COSEWIC
Assessment and Status Report

on the

Eastern Box Turtle
Terrapene carolina

in Canada

EXTIRPATED
2014

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

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

COSEWIC. 2014. COSEWIC assessment and status report on the Eastern Box Turtle *Terrapene carolina* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xi + 36 pp. (www.registrelep-sararegistry.gc.ca/default_e.cfm).

Previous report(s):

COSEWIC. 2002. (draft report). COSEWIC assessment and status report on the Eastern Box Turtle *Terrapene carolina carolina* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 32 pp.

Roche, B. 2002. (draft report). COSEWIC status report on the Eastern Box Turtle *Terrapene carolina carolina* in Canada *in* COSEWIC assessment and status report on the Eastern Box Turtle *Terrapene carolina carolina* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 1 - 32 pp.

Production note:
COSEWIC would like to acknowledge David Seburn for writing the status report on the Eastern Box Turtle (*Terrapene carolina)* in Canada. This report was prepared under contract with Environment Canada and was overseen and edited by Ronald J. Brooks, previous Co-chair of the COSEWIC Amphibians and Reptiles Specialist Subcommittee.

For additional copies contact:

COSEWIC Secretariat
c/o Canadian Wildlife Service
Environment Canada
Ottawa, ON
K1A 0H3

Tel.: 819-938-4125
Fax: 819-938-3984
E-mail: COSEWIC/COSEPAC@ec.gc.ca
http://www.cosewic.gc.ca

Également disponible en français sous le titre Évaluation et Rapport de situation du COSEPAC sur la Tortue boîte de l'Est (*Terrapene carolina*) au Canada.

Cover illustration/photo:
Eastern Box Turtle — Eastern Box Turtle, adult female. Photo courtesy of Scott Gillingwater.

Catalogue No. CW69-14/707-2015E-PDF
ISBN 978-1-100-22055-0

COSEWIC
Assessment Summary

Assessment Summary – November 2014

Common name
Eastern Box Turtle

Scientific name
Terrapene carolina

Status
Extirpated

Reason for designation
This turtle occurred historically in Ontario based on archeological evidence and Aboriginal Traditional Knowledge. Habitat modification has been extensive and the species is no longer extant. Considerable search effort has documented fewer than 10 individuals in Ontario, but these individuals all represent released captive individuals from unknown sources and are not considered part of the former Canadian population.

Occurrence
Ontario

Status history
Species considered in May 2002 and placed in the Data Deficient category. Status re-examined and designated Extirpated in November 2014.

COSEWIC
Executive Summary

Eastern Box Turtle
Terrapene carolina

Wildlife Species Description and Significance

The Eastern Box Turtle (*Terrapene carolina*) is a small terrestrial turtle rarely exceeding 16 cm in straight carapace length. It has a slightly keeled, high-domed carapace, which is usually brown to black with variable yellow to orange patterning. The plastron has a hinge, allowing the two lobes to completely close against the underside of the carapace. The Eastern Box Turtle has special cultural significance to the Iroquois. It is also the largest known freeze-tolerant animal in the world.

Distribution

The Eastern Box Turtle is found across much of eastern North America. It occurs from central Michigan to southern Maine in the north and from eastern Texas to Florida in the south. Disjunct populations occur in two areas of Mexico. No current native populations of the Eastern Box Turtle are known to exist in Canada. The remains of Eastern Box Turtles have been found at 12 archeological sites from Ontario. COSEWIC has previously assessed the Eastern Box Turtle as native to Canada (Ontario).

Habitat

The Eastern Box Turtle is associated with open deciduous or mixed woodlands. It also makes use of adjacent habitats such as old fields, pastures, riparian zones and suburban landscapes. Small wetlands, ponds, seepages or streams are also required. The Eastern Box Turtle typically lays its eggs in open areas with sandy or loamy soil, possibly outside areas used the rest of the year. Many nesting sites are in disturbed areas such as grazed fields, or along roadways. Hibernation usually occurs on land, with turtles burrowing into loose soil or under leaf litter, though some Eastern Box Turtles will overwinter aquatically at the bottom of ponds or streams.

Biology

Eastern Box Turtles typically mature in 5-6 years for males and 7-8 years for females in the southern part of their range. Individuals in the northern part of the range likely take longer to mature.

Most adult females will lay only a single clutch of eggs in a given year, although up to 4 clutches are possible in southern populations. In the northern portion of the range, the eggs are usually laid in June. Clutch size ranges from 1-11 eggs, although 4-7 eggs are more common. Incubation can last 61-90 days in the northern part of the range. The embryos have temperature dependent sex determination. In constant temperatures, males are produced at temperatures of 22.5-27.0^{o}C, whereas above 28.5 females are produced. Hatchlings average 30.3 mm in carapace length and 8.2 g in weight. Individuals can live more than 100 years in the wild.

The Eastern Box Turtle is an omnivore, although juveniles are primarily carnivorous. Confirmed food includes fungi, mosses, roots, stems, seeds, and fruits of various plants, invertebrates (snails and slugs particularly) and vertebrates (usually consumed as carrion). Nests are often depredated by raccoons, foxes and skunks. Juveniles are consumed by a wide range of predators including mammals, snakes and birds. Adults are more protected from predation but can possibly be killed by mammals.

The Eastern Box Turtle usually occupies a small home range of approximately 2 ha, although home ranges >30 ha have been observed. Seasonal movements of 10.0 km have been documented, but are unusual.

Population Sizes and Trends

There are no known extant populations in Canada, but in Ontario, individual box turtles have been found at archeological sites and observed sporadically over at least the past 55 years. During the 20th century, the Eastern Box Turtle was first reported in 1960 from Point Pelee National Park and in 1963 from Rondeau Provincial Park. There are reports of individual Eastern Box Turtles from various locations in southern Ontario (Brant, Essex, Haldimand-Norfolk, Hamilton-Wentworth, Kent, Lambton, Middlesex, Niagara, and Waterloo) ranging up to 2013. There is also a report of an Eastern Box Turtle near Montreal, Québec in 1988. Some individuals are from subspecies from the southern portion of the Eastern Box Turtle's range and most, if not all, of these reports are widely considered to be released pets.

There are many observations of Eastern Box Turtles from Point Pelee National Park spanning many years, and successful overwintering has been documented in the park. Intensive surveys for freshwater turtles at Point Pelee in 2000-2001 failed to locate any Eastern Box Turtles, though there have been a few records since then. It seems unlikely that these turtles are remnants of a native population given that intensive biological surveys conducted in the park in the early part of the 20th century failed to locate any Eastern Box Turtles.

Populations in the USA vary greatly in size from < 25 to > 1700 individuals, although small or low-density populations have poor viability. The Eastern Box Turtle remains widespread but is declining across much of its range and has disappeared from many areas especially in the northern part of its range. There have been few long-term studies but population declines of 50-75% have been documented despite the fact that annual adult survival rates as high as 96% have been documented. Egg and juvenile mortality are likely quite high. One study found 100% mortality of tracked hatchlings and juveniles.

Threats and Limiting Factors

The Eastern Box Turtle faces a number of threats across its range. Traffic mortality is a major threat for this terrestrial species, which can wander significant distances, and readily nest on roads. Legal international export of Eastern Box Turtles was once a major issue, but this has been halted by the Convention on International Trade in Endangered Species (CITES) with quotas listed at zero. Nevertheless, legal and illegal collection of individuals for sale or for personal use is still a major threat across the species' range. Habitat loss and fragmentation are also significant threats as large intact woodland areas become lost to development or divided by road construction. Mortality arising from individuals being trapped between train tracks may be significant in some areas. Cutting or mowing hay can also result in mortality. Diseases such as Iridovirus (a Ranavirus), and upper respiratory tract infections have also caused mortality in some populations. Fires, including prescribed burns, can also result in significant mortality of Eastern Box Turtles.

Protection, Status, and Ranks

The Eastern Box Turtle is listed on CITES Appendix II. Globally, it has been listed as Vulnerable, but in the USA, the species is considered Secure nationally (N5). It is listed as Critically Imperilled (S1) in two states: Maine and New Hampshire.

TECHNICAL SUMMARY

Terrapene Carolina

Eastern Box Turtle — Tortue boîte de l'Est

Range of occurrence in Canada: Ontario

Demographic Information

Generation time: Age at maturity + 1/Mortality rate = 8 +1/.05 = 28 years	~28 yrs. Three generations = 84 years
Is there an observed continuing decline in number of mature individuals?	No. No extant populations are known to exist in Canada
Estimated percent of continuing decline in total number of mature individuals within 2 generations.	N/A for native individuals. Released individuals may persist but are not expected to reproduce in the wild.
Observed percent reduction in total number of mature individuals over the last 3 generations.	N/A – native populations likely extirpated > 85 years ago.
Projected percent reduction in total number of mature individuals over the next 3 generations.	N/A
Estimated percent reduction in total number of mature individuals over any 3 generation period, over a time period including both the past and the future.	100%
Are the causes of the decline clearly reversible and understood and ceased?	Causes of the decline in the past are probably loss of forest habitat and collection for making artifacts associated with native culture. Causes have ceased but are not reversible if the species is extirpated.
Are there extreme fluctuations in number of mature individuals?	No

Extent and Occupancy Information

Estimated extent of occurrence	Unknown for historic native turtles. Not calculated for released individuals. 0 km²
Index of area of occupancy (IAO)	Unknown for historical native turtles. IAO < 50 km^2 for the observed (released) individuals IAO for released individuals ~ 10 km^2.
Is the total population severely fragmented?	No
Number of locations*	3 (for released individuals)

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

Is there an observed continuing decline in extent of occurrence?	No
Is there an observed continuing decline in index of area of occupancy?	No
Is there an observed continuing decline in number of populations?	No
Is there an observed continuing decline in number of locations?	No
Is there an observed continuing decline in area of habitat?	No
Are there extreme fluctuations in number of populations?	No
Are there extreme fluctuations in number of locations*?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

Number of Mature Individuals (in each population)

Population	**N Mature Individuals**
Canada – Number of individuals (most likely released pets) observed during last 5 years (2009-2013)	Point Pelee National Park – 2-3 Dundas – 1 Windsor – 1
Total	4-5

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	N/A

Threats (actual or imminent, to populations or habitats)

Threats to existing populations in the USA include:

1) Traffic mortality
2) Illegal collection for pets and wildlife trade
3) Habitat loss and fragmentation
4) Cutting and mowing of fields and lawns
5) Prescribed burns
6) Disease

Rescue Effect (immigration from outside Canada)

Status of outside population(s)?	N5 in USA (1996), S3 or S4 in contiguous states.
Is immigration known or possible?	Possible, though unlikely, from Michigan or Ohio
Would immigrants be adapted to survive in Canada?	Yes

Is there sufficient habitat for immigrants in Canada?	Small populations could probably be sustained in a few areas such as Rondeau and Point Pelee Parks.
Is rescue from outside populations likely?	Unlikely given the distance from existing US populations where they are not doing very well.

Status History

COSEWIC: Species considered in May 2002 and placed in the Data Deficient category. Status re-examined and designated Extirpated in November 2014.

Status and Reasons for Designation

Status: Extirpated	**Alpha-numeric code:** Not applicable
Reasons for designation: This turtle occurred historically in Ontario based on archeological evidence and Aboriginal traditional knowledge. Habitat modification has been extensive and the species is no longer extant. Considerable search effort has documented fewer than 10 individuals in Ontario, but these individuals all represent released captive individuals from unknown sources and are not considered part of the former Canadian population.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. Declines are historical.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. Declines are historical.
Criterion D (Very Small or Restricted Total Population): Not applicable.
Criterion E (Quantitative Analysis): Not applicable. Not done.

PREFACE

The status of the Eastern Box Turtle in Canada has intrigued herpetologists for many years. Remains of Eastern Box Turtles in archeological sites suggest that it was native to southern Ontario, and COSEWIC (2002) has assessed the Eastern Box Turtle as native to Canada. In this report, information on biology, archeological remains and modern records, not presented in the previous status report, are provided. Although individual Eastern Box Turtles are still occasionally reported from southern Ontario, these are most likely released captives and there is no firm evidence that any native extant populations remain in Canada.

