring tilling was resumed.

A review of the community garden history indicates that RBG was not contacted regarding the construction of a fence on RBG property, and no contact has been made with the RBG regarding use of the area as a community garden for at least 15 years. No agreement has been located that indicates the RBG property will be used as a community garden, although a note was found in the RBG achieves dating from the mid-1970s to the RBG board that indicated a community garden would be of interest in this area.

Neighbouring Subdivisions:
Turtles are often reported nesting outside of RBG in subdivisions and other developed areas nearby. Most of these areas are not surveyed by RBG staff due to constraints on time and accessibility; however, they are important to include in an assessment of threats to turtle nesting because turtles do nest in these areas. For example, the only recent sighting of a Blanding's Turtle laying eggs was in the front garden of a recent housing development. Factors threatening these nests vary with individual landowner uses, but typically include issues associated with nesting near roads, in garden beds, and on mowed lawns. Landowners may be willing to accommodate turtle nests, as was the case with the recent Blanding's nest, but need to be provided with the information and support to do so.

* Two Blanding's have been observed basking in Cootes Paradise in 2012 during the same survey, indicating that the population is a minimum of 2.

** a minimum of 16 different turtles were observed in the marsh between 2007-2012. Additional sightings support the assumption that some untagged turtles remain in Hendrie Valley.

RBG Garden Areas:
Challenges associated with garden areas include, tilling and planting practices, garden supplies management (soil, mulch, compost) and turf maintenance activities.

Garden beds subject to tilling seasonally in order to maintain loose soils can damage nests. Nest depth varies by species and is associated with body size; typically nest depth ranges from 7cm to 20cm, with some exceptional cases where nests may be shallower or deeper (Ernst and Lovich, 2009). The timing of tilling is crucial to prevent damaging newly laid eggs or killing over-wintering hatchlings. The period in the spring when most hatchlings will have emerged, but turtles have not yet started laying eggs is brief and variable and is thought to be limited to mid-May. Compost, mulch, and soil piles left uncovered in the spring in the garden areas are often used as nesting sites by Snapping Turtles. The piles are typically used up through the course of the year, and nests are inadvertently disturbed or destroyed.

Turtles nesting in garden beds have a potential for the eggs to be damaged by root systems or shaded out by garden plants. Root systems of some plants have been known to penetrate and thereby destroy turtle eggs. Soils that have not yet been planted or near plants that have been pruned back may appear like good open sunny locations for turtles to nest, but as the season goes on may become a poor habitat choice with a low chance for nest success.

The Kippax Garden constructed in 2008 on the edge of Hendrie Valley is an example of turtle and garden interactions. Its construction presented opportunities for turtle nesting, with nests found in multiple beds post-construction. As the garden matures conditions have grown less suitable with plantings filling out, and the amount of the garden shaded by trees is increasing (Photographs 10a-c). This demonstrates how modifications to the landscape present temporary nesting sites, but do not provide long-term habitat.

Photograph 10 a-c. Kippax Garden demonstrates how changes from pre-construction (a) to Grand Opening (b) to post-construction (c) of garden areas can create temporary nesting habitat, but do not provide long-term habitat.

Channel alteration of Spencer Creek: Creation of the Desjardins Canal

The natural connection of Hendrie Valley and Cootes Paradise has been altered by the construction of the Desjardins Canal, CN Rail, Highway 403, Old Guelph Rd. and York Rd. Bridge (Figure 1). Hydrological connection still exists between these two major watersheds, but it requires turtles to travel through deep, open waters, with little vegetation or woody debris for cover, and exposure to the wind and water currents of Hamilton Harbour.

The creation of the new outflow connection, which is wider and deeper than the original outflow, has also had the effect of directly connection Cootes Paradise Marsh to the Lake Ontario water cycle. This changed the water level regime of one of relative stability and driven by the inflowing rivers waters, to one where much of the marsh is subject to the large fluctuations of Lake Ontario. The change has dramatically changed the nature of the wetland, reducing its ability to host resident species such as turtles while increasing its support of migratory species like fish and birds.

Water level Regulation

Water level cycles are fundamental to creating the wetland plant community type and distribution in a coastal wetland. Since the construction of the St Lawrence Seaway and Moses Saunders Dam in 1958, most of RBG wetland water levels are controlled by the Lake Ontario Regulation Plan (1958DD). This plan controls the outflow of Lake Ontario from the upper St. Lawrence River at Cornwall. Prior to regulation Lake Ontario fluctuated about 2.1 m over 110 years. Since 1958 it has fluctuated about 1.9 m, with the regulation plan removing extreme high and low water levels (Theÿsmeÿer, 2003). This has greatly reduced the extent of emergent vegetation by removing the regenerative lower water levels, and reduced the area were dense water lily habitats would have existed by increasing the annual fall water level declines. It has also reduced the amount of meadow marsh area by eliminating the extreme high-water levels that formerly flooded out encroaching trees and shrubs. This has the effect of reducing habitat for multiple turtle species, although it may have increased habitat for Northern Map Turtle. The greater fall decline of water levels also has the effect of reducing the area regularly available for turtle hibernation. Given the large overall area of the wetlands this effect is likely not significant to the turtles.

A joint study team under the International Joint Commission is currently reviewing Plan 1958DD with the intention of updating the plan to reflect the past 50 years of learning about the effect of regulation on the St. Lawrence/Lake Ontario system. RBG has made regular submissions to this process and hosted a number of open houses. Plan 2014 is currently in the final reviews for implementation, and along with many other improvements will improve coastal wetland health by more closely following natural cycles.

Invasive Emergent Plants

Two non-native species of emergent plants have been identified as problem species at RBG: Reed Manna Grass (*Glyceria maxima*) and Common Reed (*Phragmites australis*) (Reddick, 2012; Epp, 2012, Daw, 2011). They have been documented at RBG as the dominant species in many of the meadow marsh areas and continue to colonize into new areas. Manna Grass dominated systems currently cover over 30 ha of Cootes Paradise Marsh, while Common Reed covers 2.5 ha. (Daw, 2011)

A study of the impacts of Common Reed on turtle nest success in Long Point found it to be a threat through its rapid invasion of sites (Bolton and Brooks, 2010). Turtles at the northern extent of their range rely on open sunny soils to maintain sufficient temperatures for incubation. Common Reed can grow large enough to shade out a nest after it is laid within a single growing season. This poses a significant threat to turtle nesting sites at RBG.

No direct studies could be found on the impacts of European Manna Grass on turtles. The ability of the species to form dense monocultures, reducing plant and macro-invertebrate diversity has been established (Clarke et al., 2004). It is unknown how this might impact turtles of RBG. The dense growth of both plant species is also difficult to move through and is likely preventing use of the meadow marsh habitat by turtles in the areas where it dominates. Turtles have only been observed within these areas in the early spring before the annual regrowth of the plants occurs.

Common Carp

Common Carp is considered one of the main causes of suspended sediment and loss of vegetation in both the Cootes Paradise and Grindstone Marshes. Carp were actively stocked into Lake Ontario in the late 19th century (Bowen and Theÿsmeÿer, 1998). As of 1995 the densities of carp were measured at 800kg/ha in these wetlands. Wetland Impairment appears to begin at carp densities as low as 20kg/ha. Unfortunately, this prolific species had many unintended impacts on the marsh. They quickly became the most abundant fish in the marsh, killing vegetation and muddying waters through their rooting and spawning behaviours.

Through ongoing operation of the Cootes Paradise Fishway, several smaller barriers in Grindstone Marsh, and other active management methods, the number of Carp in the marshes has been significantly reduced and the amount of aquatic vegetation is gradually increasing (Court and Bowman, 2013). The control of the carp requires active management each year to enable marsh restoration. This threat is currently being held at bay, but without continued management Carp would again be a major threat to turtles in the area through habitat loss and degradation.

Carrolls Bay in the Grindstone Marsh system, where most of the Northern Map Turtles of RBG occur, is not able to be protected by use of a carp barrier structure. There are still many Carp occurring in Carrolls Bay, and this is believed to be negatively impacting Northern Map Turtles through loss of vegetation and suspended sediment. Indirect effects of Common Carp may also be occurring through impacts to freshwater mussels, a primary food of Northern Map Turtles, as a result of habitat degradation and loss, or competition for resources of a mussel's obligate host fish with carp.

* Two Blanding's have been observed basking in Cootes Paradise in 2012 during the same survey, indicating that the population is a minimum of 2.

** a minimum of 16 different turtles were observed in the marsh between 2007-2012. Additional sightings support the assumption that some untagged turtles remain in Hendrie Valley.

Pollution (nutrients, chemical)

Nutrient Enrichment

Nutrients reach RBG marshes from Combined Sewage Overflows (CSOs), runoff (urban, rural, storm drains, landfill, waste transfer station), and a Wastewater Treatment Plant (Theÿsmeÿer et al., 2009). As a result, high levels of nutrients are present in the main wetland areas and in localized areas of sediment (Reddick & Theÿsmeÿer, 2012; Bowman and Theÿsmeÿer, 2008). The wetlands are currently extremely enriched by very high levels of phosphorus to the point of being hypereutrophic. This has ecosystem level impacts fundamentally altering the habitat creating turbid algae dominated waters that shade out aquatic macrophytes. Aquatic vegetation is a key element of turtle habitat, providing shelter and food. Nutrient reduction is a main focus of the HHRAP.

Mesotrophic environments typical of wetlands have phosphorus levels between 5 and 30 ug/l (Wetzel, 1983). The threshold level between a macrophyte versus a phytoplankton (algae) dominated system is about 50 ug/l (Cootes Paradise Water Quality Group, 2012). In the late 70s and early 80s phosphorus levels in West Pond ranged from 500-800 ug/l, however conditions throughout Cootes Paradise have been gradually lowering with improvements in wastewater capture and treatment, and changes to agricultural land use practices (Cootes Paradise Water Quality Group, 2012). The mean summer total phosphorus concentration in Cootes Paradise Marsh as of 2011 was 100 ug/l, while in Grindstone Marsh it was 132 ug/l (Reddick & Theÿsmeÿer, 2012). Localized areas (the floodplain ponds) within both marshes have nutrient levels of mesotrophic environments, reflected by the associated plant communities.

Inflowing sources of phosphorus are as follows (Theÿsmeÿer et al., 2009; O'Connor, 2010; Cootes Paradise Water Quality Group, 2012):

- Spencer Creek Watershed 60 ug/l
- Chedoke Creek Watershed 180 ug/l
- Grindstone Creek Watershed 70 ug/l
- Dundas WWTP – 220 ug/l
- Combine Sewer Overflows - 2130ug/l
- Urban runoff 330ug/l

Grindstone Creek has recently had a long-standing Wastewater Treatment Plant Removed, and all CSOs around Cootes Paradise are now largely contained within overflow tanks before they reach the local waterways (Reddick & Theÿsmeÿer, 2012).

* Two Blanding's have been observed basking in Cootes Paradise in 2012 during the same survey, indicating that the population is a minimum of 2.

** a minimum of 16 different turtles were observed in the marsh between 2007-2012. Additional sightings support the assumption that some untagged turtles remain in Hendrie Valley.

Chemical Contaminants

Hamilton Harbour, a well-known industrial area, is also thought to be a source of contamination to the marsh ecosystems. This occurs through bioaccumulation by fish in the harbour that then seasonally migrate into the wetlands. Several compounds are found at very high levels in the sediments of the harbor, including, lead, copper, iron, zinc, PCBs and PAHs (HHRAP, 1992). The concentration of several heavy metals has been found at elevated levels in the sediment of outer Carrolls Bay and is above Lowest Effect Level (LEL) set out by the Ministry of the Environment (Bowman and Theÿsmeÿer, 2008; Harrison, 2011b). Levels of PCBs (polychlorinated biphenyls) just above the LEL were found in the sediment of Carrolls Bay as well as West Pond (Bowman and Theÿsmeÿer, 2008). Testing throughout most of the wetland areas indicates that most contaminants are not at levels of concern.

