THE STATUS OF TURTLE POPULATIONS IN POINT PELEE NATIONAL PARK: A 20-YEAR UPDATE

A thesis presented to The Faculty of Graduate Studies of Lakehead University

By

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Abstract.— **Long-lived species such as turtles may appear to have healthy persistent populations if adults are consistently observed; however, study of size structures can reveal declining populations left vulnerable by limited juvenile recruitment. Long-term studies can provide insight into community and population structure changes as well as test the efficacy of previously implemented mitigation measures. Two intensive turtle studies that included trapping occurred in Point Pelee National Park (PPNP) prior to my work: Rivard and Smith (1973) and Browne (2003). Browne (2003) studied the populations, capturing six species, and started the PPNP nest protection program to mitigate heavy nest predation causing limited juvenile recruitment in Snapping and Blanding's Turtle populations.**

I captured 1834 individuals of five native and one introduced turtle species in 2022–2023 and compared my results with the results from Rivard and Smith (1973) and Browne (2003). The objective of my thesis was to estimate population sizes and compare community structure, relative abundance, sex ratios, and size structures from 2022–2023 with 1972–1973 and 2001–2002 to determine the status of PPNP turtle populations and the efficacy of the nest protection program. A total of 882 nests were protected between 2001–2021; 480 Snapping Turtle nests and 33 Blanding's Turtle nests. I found an increased catch-per-unit-effort (CPUE) and a more evenly distributed size structure with a significantly lower median MCL (mm) than Browne (2003) for Snapping Turtles. I found a decreased CPUE and a size structure with no significant changes since Browne (2003) for Blanding's Turtles. My results are consistent with the pattern expected if nest protection has helped

reverse the decline of Snapping Turtles in PPNP and suggests that nest protection can be an effective tool in turtle conservation.

Raccoons are the main turtle nest predator in PPNP, and previous studies found high Raccoon density and nest predation rates. Dense Raccoon populations also facilitate disease outbreaks such as distemper, leading to animal suffering. I located Painted and Snapping Turtle nests and monitored them to determine nest predation rates, and conducted predator surveys, using the same methodology as Browne (2003). Predators recorded included Opossums, Striped Skunks, and most notably Raccoons. I found increased Raccoon abundance in 2022 compared to 2001–2002. Following a 2022 distemper outbreak, I observed significantly fewer Raccoons in 2023 than in 2001–2002 and 2022. Nest predation rates of Painted and Snapping Turtles were also lower in 2023. Managing Raccoon populations and maintaining lower numbers closer to historical levels may help reduce nest predation while also reducing disease outbreak and animal suffering.

Browne (2003) used population models to predict the effect of road mortality and nest predation on the PPNP turtle populations. Using the same RAMAS EcoLab 2.0 software and approach, I predicted the effects of road mortality, nest predation, and nest protection for the same species. Road mortality data suggested Snapping Turtle hatchlings killed during natal dispersal were the most common road mortality victims. I incorporated 2022–2023 road mortality data, nest predation rates from previous PPNP studies, life history data reported in the literature, and nest protection. The models support the notion that nest protection can help

mitigate high nest predation in PPNP and suggest that ensuring the persistence of Blanding's Turtles in PPNP is the most contemporary concern.

Due to the vulnerability of the turtles of Point Pelee National Park to illegal collection, some sentences, tables, and figures containing sensitive information were removed from this version of my thesis. A complete version may be requested from Dr. Browne, Dr. Hecnar, Lakehead University, Taylor Hamel, Point Pelee National Park, or myself.

LAND ACKNOWLEDGEMENT

I acknowledge that Lakehead University Thunder Bay campus is located on the traditional lands of the Fort William First Nation, Signatory to the Robinson Superior Treaty of 1850. I also acknowledge that Point Pelee National Park is located on the traditional lands of the Three Fires Confederacy of First Nations (comprised of the Odawa, Ojibwa, and Potawatomi) and is located within the traditional homelands of Caldwell First Nation and Walpole Island First Nation.

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So much of not only the field work but also this thesis was based off Dr. Browne's work and Dr. Browne's supervisor 20 years ago was Dr. Hecnar! Both Dr. Browne and Dr. Hecnar can make the confusing understandable. I don't think many folks have as much experience or knowledge in the field of herpetology as Dr. Hecnar, and the opportunity to learn from him and one of Canada's top turtle scientists in Dr. Browne is pretty special. I appreciate that despite busy schedules both were always available and provided guidance, feedback, and suggestions throughout, ensuring the project was a success and we were able to do our best for the turtles of Point Pelee National Park (PPNP). Dr. Hecnar also has some great "dad jokes". My supervisory committee also included Dr. McLaren and his contributions including guidance and feedback throughout were greatly appreciated. His passion for wildlife is commendable. Pretty much just great humans, and great role models for all folks.

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GENERAL INTRODUCTION

As human populations continue to grow and negatively impact natural systems and biodiversity, conservation of species at risk becomes more urgent. Globally, Testudines (Turtles and Tortoises) are one of the most imperiled taxonomic orders on Earth with 271 of 360 (> 75%) extant or recently extinct species listed on the IUCN Red List (Rhodin et al. 2018; IUCN 2024). Along with 8 of 271 listed as extinct, 171 (> 65% of listed extant species) are at risk of extinction (IUCN 2023, 2024). This is despite surviving at least two mass extinction events (possibly three) while thriving for over 200 million years (Lyson et al. 2013; Lichtig et al. 2018). Life history traits of turtles such as late maturity and low reproductive output make them particularly vulnerable to anthropogenic threats (Congdon et al. 1994; Klemens 2000; Browne and Hecnar 2003; Browne and Hecnar 2007). All turtle species of Ontario are listed as at risk federally with designations ranging from Special Concern to Extirpated (COSEWIC 2023; Government of Canada 2023a).

Protected areas are paramount in the conservation of natural ecosystems, biodiversity, and more specifically turtles (Browne and Hecnar 2002; Browne and Hecnar 2003). While parks play an important role in conservation, they are not impervious to biodiversity loss (Rivard et al. 2000; Stanford et al. 2018). Despite protection, Point Pelee National Park (PPNP) in southern Ontario, Canada, has lost 6 of 11 amphibian species and 10 of 21 reptile species over the past century (Hecnar and Hecnar 2004). As Browne and Hecnar (2007) noted "serious conservation concerns were evident by the 1970s" within PPNP.

The most serious threats to herpetofauna globally and in Canada are habitat loss, degradation, and fragmentation (Lesbarréres et al. 2014; Stanford et al. 2020). Threats to turtles include: habitat loss, degradation, and fragmentation; nest predation; road mortality; exploitation for pet trade, food, and medicine; disease; pesticides and other contaminants; invasive species; pollution; ghost fishing gear (abandoned, lost, or discarded); and climate change (Klemens 2000; Browne and Hecnar 2003; Lesbarréres et al. 2014; Wilcox et al. 2015; Rhodin et al. 2018; Stanford et al. 2020; Clause et al. 2021). The most serious threats to turtle populations in southern Ontario have been habitat loss, degradation, and fragmentation; nest predation, and road mortality (ORAA 2024). While Canada is home to almost 60% of all freshwater lakes worldwide and 16% of the total area of Canada is covered by wetland ecosystems, southern Ontario has lost approximately 70% of its original wetland habitat (COSEWIC 2018; Safi et al. 2020). Gunson et al. (2012) reported that in southern Ontario it is not possible to travel more than 1.5 km in any direction without encountering a road (excludes large lakes and protected areas). Road mortality may disproportionately affect female turtles (Dupuis-Désormeaux et al. 2017). Ashley et al. (2007) found that road mortality is not always accidental, as 1.8% of drivers will intentionally swerve to hit a turtle. Adult survivorship is key to the success of turtle populations (Congdon et al. 1994; Whitehead 1997). For most turtle species, female reproductive output is positively correlated with size, and most species exhibit indeterminate growth (Congdon et al. 2013; Iverson et al. 2019; Edmonds et al. 2020). This means road mortality may result in the loss of individuals in the years of highest reproductive output. The turtle populations of PPNP face many threats including subsidized predators, road mortality, loss and erosion of nesting habitat, contaminants, invasive species, and poaching.

Although PPNP has been recognized as an important area for biodiversity conservation for over a century, Crowe (1999) noted misuse and mismanagement in its history. PPNP had campgrounds and trailers into the 1960s as well as houses and summer cottages into the 1970s (Crowe 1999). One landowner remained until 2001, selling their property to the park in 2002 (Constance Browne, pers. comm. 2024). Despite knowledge of Dichlorodiphenyltrichloroethane (DDT) being harmful to wildlife, the use of DDT to control mosquito populations was prevalent in the park between 1948 and 1967 (Crowe 1999). DDT was also used for pest control in apple orchards in the park into the 1960s (Crowe 1999). It is thought that DDT use within PPNP has played a major role in the decline of amphibians within the park (Russell et al. 1999). The long lifespan and use of substrates may make turtles vulnerable to some pollutants (Stanford et al. 2020). During brumation, turtles burrow into the underwater substrates or lie on the bottom of waterbodies, further exposing them to accumulated contaminants (Adams et al. 2016; Stanford et al. 2020). Hebert et al. (1993) found that organochlorines (DDT is an organochlorine) are passed from mother to egg in Snapping Turtles (*Chelydra serpentina*). Since contamination levels increase with age, it is possible that the amount of contaminant being transferred to eggs increases with maternal age (Hebert et al. 1993). Contaminants may cause decreased developmental or hatching success as clutch size and frequency increase with age (Yntema 1970; Hebert et al. 1993). In 1998, researchers detected DDT in the shallow soils of PPNP (Crowe 1999), well within the nest depths of all turtle species in the park (<20 cm, Wilhoft et al. 1979), indicating that turtle embryos could have been exposed to DDT during incubation.

High levels of turtle nest predation have been consistently found in PPNP (Rivard and Smith 1973; Kraus 1991; Whitehead 1997; Browne 2003; Phillips 2008) and along with road mortality, continues to be an issue. Browne (2003) noted that ponds and pond edges, which are key for the turtle community, made up 24.4% of the park. However, quality marsh habitat and open water has decreased because of invasive plants such as European Common Reed (*Phragmites australis australis*), Blue Cattail (*Typha x glauca*), and Narrow-leaf Cattail (*Typha angustifolia*) (Parks Canada 2021a,b). Open water habitat has decreased by ~100 hectares (~10%) since the 1950's (Parks Canada 2021a). Another concern is erosion of the shorelines bordering Lake Erie (Parks Canada 2020). Considerable erosion occurred on East Beach in 2022 and 2023 (Fig. I). Soil erosion leads to less available turtle nesting habitat and more concentrated nest sites (Constance Browne and Stephen Hecnar, pers. comm. 2022). Storm surge events result in large waves flooding and eroding shorelines, causing nest destruction (Fig. I). As climate change proceeds, more frequent and severe weather events associated with higher lake levels can be expected.

FIGURE I. Left: Nest destroyed and exposed by erosion (location removed). (Sentence removed). Middle: Protected (species removed) nest that became buried in sand after strong winds brought in large waves. Most of the logs were placed by researchers to help save the nest while the waves were coming in. Had the mesh on the Lake Erie side not been stapled to the existing log it is likely the box would have washed out. The nest was later moved to an inland area (location removed). One egg did not survive relocation but the (number removed) that did all successfully hatched and the hatchlings were released at the original nest site. One hatchling did not emerge but was alive upon excavation and successfully released. Right: Photograph of the nest pictured in the middle when first found and protected (Photographed by I. Wick 2023).

Historically, PPNP had the greatest freshwater turtle diversity in Canada with seven or eight native species (Browne and Hecnar 2002; COSEWIC 2015). I found evidence of five native species in the park while a sixth (Spiny Softshell, *Apalone spinifera*) is still thought to use the beaches for nesting (Logier 1925; Government of Canada 2023b). However, Browne (2003) determined only one of these species (Painted Turtle, *Chrysemys picta*) had a large healthy population. All turtle species within the park are of conservation concern (COSEWIC 2023; Government of Canada 2023a). Historically the Spotted Turtle (*Clemmys guttata*) was as common as the Midland Painted Turtle (*Chrysemys picta marginata*) at Point Pelee but is now considered extirpated from PPNP (Patch 1919; Browne and Hecnar 2002; Browne and Hecnar 2003; Hecnar and Hecnar

2004; Browne and Hecnar 2007). As few as 2000 Spotted Turtles remain in Ontario (Government of Ontario 2021).

