

**THE STATUS OF TURTLE POPULATIONS
IN POINT PELEE NATIONAL PARK**

by

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**Masters Thesis Submitted in Partial Fulfillment of the
Requirements for the Degree of Master of Science in Biology**

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ABSTRACT

Loss of biodiversity has been an irrepressible consequence of growing human populations and resource use. Some groups, such as turtles, are especially vulnerable because of their natural history. Turtles are threatened by habitat loss, population isolation, subsidized predators, road mortality, collection as pets, interactions with exotic species, human recreation, disease, and effects of contaminants. Parks are playing an increasingly important role of conserving natural habitats and populations in a mosaic of human development. Point Pelee National Park was historically the location of greatest turtle diversity in Canada. Recently, park staff and researchers have been concerned regarding population declines and possible extirpation for a number of the turtle species found at Point Pelee. My objectives were to determine species present, their population sizes and structure, and to examine possible causes of decline.

I used mark-recapture to determine the population sizes and population structure of turtle species present. Captured turtles were marked, measured, sexed, and released at the site of capture. I compared my data to 1972 data on turtles at Point Pelee. I searched for turtle nests during the nesting season (late May to early July) in 2001 and 2002. Nests were randomly assigned to either a predation or a contaminant study. I monitored nests in the predation study to compare predation rates among species and areas. Predator surveys were also conducted along roadsides. Nests in the contaminant study were protected from mammalian predation to examine hatching success and three eggs per nest were collected for contaminant analysis. Nests of turtles designated as 'species at risk' were protected but not included in the predation or contaminant study. I examined nest protection effectiveness by comparing predation rates on protected and unprotected nests. Turtles killed by vehicles were recorded and models were created to predict the potential effects of road mortality and nest predation on turtle populations.

I marked 1599 turtles (867 painted, 441 snapping, 95 Blanding's, 172 map, and 24 stinkpot) from 5 May 2001 to 22 August 2002. Two spiny softshells and 3 red-eared sliders were observed. No spotted turtles were observed during this study. Blanding's and snapping turtles have experienced a clear shift towards larger size classes since 1972, which suggests juvenile recruitment into these populations is limited. I found 178 turtle nests in 2001/2002. Predation rates on nests ranged from 62.5 % to 100 % among areas. Raccoon relative abundance was greatest along park roadsides. Hatching success was significantly lower in contaminated areas compared to other sites. Nest protection methods were highly effective in preventing mammalian predation. Road mortality models suggested that road mortality alone could cause population declines in Blanding's turtles but not likely in snapping and painted populations. However, high nest predation levels are a much more serious risk to these populations. High nest predation of 70 % predicted serious declines in Blanding's populations but not snapping and painted populations. However, predation rates of 90 % cannot be sustained by any species.

Despite the short duration of this study, substantial evidence suggests that several serious threats to turtle conservation exist at Point Pelee National Park. Of seven native turtle species historically recorded at Point Pelee, six remain extant; but only one has a large healthy population. High levels of nest predation have limited recruitment, causing a shift in age structure. The present community is slightly less diverse than historically, and threats to all species conservation are apparent. Turtle populations at Point Pelee, like many other turtles worldwide, are imperiled by a multitude of threats.

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TABLE OF CONTENTS

ABSTRACT.....	ii
ACKNOWLEDGEMENTS.....	iv
TABLE OF CONTENTS.....	v
LIST OF TABLES.....	vi
LIST OF FIGURES.....	vii
INTRODUCTION.....	1
METHODS AND STUDY SYSTEM	
Study Area.....	8
Historical Species Records and Prior Surveys.....	10
General Statistical Methods.....	16
Population Sizes and Structure.....	17
Habitat Use and Movements.....	25
Comparison to other Communities.....	27
Nest Protection.....	27
Nest Predation Rates.....	28
Hatching Success and Contaminants.....	31
Road Mortality and Population Models.....	33
Blanding’s Turtle Population Models.....	33
Snapping Turtle Population Models.....	35
Painted Turtles Populations Models.....	37
Environmental Stochasticity.....	38
RESULTS	
Population Sizes and Structure.....	39
Habitat Use and Movements.....	47
Comparison to other Communities.....	55
Nest Season.....	61
Nest Protection.....	61
Nest Predation Rates.....	64
Hatching Success and Contaminants.....	65
Road Mortality and Population Models.....	70
Road Mortality.....	70
Blanding’s Turtle Population Models.....	70
Snapping Turtle Population Models.....	76
Painted Turtle Population Models.....	79
DISCUSSION.....	81
Population Sizes and Structure.....	82
Habitat Use and Movements.....	89
Comparison to other Communities.....	91
Nest Season.....	92
Nest Protection.....	93
Nest Predation Rates.....	93
Hatching Success and Contaminants.....	94
Road Mortality and Population Models.....	96
CONCLUSIONS.....	100
REFERENCES.....	101

LIST OF TABLES

Table 1. List of turtle species recorded in Point Pelee National Park.....	12
Table 2. Historical surveys.....	15
Table 3. Painted turtle sex ratios (observed and calculated).....	24
Table 4. Species rank and number of individuals captured at Point Pelee.....	41
Table 5. Turtle captures for each trap type.....	44
Table 6. Distribution of turtle species throughout 14 trapping sites in Point Pelee.....	51
Table 7. Multiple regression results for species richness.....	51
Table 8. Correlations (Pearson r) between habitat variables and density for each species.....	53
Table 9. Multiple regression results for turtle density and habitat variables.....	54
Table 10. Greatest distances (m) travelled by each species and gender.....	55
Table 11. Species assemblages at Hillman Marsh and Point Pelee in 2001/2002.....	56
Table 12. Sex ratios and G -test results for Hillman Marsh and Point Pelee.....	60
Table 13. Species diversity (inverse of Simpson's index) of turtles at four sites in Ontario and Michigan.....	60
Table 14. Number of snapping turtle nests (predated/found) for six different protection methods.....	61
Table 15. Percent hatching success in 2002 for each species and for snapping turtles among sites.....	66
Table 16. Carapace length (cm) and weight (g) of hatchlings for five species of turtles in Point Pelee in 2001/2002.....	67
Table 17. Carapace lengths (cm) and weights (g) for snapping turtle hatchlings between years and among sites (2002).....	68
Table 18. Blanding's turtle extinction risks in Point Pelee as percent chance of extinction for 11 different scenarios.....	75
Table 19. Snapping turtle extinction risks in Point Pelee as percent chance of extinction for nine different scenarios.....	79
Table 20. Painted turtle extinction risks in Point Pelee as percent chance of extinction for seven different scenarios	81

LIST OF FIGURES

Fig. 1. Trapping sites for turtles in Point Pelee National Park (2001-2002).....	9
Fig. 2. Original extent of the Point Pelee marsh system.....	11
Fig. 3. Hoop trap.....	18
Fig. 4. Basking trap.....	19
Fig. 5. Folding live trap.....	20
Fig. 6. Wire screen topped nest box used to protect turtle nests from mammalian predation.....	29
Fig. 7. Wire screen nest cage used to protect turtle nests from mammalian predation in sandy areas.....	30
Fig. 8. Number of each species observed during visual surveys in 2001.....	40
Fig. 9. Distribution of snapping turtle carapace lengths (\approx age).....	45
Fig. 10. Distribution of Blanding's turtle carapace lengths (\approx age).....	46
Fig. 11. Distribution of painted turtle carapace lengths (\approx age).....	48
Fig. 12. Distribution of map turtle carapace lengths (age), 2001/2002.....	49
Fig. 13. Distribution of stinkpot turtle carapace lengths (age), 2001/2002.....	50
Fig. 14. Distribution of snapping turtle carapace lengths (\approx age) at Hillman and Point Pelee.....	57
Fig. 15. Distribution of Blanding's turtle carapace lengths (\approx age) at Hillman and Point.....	58
Fig. 16. Distribution of painted turtle carapace lengths (\approx age) at Hillman and Point Pelee.....	59
Fig. 17. Peak nesting activity of turtles in Point Pelee in 2001.....	62
Fig. 18. Peak nesting activity of turtles in Point Pelee in 2002.....	63
Fig. 19. A hatchling snapping turtle with abnormalities.....	69
Fig. 20. Snapping turtle with injuries from a vehicle.....	71
Fig. 21. Snapping turtle having carapace patched.....	72
Fig. 22. Trajectory summary for the Blanding's model based on Ramas simulation.....	74
Fig. 23. Trajectory summary for the snapping turtle model based on Ramas simulation.....	77
Fig. 24. Trajectory summary for the snapping model with extremely high nest predation based on Ramas simulation.....	78
Fig. 25. Trajectory summary for the painted model based on Ramas simulation.....	80

INTRODUCTION

A fundamental goal of ecology and conservation biology is to explain and conserve biodiversity. Biological diversity is being lost as a consequence of increasing human populations and use of natural resources. Human activities tend to fragment natural habitats with three basic consequences: loss of habitat, increasing isolation, and habitat degradation (Primack 2000). The stresses on natural ecosystems continue to be more visible as additional species are labelled at risk each year. The urgency of the role that parks and preserves play in conserving their biota is continually increasing (Arcese and Sinclair 1997). However, protected areas are not immune to continued species losses from both external and internal threats (Janzen 1983, 1986; Primack 1993; Rivard *et al.* 2000). Recently, concerns have been expressed about the loss of ecological integrity and local extinctions of species in Canada's national parks (Searle 2000, Parks Canada 2000).

Although virtually all major taxa are negatively affected by some forms of human activity, some taxa may be especially vulnerable. For example, a global decline of amphibian populations is becoming well-documented (e.g. Green 1997); but the status of reptiles is receiving less attention, even though reptiles may be of equal or greater conservation concern (Beebee 1992, Gibbons 1997). Among reptiles, turtles (Class: Testudines) are considered to be of particular conservation concern because their natural history includes low reproductive output, late maturity, and habitat requirements of wetlands and terrestrial environments (Congdon and Gibbons 1996, Klemens 2000).

Testudines is a very old taxon that originated in the Triassic period (Zangerl 1969). The development of the shell was an extremely advantageous design that allowed this taxon to diverge and occupy many different habitats (Zangerl 1969). Modern turtles differ little from their

ancestral form because the shell restricted much variation within this taxon (Zangerl 1969).

Design constraints also control many aspects of turtle life history. Turtles have delayed sexual maturity compared to other species because they devote their energetic resources towards growing and development of their shell when they are young (Zangerl 1969). The protection that the shell provides, later allows great longevity which offsets their late maturity (Zangerl 1969). Despite their long lived success, recent anthropogenic threats may cause extinctions for many species in this taxon globally.

Turtle populations in Canada are no exception. Recently, two additional species were added to COSEWIC's list of species at risk (COSEWIC 2002). The stinkpot (musk turtle; *Sternotherus odoratus*) and map turtle (*Graptemys geographica*) now join the spiny softshell (*Apalone spinifera*), spotted (*Clemmys guttata*), wood (*C. insculpta*), and Blanding's turtles (*Emydoidea blandingii*) leaving only the painted turtle (*Chrysemys picta*) and snapping turtle (*Chelydra serpentina*) not at risk (COSEWIC 2002). The most important threats to the status of turtles include habitat loss, population isolation, subsidized predators, road mortality, collection as pets, interactions with exotic species, human recreation, disease, and effects of contaminants (Garber and Burger 1995, Klemens 2000).

Habitat loss and alteration are the greatest cause of turtle population declines worldwide (Klemens 2000). One of the most simple explanations of species loss is species relaxation. When habitat area is lost biotas can become supersaturated with species and extinctions occur as the system re-equilibrates (Patterson 1987). Freshwater wetlands are one of the most endangered ecosystems because many have been drained and filled for agriculture (Klemens 2000, Mitsch and Gosselink 2000). In the Great Lakes Basin of North America, over 2/3 of the coastal wetland area has been lost; and losses in some regions exceed 90 % (e.g. Southern Ontario) (Snell 1987,

Shirose *et al.* 1995, Environment Canada 1995, Mitsch and Gosselink 2000). Complete loss of habitat to urbanization or conversion to agriculture will, obviously, not permit survival of some turtle populations. Reduction of habitat area results in smaller population sizes, and smaller populations are more vulnerable to extinction (Soulé 1987). The availability and juxtaposition of different habitat types are also important (Pope *et al.* 2000). Spotted and Blanding's turtles can be affected by apparently minor habitat loss because they require a number of different habitat types throughout the year (e.g. marsh ponds, vernal pools, and wooded swamps) (Haxton and Berrill 1999, Klemens 2000, Litzgus and Brooks 2000). The loss of one habitat could result in the extirpation of an entire population. Legislation of buffer zones generally do not adequately protect habitat for turtles (Burke and Gibbons 1995).

As habitats become fragmented, isolation between remnant habitat patches increases. Increased distance among populations on these patches can result in reduced 'rescue effects' (Brown and Kodric-Brown 1977) and gene flow (Reh and Seitz 1990) and can enforce metapopulation spatial structure on populations (Hanski 1999). Individuals dispersing through inhospitable habitat among patches can face increased risk of mortality through predation or road mortality (Klemens 2000).

Subsidized predators are native species which increase in abundance because they benefit from human impact (Garrot *et al.* 1993). Examples include raccoons (*Procyon lotor*), red foxes (*Vulpes vulpes*), opossums (*Didelphis virginiana*), and striped skunks (*Mephitis mephitis*) (Garrot *et al.* 1993). Predators may benefit if provided with increased food (handouts or garbage), habitat (edge habitat or human-dominated landscapes), or if human actions have eliminated large carnivores that act as their predators (ie. mesopredator release) (Soulé *et al.* 1988, Rogers and Caro 1998). Subsidized predators can increase predation pressures on ground

nesting animals and can effectively eliminate turtle nesting success and, ultimately, juvenile recruitment (Klemens 2000). Because turtles are typically long-lived, the presence of adults may suggest abundant populations; but if no recruitment is occurring, adult presence may mask impending local extinctions (Klemens 2000).

Adult turtles may be particularly susceptible to road mortality (ie. being killed by vehicles on roads) and collection for pets. Life history characteristics such as late age of maturity, long life span, high adult survivorship rates, and low juvenile survivorship make turtle populations especially susceptible to even very small increases in adult loss (Congdon *et al.* 1994, Heppell *et al.* 1996). Females are susceptible to collisions with vehicles because they often cross roads while searching for nest sites or when ovipositing on road shoulders. Road networks are steadily expanding and have vast effects on natural habitats (Forman and Alexander 1998, Trombulak and Frissell 2000). Reptiles and amphibians are especially vulnerable to road mortality because they are slow and not cognizant of the danger (Ashley and Robinson 1996, Forman and Alexander 1998). Few turtle populations are not affected by roads; therefore, many populations may be at risk of decline (Gibbs and Shriver 2002). Commercial collection for the pet trade is a very serious concern because turtle populations can be destroyed in a very short time period by large scale collection (Warwick *et al.* 1990). The extent of collection is very difficult to monitor. However, the large number of turtles available for sale (including species at risk) indicates that collection is common (Litzgus 2003).

Exotic species may have negative impacts on turtle populations by causing increased predation, reducing food availability, changing habitat characteristics, or by introducing disease. Exotic species can be a particularly difficult problem to overcome because once they become established, they are often impossible to eliminate (Coblentz 1990). The greatest impact on

turtles by exotic species is probably from feral domestic animals and rats affecting tortoise populations on islands (Klemens 2000). However, exotic species are likely also affecting North American populations. The zebra mussel (*Dreissena polymorpha*) in the Great Lakes competes with native mussel species, upon which map turtles and stinkpots feed (Klemens 2000). Invasive plants, such as elephant grass (*Phragmites australis*) and purple loosestrife (*Lythrum salicaria*), often have a competitive advantage over native plants in areas with degraded water quality or hydrologic regimes (Klemens 2000). Introduced red-eared sliders (*Trachemys scripta*) may also compete with native turtle species (Harding 1997). Some species of turtles, such as the bog turtle (*Clemmys muhlenbergii*), are sensitive to changes in the natural vegetative community and cannot survive in altered landscapes (Klemens 2000).

Disease is now a greater concern than historically. Even though disease is a natural process, small populations are at greater risks of extinction. The introduction of pet red-eared sliders into populations of native turtles can have negative effects because captive turtles tend to carry more diseases, and native species (e.g. painted turtles, *Chrysemys picta*) are often more susceptible to disease than the hardy red-eared slider (Vosjoli 1992).

Turtles accumulate contaminants from their diet or by absorption via pharyngeal and cloacal respiration (Helwig and Hora 1983). The long-term effects of contaminants on populations of most species of turtles are not known (Bishop and Gendron 1998). Many studies have found high levels of contaminants in snapping turtles (*Chelydra serpentina*) (Stone *et al.* 1980, Helwig and Hora 1983, Bryan *et al.* 1987, Bishop and Gendron 1998) and Bishop and Gendron (1998) found that eggs with the highest chlorinated hydrocarbon concentrations also had the poorest developmental success. Harding and Bloomer (1979) found that declines in wood turtle populations were related to pesticide use in New Jersey. Studies on the effects of PCBs on

red-eared sliders determined that eggs, when exposed to PCBs and incubated at temperatures that normally yield all male offspring, experienced a significant amount of sex reversal (Bergeron *et al.* 1994). Therefore, high levels of PCBs could alter sex ratios or disrupt reproductive and endocrine functions of turtle populations (Bergeron *et al.* 1994).

Human recreation can also negatively affect turtles. Turtles can be injured when they are incidentally captured during sport or commercial fishing. Burger and Garber (1995) found a positive relationship between wood turtle declines and increases in human recreation activities (hiking, fishing). Another potential threat is the use of turtles for target practice (Harding and Bloomer 1979, Browne, pers. obs).

Point Pelee National Park, by virtue of its geography, has the richest potential herpetofaunal diversity of all Canadian national parks. Eleven amphibian and 14 reptile species have been recorded in the Park. However, at least half of these species have become locally extinct in the Park since the turn of the century (Hecnar 1999). Historically, Point Pelee was the location of greatest turtle diversity in Canada. Among Canada's national parks, Point Pelee is recognized as being the most threatened by human actions (Searle 2000). Species losses, isolation of the Park, and both external and internal threats to the Park's fauna, make the assessment of species status urgent (Parks Canada 2000).

The status of the Park's amphibians was assessed recently (Hecnar and M'Closkey 1995), but studies of reptiles have been largely limited to studies of individual species such as the eastern fox snake, *Elaphe gloydi* (M'Closkey *et al.* 1995) and the five-lined skink, *Eumeces fasciatus* (Hecnar 1994, Hecnar and M'Closkey 1998, Hecnar *et al.* 2002). Knowledge of the turtle community in the Park is limited to portions of dated herpetofaunal surveys (Patch 1919, Logier 1925, Rivard and Smith 1973), reports of summer student investigations (Whitehead 1997, Kraus

1991) and warden reports. A paucity or lack of recent observations of individuals of some species, such as the spotted turtle and stinkpot (musk turtle), suggest that declines may be occurring. Observations also suggest that the abundance of other species (e.g. Blanding's and map turtle) may have decreased recently (Hecnar, pers. obs.; warden reports). The status of the Park's turtles remains the largest void in our knowledge of the Park's herpetofauna.

Ten turtle species have been recorded as occurring in Point Pelee National Park during the past century (see Methods-Table 1). However, the status of all species in the Park is presently unknown and five of these species (spotted turtle, spiny softshell, Blanding's, map, stinkpot) are of conservation concern. Apparently high rates of predation on turtle nests by species such as raccoons may be limiting juvenile recruitment (Rivard and Smith 1973, Whitehead 1997). Effects of contaminants on turtle populations are also a concern because high levels of DDT have been reported in the park (Crowe 1999). DDT was used for mosquito control and agriculture from 1948-1967 and remains in the top layer of soil (Crowe 1999). Studies suggest that DDT may be a major factor in the decline of amphibian populations in the Park (Russell *et al.* 1999).

My overall goal was to determine the status of turtle species at Point Pelee and examine possible causes of decline. Specific objectives were to determine: (a) species composition/richness of the present turtle community, (b) relative abundance of each species, (c) detailed population estimates of species, (d) sex and age structure of each species, (e) patterns of habitat use, (f) investigate the impact of nest predation, (g) nest hatching success, and (h) possible impacts of road mortality.

My research provides additional insight into the role that natural history characteristics play in determining species status. Determining the status of the Park's turtle populations is of utmost importance for effective management and conservation. Developing a knowledge base on

the Park's turtles is a necessary foundation for successful conservation and it will also contribute on a larger scale because of the global conservation concerns for the entire class Testudines.

METHODS AND STUDY SYSTEM

Study Area

Point Pelee National Park forms the southernmost tip of Canada's mainland (42° 10' N, 82° 30' W). The Park acts as a functional "island" because 80 % of its perimeter is surrounded by water and the other 20 % by agricultural land. These landscape features likely impose barriers resulting in a high degree of isolation for many of the Park's species. Although Point Pelee is only a small park (16 km² area) it provides important habitat for many species. The Park is important from a natural heritage perspective because it includes substantial area of two ecosystems of conservation concern. Point Pelee contains one of the few remaining sizable fragments of Carolinian forest in Canada (15.9 % of park). The Park also contains one of the few remaining deep freshwater coastal marshes in the Great Lakes. The marsh covers 43.2% of Point Pelee and is recognised as a wetland of international importance (Ramsar 2002). The ponds and pond edge (24.4 % of the park) are prime habitat for turtles within the marsh (Fig. 1). Turtles also use swamp thicket/forest areas (5.4 % of park) and wet meadows (0.6 %). The ponds inside the marsh vary from those with soft-bottomed organic rich soils to others with sandy substrate. Pond depth varies and is largely regulated by the level of water in Lake Erie. Turtles also occur in artificial canals in the Park that were excavated for irrigation or drainage for agriculture in the Park prior to the 1960's. Canals vary between those with shallow organic rich bottoms and deep canals with firm bottoms. There are abundant suitable nesting sites (open habitat with loose substrates) for turtles because the Park was formed from a sand spit and consists of a series of sand dunes. Turtles may nest in

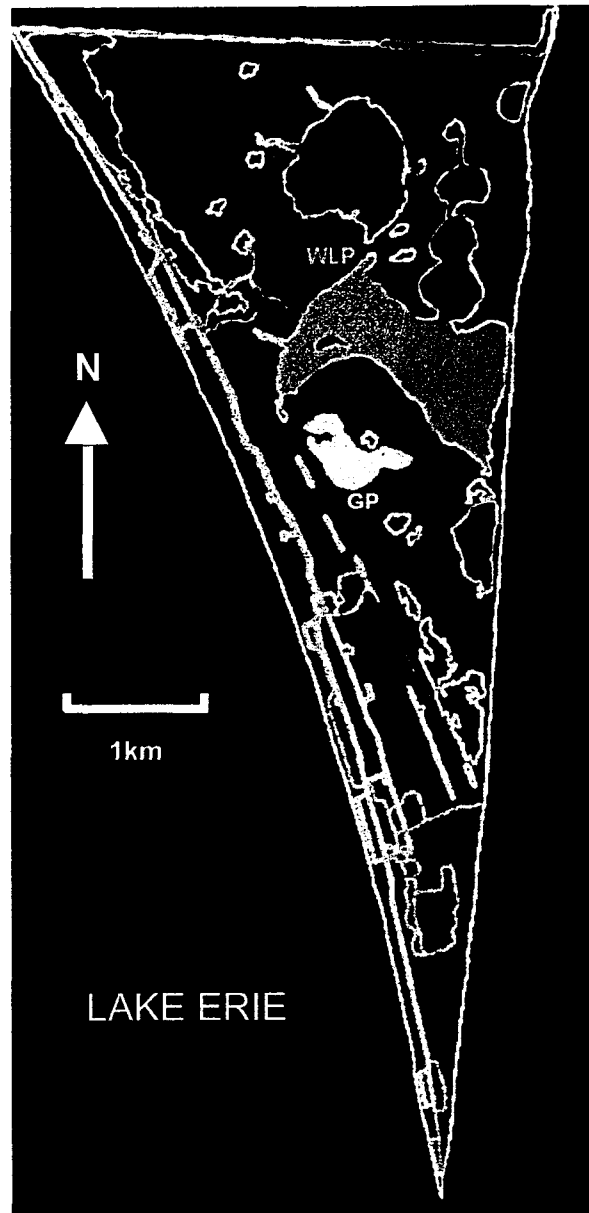


Fig. 1. Trapping sites for turtles in Point Pelee National Park (2001-2002). North Boundary ditch (WNB), North Boundary Canal (ENB), Sanctuary Pond (SA), Bush Pond (BP), West Cranberry (WC), Crossing Pond and Lilly Pond (CP and LL), East Cranberry (EC), Marsh Boardwalk and Theissen's Channel (MB), West Lake Pond (WLP), East Lake Pond (ELP), Girardins Pond (GP), Red-head Pond (RH), North DeLaurier Ponds (ND), South DeLaurier Canal (SD). Figure modified from original made by S. Hecnar and R. Russell.

beaches (6.8 % of park), old fields (2.6 % of park), or along roadsides.