Many studies have been conducted to assess the status and impacts of environmental contaminants using Snapping Turtles (a Great Lakes health indicator species) from RBG in comparison as a contaminated site to other locations in Ontario. These studies have found the following results:

- contaminated sites have higher rates of abnormalities during egg development (Bishop et al., 1991);
- external morphology in Cootes Paradise differed from reference sites with lower degrees of contamination (de Solla, et al. 1998);
- contaminant concentrations in clutches from Cootes Paradise in 1999-2000 were comparable with those recorded in 1989 and 1990 but 200 to 800 times lower than concentrations reported in 1984 and 1988; mercury levels in Cootes Paradise turtles (50 ng/g) are significantly lower than the levels known to be toxic to birds (500 ng/g) (Ashpole et al. 2003);
- organochlorine pesticides in Snapping Turtle eggs were generally highest in the Hamilton Harbour Area of Concern (Cootes Paradise and Grindstone Creek) in comparison to other sites across the lower Great Lakes (de Solla, 2007); and
- hatching success was lower at Grindstone Creek relative to clutches from reference areas (de Solla et al., 2008);

Studies have shown turtles to accumulate PCBs, dieldrin, and other contaminants in tissues and eggs (Guillette and Crain, 1996; Bishop et al., 1994; Cobb and Wood, 1997). Turtles exposed to PCBs have been found to have sex reversal and abnormal gonads (Bergeron et al., 1994, Guillette et al., 1995). Studies on the effects of contaminants on turtles have demonstrated that developing turtle embryos can readily absorb pesticides through treated soil (de Solla and Martin, 2011); and that hatchlings exposed to PCBs maternally showed signs of chronic effects and lower survival rates over a 14 month period of time post-hatching (Kelly et al., 2008). Several of the contaminants of concern as described in the HHRAP have not been studied in the turtles.

Overall, there is ample evidence that Snapping Turtles, and by extension potentially all turtles, of RBG are contaminated. There is reason to believe that this could be affecting their ability to survive and reproduce. The degree that this threat is impacting them is unclear and is the subject of ongoing research by Environment Canada as part of the HHRAP. At the same time the above controlled studies completed by Environment Canada indicate that a substantial proportion of the eggs hatch when incubated (de Solla, 2013).

* Two Blanding's have been observed basking in Cootes Paradise in 2012 during the same survey, indicating that the population is a minimum of 2.

** a minimum of 16 different turtles were observed in the marsh between 2007-2012. Additional sightings support the assumption that some untagged turtles remain in Hendrie Valley.

Invasive upland plants covering nest sites

Upland areas with loose exposed soils are important for successful nesting of turtles. Several upland plant species invade these types of habitats and convert them to heavily vegetated and shaded areas unsuitable for nesting. Herbaceous plants are typically the first to take over open areas. Bindweeds (*Calystegia spp. and Convolvulus arvensis*) form dense mats in open areas along the shoreline and Dog Strangling Vine (*Cynanchum rossicum*) is spreading throughout many of RBG's natural areas.

Shrubs including European Buckthorn (*Rhamnus cathartica*) and non-native honeysuckles (mainly *Lonicera tatarica* and *L. mackii*) are exotic shrubs that frequently invade and dominate disturbed shoreline areas. Invasive trees such as Manitoba Maple (*Acer negundo*) and Tree of Heaven (*Ailanthus altissima*) also rapidly colonize and convert open areas into shaded areas.

With all of these invasive species, very few suitable areas for turtle nesting remain within the natural lands of RBG. This means that turtles are often left to travel into manicured areas to nest which presents their own threats such as roadkill, lawn mowing, and soil alteration.

Direct Mortality

Road Mortality

At the west end of the marsh the roads of Cootes Dr., Olympic Dr., and King St. E. have been constructed within the floodplain of Cootes Paradise Marsh separating the turtles from their upland nesting habitat. At the eastern end, Old Guelph Rd. passes through the marsh and the small creek connection leading to Mercers Glen. These sections of road have high rates of mortality (Figure 29). This has been documented in monitoring by RBG in 1999 and 2001, and Dundas Turtlewatch from 2009-2012 (Pomfret 2003; Dundas Turtlewatch 2009-2012, unpublished data). In the course of this monitoring a total of 217 turtles have been recorded dead. Mortalities are most concentrated at the water crossing points of Spencer Creek and the Desjardin Canal, although they have been found scattered up and down the roads adjacent to these water bodies.

In Grindstone Marsh, areas of concern for road mortality are Plains Rd. W., Spring Garden Rd. and the various subdivision roads surrounding Hendrie Valley. Northern Map Turtles have been found dead on the road during nesting season along Plains Rd. W. The only nest on record for a Blanding's Turtle from RBG occurred in a subdivision garden that was reached by crossing a roadway in the subdivision North of Hendrie Valley (Harrison, 2013).

Turtle crossing signs of various types have existed in the area of Cootes Dr. for many years. Currently they are located on both Cootes Dr. and Olympic Dr. It is thought that on Cootes Dr., the location of the majority of roadkill, most of the turtles are unintentionally hit due to the speed of the traffic and the inability to see the smaller turtles on the road.

* Two Blanding's have been observed basking in Cootes Paradise in 2012 during the same survey, indicating that the population is a minimum of 2.

** a minimum of 16 different turtles were observed in the marsh between 2007-2012. Additional sightings support the assumption that some untagged turtles remain in Hendrie Valley.

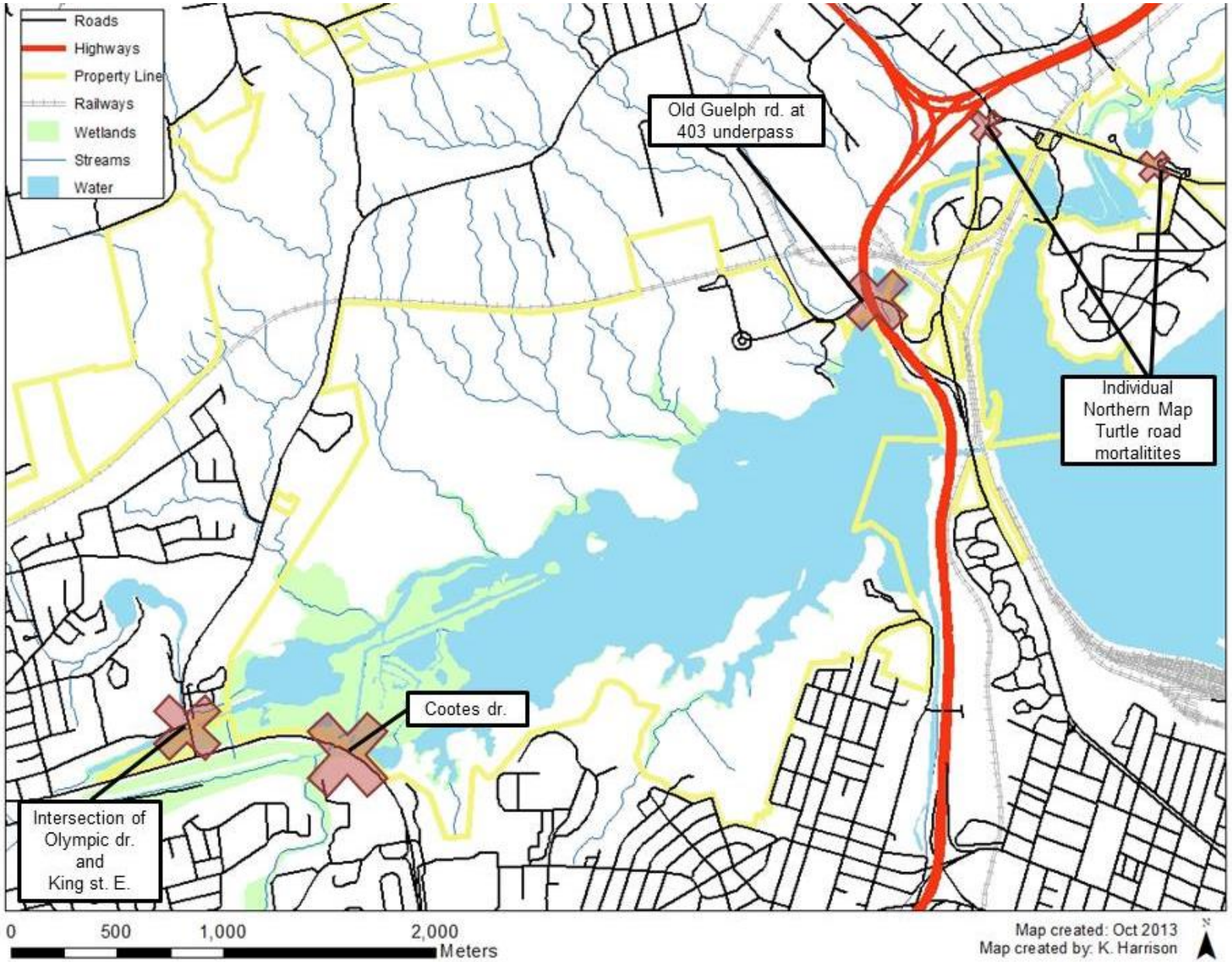


Figure 18. Road Mortality Hotspots as identified based on monitoring by RBG staff and Dundas Turtlewatch.

Figure 30. Dundas TurtleWatch volunteer road monitoring 2009-2012.

Illegal Collection and Hunting (pet trade, consumption)

There are several uses people have for turtles that pose a threat to the long-term sustainability of wild populations. Turtles are brought home or collected and sold as pets, removing them from struggling wild populations. This is especially detrimental to species at RBG with small populations (i.e. Blanding's Turtle) and those that are isolated (i.e. Northern Map Turtle). Reports have been made of native turtles being taken from the marsh near the Desjardin Canal (off of Olympic dr.) and Valley Inn. Eggs are also sometimes illegally collected. The Snapping Turtle is the species that is most readily observed nesting, and therefore the most likely eggs to be collected. While high mortality in eggs and hatchlings is natural, due to the confounding factor of heavy nest predation, egg collection is also considered an unsustainable practice.

Adult Snapping Turtles can legally be hunted for personal consumption under the Provincial Fish and Game Act with a fishing license. While this practice is permitted in Ontario it is prohibited by RBG by-law to kill or remove any wildlife from the property. There is evidence of significant bioaccumulation of contaminants in RBG turtles. Eating the contaminated turtles, even if they are legally hunted, could have negative health impacts. Consumption guidelines for turtles do not exist, but fish consumption guidelines for the Hamilton Harbour area list several species that are not recommended for consumption due to accumulated contaminant levels.

Persecution and fishing by-catch

Fear and misunderstanding of turtles, primarily Snapping Turtles, can lead to humans intentionally killing them. This is known to occur for RBG turtles along the roads where some drivers intentionally run over turtles. In addition, some people are concerned that their freedoms will be restricted by the presence of a Species at Risk on their property and illegally kill them rather than obey policies society has put in place.

Turtles are also sometimes caught by fisherman as by-catch. The process of properly removing a hook that has been swallowed by a turtle typically requires veterinary attention and sedation. Often rather than risk personal injury or take the time to seek veterinary attention, fisherman will simply cut the line and leave the turtle to its fate.