All turtles are fundamentally important to the ecosystems they inhabit. Some turtles are considered keystone species (Johnson et al. 2017; Lovich et al. 2018; Selman et al. 2019). Snapping Turtles are apex predators (Kenchington et al. 2012; Hopkins et al. 2013). While the diet of each species varies, all turtles within PPNP are omnivorous (Ford and Moll 2004; Congdon et al. 2008; Moldowan et al. 2015; Mahoney and Lindeman 2016; COSEWIC 2019a). Omnivory is key to maintaining stable food webs (Aresco et al. 2015). While biomass of turtle populations can be highly variable, omnivorous aquatic turtle populations often have some of the highest biomass values of any vertebrate within an ecosystem (Iverson 1982; Congdon et al. 1986; Lovich et al. 2018). Turtles also play an important role for energy flow in foodwebs and as nutrient cyclers (Lovich et al. 2018; Van Dyke et al. 2019). Many turtles, including the Eastern Musk Turtle (*Sternotherus odoratus*), Painted Turtle, and Snapping Turtle, play an important role in seed dispersal (Ford and Moll 2004; Padgett et al. 2010; Moldowan et al. 2015). Turtle eggs can play an important role in the redistribution of nutrients and even promote vegetation growth (Moss 2017; Lovich et al. 2018). Freshwater turtles also provide a fundamental ecosystem service by scavenging which helps maintain water quality (Santori et al. 2020). A study using mesocosms by Santori et al. (2020) found carp carcasses decomposed over four times faster when turtles were present. The Vision section of the Point Pelee National Park draft management plan 2020 includes words like “stewardship”, “resilient”, and “diversity” (Parks Canada 2020). The roles of turtles at

PPNP are fundamentally important to the biodiversity and resilience of the park, as turtles can be viewed as natural "stewards" of aquatic ecosystems.

HERPETOLOGICAL SURVEYS IN POINT PELEE NATIONAL PARK

The first survey of herpetofauna at Point Pelee was conducted in 1913 by a biological field survey crew from the Victoria Memorial Museum (now the Canadian Museum of Nature), which included Clyde L. Patch and predated the establishment of PPNP (Patch 1919; Crowe 1999; COSEWIC 2015). Patch (1919) collected 59 reptiles representing eight species over three summer months. With the addition of three species not collected during his survey, Patch provided a list of 11 reptiles found at Point Pelee. Patch also noted a need for further surveys of Point Pelee, suggesting the list was likely incomplete. This list included five turtle species (Eastern Musk Turtle, Common Snapping Turtle, Spotted Turtle, Blanding's Turtle (*Emydoidea blandingii*), and Midland Painted Turtle). Patch stated Spotted Turtles and Painted Turtles were "about equally represented".

During the summer of 1920, as part of a field team from the Royal Ontario Museum of Zoology (once part of five separate museums in one building and later combined into the Royal Ontario Museum), E.B. Shelley Logier spent six weeks conducting field work in Point Pelee (Logier 1925; ROM n.d.). During this time, Logier (1925) was able to add five reptile species to the list provided by Patch (1919), including the Northern Map Turtle (*Graptemys geographica*). Although the presence of Spiny Softshell was noted as inconclusive, stories from fisherman included observations of softshells laying eggs on a beach in PPNP and of softshells in nearby waters (presumably Lake Erie, Logier 1925). This brought the total turtle species found in the park to seven. Logier also noted

Blanding's Turtles were common in the park, especially on the east side, and that they used the beaches for nesting.

Donald H. Rivard (principal investigator) and Donald A. Smith (supervisor) of Carleton University conducted a survey of PPNP herpetofauna from 17 May – 10 September 1972 (Rivard and Smith 1973). Six hoop traps were used for capturing turtles and were noted as a "considerable success". Measurements recorded for captured turtles were length and width of the carapace and plastron. Most captured turtles were marked using a metal fingerling tag. Three Eastern Box Turtles (*Terrapene carolina*) were observed. Observations for other species were: 98 Snapping Turtles, 3 Spotted Turtles, 558 Midland Painted Turtles, 63 Blanding's Turtles, 19 Northern Map Turtles, and 4 Eastern Musk Turtles. Rivard and Smith (1973) suggested the Eastern Box Turtle was likely an introduced species. Blanding's Turtles were described as common in both southern Ontario and the park. However, Rivard and Smith (1973) suggested that predation of their nests within the park was at the very least noteworthy if not of serious concern. They also noted a concern about predation of young Blanding's Turtles, having found a partially eaten juvenile (~50 mm CL) on the cattail mat. Concerns of pet trade and habitat loss were expressed in relation to the Spotted Turtle population. Rivard and Smith (1974) conducted a second survey the following year from 24 April – 31 May 1973; however, turtle traps were not used. Three species were observed (Blanding's, Painted, and Snapping Turtle).

Daniel Kraus conducted a turtle nest predation study within the park in 1991 (Kraus 1991). Two 1.5 x 2 m predator exclosures were constructed and laid on the ground. Exclosure height was approximately 20 cm. The top was covered with chicken wire and the sides covered with 10 x 15 cm wire mesh. The design was intended to allow small to medium sized turtles in while keeping predators out. While no turtles nested in the exclosures after placement, the single turtle nest that was located within one of the exclosures at time of placement was not predated. Overall, Kraus (1991) recorded three intact nests and 90 predated nests (84 predated nests on East Beach). The majority of nests found were on East Beach because 10 field surveys were conducted at this location while the additional six were opportunistic discoveries. The most prevalent predator tracks near predated nests were Raccoon (*Procyon lotor*). The estimated number of eggs lost to predation was 1930. In addition to suggesting the continuation of his own study, Kraus (1991) suggested intensified field studies of turtle nest predation, continued status monitoring of turtles, and population estimates of Raccoons.

Grant Whitehead of University of Waterloo also studied turtle nests in PPNP for one field season (22 May – 15 August 1996) (Whitehead 1997). A total of 242 nests were found in five locations (101 eastern ridge of Lake Pond, 58 East Beach, 38 Redhead Pond, 29 Sanctuary Pond, and 16 at the original Camp Henry) and 87% of the turtle nests were predated. It was suggested that Raccoons may be the main source of nest predation. Whitehead noted that adult survivorship is more important to the success of turtle populations than recruitment rates because turtles have a Type III survivorship curve and have a life history adapted to high nest predation (Iverson 1991; Whitehead 1997). However, habitats impacted by humans often facilitate raccoon populations and high raccoon densities have caused unnaturally high levels of nest predation (Prange et al. 2003; Engeman et al. 2005; Browne and Hecnar 2007). Phillips and Murray (2005; cited in Browne and Hecnar 2007) found that the population density of Raccoons in PPNP was four times higher than the rural Ontario average.

Browne (2003) conducted the most extensive study on turtle populations at PPNP (29 April – 24 August 2001, and 1 April – 22 August 2002) with 16 sites chosen for trapping (two at Hillman Marsh outside of PPNP). Browne trapped in 14 sites in PPNP in 2001 and until 15 May 2002. Based on recapture numbers, beginning 16 May 2002 efforts were focused on eight sites. I focused on the same eight sites for my research in 2022–2023 (Fig. II).

FIGURE II. Map of areas of interest in PPNP. Each of my eight sites are outlined with pink on the map and bolded in the legend. The legend shows the meaning of each acronym in alphabetical order. The salmon coloured lines show Mersea Rd. E and Point Pelee Dr. Map created using Google Earth Pro 7.3.6.9796 (64-bit).

Browne trapped in four sites concurrently, alternating them every two weeks. Eight hoop traps, three basking traps, and one Tomahawk live trap per site were used in 2002. Tomahawk live traps were not used after 18 June 2002, as they were unsuccessful. A total of 1977 captures (800 Painted, 421 Snapping, 85 Blanding's, 172 Northern Map, 24 Eastern Musk, and 1 Red-eared Slider; and 474 recaptures) occurred in PPNP (Browne 2003). Browne suggested there were "several serious threats to turtle conservation" within PPNP, populations were declining, and there was only one species remaining (Midland Painted Turtle) with a large healthy population. A shift since 1972 to an older size structure in Blanding's and Snapping Turtles was noted and attributed to high levels of nest predation limiting recruitment. Changes in community structure included apparent extirpation of Spotted Turtles and lower relative abundance of Blanding's Turtles compared to 1972. In 2001, Browne started the turtle nest protection program in PPNP, which protected over 880 nests between 2001–2021 (Parks Canada Agency unpubl. data).

Phillips (2008) conducted nest and predator surveys in 2004 and 2005. Nest searches occurred twice daily from late May to mid-July each year. A potential nest was excavated using latex gloves to confirm the presence of eggs. Marked nests were checked twice daily. Phillips found predation rates of 57.4% (54 of 94 nests were predated) and 83.8% (166 of 198 predated) for Painted and Snapping Turtle nests respectively. Nest predation rates were higher for both species in disturbed habitat (western and northern sides of the park close to roads) than undisturbed (eastern side of the park) (Painted: 53% vs. 78%; Snapping: 66% vs. 98%). Phillips noted higher Raccoon density in disturbed habitat. Tracks and scats nearby predation events were used to determine the predator. Tomahawk live traps were also used to catch predators. Following a predation event, a trap was placed near the depredated nest for three days. As in the previous studies, Raccoons were the most common predator captured in traps. Raccoons were confirmed as predators of 71.8% of nests, and likely were the predator of another 22.2% of nests.

TURTLE SPECIES

Brief overview of turtles.— Ten turtle species have been reported in PPNP. It is likely two (Pond Slider [*Trachemys scripta*] and Wood Turtle [*Glyptemys insculpta*]), and possibly a third species (Eastern Box Turtle) were introduced, and one is thought extirpated (Spotted Turtle) (Browne and Hecnar 2002; Browne 2003; Browne and Hecnar 2003; Hecnar and Hecnar 2004). I observed Blanding's Turtle, Eastern Musk Turtle, Northern Map Turtle, Painted Turtle, Pond Slider, and Snapping Turtle in 2022–2023. The lack of a Spiny Softshell Turtle observation could be partially explained by their rarity in the park; they rarely enter PPNP from Lake Erie and may occasionally use the park beaches for nesting (Logier 1925; Hecnar and Hecnar 2005; Browne and Hecnar 2007). All turtle species of PPNP are listed as at risk (Table I).

TABLE I. Species captured in the park and their federal conservation status in 2002 and 2023 (Table adapted from Browne 2003; COSEWIC 2023; Government of Canada 2023a).

Scientific Name	Common Name	2002 Conservation Status	2023 Conservation Status
Apalone spinifera	Spiny Softshell	Threatened	Endangered
Chelydra serpentina	Snapping Turtle		Special Concern
Chrysemys picta	Painted Turtle		Special Concern

Clemmys guttata	Spotted Turtle	Special Concern	Endangered
Glyptemys insculpta	Wood Turtle	Special Concern	Threatened
Emydoidea blandingii	Blanding's Turtle	Threatened	Endangered*
Graptemys geographica	Northern Map Turtle	Special Concern	Special Concern
Sternotherus odoratus	Eastern Musk Turtle	Threatened	Special Concern
Terrapene carolina	Eastern Box Turtle	Data Deficient	Extirpated***
Trachemys scripta	Pond Slider	Introduced**	Introduced**

*=Great Lakes/St. Lawrence population. **Not a COSEWIC status. ***Occasionally found but thought to be reintroduced.

Snapping Turtle (*Chelydra serpentina*).— The Snapping Turtle is the largest turtle in Ontario by weight. Snapping Turtles spend much of their time in water and their carapace is often covered in algae (Ruthven et al. 1912; Ernst and Lovich 2009) (Fig. III).

FIGURE III. From the left: carapace, face, and plastron photos of a female Snapping Turtle (square notch 3,1-2) captured in East Lake Pond (Photographed by I. Wick 2023).

Snapping Turtles are primarily diurnal (Ernst and Lovich 2009). Ernst and Lovich (2009) note that while Snapping turtles generally live in shallow water, they can be found along the edges of deeper waterbodies such as lakes and rivers. As Snapping Turtles increase in age and grow, they are more regularly found in deeper water (Congdon et al.

1992). Ernst and Lovich (2009) noted that "Snapping Turtles can be found in almost every kind of freshwater habitat but prefer a slow-moving waterway with soft mud or sand bottom and abundant aquatic vegetation or an abundance of submerged brush and tree trunks". Snapping Turtles can also be found in brackish water (Kinneary 1993; Ernst and Lovich 2009).