I divided turtle habitat in the Park into 14 sites (Fig. 1). Three sites were artificial canals (North DeLaurier, South DeLaurier, East North Boundary) and the other 10 were ponds in the marsh (Sanctuary, Marsh Boardwalk, West Lake, East Lake, Girardin's, Red-head, East Cranberry, West Cranberry, Crossing and Lilly, Bush). A ditch just outside the Park that runs between the north boundary and Mersea Road E was included as an additional site (West North Boundary) because turtles were often observed basking in this area.

The Point Pelee marsh ecosystem is a remnant fragment of a larger marsh that was drained for agricultural conversion in the late 1800s (Fig. 2). Point Pelee National Park protects only 35.9 % of the original marsh ecosystem (Hecnar 1999). The only other fragment, Hillman Marsh, is now separated by a 6 km distance across 'reclaimed' intensively farmed land. Hillman Marsh is a very human-altered habitat (\approx 150 hectare area) consisting of two artificial circular dikes enclosing cells of water. I divided Hillman Marsh into two study sites: the east cell and the west cell which were also trapped in 2001. The water level and vegetation in these cells is controlled primarily for waterfowl management. In general, the cells are deeper than most of Point Pelee's ponds and have a firm clay bottom. There are also plenty of basking sites for turtles. Hillman Marsh is completely surrounded by roads and agricultural land with the exception of one side of the east cell which is surrounded by sandy beach bordering Lake Erie.

Historical Species Records and Prior Surveys

Ten species of turtles have been recorded as present in the Park over the past century (Table 1). This list is the product of early herpetofaunal surveys, warden reports, summer student projects, and graduate student research contracts.

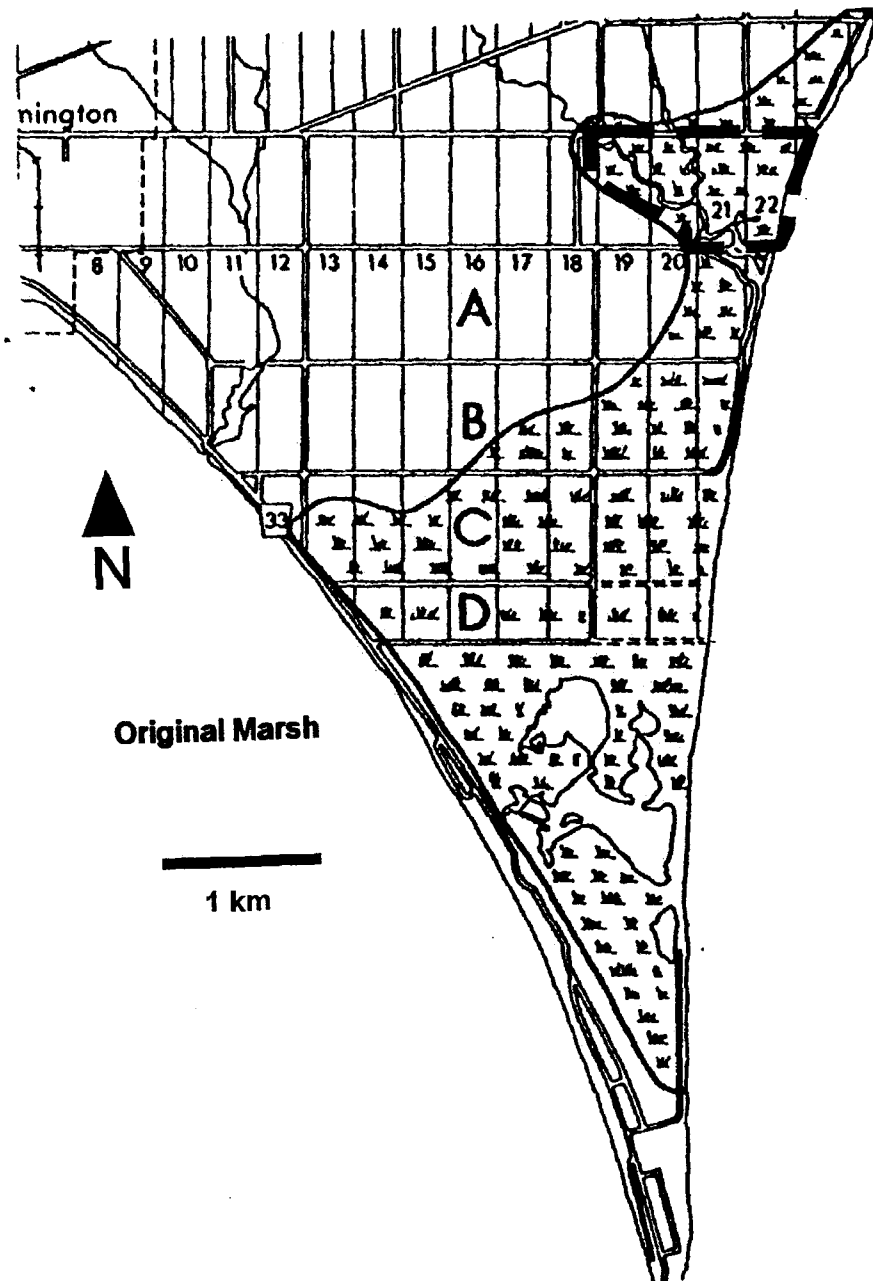


Fig. 2. Original extent of the Point Pelee marsh system. Hillman marsh is located in the area enclosed by the thick black dashed lines. Point Pelee National Park is located south of Mersea Road 'E' (south of D). The marsh between Point Pelee National Park and Hillman marsh has since been converted to agricultural land. Figure modified from original in Parks Canada (1980).

Table 1. List of turtle species recorded in Point Pelee National Park.

Scientific Name	Common Name	Conservation Status
<i>Chrysemys picta</i>	Painted Turtle	
<i>Graptemys geographica</i>	Northern Map Turtle	Special Concern ^{1,3}
<i>Emydoidea blandingii</i>	Blanding's Turtle	Threatened ^{1,2,3}
<i>Clemmys guttata</i>	Spotted Turtle	Special Concern ^{1,3}
<i>Clemmys insculpta</i>	Wood Turtle	Introduced ⁴
<i>Sternotherus odoratus</i>	Stinkpot	Threatened ^{1,3}
<i>Chelydra serpentina</i>	Snapping Turtle	
<i>Apalone spinifera</i>	Spiny Softshell	Threatened ^{1,3}
<i>Terrapene carolina</i>	Eastern Box Turtle	Data Deficient ¹
<i>Trachemys scripta</i>	Pond Slider	Introduced

¹COSEWIC 2002. ²Threatened in Nova Scotia and recommended to COSEWIC as threatened in Ontario. ³Status tracked in Ontario by the OMNR-NHIC. ⁴Introduced to Point Pelee, but Special Concern in Canada.

The first records of turtles in the Park come from two general, and perhaps somewhat cursory, herpetofaunal surveys (Patch 1919, Logier 1925). In 1913, C.L. Patch of the Victoria Memorial Museum spent three summer months in the Park and reported observations of snapping, painted, stinkpot ("musk turtle" in all reports prior to 2001), Blanding's, and spotted turtles (Patch 1919). He reported that spotted turtles were as equally represented as painted turtles. In summer 1920, E.B.S. Logier of the Royal Ontario Museum spent six weeks in the Park and added the map turtle to Patch's list of turtles for the Park (Logier 1925). He reported painted and Blanding's turtles as both quite common. Logier also reported that fisherman in Lake Erie sometimes caught softshell turtles in their pound nets and they spoke of these turtles as always living in the water and coming out on the beach only to lay eggs. These early studies established

that at least seven species of turtle occurred in the Park and that painted, spotted, snapping, and Blanding's turtles were common while stinkpot, map, and spiny softshell were less common (Patch 1919, Logier 1925). However, both authors considered their reptile lists to be incomplete because their herpetofaunal surveys were limited (Patch 1919, Logier 1925).

In May 1951, R.D. Harris and G.M. Stirrett searched for turtles and concluded that painted and Blanding's turtle were "numerous" but did not report observations of other species (Harris and Stirrett 1951). However, they only spent three days in the Park. Francis Cook of the National Museum of Canada conducted a herpetological survey of the Park for nine days in April 1967 and reported collecting snapping, painted, and Blanding's turtles but he did not provide details because "few were collected" (Cook 1967). Cook reported that there were no recent reports of spotted turtles since Patch (1919) and Logier's (1925) surveys and speculated that they may have vanished from the Park. Cook (1974) constructed a herpetofaunal list for the Park with comments on species and added the eastern box turtle as an eighth turtle species. He noted that box turtles were recorded several times from 1963-1974 and reviewed evidence for the natural occurrence of box turtles in southern Ontario. Cook concluded that these were likely released pets. He also reported a personal communication from F.D. Ross who intercepted someone attempting to release three box turtles in the Park in 1971. However, a recent review of the box turtle by COSEWIC (Roche 1999) could not rule out the possibility that this species was native to southwestern Ontario. Ross also reported that he had seen only one spotted turtle over the entire season (Ross 1971), which Cook interpreted as evidence of a marked decline relative to historical surveys. Cook also commented that the softshell turtle probably occurs mainly in Lake Erie. Studies since then have found painted, snapping, Blanding's and map turtles to still be common; but spotted, stinkpot, and spiny softshell turtles were only observed occasionally. Occasional

observations of red-eared sliders have been reported, but both the slider and box turtle are considered to be introduced (Cook 1967, 1974; Ross 1971; Bevan 1972; Damas and Smith 1981; Oldham 1984). An unsubstantiated record of an intentional introduction of wood turtles by park wardens exists. However, only a small number of wood turtles were released and no observations of wood turtles were made more than a few years after the release.

The comments in warden's notes and annual herptile monitoring reports from 1967 to 1994 are based primarily on casual observations but provide insight into the relative abundance of turtles in the Park. In general, painted, snapping, map, and Blanding's turtles were common while stinkpot, spotted, spiny softshell, red-eared slider, and box turtles were rare. These reports also noted a high level of predation on turtle nests. The reports of 1967 (Wyett 1967, Dutcher 1967, Roy 1967, and Bouckhout 1967) and 1991 (Kraus 1991) provided more detailed quantitative observational data. Similar patterns of relative abundance occurred in both 1967 and 1991 (Table 2).

In 1968, park naturalists captured, marked and released 48 turtles (Table 2; see Bevan 1972 for details and notch codes). In 1971 F.D. Ross also marked and released over 75 turtles using a hacksaw blade to file a small notch in the marginal scutes. He observed painted, snapping, Blanding's, map, stinkpot, and spotted turtles nesting in the Park. Recently confirmed observations of spotted, spiny softshell (except one near Sturgeon Creek in 2000), stinkpot and box turtles have not been made and populations of snapping, and Blanding's turtles appear to be declining.

Table 2. Historical surveys. Numbers observed during visual surveys in 1967 (Wyett 1967, Dutcher 1967, Roy 1967, and Bouckhout 1967) and 1991 (Kraus 1991) and captures in 1968 (Bevan 1972) and 1972 (Rivard and Smith 1973).

Species	1967	1968	1972	1991
painted	68	25	133	258
snapping	11	0	93	15
Blanding's	12	13	46	12
map	31	4	4	34
stinkpot	4	2	4	1
spotted	3	3	1	0
spiny softshell	0	1	0	0
eastern box	0	0	0	2
red-eared slider	0	0	0	3

The most thorough study of turtles conducted in the Park was part of a herpetological inventory conducted from May to September in 1972 (Rivard and Smith 1973). Similar to my study, they used baited hoop traps and hand captures yielding a total of 282 captures (Table 2). Rivard and Smith (1973) recorded size and sex data for their captures. They marked individuals with numbered metal 'fingerling' tags fastened to the webbing of hind feet. Unfortunately, this method is not considered permanent for turtles because of tag loss. Rivard and Smith (1973) captured three box turtles and were equivocal regarding whether they were introduced or native. They also commented on the heavy level of nest predation observed on all turtle species, and recommended to Parks Canada that a thorough study of turtles in Point Pelee be conducted.

Despite Rivard and Smith's (1973) recommendation, there has never been a thorough population study of turtles at Point Pelee. Previous studies that have been conducted were usually cursory herpetological surveys and only reported a few turtle observations (Patch 1919,

Logier 1925, Harris and Stirret 1951, Cook 1967, Ross 1971, Cook 1974). These reports were not detailed enough to determine species status or even to provide strong evidence that species not observed were indeed absent from the Park. Patch (1919) and Logier (1925) also suggested their lists were conservative.

Predation on turtle nests by raccoons (primarily), coyotes (*Canis latrans*), or skunks in the Park is believed to be one possible cause of turtle population declines. Predation rates on nests have been consistently reported as high in warden reports. Kraus (1991) and Whitehead (1997) both conducted more detailed summer student projects and quantified nest predation rates (80-100 % and 87 % respectively).

Combining data from warden reports with a study by Damas and Smith (1981) provides turtle road mortality data for 16 years (85 painted, 8 Blanding's, 2 stinkpot, 1 red-eared slider). Damas and Smith (1981) concluded that turtle mortality was more a function of seasonal activity than traffic flow. Management actions for mitigation have included posting signs to warn motorists of turtles or moving turtles off the road.

General Statistical Methods

Initially, I examined all data for normality using Lilliefors's method with the Kolmogorov-Smirnov one sample test. Data were tested for homogeneity of variances using F_{\max} -tests (Sokal and Rohlf 1995). If data were not normal or variances not homogeneous then I tried appropriate transformations (Sokal and Rohlf 1995). If transformation did not improve the data I used non-parametric analyses. I used a significance level of $\alpha = 0.05$ for all tests except when screening variables with Pearson correlation analysis to include in multiple regressions I used $\alpha = 0.2$. All ratios were compared using G -tests with Williams correction applied (Sokal and Rohlf 1995). I

used Systat (Systat version 9) for all statistical analyses.

Population Size and Structure

I conducted visual surveys from 29 April to 21 June 2001 to assess which turtle species were present, determine relative abundance, and document where they occurred in Point Pelee National Park and nearby locations. I recorded habitat, weather conditions, date, time, behaviour and UTM coordinates for all turtle sightings. Sixteen trapping sites were chosen based on the initial visual surveys: 13 inside of Point Pelee National Park, one bordering the northern boundary, and two sites at Hillman Marsh (Fig. 1). I conducted daily surveys for 'species at risk' (Blanding's, spotted, spiny softshell, map, and stinkpot; COSEWIC 2002) in Point Pelee National Park from 1 April to 31 May 2002 by wading through wetlands or travelling by canoe unless weather conditions were unfavourable for turtles to be active and visible. Captured turtles were not recorded in visual surveys.

I captured turtles during surveys or trapping sessions between 5 May and 24 August 2001 and 1 April and 22 August 2002 using a variety of methods to reduce trapping bias (Ream and Ream 1966, McKenna 2001). I used hoop (Fig. 3), basking (Fig. 4), and wire cage live traps (Fig. 5). I also captured turtles by dipnet or hand. Hoop and live traps were baited using fresh fish in a can suspended in the trap. The hoop traps consisted of three 44 cm diameter circular (flattened bottom) steel rings each 42 cm apart. They were covered by a 1" polyethylene mesh fish netting and were custom made (M. Purchase, Lawrence, MI; and Superior Net and Twine, Thunder Bay, ON). Hoop traps were set by stretching them out and fastening them to 2" x 2" wooden stakes so that they were mostly submerged but still permitted turtles to breathe. When stretched, an inward pointing mesh funnel allowed turtles to enter but restricted their exit from the



Fig. 3. Hoop trap. This trap is similar to a lobster trap. Turtles are attracted into the trap by fish in the bait bucket. They easily enter the trap but cannot escape because of the funnel shaped door. Photo by Constance Browne.

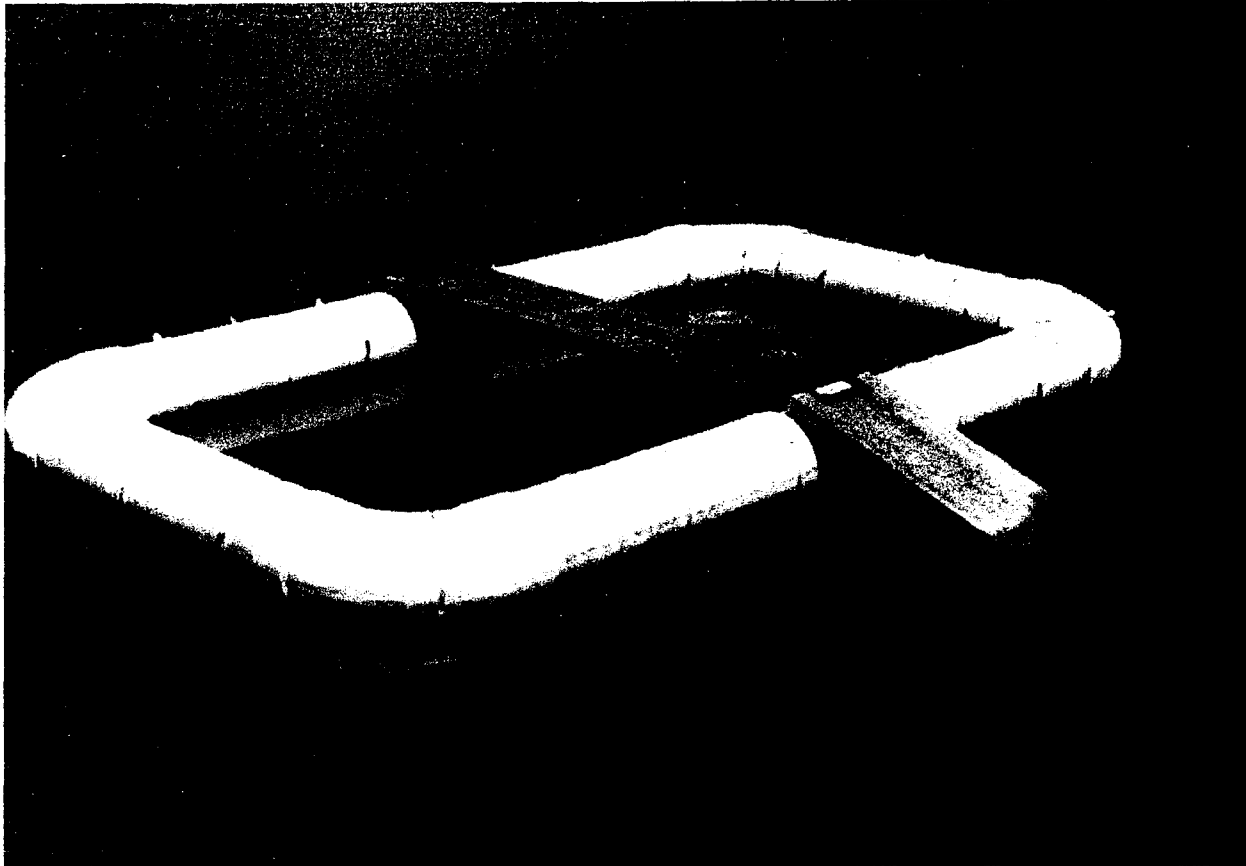


Fig. 4. Basking trap. Fish net is attached to the PVC piping under water and a ramp is placed on the trap. Turtles crawl up the board to bask, when they jump back into the water inside the rectangular shaped PVC piping frame they cannot escape. Photo by Lynn Browne.

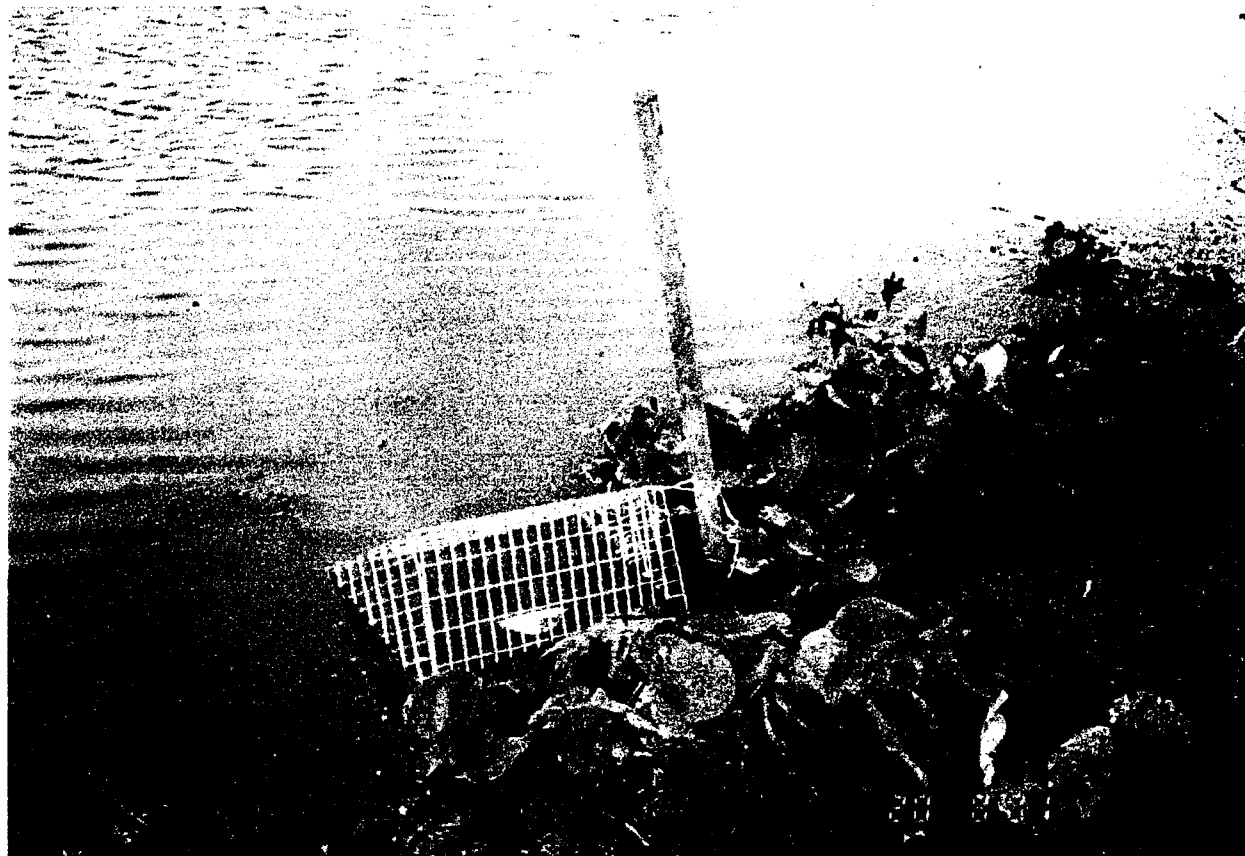


Fig. 5. Folding live trap. This trap is similar to a raccoon live trap. Turtles are attracted into the trap with bait. When they are in the trap walking towards the bait they step on a pan which triggers the door to close behind them. Photo by Constance Browne.

trap. I manufactured floating rectangular basking traps (2' x 4') using 4" white PVC sewer pipe and 90° elbows which were glued to provide a waterproof floating frame. Polyethylene 1" mesh fish netting was fastened to the outside edge of the frame by weaving it around a smaller rectangular frame of ½ " black flexible plastic water pipe or copper pipe. I then used plastic cable ties to attach the smaller frame to the floating frame. I constructed a basking platform of ½" boards (15 cm wide) with hinged ramps at each end leading to the water. The platform was fastened by screws across the top of the floating frame. The traps were anchored with concrete blocks attached to the fish netting in the middle of the trap with nylon rope. Upon my approach, turtles would run off the platform and be caught in the interior of the floating frame. For live traps, I purchased folding wire cage Tom-a-hawk™ live traps. Traps were positioned so that the open door end was submerged but the far end was partially in the air.