Ingesting or getting caught in litter

Garbage washed down from the watershed is found throughout the marshes including tires, bottles, construction debris, ropes. etc. In addition, litter is often dumped directly on site. Fishing line is regularly left at several locations including the Fishway, Princess Point, Valley Inn, and the Desjardins Canal (near Olympic dr.). Litter can be fatal or cause growth defects. Discarded fishing lines, hooks or other small pieces of litter can be ingested by turtles which can have fatal consequences. Multiple Snapping Turtles have been found dead after becoming caught in tires (de Solla, personal communication). Substantial litter is collected annually both by staff and volunteers. It is estimated that over 1,000 tires have been removed from the marshes over the past decade.

Garden and lawn maintenance activities

Turtles travelling to and from nesting sites overland may be unintentionally killed by lawn mowers. This has been reported by Dundas Turtlewatch on Cootes Dr. and by RBG Garden staff (Joanna Chapman, personal communication).

Motorized Boat Collisions

Several studies have shown shell damage/mortality, altered basking habits, and physiological indications of higher stress levels in turtles found in areas disturbed by boat traffic (Selman et al., 2013; Bulté et al., 2009; Peterman and Ryan, 2009). Motorized boats are not permitted in RBG wetlands due to potential damage they may cause to habitat and biological life. Only RBG staff and individuals with research permits are able to use motorized boats in Cootes Paradise Marsh. It has no publicly accessible boat trailer launches and the Fishway eliminates power boat access from the harbour. In Cootes Paradise Marsh there is no recent evidence of turtles with propeller injuries. In contrast, in Carrolls Bay it is not uncommon to find turtles with damaged shells. Boaters from the harbour can easily access the area. Loss of most wetland vegetation and turbid water gives boaters the impression that the waters are deeper than they are (1m or less). To mitigate this in 2006 the RBG added a buoy system to mark the outer edge of the wetland and sign the area as “No motorized Boats allowed”. This has reduced but not completely stopped the use of motorized boats in the wetland.

Introduced Pathogens and Competition from Exotic Turtle Species

Red-eared sliders (*Trachemys scripta elegans*) are observed regularly in basking, trapping and nesting surveys at RBG. They currently represent a small proportion of the total turtle observations (1-2%; Figures 4-6). As a species from the pet trade, there is the risk of releases introducing pathogens (Verneau et al., 2011). Disease can become a secondary problem as a result of primary stressors, such as habitat degradation, invasive species, or pollution (Gibbons et al., 2000). Many of these stressors impact turtles of RBG, so it is reasonable to assume that problems with disease may arise. Little evidence of disease has been reported in turtles of RBG, but this has not been adequately monitored.

A second potential threat is displacement of our native species through competition. Red-eared Sliders reproduce successfully in the wild in Ontario (Gillingwater, personal communication). In Europe, they pose a threat to native European turtles through transfer of parasites, competition for basking sites, and aggressive feeding interactions (Verneau et al., 2011, Polo-Cavia et al., 2011, Polo-Cavia et al., 2012,). Studies of the European Pond Turtle observed weight loss and high mortality when living with Red-eared Sliders (Cadi and Joly, 2004).

In Missouri, a decrease in Northern Map Turtles coincided with an increase in Red-eared Sliders in a disturbed system (Pitt and Nickerson, 2012). This study did not attribute the decline to competition. They suggested that changes were a result of habitat alteration. A similar study in California observed Sliders concentrated near urban areas and relatively rare in most areas where large Western pond turtle *Emys marmorata* populations persist (Thomson et al., 2010).

In Washington (USA) Red-eared Sliders are considered a potential threat to the Pacific Pond Turtle *Clemmys armorata* (Brown et al., 1995, Williams, 1999; Somma et al., 2009); and in British Columbia a report suggests that Red-eared Sliders may be the cause of local extirpation of the native Western Painted Turtle *Chrysemys picta bellii* from Stanley Park (Worcester, 2010). In Ontario, Red-eared Sliders released into Grenadier Pond have established a local

* Two Blanding’s have been observed basking in Cootes Paradise in 2012 during the same survey, indicating that the population is a minimum of 2.

** a minimum of 16 different turtles were observed in the marsh between 2007-2012. Additional sightings support the assumption that some untagged turtles remain in Hendrie Valley.

population thought to compete directly with the native turtles (Dog Legislation Council of Canada 1998, in Bunnell, 2005).

In summary, it is unclear if Red-eared Sliders are a threat to native Ontario turtles through competition. There is reason to believe that they could become invasive, but there is no firm evidence that they are invasive in Ontario at this time. Other non-native species from the pet trade are also introduced into the marsh. They are unlikely to become established, but still could introduce foreign diseases into the marsh.

Impairment of reproductive success

Urban sponsored predators

Nest predation has been well-documented as a source of egg and hatchling mortality in turtles (COSEWIC, 2008). Depredation of Snapping Turtle nests resulting in 100% mortality has been observed at multiple locations in southern Ontario (Browne and Hecnar, 2007; Gillingwater and Brooks, 2001; Bowles et al., 2007). Parks and suburban areas in Ontario, similar to RBG and its surroundings, have been observed to have high raccoon populations (COSEWIC, 2008; Phillips and Murray, 2005; Rosatte, 2000). Pest management services have been seen dumping raccoons into the natural lands of RBG. In addition, visitors leave seed and other food for wildlife on a regular basis, which may be sustaining higher than normal raccoon populations.

In Point Pelee, the main factor limiting recruitment in turtle populations is thought to be heavy nest predation from dense raccoon populations (Browne and Hecnar, 2007). At RBG, raccoons are seen frequently, including regular observations of raccoons watching turtles' nest and waiting for the turtle to finish so that they can eat the eggs. This has resulted in a nest protection program to reduce depredation using temporary wire mesh covers. In 2010, despite efforts to protect turtle nests from predation, 71 predated nests were observed in a single year in the lands immediately surrounding Cootes Paradise and Grindstone Marsh (Harrison, 2011a). Other egg-eating predators, such as mink, skunks, opossums, and coyotes, occur at RBG but are observed relatively infrequently in comparison to raccoons and are not thought to pose a major threat to turtles through nest depredation.

Disturbance and harassment while nesting

On many occasions nesting turtles have been disturbed and even returned to the wetland prior to, and during nesting by the public or by their dogs. In some cases, these actions can be attributed to a lack of knowledge of turtle reproduction, where the individuals believe the turtle is lost, and do not realize that turtles' nest on land.

Accidental nest destruction during garden maintenance and other soil alterations

See infilling & development near wetlands: Loss of nest habitat & roads in movement corridors - RBG Garden Areas (pg. 52)

* Two Blanding's have been observed basking in Cootes Paradise in 2012 during the same survey, indicating that the population is a minimum of 2.

** a minimum of 16 different turtles were observed in the marsh between 2007-2012. Additional sightings support the assumption that some untagged turtles remain in Hendrie Valley.

Male biased sex ratio

Midland Painted and Northern Map Turtle populations both show strongly male biased sex ratios (3.45:1 and 1.79:1 respectively). In the case of Painted Turtles this is likely a result of females being killed by vehicles during nesting movements. Northern Map Turtles show a less skewed ratio and are less likely to travel across a road to get to their nesting sites. Northern Map Turtle adult females have been found more likely to be hit by motorized boats due to their stringer preference for open waters, and this may be the cause of the male-bias on their sex ratio (Bulté et al., 2009).

Bioaccumulation of contaminants

See Pollution: Chemical Contamination (pg. 56)

* Two Blanding's have been observed basking in Cootes Paradise in 2012 during the same survey, indicating that the population is a minimum of 2.

** a minimum of 16 different turtles were observed in the marsh between 2007-2012. Additional sightings support the assumption that some untagged turtles remain in Hendrie Valley.

Global climate change

It is important to note and try to prepare for the potential threat that climate change could impose, while acknowledging that actual effects are difficult to predict. In recent years a changing climate associated with heat waves, periods of prolonged drought, intense storms, extreme wind, flooding, and erosion has been observed in the Hamilton region (HCA, 2012).

Decrease in Habitat Stability

Turtles have limited dispersal abilities making them vulnerable to rapid habitat changes (Schneider and Root, 1998). Habitat fragmentation may pose a problem for species that require changes in their range to adapt to climate change (Ihlow et al., 2012). Water flows, levels and quality may all be affected.

If the Lake Ontario water level lowers or rises 1m from current levels it could drastically reduce wetland habitat at RBG. Under the current Lake Ontario Regulation Plan minimum and maximum water levels are specified, so the dam at the Lake Ontario outflow would likely be used to mitigate any water level changes. Habitat beyond RBG is developed into urban areas, public access routes, roads, marinas and Port of Hamilton activities. This leaves few areas for turtles to move to if current habitat is flooded by increased water level. Habitat would likely be reduced to upper Grindstone Marsh and the various creek inlets to Cootes Paradise Marsh. If water levels decrease, habitat would likely be reduced to the eastern part of outer Carrolls Bay.

Extreme drought could dry up groundwater discharges. Some turtles choose to hibernate in habitat near creeks that flow all winter. Groundwater discharges are often the source of these creeks. If they were to dry up it could reduce hibernation sites. If drought conditions become more prevalent, then climate change could concentrate water pollution. In the last 20 years water quality was significantly poorer during drought years (Reddick and Theÿsmeÿer, 2012).

Extreme floods impair water quality through upstream erosion and damage of infrastructure contaminating inflowing waters to the wetlands. Extreme floods would overtop carp exclusion infrastructure reversing wetland habitat recovery.

Potential to Affect Temperature-dependent Sex Determination and Seasonal Activities

Other effects that have been predicted may not necessarily be negative including enhanced juvenile growth rates, earlier ages at maturity, and shifts in functional sex ratios (Frazer et al., 1993). RBG is located in the northern portion of most of its native turtles' ranges. Climate change would almost certainly affect the phenology of nesting and other behaviours. For example, the date of the start of egg laying in Snapping Turtles, and likely other turtles occurring in temperate areas, can be predicted based on the accumulation of heat units in a lake (Obbard and Brooks, 1987). Warmer conditions may increase the duration of the active season and increase nest success to the benefit of turtles in Ontario.

* Two Blanding's have been observed basking in Cootes Paradise in 2012 during the same survey, indicating that the population is a minimum of 2.

** a minimum of 16 different turtles were observed in the marsh between 2007-2012. Additional sightings support the assumption that some untagged turtles remain in Hendrie Valley.

Potential to Favour Introduced Species

Climate change has the potential to improve conditions for species such as Red-eared Sliders, whose range is currently south of Ontario. This could be the factor that would allow them to go from being a minor non-invasive component of RBG's current turtle populations, to an invasive species posing a threat through competition to already stressed native turtle populations.

* Two Blanding's have been observed basking in Cootes Paradise in 2012 during the same survey, indicating that the population is a minimum of 2.

** a minimum of 16 different turtles were observed in the marsh between 2007-2012. Additional sightings support the assumption that some untagged turtles remain in Hendrie Valley.

Population Demographics - Isolation and Small Populations

Widespread species (Snapping and Midland Painted Turtles)
Based on range maps (Figures 7 and 15), Midland Painted and Snapping Turtles of RBG likely are not isolated populations. They have been recorded recently (i.e. since 1993) in six of the eight 10x10 km grid squares adjacent to RBG (Ontario Nature, 2013).

It has been found that in Ontario the Snapping Turtle has a similar genetic population size to the Spotted Turtle *Clemmys guttata*, a species whose population is much less abundant and much more fragmented across the same area (Davy, 2013). This is an indication that the Snapping Turtle may be more vulnerable to the genetic impacts of inbred populations than is suggested by its abundance, movements through environments, and ability to reproduce. The paper also finds a reproductive separation between Snapping Turtles in the Golden Horseshoe and those of the rest of Ontario. This warrants further investigation in the scientific community to better understand the threat of isolation to this species.