Brown and Brooks (1994) found that Snapping Turtles in Algonquin Park moved to their overwintering sites from late August to late September. Snapping Turtles often begin brumation by late October (Ernst and Lovich 2009). Brown and Brooks (1994) noted that they display site fidelity for hibernacula. Ernst and Lovich (2009) suggested Ontario Snapping Turtles use three types of hibernacula, with the second and third being most applicable to those in PPNP; they: "(2) wedge themselves beneath or beside submerged logs or stumps (but do not bury themselves in the substrate) within 5 m of a lakeshore; (3) and burrow deep in the mud of marshy areas or beneath floating mats of vegetation". Ernst and Lovich (2009) suggested Snapping Turtles in Ontario emerge from brumation beginning late April. Males emerge sooner and are more active in May than females (Brown and Brooks 1993; Ernst and Lovich 2009; COSEWIC 2014). Females increase activity markedly during nesting season (late May and June) and following nesting (in July) females are more active than males (Ernst and Lovich 2009; COSEWIC 2014). Snapping Turtles were widely distributed in PPNP (Fig. IV).

(FIGURE IV and caption removed).

Adult Snapping Turtle tracks can be easily distinguished from other species in the park. When walking, they keep their plastron lifted off the ground, leaving behind only tracks of their feet and a drag from their tail (Fig. V & VI).

FIGURE V. Snapping Turtle walking on East Beach (Photographed by I. Wick 2023).

FIGURE VI. Snapping Turtle tracks (Photographed by I. Wick 2023).

Galbraith et al. (1989) reported that female Snapping Turtles in Algonquin park lay their first clutch at 17–19 years of age. Male Snapping Turtles reach maturity between 15–20 years of age (Ron Brooks, unpublished data cited in COSEWIC 2014). Snapping Turtles have an average clutch size of approximately 28 eggs (Congdon et al. 1987).

However, the largest single clutch observed in Rondeau Provincial Park was 68 eggs (Scott Gillingwater, pers. comm.; cited in COSEWIC 2014). Females nest in a variety of substrates and areas (Ernst and Lovich 2009; COSEWIC 2014). While beaver lodges and muskrat burrows can provide shelter in all seasons (Gotte et al. 1994; cited in Ernst and Lovich 2009), abandoned beaver lodges and muskrat houses can also provide additional nesting habitat (Obbard and Brooks 1980; COSEWIC 2014). In PPNP, Snapping Turtles nest in a variety of areas and substrate types including in the gravel along roadsides, the grass mound of the Blue Heron picnic area, and the sand of the beaches. I found a disturbed Snapping Turtle nest in a likely Muskrat mound in DeLaurier in 2022.

Painted Turtle (*Chrysemys picta*).— Midland Painted Turtles are the subspecies present in PPNP. The Midland Painted Turtle is one of four subspecies of Painted Turtle, one of three found in Canada, one of two found in Ontario, and the only found in southern Ontario (Ernst and Lovich 2009; COSEWIC 2019b). Skin colouring as well as carapace, plastron, and bridge patterning can be used to distinguish subspecies (Fig. VII). Painted turtles are abundant and widely distributed in PPNP (Fig. VIII).

FIGURE VII. Carapace, face, and plastron photos of a male Midland Painted Turtle (triangle notch 0-2,3,9) captured in Marsh Boardwalk (Photographed by I. Wick 2023).

(FIGURE VIII and caption removed).

Ernst and Lovich (2009) noted that Painted Turtles prefer “slow-moving shallow-water habitats with soft bottoms, aquatic vegetation, and abundant basking sites, such as lakes, ponds, swamps, marshes, sloughs, drainage ditches, rivers, oxbows, and creeks”. Like Snapping Turtles, Painted Turtles more frequently occupy deeper waters as they increase in size (Ernst and Lovich 2009). Ernst and Lovich (2009) noted northern populations are most active in March through October and COSEWIC (2019b) suggested the active season begins early–late April to May or when ice cover retreats. Tracks left by this species in sand include a small plastron drag with footprints (Fig. IX).

FIGURE IX. Painted Turtle tracks (Huebert 2007).

Samson (2003) reported average age of maturity of 11.2 years (8.3 for males 14.1 for females) for individuals within Algonquin Provincial Park. Female Midland Painted Turtles grow larger than their male counterparts (COSEWIC 2019b). Methods of distinguishing male and female Painted Turtles include front claw length (Fig. X).

FIGURE X. Female Midland Painted Turtles (left) have shorter front claws than males (right) (Photographed by I. Wick 2023).

Blanding's Turtle (*Emydoidea blandingii*).— Blanding's Turtles of Ontario prefer eutrophic wetlands and regardless of age prefer shallow water habitats with an organic substrate bottom (soft but firm and typically < 100 cm but up to 200 cm) (Hartwig and Kiviat 2007; Ernst and Lovich 2009; COSEWIC 2016). They prefer areas with abundant aquatic vegetation (Hartwig and Kiviat 2007; Ernst and Lovich 2009). Aquatic vegetation can even help provide support in the water column because they are not strong swimmers (Sexton 1995; cited in Ernst and Lovich 2009). Hartwig and Kiviat (2007) found that Blanding's Turtles in southeastern New York (Dutchess County) were associated with Buttonbush (*Cephalanthus occidentalis*) in natural wetlands. The plastron of this species differs from most other extant species in the park as it is hinged (Ernst and Lovich 2009). This hinge becomes fully functional around 5 years of age or ~100 mm CL (COSEWIC 2016). The plastron also retains growth lines better than the carapace (Fig. XI).

FIGURE XI. The top shows carapace, plastron, and face photos of a female Blanding's Turtle (information removed). (Sentence removed). The bottom shows carapace, plastron, and face photos of a male Blanding's Turtle (information removed). Adult males typically have a concave plastron and larger tail (Photographed by I. Wick 2023).

Blanding's Turtles can live over 77 years of age (Ernst and Lovich 2009). This long-lived species does not reach maturity until 14–25 years of age (Congdon et al. 2008; COSEWIC 2016). I found an average clutch size in the park of 10.25 eggs. Blanding's Turtles in Kejimkujik National Park showed strong nest site fidelity (Standing et al. 2000). The Blanding's Turtles of PPNP also appear to exhibit fidelity for nesting sites.

Blanding's Turtle tracks, like the Midland Painted Turtle, have a plastron drag. Tracks of the feet on each side are close together and there is a not necessarily consistent tail drag (Fig. XII).

FIGURE XII. Blanding's Turtle tracks. The plastron dragging along the sand leaves a flattened pattern between the footprints. The flattened sand is separated by a non-consistent and at times wavy line left by their tail dragging. (Sentence removed) (Photographed by I. Wick 2023).

Blanding's Turtles are primarily diurnal (Ernst and Lovich 2009). Pappas et al. (2000) studied one of the largest populations of Blanding's Turtles worldwide in Minnesota, USA. Between 1974 and 1977 adults emerged from overwintering between 13 March and 8 April (Pappas et al. 2000). (Remainder of paragraph removed) (Fig. XIII).

(FIGURE XIII and caption removed).

Northern Map Turtle (*Graptemys geographica*).— Northern Map Turtles prefer large bodies of water like lakes and rivers (Ernst and Lovich 2009). Northern Map Turtles typically overwinter on a lake or river bottom and maintain reduced mobility while hibernating (Crocker et al. 2000; Ultsch et al. 2000; COSEWIC 2012a). They require well oxygenated overwintering sites and display overwintering site fidelity (Crocker et al. 2000; Ultsch et al. 2000; COSEWIC 2012a; Bultè et al. 2024). Tracks left by females have a plastron drag and the large back feet make them distinguishable from tracks of other species in the park. Northern Map Turtles have strong sexual dimorphism; males have large tails and small heads, while females grow much larger than males (Fig. XIV).

FIGURE XIV. The top shows carapace, face, and plastron photos left to right for a female Northern Map Turtle (square notch 3,9-0) captured in East Lake Pond. The bottom shows carapace, face, and plastron photos for a male Northern Map Turtle (square notch 2-2) captured in East Cranberry (Photographed by I. Wick 2023).

Based on my capture data and observations they prefer East Cranberry, East Lake Pond, and East North Boundary but are also found in Marsh Boardwalk and Redhead Pond with some regularity. I also had two captures in each of Bush Pond and South DeLaurier. In addition to being found in almost every site in the park, I often observed Northern Map Turtle's in Lake Erie along East Beach (Fig. XV).

(FIGURE XV and caption removed).

Eastern Musk Turtle (*Sternotherus odoratus*).— Eastern Musk Turtles are a secretive species. Their presence in PPNP was first reported by Patch (1919). Unlike other species in the park, Eastern Musk Turtles have noticeable fleshy patches on their plastron along with a small hinge (not as effective as that of the Blanding's Turtle) and typically have only 11 marginal scutes (rather than 12) on each side of the carapace (Fig. XVI).

FIGURE XVI. Female Eastern Musk Turtle (square notch 11-8) captured in East Lake Pond (Photographed by I. Wick 2023).

Eastern Musk Turtles are highly aquatic and, while occurring in depths of up to 9 m, prefer the shallow waters of littoral zones (< 60 cm) (Ford and Moll 2004; Ernst and Lovich 2009; COSEWIC 2012b). They prefer areas with abundant aquatic vegetation (floating and submerged) and soft bottoms but can be found in gravel bottom streams as well (Ernst and Lovich 2009; COSEWIC 2012b). Ernst and Lovich (2009) noted they can be found "in rivers, streams, lakes, ponds, sloughs, canals, swamps, bayous, and oxbows". Smith and Iverson (2004) noted that the Eastern Musk Turtles at their study site in Indiana were crepuscular with a preference for dawn activity over dusk. I had six opportunistic captures (hand captures) and the times of capture ranged from 09:39 to 17:09, with individuals displaying a variety of behaviours (floating at the surface basking, basking on a log, walking on land, walking on East Lake Pond bottom) prior to capture. Ernst and Lovich (2009) noted that in their experience Eastern Musk Turtles are mostly inactive during the day.

Eastern Musk Turtles most commonly nest within 7 m of the shoreline in PPNP (Huebert 2009). Nests are typically shallow (at a maximum depth of 10 cm) and can occur in a variety of substrates/locations (COSEWIC 2012b). They will use Muskrat and

Beaver lodges/burrows for both nesting and shelter (Kiviat 1978; Ernst and Lovich 2009; COSEWIC 2012b). They are the smallest turtle species in Ontario and have the smallest clutch size (3-7 eggs) (COSEWIC 2012b). Huebert (2005) noted that 13 of the 14 protected Musk nests in PPNP in 2005 were on the beach. I did not observe any Eastern Musk tracks. However, I did observe a female walking on East Beach (presumably after nesting). There appeared to be no plastron drag, and she walked very much like a small Snapping Turtle. I captured Eastern Musk Turtles in all sites except North and South DeLaurier (Fig. XVII).

(FIGURE XVII and caption removed).

Additional species.— In addition to the above species, the Spiny Softshell Turtle, Western Painted Turtle (*Chrysemys picta bellii*), Wood Turtle, Eastern Box Turtle, Red-eared Slider (*Trachemys scripta elegans*), and Yellow-bellied Slider (*Trachemys scripta scripta*) have been reported in PPNP. On 28 June 2021, a Red-eared Slider nested on the artificial nesting mound located in Marsh Boardwalk, laying 18 eggs (Parks Canada Agency unpubl. data). I captured one Red-eared Slider in 2022–2023. She was captured in East North Boundary on 19 July 2023. I captured the first recorded Yellow-bellied Slider in PPNP on 14 July 2023 on East Beach (Fig. XVIII).

FIGURE XVIII. Female Yellow-bellied Slider found while wandering East Beach in 2023. This was the first Yellow-bellied Slider captured in the park. This individual was likely a released pet (Photographed by I. Wick 2023).

Chapter 1.— Changes in Community and Population Structure Over 50 Years at Point Pelee National Park: Nest Protection Helps to Reverse Decline of Turtles

Introduction

While Testudines (turtles and tortoises) have persisted for over 200 million years, surviving at least two mass extinction events, they are now one of the most imperiled orders globally (Lichtig et al. 2018; Rhodin et al. 2018). Life history traits of turtles, such as late maturity and low reproductive output, make them particularly vulnerable to anthropogenic threats (Congdon et al. 1994; Klemens 2000; Browne and Hecnar 2003; Browne and Hecnar 2007). Testudines are fundamentally important to the ecosystems they inhabit (Iverson 1982; Lovich et al. 2018; Santori et al. 2020). The loss of turtles or changes to population and community structure can impact an ecosystem profoundly (Lovich et al. 2018). In Canada, all turtle species occurring in Ontario are listed as species at risk federally with conservation status ranging from special concern to extirpated (COSEWIC 2023; Government of Canada 2023a). Well managed protected areas are important for the conservation of species at risk such as turtles (Browne and Hecnar 2002, 2003; Stanford et al. 2018; Acreman et al. 2020), but population declines still occur in protected areas (Browne 2003; Keevil et al. 2018).