COSEWIC HISTORY

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

COSEWIC MANDATE

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

COSEWIC MEMBERSHIP

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

DEFINITIONS
(2014)

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

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

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

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

Environment Canada / Environnement Canada
Canadian Wildlife Service / Service canadien de la faune
Canada

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

COSEWIC Status Report

on the

Eastern Box Turtle

Terrapene carolina

in Canada

2014

TABLE OF CONTENTS

List of Figures

List of Tables

WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Class:	Reptilia
Order:	Testudines
Family:	Emydidae
Genus:	Terrapene
Species:	*Terrapene carolina* (Linnaeus 1758)
Common name:	English: Eastern Box Turtle French: Tortue boîte de l'Est

The Eastern Box Turtle (*Terrapene carolina*) (Linnaeus 1758) is a small terrestrial turtle from eastern North America and parts of Mexico. The genus *Terrapene* consists of four species. Only the Eastern Box Turtle was native to Canada. Until recently, six subspecies of the Eastern Box Turtle were recognized: 1) Florida Box Turtle (*T. c. bauri*); 2) Woodland Box Turtle (*T. c. carolina*); 3) Gulf Coast Box Turtle (*T. c. major*); 4) Mexican Box Turtle (*T. c. mexicana*); 5) Three-toed Box Turtle (*T. c. triunguis*); 6) Yucatan Box Turtle (*T. c. yucatana*). A new analysis has placed the latter three subspecies into a new species, *T. mexicana*, and retained the first three as *T. carolina* although suggesting that further revision of these may be forthcoming (Martin *et al*. 2013). Only the Woodland Box Turtle subspecies *T. c. carolina* was native to Canada.

Morphological Description

Terrapene carolina can grow to approximately 23 cm in carapace length (Ernst and Lovich 2009); however, individuals of *T. c. carolina* rarely exceed 16 cm carapace length (Harding 1997, Farrell *et al*. 2006). The species has a slightly keeled, high-domed carapace, which is usually brown to black with variable yellow to orange patterning (Figure 1). The plastron has a well-developed hinge between the pectoral and abdominal scutes, allowing the two lobes to meet the underside of the carapace, enclosing the body completely. Males usually have a red iris, whereas females have a brown or reddish brown iris (Ernst and Lovich 2009). In addition, the plastron of males is usually slightly concave, whereas the plastron of females is flat or slightly convex, and the tail of the male is slightly longer and wider than that of the female. On average, males are larger than females and grow to a larger maximum size (Dodd 2001).

Figure 1. Adult *Terrapene carolina* showing variability in patterning. Top and middle photos are adult females, bottom photo is an adult male. Photos courtesy of Scott Gillingwater.

Genetic Description

Three of the USA subspecies (*T. c. bauri, T. c. carolina*, and *T. c. triunguis*) are morphologically distinct and possess divergent mitochondrial haplotypes (Butler *et al*. 2011). The validity of the fourth USA subspecies (*T. c. major*) has been questioned owing to the lack of morphological and genetic distinctiveness (Butler *et al*. 2011; Martin *et al.* 2013). The two Mexican subspecies (*T. c. mexicana* and *T. c. yucatana*) and *T. c. triunguis* may form a distinct species based on evidence from mtDNA and nuclear DNA (Martin *et al.* 2013).

Designatable Units

Recent observations of *T. carolina* in Canada are likely released pets from unknown source populations. Archeological remains have not been used to assess distinctiveness over their historical range in Canada so Eastern Box Turtles are considered to be a single designatable unit.

Special Significance

Terrapene carolina has special culture significance to the Iroquois (Pearce 2005). *Terrapene carolina* is also the largest known freeze-tolerant animal in the world (Costanzo and Claussen 1990). *Terrapene carolina* may also play an important role in seed dispersal of plants (Braun and Brooks 1986; Liu *et al*. 2004) and spore dispersal of fungi (Jones *et al*. 2007).

DISTRIBUTION

Global Range

Terrapene carolina has a more or less continuous distribution over much of the eastern United States (Figure 2, Ernst and Lovich 2009). It occurs from central Michigan to southern Maine in the north and from eastern Texas to Florida in the south. In Mexico, disjunct populations occur in the states of Campeche, Quintana Roo, San Luis Potosí, Tamaulipas, Veracruz, and Yucatán (Ernst and Lovich 2009). The northern limits of the species are unclear, because *T. carolina* is a popular pet and individuals are often released outside their native range, and because the species has disappeared from several northern parts of its pre-European settlement range (Adler 1970; Harding 1997; Dodd 2001; Farrell *et al*. 2006; Ernst and Lovich 2009). Reports of *T. carolina* from southern Vermont have generally been considered released pets, though a cluster of observations from the southern Connecticut River valley suggests these may represent a remnant native population (Vermont Reptile and Amphibian Atlas 2012). The current northern limit of the species' range is around the lower Great Lakes, including parts of Michigan, Ohio, Pennsylvania, and New York with other populations in Massachusetts, Connecticut, New Hampshire and Maine. Extant populations in southeastern Michigan and northeastern Ohio are less than 100 km from Essex County in southern Ontario.

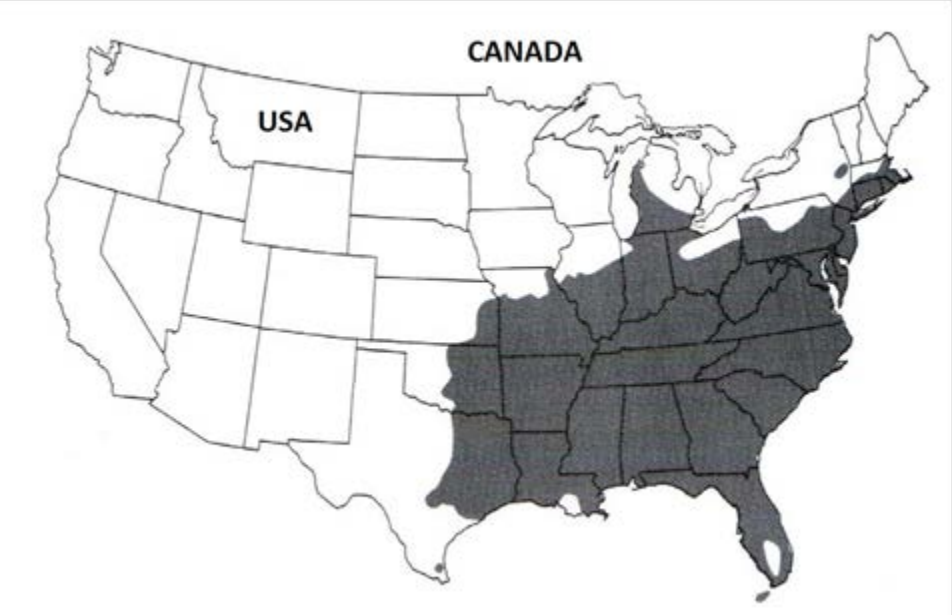

Figure 2. North American distribution of *Terrapene carolina* (modified from map in Ernst and Lovich 2009).

Canadian Range

There appear to be no known extant native populations of *T. carolina* in Canada. There are four lines of evidence regarding the historical and extant presence/absence of *T. carolina* in Canada: (1) archeological evidence; (2) biological traits of box turtles; (3) historical and current distribution of box turtles outside Ontario; (4) recent observations of individuals in Ontario.

1) Archeological evidence

The Eastern Box Turtle is considered to be a part of the Canadian biodiversity by Aboriginal people. Turtle bones of several species have been reported from a number of archeological sites in southern Ontario and Quebec (Bleakney 1958; Adler 1970; Dodd 2001; Pearce 2005). Turtle remains include unmodified bone fragments, worked or shaped bones (e.g., pendants, tools), bowls made from turtle carapaces and rattles made from turtle shells (Bleakney 1958; Pearce 2005).

Rattles constructed from turtle shells were used by Iroquoian people since at least 1000 AD (Pearce 2005). Over 70 rattles have been found at 34 sites in Ontario (R.J. Pearce pers. comm. 2012). Rattles were made from four turtle species: Blanding's Turtle (*Emydoidea blandingii*), Painted Turtle (*Chrysemys picta*), Snapping Turtle (*Chelydra serpentina*) and *T. carolina*. At least 19 rattles were also made from unidentified turtles.

The most commonly identified species of turtle used in rattles in Ontario is *T. carolina.* At least 24 rattles made from this species have been found at 10 archeological sites in Ontario (R.J. Pearce pers. comm. 2012; Table 1, Figure 3). Up to 12 *T. carolina* have been found at a single site (R.J. Pearce pers. comm. 2012). The second most common species is the Painted Turtle (*Chrysemys picta*) with at least 23 rattles from six sites (R.J. Pearce pers. comm. 2012). Some caution should be used in interpreting the frequency of occurrence data, as rattles made from *T. carolina* may be easier to identify than those from some other species and identification may not always be valid. The earliest known *T. carolina* rattle from Ontario dates from pre-contact 1300-1400s, but most date from post-contact 1500-1600s (R.J. Pearce pers. comm. 2012). In contrast, the oldest *T. carolina* archeological remains from New York date from 2575-3433 BC (Adler 1970).

Table 1. Locations of archeological sites in Ontario with *T. carolina* remains.

County	Site	Notes
Sites with rattles (source: Pearce pers. comm. 2012)		
Kent	Clearville	1 rattle, possibly Box Turtle
Halton	Irving-Johnson	1 rattle
Hamilton-Wentworth	Christianson	1 rattle
Hamilton-Wentworth	Dwyer Ossuary	2 rattles
Brant	Walker	2 rattles
Niagara	Grimsby Cemetery	12 rattles
Halton	Milton Heights (Gaetan)	1 rattle
Hamilton-Wentworth	Lake Medad	1 rattle
Niagara	Orchid Area B	1 rattle
Simcoe	Sidey-Mackay	2 rattles
Sites with non-rattle remains (source: Pearce 2005)		
Haldimand-Norfolk	Boyd Lakefront	“elements of Box turtle were found”
Northumberland	East Sugar Island, Rice Lake	Partial remains of a bowl made from a Box turtle carapace found

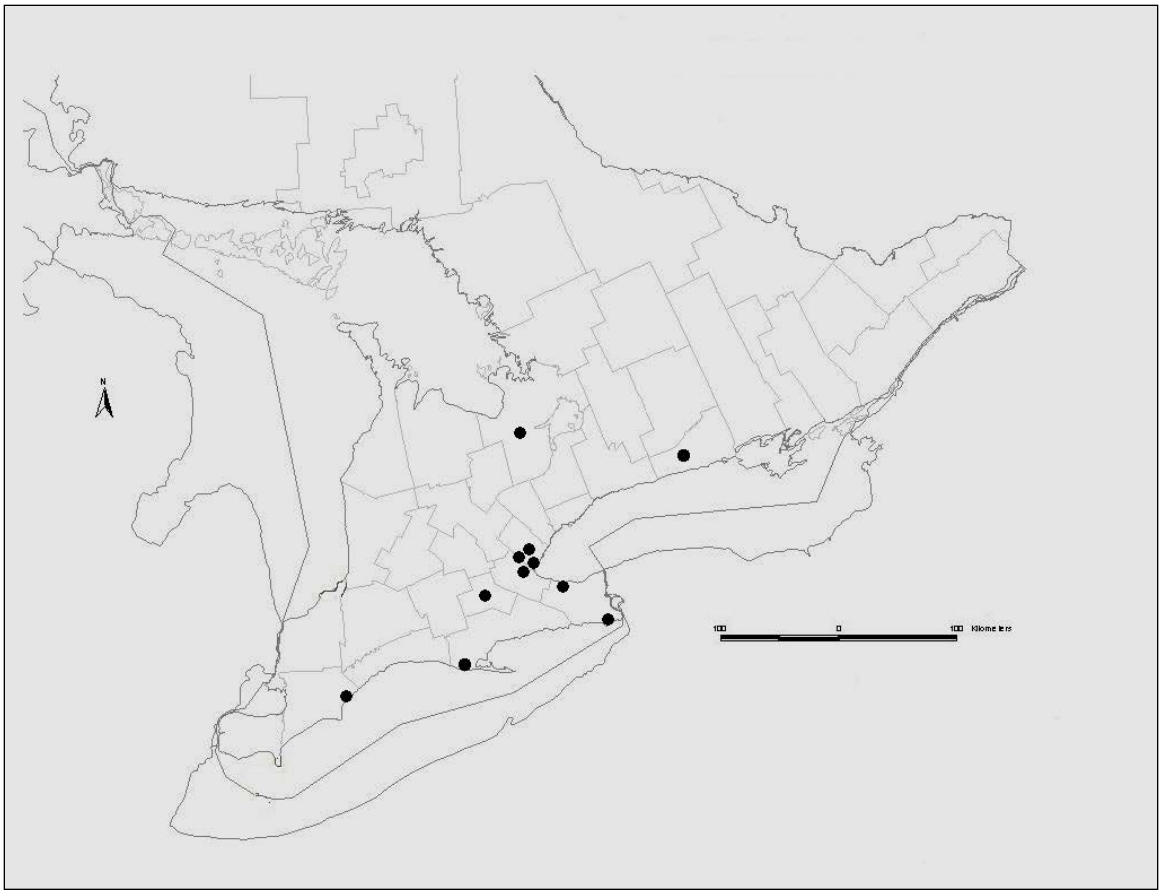

Figure 3. Approximate locations of 12 sites in southern Ontario with archeological remains of *Terrapene carolina*. Note that two sites in the Burlington area are mapped as one location. Source of data: Pearce 2005, R.J. Pearce pers. comm. 2012. Map created by D. Seburn.