Abundant but Isolated species (Northern Map Turtle)
The range of Northern Map Turtles at RBG spans two 10x10 grid squares. It is divided into two separate areas: Cootes Paradise and Carrolls Bay. There is evidence of some movement of individuals between the two, but it is unknown to what degree these areas are genetically separated both historically and at present. Changes in the landscape would suggest a decrease in connectivity, but whether or not it is substantial enough to threaten the genetic integrity of the population is unknown.

The nearest documented Map turtles outside of RBG are roughly 20km to the Southwest (Figure 11). Based on the Ontario Reptile and Amphibian Atlas there are no records of connection presently or historically from this area to RBG Map turtles. Northern Map turtles are typically found in large bodies of water and do not usually move far from water, supporting the assumption that there was no overland connection between these groups of turtles. Barriers that isolate RBG Map turtles from those to the southwest are therefore not considered a threat to this species' population at RBG based on current information. To the east, historical records on the northern shore of Lake Ontario suggest connection to the area at the mouth of the Credit River. There has been extensive development resulting in wetland habitat loss and degradation along this shoreline and it appears that these populations are not presently connected (Figure 11). In the absence of habitat restoration that would reconnect these two areas or research providing evidence of individuals travelling between them, RBG's Northern Map Turtles should be considered as an isolated population.

The combined population estimate of Northern Map Turtles at RBG is 350 individuals (pg. 25). No genetic studies have been conducted on these individuals to determine the effective population size (i.e. the size of a population meeting the requirements of an 'ideal' population that would behave like the population in question). This information is needed to evaluate the genetic threats of isolation to the population and its long-term stability.

In the wild effective population size averages 11% of the census population size (Frankham, 1996); however, this ratio is not species specific and has a large degree of error associated with

* Two Blanding's have been observed basking in Cootes Paradise in 2012 during the same survey, indicating that the population is a minimum of 2.

** a minimum of 16 different turtles were observed in the marsh between 2007-2012. Additional sightings support the assumption that some untagged turtles remain in Hendrie Valley.

it. By applying this to our estimate of the RBG Map Turtle population, the effective population size would be 39. In Davy's study of conservation genetics of three freshwater turtles (Spotted, Snapping, and Blanding's Turtles) in Ontario, effective population sizes ranged from 22 to 63 (2013). Traditional Conservation Genetics principles estimate that an effective population size of 50 or greater is required to avoid negative impacts from inbreeding in the short term (Franklin, 1980). By the same standards, an effective population of 500 is needed for long-term maintenance of genetic diversity. Based on this information, despite their apparent abundance at RBG, the Northern Map Turtle may face genetic problems if effective population size is too low.

It should be noted that long lifespans, over-lapping generations and promiscuous mating systems violate some of the assumptions of these theories. One or more of these factors may be relevant to Northern Map turtles and this should be kept in mind. The 50:500 rule can be used at present as the best available guideline based on current information available. Future research will likely improve our knowledge of this species and should be used to re-evaluate the need for genetic management of the species.

Rare Isolated Species (Blanding's Turtle)
In Blanding's Turtles the potential for loss of genetic diversity in small isolated populations through drift and inbreeding is a recognized concern (Congdon and Keinath, 2006). In the recent assessment of Blanding's Turtle conservation genetics in Ontario, it was found that there is evidence of a genetic barrier between Blanding's in Lake Erie, the Golden Horseshoe, and Southern Lake Huron, and those north of Lake Ontario (i.e. from Kincardin north; Davy, 2013).

The population of Blanding's at RBG shows no recent records of connections to other populations (Figure 21). Prior to 1993 evidence of connections to the East and West did exist. The nearest extant population to the East following historical records is approximately 40km away along the Southern shore of Lake Ontario (Figure 21). Blanding's from the North shore of Lake Ontario in the Toronto area do not show historical connection to RBG; however, due to the great distances Blanding's turtles are known to move (up to 6.8 km; Joyal et al., 2001), it is possible that they were connected at some point.

To the West a much closer present day population can be found along the Grand River roughly 20km away. The historical records connect through a route that heads North-east, rather than directly East. This likely follows the course of Spencer Creek up a number of small streams that drain from the Galt Moraine into Beverly Swamp (Chapman and Putnam, 1984). It is also reasonably possible that a second connection may have existed along Ancaster Creek then following a series of slough ponds to the Lower Grand.

The loss of these connections to other populations and the low population at RBG could pose a significant long-term threat to Blanding's of RBG. This could be amplified by the long lifespan of Blanding's which makes it possible, if there are no mechanisms preventing breeding with offspring, for turtles to inbreed across one or even two generations (Congdon and Keinath, 2006).

* Two Blanding's have been observed basking in Cootes Paradise in 2012 during the same survey, indicating that the population is a minimum of 2.

** a minimum of 16 different turtles were observed in the marsh between 2007-2012. Additional sightings support the assumption that some untagged turtles remain in Hendrie Valley.

Despite the long-term threat posed by genetic isolation, priority should go first to more immediate threats. A recent study states that based on an analysis of the genetics of Blanding's in Ontario there is no need for recovery plans to consider genetic management measures at this time (Davies, 2013). Efforts should instead be used to mitigate high adult mortality and low recruitment.

* Two Blanding's have been observed basking in Cootes Paradise in 2012 during the same survey, indicating that the population is a minimum of 2.

** a minimum of 16 different turtles were observed in the marsh between 2007-2012. Additional sightings support the assumption that some untagged turtles remain in Hendrie Valley.

Legal Protections

Several legal protections are in place for turtles of Ontario. Blanding's, Eastern Musk, Eastern Spiny Softshell, and Wood Turtle are listed both provincially and federally as Threatened (Schedule 1). This affords them protection under the federal Species at Risk Act (SARA) and provincial Endangered Species Act (ESA). Snapping and Northern Map Turtle are listed on these acts as Special Concern (SARA – Schedule 1).

The global trade of all Map Turtles (*Graptemys* spp.) is regulated under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES, 2012).

The Provincial Policy Statement protects the habitat of Endangered and Threatened species from development or site alteration and also protects significant wildlife habitat.

Protection under the Fish and Wildlife Act includes all native Ontario turtles, excluding Common Snapping Turtle, in the list of Specially Protected Wildlife. The Act prohibits the hunting and trapping of these species. It also restricts the amount of Common Snapping Turtle harvest, and the methods by which it can be trapped.

RBG has a written by-law (By-law No. 10-4) protecting the wildlife of RBG property. This by-law states that it is "unlawful to feed, disturb, molest, wound, kill, attempt to kill, or in any other way interfere with any bird, fish, or other animal, vertebrate or invertebrate, whether kept in captivity or in a state of nature" (Section 5[i]). The by-law also restricts introduction of species declaring it "unlawful to lead or let loose on Gardens properties any other animal, vertebrate or invertebrate, domestic or wild, without permission of the Board."

* Two Blanding's have been observed basking in Cootes Paradise in 2012 during the same survey, indicating that the population is a minimum of 2.

** a minimum of 16 different turtles were observed in the marsh between 2007-2012. Additional sightings support the assumption that some untagged turtles remain in Hendrie Valley.

If you see someone at RBG poaching turtles, or violating natural resource laws in any other way please contact the Ontario Ministry of Natural Resources (see below). In addition, RBG staff would like to be notified of any reports. Call RBG @ 905-527-1158.

Excerpt from http://www.mnr.gov.on.ca/en/Business/Enforcement

All Ontarians can play a part in protecting our natural resources from waste, abuse and depletion. If you are witness to a resource violation within Ontario, please call the Ministry of Natural Resources TIPS line at:

1-877-TIPS-MNR (847-7667)

In order to investigate an occurrence, it will assist an officer to know the following information:

- Nature of violation (see list in right column)
- Vehicle information
- Location of violation (address, county, township, municipality, lot, concession)
- Particulars of violation, other relevant information

* Two Blanding's have been observed basking in Cootes Paradise in 2012 during the same survey, indicating that the population is a minimum of 2.

** a minimum of 16 different turtles were observed in the marsh between 2007-2012. Additional sightings support the assumption that some untagged turtles remain in Hendrie Valley.

Current Recovery Initiatives

Several projects related to protecting and recovering turtles and their habitats have been completed or are currently underway. These projects are briefly summarized below.

Marsh Restoration

Project Paradise is a long-term restoration project led by Royal Botanical Gardens with the goal of returning all the marsh areas of RBG to healthy functional ecosystems (Court and Bowman, 2013). It was initiated in 1994 and is integrated with the Hamilton harbour Remedial Action Plan. This on-going initiative is instrumental to maintaining and improving turtle habitat at RBG. It focuses on restoring vegetation in the marsh by removing the stressors of habitat destruction by Common Carp and excessive herbivory by an unbalanced population of Canada Geese. It works with partners to correct underlying problems of inflowing water pollution and water level regulation. Removal of stressors is intended to allow natural marsh regeneration.

The Hamilton Harbour Remedial Action Plan (RAP), initiated in 1985, aims to “bring about sustainable natural ecosystems in Hamilton Harbour and its entire watershed, and to improve the potential for more extensive recreational uses while maintaining the Harbour’s and the watershed’s essential economic function” (HHRAP, 1992). The HHRAP is the most important Great Lakes initiative of the federal and provincial governments affecting turtle habitat in this region. The most important dimension of the HHRAP is the recovery of water quality and removal of contaminants particularly in the harbour itself. This assists wetland habitat recovery by requiring improvements to inflowing water. Currently poor water quality conditions annually create anoxic waters in Hamilton Harbour. This favours Common Carp, a species tolerant of anoxic conditions, over many more sensitive native species. Wetland habitat while still impaired has greatly improved as of 2013.

Road Mortality Mitigation

Monitoring programs have been undertaken in the western end of Cootes Paradise to understand the migration patterns and amount of roadkill occurring. Over two years in 1999 and 2001, 105 roadkill turtles were found along Cootes Dr. including a Blanding’s Turtle (Pomfret, 2003). The majority of the turtles found were located close to President’s Pond. In an attempt to reduce roadkill, a temporary roadside barrier (silt fence) has been trialed from 2011-2013 on this section. It runs between Spencer Creek Bridge and McMaster University, directing turtles under the Spencer Creek Bridge. Along Cootes Dr. where the temporary barrier was installed no turtles were killed along the main section although two turtles were killed at the ends, and an additional turtle was rescued before being hit. This prompted the southward extension of the temporary fence which resolved the issues.

Dundas Turtlewatch is a group of dedicated volunteers in the Dundas area founded by Joanna Chapman. Since 2008, these individuals have participated in monitoring and protecting turtles along Cootes Dr., Olympic Dr., and King St. E. Their monitoring has reduced mortality, identified hot spots, and been used to evaluate the effectiveness of the temporary barrier. The group has made recommendations to improving signage, lower speed limits, alter roadside mowing

* Two Blanding’s have been observed basking in Cootes Paradise in 2012 during the same survey, indicating that the population is a minimum of 2.

** a minimum of 16 different turtles were observed in the marsh between 2007-2012. Additional sightings support the assumption that some untagged turtles remain in Hendrie Valley.

patterns, create nest habitat in the area behind the hydro yard, and expand and improve on the roadside guide fence (Dundas Turtlewatch, meeting Aug. 2013).

Valley Inn Rd. on the west side Grindstone Marsh was recently permanently closed to public vehicle traffic. This road is located adjacent to important Northern Map Turtle habitat and its closure represents a significant contribution to habitat protection in the area of Carrolls Bay.