Historically, Point Pelee National Park (PPNP) had the greatest freshwater turtle diversity in Canada, with seven or eight native species (Browne and Hecnar 2002; COSEWIC 2015). I found five native species in PPNP in 2022–2023. Eastern Box

Turtles (*Terrapene carolina*) are considered extirpated from Canada (COSEWIC 2015) and Spotted Turtles (*Clemmys guttata*) are believed extirpated from the park, having not been observed since 1994 (Hecnar and Hecnar 2004). Spiny Softshell Turtles (*Apalone spinifera*) are still thought to both enter the park and use the beaches for nesting on occasion (Logier 1925; Hecnar and Hecnar 2005; Browne and Hecnar 2007; Government of Canada 2023b). Two surveys, separated by 30 years and using hoop traps to capture turtles have previously been conducted in PPNP (Rivard and Smith 1973; Browne 2003). Browne (2003) determined that only one turtle species (Painted Turtle, *Chrysemys picta*) in PPNP had a large healthy population. Browne and Hecnar (2007) found changes in community structure when comparing the two datasets with Blanding's Turtle rank falling below Northern Map Turtle. Along with the loss of Spotted Turtles and a decline of Blanding's Turtles (*Emydoidea blandingii*), population size structure changes were a concern. More top-heavy size structures of Blanding's and Snapping Turtle populations suggested that populations were in decline and that juvenile recruitment was limited (Rivard and Smith 1973; Browne 2003; Browne and Hecnar 2007). Browne and Hecnar (2007) (cited Bodenheimer 1958; Alexander 1958; Smith and Smith 2001) noted "in general, broad based age structure pyramids indicate growing populations whilst top-heavy pyramids indicate insufficient recruitment and declining populations". Based on data from predator surveys and observations of predated nests, Browne (2003) concluded that nest predation (primarily by Raccoons, *Procyon lotor*) was the major contributor to the declining populations of Blanding's and Snapping Turtles and started the nest protection program that continues today. Over the course of 21 years (2001–2021), the nest protection program helped protect 882 nests, 480 of which were Snapping Turtle nests (see Chapter 3, Table 3.2).

Browne (2003) started the nest protection program while conducting an extensive study of the turtle community, trapping in 14 sites in PPNP in 2001–2002. Efforts were focused on eight sites beginning 16 May 2002. In 2022–2023, I surveyed those same eight sites. I used the same basic data collection methods and gathered the same standard measurements as Rivard and Smith (1973) and Browne (2003).

My goal was to survey the turtle community to provide an update on the status of PPNP turtle populations. Specific objectives included comparing community structure, relative abundance, sex ratios, and size structures to the previous snapshots in time, as well as determine the efficacy of the nest protection program. If nest protection has helped to mitigate the effects of nest predation, I expected to see an increased catch-per-unit-effort (CPUE) and a size structure that indicates increased juvenile recruitment for the species that has received the most nest protection, Snapping Turtles.

METHODS

Study Area. — Point Pelee National Park (PPNP; 41.9628°N, -82.5184°W) is in Essex County, Ontario. Only 6.5% of Essex County's area (~1844.21 km^2) is natural habitat (Choquette and Jolin 2018; Stats Canada 2023). PPNP represents approximately 13% of the natural habitat remaining in all of Essex County. Over 46 million humans live within a 450 km radius of PPNP (Parks Canada Agency 2016). PPNP was Canada's first national park established (in 1918) for its biological importance and is Canada's second smallest (15.5 km^2) national park (Crowe 1999; Parks Canada Agency 2016). It represents the southernmost point of Canada's mainland and is the most ecologically diverse national park in Canada (Browne 2003; Parks Canada 2023a). PPNP protects critical habitat for many species at risk in the Mixedwood Plains Ecozone. This park averages over 330,000 visitors annually (1991-2023) with numbers exceeding 500,000 in some years (Parks Canada Agency unpubl. data). PPNP includes one of the largest marshes remaining in the southern Great Lakes and is globally recognized as a Ramsar site, meaning it has been recognized as a wetland of international importance (Ramsar 2024). Less than half of the original extent of the marsh system of Point Pelee remains in the park because the northern portion was historically converted to agriculture (Fig. 1.1).

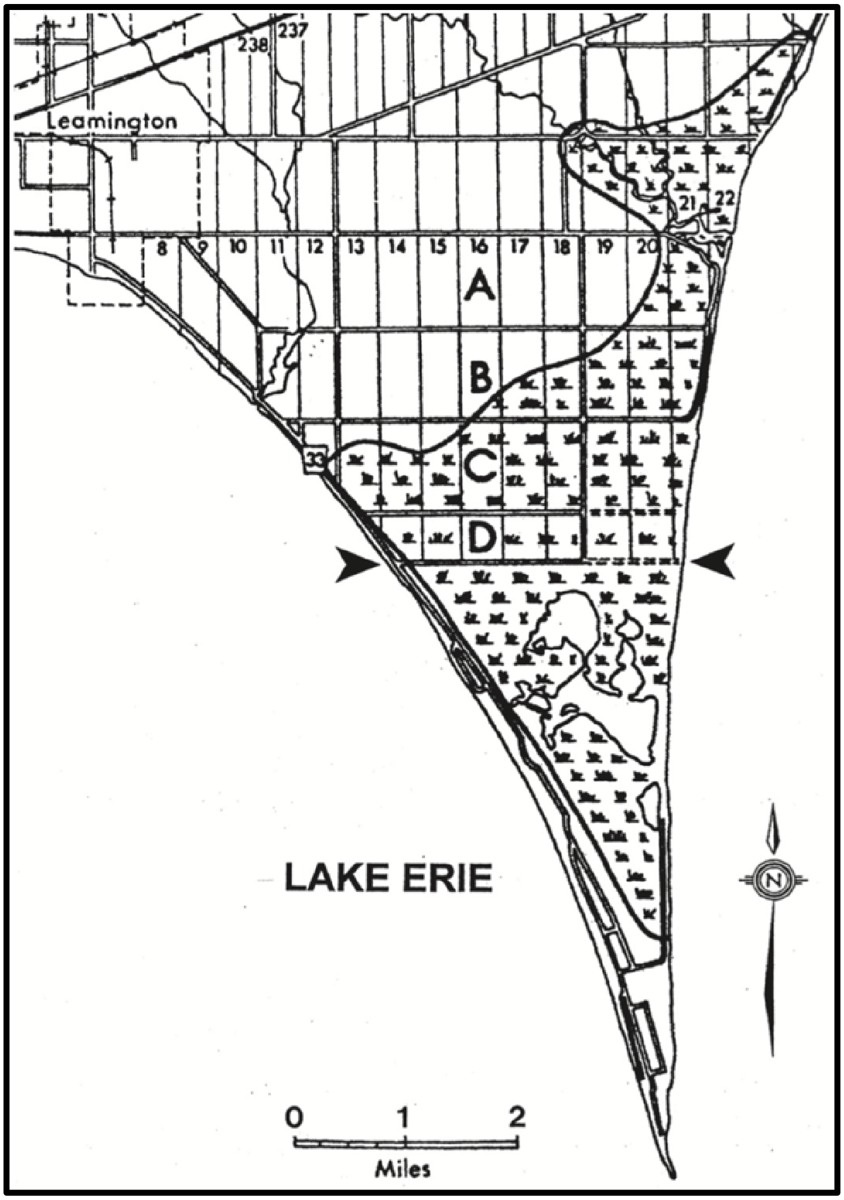

FIGURE 1.1. The original extent of the marsh system of Point Pelee. The black arrows on the east and west side of the point show the north boundary of Point Pelee National Park. Everything contained within the borders created by Lake Erie and south of the north boundary is PPNP. This shows PPNP is less than half the size of the original marsh system (Hecnar and Hecnar 2004 and adapted from H. Beldon and Co. map, ca. 1880-1881).

Trapping focused on eight sites: Bush Pond, East Cranberry Pond, East Lake Pond, East North Boundary, Marsh Boardwalk, North DeLaurier, Redhead Pond, and South DeLaurier. Each site was marsh habitat except North and South DeLaurier which are swamp forest (Parks Canada 2023b). Shoreline perimeter distance (km) and surface area (ha) of East Lake Pond was the largest among sites while North DeLaurier had the smallest surface area and Bush Pond the shortest shoreline perimeter distance (Table 1.1 and Fig. 1.2).

TABLE 1.1. Shoreline perimeter distance (km) and surface area (ha) of each site. Measurements were calculated using Google Earth Pro.

Site	Shoreline distance (km)	Surface area (ha)
Bush Pond	0.97	3.79
East Cranberry	2.22	25.57
East Lake Pond	3.42	63.08
East North Boundary	3.17	6.59
Marsh Boardwalk	2.57	3.17
North DeLaurier	1.54	0.98
South DeLaurier	1.91	1.77
Redhead Pond	1.92	14.3

*Shoreline distance does not always refer to a true shoreline. For example, in South DeLaurier what I considered the east shoreline leads into swamp forest or in many sites it is a floating cattail mat shoreline in at least some areas. Where our trapping area met the boardwalk in Marsh Boardwalk was included in shoreline distance. It was difficult to see the shoreline in North and South DeLaurier using the 2023 imagery, so I used 14 April 2016 imagery to create polygons and calculate measurements.

FIGURE 1.2. Map of each site. There is no significance to the outline or fill colour of the polygons. A different outline colour was used for South DeLaurier to ensure North and South DeLaurier were clear. The polygons were created using imagery from 23 October 2023 for all sites except North and South DeLaurier. I used Google Earth Pro imagery from 14 April 2016 for those sites. Map created using Google Earth Pro 7.3.6.9796 (64-bit).

Field Methods.— The 2022 field season began on 29 April and ended 30 August. The 2023 field season began 19 April and ended 6 October. Turtles were primarily captured using baited hoop traps (two sizes) and basking traps. In 2022 I used large white and small black hoop traps. Large white hoop traps consisted of three 76.2 cm diameter rings each ~56 cm apart, with 2.54 cm mesh. They were ~165 cm in length from front hoop to tail end when fully extended and had flat throats. Small black hoop traps consisted of three 45.72 cm diameter rings each ~48 cm apart, with 2.54 cm mesh. They were ~137 cm in length from front hoop to tail end when fully extended and had flat throats. In 2023 I used large, small, and small unmodified/original (OG) black hoop traps. The large black hoop traps consisted of three 76.2 cm diameter rings each ~43 cm apart, with 2.54 cm mesh. They were ~121 cm in length from front hoop to tail end when fully extended and had flat throats. The small black hoop traps were the same as those used in 2022. They had a modified mouth aimed at making the trap more available to adult Snapping Turtles while the OG smalls were unmodified. They both consisted of three 45.72 cm diameter rings each ~48 cm apart, with 2.54 cm mesh. They were ~137 cm in length from front hoop to tail end when fully extended. While both had flat throats the OG smalls were more variable in mouth shape. Hoop traps were secured in place using wooden stakes or rebar. All hoop traps contained a water bottle or container of some kind (suited to each trap considering size) as a precautionary floatation device to ensure a headspace for entrapped turtles was maintained if water levels fluctuated unexpectedly or trap failure occurred (Fig. 1.3).

FIGURE 1.3. Small hoop trap set in Marsh Boardwalk 2023 (Photographed by I. Wick 2023).

I used two sizes of basking traps. Large basking traps had outside dimensions of ~ 152 x 91 cm with 18.11 cm wide wooden ramps. Small basking traps had outside dimensions of ~ 127 x 79 cm with 13.67 cm wide wooden ramps. All basking traps were constructed using 4 in polyvinyl chloride (PVC) pipe and 2.54 cm mesh. In 2023 some large basking traps were also equipped with a black aluminum rectangle in the centre of the basking platform which was held in place using four screws and caulking helped ensure the metal edges were not a hazard (Fig. 1.4).

FIGURE 1.4. Large metal basking (LMB) trap set in Marsh Boardwalk 2023. Most of the trap was built using PVC pipe and wood; however, I referred to these ones as LMB because of the black aluminum rectangle in the centre of the basking platform (Photographed by I. Wick 2023).

Basking traps were secured in place using an anchor, rebar, a fixed object (e.g. tree stump), or a combination. I also captured turtles using a dipnet or by hand. I also had two visual captures (confirmed identification of the individual using their notch code without needing to disturb them).

I checked all traps daily. Canned Sardines, Channel Catfish (*Ictalurus punctatus*), and Common Carp (*Cyprinus carpio*), along with Yellow Perch (*Perca flavescens*) and Walleye (*Sander vitreus*) heads (Yellow Perch and Walleye bodies were used rarely), as well as by-catch Mullet (*Catostomus* spp.), Freshwater Drum (*Aplodinotus grunniens*), and White Perch (*Morone americana*) were used as bait. All bait except the canned

Sardines were provided by Loop Fisheries, a local establishment. Bait was suspended near the rear of the hoop trap in a container with holes and refreshed every 1–2 days.