Trapping took place from 19 June to 24 August 2001 and 5 April to 30 July 2002. Traps were set for two days then checked and moved to the next site in 2001. Two sites were set at a time. I used six baited hoop traps per site starting 19 June 2001, three basking traps per site starting 16 July and two live traps per site starting 18 August. I used basking traps from 5 April to 30 July 2002. Hoop traps and live traps were also used from April 27 to 30 July 2002 once the water had warmed sufficiently (~10°C) to stimulate feeding in turtles. However, the live traps were not used after 18 June 2002 because of extremely low capture success. All traps were checked daily in 2002.

In 2002, eight hoop traps, three basking traps, and one live trap were set in a site. Traps were set in North DeLaurier and South DeLaurier from 5 April to 18 May. I trapped for long periods in these sites so that population estimates could be made in at least some areas of the Park. It was not possible to capture sufficient numbers of turtles to obtain population estimates in

the entire park due to its large size. Additional traps were purchased and set 9 May alternating between the other 14 sites every other day until 15 May. Due to the low number of recaptures I decided to focus on eight sites rather than 14. Sites abundant with turtles and species at risk present were chosen: North DeLaurier, South DeLaurier, Bush Pond, East North Boundary Canal, Marsh Boardwalk, East Lake Pond, East Cranberry Pond, and Red-head Pond. Traps were set in four sites concurrently and alternated every two weeks.

I recorded habitat, weather conditions, date, time, behaviour, trap type and UTM coordinates for all captures. All adult turtles captured were marked by filing marginal scutes to provide a unique code for identification of individuals (Cagle 1939). Snapping turtles were marked using a slightly different method to avoid working near their heads. Instead of counting the scutes from the nuchal (marginal scute behind the head) I counted from the rear, so scute number 12 was considered scute number one. Only the rear five scutes on each side of the snapping turtle were used for marking and up to two notches per scute could be used. I also marked painted and snapping turtles by painting a number on the carapace using waterproof pipe paint markers (LA-CO Industries, Inc./Markal Company). This allowed identification from a distance until the turtle shed its scutes. I also marked Blanding's, spotted and spiny softshell turtles (with carapace lengths greater than 80 mm) with a PIT tag (12 mm x 2 mm) injected subcutaneously into a rear leg using a 12 gauge syringe. I used 70 % isopropyl alcohol to sterilize all needles, PIT tags, and the site of injection, prior to tagging. Krazy glue (the equivalent to surgical glue) was used to bond the site of injection. I weighed (to nearest g), took standard measurements (midline and total carapace and plastron lengths, width, height, vent to tail tip length, shell to tail tip length, carapace curved width; to nearest mm) and recorded ID for each captured individual. I also recorded the age, sex, abnormalities, injuries, signs of parasitism or

disease, and determined if females were gravid. Turtles were then released at the site of capture.

To determine if the abundances of turtles changed from 1972 to present, I used Spearman's rank correlation to compare ranked abundance of species captured by Rivard and Smith (1973) to my results. I compared the ratio of relative abundance of snapping and Blanding's turtles to painted turtles between time periods. The Jolly-Seber method was used to determine population sizes in each site using mark-recapture data (Krebs 1999). The Jolly-Seber method is a robust technique that requires recaptures from multiple sessions and can be used on open populations (Krebs 1999). The assumptions of the Jolly-Seber method are: (1) equal catchability, (2) equal survivorship of individuals, (3) sampling time is negligible compared to time between samples, and (4) marks are not lost (Krebs 1999). I calculated the average density of turtles (for each species) using area and population size estimates from the sites which were intensively trapped. The total area of potential habitat for each species was calculated and then multiplied by the average density of each species to estimate population sizes for the entire park. Potential habitat was considered to be the area of water from ponds in which the species of turtle had been observed in at least once. I used the Lincoln-Petersen method to estimate stinkpot population size because there was only one recapture for this species. However, this estimate may still be biased because the Lincoln-Petersen method requires at least seven recaptures to give accurate results. Assumptions of the Lincoln-Petersen method are: (1) closed populations, (2) equal catchability, (3) marks are not lost (Krebs 1999).

The equal catchability assumption may have been violated because many studies suggest that different trap types may favour the capture of either males, females, or adults (Ream and Ream 1966, Koper and Brooks 1998, McKenna 2001). One suggested method to overcome sex bias is to calculate population size with males and females separated then pool the estimates

(Koper and Brooks 1998). However, because of few recaptures in this study, separating the sexes meant reducing the sample size to such low numbers that calculation was not always possible. To test if this assumption was met, I estimated population sizes for painted turtles with males and females separated for each site. The observed sex ratio of painted turtle captures was compared to the sex ratio calculated from population size estimates of male and female painted turtles for each site using Wilcoxon's signed-ranks test. I assumed that trapping bias was either minimal or did not exist because the direction of sex ratio bias did not differ among sites (Table 3). Sex ratios of different trap types were reported for each species.

Table 3. Painted turtle sex ratios (observed and calculated). Observed sex ratios were compiled from all capture data. Calculated sex ratios were based on separate population size estimates of males and females from a number of sites. Wilcoxon signed ranks test indicated that there was no significant difference ($p > 0.05$) between observed sex ratio and calculated sex ratio among sites.

Site	Observed Sex Ratio ($\sigma^{\circ}:\text{♀}$)	Calculated Sex Ratio ($\sigma^{\circ}:\text{♀}$)
South DeLaurier	2.59:1	1.64:1
North DeLaurier	3.4:1	12.9:1
Marsh Boardwalk	6.2:1	17.2:1
East North Boundary	2.4:1	1:3.6
Bush Pond	1.77:1	1.8:1

I examined population structure by determining sex ratios and age/size structure. Adult turtles can not be aged accurately by counting rings on plastral scutes (Ross 1989). However, turtles have indeterminate growth (growth rate slows with aging) and larger turtles are usually older (Zweifel 1989). Growth is rapid during the first year and then steadily declines (Ross 1989). Although exact age cannot be determined by size, relative age can be compared by

examining sizes (e.g. carapace lengths) of individuals from a population. Sex ratios were compared to a 1:1 ratio and to data reported in Rivard and Smith (1973). The carapace lengths of 1972 were compared to 2001-2002 using a Mann-Whitney *U* test. In addition, I used Kolmogorov-Smirnov two sample test to compare both shape and central tendency of carapace length distributions between time periods.

Habitat Use and Movements

Patterns of habitat use were analysed to determine if the turtle community species richness showed a nested pattern among sites in Point Pelee and also to determine which habitat variables were associated with species richness. Nestedness is the condition where species occurring in depauperate sites constitute subsets of those species occurring in successively richer sites (Patterson and Atmar 1986). Nested analyses can provide valuable insight into explaining patterns of community structure and in predicting which species are most vulnerable to extinction (MacDonald and Brown 1992, Atmar and Patterson 1993). I used the Nested Temperature Calculator computer program (Atmar and Patterson 1993) for analysis. This program uses a simple thermodynamic measure of order and disorder apparent in nested patterns (Atmar and Patterson 1993). A temperature (*T*) is assigned to the system; a completely ordered system (high nestedness) has a low temperature (0°) and a completely random system (low nestedness) has a high temperature (100°) (Atmar and Patterson 1993). The observed *T* is compared to a distribution of *T* scores obtained through Monte Carlo simulations (1000 iterations) to determine significance.

I examined the association of species richness and also the proportion of captures/trap for each species with thirteen habitat variables: pond type (natural or manmade), visitor activity (low,

medium, high), perimeter (m), area (m²), depth (shallow or deep), swimming distance (avoiding cattails) to shore (m), straight line distance to shore (m), swimming distance to road (m), straight line distance to road (m), swimming distance to Lake Erie (m), straight line distance to Lake Erie (m), bottom type (clay like, soft organic mud, or combination of soft organic mud and sand), and aquatic vegetation cover (low, medium, abundant). I entered pond type as a dummy variable. Particle size of each of the bottom types were used to classify this data into scale data using Pettijohn's (1949) classification of particle size (smallest to largest). I used the proportion of captures/trap as an index of relative abundance. I calculated this by using the number of turtles captured divided by the number of traps (times the number of days used) for each site; using basking and hoop traps for painted turtles, basking traps for map turtles, and hoop traps for snapping, Blanding's, and stinkpots. I initially screened variables using a Pearson Correlation analysis to determine which of the 13 habitat variables were correlated with species richness, or density of individual species. Correlated variables were retained and used in forward stepwise multiple regressions.

Recapture data provided crude information on movements of turtles. I calculated the greatest distance travelled between all captures for each individual turtle and statistics on these distances for each species. The greatest distances travelled were compared among males, females, and juveniles for each species and among species using a Kruskal-Wallis test. A Mann-Whitney U test was used to compare among age/sex classes if there were no data on juveniles. I also conducted an ANOVA and Tukey post hoc test; but only if the ANOVA results agreed with the Kruskal-Wallis results. The Tukey post hoc test was then used to determine which species significantly differed in movement distances.

Comparisons to other Communities

To determine species present and relative abundance of turtles at Hillman Marsh, I used the same methods for capturing and marking turtles in 2001 as in Point Pelee. Sex ratios were compared between Hillman Marsh and Point Pelee. I excluded hand captures from the sex ratio analysis because this method favoured the capture of nesting females. I compared carapace lengths between Hillman Marsh and Point Pelee using a Mann-Whitney *U* test. A Kolmogorov-Smirnov two sample test was used to compare the shape and central tendency of carapace length distributions between Hillman Marsh and Point Pelee.

I obtained data on captures from population studies conducted at Long Point, ON and the E.S. George Reserve, MI from the literature (Samure 1995, Congdon and Gibbons 1996). Comparisons of species diversity were made using the inverse of Simpson's index (Simpson 1949) among Point Pelee (1972), Point Pelee (2001-2002), Hillman Marsh (2001), Long Point (1992-1994), and the E.S. George Reserve (1975-1994).

Nest Protection

I located turtle nests from 23 May to 30 June 2001. To determine effective methods to protect turtle nests from predation, I tried a number of different protective measures during the nesting season of June 2001. I constructed wooden boxes with hardware cloth tops as a physical barrier for predators for a number of nests. Also, a couple of nests were covered with objects such as rocks or debris from the shore. In one case wire screen flaps were added to a wire screen box to increase the digging effort of predators. Cayenne pepper was used as a deterrent, assuming that when a raccoon digs up a turtle nest the pepper will cause irritation to its mouth and eyes. Later in the season I made a pepper spray mixture (cayenne pepper mixed with vegetable oil) to

increase persistence and adhesion to the soil around the nest and to the predators paws.

I located turtle nests from 1 June to 17 July 2002. The effectiveness of nest protection techniques was examined in 2002 by comparing two different methods: screen topped-wooden boxes with pepper spray (the most effective method in 2001) and wire screen cages (the method used in Rondeau Provincial Park). Predation rates of protected nests were compared to unprotected nests in the same nest site using *G*-tests. A nest was considered successfully protected if it was not destroyed by mammalian predators. Painted turtle nests and snapping turtle nests were assigned randomly to be either protected (treatment) or unprotected (control). All nests of species at risk (map, stinkpot, Blanding's, spotted, and spiny softshell) were protected from mammalian predators.

The wire screen-topped boxes were made of a wooden frame (~90 x 90 cm x 15 cm high for most, ~60 x 60 cm x 15 cm high for roadsides with narrow shoulders) and covered with 1/4 or 1/2 inch mesh galvanized hardware cloth (Fig. 6). I used these boxes in areas where the ground was fairly difficult to dig through. The pepper spray mixture was sprayed around the perimeter of the box to discourage digging by mammals. I used wire screen cages (~30 cm in diameter and 40 cm high, 1/4 inch hardware cloth) in sandy areas. The cages were buried beneath the ground approximately 25 cm around the nests so that there was about a 15 cm space above ground for when the hatchlings emerged (Fig. 7). However this still permitted predation by Sarcophagid fly larvae (R. Brooks, pers. comm.) and possibly by eastern moles (*Scalopus aquaticus*).

Nest Predation Rates

I monitored unprotected nests daily to determine if predation occurred and to calculate predation rates. Predation rates of snapping turtles were compared to painted turtles to test if predation

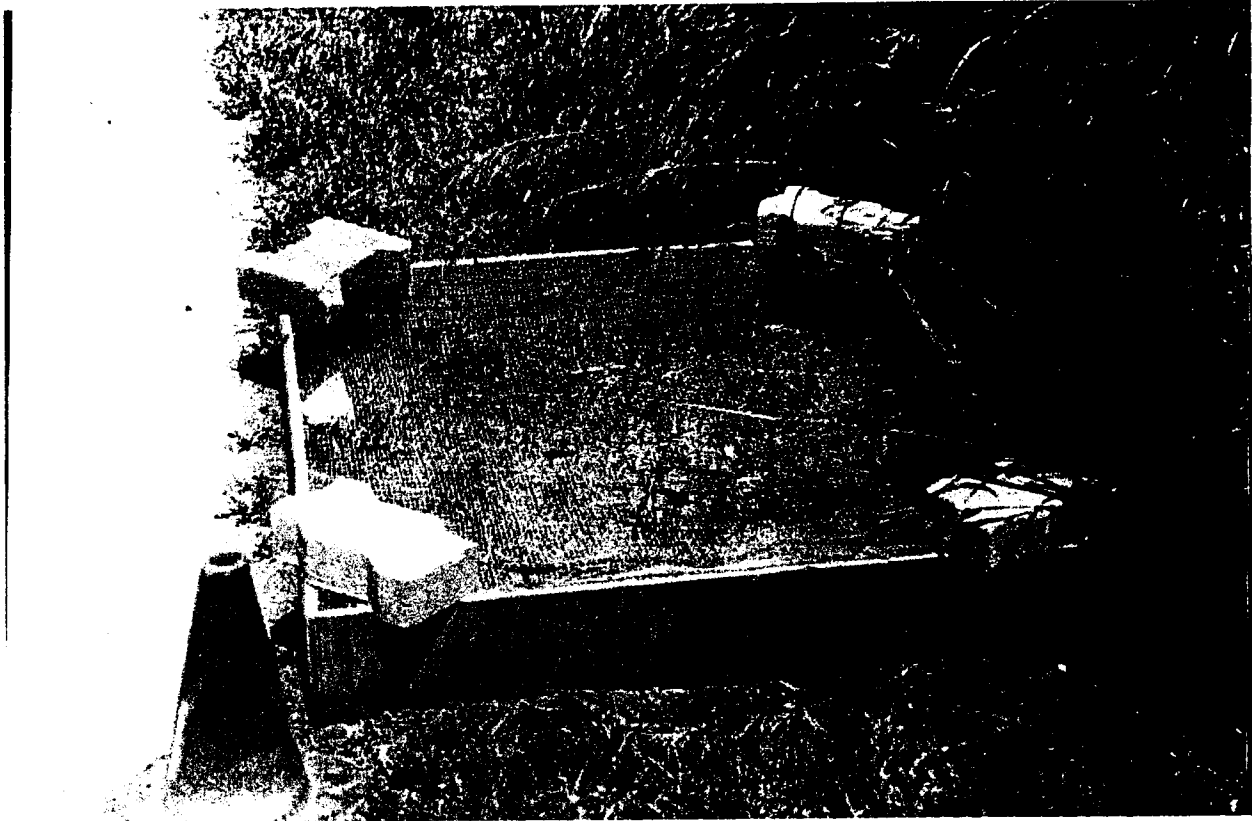


Fig. 6. Wire screen topped nest box used to protect turtle nests from mammalian predation.
Photo by Lynn Browne.



Fig. 7. Wire screen nest cage used to protect turtle nests from mammalian predation in sandy areas. Photo by Lynn Browne.

rates differed among species. If no difference existed, I assumed that predation rates were similar for all turtle species that nest in the same areas. I divided nest sites into three sections: East Beach, park roadsides, and Mersea Road E. The ratio of predated nests in these three areas was also compared.

I conducted predator surveys along park roadsides and Mersea Road E to determine the relative abundance of possible predators such as raccoons, skunks, and opossums. Surveys were conducted by driving down these roads one to two hours after dusk and recording all predators observed. Two surveys were conducted in the same night (driving into and driving out of the Park) once a week. I used the average number of predators from the two surveys for analysis. I calculated the average number of predators per kilometre for both the Park roadsides and Mersea Road E turtle nesting sites.

Hatching Success and Contaminants

Hatching success is the percentage of eggs that produce hatchlings. I examined hatching success in the absence of mammalian predation for all protected nests. The number of eggs were counted for each freshly laid nest in 2002 so that I could be sure that no eggs or hatchlings were missing in the fall when hatching success was examined. Park wardens monitored protected nests in September 2001 for emerging hatchlings and I monitored them daily from 17 August to 5 October 2002. All hatchlings were weighed, carapace length taken, and any abnormalities recorded. One of every five hatchlings had all standard measurements (same as adults) recorded. Approximately one week after hatchlings began emerging, I carefully excavated the nest to examine the remaining eggs for possible causes of failure. If viable eggs were found in the nest it was reburied and examined again later. Nests which did not hatch by 5 October 2002 were excavated to determine

their hatching success.

Three eggs from snapping turtle nests and two from painted turtle nests were collected and stored frozen for contaminant analysis to establish the level of maternal transfer to eggs. This analysis will be conducted by Dr. Ron Russell, St. Mary's University when funds become available. Once contaminant levels for these nests are known they can be compared to hatching success to determine if higher contaminant levels result in lower hatching success.

Nesting areas were divided into four sites: Contaminant site, park roadsides, Mersea Road E, and the East Beach. The contaminant site encompasses the former Camp Henry, DeLaurier area and the former Warden complex. These areas are known to have high levels of DDT and metabolites (Russell and Haffner 1997, Crowe 1999). Camp Henry and the Warden complex were closed in 1998 because DDT and DDE levels exceeded provincial health guidelines for soil concentrations (Russell and Haffner 1997, Crowe 1999). The Roadside nesting sites extended approximately 3.2 km into the Park from the Gate. These sites have low levels of contaminants (Crowe 1999). Mersea Road E is located along the north boundary of the Park. This site would most likely be affected by more recent inputs of contaminants. Farmers in this area now use modern pesticides that are less persistent than organochlorines. East Beach is also a relatively clean site which runs parallel to the marsh. The beaches adjacent to Bush, Lake, and Red-head pond are also included in this site. I used a Kruskal-Wallis test to determine if hatching success differed among these four areas, among species, and also if hatchling size differed among areas in 2002. I compared hatchling size for painted and snapping turtles between years using a Mann-Whitney *U* test. Although it's most likely for turtles that nest in one of these sites to occupy nearby habitat, they could possibly also move from one area to nest in another. Therefore, turtles that nest in contaminated sites may not have greater amounts of contaminants in

their eggs. Comparing the actual contaminant levels to hatching success should lead to a much more accurate assessment of the role of contaminants in hatching success.

Road Mortality and Population Models

I recorded all incidents of turtle road mortality in both 2001 and 2002 and added the 16 years of previous road mortality data to determine average yearly mortality rates. I used Ramas Ecolab (Akçakaya *et al.* 1999) to simulate the effects of road mortality and nest predation on the Parks Blanding's, snapping, and painted turtle populations. I used demographic data from the literature for survival and fecundity and my population estimates for initial abundances. I used demographic stochasticity for all models. Emigration was assumed to be equal to immigration. If the accuracy for any of the input parameters was in question, simulations were run for two different values. I considered age 0 to be from the time eggs are laid to hatchling emergence. All simulations had 1000 iterations and numbers reported from simulations were the average of these replications.

Blanding's Turtle Population Models:

I used life history data reported in Congdon *et al.* (1993) and Ernst *et al.* (1994) from studies on Blanding's turtles as input parameters for an ideal population before disturbance at Point Pelee. Life stages were broken into five groups: (1) juveniles age 0-17, (2) young adults age 18-35, (3) adults age 36-53, (4) adults age 54-71, and (5) adults over 71 years. I used the average age of female maturity (17.5 years; Congdon *et al.* 1993) for the separation age between juveniles and adults. Survival for age 0 was calculated to be 34.35 %: the average nest success before the collapse of the fur trade, 43.8 % (Congdon *et al.* 1993) multiplied by the percent hatching success, 78.43 %. The percent hatching success was calculated by dividing the average

number of eggs which fail to develop, 2.2 (Ernst *et al.* 1994) by the average clutch size, 10.2 (Congdon *et al.* 1993) and subtracting this number from one. No studies have determined survival of juveniles age 1-13, however Congdon *et al.* (1993) estimated survival to be 78.26 %/year. Congdon *et al.* (1993) suggest that adult survival (ages 14 and older) is approximately 96 %/year. Survival for the age class 0-17 is therefore calculated to be $(0.3435)[(0.7826)^{13}][(0.96)^4] = 0.0121$. Survival for the four adult age classes are each calculated to be $[(0.96)^{18}] = 0.4796$. Fecundity was calculated as the average number of eggs/clutch, 10.2 (Congdon *et al.* 1993), multiplied by the average number of clutches per year, 0.48 (Ernst *et al.* 1994) divided by two (assumes a 1:1 sex ratio) multiplied by 18 because there are 18 years per stage. Therefore, fecundity for each adult stage is 44.064. I estimated the initial population size at 642 individuals because this was the estimated population size of Blanding's turtles for the Park (see Results). The 642 individuals were evenly distributed between the first four age stages and rounded down to 160 turtles/stage. I also modelled several scenarios using a population size of 160 (1/4 of the estimated population size) because the estimated population size is most likely an overestimate and a population size of 160 is likely more accurate (see Results).

I analysed the effects of high nest predation (nest survival in 2002) or extremely high nest predation (nest survival 1991/1997) by changing the nest survival from 43.8 to 30 or 10 %, respectively. Therefore, survival of age class 0 changed to 23.5 and 7.8 from 34.35 % and the proportion of stage 0-17 survival changed to 0.0082 and 0.0028 from 0.0108.

I analysed the effects of road mortality by including a loss of nine adults for each 18 year time frame using the harvest function in Ramas. This number for mortality was used because the road mortality data collected over 18 years in the Park indicated an average of one turtle lost every two years. I also analysed the effects of high nest predation and road mortality combined.

The above method simulates the effects of road mortality and high nest predation rates observed at Point Pelee on an ideal population living in an area the size of Point Pelee. However, the Blanding's population at Point Pelee may be female-biased. Seventy percent of adult Blanding's captured in Point Pelee were females (see Results). Whether this female bias is real or apparent (perhaps trapping methods favoured females, ie. captures in nest sites) is difficult to determine. If the bias is real then fertility may be increased. Changing the female to male ratio in the ideal population parameters increased the fertility estimate to 61.69 per stage for each adult stage $(10.2 \text{ eggs/clutch})(0.48 \text{ clutches/year})(0.7 \text{ proportion of females in population})(18 \text{ years/stage})$. The effects of high nest predation, road mortality, and a combination of high nest predation and road mortality were analysed again using the same parameters as before but with the new higher fertility estimate.

Population models were used to determine what percentage of nests must survive predation to compensate for road mortality with or without a female bias. I varied the percentage of nest predation (thereby changing survivorship of the 0-17 year old stage) to determine the critical percentage that determines whether the population would decline or increase. Estimates were made to the nearest 1 %. A crude estimate of the number of nests that must be protected by park staff each year to prevent declines in Blanding's populations was calculated.