Including non-rattle archeological material, *T. carolina* has been found at 12 sites in southern Ontario (Table 1, Figure 3). Most biologists looking at these data (Adler 1968, 1970; Froom 1976; Harding 1997; Dodd 2001) concluded that box turtles were likely native to Ontario, but were reduced in number or extirpated by native hunting and habitat loss (logging, burning of forests) by natives and early settlers. However, Bleakney (1958), in an earlier assessment, concluded that box turtles were not native because they could not cross the barrier of the lower Great Lakes, and were imported by Aboriginal people, either as live animals or bones and shells turned into various artifacts. It is possible too that they were both native and also traded into Ontario from other areas, given the significance of turtles in Iroquoian culture and the preference for using *T. carolina* to construct rattles and other items (e.g., Pearce 2005).

The Iroquois people occupied much of what is now southern Ontario and most of New York State (Snow 1996). The Iroquois population is estimated to have been approximately 95,000 by the 1600s. The men of these villages frequently undertook “long trips and gift exchange” (Snow 1996). The archeological evidence from Iroquois sites indicates “that a series of overlapping exchange networks operated across northeastern North America” (Bradley 1987). Many artifacts have been found far from their source. For example, New York chert and soapstone as well as silver believed to be from Georgia have been found in Ontario archeological sites (R.J. Pearce pers. comm. 2012). Marine shells have also commonly been found at Iroquoian archeological sites, including Ontario locations at Rice Lake in Northumberland County (Pearce 2005) and in Simcoe County (Hamalainen 1999). Items not available in current-day Ontario were likely highly desired trade objects (Pendergast 1991). The lack of recent observations of *T. carolina* from central and western New York compared with the number of archeological sites with *T. carolina* has been interpreted as evidence that *T. carolina* was historically more widespread in New York state and Ontario (Adler 1970; Harding 1997; Dodd 2001) as well as Michigan (Harding 1997; Holman 2012). Many of the *T. carolina* archeological remains in New York state are unworked bones suggesting that the species was harvested locally for food (Adler 1968, 1970), although some evidence exists that native people did not eat Box Turtles or Wood Turtles (*Glyptemys insculpta*) because they have orange and red colours suggesting they contain natural toxins (Bleakney 1958; Gibbons 1983). If *T. carolina* was more widespread historically in New York then it would have made trade and natural immigration into Ontario highly likely.

2) Biological and climatological evidence

There is no obvious reason why Eastern Box Turtles would not have been able to colonize southern Ontario from the USA as other turtles did after the last ice age (e.g., Amato *et al.* 2008). The Great Lakes “barrier” postulated by Bleakney (1958) did not exist in the hypsithermal period (~ 5.5 - 4.5 thousand years ago) (Holman 2012) when many reptiles and amphibians migrated north into Ontario, and even the present-day Great Lakes should not be a barrier as box turtles float and are good swimmers (Ernst and Lovich 2009). Box turtles occurred in southeastern Michigan and northwestern Ohio contiguous to the USA-Canadian border until recently (Harding 1997; Holman 2012). Box turtles can overwinter and reproduce in Ontario, and the constraint of cool summer temperatures on incubation success would not be as significant as for some native turtles (Bobyn and Brooks 1994; Burke and Capitano 2011; R.J. Brooks unpub. Data; S. Gillingwater unpub. data). In addition, the box turtle is the only turtle that is freeze-tolerant as an adult. Because they often hibernate in relatively shallow sites, freeze tolerance is a significant adaptation to winter survival (Costanzo and Claussen 1990).

A *T. carolina* marked in 1979 at Point Pelee National Park was recaptured in 1983, 1988 and 1989, confirming that the species can overwinter in southern Ontario (COSEWIC 2002). This is believed to be the same individual that has been fitted with a radio transmitter and is currently being tracked (S. Marks pers. comm. 2014). Captive *T. c. carolina* have also successfully overwintered in outdoor enclosures for multiple years in southern Ontario (S. Gillingwater pers. comm. 2012). Females have nested in these enclosures and the eggs have successfully hatched on their own with no supplemental heat. There appear to be no climatic or other limits for the species to exist and survive in southern Ontario.

3) Historical and current distribution outside Ontario

The Eastern Box Turtle has disappeared from many areas, particularly in the northern parts of its range (Adler 1970; Dodd 2001; Ernst and Lovich 2009). Given the biological evidence and their apparent historical distribution as well as the pattern of loss of that distribution (Adler 1968, 1970; Dodd 2001), it is possible that native Ontario *T. carolina* became extirpated as a result of habitat loss and overharvesting. Given its unusually long-lived life history, accessibility to humans for "harvest", and exposure from loss of forest cover, box turtles are vulnerable to human disturbance (Hall *et al*. 1999; Henry 2003; Converse *et al*. 2005) and are in decline over most of their range (Dodd 2001). Most contemporary box turtle populations in the USA have densities far below optimal (Williams 1961; Stickel 1978, 1989; Schwartz *et al.* 1984; Williams and Parker 1987; Klemens 2000; Lieberman 1994; Hall *et al.* 1999; Dodd 2001; Belzer 2002) and are poor at rebounding from adult losses (Adler 1970; Stickel 1978; Williams and Parker 1987; Hall *et al*. 1999). Among the 20 chelonian genera found in the United States and Canada, *Terrapene* has a lowest median clutch size (Belzer and Seibert 2009). Demographic analyses reveal that population dynamics in many turtles (including *Terrapene*) are so precarious that the annual loss of very few adults will produce an inevitable, albeit slow, extinction of those populations (Klemens 2000). These biological traits have presumably led to the decline or disappearance of the Eastern Box Turtle throughout its range as this species is widely collected for pets and other uses.

4) Recent observations in Canada

During the 20th century, *T. carolina* was first reported in Ontario in 1960 when one individual was photographed at Point Pelee National Park (Table 2). *Terrapene carolina* has also been observed at many other localities in southwestern Ontario (Table 3, Figure 4). In total, there are reports from nine counties. Essex county has the most reports, even excluding the observations from Point Pelee National Park. There is also one report of a *T. carolina* from near Montréal in Québec in 1988 (Bider and Matte 1991).

Table 2. Observations of *Terrapene carolina* from Point Pelee National Park. NMC # indicates specimen record number in the Canadian Museum of Nature (formerly National Museum of Canada). OHS # indicates entry number in Ontario Herpetofaunal Summary database. PPNP # indicates entry number in Point Pelee National Park database. Subspecies codes: U – Unknown; carolina – *T. c. carolina*.

Year	Date	Notes	Subspp	Source
1960	?	"photographed"	U	OHS #212249
1969	?	"1 seen"	U	OHS #212253
1972	?	"captured"	U	OHS #112762
1972	?	"3 found during summer"	U	OHS #212250
1972	19 Aug	"observed"		OHS #110972
1972	20 Aug	"tagged"	U	OHS #114214
1972	24 Aug	"tagged"	U	OHS #114215
1972	2 Sept	"tagged"	U	OHS #114216
1972	13 Sept	"tagged"	U	OHS #114217
1972	18 Sept	"tagged"	U	OHS #114218
1972	? Sept	"2 found during week previous to 25 Sept"	U	OHS #212251
1972	26 Sept	"tagged"	U	OHS #114219
1972	14 Oct	"tagged"	U	OHS #114220
1972	15 Oct	"tagged"	U	OHS #114221
1974	6 May	Specimen card indicates shell found on path in "middle orchard".	carolina	NMC #15923 OHS #108274
1975	?	"caputred [sic] and released"	U	OHS #108802
1975	?	"sighting"	U	OHS #109024
1975	23 June	"75 meters south of Tilden's. Going east across main road… marked it with a triangular notch in the center of the 11th marginal scale on the right side." 7 5/8 inches CL, 5 5/8 inches PL.	U	PPNP Turtle report form
1975	5 July	"South of Tilden's. Just before group camping. Going east." Same turtle as 23 June.	U	PPNP Turtle report form
1976	1 June	"off west bend of 1/4 mile woodland trail, 26 yards north along first deer trail"	U	PPNP #2412
1976	8 June	"North of Black Willow exit on West Road"	U	PPNP #2413
1976	22 June	"110 metres down woodland trail (1,1/2 trail)"	U	PPNP #2414
1977	25 May	"Entrance of nature trail"	U	PPNP #2415
1977	17 June	"along path leding [sic] from driveway to front of centre"	U	PPNP #2416
1979	19 Aug	"east beach rd."	U	PPNP #6735
1980	5 June	"Tilden woods"	U	PPNP #6741

Year	Date	Notes	Subspp	Source
1981	23 July	“picked up in Krause’s garden, released at NE corner of Tilden Woods”	U	PPNP #6742
1983	20 May	East beach bath house. Previously notched. Turtle 22. Male. Previously caught 4 years ago. Not released until 30 May.	U	PPNP Turtle report form & PPNP #6736
1983	18 Aug	“east beach rd”	U	PPNP #6737
1983	28 Aug	“woodland trl”	U	PPNP #6738
1985	26 May	“1, CL=5inches, W side Nature Trail”	U	OHS #24312
1986	15 May	“1 Savannah Trail, Woodland Nat Tr, 200 ft S of Cactus”	U	OHS #24313
1986	22 June	“1 on DeLaurier Trail”	U	OHS #24314
1986	22 Sept	“1, 0.25 mi S of Visitor Centre on road to tip”	U	OHS #24315
1987	17 April	“1 F (plastron flat)(CL=ca 6in), Woodland Nature Tr, 1400h”	U	OHS #24316
1988	6 June	“1 seen, male, central trail of Woodlands Trail, photos”	U	OHS #31875
1988	24 Aug	“1 seen, male, S end Central Trail”	U	OHS #31891
1988	25 Aug	“west rd. at white pine”	U	PPNP #6739
1988	1 Oct	“1 seen, male, Woodlands Nature Trail, same one on 24 Aug”	U	OHS #31895
1989	7 June	“tip rd. 200m S of interp”	U	PPNP #6740
1990	26 June	“1 noted, CNT, ca 6in shell, red eyes”	U	OHS #56862 (OHS #57020 appears to be duplicate record)
1991	10 May	“PPNP, savannah trail on Woodland Nature Trail”	U	PPNP #73
1991	3 Aug	“PPNP, 1km north of tip facilities”	U	PPNP #74
1994	11 April	No locality information	U	PPNP Visitor observation book
1995	10 May	Reported along Center Trail	U	PPNP Visitor observation book
1995	29 May	“Woodland trail, between 3 and 4”	U	PPNP #2176
1995	15 August	“woodland nature trail”	U	PPNP #2224
1997	21 May	Reported from Tip Road	U	PPNP Visitor observation book
1997	10 Sept	“Tip Area?”	U	PPNP #6734
2001	1 May	Reported along Woodland Nature Trail	U	PPNP Visitor observation book
2001	8 May	Reported from Tilden’s Woods	U	PPNP Visitor observation book
2007	9 May	Reported along Woodland Nature Trail	U	PPNP Species reporting form
2007	10 May	Reported along Woodland Nature Trail	U	PPNP Visitor observation book
2007	3 Oct	1 observed crossing road (west to east) about 1 km south of visitor’s centre	U	PPNP Species reporting form

Year	Date	Notes	Subspp	Source
2012	18 June	Adult male, 17 cm CL, 13 cm PL, some scutes peeling off carapace. Photo.	carolina	Personal communication from T. Dobbie
2012	Early July	Photographed by park visitor. ID confirmed by park staff, but no photo obtained. Appeared to be different turtle than one found in June 2012.	carolina	Personal communication from T. Dobbie
2013	11 Oct	Adult male, ~14.5 cm CL. Photos.	carolina	Personal communication from T. Dobbie

Table 3. Observations of *Terrapene carolina* in Canada (excluding observations from Point Pelee National Park). NMC # indicates specimen record number in the Canadian Museum of Nature (formerly National Museum of Canada). OHS # indicates entry number in Ontario Herpetofaunal Summary database. Subspp = subspecies. Subspecies codes: U – Unknown; carolina – *T. c. carolina*; major – *T. c. major*; triunguis – *T. c. triunguis*.