Traps were set in two sites concurrently. Each set of sites were trapped for one or two 14–day sessions between 2 May and 26 August 2022 and one or two 13–day sessions between 1 May and 27 August 2023. I also set three traps between 25 April and 28 April in North and South DeLaurier in 2023.

When checking or setting traps year, date, time, site, trap type and ID, GPS coordinates, weather, bait type/change information, field crew, and additional information such as visual observations were recorded. Location description was also recorded when setting traps and captures by species as well as by-catch information recorded when checking traps. If a trap was moved during its time at a site, new coordinates were recorded. I placed traps in locations that appeared to have the best potential for capturing turtles. I tried to keep traps of the same type a minimum of 50 m apart and in general traps of any type as logically spaced as possible given the space available and site constraints. I tried to avoid areas where North American Beaver (*Castor canadensis*) or Muskrat (*Ondatra zibethicus*) activity was apparent to prevent harm or damage to either the mammals or the traps. An additional constraint was water depth (too deep to securely place rebar).

Standard photographs of each turtle were taken of carapace, plastron, and face to help with identification or review. Species, sex, weight (to nearest g or lb depending on size and scale used), abnormalities, injuries, signs of parasitism or disease, year, date, time, behaviour, trap type and ID, site, field crew, and GPS coordinates were recorded for all captures. I checked for fishing related injuries and recorded yes or no as fishing has recently been banned in the park. Carapace midline and maximum length (Iverson and

Lewis 2018), plastron midline and maximum length (Iverson and Lewis 2018), width, and height were also recorded. Measurements were recorded to the nearest mm using calipers. I also recorded shell wear and number of growth lines (growth lines often only recorded for juveniles). In 2023 I began recording notch shape because I started notching with both square and triangular files. I examined females to determine if they were gravid by feeling the rear leg pockets for the firm rounded shape of eggs, and this was recorded. Most new adult or juvenile turtles captured were marked by filing the marginal scutes using Cagle's (1939) notch code system, but with Browne's (2003) modification for Snapping Turtles. This provided a unique identification code for each individual (Browne 2003). Toenail clippers were used for individuals that were too small or when their carapace was too flimsy for a file. Some hatchlings were notched with a simple single digit notch code (not necessarily a new notch code). Square notch codes used in Browne's (2003) study were not used for individuals of the same species/sex. Turtles marked using this system in the past were identified based on their codes. No turtles marked with metal fingerlings by Rivard and Smith (1973) were recaptured. Turtles were released at the site of capture.

Notable trap specifications of Rivard and Smith (1973) and Browne (2003).— Rivard and Smith (1973) used hoop traps to capture turtles while Browne (2003) used hoop and basking traps. Hoop traps used by Rivard and Smith were approximately 91.44 cm long. They featured four hoops and were kept rigid using wooden dowels attached to the exterior of the trap. Hoop traps used by Rivard and Smith had two throats (one on either end) meaning unlike Browne (2003) and 2022–2023 traps, they lacked a tail. Hoop trap setup used by Browne was most like my 2022 trap setup but similar to 2023 trap setup. Bait was at times an additional difference. I used a variety of bait outlined in the field methods subsection while Rivard and Smith used canned Sardines in oil and Browne used Common Carp. Browne checked traps every other day in 2001 and often daily in 2002 while trap checking frequency of Rivard and Smith is unknown. Hoop traps used by Rivard and Smith (1973) and Browne (2003) were roughly the same size as 2022–2023 small hoop traps (Table 1.2).

TABLE 1.2. Specifications of hoop traps used in 1972, 2001–2002, and 2022–2023 hoop traps. SOG refers to small unmodified/original hoop traps. Hoop traps used by Rivard and Smith (1973) had two throats while each other study period used traps with one throat.

Trap	Number of hoops	Hoop diameter (cm)	Distance between hoops (cm)	Mesh size (cm)
Rivard and Smith (1973)	4	~48	~30.5	5.08
Browne (2003)	3	~44.5	~42	2.54
Small and SOG (2022-2023)	3	~46	~48	2.54
Large (2022)	3	~76	~56	2.54
Large (2023)	3	~76	~43	2.54

Basking traps used by Browne (2003) were the same dimensions as 2022–2023 small basking traps. The centre basking platform of basking traps used by Browne (2003) were screwed into the PVC making it slightly more rigid. This was the only difference between 2001–2002 and 2022–2023 small basking traps. One 2022–2023 small basking trap was used by Browne (2003).

PPNP nest protection program. — The nest protection program began in 2001 as part of Browne's (2003) study of the PPNP turtle populations. Browne used protective nest boxes and cages. Two sizes of boxes were used: most were ~ 89 cm x 89 cm x 15 cm high but for roadsides with narrow shoulders boxes were ~ 61 cm x 61 cm x 15 cm high. Browne used pepper spray (cayenne pepper mixed with vegetable oil) around the perimeter to discourage predators from digging. The nest cages were ~30 cm in diameter and ~40 cm high. They were dug in ~25 cm with ~15 cm of space left above ground for hatchlings upon emergence. Browne noted neither method would protect against predation by Sarcophagid fly larvae (cited Ron Brooks, pers. comm.) and possibly not against Eastern Moles (*Scalopus aquaticus*).

Since Browne (2003), the nest protection program has used both protective nest boxes and cages. Use of each has varied among years influenced by factors including nest location with cages typically used in sandy areas (Taylor Hamel, pers. comm.). However, altogether similar quantities of each have been used. In recent years nest cages have fully encompassed the nest.

The protective nest boxes were constructed primarily of ~ 3.8 x 9 cm "2x4" lumber and galvanized steel mesh (Fig. 5). Nest boxes were placed over top of a nest and held in place using pegs pushed into the ground through the metal mesh skirt that surrounds the wooden box and by placing bricks on the corners. This helps to prevent predators from lifting the boxes.

Protective nest cages were more variable in size but typically range between ~ 35.5 x 35.5 cm and ~ 50.8 x 50.8 cm (Taylor Hamel, pers. comm.) The height is dependent on the depth they are buried. They can be constructed to be placed over top or require excavation as they can encompass the entirety of the nest. Nest cages were constructed primarily of metal mesh. To use a nest cage that encompasses a nest from all sides as well as above and below, a nest must be excavated. A nest cage encompassing the entire nest can help prevent predation by moles but was typically only used when a nest is moved (Fig. 1.5).

FIGURE 1.5. Left: ~ 61 cm x 61 cm x 9 cm high nest protection boxes with hatchling doors measuring 2.54 cm tall x 5.08 cm wide. Centre: Protective nest cage encompassing the entire nest after having been moved from East Beach. Right: Protective nest box constructed to fit against fallen log beside a typical nest protection box (rocks were not typically placed on the mesh skirt) (Photographed by I. Wick 2022 and 2023).

Data Analysis. — For individuals captured more than once I used measurements of the earliest capture for analyses that I used individuals. Because all measurements for recaptures in 2001–2002 and 2022–2023 were not always recorded, it is possible that an individual was not measured the first time it was captured in a particular trap type because it had been previously captured in a different trap type. In this instance, for midline carapace length (MCL [mm]), I used the value from the closest date, regardless of trap type. Often growth can be negligible when individuals are captured in the same session. Adults also have slower growth rates than juveniles (Galbraith et al. 1989; Congdon and van Loben Sels 1991). However, the change in size of an individual can be large depending on life stage and time between captures. For example, two Northern Map Turtles (*Graptemys geographica*) first captured in 2022 and recaptured in 2023 displayed dramatic growth: MCL (mm) of one individual increased from 67 mm to 97 mm and the other from 69 mm to 90 mm.

I used statistical software R version 4.2.2 along with RStudio version 2023.12.0+369 to analyze data. For all statistical tests I considered a P value of < 0.05 significant. I compared sex ratios of among the three study periods for basking and hoop traps as well as all capture methods using Fisher's Exact test. I compared relative abundance of Painted and Snapping Turtles as well as Painted and Blanding's Turtles using individuals captured in hoop traps from Study Period 1 (1972), Study Period 2 (2001–2002), and Study Period 3 (2022–2023) using Fisher's exact test. I used the Shapiro-Wilk test to determine normality of MCL (mm) data for each species and which tests to use. I used the Mann-Whitney *U* test to compare median MCL (mm) from Rivard and Smith (1973) and Browne (2003) with 2022-2023 and the Kolmogorov-Smirnov test to compare shape and central tendency of the MCL (mm) distributions. (Sentence removed). I used Spearman's rank correlation coefficient to compare community structure among the three study periods by comparing individuals captured among all capture methods combined and specifically hoop traps.

Using adult captures of all capture methods during the sampling periods of each site, I estimated population sizes of adult Painted and Snapping Turtles for each site. I used the mrOpen() function in R to use the Jolly-Seber method. The assumptions of Cormack-Jolly-Seber from Krebs (2014) are:

1. "Every individual has the same probability (α_t) of being caught in the *t*-th sample, regardless whether it is marked or unmarked"
2. "Every marked individual has the same probability (Φ_t) of surviving from the $t -^{th}$ to the $(t + 1)^{th}$ sample"
3. "Individuals do not lose their marks and marks are not overlooked at capture"
4. "Sampling time is negligible in relation to intervals between samples"

Using surface area (ha) of each site I then calculated density for each site. I created a map using Google Earth Pro 7.3.6.9796 (64-bit) showing all areas used to calculate park-wide population size estimates using surface area (ha) (Appendix Fig. 1.15). I estimated park-wide adult population sizes for Snapping and Painted turtles.

I estimated Snapping Turtle population sizes of males and females separately for each site. I did not estimate female population size for East North Boundary (no recaptures) or North DeLaurier (no captures during first sampling period). I did not estimate juveniles for any site due to insufficient recaptures.

I estimated Painted Turtle adult population size for each site. East Cranberry and East Lake Pond were combined because of low recaptures. I combined visit three and four of Redhead because there were no recaptures during the third visit.

Recaptures of Blanding's Turtles were insufficient to calculate population size estimates park-wide but I was able to estimate population size in East North Boundary. Refer to Appendix for Method B tables for each population size estimate. I did not estimate population size for Eastern Musk Turtles or Northern Map Turtles because of insufficient recaptures.

RESULTS

I captured 1834 individuals of six turtle species (Table 1.3). Total effort was 6,492 trap days (3186 in 2022 and 3306 in 2023). This included 4425 for hoop traps (2184 in 2022 and 2241 in 2023) and 2067 for basking traps (1002 in 2022 and 1065 in 2023). I had 2473 captures (1084 in 2022 and 1389 in 2023). I had 2180 captures in hoop and basking traps, 253 hand captures (not including hatchlings that had yet to reach water), 38 dipnet captures, and 2 observations with confirmed identification of the individual.

TABLE 1.3. Trapping results of all capture methods combined. Unknown refers to turtles that escaped or were released prior to processing.

Species	Code	Captures	Individuals	Recaptures	Unknown
Chelydra serpentina	SNTU	1042	619	408	15
Chrysemys picta	MPTU[1]	989	830	156	3
Graptemys geographica	MATU	281	258	21	2
Emydoidea blandingii	BLTU	83	52	30	1
Sternotherus odoratus	MUTU	76	73	2	1
Trachemys scripta[2]	n/a	2	2	n/a	0
Totals		2473	1834	617	22

[1]Midland Painted Turtle [2]One Red-eared Slider and one Yellow-bellied Slider *Table does not include nest box, nest, and roadside/trailside/beach hatchlings (hatchlings that had not yet entered the marsh).

Basking Traps. — In Study Period 3, I had a total of 362 basking trap captures (187 MATU, 174 MPTU, 1 BLTU) across 2067 basking trap days. I captured 346 individuals (173 MATU, 172 MPTU, 1 BLTU). The 2022-2023 Blanding's capture was a juvenile. Three captures (2 MATU, 1 MPTU) were not processed (16 June 2022) and therefore not included as individuals.

In Study Period 2, there were a total 450 basking trap captures (285 MPTU, 162 MATU, 1 BLTU, 1 SNTU, 1 Red-eared Slider (RES)) across 1449 basking trap days of 384 individuals (236 MPTU, 145 MATU, 1 BLTU, 1 SNTU, 1 RES).

Fisher's Exact tests indicated no significant differences in sex ratios between Period 2 and Period 3 for Painted Turtles ($P = 0.140$) or Northern Map Turtles ($P = 0.228$; Table 1.4).