Snapping Turtle Population Models:

I used life history data reported in Congdon *et al.* (1987, 1994) and Ernst *et al.* (1994) to calculate input parameters for an ideal snapping turtle population at Point Pelee. Life stages were broken into four groups: (1) juveniles age 0-16, (2) young adults age 17-33, (3) adults age 34-50, and (4) adults age 51+. Survival for age 0 was calculated to be 25.56 %; the average nest

success (30 %) observed by Congdon *et al.* (1987) and myself in 2002 multiplied by the percent hatching success (85.2 %; Congdon *et al.* 1987). Congdon *et al.* (1994) reported that the survival rate for snapping turtle yearlings is 47 % and juveniles age 2 to 12 averages approximately 77 %. Adult survival was calculated to be approximately 93 %/year (Congdon *et al.* 1994). Survival for the age class 0-17 is therefore calculated to be $(0.2556)(0.47)[(0.77)^{11}][(0.93)^4] = 0.005$. Survival for the three adult age classes are each calculated to be $[(0.93)^{17}] = 0.291$. Fecundity was calculated using 28 eggs/clutch as the mean clutch size as reported in Congdon *et al.* (1987, 1994). Clutch frequency was estimated to be 0.85 clutches/year (Congdon *et al.* 1994). A sex ratio of 1.8 males to 1 female was used since this was the ratio that I observed in Point Pelee. Therefore fecundity was calculated to be 144.5 (28 eggs/clutch x 0.85 clutches/year x 0.36 female proportion of population x 17 years/stage). The initial population size was the estimated population size of snapping turtles for the Park (1385). The 1385 individuals were evenly distributed between the four stages rounded down to 346 turtles/stage.

I analysed the effects of extremely high nest predation by changing nest survival from 30 to 10 % (the survival of nests for the Park in 1991 and 1997). Therefore, survival of age class 0 changed to 8.52 % from 25.56 % and the proportion of stage 0-17 survival changed to 0.0017 from 0.005. I analysed the effects of road mortality by including a loss of two adults for each 17 year time frame. I also analysed the effects of high nest predation and road mortality combined. The clutch size of snapping turtles in the Park was much higher on average than those reported in Congdon *et al.* (1994). I found that the mean clutch size was 37 eggs/clutch (N = 32, SD = 10.8) in 2002. Therefore, I did all analyses again using a clutch size of 37 eggs/clutch and fecundity of 190.9 (37 eggs/clutch x 0.85 clutches/year x 0.36 female proportion of population x 17

years/stage).

Painted Turtle Population Models:

Input parameters for an ideal population of painted turtles were estimated based on life history data reported in Tinkle *et al.* (1981), Mitchell (1988), Ernst *et al.* (1994), and Congdon and Gibbons (1996). I used five life stages: (1) juveniles age 0-7, (2) young adults age 8-15, (3) adults age 16-23, (4) adults age 24-31, and (5) adults age 32+. Survival for age 0 was calculated to be 69.52 %; the average nest success (79 %) observed by Tinkle *et al.* (1981) multiplied by the percent hatching success (88 %; Tinkle *et al.* 1981). Mitchell (1988) reported that the survival rate for painted turtle juveniles age one to four averages approximately 46 %. Recent analysis of data of the long term studies at the E.S. George Reserve in Michigan and Algonquin Park in Ontario suggest that adult survivorship is extremely high and averages approximately 98 % (R.J. Brooks, pers. com.). I calculated survival for the age class 0-7 to be $(0.6952)[(0.46)^4][(0.98)^3] = 0.0293$. Survival for the four adult age classes are each calculated to be $[(0.98)^8] = 0.8508$. I calculated fecundity using seven eggs/clutch as the mean clutch size (Congdon and Gibbons 1996). I estimated clutch frequency to be one clutch/year because, although, some turtles lay two clutches/year others don't lay every year (Ernst *et al.* 1994). I used the sex ratio at Point Pelee (2.7 males to 1 female) for the proportion of females. Fecundity was calculated to be 15.14 (7 eggs/clutch x 1 clutches/year x 0.27 [female proportion of population] x 8 years/stage). I used the estimated population size of painted turtles for the Park (7186) as the initial population size. The 7186 individuals were evenly distributed between the five age stages and rounded down to 1437 turtles/stage.

I analysed the effects of high nest predation (70 %) and extremely high nest predation (90

%) by changing the amount of nest survival from 79 to 30 and 10 % (the survival of nests for the Park in 2002, and 1991/1997, respectively). Therefore, survival for stage 0-7 changed to 0.0111 and 0.0037 respectively from 0.0293. The effects of road mortality were analysed by including a loss of 42 adults (5.3 turtles/year) for each eight year time frame. I also analysed the effects of high nest predation and extremely high nest predation combined with road mortality.

Environmental Stochasticity:

These models underestimate the risk of extinction because environmental stochasticity was not considered. Environmental stochasticity can be incorporated into the models by including standard deviations with the input parameters for survival and fecundity. However, the standard deviations were not reported in the literature for any of the input parameters used. Standard error was reported for nest survival and adult survival for Blanding's turtles and clutch size for painted and snapping turtles. I calculated standard deviations from these standard errors ($SD = \text{sq root } [n(SE)^2]$). The standard deviation compared to the mean was calculated to be 179.2 % for nest survival (43.8 ± 78.5), 1.5 % for adult survival (96 ± 1.4), 22.4 % for snapping turtle clutch size (28 ± 6.27), and 22.9 % for painted turtle clutch size (7 ± 1.6). I calculated standard deviations for adult survivorship, juvenile survivorship, and fecundity using percentages of their input parameters. I used 1.5 % for adults of all species, the average of nest survival and adult survivorship (90.35 %) for juvenile survivorship, and the average of painted and snapping turtle clutch size (22.65 %) for fecundity for all species.

RESULTS

Population Sizes and Structure

I observed and trapped individuals of six of the seven native species that inhabited Point Pelee National Park historically (painted, snapping, Blanding's, map, stinkpot, and spiny softshell) plus the introduced red-eared slider. I did not find the spotted turtle despite extensive searches. I observed 865 turtles during the visual surveys in 2001 (Fig. 8). These numbers must be interpreted as an activity index rather than an estimation of absolute population size because individual turtles may have been counted more than once and some species were easier to observe than others.

I captured 1977 turtles in Point Pelee National Park in 2001 and 2002 combined. These included 800 painted, 421 snapping, 85 Blanding's, 172 map, and 24 stinkpot individuals plus 474 recaptures. Two spiny-softshells and 3 red-eared sliders were observed and 1 red-eared slider was captured and removed.

Species assemblages (based on captures) are ranked slightly different for 2001-2002 relative to 1972-1973. In 1972-1973 Blanding's turtles were more abundant than map turtles, a spotted turtle was captured, and no spiny softshells were observed (Table 4). The relative abundance of Blanding's turtle when compared to painted turtle abundance is significantly lower now than in 1972 ($G = 147.99$, $df = 1$, $p < 0.001$). However, snapping turtle relative abundance compared to that of the painted turtle has not changed ($G = 0.52$, $df = 1$, $p > 0.05$).

Visual Survey Turtle Observations

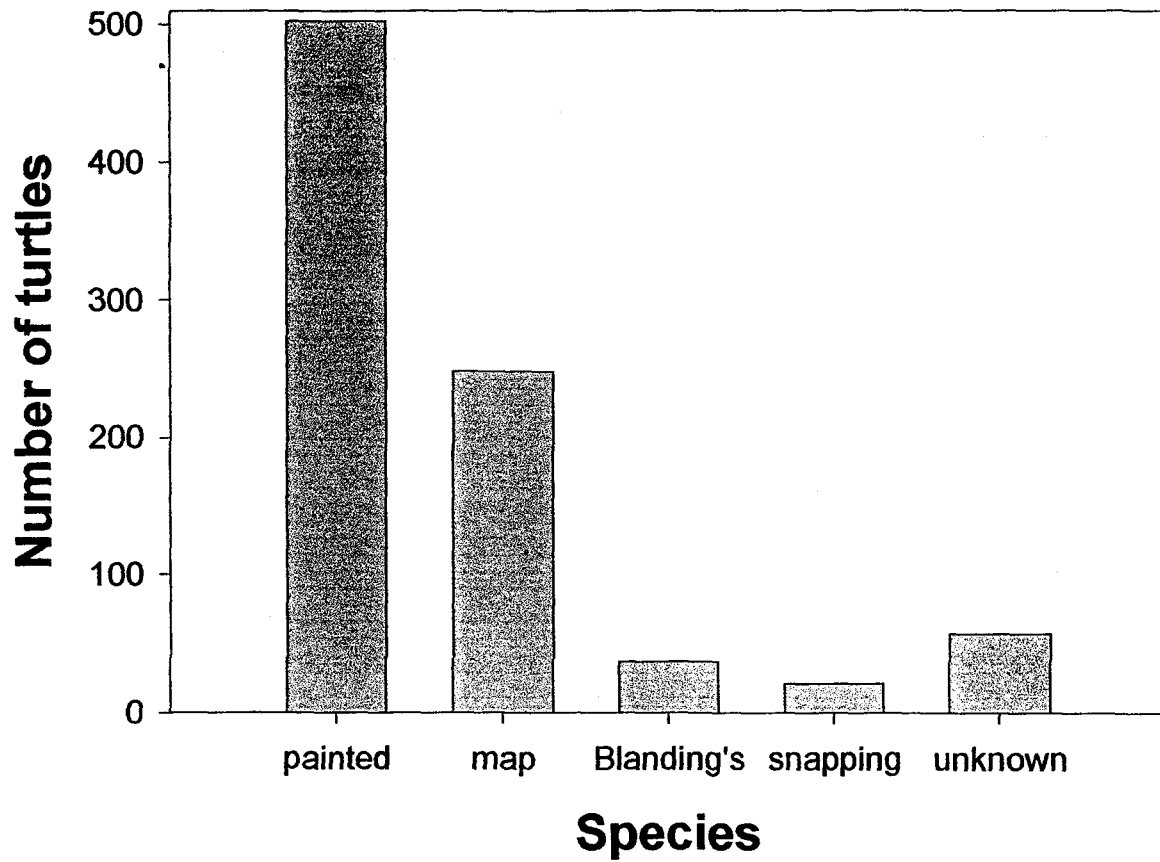


Fig. 8. Number of each species observed during visual surveys in 2001.

Table 4. Species rank and number of individuals captured at Point Pelee. Spearman rank correlation indicated that these species assemblages were marginally correlated with each other ($r_s = 0.901$, $n = 7$, $p < 0.05$).

Species	1972 rank	2002 rank	1972 captures	2002 captures
Painted	1	1	133	800
Snapping	2	2	93	421
Blanding's	3	4	46	85
Map	4.5	3	4	172
Stinkpot	4.5	5	4	24
Spotted	6	7	1	0
Spiny Softshell	7	6	0	2 ¹

¹ Two observations but no captures.

Painted turtle population estimates could be made for six sites: North DeLaurier (229 ± 126.4), South DeLaurier (329 ± 134.9), East North Boundary Canal (176 ± 257.2), Marsh Boardwalk (59 ± 6.9), East Cranberry (72 ± 227.2), and Bush Pond (64 ± 194.5). Population densities for these six sites are 498.5, 248.5, 65.2, 12.2, 2.7, and 12.5 painted turtles/ha, respectively. The average density of these sites is 22.5 painted turtles/ha (928.8 painted turtles/ 41.29 ha). Painted turtles also occurred in Red-head Pond, East Lake Pond, West North Boundary Ditch, Sanctuary Pond, West Lake Pond, Girardin's Pond, West Cranberry, Crossing and Lilly Ponds, Bush Pond, South Pond, Death Trap Pond, and Camp Henry Canal. These ponds and canals encompass a total area of 319.4 ha. Therefore, the population estimate of painted turtles for the Park is 7186 (319.4 ha x 22.5 painted turtles/ha).

Snapping turtle population estimates could be made for 5 sites: North DeLaurier (42 ± 16.0), South DeLaurier (67 ± 18.2), Red-head (51 ± 40.7), Marsh Boardwalk (61 ± 61.4), and East Lake Pond (144 ± 158.1). Population densities for these 5 sites are 91.2, 50.3, 3.1, 12.6,

and 2.3 snapping turtles/ha, respectively. The average density of these sites is 4.3 snapping turtles/ha (364.5 snapping turtles/84.7 ha). Snapping turtles also occurred in East North Boundary Canal, West North Boundary Ditch, Sanctuary Pond, West Lake Pond, Girardin's Pond, East Cranberry, West Cranberry, Crossing and Lilly Ponds, Bush Pond, South Pond, Tilden Canal, Round Pond, Death Trap Pond, Camp Henry Canal, and Snapper Pond. These ponds and canals encompass a total area of 322.1 ha. Therefore, the population estimate of snapping turtles is 1385 (322.1 ha x 4.3 snapping turtles/ha).

I could only estimate Blanding's turtle population size for North DeLaurier and South DeLaurier combined. The population size estimate for this area was 8 ± 6.0 Blanding's turtles and the population density is 4.5 Blanding's/ha. Blanding's turtles also occurred in Red-head Pond, Marsh Boardwalk, East Lake Pond, East North Boundary Canal, West North Boundary Ditch, Sanctuary Pond, Bush Pond, South Pond, Camp Henry Canal, and Tilden Canal. The total area of these sites is 142.8 ha. Therefore, the estimated population size for the Park is 642 Blanding's turtles (142.8 ha x 4.5 Blanding's/ha). However, using this method for Blanding's most likely overestimates the population size because the average density used was obtained from population estimates of only North and South DeLaurier which appear to be 'hotspots'. North DeLaurier, South DeLaurier, and Camp Henry Canal appear to have much greater densities of Blanding's turtles relative to other sites (based on visual surveys and trapping data). Therefore, the actual population size of Blanding's turtles for the entire park is most likely much less than 642 turtles.

I could only estimate map turtle population size for East Lake Pond. The population estimate for this area was 43 ± 6.4 map turtles and population density was 0.7 map/ha. Map turtles also occurred in Red-head, Marsh Boardwalk, East North Boundary Canal, West Lake

Pond, East Cranberry, West Cranberry, and Bush Pond. The total area of these sites is 241.3 ha. Therefore, I estimated the map turtle population size for the Park at 169 map turtles (241.3 ha x 0.7 map/ha). However, map turtles generally move greater distances than the other turtles and these turtles may be part of a larger population which also uses Lake Erie. Map turtles likely move to East Lake Pond to bask but also use many other areas in and out of the Park. Therefore, this is most likely an underestimate.

I used the Lincoln-Petersen method to estimate stinkpot populations for the entire park. Turtles captured in 2001 were considered to be session one and turtles captured in 2002 were considered to be session two. The population estimate for stinkpots in Point Pelee is 84 ± 76.8 .

Sex ratios differed greatly for painted, snapping, and Blanding's turtles among the different trap methods used (Table 5). Compared to a 1:1 sex ratio painted and snapping were male-biased (2.7 males: 1 female, $G = 161.76$, $df = 1$, $p < 0.001$ and 1.8 males: 1 female, $G = 34.92$, $df = 1$, $p < 0.001$ respectively). Painted turtles were significantly more male-biased in 2001-2002 than in 1972 ($G = 39.82$, $df = 1$, $p < 0.001$). However, snapping turtles had exactly the same ratio. Blanding's and map turtles both had female-biased populations compared to a 1:1 ratio (1 male: 2.32 females, $G = 13.41$, $df = 1$, $p < 0.001$ and 1 male: 2.6 females, $G = 34.08$, $df = 1$, $p < 0.001$ respectively). Blanding's were more female-biased in 2001-2002 than in 1972 ($G = 4.16$, $df = 1$, $p < 0.05$). Stinkpot sex ratios did not differ significantly from a 1:1 ratio ($G = 0.384$, $df = 1$, $p > 0.05$).

Table 5. Turtle captures for each trap type. Numbers of male, female, and juvenile turtles caught for each species using different trap types. Sex ratios significantly differed between trap types for each species (G -values ranged from 9.06 to 51.05) except for painted turtles between hand and basking ($G = 2.90$), map between hoop and hand, and stinkpot between hoop and hand ($G = 3.23$).

Species	Trap	Males	Females	Juveniles
painted	hoop	373	79	10
painted	hand	54	50	26
painted	basking	109	72	16
snapping	hoop	213	97	14
snapping	hand	41	45	4
Blanding's	hoop	15	14	2
Blanding's	hand	10	43	0
map	hoop	0	12	0
map	hand	0	12	3
map	basking	45	94	5
stinkpot	hoop	7	8	1
stinkpot	hand	0	3	0

Median carapace lengths were significantly smaller for painted turtles ($U = 55458.5$, $N_{2002} = 800$, $N_{1972} = 123$, $p = 0.006$) and significantly larger for snapping ($U = 12053$, $N_{2002} = 420$, $N_{1972} = 93$, $p < 0.001$) and Blanding's turtles ($U = 618.5$, $N_{2002} = 85$, $N_{1972} = 47$, $p < 0.001$) in 2001/2002 compared to 1972. The shape and central tendency of carapace length distributions were also significantly different from 1972 for painted turtles ($D = 0.178$, $N_{2002} = 800$, $N_{1972} = 123$, $p = 0.003$), snapping ($D = 0.305$, $N_{2002} = 800$, $N_{1972} = 123$, $p < 0.001$), and Blanding's turtles ($D = 0.605$, $N_{2002} = 800$, $N_{1972} = 123$, $p < 0.001$). Snapping (Fig. 9) and Blanding's turtles (Fig. 10) both exhibited a clear shift towards larger size classes (older age) from 1972 to now, but the

Snapping turtles

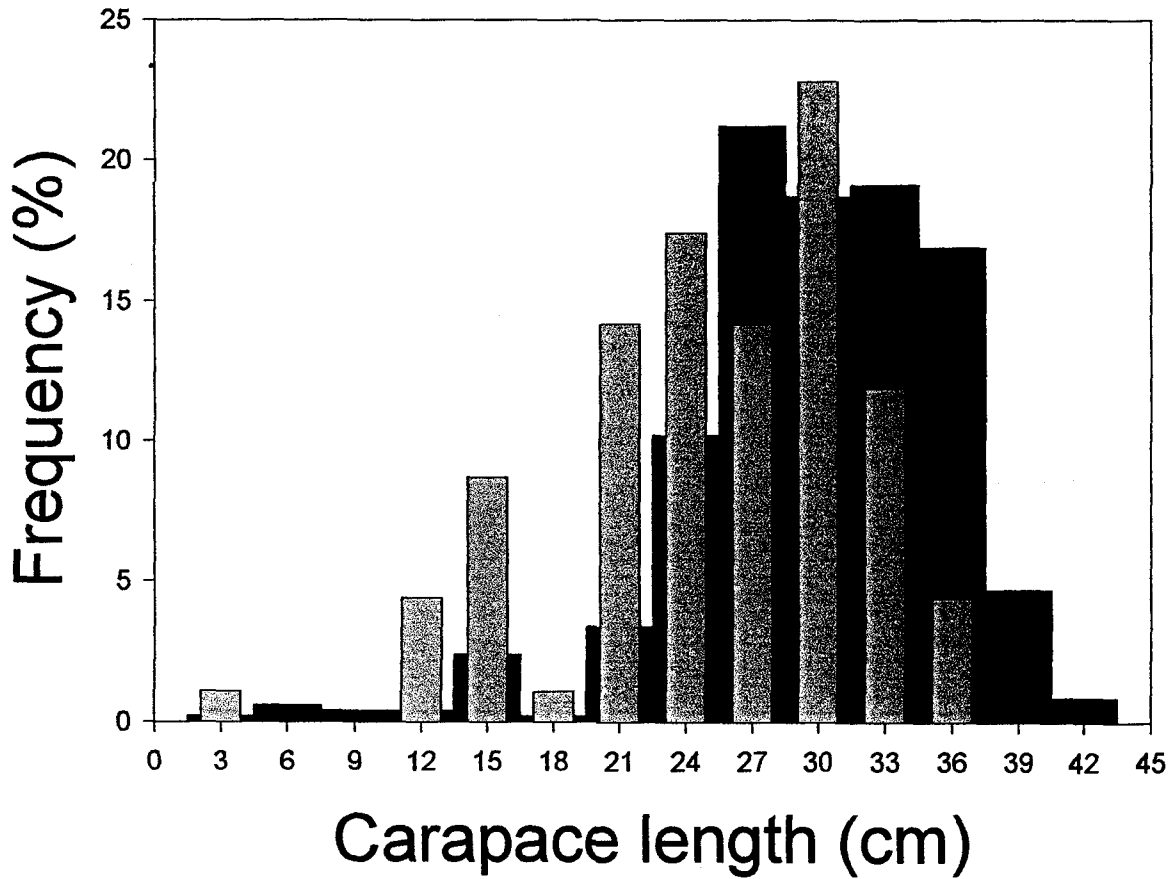


Fig. 9. Distribution of snapping turtle carapace lengths (\approx age). Turtles captured in 2001/2002 are shown in black and 1972/1973 in grey. Data for 1972/1973 are continuous but illustrated as a bar chart to facilitate comparison.

Blanding's turtles

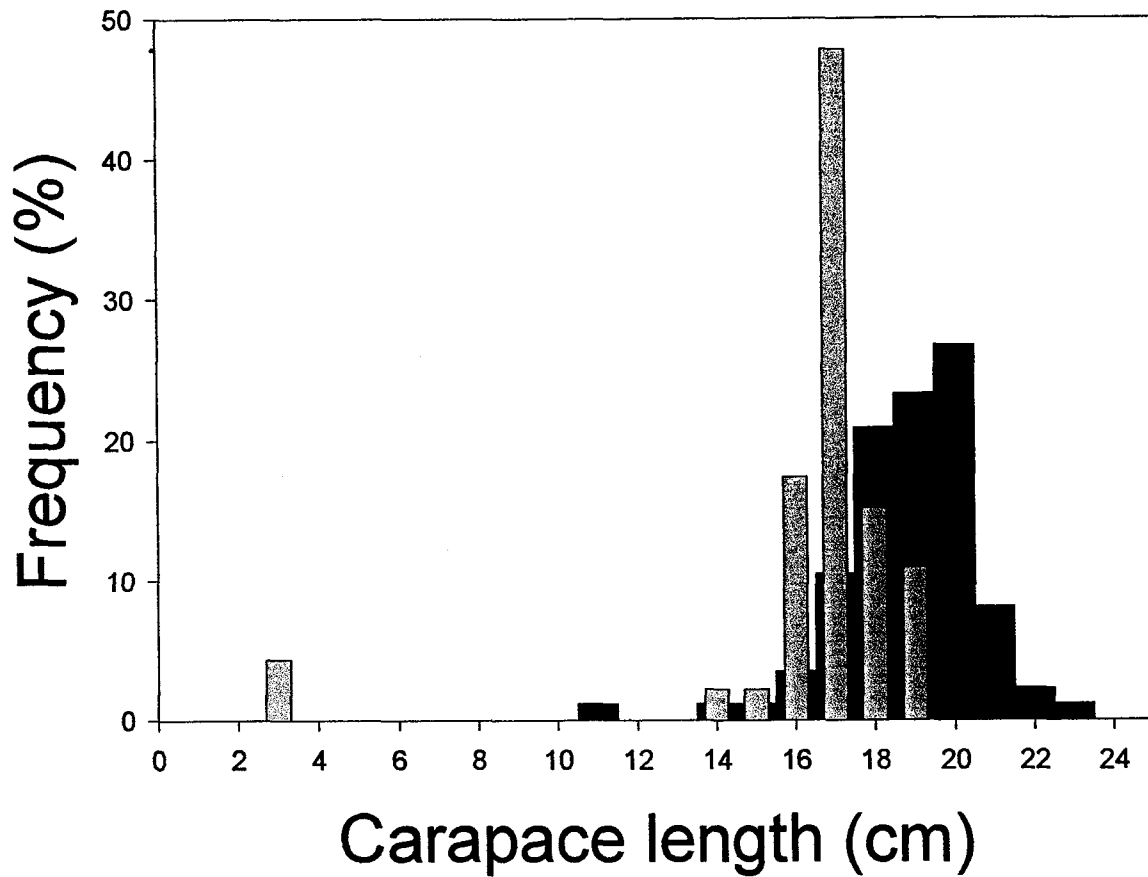


Fig. 10. Distribution of Blanding's turtle carapace lengths (\approx age). Turtles captured in 2001/2002 are shown in black and 1972/1973 in grey. Data for 1972/1973 are continuous but illustrated as a bar chart to facilitate comparison.

painted turtle did not (Fig. 11). The majority of map turtles caught were in the 9 and 10 cm carapace length size classes (Fig. 12). Fairly equal representation existed from size classes 11 to 25 cm and relatively few turtles were sizes 2 to 8 cm. The majority of stinkpot turtles captured were adults between 10.5 and 11.5 cm in length (Fig. 13).