Special Protection Areas

A number of Special Protection Areas have been created at RBG where public access has been removed to address issues caused by disturbance, habitat degradation and poaching. This represents an area of roughly 20% of RBG property with no public access. Two of these areas, South Pasture Swamp (Grindstone Marsh) and Spencer Creek Floodplain (Cootes Paradise Marsh) are central areas of residence for Blanding's Turtles. While public access to these areas has greatly reduced, evidence of trespassers continues to be regularly encountered at all sites.

Litter cleanups

RBG and volunteers annually remove accumulated litter from the shores of Cootes Paradise and Grindstone Marshes, with activities focused in September and October as the water declines and fish and wildlife migrate out of the area. A public event is integrated into the Great Canadian Shoreline Cleanup event occurring each September and headed up by the Vancouver Aquarium. Extra attention was given to Grindstone Marsh in the fall of 2007 and 2008 with several large disposal bins of historically deposited trash removed. In Cootes Paradise during the low water period of fall 2012 staff and volunteers made a focused effort to remove every tire and piece of litter exposed by the low water, with 95% of the material removed, including about 250 tires. In response to the issue of litter in Cootes, the Stewards of Cootes Watershed recently formed, whose focus is to intercept garbage in the floodplain and creeks before it enters Cootes Paradise Marsh. To date they have removed 30,000lbs of garbage from the watershed of Cootes Paradise Marsh.

Carrolls Bay Marsh Buoy System

As a result of loss of the wetland vegetation and increasing power boat traffic on the improving waters of Hamilton Harbour, the RBG installed a buoy system at the outer edge of Carrolls Bay Marsh 2006. The buoys state "No motorized boats beyond this Point – Carrolls Bay Nature Sanctuary". The loss of vegetation and turbid waters of the marsh gave the false impression that the waters were deeper. Water depths fluctuate in the area as per the Lake Ontario water cycle and range from 1.2m to as low as fully exposed mudflat. With the installation in 2006 visits were made by RBG staff to the local marinas and boating clubs and presentation were made regarding the purpose of the buoys. To maintain the system, the buoys are removed and installed annually to prevent them from being lost by the shifting ice of the harbour. Subsequently, almost no motorized boats have been observed within the designated zone.

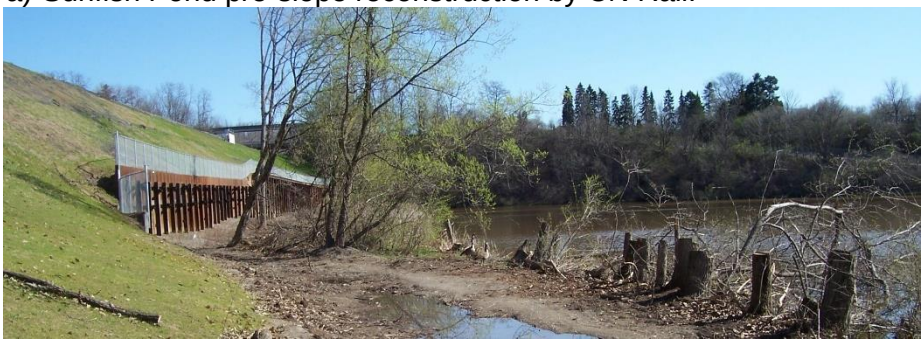
* Two Blanding's have been observed basking in Cootes Paradise in 2012 during the same survey, indicating that the population is a minimum of 2.

** a minimum of 16 different turtles were observed in the marsh between 2007-2012. Additional sightings support the assumption that some untagged turtles remain in Hendrie Valley.

Improvement of Reproductive Success

Soil amendments were undertaken at the edge of the Laking Garden in the early 2000s to create nesting habitat (Pomfret, 2003). Based on observations from 2008 to present, very few turtles use these areas. The substrates consist of gravel screenings and are located along the forest edge where they have become partially shaded. Turtles currently choose finer soils with more sun exposure found in nearby tilled garden beds and fertilizer/soil piles.

a) Sunfish Pond pre-slope reconstruction by CN Rail.



b) Sunfish Pond immediately after slope reconstruction.

c) Sunfish Pond slope after shoreline stabilization plantings filled out.

* Two Blanding's have been observed basking in Cootes Paradise in 2012 during the same survey, indicating that the population is a minimum of 2.

** a minimum of 16 different turtles were observed in the marsh between 2007-2012. Additional sightings support the assumption that some untagged turtles remain in Hendrie Valley.

d) Portion of lower Sunfish Pond slope where weeding is used to maintain nesting habitat.

Photograph 11 a-d. Sunfish Pond slope stabilization by CN Rail and turtle nesting area.

The slope along Sunfish Pond was altered due to CN Rail repairs in 2007. This project left a narrow portion of exposed soils abutting a steel reinforcing wall. It was found upon completion of the works that Snapping and Northern Map Turtles were using this area to nest. The majority of this stretch of shoreline had to be planted to prevent the sediment from eroding away, but a small portion was left open for turtles to nest in. Active management is used to maintain the area by weeding and removing woody material as needed throughout the spring and summer. Evidence of nesting has been observed in this area annually since 2008. Due to difficulties with accessing the site to protect nests, egg predation has been an on-going issue.

In 2012 invasive shrubs were removed between the wetland and the road along Cootes Dr. and the western shoreline of Carrolls Bay. The Carrolls Bay site was once used as a road but has since regenerate with mainly non-native shrubs and small trees. Based on a radio-telemetry study that showed a Northern Map Turtle moved through this shrubby area and climbed up to the CN rail beds beyond it to nest (Harrison, 2011a). The removal of shrubs left loosened exposed soils. Nesting has not yet been observed in either of these locations. Improvements including soil amendments and adjusting the grade of the slope are recommended.

Since 2008 wire mesh and ground staples have been used as covers to protect nests in the spring in hundreds of locations. Covers are removed in early August prior to hatchlings beginning to emerge. Up until 2012 nests were not excavated to confirm the presence of eggs and many false nests were likely recorded and protected, taking the ‘err on the side of caution’ approach to covering the ‘nests’. This makes it difficult to assess the effectiveness of nest protection prior to 2012. In 2013, 10 nests were excavated to confirm eggs and then covered. None of these nests were predated prior to the removal of the covers in early August.

In 2013, recognizing that some nests could not be properly protected in-situ, RBG purchased an incubator and successfully incubated 135 hatchlings (134 Snapping and 1 Painted Turtle) from nests that were otherwise considered to have a very low chance of success. This included nests
* Two Blanding’s have been observed basking in Cootes Paradise in 2012 during the same survey, indicating that the population is a minimum of 2.

** a minimum of 16 different turtles were observed in the marsh between 2007-2012. Additional sightings support the assumption that some untagged turtles remain in Hendrie Valley.

from garden beds that were being turned, a roadside, an access road, a high-use compacted trail, and a roadkill turtle. This project was considered a success and will expand into the future to accommodate as many nests as possible from RBG that are found in poor locations.

Using radio telemetry, a female Blanding's Turtle was tracked to its nesting site in 2012 in a sub-division. Its nest was protected, eight eggs hatched successfully, and the hatchlings were taken to their maternal pond. This nest would almost certainly have been predated if not for the turtle tracking and nest protection.

* Two Blanding's have been observed basking in Cootes Paradise in 2012 during the same survey, indicating that the population is a minimum of 2.

** a minimum of 16 different turtles were observed in the marsh between 2007-2012. Additional sightings support the assumption that some untagged turtles remain in Hendrie Valley.

Turtle Recovery Open House Information Summary

An open house was held on January 10th, 2013 to gather input on RBG's turtle related work. Participants identified the top three threats as roads, nest predation, and lack of nesting habitat. There was a tie for fourth between invasive species and loss of vegetation (Figure 31). A summary of the comments provided on each of the top five threats is provided below.

Road Mortality – The speed limit should be lowered and enforced. Seasonal closure of high mortality roads should be considered. Barriers/culverts should be used to prevent turtles from crossing major roads. The guide fence on Cootes Dr. should be extended and made permanent. Improved lighting and signs (flashing lights) would improve the ability for vehicles to stop. Education of the public should increase by engaging students and using media to highlight road crossing seasons. A nest webcam could be used to inspire turtle stewardship. Information should be provided about what to do if you hit a turtle with your car.

Nest Depredation (i.e. raccoons) - Green bin locks could be used to reduce the unnatural food sources supporting excessive numbers of urban predators. Chemical deterrents could be investigated. Egg incubation should be used to increase recruitment. Modifications could be considered for nest covers. Volunteers should be recruited for nest protection surveys. Raccoon population studies could be conducted to evaluate the problem.

Lack of Nesting Habitat - Create nesting habitat between turtle populations and roads, so they will nest before they hit the roads. Protect current nesting habitat and keep nesting turtles on protected RBG grounds. Enhance nest habitat around Laking Garden to deter turtles from laying nests in garden beds where tilling threatens nest success.

Loss of vegetation/Invasive Species – Continue carp management. Remove invasive shrubs.

Several Suggestions were given of organizations for partnerships, support, and funding: McMaster University/Hospital, Niagara College, Dundas Turtlewatch, Ontario Turtle Tally (Toronto Zoo), Hamilton Conservation Authority, media (The Spectator, CHCH, radio), City of Hamilton, Hamilton Police (speed enforcement), Canada Centre for Inland Waters, Water Quality Network (University of Waterloo), Science Horizons, Nature Conservancy Canada, Ontario Road Ecology Working Group (Toronto Zoo/ROM), Adopt a Pond (Toronto Zoo), and Kawartha Turtle Trauma Center.

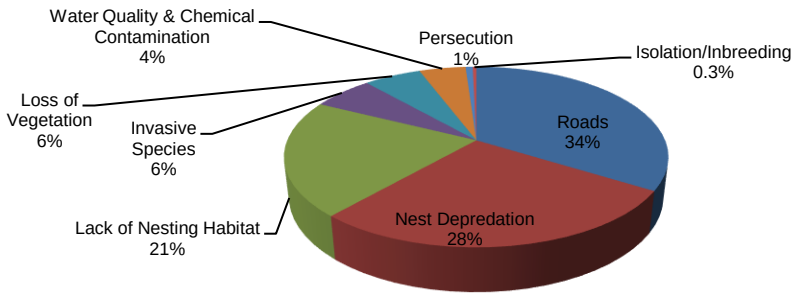


Figure 20. Ranks assigned to each threat by open house attendees. The top four threats to RBG turtles were ranked in order of importance. A point system was assigned with the top issue receiving 4 points, the 2nd receiving 3 points, and so on.

Research Needs

There are many potential threats that require further investigation in order to be understood. These include, but are not limited to the following topics:

Effects of environmental contaminants during hibernation - two known hibernation sites have a history of sewage pollution (Westdale Inlet and West Pond). Research is needed to assess hibernation tolerance of elevated ammonia levels in the sediment.

Northern Map Turtle Hibernation Sites - It is still unclear at this point where Northern Map Turtles are hibernating. Radio-telemetry has been used previously, but due to the frequency that the map turtles shed their scutes (and attached tags) over-wintering data is questionable.

Turtle movement between sanctuaries and outside RBG boundaries - Interference around the 403 and near West Pond/President's Pond/ Cootes Dr. has made it difficult to track the movements of turtles in these areas. How far turtles travel up Spencer Creek and the amount of connectivity through the Desjardins Canal is relatively unknown. Opportunities should be sought out to utilize advancements in technology to better understand habitat usage.