Year	Date	County	Location	Notes	Subspp	Source
Quebec						
1988	?	Montréal	Montréal	One found near Montréal	U	Bider and Matte 1991
Ontario						
1963	29 July	Kent	Rondeau Prov Park	Specimen card indicates turtle found on Poplar Street, N. campground.	triunguis	NMC #19135 OHS #101742
1972	?	Niagara	Niagara Peninsula	"CAC given ad,wandering,wild nr border,PD Pratt had spec"	U	OHS #212252
1974	20 June	Essex	Fish Point, Pelee Island	Specimen card indicates the turtle was found dead "in field". The location is described as "southern tip of island some distance from habitation."	carolina	NMC #16670 OHS #100664
1976	?	Essex	Fish Point, Pelee Island	"inventory(1973),Campbell (1976b) ref 127"	U	OHS #110674. Possible duplicate of OHS #100664
1978	27 June	Essex	Highway 3, near E Mersea School	"female, 140mm, Watson Sideroad next to RR tracks, N Hwy 3"	U	OHS #121988
1979	25 Aug	Nipissing	Algonquin Park	Length 14.5 cm. South Lookout Trail (mile 26.1), ¼ mile from Hwy 60, 200 yards W of trail.	carolina	Coll. J. Reynolds, Algonquin Park Museum Records.
1984	31 Aug	Essex	Willow Beach	"1 ad male"	U	OHS #24309
1985	3 Oct	Niagara	~2 km NW of Fort Erie	"1 M,CL=114.2mm,ca 18-21 yrs,remote part large woodlot,pm"	U	OHS #24317

Year	Date	County	Location	Notes	Subspp	Source
1985	24 July	Waterloo	1.5 km W of Freeport	“1, found in farmers hay, barn, perhaps a pet”	U	OHS #24318
1987	24 March	Essex	Ojibway Park	“1 sick M,died next day (spec NMC),3-toed ssp(triunguis)”	triunguis	OHS #24310
1988	1 Sept	Essex	Fish Point, Pelee Island	“1 ad, 16.2cm carapace, woodland near W shore,photo,1300h”	U	OHS #24311
1989	21 May	Hamilton-Wentworth	4.6 km SE of Copetown	“1 by path at edge of pine plantation/young woodlot”	U	OHS #38243
1990s	?	Haldimand-Norfolk	Near Port Rowan	Found dead on road	carolina	S. Gillingwater pers. comm.
1990s	?	Haldimand-Norfolk	?	Found along roadside	carolina	S. Gillingwater pers. comm.
1990s	?	Haldimand-Norfolk	?	Found near a wetland	carolina	S. Gillingwater pers. comm.
1993	?	Brant	Paris	Juvenile found in woods near Pinehurst Lake	triunguis	S. Gillingwater pers. comm.
1996	Spring	Essex	Pelee Island	1 observed	U	J. Litzgus pers. comm.
2001	?	Kent	Rondeau Provincial Park	1 juvenile	triunguis	S. Gillingwater pers. comm.
2002	?	Middlesex	London	Adult found in Sifton Bog. Photo	triunguis	S. Gillingwater pers. comm.
2002	?	Middlesex	Dorchester	Adult male found in Dorchester Swamp	major	S. Gillingwater pers. comm.
2002	?	Middlesex	London	Adult female found along shore of the Thames River	triunguis	S. Gillingwater pers. comm.
2002	Spring	Haldimand-Norfolk	Walsingham	Adult male. Observed in a slough forest SW of Walsingham	carolina	S. Gillingwater pers. obs.
2003	Spring	Haldimand-Norfolk	Walsingham	Same turtle as observed in 2002. Observed in a slough forest SW of Walsingham	carolina	S. Gillingwater pers. obs.
2008	11 June	Waterloo	Kitchener	Turtle found on road in Kitchener.	U	Ontario Turtle Tally #1106
2011	28 May	Hamilton-Wentworth	Dundas	Adult male. Photo.	carolina	Ontario Turtle Tally #4194
2012	?	Essex	Windsor	Adult male. Photo	carolina	S. Gillingwater pers. comm.
?	?	Lambton	Near Port Franks	Adult female	carolina	S. Gillingwater pers. comm.

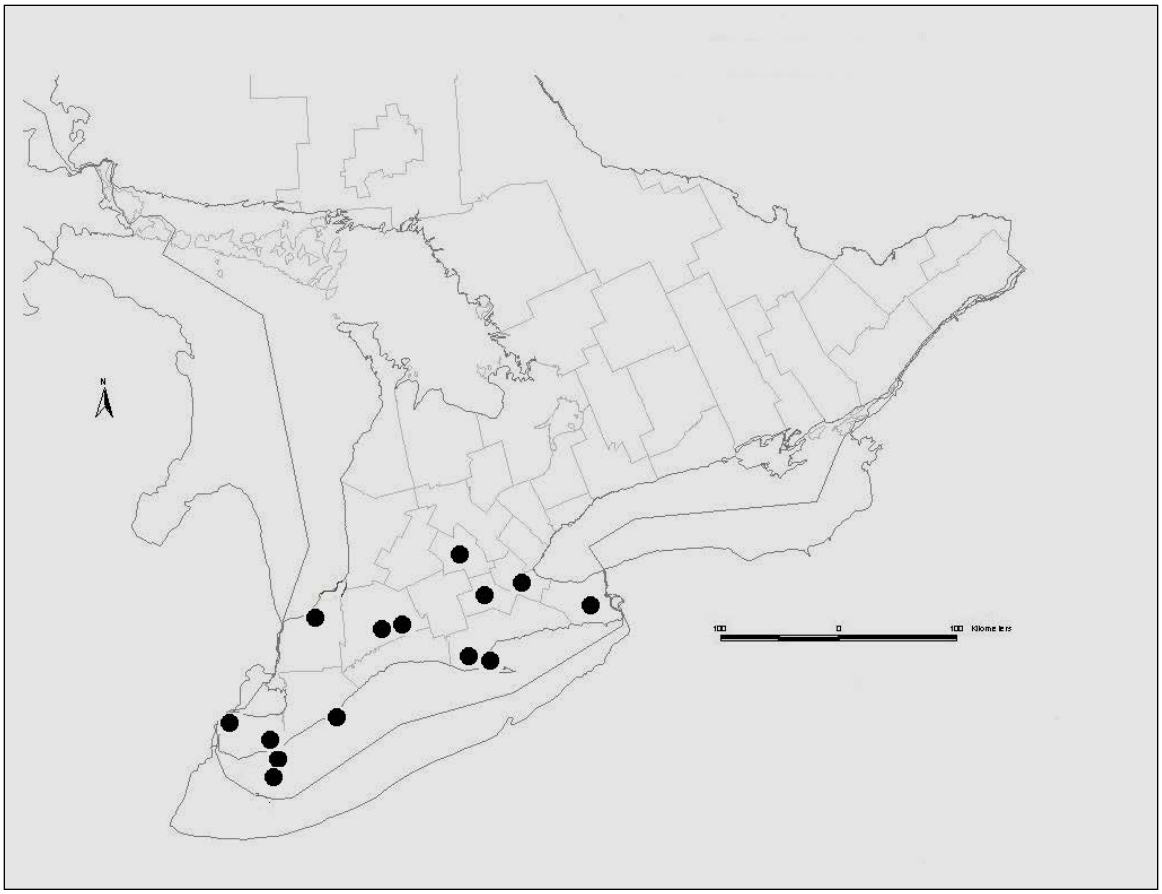

Figure 4. Approximate locations of observations of *Terrapene carolina* from southern Ontario from the 20th century. See Tables 2 and 3 for detailed information on observations. Map created by D. Seburn.

It seems improbable that most localities with single observations represent remnant populations of *T. carolina*. Most sightings are of individual turtles that were never observed again. If small populations remained in these areas, it is likely that additional turtles would eventually be observed. The localities of many of the observations (e.g., subdivisions, suburban backyards) also suggest these are likely released or escaped pets (NHIC 2012). However, many box turtle populations in the USA survive in urban areas after their natural habitat has been removed, and there are instances of box turtles surviving 120 years in the wild, providing weak evidence that some specimens could be native remnants. The literature on declining box turtle populations led Belzer (2002) to suggest that a self-sustaining population may need adult densities of more than 25 turtles/ha to achieve sufficient reproductive activity to rebound from reduced numbers. If true, then Ontario "populations" are certainly not viable populations.

Some of the box turtles recently found in Ontario were subspecies other than *T. c. carolina*. One *T. c. major* was found in Middlesex County in 2002 and six *T. c. triunguis* have been found in Brant, Essex, Kent and Middlesex counties (Table 3). The 1963 specimen collected from Rondeau Provincial Park was identified as *T. c. triunguis* (Table 3). These specimens show that released pets were present in Ontario as early as 1963 and suggests that all *T. carolina* found in Ontario from 1960 onward could be released pets.

There are more than 50 sightings of *T. carolina* from Point Pelee National Park since 1960. These turtles could represent remnants of a native population. Although it is difficult to disprove this hypothesis, it is odd that *T. carolina* was not observed before 1960, as significant surveys for amphibians and reptiles were conducted at Point Pelee National Park in the early 20th century. Clyde Patch spent "the three summer months" at Point Pelee as part of a biological survey team from the Victoria Memorial Museum (now the Canadian Museum of Nature) and reported finding five species of turtles in 1913 (Patch 1919). E.B. Shelley Logier spent "about six weeks" at the park as part of a survey team with the Royal Ontario Museum in 1920 (Logier 1925). Logier (1925) added the Northern Map Turtle (*Graptemys geographica*) to Patch's species' list, and also reported that fishers had caught the Spiny Softshell (*Apalone spinifera*). Both Patch and Logier felt their reptile lists were likely incomplete, but only two additional turtle species have been reported at Point Pelee since 1920: the introduced Red-eared Slider (*Trachemys scripta elegans*) and Eastern Box Turtles (Browne 2003). Given the amount of time Patch and Logier spent at Point Pelee (and the reports they solicited from other people) it seems highly unlikely that a conspicuous terrestrial turtle like *T. carolina* could have been overlooked, especially given that there are more than 50 observations after 1960. Further evidence that *T. carolina* was introduced to Point Pelee National Park is a report from F.D. Ross encountering someone attempting to release three *T. carolina* at Point Pelee in 1971 (Cook 1974). More recently, there are several documented instances of people releasing pet box turtles at Point Pelee (S. Marks pers. comm. 2014).

HABITAT

Habitat Requirements

Terrapene carolina is mainly a species of mesic open deciduous or mixed woodlands (Harding 1997; Ernst and Lovich 2009). It also makes use of adjacent habitat such as thickets, old fields, pastures, wet meadows and riparian zones (Harding 1997; Ernst and Lovich 2009). It is frequently associated with deciduous forest and the ecotonal areas between forest and field habitat (Hulse *et al*. 2001). In forests, it prefers areas with dense plant cover (McKnight 2011). Access to water such as small ponds, seepages, or slow streams is also generally required. *Terrapene c. carolina* can use wetland habitat as often as terrestrial habitat in some areas (Marchand *et al*. 2003). Juvenile *T. carolina* tend to occupy fewer types of habitat; areas with dense cover, abundant leaf litter and moist soils are most commonly used (Jennings 2007).

Nesting habitat for *T. carolina* is typically open, elevated patches of sandy or loamy soil (Ernst and Lovich 2009). Nesting areas may be outside the usual area used by the turtles for foraging (Stickel 1950). Nesting habitat typically has virtually no woody vegetation, significant areas of bare ground (mean: 39%), little leaf litter, and low canopy cover (Flitz and Mullin 2006). Nest sites are commonly in disturbed areas such as camp sites, roadways and grazed fields (Flitz and Mullin 2006; Burke and Capitano 2011a).