Habitat Use and Movements

The pattern of species presence in the ponds at Point Pelee was found to be significantly nested (Table 6; observed $T = 9.08^\circ$, $p = 0.002$, expected $T = 34.12^\circ$, $SD = 17.45^\circ$). Pearson Correlation analysis showed that species richness was correlated ($\alpha = 0.2$) with swimming distance to Lake Erie (-0.618 , $p = 0.019$), straight distance to Lake Erie (-0.471 , $p = 0.089$), swimming distance to shore (-0.528 , $p = 0.052$), and bottom type (0.557 , $p = 0.039$). Species richness was negatively associated with swimming distance to Lake Erie and positively associated with bottom complexity (both sand and mud) (Table 7).

Painted turtles

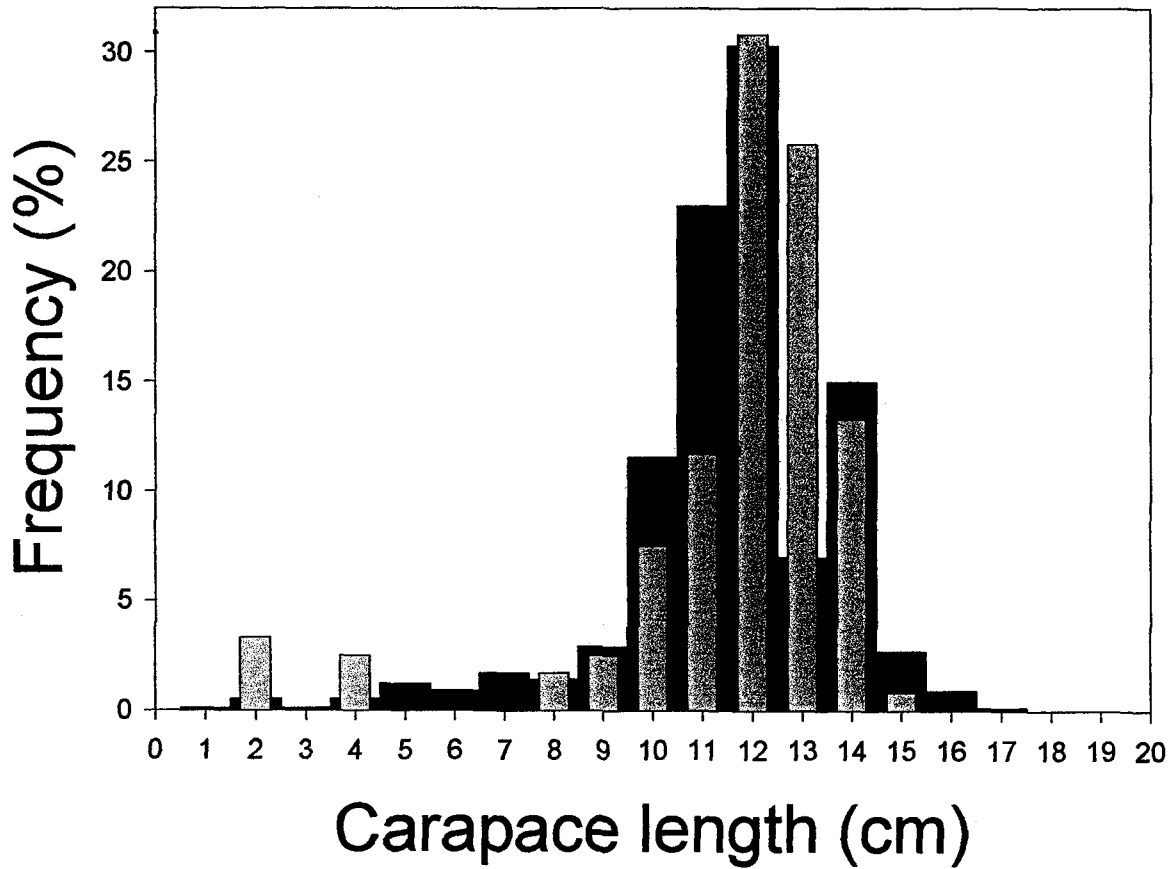


Fig. 11. Distribution of painted turtle carapace lengths (\approx age). Turtles captured in 2001/2002 are shown in black and 1972/1973 in grey. Data for 1972/1973 are continuous but illustrated as a bar chart to facilitate comparison.

Map turtles

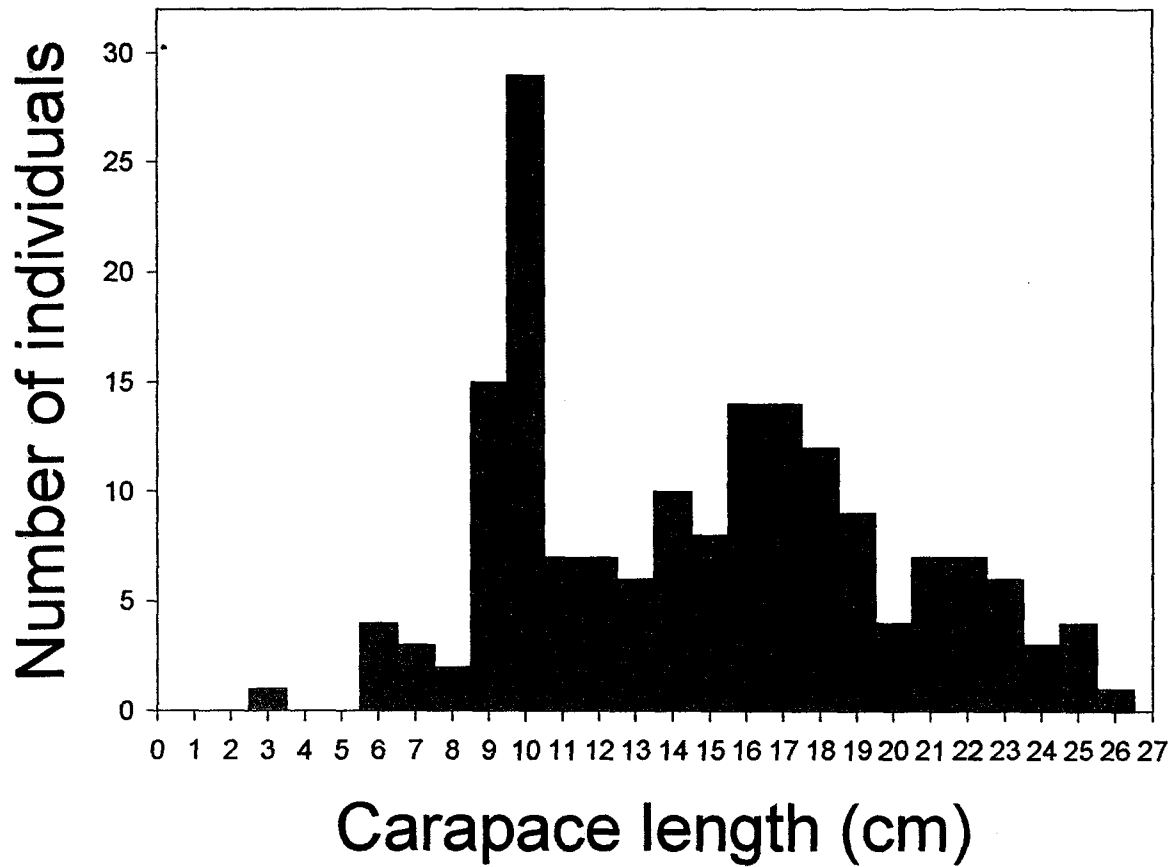


Fig. 12. Distribution of map turtle carapace lengths (age), 2001/2002.

Stinkpot turtles

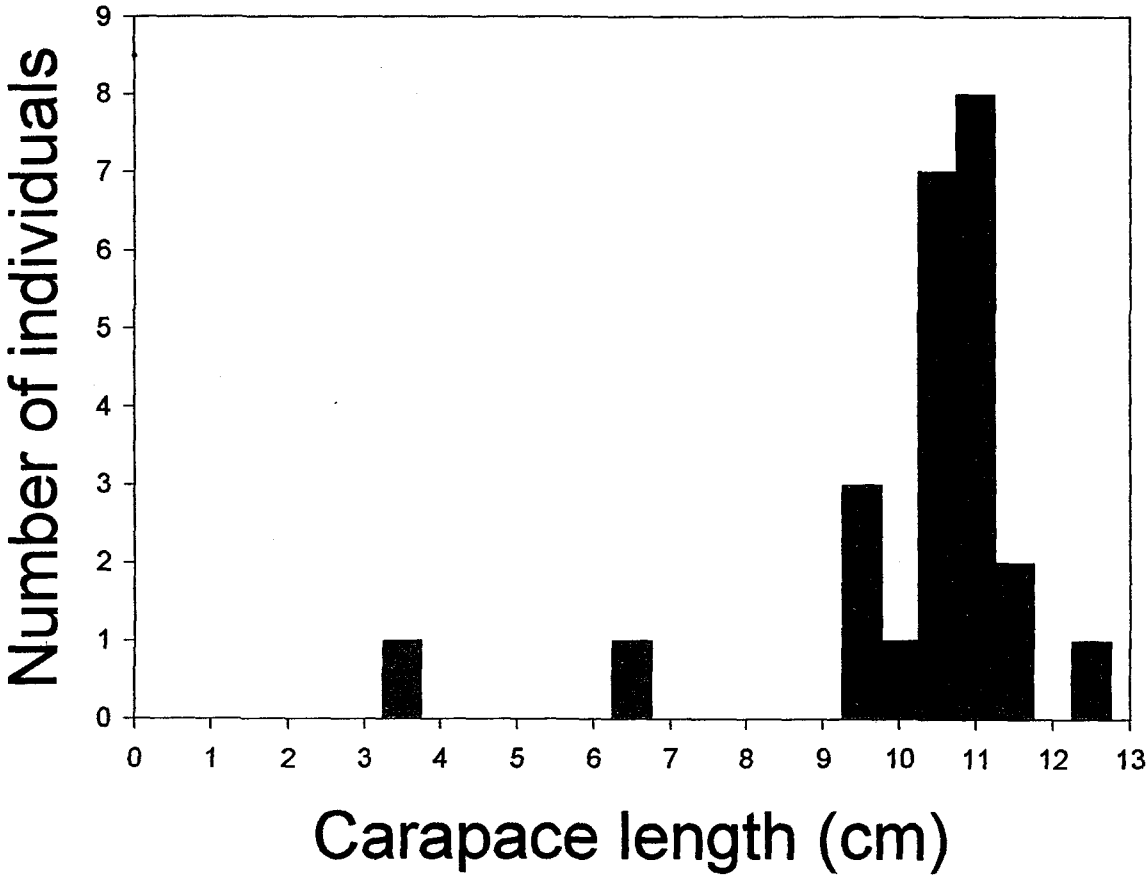


Fig. 13. Distribution of stinkpot turtle carapace lengths (age), 2001/2002.

Table 6. Distribution of turtle species throughout 14 trapping sites in Point Pelee. An x denotes presence.

Pond	Painted	Snapping	Blanding's	Map	Stinkpot
East Lake Pond	x	x	x	x	x
Red-head Pond	x	x	x	x	x
Bush Pond	x	x	x	x	x
East North Boundary	x	x	x	x	
Marsh Boardwalk	x	x	x	x	
East Cranberry	x	x		x	x
West Cranberry	x	x		x	x
North DeLaurier	x	x	x		
South DeLaurier	x	x	x		
West North Boundary	x	x	x		
Sanctuary	x	x	x		
West Lake Pond	x	x		x	
Crossing and Lilly Ponds	x	x			
Girardin's	x	x			

Table 7. Multiple regression results for species richness. Species richness was significantly related to swimming distance to Lake Erie and bottom type ($R^2 = 0.621$, $F = 9.018$, $df = 2, 11$, $p = 0.005$).

Variable	Coefficient	Tolerance	t	p
constant	2.6073		4.143	0.002
swim lake	-0.0009	0.987	-3.004	0.012
bottom	0.7367	0.987	2.636	0.023

At least two significant correlations for each species were detected and examined further for associations between species density and habitat variables (Table 8). The multiple regressions were significant for all but the map turtle ($F = 2.817$, $df = 1, 12$, $p = 0.119$). Pond type and straight line distance to the road were the only two variables that contributed to the painted turtle model (Table 9). Painted turtle densities were greatest in man-made ponds and close to roads. The multiple regression examining snapping turtle densities was only marginally significant and depth was the only variable that contributed (Table 9). Snapping turtle densities were highest in shallow ponds. Pond type and perimeter were the two variables that contributed to the Blanding's turtle model (Table 9), with Blanding's densities being highest in man-made ponds with small perimeters. Visitor activity, swimming distance to Lake Erie, and bottom type all contributed to the stinkpot model (Table 9). Stinkpots were most abundant in sites that had low visitor activity, were close to Lake Erie, and had a bottom type with mud and sand.

I calculated statistics on greatest movements for each species and sex (Table 10). There was no significant difference between movement distance of male, female, and juvenile painted ($H = 1.898$, $df = 2$, $p = 0.387$), snapping ($H = 2.400$, $df = 2$, $p = 0.301$), Blanding's ($U = 75.000$, $df = 1$, $p = 0.450$), or map turtles ($H = 1.496$, $df = 2$, $p = 0.473$). Only one stinkpot recapture occurred and he moved 858 m in East Lake Pond from 13 August 2001 to 1 June 2002. The greatest distance moved differed significantly among species ($H = 8.823$, $df = 3$, $p = 0.032$). Map turtles moved the greatest distances followed by Blanding's, then snapping turtles and painted turtles moved the least. Since the ANOVA results concurred with the Kruskal-Wallis, the Tukey post hoc test was used. It indicated that the only significant difference in distances moved among species was between map and painted turtles ($p = 0.015$).

Table 8. Correlations (Pearson r) between habitat variables and density for each species. Habitat variables that were correlated ($p < 0.2$) with species density are marked with an “*” and were used in the multiple regression analysis.

Variable	Painted	Snapping	Blanding's	Map	Stinkpot
pond type	0.69*	0.27	0.59*	-0.02	-0.37*
visitor activity	0.54*	0.31	0.14	0.06	-0.38*
perimeter	0.26	0.51	-0.40*	-0.07	-0.45*
area	-0.93*	0.19	-0.45*	0.30	0.01
depth	-0.64*	-0.54*	0.05	0.24	0.31
swim shore	-0.33	-0.17	-0.40*	-0.29	-0.32
straight shore	-0.47*	0.06	-0.33	-0.22	-0.21
swim road	-0.70*	-0.39*	-0.40*	0.09	0.48*
straight road	-0.76*	-0.30	-0.34	0.13	0.44*
swim lake	-0.13	-0.04	-0.36	-0.38*	-0.45*
straight lake	-0.16	0.21	-0.25	-0.44*	-0.53*
bottom	-0.58*	-0.33	-0.30	0.27	0.74*
vegetation	-0.11	-0.05	0.03	-0.12	0.37*

Table 9. Multiple regression results for turtle density and habitat variables. Painted turtle density was significantly related to pond type and straight line distance to road ($R^2 = 0.686$, $F = 12.009$, $df = 2, 11$, $p = 0.002$). Snapping turtle density was significantly related to depth ($R^2 = 0.287$, $F = 4.825$, $df = 1, 12$, $p = 0.048$). Blanding's turtle density was significantly related to pond type and perimeter ($R^2 = 0.494$, $F = 5.376$, $df = 2, 11$, $p = 0.024$). Stinkpot density was significantly related to visitor activity, swimming distance to Lake Erie, and bottom type ($R^2 = 0.786$, $F = 12.250$, $df = 3, 10$, $p = 0.001$).

Variable	Coefficient	Tolerance	<i>t</i>	<i>p</i>
<u>Painted turtle</u>				
constant	0.07642		0.766	0.46
pond type	0.12229	0.712	1.983	0.073
straight road	-0.00011	0.712	-2.719	0.02
<u>Snapping turtle</u>				
constant	0.36215		3.930	0.002
depth	-0.11048	1.000	-2.197	0.048
<u>Blanding's turtle</u>				
constant	-0.00404		-0.267	0.794
pond type	0.02399	0.999	2.702	0.021
perimeter	-0.00001	0.999	-1.777	0.103
<u>Stinkpot turtle</u>				
constant	0.00404		0.677	0.514
visitor activity	-0.00336	0.552	-2.159	0.056
swim lake	-0.00001	0.677	-3.271	0.008
bottom	0.00439	0.683	2.768	0.020

Table 10. Greatest distances (m) travelled by each species and gender.

Group	N	Min	Max	Median	Mean	SD
painted	159	0	2326	102	247.79	391.775
painted males	115	0	2326	110	265.37	417.530
painted females	37	0	1513	100	205.76	333.211
painted juveniles	6	0	380	48.5	127.00	158.516
snapping	98	0	2133	174.5	315.98	385.790
snapping males	66	0	2133	198	346.46	413.307
snapping females	31	0	1345	139	259.87	321.483
snapping juvenile	1	44	44	44	44.00	NA
Blanding's	23	0	2583	158	360.39	584.404
Blanding's males	9	0	497	111	175.11	159.395
Blanding's females	14	0	2583	169.5	479.50	723.389
map	16	0	2773	470	584.94	715.398
map males	7	0	2773	539	791.43	1014.789
map females	8	0	889	470	477.38	330.577
map juvenile	1	0	0	0	0	NA

Comparisons to other Communities

Species assemblages (based on captures) were very different between Hillman Marsh and Point Pelee because only three species occurred at Hillman Marsh. However, species ranks are similar (Table 11). No other species of turtles were observed during visual surveys.

Table 11. Species assemblages at Hillman Marsh and Point Pelee in 2001/2002.

Species	Hillman rank	Pelee rank	Hillman captures	Pelee captures
Painted	1	1	67	800
Snapping	2	2	20	421
Blanding's	3	4	10	85
Map		3	0	172
Stinkpot		5	0	24
Spiny Softshell		6	0	2 ¹

¹ Two observations but no captures.

Sex ratios of painted and snapping turtles were not significantly different between Hillman Marsh and Point Pelee; however, Blanding's turtles were significantly more male-biased at Hillman Marsh (Table 12). Median carapace lengths were not significantly different for painted ($U = 28154.5$, $N_{\text{Pelee}} = 800$, $N_{\text{Hillman}} = 67$, $p = 0.503$) or snapping turtles ($U = 4976.5$, $N_{\text{Pelee}} = 420$, $N_{\text{Hillman}} = 19$, $p = 0.068$). However, Blanding's turtles were significantly larger ($U = 648.5$, $N_{\text{Pelee}} = 85$, $N_{\text{Hillman}} = 9$, $p = 0.001$) at Hillman Marsh compared to Point Pelee. The shape and central tendency of carapace length distributions were not significantly different between Hillman and Point Pelee for painted turtles ($D = 0.129$, $N_{\text{Pelee}} = 800$, $N_{\text{Hillman}} = 67$, $p = 0.259$). However, they were significantly different for snapping ($D = 0.360$, $N_{\text{Pelee}} = 420$, $N_{\text{Hillman}} = 19$, $p = 0.013$) and for Blanding's turtles ($D = 0.738$, $N_{\text{Pelee}} = 85$, $N_{\text{Hillman}} = 9$, $p < 0.001$). The majority of individuals are in larger size classes (older age) at Hillman Marsh for both the snapping turtle (Fig. 14) and Blanding's turtle (Fig. 15). Painted turtle size structure appears similar between Hillman Marsh and Point Pelee (Fig. 16).

Snapping turtles

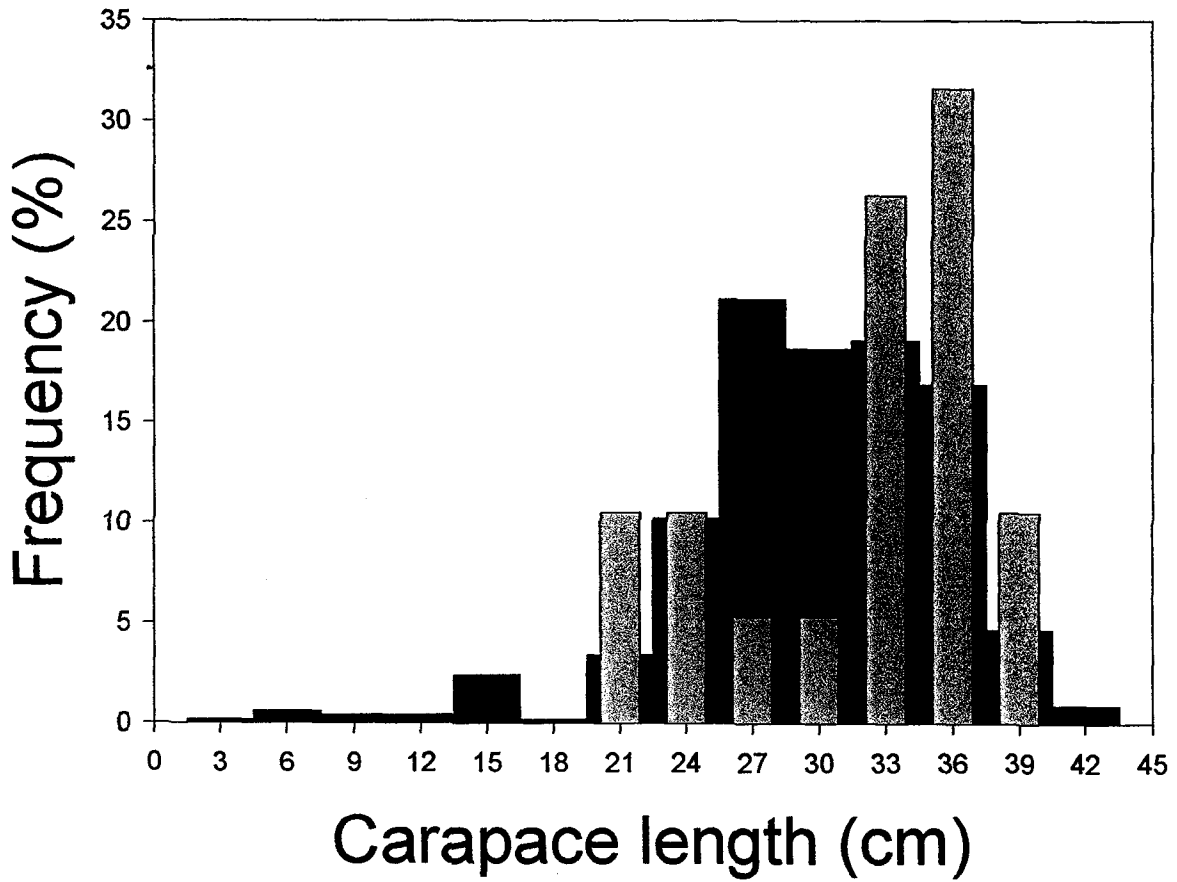


Fig. 14. Distribution of snapping turtle carapace lengths (\approx age) at Hillman and Point Pelee. Turtles captured in Point Pelee are shown in black and Hillman Marsh in grey. Data for Hillman Marsh are continuous but illustrated as a bar chart to facilitate comparison.