Population status and dynamics - Long-term population monitoring is needed to improve estimates and observe changes over time. Protocols need to be formalized for basking, nesting, and trapping surveys so data can be consistently compared across years and to outline a monitoring schedule. Ideally this would be based on federal or provincial standardize protocols. Population genetic studies and modeling should be used to determine population viability and carrying capacity for the purposes of defining target population sizes.

Health, accumulated contaminants, and genetic studies - Collection of blood samples during surveys, and incidental encounters would provide information about the health and other factors that might be threatening turtles. Information can also be obtained about the effective population size and relatedness to other populations through genetic analysis. This would require proper training and collaboration with institutions to analyze data. Dead turtles should also be submitted for autopsies, excluding when cause of death is obvious (i.e. roadkill). The Blanding's turtle is the priority species.

Effects of Pollutants - The fact that turtles of RBG are contaminated has been established, but the effects on reproduction and behaviour are in need of further research. Current studies are working to evaluate effects on eggs and hatchlings (de Solla, 2013). Further long-term studies are also needed to understand the extent of the problem.

Status of groundwater quality at hibernation sites - An assessment of contamination levels of groundwater discharging into Presidents Pond, Mac Landing, Westdale Inlet, South Pasture Swamp and Osprey Marsh should be undertaken to assess sources of pollution.

Blanding's Turtle Nest site identification – From 2008-2012 a single Blanding's Turtle from RBG has been observed nesting and two others have been observed on land during nesting season.
* Two Blanding's have been observed basking in Cootes Paradise in 2012 during the same survey, indicating that the population is a minimum of 2.

** a minimum of 16 different turtles were observed in the marsh between 2007-2012. Additional sightings support the assumption that some untagged turtles remain in Hendrie Valley.

Due to the small remaining population, to assist in survival and successful reproduction tracking nesting females is recommended. Establishing where these turtles' nests will require intensive monitoring during nesting season until the movements are sufficiently understood.

* Two Blanding's have been observed basking in Cootes Paradise in 2012 during the same survey, indicating that the population is a minimum of 2.

** a minimum of 16 different turtles were observed in the marsh between 2007-2012. Additional sightings support the assumption that some untagged turtles remain in Hendrie Valley.

Strategies to Address Threats (Action Plan)

In the executive summary, strategies are identified to reduce threats: improve habitat quality, reduce adult mortality, increase recruitment rates, educate the public, promote stewardship, improve data management, collaborate with outside organizations, manage non-native turtle species, and monitor change. These have been compiled into an action plan of activities with target completion dates and a map of habitat improvement areas (Table 5; Figure 32).

Table 5. Recommended Action Plan.

Category	Activity	Target Completion
Habitat Improvement	Maintain Sunfish Pond nesting area	Annual
	Increase/improve nesting habitat (invasive plant removal, soil amendments, etc.) Focal areas: Carrolls Bay western shoreline, Cootes Dr., the 'Lodge' on Plains Rd. W., and behind Hydro One on Olympic Dr.	Initiated by 2016, Maintenance on-going
	Permanent guide fence installed along Cootes Dr.	2015
	Develop and implement projects to address road mortality hotspots (Focal areas: Cootes Dr., intersection of Olympic and King St. E., Old Guelph Rd., Plains Rd. W., and Spring Garden Rd.) through permanent crossing structures, guide fences, reduced speed limits, signage, and/or road closures in identified areas of high turtle road mortality.	2020
	Project Paradise marsh restoration (including carp management, vegetation plantings and water quality monitoring)	Annual
	Restore nesting habitat in or adjacent to Spencer Creek Floodplain and South Pasture Swamp Special Protection Areas, near West Pond (Community Garden) and near Churchill Park	2015
	Lead and support volunteer litter clean-ups	Annual
	Undertake initiatives to eliminate monocultures of non-native emergent plants	2020
Monitoring & management	Monitor nesting and increase reproductive success using nest covers and incubation when necessary.	Annual
	Track female Blanding's to their nest sites	Annual (as needed)
	Dundas Turtlewatch volunteer road monitoring	Annual
	Population monitoring (Trapping)	5-year cycle
	Population monitoring (Basking)	Annual
	Submission of turtles that are deceased due to causes unknown for autopsies	Annual

* Two Blanding's have been observed basking in Cootes Paradise in 2012 during the same survey, indicating that the population is a minimum of 2.

** a minimum of 16 different turtles were observed in the marsh between 2007-2012. Additional sightings support the assumption that some untagged turtles remain in Hendrie Valley.

	Assess and reduce human related sources of food for raccoons at RBG	2015
Staff Training	Blood sample collection (Training and setting up protocols)	2015
	Genetic tissue sample collection (Training and setting up protocols)	2015

* Two Blanding's have been observed basking in Cootes Paradise in 2012 during the same survey, indicating that the population is a minimum of 2.

** a minimum of 16 different turtles were observed in the marsh between 2007-2012. Additional sightings support the assumption that some untagged turtles remain in Hendrie Valley.

Outreach & Education	Send out formal requests to institutions related to animal control and rehabilitation to not release in or around RBG lands	2015
	Meet with adjacent landowners and discuss potential projects to restore connectivity to other areas	2014
	Lead, participate in, and support garbage clean-ups	Annual
	Inform adjacent landowners about turtles and provide recommended approaches for what to do if they are found on your property	2014
	Meet with Olympic Dr. Community Garden owners and operators and discuss management strategies that support turtle nesting	2015
	Contact adjacent landowners in the Spencer Creek and King St. E. areas (HCA, McMaster, City of Hamilton, Hydro One) and inquire about opportunities to work together on reducing mortality, increasing nest success, and improving connectivity between habitats	2014
	Participate in annual Dundas Turtlewatch meetings, provide advice on monitoring start and stop dates, complete annual summaries of monitoring data, and where possible incubate eggs from roadkill tests and roadside nests.	Annual
	Provide a summary of turtle related research needs and potential projects to educational institutions who might be interested in partnering on projects	2015
	Provide input towards Lake Ontario and St. Lawrence River Regulation study team	As needed
	Contribute where possible to broader research community on studies of issues relevant to turtles including genetics, environmental contaminants, and climate change	As needed
	Encourage upstream water quality improvement initiatives as identified in the HHRAP	On-going
	Disseminate information about the negative impacts of turtle pet releases, options for unwanted pet turtles, and considerations before taking on a pet turtle	On-going
Policy	Develop institutional policies related to staff interactions with turtles and nests and integrated them into each department's operational practices	**2015**
	Restrict or prohibit fishing within RBG nature sanctuaries	Pending board approval
	Consider population augmentation and reintroductions once threats are mitigated	Pending other projects

* Two Blanding's have been observed basking in Cootes Paradise in 2012 during the same survey, indicating that the population is a minimum of 2.

** a minimum of 16 different turtles were observed in the marsh between 2007-2012. Additional sightings support the assumption that some untagged turtles remain in Hendrie Valley.

	Create a formal RBG response to inquiries about unwanted captive turtles, providing options other than release into the wild and disseminate the information to all staff involved in public communications.	2015

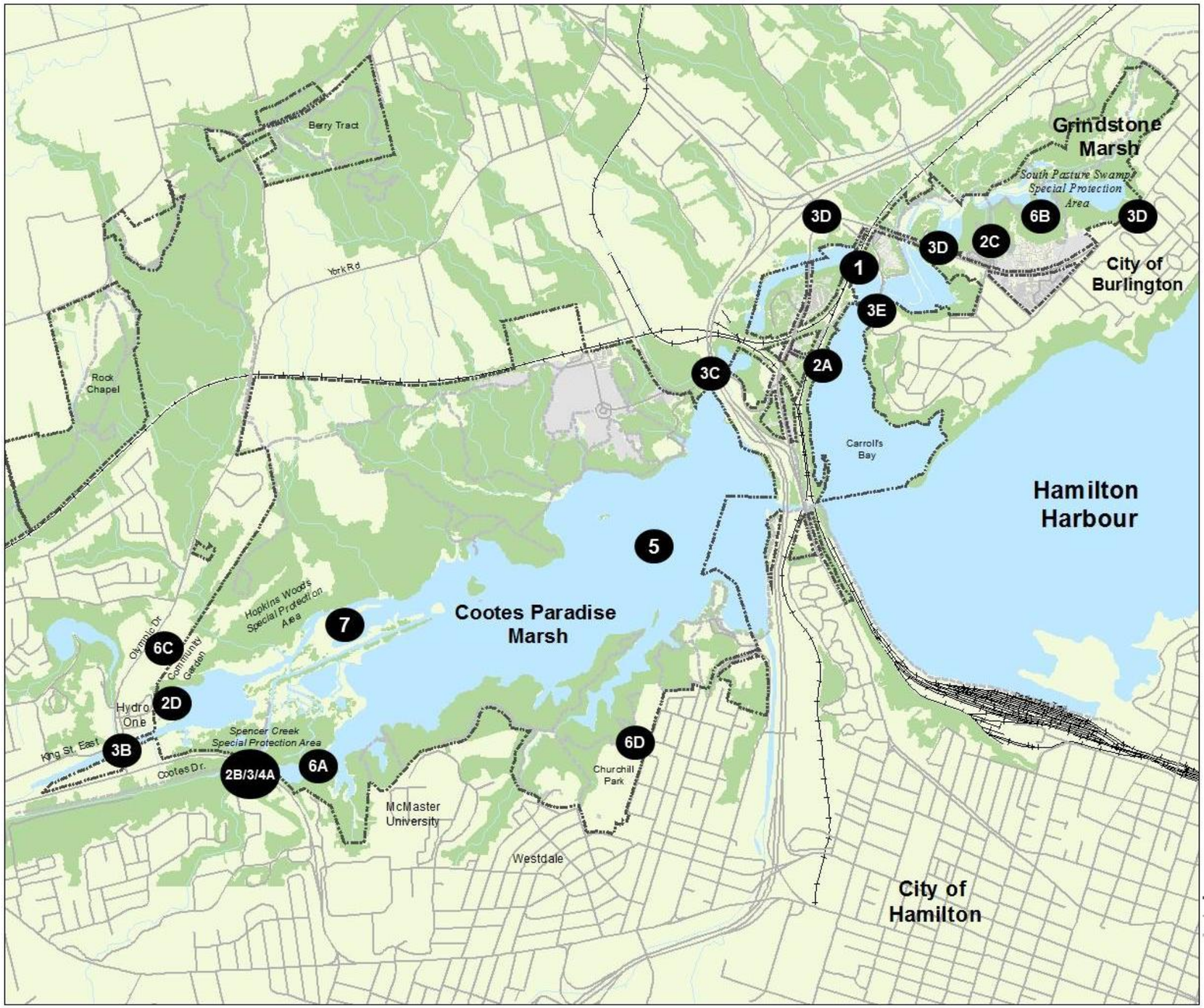
* Two Blanding's have been observed basking in Cootes Paradise in 2012 during the same survey, indicating that the population is a minimum of 2.

** a minimum of 16 different turtles were observed in the marsh between 2007-2012. Additional sightings support the assumption that some untagged turtles remain in Hendrie Valley.

Data Collection & Management	Improve the database for turtle monitoring and research at RBG	2015
	Add website record reporting abilities	2015
	Standardize turtle monitoring and marking protocols (Following provincial guidelines as they are provided)	2015
Enforcement	Solicit increased monitoring and enforcement for poaching and littering through the appropriate authorities	2014
	Undertake measures to ensure visitors are aware of by-laws and encourage them to report violations	2014

* Two Blanding's have been observed basking in Cootes Paradise in 2012 during the same survey, indicating that the population is a minimum of 2.

** a minimum of 16 different turtles were observed in the marsh between 2007-2012. Additional sightings support the assumption that some untagged turtles remain in Hendrie Valley.