Most *T. carolina* hibernate on land. The turtles select areas of loose soil or sand with an abundant layer of leaf litter (Dolbeer 1971, Sava *et al*. 2010). Over half of tracked individuals in Massachusetts overwintered in depressions next to tip-up mounds of fallen trees (Willey 2010). Individual turtles can burrow down as much as 60 cm (Dolbeer 1971). Even in the northern parts of the range (Ohio), hibernation depth did not exceed 14 cm and averaged only 4-5 cm, plus leaf litter (Claussen *et al*. 1991). Some *T. carolina* hibernate under water, burrowing into the substrate of ponds or stream bottoms (Ernst and Lovich 2009). Box turtles commonly return to the same site to hibernate in subsequent years (Stickel 1989; Hall *et al*. 1999; Sava *et al*. 2010).

Habitat Trends

Most of southwestern Ontario was covered by closed canopy forest prior to European settlement, but by the 20th century forest cover was only 19% across much of the area, with 80% of forest patches < 3 ha in size (Pearce 1993). Based on box turtle sightings (Tables 2, 3), suitable habitat exists for adult turtles to survive in Ontario but established, or perhaps reintroduced, populations would be subject to many of the same threats in Ontario as found in the U.S. [**see Threats and Limiting Factors]**. The reasons for extirpation of Canadian Box Turtles are not known.

BIOLOGY

Life Cycle and Reproduction

In Florida, male *T. carolina* typically mature between 5-6 years of age, and females mature between age 7-8 (Dodd 1997a). In the northern part of the range individuals likely take longer to mature. Mating can occur from spring to fall (Ernst and Lovich 2009), but peak mating appears to be in June, July and October (Hulse *et al*. 2001). A captive colony kept outdoors year-round in Ontario showed peak mating in May and September, generally during heavy rains (Gillingwater pers. comm. 2012). A female can lay fertilized eggs for up to 4 years after mating (Ewing 1943).

Females in the northern portion of the range typically produce a single clutch of eggs per year (Kipp 2003; Burke and Capitano 2011a). Even in Florida, most females lay only a single clutch, although up to three have been reported (Dodd 1997b), and up to five clutches per year may be possible (Tucker *et al*. 1978). The eggs are usually laid during June in the northern portion of the range (Burke and Capitano 2011a) and within a captive group kept outdoors in Ontario (Gillingwater pers. comm. 2012). Not all females breed every year (Kipp 2003; Wilson and Ernst 2005; Buchman *et al*. 2010).

Clutch size varies from 1-11 eggs (Ernst and Lovich 2009). The average clutch size in the northern portion of the range varies from 4.1 (Burke and Capitano 2011a) to 6.7 eggs (Klemens 1993). Clutch size is positively correlated with the female's carapace length in some populations (e.g., Florida, Dodd 1997b; Illinois, Tucker 1999; Maryland, Kipp 2003; Texas, Buchman *et al.* 2010) but is not correlated in other populations (e.g., Virginia, Wilson and Ernst 2005; New York, Burke and Capitano 2011a). Egg viability, in the absence of predation, is usually high (e.g., 90%, Tucker *et al.* 1978; 94%, Burke and Capitano 2011a), but it can be as low as 24% (Congello 1978).

The eggs are elliptical, have thin, flexible shells, and vary from 24-40 mm in length (Ernst and Lovich 2009). The incubation period is highly variable, but can last 61-90 days in New York, at the northern part of the range (Burke and Capitano 2011b). Although some hatchlings may remain in the nest after hatching (Madden 1975), none of the hatchlings in monitored nests in New York (Burke and Capitano 2011b) or Maryland (Kipp 2003) overwintered in the nest.

The embryos of *T. carolina* have temperature-dependent sex determination. Constant incubation temperatures of 22.5-27.0^{o}C produce mainly males, whereas temperatures of 28.5^{o}C or higher produce mainly females (Dimond 1983; Ewert and Nelson 1991; Ewert *et al.* 2004). Hatchlings average 30.3 mm (range: 26.9-35.9 mm) in carapace length and 8.2 g (range: 5.2-10.0 g) in mass (Ernst and Lovich 2009).

Long-term studies indicate that individuals can live more than 70 years (Hall *et al*. 1999) and there is compelling evidence that *T. carolina* can live more than 100 years (Oliver 1955; Graham and Hutchison 1969; Gibbs *et al*. 2007). Females can still lay fertile eggs after age 50 (Hall 2003). A generation time of 28 years for the Eastern Box Turtle was calculated (see formula in Demographic Information).

Diet and Feeding

Terrapene carolina is omnivorous. Juveniles are primarily carnivorous, but individuals become more herbivorous with age (Ernst and Lovich 2009). Fungi (including mushrooms and bracket fungi), moss, and the roots, stems, seeds and fruits of various plants are eaten by *T. carolina* (Ernst and Lovich 2009). *Terrapene carolina* has been documented to eat a wide variety of invertebrates including slugs, snails, earthworms, millipedes, spiders, ants, beetles, caterpillars, crickets, grasshoppers, cockroaches and true bugs (Ernst and Lovich 2009). Documented vertebrate prey (usually consumed as carrion) includes fish, frogs (tadpoles and adults), salamanders, turtle eggs, lizards, snakes, birds, and small mammals such as mice or shrews (Ernst and Lovich 2009). Snails and slugs are often the most common food item by volume (Barbour 1950; Bush 1959), although fungi can be the most common item at times (Stickel 1950).

Predation

The nests of *T. carolina* are often destroyed within 24 hours of oviposition (Flitz and Mullin 2006). Nest predators include the introduced Fire Ant (*Solenopsis invicta*; Montgomery 1996), as well as native predators such as badgers, Foxes, Raccoons, and Skunks (Ernst and Lovich 2009). Juveniles are consumed by a wide range of predators including mammals (e.g. Raccoons, Skunks, Foxes and Shrews), snakes, and birds (Ernst and Lovich 2009), as well as Fire Ants (Montgomery 1996). Adults are more protected from predation given their size and hinged shell; however, the shells of *T. carolina* have been found in the nests of Bald Eagles (*Haliaeetus leucocephalus*; Clark 1982). Hogs (Ernst and Lovich 2009), Raccoons (Franz and Dodd 1993), feral housecats (Hester *et al*. 2008) and dogs (Ferebee and Henry 2008) may kill adults.

Physiology and Adaptability

Terrapene carolina is typically active above air temperatures of 17^{o} C (Dodd *et al*. 1994; Farrell *et al*. 2006) although it can be active at body temperatures as low as 11.2^{o} C (Boucher 1999). *Terrapene carolina* loses its righting response at body temperatures of 39-42^{o} C and will die at body temperatures of 41.5-43.9^{o} C (Hutchison *et al*. 1966). The critical thermal maximum does not appear to vary across the range (Hutchison *et al*. 1966).

Terrapene carolina typically overwinters on land. It is the largest known freeze-tolerant animal, and can survive freezing of at least 58% of its total body water (Costanzo and Claussen 1990). Laboratory experiments indicate that *T. carolina* can survive temperatures as low as -3.6^{o} C for up to 3-4 days (Costanzo and Claussen 1990). The organs experience a 4- to 22-fold increase in glucose during freezing (Storey *et al*. 1993). Glucose is used as a cryoprotectant.

Dispersal and Migration

In general, *T. carolina* is relatively sedentary, occupying a small area. Mean home range is approximately 2-3 ha (e.g., Madden 1975; Kuhns 2004; Donaldson and Echternacht 2005; Ferebee and Henry 2008; Kapfer *et al.* 2013) although home ranges of individual turtles can be >30 ha (Farrell *et al*. 2006; Baker 2009). Females may have larger home ranges than males, likely because of nesting forays (e.g., Farrell *et al*. 2006; Swarth and Quinlan 2007); however, in other populations there is no difference in home range size between males and females (e.g., Baker 2009), and in some populations males have larger home ranges (Kuhns 2004). Individuals in isolated areas move less than those in more continuous habitat (Iglay *et al.* 2007). Some *T. carolina* will wander long distances and are considered transients (e.g., Stickel 1950). One radio-tracked adult male moved a straight-line distance of 10.0 km (Kiester *et al*. 1982). Another male crossed five highways and a river (Schwartz *et al*. 1984).

Interspecific Interactions

Hybridization with *T. ornata* can be common where the two species overlap (Cureton II *et al*. 2011). Intergradation among subspecies is known throughout areas of range overlap (Ernst and Lovich 2009).

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

Intensive surveys for all turtle species at Point Pelee National Park during 2001-2002 resulted in the capture of 1,977 turtles, but no *T. carolina* were caught, suggesting that few individuals are present in the park (Browne and Hecnar 2007); however, there were two reports of *T. carolina* by park visitors in 2001 (T. Dobbie pers. comm. 2012). No surveys have been specifically conducted for *T. carolina* in southern Ontario but intensive surveys for a number of other wildlife species have been conducted throughout many areas of southern Ontario, including areas where *T. carolina* have been previously observed (e.g., Rondeau Provincial Park, Port Franks, Pelee Island, etc.) and other areas with potential habitat (Long Point National Wildlife Area, Pinery Provincial Park, Skunk's Misery, etc.). Reports of *T. carolina* are occasionally submitted to monitoring programs such as the Toronto Zoo Turtle Tally, and the Ontario Reptile and Amphibian Atlas and NHIC.

Abundance

At Point Pelee National Park at least eight different *T. carolina* were captured in 1972 (Watt 1972). The number of observations at the park varies from year to year, but one or two observations are common in most recent years (Table 2). These observations from park visitors were often not documented with photographs and mis-identification is possible. Mostly single observations have been recorded at other sites in Ontario, with one individual observed twice over two consecutive seasons in Norfolk County (Table 3). There is an estimated number of four or five individual Eastern Box Turtles in Ontario. Such low densities would not constitute a self-sustaining population (Belzer 2002).

In the U.S., populations in small fragmented habitat patches can consist of < 25 individuals (Nazdrowicz *et al.* 2008), whereas populations in larger natural areas can exceed 1700 adults (Schwartz and Schwartz 1991). Population densities ranging from 0.8 (Nazdrowicz *et al*. 2008) to 26.9/ha (Schwartz *et al.* 1984) have been observed. Although a number of populations have densities <5/ha (Williams and Parker 1987; Ferebee and Henry 2008; Nazdrowicz *et al.* 2008), a few populations have densities of at least 16/ha (Langtimm *et al*. 1996; Pilgrim *et al*. 1997; Wilson and Ernst 2005).

Fluctuations and Trends

Although detailed population information is lacking for most sites, many states (Connecticut, Florida, Illinois, Indiana, Iowa, Maryland, Massachusetts, Michigan, Missouri, New Jersey, New York, Ohio, Oklahoma, Tennessee, Virginia, West Virginia, and Wisconsin) have reported that *T. carolina* has declined (Lieberman 1994; Holman 2012). *Terrapene carolina* appears to have been extirpated from 13 of the 31 counties it was known from in Michigan (Adler 1968; Marsack and Swanson 2009), and these counties were in the eastern and northern parts of the species' earlier distribution (Holman 2012).

Populations that have been monitored for more than a few decades all seem to have declined. A population of *T. c. carolina* monitored from 1945-1975 in Maryland declined by 50% (Stickel 1978). Subsequent surveys in 1995 indicated that the population had declined by 75% (Hall *et al*. 1999). The habitat is protected and the main cause of the decline is suspected to be changes in hydrology that exacerbated flooding. A population of *T. c. carolina* in Indiana declined from 8.9 turtles/ha in 1961 (Williams 1961) to 2.7/ha in 1983 (Williams and Parker 1987). Possible causes of the decline include habitat loss and collecting. A population limited to an 18.5 ha habitat patch in Delaware declined by over 70% from 1968 to 2002 (Nazdrowicz *et al*. 2008).

Annual survival rates for adult *T. carolina* have been estimated as 88.0% in Florida (Dodd *et al*. 2006), 93.2% in South Carolina (Brisbin *et al.* 2008), and 96.2% in Indiana (Currylow *et al.* 2011). Given the great longevity of the species, it seems probable that the latter estimate is typical in non-declining populations.

Juveniles are not commonly observed so little is known about their survivorship and recruitment. One study of *T. c. triunguis* found 100% mortality of 22 radio-tracked hatchlings in just 4 months and 100% mortality of 16 radio-tracked juveniles in 16 months in a 153-ha forested area of Texas (Koukl *et al*. 2007). If such mortality rates are common then many populations may no longer be recruiting new adults into the population fast enough to offset adult mortalities. Recruitment was extremely low in a Florida population where juveniles made up only 3% of the population (Pilgrim *et al.* 1997).

Males apparently require visual cues to locate females for mating (Belzer 2002; Belzer and Seibert 2009) and at low population densities turtles may have limited mating opportunities.