Blanding's turtles

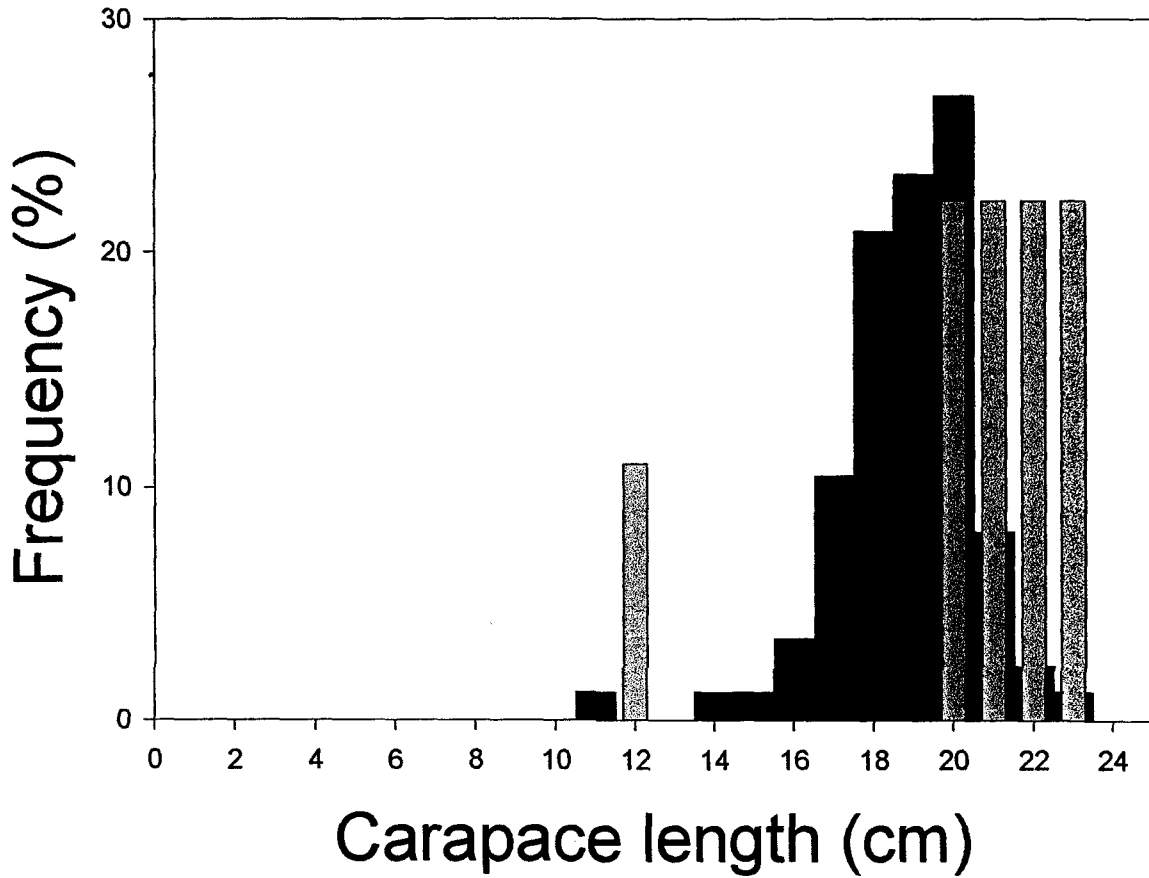


Fig. 15. Distribution of Blanding's turtle carapace lengths (\approx age) at Hillman and Point Pelee. Turtles captured in Point Pelee are shown in black and Hillman Marsh in grey. Data for Hillman Marsh are continuous but illustrated as a bar chart to facilitate comparison.

Painted turtles

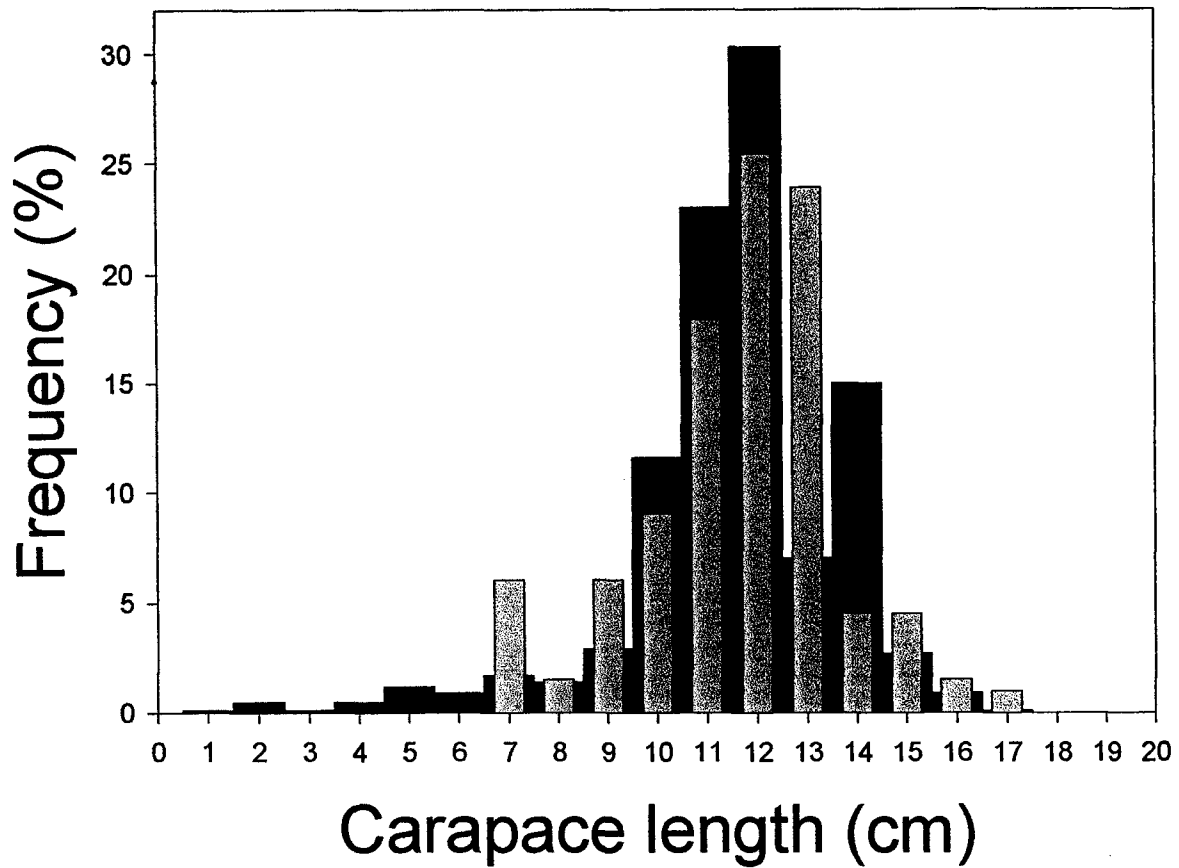


Fig. 16. Distribution of painted turtle carapace lengths (\approx age) at Hillman and Point Pelee. Turtles captured in Point Pelee are shown in black and Hillman Marsh in grey. Data for Hillman Marsh are continuous but illustrated as a bar chart to facilitate comparison.

Table 12. Sex ratios and *G*-test results for Hillman Marsh and Point Pelee. Ratios were calculated using trap captures only.

Species	Hillman (σ^7 : f)	Point Pelee (σ^7 : f)	<i>G</i> -test score	<i>p</i> -value
painted	5.7:1	3.2:1	2.84	> 0.05
snapping	3.5:1	2.2:1	0.687	> 0.05
Blanding's	8:1	1.1:1	5.3	< 0.05

Species diversity was greatest at Long Point and the lowest at Hillman Marsh of four locations examined (Table 13). Presently, species diversity at Point Pelee is similar to 1972 although it is slightly lower (Table 13).

Table 13. Species diversity (inverse of Simpson's index) of turtles at four sites in Ontario and Michigan. Capture numbers of each species present and the Simpson's diversity index (*D*) are reported for each location (Samure 1995, Congdon and Gibbons 1996). Simpson's diversity index ($D = 1 / \sum p_i^2$; p_i is the number of individuals of a species divided by the total number of individuals).

Species	Point Pelee	Point Pelee	Hillman	Long Point	E.S. George
	1972	2001-2002	2001	1992-1994	1975-1994
painted	133	800	67	279	3903
snapping	93	421	20	242	1647
Blanding's	46	85	10	178	750
map	4	172	0	3	1
stinkpot	4	24	0	0	46
spotted	1	0	0	56	0
spiny softshell	0	2	0	0	1
<i>D</i>	2.772	2.647	1.886	4.026	2.177

Nest Season

The nesting season spanned approximately four weeks in both 2001 and 2002. Peak nesting occurred during the second week of June in 2001 (Fig. 17) and the third week of June in 2002 (Fig. 18). The snapping turtle nesting peak occurred before the other species in both 2001 and 2002 (Fig. 17, 18).

Nest Protection

I found 39 snapping nests, four painted, and one map nest in 2001. I only used snapping turtle nests to compare different nest protection methods because of small sample sizes for the other species. Preliminary results from 2001 indicated that predation pressures differed among areas and that the combination of a protective wire screen box and pepper spray eliminated mammalian predation (Table 14).

Table 14. Number of snapping turtle nests (predated/found) for six different protection methods. Nesting sites were divided into five different locations.

Treatment	Roads	Blue Heron	Camp Henry	Road E	East Beach
Large box and pepper spray		0/1			
Box and pepper spray	0/7		0/3	0/11	
Box and cayenne	1/6	2/2	0/1		0/2
Cayenne and objects					0/1
Cayenne	1/1				0/2
Control	2/2				

In 2002, wire screen boxes were used along roadsides and wire screen cages used in sandy areas such as the East Beach. Along roadsides, unprotected nests experienced predation rates of

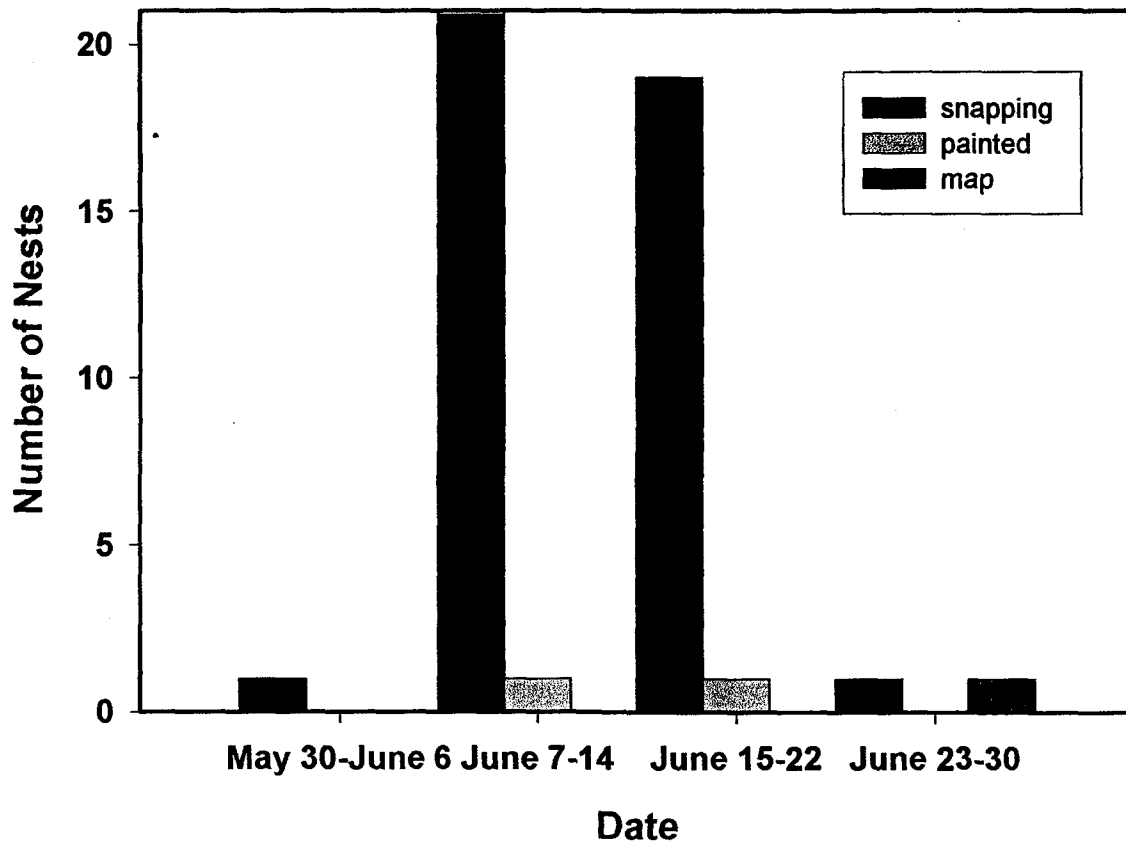


Fig. 17. Peak nesting activity of turtles in Point Pelee in 2001.

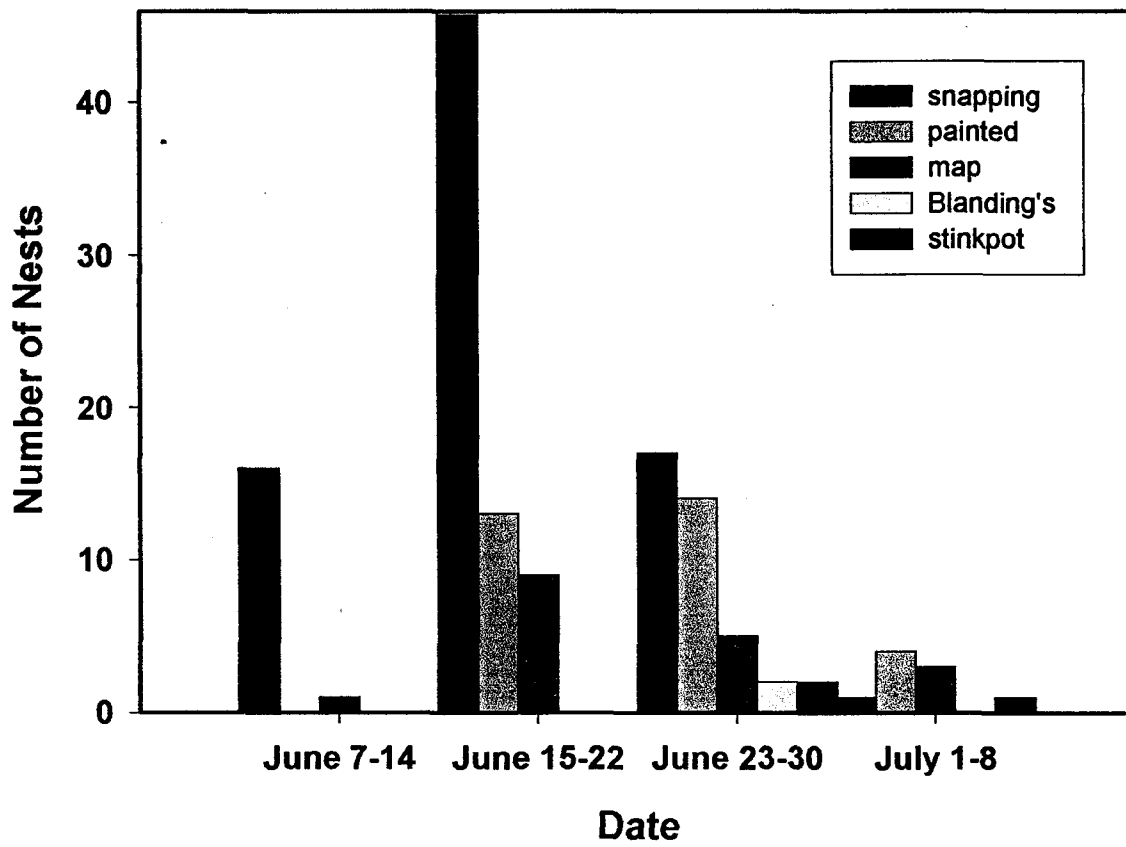


Fig. 18. Peak nesting activity of turtles in Point Pelee in 2002.

82.4 % (n = 17), whereas only 16 % of nests that were properly protected using the wire screen-topped boxes (n = 25) were predated. The East Beach had predation rates of 63.6 % for unprotected nests (n = 33), while only 4 % of nests protected with the wire screen cages were predated (n = 50). Two additional nests that were protected using wire screen-topped boxes were also predated; however, these were dropped from the analysis because sign poles prevented the proper placement of the box. Both of these nest protection methods significantly improved the chance that nests would not be predated ($G = 51.5$, $df = 1$, $p < 0.001$, and $G = 81.22$, $df = 1$, $p < 0.001$, respectively).

Nest Predation Rates

I found 134 turtle nests in 2002 and 50 (35 snapping, 15 painted) of these were assigned to the predation study. The ratio of predated to non-predated nests was 2.75:1 for painted turtles and 2.19:1 for snapping turtles. Predation rates did not differ significantly between snapping and painted turtle nests ($G = 0.15$, $df = 1$, $p > 0.05$). Predation rates were the same at the East Beach (21 of 33 predated) and Mersea Road E (5 of 8 predated) but significantly differed from predation rates along park roadsides (9 of 9 predated; $G = 8.09$, $df = 1$, $p < 0.01$).

I conducted 18 predator surveys during nine weeks from May to July. I observed 28 raccoons, six opossums, three skunks, and one weasel (*Mustela sp.*) along park roadsides (7 km) and seven raccoons along Mersea Road E (3 km). Predator densities were 0.30/km along park roadsides and 0.13/km along Mersea Road E. Raccoon densities were 0.22/km along park roadsides and 0.13/km along Road E.

Hatching Success and Contaminants

I found 134 turtle nests in 2002 (80 snapping, 31 painted, 18 map, 2 Blanding's, and 3 stinkpot nests). I protected all species at risk nests (Blanding's, map, and stinkpot). Thirty-eight snapping turtle nests and 14 painted turtle nests were assigned to the contaminant study. Two painted nests were protected but no eggs collected because they were misidentified as map turtle nests in June. I found seven partially predated snapping turtle nests. Often feeding predators were scared away by approaching researchers but sometimes nests were found predated with a few intact eggs. These partially predated nests were reburied then rehydrated (because of desiccation from sun exposure) and then protected.

I found 44 nests (39 snapping, 4 painted, and 1 map) in 2001. However, hatching success could not be determined for these nests because the accuracy of the results was in question. The eggs and hatchlings for a few nests were completely missing and a number of nests had much smaller clutch sizes than expected. Therefore, either the nests boxes were moved, a predator was able to eat the eggs without disturbing the nest boxes, or hatchlings escaped.

All painted, Blanding's, map, and stinkpot nests were successfully protected from mammalian predation in 2002. However, one painted turtle and one map turtle nest were partially predated (some individuals killed, while others unaffected) by Sarcophagid fly larvae. The fate of one map nest is unknown because the protective box was washed away during high waters on a windy day and the original location could not be determined. Eight of the 38 protected snapping turtle nests in the contaminant study were lost to mammalian predators. Of the remaining 30 snapping nests, five were partially predated by fly larvae. One of these nests also had a mole tunnel to it; of 45 eggs, 15 hatchlings were infested by fly larvae and the other 30 were missing. Two other nests also had mole (*Scalopus aquaticus*) burrows leading to the nest, both nests were

missing a small number of eggs/hatchlings. Three of the seven partially predated snapping turtle nests were completely destroyed by predators after being protected.

Emergence for individual nests lasted from one to 14 days but for the majority of nests all hatchlings emerged on the same day (median = 1 day, mean = 3 ± 3.3 days, $N = 61$). Hatching success was highest for the map turtle and lowest for the stinkpot (Table 15). The snapping turtle nests that were protected after partial predation had very good hatching success rates (median = 100, $\bar{x} = 82.3 \pm 35.50$ %, range 29-100 %, $n = 4$). Snapping turtle hatching success significantly differed among sites ($H = 14.622$, $df = 3$, $p = 0.002$). The East Beach had the highest hatching success rate (7 of 10 nests had 100 % hatching success) and the contaminant site had the lowest (Table 15).

Table 15. Percent hatching success in 2002 for each species and for snapping turtles among sites.

name	median	mean	SD	range	n
<u>Species</u>					
map	100	87.8	25.13	0-100	17
Blanding's	93	93.0	9.90	86-100	2
snapping	93	71.1	36.32	0-100	29
painted	71	60.4	42.66	0-100	16
stinkpot	0	22.3	38.68	0-67	3
<u>Location</u>					
East Beach	100	98.3	2.95	93-100	10
Mersea Road E	87	63.7	39.57	0-100	10
park roadsides	54	63.0	32.37	29-100	5
contaminant site	23.5	32.0	37.34	0-81	4

Basic statistics were calculated for the size data of hatchlings of each species (Table 16). Painted turtle hatchling size (carapace length and weight) did not differ between 2001 and 2002 ($U = 49$, $df = 1$, $p = 0.478$ and $U = 49$, $df = 1$, $p = 0.737$, respectively). However, size of snapping turtle hatchlings differed significantly between 2001 and 2002 (carapace length: $U = 230813$, $df = 1$, $p < 0.001$ and weight: $U = 158054.5$, $df = 1$, $p < 0.001$). Carapace lengths were slightly larger in 2001 than 2002, however, weights were slightly greater in 2002 than 2001 (Table 17). Carapace length and weight for snapping turtle hatchlings differed significantly among the 4 sites ($H = 15.094$, $df = 3$, $p = 0.002$ and $H = 36.149$, $df = 3$, $p < 0.001$, respectively). Carapace lengths and weights were slightly greater for hatchlings from the contaminant site (Table 17).

Table 16. Carapace length (cm) and weight (g) of hatchlings for five species of turtles in Point Pelee in 2001 and 2002.

species	size measurement	median	mean	SD	min	max	n
painted	carapace length	2.5	2.49	0.164	2.0	2.7	46
painted	weight	4.25	4.43	0.843	2.5	5.7	40
snapping	carapace length	3.0	3.01	0.152	2.2	3.5	1266
snapping	weight	10.2	10.19	1.081	6.0	14.0	1253
Blanding's	carapace length	3.6	3.53	0.130	3.3	3.7	16
Blanding's	weight	9.4	9.09	1.012	5.5	9.8	16
map	carapace length	3.1	3.10	0.154	2.6	3.4	131
map	weight	7.8	7.99	1.057	4.7	10.3	131
stinkpot	carapace length	2.3	2.28	0.126	2.1	2.4	4
stinkpot	weight	2.8	2.78	0.222	2.5	3.0	4

Table 17. Carapace lengths (cm) and weights (g) for snapping turtle hatchlings between years and among sites (2002).

site (year)	median	mean	SD	min	max	n
<u>carapace length</u>						
Point Pelee (2001)	3.0	3.03	0.165	2.2	3.5	579
Point Pelee (2002)	3.0	2.99	0.137	2.4	3.3	687
contaminant site (2002)	3.1	3.07	0.109	2.8	3.3	31
East Beach (2002)	3.0	2.99	0.115	2.7	3.3	285
Mersea Road E (2002)	3.0	2.98	0.157	2.4	3.3	274
park roadsides (2002)	3.0	2.97	0.131	2.5	3.2	97
<u>weights</u>						
Point Pelee (2001)	10.0	10.01	1.223	6.0	14.0	579
Point Pelee (2002)	10.4	10.35	0.904	6.0	13.0	674
contaminant site (2002)	10.5	10.64	1.270	6.4	12.5	31
East Beach (2002)	10.4	10.46	0.802	7.9	12.9	272
Mersea Road E (2002)	10.5	10.39	0.890	6.0	13.0	274
park roadsides (2002)	9.8	9.81	0.890	7.2	11.5	97

Of the 893 hatchlings I examined in 2002, 14 exhibited abnormalities. Abnormalities included: crooked or curly tails (5), irregular carapace scutes (5), a plastron that was not level, soft balloon at the navel (Fig. 19), soft plastron, an extra tail, bloated, extremely small size, uncoordinated leg movements, and one hatchling that appeared weak and inactive. Three of these abnormalities were from park roadside hatchlings (2.9 %), four from Mersea Road E (1.5 %), seven from the East Beach (1.5 %), and none from the contaminant site.

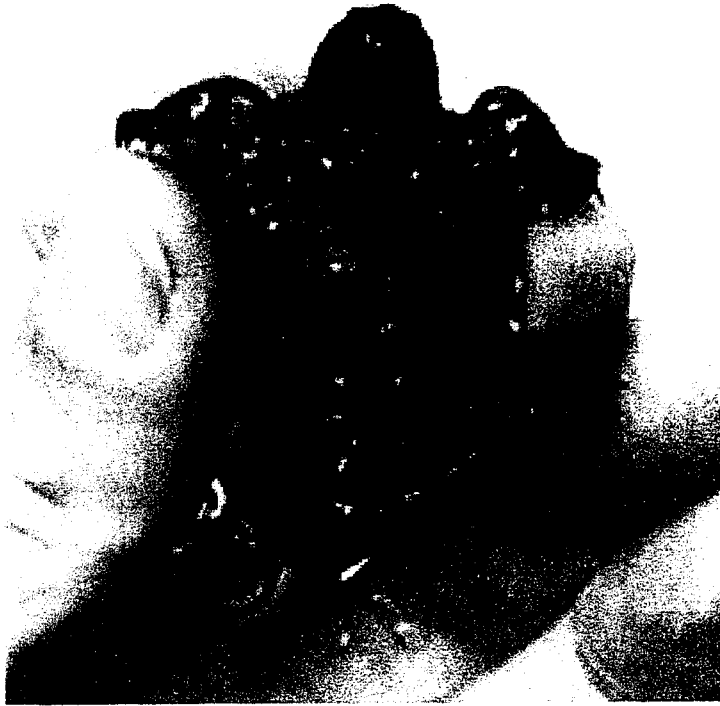


Fig. 19. A hatchling snapping turtle with abnormalities. The tissue on the plastron at the navel is soft and swelled out like a balloon and the tail is crooked. The plastron should become normal eventually (S. Gillingwater, pers. comm.). Photo by Lucas Foerster.