1. Maintain Sunfish Pond nesting area.

2. Increase/improve nesting habitat (invasive plant removal, soil amendments, etc.)

   Focal areas:
   A. Carrolls Bay western shoreline,
   B. Cootes Dr.,
   C. the 'Lodge' on Plains Rd. W.,
   D. behind Hydro One on Olympic Dr.

3. Permanent guide fence installed along Cootes Dr.

4. Develop and implement projects to address road mortality hotspots through permanent crossing structures, guide fences, reduced speed limits, signage, and/or road closures in identified areas of high turtle road mortality.

   Focal areas:
   A. Cootes Dr.,
   B. intersection of Olympic and King St. E.,
   C. Old Guelph Rd.,
   D. Plains Rd. W. (multiple areas),
   E. Spring Garden Rd.

5. Project Paradise marsh restoration (including carp management, vegetation plantings and water quality monitoring).
   [all of Cootes Paradise and Grindstone Marsh]

6. Restore nesting habitat in or adjacent to:
   A. Spencer Creek Floodplain Special Protection Area
   B. South Pasture Swamp Special Protection Area
   C. West Pond (Community Garden)
   D. Churchill Park.

7. Lead and support volunteer litter clean-ups.
   [all of Cootes Paradise and Grindstone Marsh]

8. Undertake initiatives to eliminate monocultures of non-native emergent plants.
   [multiple areas in Cootes Paradise & Grindstone Marsh]

Figure 21. Habitat improvement areas listed in the Action Plan.

References

Ashpole, S.L., Bishop, C.A. and R.J. Brooks. 2003. Contaminant Residues in Snapping Turtle (*Chelydra s. serpentina*) Eggs from the Great Lakes–St. Lawrence River Basin (1999 to 2000). Arch. Environ. Contam. Toxicol. 47, 240–252

Bergeron, J.M., Crews, D. and J.A. McLachlan. 1994. PCBs as environmental estrogens: turtle sex determination as a biomarker of environmental contamination. Environ Health Perspect. 102 (9): 780–781

Bishop, C. 1985. Report on the reptile and amphibian populations at the Royal Botanical Gardens, Burlington, Ontario. Unpublished report.

Bishop, C.A., Brooks, R.J., Carey, J.H., Ng, P., Norstrom, R.J. and D.R. Lean. 1991. The case for a cause-effect linkage between environmental contamination and development in eggs of the common snapping turtle (*Chelydra s. serpentina*) from Ontario, Canada. Canadian Wildlife Service, Ontario Region, Canada. J Toxicol Environ Health. 33(4): 521-47.

Bishop, C.A., Brown, G.P., Brooks, R.J., Lean, D.R.S. and J. H. Carey. 1994. Organochlorine Contaminant Concentrations in Eggs and Their Relationship to Body Size, and Clutch Characteristics of the Female Common Snapping Turtle (*Chelydra serpentina serpentina*) in Lake Ontario, Canada. Arch. Environ. Contam. Toxicol. 27: 82-87

Bolton, R. M. and R. J. Brooks. 2010. Impact of the Seasonal Invasion of Phragmites australis (Common Reed) on Turtle Reproductive Success. Chelonian Conservation and Biology: December 2010, Vol. 9, No. 2, pp. 238-243.

Bowen, Kelly and Tys Theÿsmeÿer. 1998. Carp Elimination. Royal Botanical Gardens. Hamilton, Ontario, Canada. http://www.rbg.ca/files/pdf/exploreandlearn/naturallands/CarpElimination.pdf

Bowles, R.L., J. Laverty, and D. Featherstone. 2007. Minesing Wetlands Biological Inventory. Unpublished report to Nottawasaga Valley Conservation Authority, Utopia, Ontario.

Bowman, J.E., and T. Theÿsmeÿer. 2008. Supplementary Marsh Sediment Characterization; Carroll's Bay and West Pond Areas. RBG Report No. 2008-02. Royal Botanical Gardens. Hamilton, Ontario.

Brown, G.P., and R.J. Brooks. 1994. Characteristics of and fidelity to hibernacula in a northern population of snapping turtles, *Chelydra serpentina.* Copeia 1994: 222-226

Brown, H.A., Bury, R.B., Darda, D.M., Diller, L.V., Peterson, C.R. and R.M. Storm. 1995. Reptiles of Washington and Oregon. Seattle Audubon Society, Seattle. 176 pp.

Browne, C.L. and S.J. Hecnar. 2007. Species loss and shifting population structure of freshwater turtles despite habitat protection. Biological Conservation 138 pp. 421-429.

Bulté, G., Carrière, M.-A., and G. Blouin-Demers. 2009. Impact of recreational power boating on two populations of northern map turtles (*Graptemys geographica*).

Bunnell, C.G. 2005. Field Survey of red-Eared Sliders (*Trachemys scripta elegans*) In The Lower Fraser River Valley, British Columbia, In 2005. Featrured Article Wildlife Afield

Cadi, A. and P. Joly. 2004. Impact of the introduction of the red-eared slider (*Trachemys scripta elegans*) on survival rates of the European pond turtle (*Emys orbicularis*). Biodiversity & Conservation. 13(13). December 2511-2518.

Canadian Amphibian and Reptile Conservation Network (CARCNET). 2012. Conservation Concerns. http://www.carcnet.ca/english/reptiles/issues/rconserv.php. Accessed: Jan 16, 2014

Chapman, L.S. and D.F. Putnam 1984. The Physiography of Southern Ontario. Ontario Geological Survey, Special Volume 2, Ontario Ministry of Natural Resources. Toronto.

Clarke, A., Lake, P.S. and D. J. O'Dowd. 2004. Ecological impacts on aquatic macroinvertebrates following upland stream invasion by a ponded pasture grass (*Glyceria maxima*) in southern Australia Marine and Freshwater Research 55(7) 709–713

Cobb, G.P. and P.D. Wood. 1997. PCB concentrations in eggs and chorioallantoic membranes of loggerhead sea turtles (Caretta caretta) from Cape Romain National Wildlife Refuge. Chemosphere 34: 539-549

Congdon, J.D. and D.A. Keinath. 2006. Blanding's Turtle (*Emydoidea blandingii*): a technical conservation assessment. [Online]. USDA Forest Service, Rocky Mountain Region. Available: http://www.fs.fed.us/r2/projects/scp/assessments/blandingsturtle.pdf [9/30/2013].

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). 2012. Article XVI and Appendix III. http://www.cites.org. valid from 25 September 2012

Cootes Paradise Water Quality Group. 2012. Cootes Paradise Marsh: Water Quality Review and Phosphorus Analysis. Hamilton Harbour Remedial Action Plan (HHRAP).

COSEWIC 2002a. COSEWIC assessment and status report the stinkpot *Sternotherus odoratus*. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 18 pp.

COSEWIC 2002b. COSEWIC assessment and update status report on the spiny softshell turtle *Apalone spinifera* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 17 pp.

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

COSEWIC 2006. COSEWIC assessment and status report on the Western Painted Turtle *Chrysemys picta bellii* (Pacific Coast population, Intermountain-Rocky Mountain population and Prairie/Western Boreal - Canadian Shield population) in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 40 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

COSEWIC. 2007. COSEWIC assessment and update status report on the Wood Turtle *Glyptemys insculpta* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 42 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

COSEWIC. 2008. COSEWIC assessment and status report on the Snapping Turtle *Chelydra serpentina* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 47 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

COSEWIC. 2012. COSEWIC assessment and status report on the Northern Map Turtle *Graptemys geographica* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xi + 63 pp. (www.registrelep-sararegistry.gc.ca/default_e.cfm).

Court, A. and J.E. Bowman. 2013. Project Paradise Season Summary Report 2012, RBG Report No. 2013-11. Royal Botanical Gardens. Hamilton, Ontario.

Court, A. and D. Reddick. 2014. Emergent and Meadow Marsh Vegetation Summary of Hendrie Valley Sanctuary. RBG Report No. 2014-2.

Davy, C. M. 2013. Conservation Genetics of Freshwater Turtles. (Doctoral dissertation). Department of Ecology and Evolutionary Biology. University of Toronto.

Daw, C. 2011. Ecological Land Classification of Cootes Paradise Marsh. Royal Botanical Gardens. Hamilton, Ontario. RBG Report No. 2011-01.

de Solla, S.R., Bishop C.A., Van der Kraak, G, and R.J. Brooks. 1998. Impact of Organochlorine Contamination on Levels of Sex Hormones and External Morphology of Common Snapping Turtles (*Chelydra serpentina serpentina*) in Ontario, Canada. Environmental Health Perspectives. Vol. 106 (5): pp. 253-260

de Solla S.R., Fernie, K.J., Letcher, R.J., Chu, S.G., Drouillard, K.G. and S. Shahmiri. 2007. Snapping Turtles (*Chelydra serpentina*) as Bioindicators in Canadian Areas of Concern in the Great Lakes Basin. 1. Polybrominated Diphenyl Ethers, Polychlorinated Biphenyls, and Organochlorine Pesticides in Eggs. Environ. Sci. Technol. 41: 7252-7259

de Solla, S.R., Fernie, K.J., and S. Ashpole. 2008. Snapping turtles (Chelydra serpentina) as bioindicators in Canadian Areas of Concern in the Great Lakes Basin. II. Changes in hatching success and hatchling deformities in relation to persistent organic pollutants. Environmental Pollution. Vol: 153 (3). pp. 529-536

de Solla, S.R. and P.A. Martin. 2011. Absorption of current use pesticides by snapping turtle (Chelydra serpentina) eggs in treated soil. Chemosphere. 85: pp. 820–825

de Solla, 2013. Unpublished data.

Dundas Turtlewatch. Unpublished Data.

Environment Canada, 2004. How much Habitat is Enough? Second Edition. Environment Canada, Toronto, Ontario.

Environment Canada, 2010. Hamilton Harbour Area of Concern: Status of Beneficial Use Impairments.

Environment Canada, 2013. How much Habitat is Enough? Third edition. Environment Canada, Toronto, Ontario.

Epp J. M. 2012. Emergent and Meadow Marsh Vegetation Summary, RBG Report No. 2012-6.

Ernst, C.H. and J.E. Lovich. 2009. Turtles of the United States and Canada. Second edition. Johns Hopkins University Press. 827 pgs.

Frankham, R., 1996. Relationship of genetic variation to population size in wildlife. Conservation Biology. Vol 10: pp. 1500–1508

Franklin, R.1980. Evolutionary change in small populations. In: Soulé ME, Wilcox BA (eds.), Conservation Biology: An Evolutionary Ecological Perspective. Sinauer Associates, Sunderland, Massachusetts, pp 135–140

Frazer, N. B., J. L. Greene, and J. W. Gibbons. 1993. Temporal variation in growth rate and age at maturity of male painted turtles, Chrysemys picta. American Midlands Naturalist 130:314–324.

Frazer, N.B. 2000. Foreward. *In* Turtle Conservation. *Edited by* M.W. Klemmens. Smithsonian Institution Press, Wash. Pp. xi-xiv.

Galbraith, D. A. 1988. Factors affecting the density of populations of common snapping turtles (Chelydra serpentina serpentina). Canadian Journal of Zoology. Vol. 66. pp.1233-1240.

Gibbons, W.J., Scott D.E., Ryan, T.J. Buhlmann, K.A., Tuberville, T.D., Metts, B.S. Greene, J.L., Mills, T., Leiden, Y., Poppy, S. and C.T. Winne. 2000. The Global Decline of Reptiles, Déjà Vu Amphibians. BioScience. Vol. 50 No. 8. pp. 653-666.