TABLE 1.4. Male/female adult sex ratio and catch per unit effort (CPUE) for Study Period 2 (2001–2002) and Study Period 3 (2022–2023) individuals captured in basking traps.

Species	Year	Male	Female	Juvenile	M:F Ratio	Trap days	CPUE
MPTU	2001-2002	135	82	19	1.65:1	1449	0.163
	2022-2023	68	59	45	1.15:1	2067	0.083
MATU	2001-2002	45	95	5	1:2.11	1449	0.100
	2022-2023	33	100	40	1:3.03	2067	0.084

Hoop Traps. — In Study Period 1 there were 225 hoop trap captures (103 MPTU, 91 SNTU, 28 BLTU, 2 MUTU, 1 MATU) of 223 individuals (102 MPTU, 90 SNTU, 28 BLTU, 2 MUTU, 1 MATU) across 522 trap days. In Study Period 2 there were 1134 hoop trap captures (576 MPTU, 479 SNTU, 49 BLTU, 17 MUTU, 13 MATU) of 901 individuals (492 MPTU, 341 SNTU, 39 BLTU, 16 MUTU, 13 MATU) across 3153 trap days. In Study Period 3, I had 1818 hoop trap captures (985 SNTU, 678 MPTU, 70 MUTU, 51 BLTU, 34 MATU) of 1273 individuals (575 SNTU, 561 MPTU, 67 MUTU, 36 BLTU, 34 MATU) across 4425 trap days. The 19 turtles that escaped or were released prior to processing were included in my capture numbers but not included for individuals. Snapping Turtles were the most frequently captured individuals in hoop traps, while Painted Turtles were second, and Blanding's Turtles are now ranked behind Eastern Musk Turtles (Table 1.5).

TABLE 1.5. Individuals captured in hoop traps during Study Period 1 (1972), Study Period 2 (2001–2002), and Study Period 3 (2022–2023). Rank column reflects individuals. Spearman's Rank shows 1972 ($r_s = 0.8$, n = 5, $P = 0.104$) and 2001–2002 ($r_s = 0.8$, n = 5, $P = 0.104$) are not correlated with 2022–2023.

Species	Individuals			Rank		
	1972	2001-02	2022-23	1972	2001-02	2022-23
Painted	102	492	561	1	1	2
Snapping	90	341	575	2	2	1
Blanding's	28	39	36	3	3	4
Musk	2	16	67	4	4	3
Map	1	13	34	5	5	5
Total	223	901	1273	n/a	n/a	n/a

To further explore changes among time periods I then compared the relative abundance of Blanding's and Snapping Turtles to Painted Turtles. There was no significant difference in relative abundance between Rivard and Smith (1973) and 2022–2023 for MPTU:SNTU ($P = 0.350$). There was a significant difference between Browne (2003) and 2022–2023 for MPTU:SNTU ($P < 0.001$). There was a significant difference between Rivard and Smith (1973) and 2022–2023 for MPTU:BLTU ($P < 0.001$). There was no significant difference between Browne (2003) and 2022–2023 for MPTU:BLTU ($P = 0.403$).

While CPUE for Northern Map Turtles, Eastern Musk Turtles, and Snapping Turtles increased from 2001–2002 to 2022–2023, there was a considerable decrease for Painted Turtles and Blanding's Turtles (Fig. 1.6 and Table 1.6).

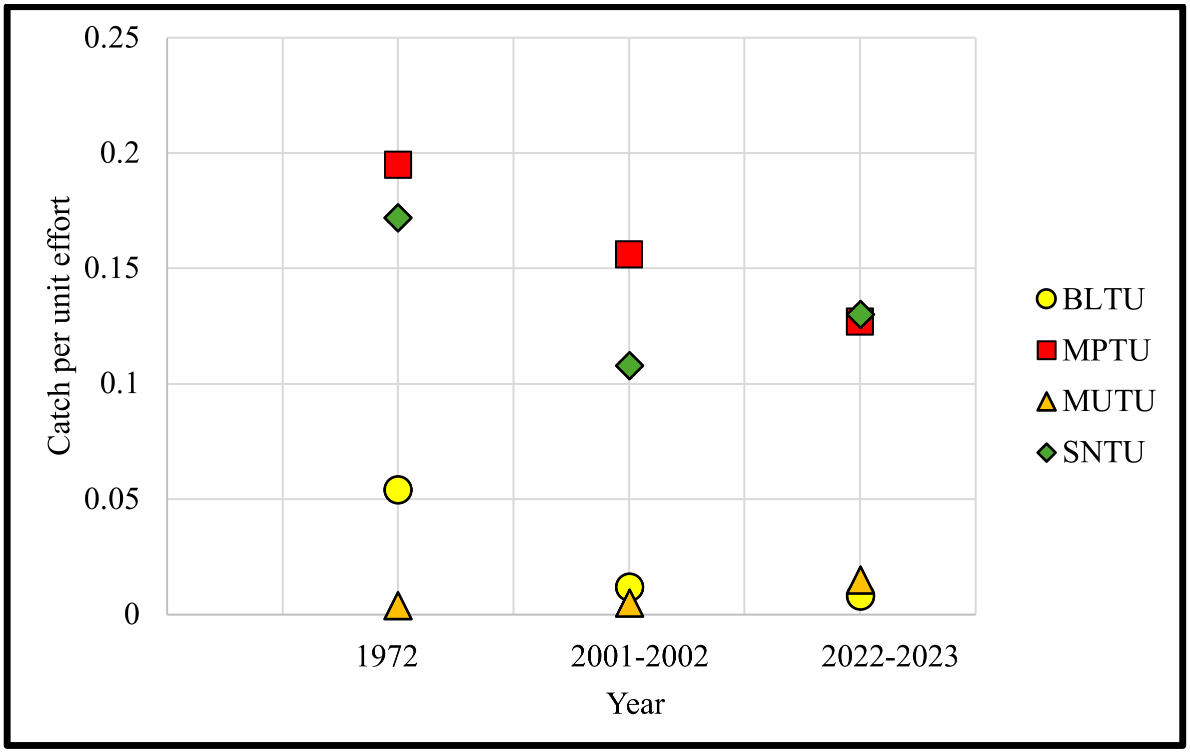

FIGURE 1.6. CPUE of Blanding's, Painted, Eastern Musk, and Snapping Turtles captured in hoop traps during Rivard and Smith (1973), Browne (2003), and 2022–2023.

TABLE 1.6. Male:female adult sex ratio and CPUE for 1972, 2001–2002, and 2022–2023 hoop traps (M = Male, F = Female, and J = Juvenile).

Species	Year	M	F	J	M:F Ratio	Trap days	CPUE	% change (CPUE)
MPTU	1972	72	30	0	2.4:1	522	0.195	n/a
	2001/02	397	85	10	4.67:1	3153	0.156	-20%
	2022/23	401	132	28	3.04:1	4425	0.127	-19%
SNTU	1972	53	28	9	1.89:1	522	0.172	n/a
	2001/02	224	101	14	2.22:1	3153	0.108	-37%
	2022/23	296	209	70	1.42:1	4425	0.130	+20%
MUTU	1972	0	2	0	n/a	522	0.004	n/a
	2001/02	7	8	1	1:1.14	3153	0.005	+25%
	2022/23	33	23	11	1.43:1	4425	0.015	+200%
BLTU	1972	16	12	0	1.33:1	522	0.054	n/a
	2001/02	19	17	3	1.12:1	3153	0.012	-78%
	2022/23	15	15	6	1:1	4425	0.008	-33%
MATU	1972	0	1	0	n/a	522	0.002	n/a
	2001/02	0	13	0	n/a	3153	0.004	+100%
	2022/23	2	31	1	1:15.5	4425	0.008	+100%

Fisher's exact test for Painted and Snapping Turtles indicated the proportion of males were significantly greater in 2001–2002 than in 2022–2023 (Table 1.7).

TABLE 1.7. Fisher's exact test results comparing differences in sex ratios for each species. Blue fill indicates a significant *P* value.

Species	Comparison to 2022-2023	*P*-value
MPTU	Rivard and Smith (1973)	0.324
MPTU	Browne (2003)	0.006
SNTU	Rivard and Smith (1973)	0.274
SNTU	Browne (2003)	0.003
MUTU	Rivard and Smith (1973)	0.182
MUTU	Browne (2003)	0.559
BLTU	Rivard and Smith (1973)	0.610
BLTU	Browne (2003)	1
MATU	Rivard and Smith (1973)	1
MATU	Browne (2003)	1

All Capture methods. — Data for all capture methods combined (basking, hoop, dipnet, and hand). Ranked abundance considering all capture methods from 1972, 2001–2002, and 2022–2023 showed Painted and Snapping Turtles ranked first and second respectively in each Study Period. However, Blanding's Turtles now rank fifth after dropping in rank again in 2022–2023 (Table 1.8).

TABLE 1.8. Species rank and number of individuals captured for all capture methods combined. 1972–1973 ($r_s = 0.873$, n = 7, $P = 0.01$) and 2001–2002 ($r_s = 0.955$, n = 7, $P < 0.001$) are strongly correlated with 2022–2023 (adapted from Browne and Hecnar 2007).

Species	Individuals			Rank		
	1972-1973	2001-2002	2022-2023	1972-1973	2001-2002	2022-2023
Painted	133	800	830	1	1	1
Snapping	93	421	619	2	2	2
Blanding's	46	85	52	3	4	5
Map	4	172	258	4.5	3	3
Musk	4	24	73	4.5	5	4

Spotted	1	0	0	6	7	6.5
Softshell[1]	0	2[1]	0	7	6	6.5

[1]No Spiny Softshell were captured in 2001–2002 but two individuals were observed.

I captured considerably more Eastern Musk and juvenile Northern Map Turtles in 2022–2023 than were captured in 1972 and 2001–2002. Fisher's Exact test showed that the Painted Turtle population was significantly more male biased in 2001–2002 than in 2022–2023 (P = 0.044). No other sex ratio comparisons for other species between 1972 or 2001–2002 and 2022–2023 were significant (Table 1.9).

TABLE 1.9. Male:female adult sex ratio from all capture methods combined.

Species	Year	Male	Female	Juvenile	M:F Ratio
MPTU	1972	72	44	4	1.64:1
	2001-2002	546	203	51	2.69:1
	2022-2023	479	226	125	2.12:1
SNTU	1972	53	28	11	1.89:1
	2001-2002	257	143	18	1.80:1
	2022-2023	296	209	70	1.42:1
MUTU	1972	0	4	0	n/a
	2001-2002	10	13	1	1:1.30
	2022-2023	34	28	11	1.21:1
BLTU	1972	18	25	0	1:1.39
	2001-2002	25	57	3	1:2.28
	2022-2023	19	26	7	1:1.37
MATU	1972	0	3	1	n/a
	2001-2002	46	119	7	1:2.59
	2022-2023	36	138	84	1:3.83

Size structure histograms. — Northern Map Turtles. — I compared Northern Map Turtle size structure using basking trap captures. 2001–2002 (W = 0.950, P < 0.001) and 2022–2023 (W = 0.910, P < 0.001) Northern Map Turtle MCL (mm) data were not normally distributed. Median carapace lengths in 2001–2002 (146 mm, n = 145) were significantly larger than 2022–2023 (104 mm, n = 173) ($U = 8716$, $P < 0.001$). Shape and central tendency were significantly different as well ($D = 0.360$, $P < 0.001$) (Fig. 1.7).