Road Mortality and Population Models

Road Mortality:

I found eight turtles killed by vehicles in 2001 and five in 2002. These included one adult male painted turtle, five adult female painted turtles, two juvenile painted turtles, two painted turtles where sex was not recorded, one juvenile snapping turtle, one adult female Blanding's turtle, and one juvenile female map turtle. In addition to these 13 turtles numerous hatchlings were also killed. One gravid female snapping turtle struck by a vehicle would have died if she had not received veterinary treatment (Dr. Jim Sweetman, Downtown Veterinary Clinic, Windsor, see Fig. 20, 21). This snapping turtle was included in further analysis. Road mortalities commonly occurred along Mersea Road E, the dirt turning spot at the east end of Mersea Road E, and along the Park road between the gate and DeLaurier. I found one snapping turtle hatchling road kill just south of White Pine near the 50 km/hour sign. This is not a common area for turtles because it is quite a distance from their preferred sites, however there are a few snapping turtles in the Tilden Canal that may nest in this area.

Average road mortality was 5.3 painted/year, 0.5 Blanding's/year, 0.11 stinkpot/year, 0.11 snapping/year, and 0.06 map/year (calculated using these numbers and road mortality data from 16 previous years in the Park). The percentage of the population lost to road mortality each year (using population estimates) are approximately 0.074 % for painted turtles, 0.008 % for snapping turtles, 0.079 % for Blanding's, 0.036 % for map, and 0.131 % for stinkpots.

Blanding's Turtle Population Models:

The chance of extinction for Blanding's turtle was determined for 11 different scenarios (Table 18). The input parameters for the ideal population led to an increase in population size but



Fig. 20. Snapping turtle with injuries from a vehicle. She was struck by a vehicle on the park road just south of the North West Beach sign while attempting to nest. A large piece of her carapace was broken off leaving her back muscles, backbone, and spinal cord exposed. She likely would have died from maggot infestation or by mammalian predation if she had not been treated.



Fig. 21. Snapping turtle having carapace patched. A restraining device was used to prevent her from biting while her shell was repaired with fibreglass.

an initial decrease in the number of adults. The adult population increased slowly thereafter; therefore, this appears to be a realistic model. The population is predicted to decline to extinction when either high nest predation rates (70 %) or road mortality are introduced into the model; however, the chance of extinction is greater with high nest predation rates (Table 18). The risk of extinction is always greater when lower initial abundances are used or when threats are combined (Table 18, Fig. 22). Accounting for a bias towards females in the population made a significant difference in the population trajectories. Changing only the fecundity from the ideal model changed the prediction to a rapid increase in population size. The female-biased population continued to increase even when road mortality was included. However, when the high predation rate was included, the population slowly declined despite the increased fecundity (Table 18).

Adjusting the survival rate of nests for the female biased model indicated that if 33 % of all nests escaped predation, the population would increase despite road mortalities (0.5 turtles/year). However, if only 32 % of nests survived then the population would slowly decline to extinction. The ideal population with an equal sex ratio required a much higher nest survival rate to overcome road mortalities and allow population persistence. A survival rate of 46 % of all nests would permit the population to increase slowly while the population would decrease if only 45 % of nests survived.

Trajectory summary

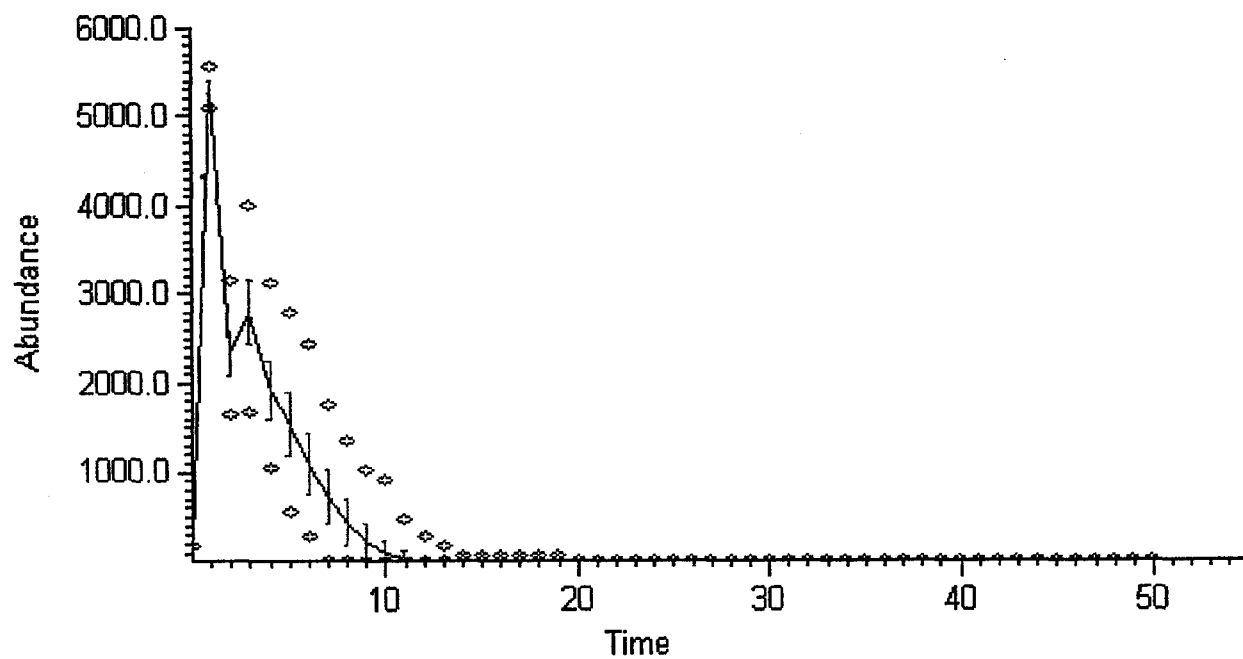


Fig. 22. Trajectory summary for the Blanding's model based on Ramas simulation. Ideal population of Blanding's turtles with high predation rates (70%), road mortality, and an initial abundance of 160 individuals. Each time step is 18 years.

Table 18. Blanding's turtle extinction risks in Point Pelee as percent chance of extinction for 11 different scenarios (based on Ramas simulations). Scenario: 1 = ideal population, 2 = high nest predation (70 %), 3 = road mortality, 4 = high nest predation and road mortality, 5 = initial abundances of 160, high predation, and road mortality, 6 = female bias and high nest predation, 7 = female bias, high nest predation, and road mortality, 8 = female bias, initial abundance of 160, high predation, and road mortality, 9 = extremely high nest predation (90 %) and road mortality, 10 = initial abundance of 160, extremely high predation, and road mortality, 11 = scenario 5 with standard deviations included for survivorship and fecundity.

Scenario	100 years	300 years	500 years	900 years	1800 years
1	0	0	0	0	0
2	0	0	0.2	65.5	100
3	0	0	0	8.5	100
4	0	11	100	100	100
5	0	99.6	100	100	100
6	0	0	0	0	0
7	0	0	0	76.5	100
8	0	61.8	100	100	100
9	0	98.8	100	100	100
10	3.7	99.8	100	100	100
11	0.4	95.2	99.8	100	100

If the following assumptions are made: equal sex ratios, road mortality is one turtle every two years, 30 % nest survival and there are no other unnatural causes of mortality, I can estimate the number of nests that need to be protected annually to maintain the current population size (note that this is a very crude estimate). If the population size is 642 individuals, taking the observed adult to juvenile ratio (83 adults: 2 juvenile) I can estimate the number of adults to be 627. Therefore, approximately 314 of these adults would be female and 150 may nest each year (0.48 clutch/year average). The percentage of nests required to survive to prevent population

decline despite road mortalities is 46 %. Therefore, 69 of the 150 nests must survive. If 30 % naturally survive that would be 45 nests, therefore 24 nests (69-45) that would have otherwise been predated must be protected. Since an average of seven nests of 24 (30 %) would have naturally survived then an additional seven nests should be protected. Therefore if 31 Blanding's nests are protected each year this could, theoretically, maintain the population.

Snapping Turtle Population Models:

The chance of extinction for the snapping turtle population was determined for 9 different scenarios (Table 19). The input parameters for the ideal population led to a slow increase in population size; therefore, these appear to be reasonable estimates. Modelling this population with the fecundity increased to an average clutch size of 37 eggs/clutch rather than 28 eggs/clutch predicts a rapid population increase. The population is predicted to decline when nest predation is increased to 90 % for either the ideal population or population with increased fecundity. However, the chance of extinction was much lower for the population with increased fecundity (Table 19). The effects of road mortality at the rate observed in Point Pelee (one turtle every nine years) have negligible effects on both the ideal population and the ideal population with increased fecundity (Fig. 23). However, if road mortality is increased to an average of one turtle every two years the population would decline to extinction. The combination of extremely high nest predation rates and road mortality put the snapping turtle population at high risk for both the ideal population and ideal with increased fecundity (Fig. 24, Table 19).

Trajectory summary

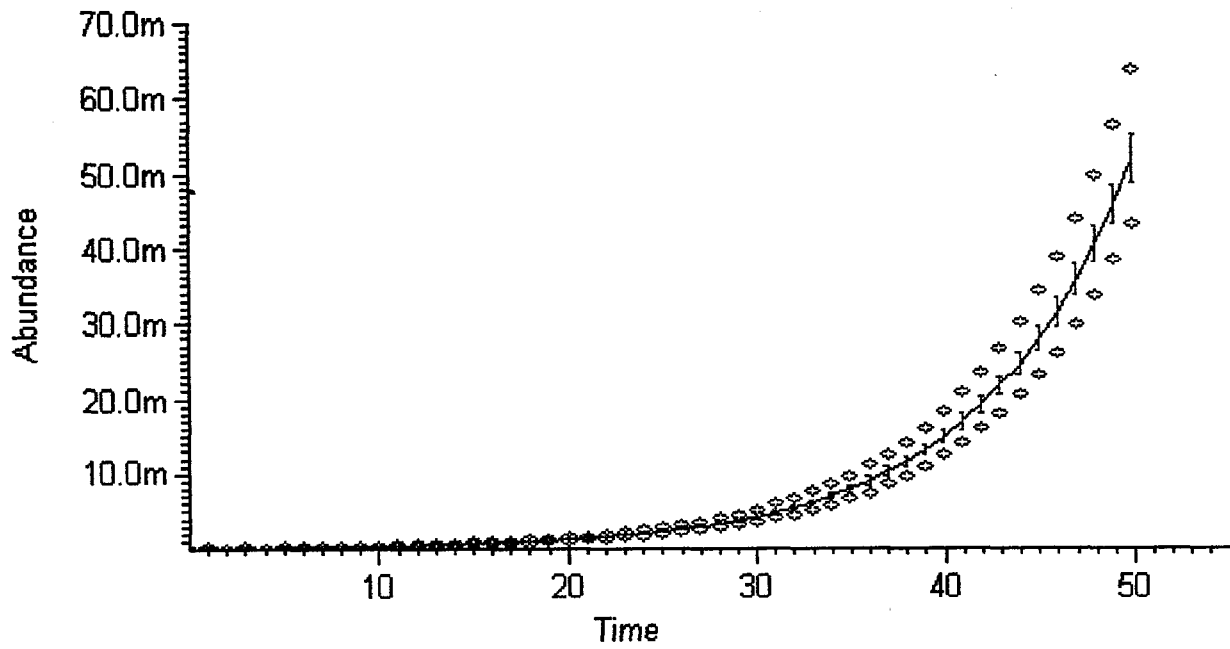


Fig. 23. Trajectory summary for the snapping turtle model based on Ramas simulation. Ideal population of snapping turtles with road mortality, and a fecundity of 37 eggs/clutch. Each time step is 17 years.

Trajectory summary

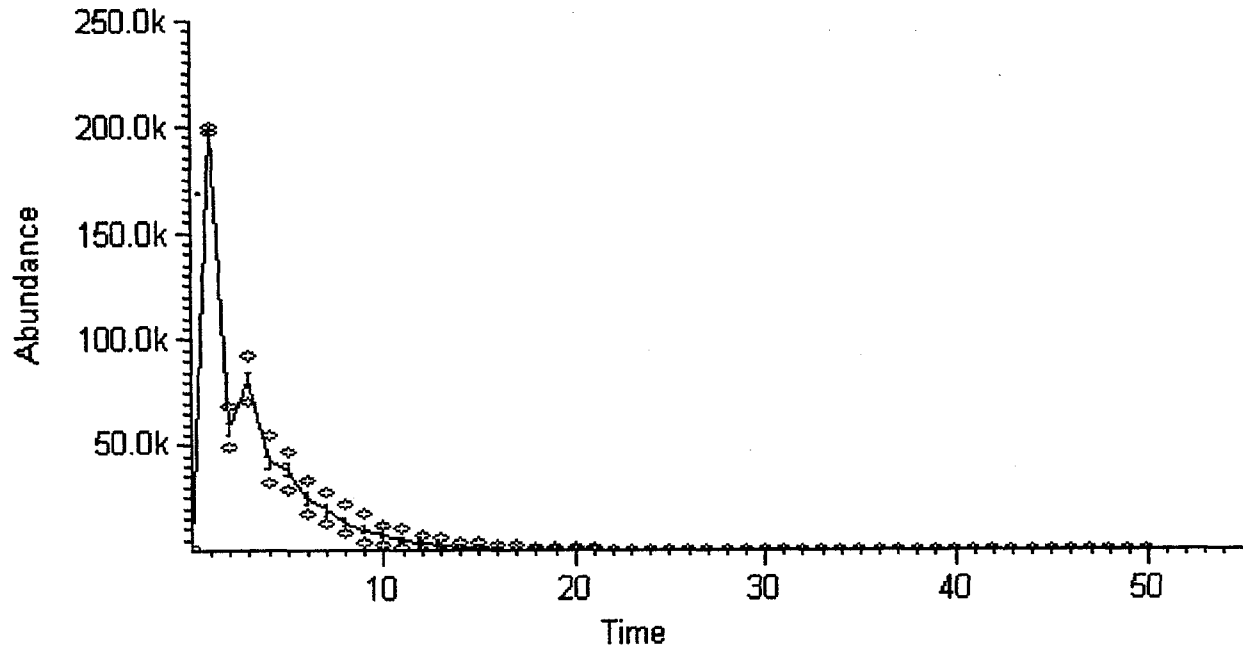


Fig. 24. Trajectory summary for the snapping model with extremely high nest predation based on Ramas simulation. Ideal population of snapping turtles with extremely high nest predation rates (90%), road mortality, and a fecundity of 37 eggs/clutch. Each time step is 17 years.

Table 19. Snapping turtle extinction risks in Point Pelee as percent chance of extinction for nine different scenarios. Scenario: 1 = ideal population, 2 = clutch size 37, 3 = 10 % nest survival, 4 = clutch size 37 and 10 % nest survival, 5 = road mortality, 6 = clutch size 37 and road mortality, 7 = 10 % nest survival and road mortality, 8 = clutch size 37, 10 % nest survival, and road mortality, 9 = scenario 8 with standard deviations included for survivorship and fecundity.

Scenario	100 years	300 years	500 years	850 years	1700 years
1	0	0	0	0	0
2	0	0	0	0	0
3	0	49.5	99.5	100	100
4	0	4.6	92.1	100	100
5	0	0	0	0	0
6	0	0	0	0	0
7	0	98.9	100	100	100
8	0	64.2	100	100	100
9	0.1	78.7	99.8	100	100

Painted Turtle Population Models:

The chance of extinction for the painted turtle population was determined for seven different scenarios (Table 20). The input parameters for the ideal population led to a extremely rapid increase in population size. The modelled population was predicted to still increase when nest survival rates were lowered to 30 %. However, the population can not sustain extremely high predation rates (90 %) and under these circumstances the population is predicted to decline. Road mortality of an average of 5.3 turtles/year is not predicted to have an impact on the ideal population or the population with nest survival rates of 30 % (Fig. 25). However, road mortality could cause population decline if other sources of mortality are increased. The probability of extinction increased to 100 % in 800 years when the threats of 90 % nest predation rates and road mortality were combined (Table 20). The ideal population with nest survivorship of 30 % would

Trajectory summary

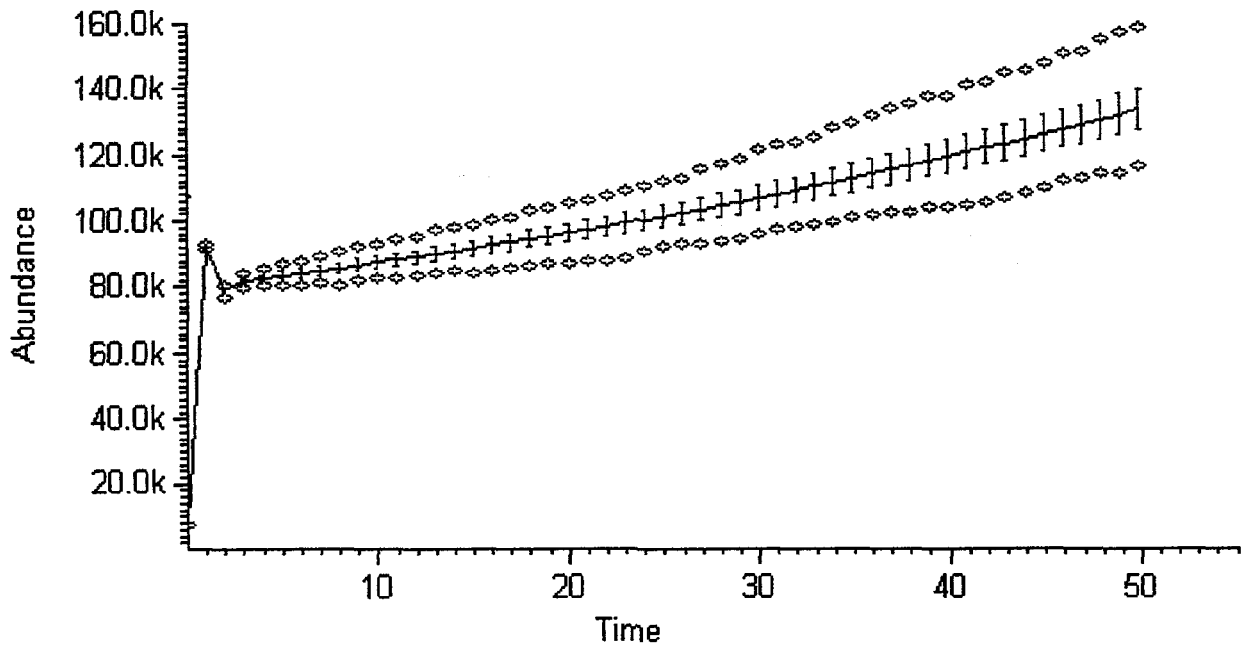


Fig. 25. Trajectory summary for the painted model based on Ramas simulation. Ideal population of painted turtles with high nest predation rates (70%) and road mortality. Each time step is 8 years.

decline slowly to extinction if road mortality (and all other unnatural causes of mortality) was increased to an average of 12 painted turtles/year.

Table 20. Painted turtle extinction risks in Point Pelee as percent chance of extinction for seven different scenarios. Scenario: 1 = ideal population, 2 = 30 % nest survival, 3 = 10 % nest survival, 4 = road mortality, 5 = 30 % nest survival and road mortality, 6 = 10 % nest survival and road mortality, 7 = scenario 5 with standard deviations included for survivorship and fecundity.

Scenario	100 years	200 years	400 years	800 years	1200 years
1	0	0	0	0	0
2	0	0	0	0	0
3	0	0	0	70.6	100
4	0	0	0	0	0
5	0	0	0	0	0
6	0	0	1.8	100	100
7	0	0	0	0	0

DISCUSSION

Two years of intensive study of turtles at Point Pelee has revealed much about the biology of the Park's turtles but it has also indicated that there are several conservation concerns. Although, seven native species occurred historically in Point Pelee, my results suggest that only six species are extant and only one has a large healthy population. Shifts in age structure towards older age classes suggest that juvenile recruitment is limited. High predation rates on nests may be responsible. The extirpation of the spotted turtle from a large healthy population in only a few generations demonstrates the severe stress on these populations. Despite the fact that my analyses were very conservative in risk assessment, they suggest that populations are still declining. In the models I assumed exponential growth, no carrying capacity, modest

environmental stochasticity and did not include disease or possible effects of contaminants. The recovery of turtle populations from decline is especially slow and difficult because of their life history traits (Klemens 2000). Once declines have become detectable, management efforts to restore populations may take decades before noticeable increases occur (Klemens 2000). Therefore, it is important that managers respond promptly to population declines before recovery becomes difficult or impossible (Klemens 2000).

Population Sizes and Structure

Species ranks based on 2002 capture data appear to be accurate in ranking the abundance of these species because visual surveys and the proportion of recaptured animals also support the ranking (most to least) as painted, snapping, map, Blanding's, stinkpot, then spiny softshell. Although the low captures of map turtles by Rivard and Smith (1973) were most likely because they did not use basking traps, the change in rank between Blanding's and map turtles is quite possible based on visual reports. The ranking of Blanding's turtles below map turtles and the fact that the proportion of captured Blanding's to painted turtles is less than in 1972 is concerning and provides further evidence that a serious decline has occurred within the past 30 years.

The spotted turtle is in all likelihood extirpated from Point Pelee. Considering historical evidence of decline in the Park and the last observation was in 1992 (despite intensive searches), it is most certainly gone. This extirpation adds another significant loss to the Park's ecosystem. It is unlikely that the spotted turtle could ever recolonise Point Pelee on its own because of the distance and isolation of Point Pelee from other spotted turtle populations. Repatriation may be the only alternative; however, translocation of herpetofauna can be problematic (Dodd and Seigal 1991). The low frequency of spiny softshell sightings is not surprising because this species has

never been common in Point Pelee. Spiny softshell turtles observed are likely part of the Lake Erie population which occasionally enters Point Pelee. M'Closkey and Hecnar (1997) reviewed the distribution and threats to the spiny softshell in Lake Erie. A number of threats could be causing declines in the spiny softshell population; however, documenting decline is difficult because little is known of its historical abundance. M'Closkey and Hecnar (1997) suggested that conservation efforts for this species be focussed on increasing knowledge through basic research and habitat protection. Although the release of red-eared sliders is considered a conservation concern (Harding 1997) it is not likely a major threat at Point Pelee because only a few individuals were observed. However, more education on pet owner responsibility and the effects of exotic species on natives is needed to discourage the purchase of slider hatchlings as short-term pets and their subsequent release into the wild.

My estimates of population size suggest that only the painted turtle has a sizable (1000s) population. However, my estimates may contain biases because some assumptions were violated. For the Jolly-Seber analysis, sampling time was not always negligible compared to the time between samples; therefore, this could have biased the estimates slightly. Additionally, each individual may not have been equally likely to be captured. Although it does not appear that hoop traps (the method having most captures) favoured the capture of males, they may have favoured the capture of adults. Juvenile captures may have been under-represented because they are harder to capture (Ream and Ream 1966, Koper and Brooks 1998). Therefore, my estimates may be more representative of adult population sizes than total population size. The stinkpot estimate may be biased because the entire park was not sampled equally and one of the assumptions of the Lincoln-Petersen method is that the population is closed and sampled evenly. However, ponds where stinkpots are abundant (East Lake Pond, Red-head Pond, Bush Pond, and East Cranberry)

were sampled with equal effort so violating this assumption likely did not greatly affect the results. My estimates for Blanding's turtle were most likely greatly overestimated because the average density used to calculate population sizes for the Park were from North and South DeLaurier. These locations appear to be 'hotspots' of density for Blanding's turtles based on visual surveys and capture data. My recapture data suggested that I was getting close to capturing a sizeable proportion of the Blanding's population because by the last month of trapping about half of the captures were recaptures.