Rescue Effect

Terrapene carolina occurs in all four lower Great Lakes states that border Ontario: Ohio, Pennsylvania, New York, and Michigan. In New York, there are no longer extant populations within 100 km of the Ontario border and thus movement from New York is highly unlikely. Populations in Michigan have been documented in Monroe County (NatureServe 2011), which is less than 50 km from the Ontario border, but migration is unlikely given that the maximum known dispersal distance for *T. carolina* is only 10 km (Kiester *et al.* 1982) and both natural barriers and anthropogenic changes to habitat are likely to impede or prevent such movement. If such movements were possible, it is unlikely that such migration would allow sufficient numbers of individuals to form a breeding population given the difficulty *T. carolina* males have in locating females (Belzer 2002), as well as the high rates of nest predation (Flitz and Mullin 2006) and hatchling mortality (Koukl *et al*. 2007) that many populations face. Similar difficulties make rescue from Ohio or Pennsylvania highly improbable.

THREATS AND LIMITING FACTORS

Threat information has been gleaned from studies in the USA. If native populations of *T. carolina* still existed in Canada then these threats would be of similar or greater severity, given that southern Canada would be at the northern limit of the species' range.

Traffic mortality is a significant and increasing threat for turtles as vehicular traffic has doubled since the 1980s (US Department of Transportation 2006). Model simulations predict that "land turtles," such as Box Turtles, experience excessive annual mortality rates on roads (>5% of individuals) throughout most of the range of *T. carolina* (Gibbs and Shriver 2002). Female *T. carolina* may be more prone to road mortality as female turtles are more likely to cross or walk along roads when seeking a nesting site (Steen *et al*. 2006). *Terrapene carolina* made up 85% of the turtles killed on roads in Alabama (Dodd *et al*. 1989) and 70% of all road-killed reptiles in West Virginia (Pauley 1992). Annual road mortality was 2.6% of the estimated population at one site in Maryland (Hagood 2009). Given that *T. carolina* has been documented to move 10 km over the landscape (Kiester *et al*. 1982), road mortality could seriously reduce gene flow in areas of high road density, on roads with high traffic density or along roads with limited permeability. All three of these features are prominently present in southern Ontario (Fenech *et al*. 1996).

Collection of *T. carolina* for pets is a serious threat across the range. Limited data exist on collecting for personal use, but export data indicate that 79,122 Box Turtles were exported from the USA in 1989-1996 (Telecky 2001). The peak export year was 1994, when 22,209 were exported. The genus *Terrapene* was placed on CITES Appendix II in 1994 and the export limit from the USA is now set at zero (Thorbjarnarson *et al*. 2000). Capture of *T. carolina* for personal pets still occurs at a substantial rate. At one site in Florida, over 14 individuals of non-native sub-species were located (Heinrich 1996), suggesting individuals are sometimes moved long distances. *Terrapene carolina* is also captured for turtle races held at county fairs and festivals. Surveys indicate there are over 520 annual turtle races in 35 states (Heeb 2007), and it is estimated that over 26,000 box turtles (*T. carolina* and *T. ornata*) are temporarily captured each year for these events. Many individuals are not returned to their capture location, and re-located *T. carolina* tend to have high rates of mortality (Cook 2004; Hester *et al*. 2008). In some landscapes, *T. carolina* may use suburban environments, increasing their likelihood of encountering people. One study found individual turtles encountered humans as often as three times per year (Brisbin *et al*. 2008).

Train tracks may also pose a significant threat to *T. carolina*. Individuals have been found trapped between rails often leading to mortality (Dodd 2001; Kornilev *et al*. 2006). Kornilev *et al*. (2006) suggests that *T. carolina* can enter between rails at road crossings, where the rails are flush with the pavement, but have difficulty climbing over the rails in other areas.

Severe injuries to *T. carolina* are common. An average of 32.7 injured *T. carolina* were brought to a wildlife clinic in Tennessee annually (Schrader *et al.* 2010). Injuries were sustained from vehicles, garden equipment (e.g., mowers) and animal attacks (e.g., dogs). Thirteen *T. carolina* were reported killed from the cutting and harvesting of alfalfa and hay during a 2-year study in Delaware (Nazdrowicz *et al*. 2008). Mortality was reduced when blade heights were at least 15 cm above the ground, but some turtles were still killed because of uneven topography. Mortality has also been reported from power mowers in suburban areas (Brisbin *et al*. 2008).

Habitat fragmentation may pose a long term threat to *T. carolina*. A population in an isolated 18.5 ha wooded area surrounded by agricultural fields declined from an estimated 91 ± 7.8 *T. carolina* in 1968 to 22 ± 3.0 turtles in 2002 (Nazdrowicz *et al*. 2008). One-third of the radio-tracked turtles were found dead either from mowing or natural causes. The sex ratio became increasingly male-biased over time (Nazdrowicz *et al.* 2008). Habitat fragmentation can lead to increased mortality in turtle populations from traffic mortality and from subsidized predators (e.g., Mitchell and Klemens 2000) and increased nest predation (Temple 1987). Older *T. carolina* are associated with larger forested areas (Budischak *et al*. 2006), suggesting reduced survivorship in smaller forest patches.

Habitat fragmentation can lead to small population size and low density, further exacerbating an already-low capacity for recruitment. Belzer (2002) suggests that a density <25 adults/ha may be insufficient for a population to maintain itself. Given the ability of adults to survive over a century, small numbers may persist for decades as the population declines to extirpation, due in part to low recruitment based on poor mating success, low fertility and limited juvenile survival.

Iridoviruses of the genus *Ranavirus* have been detected in *T. carolina.* They are believed to have killed five captive individuals in North Carolina (De Voe *et al.* 2004) and 16 individuals in a repatriated population in Pennsylvania (Johnson *et al*. 2008). Iridovirus has also been detected in Alabama, Tennessee, Virginia (Allender *et al*. 2011; Allender *et al*. 2013) and Indiana (Currylow *et al.* in press). Prevalence detection rates are typically low (~1.5%) but this is characteristic of an acute disease process (Allender *et al*. 2013). Upper respiratory tract disease-like syndrome (URTD-LS) has been detected in free-ranging *T. c. carolina* from Virginia (Feldman *et al.* 2006).

Terrapene carolina is found in many areas that are prone to fire. From 10.2-21.6% of *T. carolina* perished during wet season fires in Florida (Platt *et al.* 2010) and mortality from prescribed burns is commonly observed (Frese 2003; Farrell *et al.* 2006). Some individuals have also been killed from the burning of backyard brush piles (Brisbin *et al.* 2008).

Nest predation can be quite high in many areas. Baker (2009) reported 100% of unprotected *T. carolina* nests were preyed upon at one site in Illinois.

PROTECTION, STATUS, AND RANKS

Legal Protection and Status

Terrapene carolina was listed on Appendix II of the Convention on International Trade in Endangered Species (CITES) in 1994. Listing on Appendix II still permits monitored legal trade, though the export limit from the USA is currently set at zero. *Terrapene carolina* is listed as Endangered in the state of Maine, Protected in Rhode Island and Special Concern in Connecticut, Indiana, Massachusetts, Michigan, New Hampshire, New Jersey, New York, Ohio, and Pennsylvania (Kapfer *et al*. 2013).

Non-Legal Status and Ranks

Globally, *T. carolina* has been listed as Vulnerable (van Dijk 2011), although in the United States, it has been listed as Secure (N5; Last reviewed Oct. 31, 1996: NatureServe 2014). Across its range in the USA it is listed as Critically Imperilled (S1) in Maine and New Hampshire; Threatened to Vulnerable (S2/3) in Michigan; Vulnerable (S3) in District of Columbia, Massachusetts, and New York; Vulnerable/Apparently Secure (S3/S4) in Pennsylvania; Apparently Secure (S4) in Arkansas, Connecticut, Kansas, Rhode Island, Tennessee, and Virginia; Apparently Secure/Secure (S4/S5) in Ohio; Secure (S5) in Alabama, Delaware, Florida, Georgia, Illinois, Kentucky, Louisiana, Maryland, Mississippi, New Jersey, North Carolina, Oklahoma, Texas, West Virginia. It is not-ranked (SNR) in Indiana, Missouri, and South Carolina; and its status is unknown (SU) in Iowa.

Habitat Protection and Ownership

No current native populations of *T. carolina* are known to exist in Canada and hence no habitat is protected for this species.

ACKNOWLEDGEMENTS AND AUTHORITIES CONTACTED

A number of people provided valuable information which improved this report. The report writer would like to thank Tammy Dobbie (Point Pelee National Park), Robert J. Pearce (Museum of Ontario Archaeology, University of Western Ontario), Julia Phillips (Adopt-a-Pond Coordinator, Toronto Zoo), Scott Gillingwater (Upper Thames River Conservation Authority), and Michele Steigerwald (Canadian Museum of Nature). Beneficial review comments were provided by Ron Brooks, Scott Gillingwater, Tom Herman and Jacqueline Litzgus.

INFORMATION SOURCES

Adler, K.K. 1968. Turtles from archaeological sites in the Great Lakes Region. The Michigan Archaeologist 14(3-4): 147-163.

Adler, K.K. 1970. The influence of prehistoric man on the distribution of the box turtle. Annals of the Carnegie Museum 41:263-280.

Allender, M.C., M. Abd-Eldaim, J. Schumacher, D. McRuer, L.S. Christian, and M. Kennedy. 2011. PCR prevalence of *Ranavirus* in free-ranging Eastern Box Turtles (*Terrapene carolina carolina*) at rehabilitation centers in three southeastern US states. Journal of Wildlife Diseases 47:759-764.

Allender, M.C., M.A. Mitchell, D. McRuer, S. Christian, and J. Byrd. 2013. Prevalence, clinical signs, and natural history characteristics of Frog Virus 3-like infections in Eastern Box Turtles (*Terrapene carolina carolina*). Herpetological Conservation and Biology 8:308-320.

Amato, M.L., R.J. Brooks, and J. Fu. 2008. A phylogeographic analysis of populations of the wood turtle (*Glyptemys insculpta*) throughout its range. Molecular Ecology 17:570-581.

Baker, J.M. 2009. Home range and movement of the Eastern Box Turtle (*Terrapene carolina*) in east central Illinois. Unpublished master's thesis. University of Illinois at Urbana-Champaign. 78 pp.

Barbour, R.W. 1950. The reptiles of Big Black Mountain, Harlan County, Kentucky. Copeia 1950:100-107.

Belzer, B. 2002. A nine year study of Eastern Box Turtle courtship with implications for reproductive success and conservation in a translocated population. Turtle and Tortoise Newsletter 6:17-26.

Belzer, W.R. and S. Seibert. 2009. How do male box turtles find mates? Turtle and Tortoise Newsletter 13:11-21.

Bider, J. R. et S. Matte. Compilers. 1991. Atlas des amphibians et des reptiles du Québec 1988-89. Version detailes. Societe d'Histoire Naturelle de la Vallee du St-Laurent, Ste-Anne-de-Bellevue, Québec, et Ministere du Loisir, de la Chasse et de la Peche, Direction de la Gestion des Especes et des Habitats, Service des etudies ecologiques, Québec.

Bleakney, J.S. 1958. The significance of turtle bones from archaeological sites in southern Ontario and Quebec. Canadian Field-Naturalist. 72:1-5.

Boucher, T.P. 1999. Population, growth, and thermal ecology of the Eastern Box Turtle, *Terrapene carolina carolina* (L.), in Fairfax County, Virginia. PhD dissertation. George Mason University, Fairfax, Virginia.

Bradley, J.W. 1987. Evolution of the Onondaga Iroquois: Accommodating change, 1500-1655. Syracuse University Press, Syracuse, New York. xv + 252 pp.

Braun, J. and G.R. Brooks Jr. 1986. Box turtles (*Terrapene carolina*) as potential agents for seed dispersal. American Midland Naturalist 117:312–318.

Brisbin, Jr, I.L., R.A. Kennamer, E.L. Peters, and D.J. Karapatakis. 2008. A long-term study of Eastern Box Turtles (*Terrapene c. carolina*) in a suburban neighbourhood: survival characteristics and interactions with humans and conspecifics. In J.C. Mitchell and R.E.J. Brown (eds.), Urban Herpetology. Society of the Study of Amphibians and Reptiles. Herpetological Conservation 3:373-385.

Browne, C.L. 2003. The status of turtle populations in Point Pelee National Park. Unpublished master's thesis. Lakehead University. 114 pp.