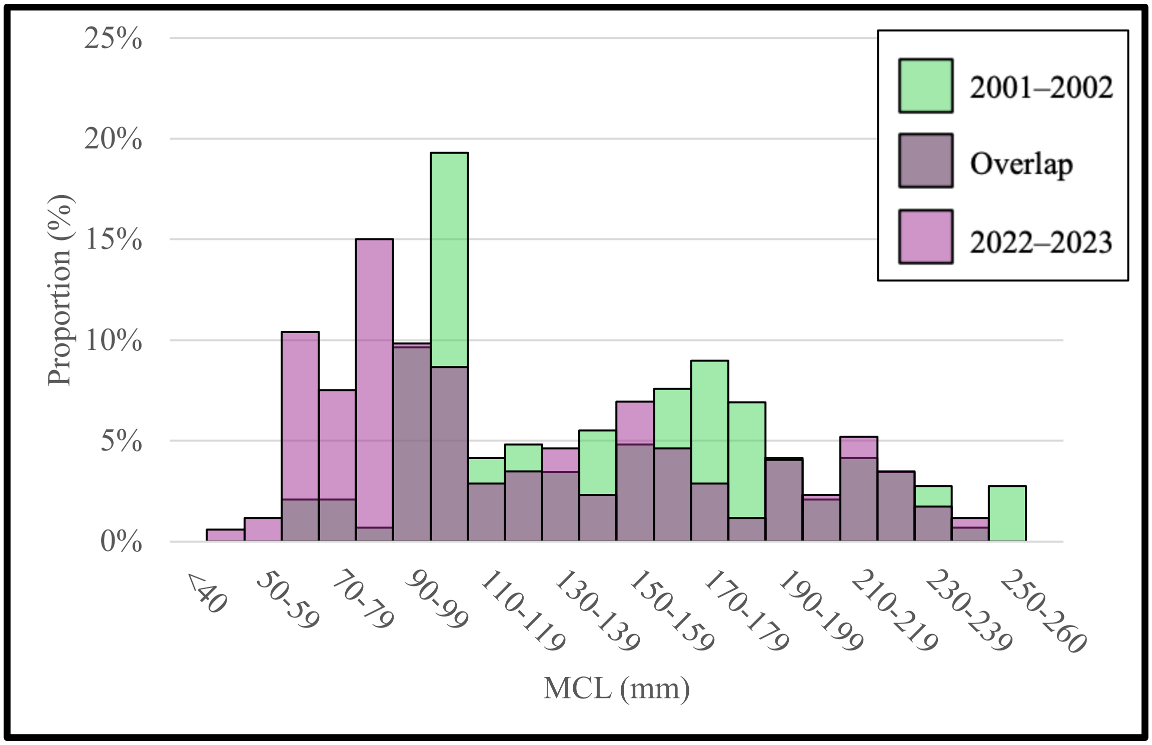

FIGURE 1.7. Northern Map Turtle size distribution of 2001–2002 and 2022–2023 individuals captured in basking traps. Light green represents 2001–2002, light purple represents 2022–2023, and dark purple represents overlap. The y-axis is the percentage of individuals captured and the x-axis is the midline carapace length (mm).

Eastern Musk Turtles. — I compared the size structure of Eastern Musk Turtle individuals captured in hoop traps in 2001–2002 and 2022–2023. The 2001–2002 ($W = 0.751$, $P < 0.001$) and 2022-2023 ($W = 0.960$, $P = 0.031$) data were not normally distributed. There was no significant difference in median MCL (mm) ($U = 405.5$, $P = 0.133$) or distribution ($D = 0.323$, $P = 0.093$) between study periods (Fig. 1.8).

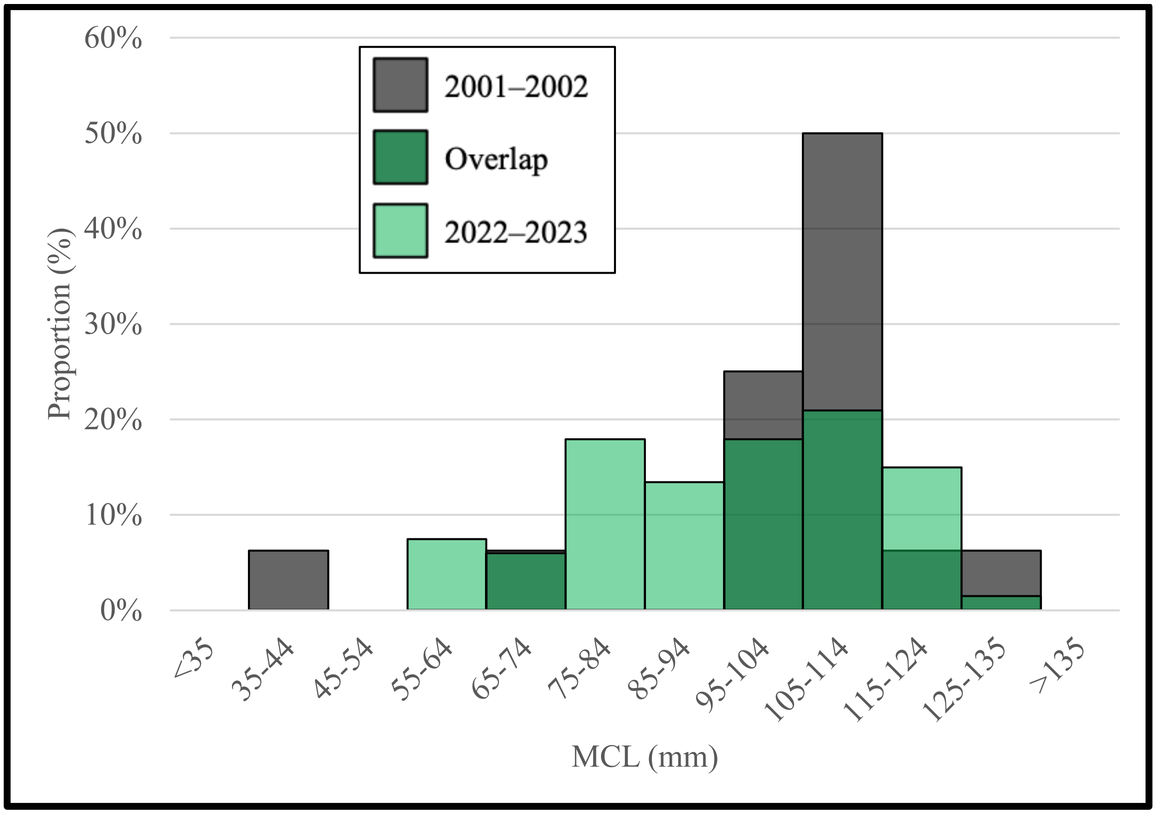

FIGURE 1.8. Eastern Musk Turtle size distribution of 2001-2002 (median = 107.5 mm, n = 16) and 2022–2023 (median = 101 mm, n = 67) individuals captured in hoop traps. Dark grey represents 2001–2002, light green represents 2022–2023, and dark green represents overlap. The y-axis is the percentage of individuals captured and the x-axis is the midline carapace length (mm).

Painted Turtles. — I compared MCL (mm) of Painted Turtles captured in hoop traps in 1972 with 2022–2023. MCL (mm) data from 1972 ($W = 0.968$, $P = 0.013$) and 2022–2023 ($W = 0.970$, $P < 0.001$) was not normally distributed. The Mann-Whitney U test indicated median MCL (mm) from 1972 (125 mm, n = 102) was significantly larger than 2022–23 (122 mm, n = 561) ($U = 25092$, $P = 0.048$). However, the Kolmogorov-Smirnov test indicated no significant difference in distribution ($D = 0.143$, $P = 0.060$) (Fig. 1.9).

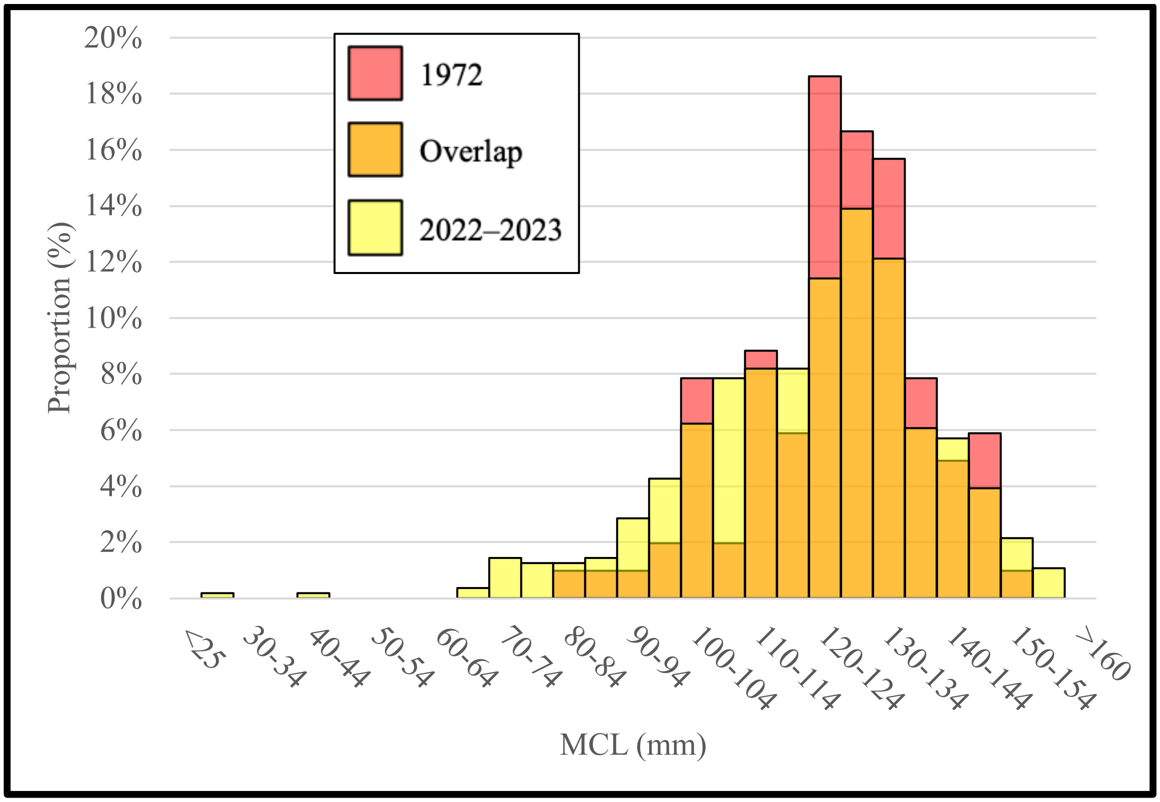

FIGURE 1.9. Midland Painted Turtle size distribution of 1972 and 2022–2023 individuals captured in hoop traps. Red represents 1972, yellow 2022–2023, and orange represents overlap. The y-axis is the percentage of individuals captured and the x-axis is the midline carapace length (mm).

I then compared 2001–2002 and 2022–2023 size structure of Painted Turtles captured using all methods. The 2001-2002 ($W = 0.892$, $P < 0.001$) and 2022–2023 ($W = 0.934$, $P < 0.001$) data were not normally distributed. Median MCL (mm) was significantly larger in 2001–2002 ($U = 299663$, $P = 0.002$) and the distribution differed significantly ($D = 0.164$, $P < 0.001$) (Fig. 1.10).

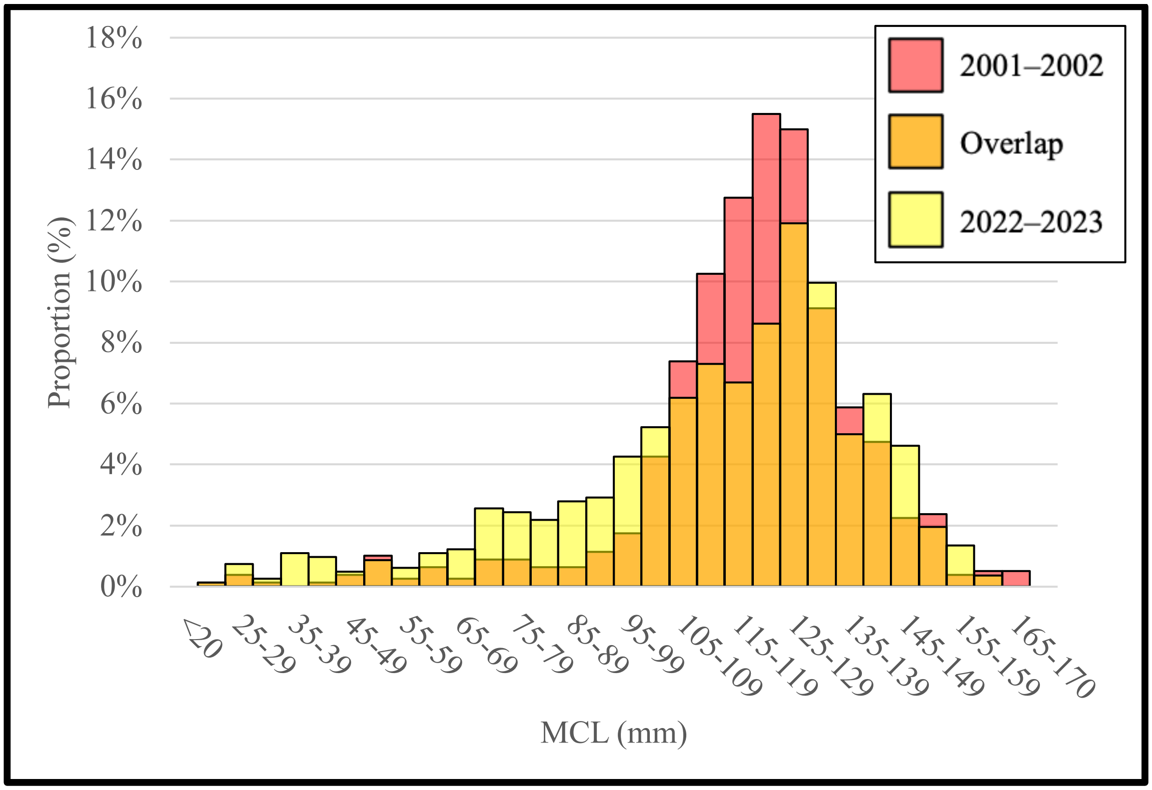

FIGURE 1.10. Midland Painted Turtle size distribution of 2001–2002 (median = 122 mm, n = 800) and 2022–2023 (median = 120 mm, n = 823) individuals from all capture methods. Red represents 2001–2002, yellow represents 2022–2023, and orange is overlap. The y-axis is the percentage of individuals captured and the x-axis is the midline carapace length (mm).