Gillingwater, S.D. and R. J. Brooks. 2001. A selective herpetofaunal survey, inventory and biological research study of Rondeau Provincial Park. Report to Endangered Species Recovery Fund (WWF). 94 pp.

Guillette L.J. Jr.,Crain, D.A.,Rooney, A.A., and D.B. Pickford. 1995. Organization versus activation: The role of endocrine - disrupting contaminants (EDCs)

* Two Blanding's have been observed basking in Cootes Paradise in 2012 during the same survey, indicating that the population is a minimum of 2.

** a minimum of 16 different turtles were observed in the marsh between 2007-2012. Additional sightings support the assumption that some untagged turtles remain in Hendrie Valley.

during embryonic development in wildlife. Environmental Health Perspectives 103 (Supplement 7): 157–164.
Guillette L.J. Jr., and D.A. Crain. 1996. Endocrine-disrupting contaminants and reproductive abnormalities in reptiles. Comments in Toxicology 5: 381–399.

Hamilton Conservation Authority (HCA). 2012. Climate Change Strategy. Accessed from: http://www.conservationhamilton.ca/images/PDFs/Climate%20Change/HCA%20Climate%20Change%20Strategy%20March%201%202011.pdf
Hamilton Harbour Remedial Action Plan (HHRAP), 1992. Remedial Action Plan for Hamilton Harbour: environmental conditions and problem definition. Stage 1 report. 2nd ed.
Hamilton Harbour Remedial Action Plan (HHRAP). 2002. Remedial Action Plan for Hamilton Harbour Stage 2 Update 2002. Burlington, Ontario: Hamilton Harbour RAP office.
Harrison, K. 2011a. Summary Report to the John & Pat McCutcheon Charitable Foundation: Enhancing Woodland and Wetland Ecosystems for Species at Risk at Royal Botanical Gardens: 2007-2010. Royal Botanical Gardens. Hamilton, Ontario. RBG Report No. 2011-3.
Harrison, K. 2011b. Carroll's Bay Sediment Study 2010. Internal Report No. 2011-9. Royal Botanical Gardens. Hamilton, Ontario.
Harrison, K. 2012. Species at Risk Summary Report 2011-2012. Funding report to OMNR Stewardship Fund. Royal Botanical Gardens. Hamilton, Ontario. RBG Report No. 2012-2.
Harrison, K. 2013. Species at Risk Summary Report 2012-2013. Funding report to OMNR Stewardship Fund. Royal Botanical Gardens. Hamilton, Ontario. RBG Report No. 2013-7.
Ihlow, F., Dambach, J., Engler, J.O., Flecks, M., Hartmann, T., Nekum, S., Rajaei, H. and D. Rödder. 2012. On the brink of extinction? How climate change may affect global chelonian species richness and distribution. Global Change Biology. 18 (5), pg. 1520-1530
International Union for Conservation of Nature (IUCN), 2012. Table 4a: Red List Category summary for all animal classes and orders. http://www.iucnredlist.org/documents/summarystatistics/2012_2_RL_Stats_Table_4a.pdf. Accessed: Jan 16, 2014.
Joyal, L. A., M. McCollough, and M. L. Hunter Jr. 2001. Landscape ecology approaches to wetland species conservation: A case study of two turtle species in southern Maine. Conservation Biology 15(6): 1755-62.
Kelly, S. M., Eisenreich, K. M., Baker, J.E., and C.L. Rowe. 2008. Accumulation and maternal transfer of polychlorinated biphenyls in Snapping Turtles of the upper Hudson River, New York, USA. Environmental Toxicology and Chemistry. Vol. 27 (12): pp. 2565-2574
Lamond, W.G. 1994. The Reptiles and Amphibians of the Hamilton Area. Hamilton Naturalists' Club.
O'Connor, K.M. 2010. Contaminant Loadings and Concentrations to Hamilton Harbour: 2003-2007 Update. Hamilton Harbour RAP Technical Team. ISBN: 978-0-9810874-4-3
Obbard, M.E. and R.J. Brooks. 1987. Prediction of the onset of the annual nesting season of the common snapping turtle, *Chelydra serpentina*. Herpetologica. Vol. 43, no. 3, pp. 324-328.
Ontario Nature. 2013. Ontario's Reptile and Amphibian Atlas. http://www.ontarionature.org/protect/species/reptiles_and_amphibians/index.php
Peterman, W. E. and T. J. Ryan. 2009. Basking Behavior of Emydid Turtles (*Chysemys picta*, *Graptemys geographica*, and *Trachemys scripta*) in an Urban Landscape. Northeastern Naturalist. Vol. 16(4): pp. 629–636.
Pettit, K. E., Bishop, C. A., and R. J. Brooks. 1995. Home range and movements of the common snapping turtle, *Chelydra serpentina serpentina*, in a coastal wetland of Hamilton Harbour, Lake Ontario, Canada. Canadian Field-Naturalist. 109(2):192-200.
Phillips, J. and D. Murray. 2005. Racoon (Procyon lotor) population demographics in Point Pelee National Park and implications for the management of turtle species at risk. Contract Report for Parks Canada.
Pitt, A. L. and M.A. Nickerson. 2012. Reassessment of the Turtle Community in the North Fork of White River, Ozark County, Missouri. COPEIA. (3) pgs. 367-374
Polo-Cavia, N., Lopez, P. and J. Martın. 2011. Aggressive interactions during feeding between native and invasive freshwater turtles. Biol Invasions 13:1387–1396
Polo-Cavia, N., López, P. and J. Martín. 2012. Feeding status and basking requirements of freshwater turtles in an invasion context. Physiology & Behavior. 105 (5), pg. 1208-1213
Pomfret, B. 2003. The Turtles of Royal Botanical Gardens. http://www.rbg.ca/Document.Doc?id=54. Accessed: 10/21/2013. 6 pgs.
Raymond A.S., Walde, A.D. and T.A. Wheeler. 2006. Nonpredatory Fly Larvae (*Delia platura*: Anthomyiidae) in a Nest of a Northern Map Turtle (*Graptemys geographica*). Chelonian Conservation

* Two Blanding's have been observed basking in Cootes Paradise in 2012 during the same survey, indicating that the population is a minimum of 2.

** a minimum of 16 different turtles were observed in the marsh between 2007-2012. Additional sightings support the assumption that some untagged turtles remain in Hendrie Valley.

and Biology: December 2006, Vol. 5, No. 2, pp. 274-275.
Reddick, D. 2012. Ecological Land Classification of Hendrie Valley. Royal Botanical Gardens. Hamilton, Ontario. Unpublished data.
Reddick, D. and T. Theÿsmeÿer, 2012. 20 Year Trends in Water Quality, Cootes Paradise and Grindstone Marsh. Royal Botanical Gardens. Burlington, Ontario.
Rosatte, R. 2000. Management of raccoons (*Procyon lotor*) in Ontario, Canada: do human intervention and disease have significant impact on raccoon populations. Mammalia. 64(4):369-390.
Schneider, S.H. and T.L. Root. 1998: Impacts of Climate Changes on Biological Resources. In Status and Trends of the Nation's Biological Resources, 2 vols. (M.J. Mac, P.A. Opler, C.E. Puckett Haecker and P.D. Doran, eds.), U.S. Department of the Interior, U.S. Geological Survey, Reston, VA. Vol. 1: 89-116
Selman, W., Qualls, C., and J. C. Owen. 2013. Effects of Human Disturbance on the Behavior and Physiology of an Imperiled Freshwater Turtle. The Journal of Wildlife Management. Vol. 77 (5): pp. 877–885.
Semlitsch, R.D. and J.R. Bodie. 2003. "Biological criteria for buffer zones around wetlands and riparian habitats for amphibians and reptiles." Conservation Biology 17(5): 1219-28.
Somma, L.A., Foster, A. and P. Fuller. 2014. *Trachemys scripta*. USGS Nonindigenous Aquatic Species Database, Gainesville, FL. http://nas.er.usgs.gov/queries/FactSheet.aspx?speciesID=1259 Revision Date: 10/28/2009
Spence-Diermair, K. 2008. Species at Risk Summary Report, 2007. . Royal Botanical Gardens. Hamilton, Ontario.
Spence-Diermair, K. 2009. Species at Risk Summary Report, 2008. Royal Botanical Gardens. Hamilton, Ontario.
Spence-Diermair, K. 2010. Species at Risk Summary Report, 2009. Royal Botanical Gardens. Hamilton, Ontario.
Statistics Canada, 2012. Population and dwelling counts, for census metropolitan areas and census agglomerations, 2011 and 2006 censuses. 2011 Census. Date modified: 01 13 2014
Struger, J., Elliott, J.E., Bishop, C.A., Obbard, M.E., Norstrom R.J., Weseloh, V.V., Simon, M. and P. Ng. 1993. Environmental contaminants in eggs of the common snapping turtle (*Chelydra serpentina serpentina*) from the Great Lakes-St. Lawrence River Basin of Ontario, Canada (1981-1984). International Assoc. for Great Lakes Research, (1993): 5091.
Theÿsmeÿer, T. 2003. Environmental Considerations Lake Ontario Water Regulation as it pertains to the coastal marsh Cootes Paradise. Royal Botanical Gardens, Hamilton, Ontario. Pg. 15.
Theÿsmeÿer, T., Reich, B. and J.E. Bowman. 2009. Water Quality Characterization of the Main Tributaries of the Garden's Property - Spencer Creek, Chedoke Creek, Borers Creek and Grindstone Creek, 2008/09, RBG Report No. 2009-06. Royal Botanical Gardens. Hamilton, Ontario.
Thomson, R.C., Spinks, P. and B. Shaffer. 2010. Distribution and Abundance of Invasive Red-Eared Sliders (*Trachemys scripta elegans*) in California's Sacramento River Basin and Possible Impacts on Native Western Pond Turtles (*Emys marmorata*). Chelonian Research Foundation. Chelonian Conservation and Biology, 2010, 9(2): 297–302
Turtle Conservation Fund. 2002. A Global Action Plan for Conservation of Tortoises and Freshwater Turtles. Strategy and Funding Prospectus 2002–2007. Washington, DC: Conservation International and Chelonian Research Foundation, 30 pp.
Van Dijk, P.P. 2010. Status of the World's Tortoises and Freshwater Turtles: a summary overview [draft, August 2010]. Conservation International and IUCN TFTSG. www.conservation.org. Accessed 1/8/2014.
Verneau, O., Palacios, C., Platt, T., Alday, M., Billard, E., Allienne, J.F., Basso, C., and L.H du Preez. 2011. Invasive species threat: parasite phylogenetics reveals patterns and processes of host-switching between non-native and native captive freshwater turtles. Parasitology. Vol. 138: pp. 1778–1792.
Warren, A.E. 1950. The Fauna of the Royal Botanical Gardens, Hamilton, Ontario. Can. Field Nat. 64: July-Aug; 130-133.
Wetzel, R.G. 1983. Limnology, 2"d Edition. Saunders College Publishing, Philadelphia, PA.
Williams, T. 1999. The terrible turtle trade. Audubon 101(2):44, 46-48, 50-51.
Worcester, R. 2010. State of the Park Report for the Ecological Integrity of Stanley Park. Stanley Park Ecology Society. http://stanleyparkecology.ca/wp-content/uploads/downloads/2012/03/State-of-the-Park-Report-for-the-Ecological-Integrity-of-Stanley-Park-full-report.pdf Accessed: Oct 9 2013

* Two Blanding's have been observed basking in Cootes Paradise in 2012 during the same survey, indicating that the population is a minimum of 2.

** a minimum of 16 different turtles were observed in the marsh between 2007-2012. Additional sightings support the assumption that some untagged turtles remain in Hendrie Valley.