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

Buchman, A.B., J.C. Cureton II, W.I. Lutterschmidt, and E.D. Wilson. 2010. Seasonal occurrence of activity and reproduction of the Three-toed Box Turtle (*Terrapene carolina triunguis*) in east Texas. BIOS 81:84-90.

Budischak, S.A., J.M. Hester, S.J. Price, and M. E. Dorcas. 2006. Natural history of *Terrapene carolina* (box turtles) in an urbanized landscape. Southeastern Naturalist 5:191-204.

Burke, R. and W. Capitano. 2011a. Nesting ecology and hatching success of the Eastern Box Turtle, *Terrapene carolina*, on Long Island, New York. American Midland Naturalist 165:137-142.

Burke, R. and W. Capitano. 2011b. Eastern Box Turtle,*Terrapene carolina*, neonate overwintering ecology on Long Island, New York. Chelonian Conservation and Biology 10:256-259.

Bush, F.M. 1959. Foods of some Kentucky herptiles. Herpetologica 15:73-77.

Butler, J.M., C.K. Dodd Jr, M. Aresco, and J.D. Austin. 2011. Morphological and molecular evidence indicates that the Gulf Coast Box Turtle (*Terrapene carolina major*) is not a distinct evolutionary lineage in the Florida Panhandle. Biological Journal of the Linnean Society 102:889-901.

Clark, W.S. 1982. Turtles as a food source of nesting bald eagles in the Chesapeake Bay region. Journal of Field Ornithology 53:49-51.

Claussen, D.L., M.P. Daniel, S. Jiang, and N.A. Adams. 1991. Hibernation in the Eastern Box Turtle, *Terrapene c. carolina*. Journal of Herpetology 25:334-341.

Congello, K. 1978. Nesting and egg laying behavior in *Terrapene carolina*. Proceedings of the Pennsylvania Academy of Sciences 52:51-56.

Cook, F.R. 1974. The amphibians and reptiles of Point Pelee National Park: Species list and comment. Unpublished report to Point Pelee National Park, Leamington, Ontario.

Cook, R.P. 2004. Dispersal, home range establishment, survival, and reproduction of translocated Eastern Box Turtles, *Terrapene c. carolina*. Applied Herpetology 1:197-228.

COSEWIC. 2002. COSEWIC assessment and status report on the Eastern Box turtle *Terrapene carolina carolina* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 34 pp.

Costanzo, J.P. and D.L. Claussen. 1990. Natural freeze tolerance in the terrestrial turtle, *Terrapene carolina*. Journal of Experimental Zoology 254:228-232.

Cureton II, J.C., A.B. Buchman, R. Deaton, and W.I. Lutterschmidt. 2011. Molecular analysis of hybridization between the Box Turtles *Terrapene carolina* and *T. ornata*. Copeia 2011:270-277.

Currylow, A.F., P.A. Zollner, B.J. MacGowan, and R.N. Williams. 2011. A survival estimate of Midwestern adult Eastern Box Turtles using radiotelemetry. American Midland Naturalist 165:143-149.

Currylow, A.F., A.J. Johnson, and R.N. Williams. In press. Evidence of Ranavirus infections among sympatric larval amphibians and Box Turtles. Journal of Herpetology.

De Voe, R., K. Geissler, S. Elmore, D. Rotstein, G. Lewbart, and J. Guy. 2004. Ranavirus-associated morbidity and mortality in a group of captive Eastern Box Turtles (*Terrapene carolina carolina*). Journal of Zoo and Wildlife Medicine. 35(4):534-543. 2004

Dimond, M.T. 1983. Sex of turtle hatchlings as related to incubation temperature. Proceedings of the 6th Reptile Symposium on Captive Propagation, Husbandry, and Zoological Conservation. Thurmont, Maryland. pp. 88-101.

Dodd, Jr, C.K. 1997a. Population structure and the evolution of sexual size dimorphism and sex ratios in an insular population of Florida Box Turtles (*Terrapene carolina bauri*). Canadian Journal of Zoology 75:1495-1507.

Dodd, Jr, C.K. 1997b. Clutch size and frequency in Florida Box Turtles (*Terrapene carolina bauri*): implications for conservation. Chelonian Conservation and Biology 2: 370-377.

Dodd, Jr, C.K. 2001. North American Box Turtles: A Natural History. University of Oklahoma Press, Norman, Oklahoma.

Dodd, Jr, C.K., K.M. Enge, and J.N. Stuart. 1989. Reptiles on the highways in north-central Alabama, USA. Journal of Herpetology 23:197-200.

Dodd, Jr, C.K., R. Franz, and L.L. Smith. 1994. Activity patterns and habitat use of box turtles (*Terrapene carolina bauri*) on a Florida island, with recommendations for management. Chelonian Conservation and Biology 1:97-106.

Dodd, Jr, C.K., A. Ozgul, and M.K. Oli. 2006. The influence of disturbance events on survival and dispersal rates of Florida Box Turtles. Ecological Applications 16:1936–1944.

Dolbeer, R.A. 1971. Winter behavior of the Eastern Box Turtle, *Terrapene c. carolina* L., in Tennessee. Copeia 1971:758-760.

Donaldson, B.M. and A.C. Echternacht. 2005. Aquatic habitat use relative to home range and seasonal movement of Eastern Box Turtles (*Terrapene carolina carolina*: Emydidae) in eastern Tennessee. Journal of Herpetology 39:248-287.

Ernst, C.H. and J.E. Lovich. 2009. Turtles of the United States and Canada. Second edition. Johns Hopkins University Press, Baltimore, Maryland. xii + 827 pp.

Ewert, M.A. and C.E. Nelson. 1991. Sex determination in turtles: Diverse patterns and some possible adaptive values. Copeia 1991:50-69.

Ewert, M.A., C.R. Etchberger, and C.E. Nelson. 2004. Turtle sex determining modes and TSD patterns, and some TSD pattern correlates. In N. Valenzuela and V.A. Lance (eds.), Temperature-dependent Sex Determination in Vertebrates. Smithsonian Institution Press, Washington, DC. pp. 21-32.

Ewing, H.E. 1943. Continued fertility in female box turtles following mating. Copeia 1943:112-114.

Farrell, T.M., C.K. Dodd Jr, and P.G. May. 2006. *Terrapene carolina* – Eastern Box Turtle. Chelonian Research Monograph. 3:235-248.

Feldman, S.H., J. Wimsatt, R.E. Marchang, A.J. Johnson, W. Brown, J.C. Mitchell, and J.M. Sleeman. 2006. A novel mycoplasma detected in association with upper respiratory disease syndrome in free-ranging Eastern Box Turtles (*Terrapene carolina carolina*) in Virginia. Journal of Wildlife Diseases. 42:279-89.

Fenech, A., Taylor, B., Hansell, R. and Whitelaw, G. (1996). Major road changes in southern Ontario 1935-1995: Implications for protected areas. from*:http://www.utoronto.ca/imap/papers/road_changes.htm.*

Ferebee, K.B. and P.F.P. Henry. 2008. Movements and distribution of Terrapene carolina in a large urban area, Rock Creek National Park, Washington, D.C. In J.C. Mitchell and R.E.J. Brown (eds.), Urban Herpetology. Society of the Study of Amphibians and Reptiles. Herpetological Conservation 3:48-55.

Flitz, B.A. and S.J. Mullin. 2006. Nest-site selection in the Eastern Box Turtle, *Terrapene carolina carolina*, in Illinois. Chelonian Conservation and Biology 5:309-312.

Franz, R. and C.K. Dodd, Jr. 1993. Raccoon predation on Florida Box Turtles at Egmont Key, Hillsborough County, Florida. Florida Scientist 56 (Supplement 1):23.

Frese, P.W. 2003. Tallgrass prairie amphibian and reptile assemblage. Fire mortality. Herpetological Review 34:159-160.

Froom, B. 1976. The Turtles of Canada. McLelland Stewart Toronto.

Gibbons, W. 1983. Their Blood Runs Cold. University of Alabama Press. Tuscaloosa Alabama. 180 pp.

Gibbs, J.P. and W.G. Shriver. 2002. Estimating the effects of road mortality on turtle populations. Conservation Biology 16:1647-1652.

Gibbs, J. P., A. R. Breisch, P. K. Ducey, G. Johnson, J. L. Behler, and R. C. Bothner. 2007. The Amphibians and Reptiles of New York state. Oxford University Press, New York.

Godfrey, W.E. 1986. The Birds of Canada. Revised edition. National Museum of Natural Sciences, Ottawa. 595 pp.

Graham, T. and V.H. Hutchison. 1969. Centenarian box turtles. International Turtle and Tortoise Society Journal 3:25-29.

Griffith, J.A., S.V. Stehman, and T.R. Loveland. 2003. Landscape trends in mid-Atlantic and southeastern United States ecoregions. Environmental Management 32:572-588.

Hagood, S. 2009. Genetic differentiation of selected eastern box turtle (*Terrapene carolina*) populations in fragmented habitats, and a comparison of road-based mortality rates to population size. Unpublished PhD dissertation, University of Maryland, College Park, Maryland. xii + 157 pp.

Hall, R.J. 2003. The Eastern Box Turtle at the Patuxent Wildlife Research Centre 1940s to present: another view. Experimental Gerontology 38:773-776.

Hall, R.J., P.F.P. Henry, and C.M. Bunck. 1999. Fifty-year trends in a box turtle population in Maryland. Biological Conservation 88:165-172.

Hamalainen, P. 1999. An analysis of bone artifacts from the Sidey-Mackay site. Unpublished report to the Petun Research Institute, North York, Ontario. 16 pp.

Harding, J.H. 1997. Amphibians and Reptiles of the Great Lakes Region. University of Michigan Press, Ann Arbor, Michigan. xvi + 378 pp.

Heeb, A. 2007. The unseen effects of box turtle races. Conference abstract. Third box turtle conservation workshop, 9-10 November, 2007, Laurel, Maryland. http://www.boxturtlesintrouble.org/abstracts.html. Accessed 15 March, 2012.

Heinrich, G. 1996. Box turtle study and conservation effort in Pinellas County, Florida. Box Turtle Research and Conservation Newsletter 4:12.

Henry, P.F.P. 2003. The Eastern Box Turtle at the Patuxent Wildlife Research Center 1940s to the present: another view. Experimental Gerontology 38: 773-776.

Hester, J.M., S.J. Price, and M.E. Dorcas. 2008. Effects of relocation on movements and home ranges of Eastern Box Turtles. Journal of Wildlife Management 72:772-777.

Holman, J.A. 1995. Pleistocene Amphibians and Reptiles in North America. Oxford University Press, New York, New York. 243 pp.

Holman, J.A. 2001. In Quest of Great Lakes Ice Age Vertebrates. Michigan State University Press, East Lansing, Michigan. ix + 230 pp.

Holman, J.A. 2012. The Amphibians and Reptiles of Michigan. Wayne State University Press, Detroit Michigan. 291 pp.

Hulse, A.C., C.J. McCoy, and E.J. Censky. 2001. Amphibians and Reptiles of Pennsylvania and the Northeast. Cornell University Press, Ithaca, New York. xi + 419 pp.

Hutchison, V.H., A. Vinegar, and R.J. Kosh. 1966. Critical thermal maxima in turtles. Herpetologica 22:32-41.

Iglay, R.B., J.L. Bowman, N.H. Nazdrowicz. 2007. Eastern Box Turtle (*Terrapene carolina carolina*) movements in a fragmented landscape. Journal of Herpetology 41:102-106.

Jennings, A.H. 2007. Use of habitats and microenvironments by juvenile Florida Box Turtles, *Terrapene carolina bauri*, on Egmont Key. Herpetologica 63:1-10.

Johnson, A.J., A.P. Pessier, J.F.X. Wellehan, A. Childress, T.M. Norton, N.L. Stedman, D.C. Bloom, W.R. Belzer, V.R. Titus, R. Wagner, J. Brooks, J. Spratt, and E.R. Jacobson. 2008. Ranavirus infection of free-ranging and captive box turtles and tortoises in the United States. Journal of Wildlife Diseases 44:851-863.

Johnson, C.A. 1994. Cumulative impacts to wetlands. Wetlands 14:49-55.

Jones, S.C., W.J. Jordan IV, S.J. Meiners, A.N. Miller, and A.S. Methven. 2007. Fungal spore dispersal by the Eastern Box Turtle (*Terrapene carolina carolina*). American Midland Naturalist 157:121-126.