The population estimate for map turtles was slightly less than the number of marked individuals which suggests that this is an underestimate. This situation would be possible if some of the turtles had emigrated or died and if most turtles were marked. However, I had relatively few recaptures of map turtles so the majority of the population was likely not marked. The Jolly-Seber method uses the ratio of recaptures to captures and the time of last capture from a series of trapping sessions to determine population size at a particular time and it accounts for immigration and emigration. Map turtles at Point Pelee appear to be using Lake Erie as well as ponds and canals in the Park. The patterns of recaptures in the Park suggest that map turtles are using Lake Erie as a travel corridor. Also, I observed a map turtle travel from the Marsh Boardwalk across the parking lot and along the North West Beach road to enter Lake Erie from the west beach. Because map turtles are likely using Lake Erie and I did not include this area in my population size estimates, population size is likely underestimated.

Painted turtles and snapping turtles are habitat generalists (Ernst *et al.* 1994) and occurred in almost every pond in the Park. Their adaptability probably explains why they have been able to maintain larger population sizes. However, the species-at-risk turtles have not been as successful and have much smaller population sizes. The Blanding's and spotted turtles have undergone

dramatic population declines within the past 100 years. These two species were once very abundant in Point Pelee (Patch 1919) and Blanding's now exist only in very low numbers and the spotted turtle has been extirpated. These population declines are most likely caused by a combination of factors. Point Pelee has changed vastly over the past 100 years. Much of the swamp forest was lost in the early 1900's when canals were excavated to drain the land for farming (M. Smith, pers. comm.). The highest concentrations of DDT occur in the former apple orchards (Crowe 1999) adjacent to the Blanding's 'hotspots'. In recent decades there has also been succession from open habitats such as old fields to closed canopy upland forest. Loss of large carnivores from this system would allow meso-predator populations (such as raccoons) to explode (Rogers and Caro 1998); however, they were likely controlled during the early part of the century by hunting. Point Pelee is a heavily-used park, considering its relatively small size and up to 500,000 visitors annually. The large number of cottagers and visitors were likely a heavy threat to turtle populations because individuals could easily be collected for the pet trade and heavy traffic likely resulted in a large number of road mortalities.

Loss of the spotted turtle was likely due to a number of threats. Habitat loss of swamp forests likely forced many individuals into inferior habitat. The concentration of these small turtles in the relatively few remaining shallow wetlands likely put them at great risk to intelligent predators, such as raccoons, which could easily capture individuals hiding on the bottoms of shallow ponds. Also the spotted turtle would likely be more prone to pet collection because of their attractive appearance and small size, and relatively terrestrial habits may increase encounters with humans. Raccoon populations likely increased after Point Pelee became a national park because hunting became illegal. Raccoons are considered the greatest predator to turtles of all life stages (Ernst *et al.* 1994), therefore, dramatic increases of nest predation and predation on

juveniles and adults likely resulted. Raccoon populations likely increased most in areas where human disturbance occurred because these generalists prosper in human modified habitats (Garrott *et al.* 1993). The greatest changes to the habitat within the Park have been made on the west side of the marsh. Therefore, this can explain why the Blanding's turtle and spotted turtle have been the most affected because the majority of shallow wetlands (their preferred habitat) are also along the west side of the marsh.

The simple test comparing observed sex ratios to calculated sex ratios did not indicate that sex ratios were biased towards the capture of males as suggested in much of the literature (Ream and Ream 1966, Koper and Brooks 1998, McKenna 2001). Hoop traps yielded male-biased ratios for snapping and painted turtles, female-biased for map turtles, and equal sex ratios for Blanding's and stinkpot turtles. Therefore, there are likely real sex ratio biases in the populations rather than trap bias. Basking traps yielded a slightly higher ratio of females to males than the hoop trap for painted turtles but lower for map turtles. Although there might have been slight sex biases in these trap techniques, I do not believe that it seriously affected my interpretation. However, hand captures most likely favoured capture of females because many captures were made at nesting sites. Hand captures for the painted turtle had equal sex ratios likely because a number of captures were made by dip net (not in nesting sites) and this population is likely male-biased.

Unequal sex ratios may be natural for these populations and do not necessarily indicate problems unless they alter effective population size and overall fecundity. Sex bias in populations can develop if mortality on one sex is elevated. For example, females may have a higher risk of road mortality or predation because they travel long distances during nesting migrations (Ernst *et al.* 1994). The sex ratio of snapping turtles has not become more male-biased over the past 30

years. Therefore, the sex ratio for snapping turtles is probably natural for this population.

However, the sex ratio has become more male-biased in the painted turtle population. Painted turtles are killed by vehicles more often than other species and would likely be at a greater risk of being hit and predation than other turtles because of their small size. It's possible that elevated threats to females are driving the male-bias in the painted turtle population. Map turtle populations are male-dominated in most areas (Ernst *et al.* 1994). It is unclear why the map turtle population at Point Pelee is female-dominated. Stinkpot and Blanding's turtles both had equal sex ratios for captures from the hoop traps. There is no evidence to suggest that their sex ratios deviate from a 1:1 ratio.

Sex ratios may also be altered by chemical contaminants. Recently, evidence has indicated that pesticides may cause endocrine disruption and alter reproductive development (Bergeron *et al.* 1994, Guillette *et al.* 1996). Although pesticide contamination at Point Pelee is well documented (Russell and Haffner 1997, Crowe 1999, Russell *et al.* 1999) effects on turtles have not been investigated. All of the species at Point Pelee except for the spiny softshell have temperature-dependent sex determination (Ernst *et al.* 1994). Janzen (1994) investigated the relationship between local climatic variation in temperature and offspring sex ratio for species with temperature-dependent sex determination. An increase in mean temperature of 4°C could effectively eliminate production of male offspring for some species (e.g. painted turtle) (Janzen 1994). Climate change is unlikely a threat to turtles at Point Pelee because the pattern of sex ratios among species do not indicate that temperature is responsible for skewed sex ratios.

The top heavy age structure of Blanding's turtles at Point Pelee is consistent with many other areas within its range. Numerous studies on Blanding's turtles have noted under-representation of juveniles (Gibbons 1968, Graham and Doyle 1977, Kofron and Schreiber 1985,

Congdon *et al.* 1993, Herman *et al.* 1995). All of these studies except for Herman *et al.* (1995) suggested that the low numbers of juveniles observed were likely because they were not detected. However, McMaster and Herman (2000) found that juvenile Blanding's are more visible than adults and young juveniles are more visible than older juveniles. Therefore, a number of turtle populations may be at a greater conservation risk than previously thought.

The shift in age structure towards older age classes for Blanding's and snapping turtles at Point Pelee suggests that juvenile recruitment into these populations is limited and that these populations will not be sustainable if the trend continues. Recruitment problems may be occurring at the nest stage and/or on hatchlings/juveniles. Heavy predation from raccoons is most likely responsible. Also, tilling in agricultural fields outside of the Park would destroy any nests in these areas. The more dramatic shift observed in Blanding's turtles compared to snapping turtles may be because threats are greater for Blanding's young or because clutch sizes for Blanding's are much smaller than for snapping turtles. If efforts to reduce threats to turtle nests and juveniles are not made, the Blanding's and possibly the snapping turtle could become extinct.

The overall distribution of painted turtle size structure does not indicate that it has changed over the past 30 years. Therefore, the painted turtle population is likely viable. There were no data on map turtle age structure from 1972; however, the size class distribution does not suggest recruitment problems. The high frequency of map turtles in the 9-10 cm size range can easily be explained because male map turtles mature at this size and their growth slows (Ernst *et al.* 1994). Female map turtles continue to grow into the 11-25 cm size range. The distribution of turtles sized 11-25 cm is fairly even, suggesting that the age structure may be stable because map turtles continue to grow slowly and adult survivorship is extremely high. Too few stinkpots were captured to assess their population structure.

Habitat and Movements

The nested distribution of turtle species among ponds suggests that sites differed in quality or provided more varied micro-habitat than others. Species richness was significantly associated ($R^2 = 0.62$) with bottom type and swimming distance to Lake Erie. Species richness was highest in ponds with bottoms composed of sand and mud. Increased habitat complexity may include sufficient resources for a number of different species or may allow habitat specialists to occupy the site (Guegan *et al.* 1998). An advantage of the combination of sand and muddy bottom types may be that there is a greater diversity of food and more varied micro-habitats for foraging. The actual physical uses of these bottom types might also be of importance. Some turtles hibernate in areas with muddy bottoms (St. Clair and Gregory 1990) but sandy bottoms are also likely close to suitable nesting habitat. Swimming distance to Lake Erie was the most significant habitat characteristic and may have been driven by the presence or absence of map turtles because they were mostly present in the sites that were closest to Lake Erie. Swimming distance is probably most important for map turtles because they use Lake Erie more so than the other species. Swimming distance to Lake Erie being significant rather than straight line distance demonstrates the aversion turtles have to travelling over cattail mats rather than swimming (Ross and Anderson 1990).

Painted turtle densities were significantly higher in man-made ponds close to roads. Higher abundance in human altered habitats may result because of less interspecific competition (if specialist species can not survive in these areas). Snapping turtle densities did not appear to be strongly controlled by habitat characteristics. Snapping turtles occurred in all ponds examined (see Results); however, were more abundant in shallow ponds. Anderson *et al.* (2002) examined habitat use by turtles in the Upper Mississippi River and also found that snapping turtles were

more abundant in more shallow sites. Blanding's turtle densities were positively associated with small man-made ponds. The use of small ponds is consistent with other studies (Klemens 2000). Ross and Anderson (1990) also found that Blanding's turtles had higher than expected densities (based on available habitat) in ditches than marshes and suggested that ditches act as travel corridors when turtles search for suitable feeding areas. Visitor activity, swimming distance to Lake Erie, and bottom type explained 78.6 % of the variability in stinkpot density. Stinkpots appear to be sensitive to disturbance because they were negatively associated with increasing visitor activity. Stinkpots also appear to be greatly affected by bottom type because they only occurred in or nearby areas with both sand and organic mud bottoms. Map turtle densities were not significantly related to any of these habitat variables. Therefore, either the scale that these variables were measured was not appropriate for map turtles or other variables must be controlling their distribution.

Painted, snapping, Blanding's and map turtles all moved on average less than distances reported by other studies (Ernst *et al.* 1994). However, my movement data were limited to small numbers of recaptures. Most long distance movements are made by females searching for nesting areas or by turtles moving among ponds (Ernst *et al.* 1994). An alternative hypothesis why turtles move less on average at Point Pelee may be because there are a large number of suitable ponds in close proximity. Painted and snapping turtles (the two habitat generalists) moved less on average than Blanding's, map, and stinkpot turtles. Perhaps average distance moved was less because painted and snapping turtles would not have to travel far to find suitable habitat while the other three species may be more selective and have to travel slightly farther.

Comparisons to other Communities

Species richness was much lower at Hillman Marsh than Point Pelee. Hillman Marsh is much smaller than Point Pelee and the difference in richness may simply be explained by the species area effect (Primack 2000). I expected to find the same species at Hillman Marsh as Point Pelee if habitat quality remained the same since they were separated. Species that were rare in Point Pelee were also rare in Hillman Marsh; however, there have been sightings of spotted and spiny softshell as recent as 1994 in Hillman Marsh (D. Lebedyk, pers. comm.). Habitat characteristics might explain why certain species have remained while others are extirpated. The painted and snapping turtle likely are present because they are habitat generalists. Blanding's turtles may be present because they can occupy human altered habitats, while other species may not be able. For example, stinkpots were negatively associated with visitor activity at Point Pelee and were absent from Hillman Marsh. The cells at Hillman Marsh are enclosed by dikes which are used as walking trails which leaves few areas which are not occasionally disturbed by humans.

The abundance of males in Blanding's turtles observed at Hillman Marsh may be caused by road mortality of nesting females. Few nesting sites at Hillman Marsh that do not require road crossing because the cells are surrounded by narrow dikes near roads. Blanding's turtles would most likely be affected by road mortality in this setting because they tend to travel farther to find suitable nesting sites (Gibbs and Shriver 2002). Juvenile recruitment appears to be even more restricted at Hillman Marsh relative to Point Pelee because the age structure of Blanding's and snapping turtles are significantly more top-heavy at Hillman Marsh. Hillman Marsh may be faced with greater predation pressures on nests and juveniles or be suffering more from the effects of contaminants. The disparity in age structure for Blanding's turtles may also be a result of the sex ratio bias. The effective population size for Blanding's turtles may be much smaller than the

actual population size if there are only a small number of reproducing females. Painted turtles appear to be able to cope with elevated mortality factors because their populations appear to be viable at Point Pelee and Hillman Marsh despite declines of other species.

The large freshwater marshes enclosed in the sandspits of Point Pelee National Park and Long Point that jut into Lake Erie appear to be great habitat for turtles because these two locations had the highest species diversity of four locations examined (Samure 1995, Congdon and Gibbons 1996). Hillman Marsh likely lost species through relaxation since the marsh has been separated from Point Pelee by agriculture and reduced in size.

Congdon and Gibbons (1996) reported only four species of turtles from their study sites. However, there are also populations of spiny softshell, map, and spotted turtles in the deeper marshes and backwater areas of lakes near the E.S. George Reserve (Congdon and Gibbons 1996). If Congdon and Gibbons trapped in the deeper marshes and backwaters, then perhaps the of species diversity would be greater for the E.S. George Reserve. Species diversity at Point Pelee has decreased slightly over the past 30 years; the painted turtle is dominating this community more than before. A continued loss of species diversity will likely occur unless further population declines are prevented.

Nest Season

Other studies have found peak nesting to occur from mid-May to mid-June for snapping turtles (slightly later in northern locations), June and early July for painted turtles, and usually the second or third week of June for map turtles (Ernst *et al.* 1994). Therefore, peak nesting period at Point Pelee is similar to other areas. The time of peak nesting in the Park coincides with high human visitor numbers. Human recreation activities have been documented as having negative effects on

turtles (Garber and Burger 1995). Therefore, disturbance by visitors to nesting turtles may be a slight threat to these populations.

Nest Protection

Predation pressures differed among areas and likely corresponds to the availability of food and amount of competition. Areas with higher predation pressures required more elaborate methods to successfully protect nests. For example, in 2001, two nests on the East Beach that were only protected with cayenne pepper were not predated but three of eight nests in the Park roadsides/Blue Heron area were predated when they were protected with a combination of cayenne pepper and a protective box. In general, the greater the deterrent, the less likely predation would occur.

The two nest protection methods used in 2002 (wire screen topped boxes and wire screen cages) were not compared directly to each other because they were used in areas with different predation rates of unprotected nests. However, both of these methods were highly effective in protecting turtle nests from mammalian predators. Additional actions to improve the protective devices would be to increase the size of the boxes and cages, place bricks or rocks along the periphery, or to increase the amount of pepper spray mixture used.

Nest Predation Rates

Snapping turtle nests are larger and more obvious (possibly more odorous) because they leave a large disturbed area in the ground, whereas painted turtle nests are barely detectable visually.

Therefore, snapping turtle nests should have higher predation rates than painted turtle nests. I did not find a significant difference in the rates of predation between snapping and painted turtles in

the areas that I searched. However, there still may be a difference overall for these populations in the Park because I found fewer painted turtle nests than snapping turtle. Painted turtles may also be nesting in areas I did not search. Bushy areas likely experience lower nest predation rates than areas along edge habitat, such as roadsides (Temple 1987).

Raccoons are considered the worst natural enemy for many freshwater turtles of all life stages (Ross 1988 in Ernst *et al.* 1994) and were the predator most often observed at Point Pelee. Raccoon densities were much lower outside the Park along Mersea Road E than along park roads. This may be because hunting is permitted outside the Park. Predation rates along the East Beach were similar to those outside of the Park; therefore, predator densities are likely lower along the East Beach than along park roadsides. Raccoon densities may be unnaturally high along park roadsides because raccoons prefer edge habitats (Heske *et al.* 1999) and likely receive food from visitors. Predation rates on turtle nests along park roadsides were 100 %. If this rate continues there will be no juvenile recruitment from these ponds and their survival would be completely dependant on immigration.

Hatching Success and Contaminants

Hatching success of turtle nests can vary greatly annually. However, the hatching success that I observed was similar to those reported elsewhere for painted (Tinkle *et al.* 1981, St. Clair and Gregory 1990, DePari 1996), snapping (Hammer 1969, Congdon *et al.* 1987) and Blanding's turtles (Congdon *et al.* 1983, Standing *et al.* 1999). Hatching success for stinkpots (mean 22 %) was lower than those reported in the literature (Ernst *et al.* 1994), however, my sample size was very small ($n = 3$). Little is known of the hatching success for map turtles (Ernst *et al.* 1994). However, I observed a high hatching success (mean 88 %).

Predation by Sarcophagid fly larvae on turtle eggs/hatchlings may be a threat to some turtle populations (R. Brooks, pers. comm.) but does not appear to be a threat to Point Pelee populations considering its low incidence. The interaction between moles and turtle nests is unclear because I cannot determine whether missing eggs/hatchlings from nests were predated or if the hatchlings travelled down the mole tunnels after hatching. In either case, the impact of mole tunnels is likely negative to hatchling survival. However, only a small number of nests were in contact with mole tunnels so the threat to turtle populations is likely minimal.

Partially predated nests that were re-buried, rehydrated and protected had high hatching success rates. Therefore, this appears to be an effective method to protect eggs that are found from partially predated nests. Turtle embryos are normally killed if eggs are turned unless eggs are freshly laid (Mehrtens 1984). The turtle nests that I found partially predated were likely freshly laid nests because I surveyed the nesting sites daily. Therefore, movement of the eggs by the predator likely did not affect the eggs greatly.

There was a significant difference in hatching success between sites, with the contaminant site having the lowest success. Therefore, contaminants may be having a negative impact on turtle hatching success. However, these differences could be due to other differences among sites. Therefore, it is important to examine the contaminant levels in individual nests to compare to hatching success. Although hatching success was lower in the contaminant site, hatchling size was larger. The significance of this relationship is not clear.

There was a significant difference in snapping turtle hatchling carapace lengths and weights between 2001 and 2002. The actual mean size differences were small; however, the large sample size allowed this difference to be detected. The majority of snapping turtle nests hatched within a very short time period in 2001 and most hatchlings could not be measured the day that

they hatched. Therefore, the hatchlings may have grown slightly before being measured and lost a slight amount of weight because they were not eating during this period. All hatchlings in 2002 were measured and weighed within 24 hours of emergence. All painted turtles were measured within 24 hours of emergence in both years and there was no difference in carapace lengths and weights.

Abnormalities were only observed in a small percentage of the hatchlings observed (1.6%). Although the abnormalities may put these individuals at a disadvantage most of the abnormalities did not appear to be life threatening. There does not appear to be a connection between contaminants and abnormalities considering that no abnormalities were observed at the contaminant site.

Road Mortality and Population Models

The number of road kills recorded and used for the population models is most likely an underestimate because I did not conduct surveys specifically looking for road kills and some turtles may have been moved off the road by park staff, visitors, or predators, before I had the opportunity to record them. Also, the 16 years of road mortality data before my study likely did not include Mersea Road E in their total for road mortalities. Road kills from Mersea Road E should be included in any estimates to examine the impact of road mortality on park turtles because these turtles are part of the Park population which use area inside and outside of the Park. In addition, my models underestimate the risk to turtles because not all unnatural sources of mortality were considered. I did not consider other sources of mortality, such as contaminants, collection, and vandalistic shooting, which could also be affecting turtles. Vandalistic shooting has not been previously documented as a source of mortality for the Park's turtles; however, I

removed a pellet from the carapace of a Blanding's turtle captured in the northern part of the Park in 2002.

The majority of the input parameters for the models were taken from other studies. Therefore, I recommend that these models only be used to assess the relative importance of threats. If the parameters are different from the actual rates occurring at Point Pelee results could be very different. For example, the Blanding's turtle model with road mortality predicted population decline when sex ratios were equal, but didn't when a female-biased ratio was used.

High nest predation rates (70 %) were a greater threat to all three turtle species than road mortality. Blanding's turtles were predicted to decline much quicker when subjected to high nest predation rates rather than road mortalities. Painted and snapping turtle populations were predicted to increase despite either 70 % predation rates or road mortality. However, they increased much slower when 70 % predation rates were included rather than road mortality. However, the effects of road mortality may be greater than predicted because the model assumes that road mortality is equal between male and female turtles, while it is actually greater for nesting females. The combination of road mortality and high nest predation rates did not cause decline in the snapping and painted populations, but again caused an increased decline in the Blanding's. However, extremely high nest predation rates (90 %) could not be sustained by any of these species. The snapping turtle appears to be more affected than the painted turtle by high nest predation rates and road mortality.

The models predicted that road mortality is having the greatest negative impact on Blanding's turtle populations followed by snapping then painted turtles. Gibbs and Shriver (2002) also found that road mortality is a greater threat to Blanding's populations and to a lesser extent snapping populations, but not painted populations. However, they used a completely different

approach to examine this problem. Gibbs and Shriver (2002) examined the effects of road mortality on turtle populations in eastern and central United States by the use of road maps, traffic-volume data, and simulated movements of small-bodied pond turtles (including painted turtles), large-bodied pond turtles (including snapping turtles), and terrestrial/semiterrestrial turtles (including Blanding's).

Snapping turtle clutch size at Point Pelee differed from the E.S. George Reserve (Congdon *et al.* 1994). Larger snapping turtles tend to lay larger clutches (Congdon *et al.* 1987); therefore, clutch size is likely much larger in Point Pelee than the E.S. George Reserve because the snapping turtle size distribution at Point Pelee has shifted to larger size classes. Therefore, if recruitment is increased into the population and size distribution becomes more even it is likely that the average clutch size would be reduced.

The Blanding's turtle model which is probably the closest to the actual situation occurring at Point Pelee included equal sex ratios, high nest predation rates (70 %), road mortality, an initial population size of 160, and standard deviations. This model predicted a relatively rapid decline to extinction for the Blanding's turtle. The best representation of the snapping turtle population is probably somewhat between the model with increased fecundity and road mortality (which predicts a viable population) and the model with increased fecundity, road mortality, extremely high predation rates, and standard deviations (which predicts a population decline). The painted turtle population is probably best represented by the model with high nest predation rates (70 %), road mortality, and standard deviations which predicted a viable population. Although the estimates for standard deviations came from other studies, they do demonstrate how incorporating environmental stochasticity increases the risk of extinction. It should be noted that the standard deviations I used were conservative and may underestimate risks to these

populations. Environmental stochasticity may be greater in Point Pelee than other populations because there are many stresses on Point Pelee's turtle populations.

The ideal Blanding's model used would require a nest survival rate of 46 % to overcome road mortality. Protecting turtle nests to sustain the Blanding's population may be a viable option. My calculation suggests that protecting approximately 31 Blanding's nests each year should sustain this population. Kejimikujik National Park, Nova Scotia, had similar problems with high nest predation rates causing declines in Blanding's turtle populations. They have been protecting nests for approximately 15 years to compensate for high predation rates. Preliminary evidence suggests these efforts may be beginning to help the Kejimikujik population (J. McNeil, pers. comm.). Although the researchers at Kejimikujik never located 31 nests in one year, the population size at Kejimikujik is estimated to be smaller than Point Pelee. However, locating Blanding's nests will be difficult at Point Pelee until more is known of the nesting locations (only 2 nests were found in 2002). Radio tracking females and increasing nest search efforts should aid in finding nest sites. Once nest sites are known efforts can be focussed on these areas because site fidelity is common with Blanding's turtles (Congdon *et al.* 1983).

CONCLUSIONS

Historical surveys, although limited, suggest that Point Pelee originally had a diverse assemblage of turtle species, but serious conservation concerns were evident by the 1970s. The present assemblage is less diverse, one species has been extirpated, and all but one species have either small populations or unstable age structure. Over the past 30 years, shifts in size structure indicate that recruitment is seriously threatening the viability of turtle populations in the Park. Actions of subsidized predators, road mortality, and possibly chemical contamination are important threats. The nature of threats and the status of Point Pelee's turtles appear to mirror the global conservation situation for this taxon. Despite protecting a sizable fragment of turtle habitat, Point Pelee has lost diversity and one species through time. Today only one species appears to have a large healthy population.

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