Kapfer, J.M., D.J. Muñoz, J.D. Groves, and R.W. Kirk. 2013. Home range and habitat preferences of Eastern Box Turtles (*Terrapene carolina* Linnaeus, 1758) in the Piedmont Ecological Province of North Carolina (USA). Herpetology Notes 6:251-260.

Kautz, R.S. 1998. Land use and land cover trends in Florida 1936-1995. Florida Scientist 61:171-187.

Kiester, A.R., C.W. Schwartz, and E.R. Schwartz. 1982. Promotion of gene flow by transient individuals in an otherwise sedentary population of box turtles (*Terrapene carolina triungis*). Evolution 36:617-619.

Kipp, R.L. 2003. Nesting ecology of the Eastern Box Turtle (*Terrapene carolina carolina*) in a fragmented landscape. Unpublished master's thesis. University of Delaware. 78 pp.

Klemens, M.L. 1993. Amphibians and Reptiles of Connecticut and Adjacent Regions. Bulletin No. 112 of the State Geological and Natural History Survey of Connecticut. Hartford, Connecticut. 318 pp.

Klemens, M.L. (editor). 2000. Turtle Conservation. Smithsonian Institution. Washington DC. 332 pp.

Kornilev, Y.V., S.J. Price, and M.E. Dorcas. 2006. Between a rock and a hard place: responses of Eastern Box Turtles (*Terrapene carolina*) when trapped between railroad tracks. Herpetological Review 37:145-148.

Koukl, J.F., A. Byboth, K. Rispin, D. Bolanowski, J. Keyes. 2007. Radiotelemetry studies on hatchling, juvenile, resident and relocated adult, Three-toed Box Turtles (*Terrapene carolina triunguis*) in East Texas. Conference abstract. Third box turtle conservation workshop, 9-10 November, 2007, Laurel, Maryland. http://www.boxturtlesintrouble.org/abstracts.html. Accessed 15 March, 2012.

Kuhns, A.R. 2004. Ecological adaptations of sympatric box turtles (*Terrapene*). Unpublished master's thesis, Illinois State University, Normal, Illinoise. 282 pp.

Langtimm, C.A., C.K. Dodd, Jr, and R. Franz. 1996. Estimates of abundance of box turtles (*Terrapene carolina bauri*) on a Florida island. Herpetologica 52:496-504.

Lieberman, S. 1994. Can CITES save the box turtle? Endangered Species Technical Bulletin 19(5):1, 16-17.

Liu, H., S.G. Platt, and C.K. Borg. 2004. Seed dispersal by the Florida Box Turtle (*Terrapene carolina bauri*) in pine rockland forests of the lower Florida Keys, United States. Oecologia 138:539-546.

Logier, E.B.S. 1925. Notes on the herpetology of Point Pelee, Ontario. Canadian Field-Naturalist 39:91-95.

Madden, R. 1975. Home range, movements, and orientation in the eastern box turtle, *Terrapene carolina carolina*. Unpublished PhD dissertation. City University of New York.

Marchand, M.N., M.M. Quinlan, and C.W. Swarth. 2003. Movement patterns and habitat use of Eastern Box Turtles at the Jug Bay Wetlands Sanctuary, Maryland. *In* C.W. Swarth, W.M. Roosenburg, and E. Kiviat (eds.), Conservation and Ecology of Turtles of the Mid-Atlantic Region: A symposium. Bibliomania, Salt Lake City, Utah. pp. 54-61.

Marsack, K. and B.J. Swanson. 2009. A genetic analysis of the impact of generation time and road-based habitat fragmentation on eastern box turtles (*Terrapene c. carolina*). Copeia 2009:647-652.

Martin, B.T., N.P. Bernstein, R.D. Birkhead, J.F. Koukl, S.M. Mussmann, J.S. Placyk Jr. 2013. Sequence-based molecular phylogenetics and phylogeography of the American box turtles (*Terrapene* spp.) with support from DNA barcoding. Molecular Phylogenetics and Evolution 68:119-134.

McKnight, D.T. 2011. Observed plant preferences of Eastern Box Turtles (*Terrapene carolina carolina*) in a Maryland forest. Herpetology Notes 4:97-102.

Mitchell, J.C. and M.W. Klemens. 2000. Primary and secondary effects of habitat alteration. *In*, M.W. Klemens (ed.), Turtle Conservation. Smithsonian Institution Press, Washington, DC. pp. 5-32.

Montgomery, W.B. 1996. Predation by the fire ant, *Solenopsis invicta*, on the Three-toed Box Turtle, *Terrapene carolina triunguis*. Bulletin of the Chicago Herpetological Society 31:105-106.

Nazdrowicz, N.H., J.L. Bowman, and R.R. Roth. 2008. Population ecology of the Eastern Box Turtle in a fragmented landscape. Journal of Wildlife Management 72:745-753.

NatureServe. 2011. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. Accessed 8 March, 2012.

NHIC. 2012. Element Summary Report for *Terrapene carolina*. Natural Heritage Information Centre, Ontario Ministry of Natural Resources, Peterborough, Ontario. www.biodiversityexplorer.mnr.gov.on.ca/nhicWEB/nhicIndex.jsp Accessed 24 February, 2012.

Oliver, J.A. 1955. North American Amphibians and Reptiles. D. Van Norstrand Company. New York, NY. 359 pp.

Patch, C.L. 1919. A rattlesnake, melano garter snakes and other reptiles from Point Pelee, Ontario. Canadian Field-Naturalist 33:60-61.

Pauley, T.K. 1992. Report on amphibian and reptile roadkills in West Virginia. Proceedings of the West Virginia Academy of Sciences 64: 32.

Pearce. C.M. 1993. Coping with forest fragmentation in southwestern Ontario. In Size and Integrity Standards for Natural Heritage Areas in Ontario. Proceedings of a seminar. Edited by S.F. Poser, W.J. Crins, and T.J. Beechey. Parks and Natural Heritage Branch, Ontario Ministry of Natural Resources, Huntsville, Ontario. pp.100-113.

Pearce, R.J. 2005. Turtles from turtle island: An archaeological perspective from Iroquoia. Ontario Archaeology 79/80:88-108.

Pendergast, J.F. 1991. The Massawomeck: Raiders and traders into the Chesapeake Bay in the seventeenth century. American Philosophical Society. 101 pp.

Pilgrim, M.A., T.M. Farrell, and P.G. May. 1997. Population structure, activity, and sexual dimorphism in a central Florida population of box turtles, *Terrapene carolina bauri*. Chelonian Conservation and Biology 2:483-488.

Pimm, S.L. and R.A. Askins. 1995. Forest losses predict bird extinctions in eastern North America. Proceedings of the National Academy of Sciences 92:9343-9347.

Platt, S.G., H. Liu, and C.K. Borg. 2010. Fire ecology of the Florida Box Turtle (*Terrapene carolina bauri* Taylor) in the Pine Rocklands Forests of the lower Florida Keys. Natural Areas Journal 30:254-260.

Sava, Y., C.W. Swarth, J. Gupchup, and K. Szlavecz. 2010. Thermal environments of overwintering eastern box turtles (*Terrapene carolina carolina*). Canadian Journal of Zoology 88:1086-1094.

Schrader, G.M., M.C. Allender, and A. Odoi. 2010. Diagnosis, treatment, and outcome of Eastern Box Turtles (*Terrapene carolina carolina*) presented to a wildlife clinic in Tennessee, USA, 1995-2007. Journal of Wildlife Diseases 46:1079-1085.

Schwartz, E.R., and C.W. Schwartz. 1991. A quarter-century study of survivorship in a population of Three-toed Box Turtles in Missouri. Copeia1991:1120-1123.

Schwartz, E.R., C.W. Schwartz, and A.R. Kiester. 1984. The Three-toed Box Turtle in central Missouri. Part II. A nineteen year study of home range, movements and population. Missouri Department of Conservation, Terrestrial Series no. 12. Jefferson City, Missouri.

Snow, D.R. 1996. The Iroquois. Blackwell Publishers, Malden, Massachusetts. xvii + 270 pp.

Steen, D.A., M.J. Aresco, S.G. Beilke, B.W. Compton, E.P. Condon, C.K. Dodd, Jr., H. Forrester, J.W. Gibbons, J.L. Greene, G. Johnson, T.A. Langen, M.J. Oldham, D.N. Oxier, R.A. Saumure, F.W. Schueler, J.M. Sleeman, L.L. Smith, J.K. Tucker, J.P. Gibbs. 2006. Relative vulnerability of female turtles to road mortality. Animal Conservation 9:269-273.

Stickel, L.F. 1950. Populations and home range relationships of the box turtle, *Terrapene c. carolina* (Linnaeus). Ecological Monographs 20:351-378.

Stickel, L.F. 1978. Changes in a box turtle population during three decades. Copeia 1978:221-225.

Stickel, L.F. 1989. Home range behavior among box turtles (*Terrapene c. carolina*) of a bottomland forest in Maryland. J. Herpetol. 23:40-44

Storey, K.B., J.R. Layne, M.M. Cutwa, T.A. Churchill, and J.M. Storey. 1993. Freezing survival and metabolism of box turtles, *Terrapene carolina*. Copeia 1993:628-634.

Swarth, C. and M. Quinlan. 2007. Differences in the home range of male and female Eastern Box Turtles. Conference abstract. Third box turtle conservation workshop, 9-10 November, 2007, Laurel, Maryland. http://www.boxturtlesintrouble.org/abstracts.html. Accessed 15 March, 2012.

Telecky, T.M. 2001. United States import and export of life turtles and tortoises. Turtle and Tortoise Newsletter 4:8-13.

Temple, S.A. 1987. Predation on turtle nests increases near ecological edges. Copeia 1987:250-252.

Thorbjarnarson, J., C.J. Lagueux, D. Bolze, M.W. Klemens, and A.B. Meylan. 2000. Human use of turtles: A worldwide perspective. *In*, M.W. Klemens (ed.), Turtle Conservation. Smithsonian Institution Press, Washington, DC. pp. 33-84.

Tucker, J.K. 1999. Reproductive output of *Terrapene carolina*, *Chrysemys picta*, and *Sternotherus odoratus* from west-central Illinois. Bulletin of the Maryland Herpetological Society 35:61-75.

Tucker, J.K., R.S. Funk, and G.L.Paukstis. 1978. The adaptive significance of egg morphology in two turtles (*Chrysemys picta* and *Terrapene carolina*). Bulletin of the Maryland Herpetological Society 14:10-22.

US Department of Transportation. 2006. Highway statistics series table VM-2. Washington, DC. http://fhwainter.fhwa.dot.gov./policy/ohpi/qftravel.htm

van Dijk, P.P. 2011. *Terrapene carolina*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. <www.iucnredlist.org>. Downloaded on 22 October 2013.

Vermont Reptile and Amphibian Atlas. 2012. Eastern Box Turtle species account. http://community.middlebury.edu/~herpatlas/ Accessed 10 February 2012.

Watt, R. 1972. Data on Eastern Box Turtles found at Point Pelee National Park. Unpublished report to Point Pelee National Park, Leamington, Ontario.

Willey, L.L. 2010. Spatial ecology of Eastern Box Turtles (*Terrapene c. carolina*) in central Massachusetts. Unpublished doctoral dissertation. University of Massachusetts.

Williams Jr, E.C. 1961. A study of the box turtle, *Terrapene carolina carolina* (L.), population in Allee Memorial Woods. Proceedings of the Indiana Academy of Sciences 71:399-406.

Williams Jr, E.C. and W. S. Parker. 1987. A long-term study of a box turtle (*Terrapene carolina*) population at Allee Memorial Woods, Indiana, with emphasis on survivorship. Herpetologica 43:328-335.

Wilson, G.L. and C.H. Ernst. 2005. Reproductive ecology of the *Terrapene carolina carolina* (Eastern Box Turtle) in central Virginia. Southeastern Naturalist 4:689-702.

Yagi A.R., A. Brant and R.Tervo. 2009. Niagara Region Natural Areas Inventory Reptile and Amphibian Study 2006 to 2008. Ontario Ministry of Natural Resources and Land Care Niagara unpublished report for the Natural Areas Inventory prepared for the Niagara Peninsula Conservation Authority.

BIOGRAPHICAL SUMMARY OF REPORT WRITER

David Seburn completed his MSc from the University of Alberta. He is an independent consultant specializing in the conservation of amphibians and reptiles. He was a member of the Ontario Multi-Species Turtles at Risk Recovery Team when it existed and is the author of a draft recovery strategy for the species at risk turtles of Ontario.

NOTE: A threats calculator was not completed for this species because it is Extirpated.