Blanding's Turtles. — I compared 1972 Blanding's Turtle hoop trap size structures to 2022–2023. While the 1972 data was normally distributed ($W = 0.979$, $P = 0.822$), the 2022–2023 data was not ($W = 0.931$, $P = 0.026$). Blanding's Turtle MCL (mm) was significantly larger in 2022–2023 than in 1972 ($U = 320$, $P = 0.013$) and shape and central tendency were significantly different as well ($D = 0.504$, $P < 0.001$) (Fig. 1.11).

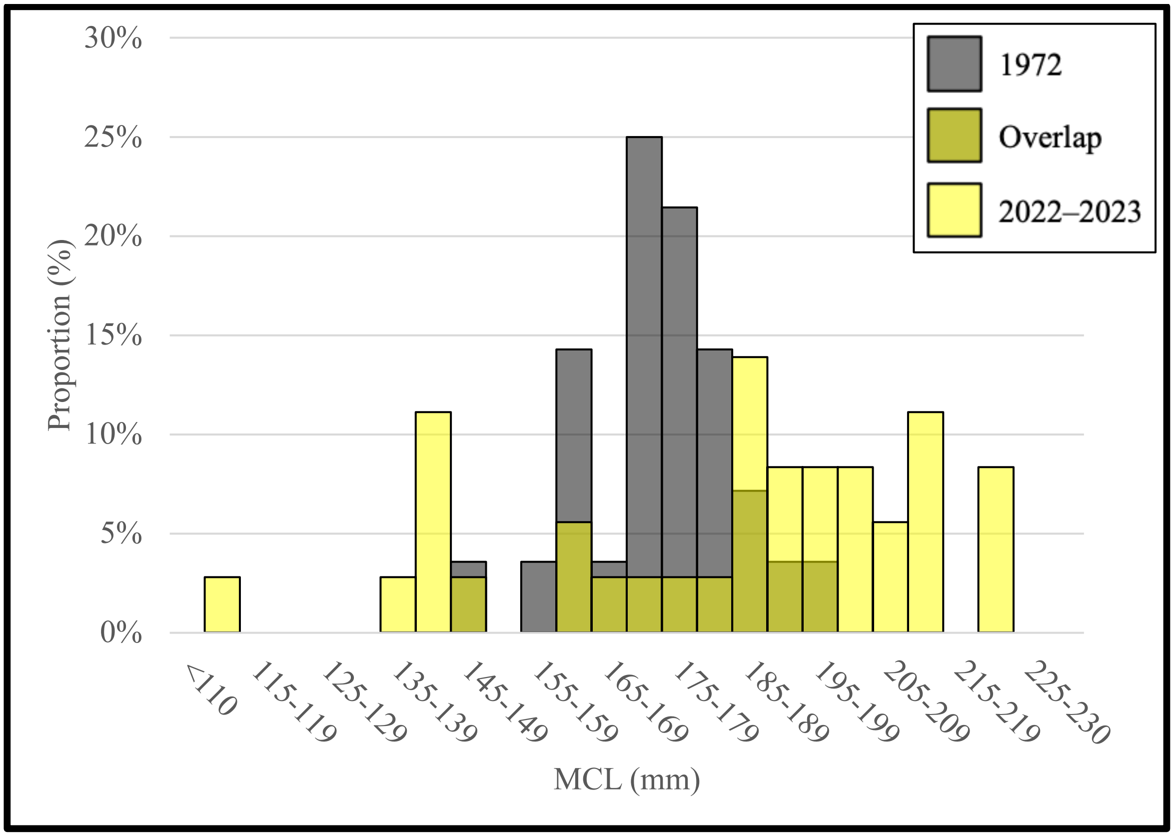

FIGURE 1.11. Blanding's Turtle size distribution of 1972 (median = 174.5 mm, n = 28) and 2022–2023 (median = 189.5 mm, n = 36) individuals captured in hoop traps. Dark grey represents 1972, yellow 2022–2023, and dark yellow represents overlap. The y-axis is the percentage of individuals captured and the x-axis is the midline carapace length (mm).

I then compared captures using all methods from 2001–2002 and 2022–2023. Both 2001–2002 ($W = 0.892$, $P < 0.001$) and 2022–2023 ($W = 0.921$, $P = 0.002$) were not normally distributed. There was no significant difference in MCL (mm) between 2001–2002 and 2022–2023 ($U = 2107$, $P = 0.6491$) or distribution ($D = 0.172$, $P = 0.205$) (Fig. 1.12).

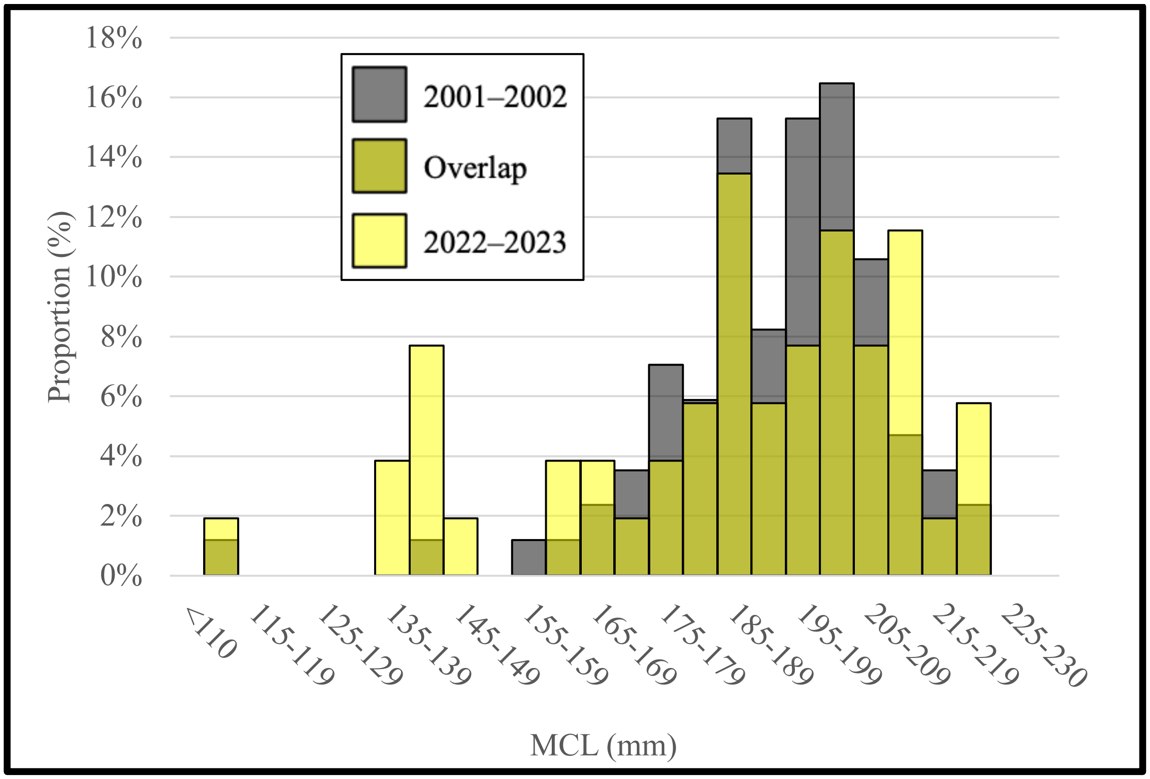

FIGURE 1.12. Blanding's Turtle size distribution of 2001–2002 (median = 195 mm, n = 85) and 2022-2023 (median = 190 mm, n = 52) individuals from all capture methods. Dark grey represents 2001–2002, yellow represents 2022–2023, and dark yellow represents overlap. The y-axis is the percentage of individuals captured and the x-axis is the midline carapace length (mm).

(Paragraph and TABLE 1.10 along with caption removed. Corresponding appendix FIGURE [1.16] and caption also removed).

Snapping Turtles. — I compared Snapping Turtle population size structures among the 1972, 2001–2002, and 2022–2023 study periods using hoop trap captures. The Shapiro-Wilk test showed that the data from 1972 ($W = 0.959$, $P = 0.007$), 2001–2002 ($W = 0.956$, $P < 0.001$), and 2022–2023 ($W = 0.957$, $P < 0.001$) were not normally distributed. Median MCL (mm) of 1972 captures was significantly less than median

MCL in 2022–2023 (U = 21673, P = 0.015) and shape and central tendency were significantly different between study periods (D = 0.177, P = 0.016) (Fig. 1.13).

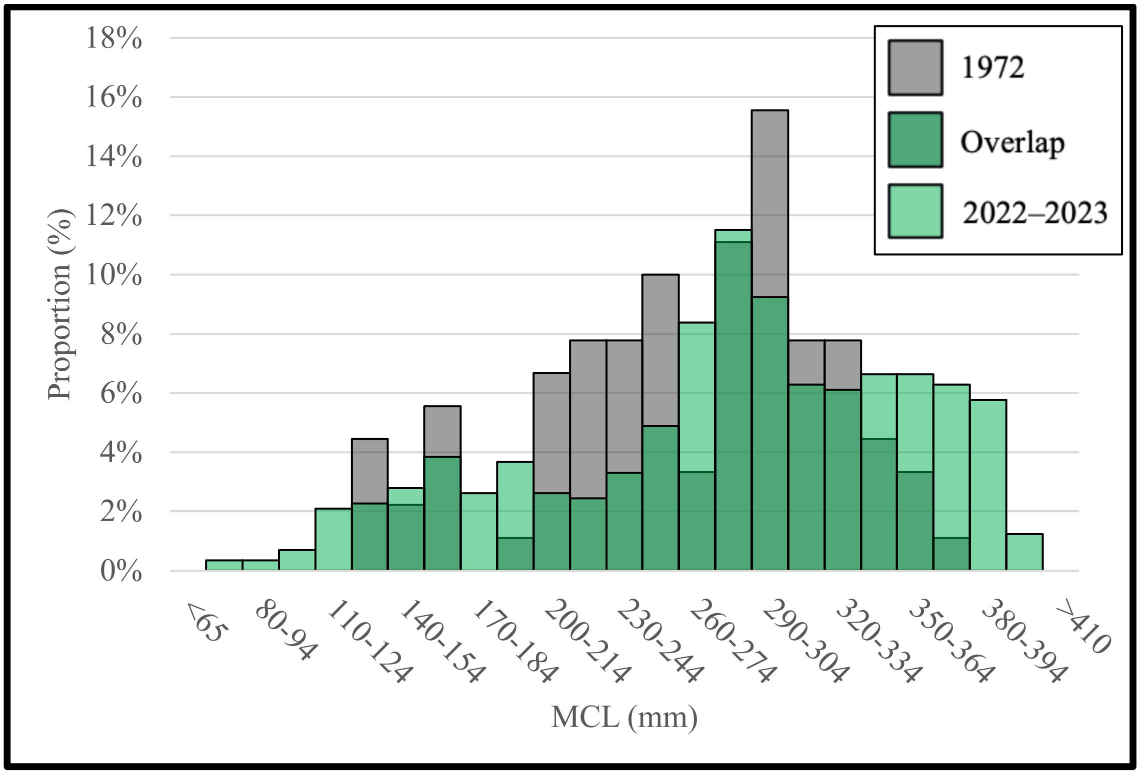

FIGURE 1.13. Snapping Turtle size distribution of 1972 (median = 276 mm, n = 90) and 2022–2023 (median = 288 mm, n = 573) individuals captured in hoop traps. Grey represents 1972, light green represents 2022–2023, and dark green represents overlap. The y-axis is the percentage of individuals captured and the x-axis is the midline carapace length (MCL, mm).

When comparing the size distribution of 2001–2002 and 2022–2023 I included a dotted line (Fig. 1.14) indicating the approximate time the nest protection program began. Median MCL (mm) was significantly larger in 2001–2002 (U = 82927, P < 0.001) and the shape and central tendency was significantly different as well (D = 0.165, P < 0.001) (Fig. 1.14).

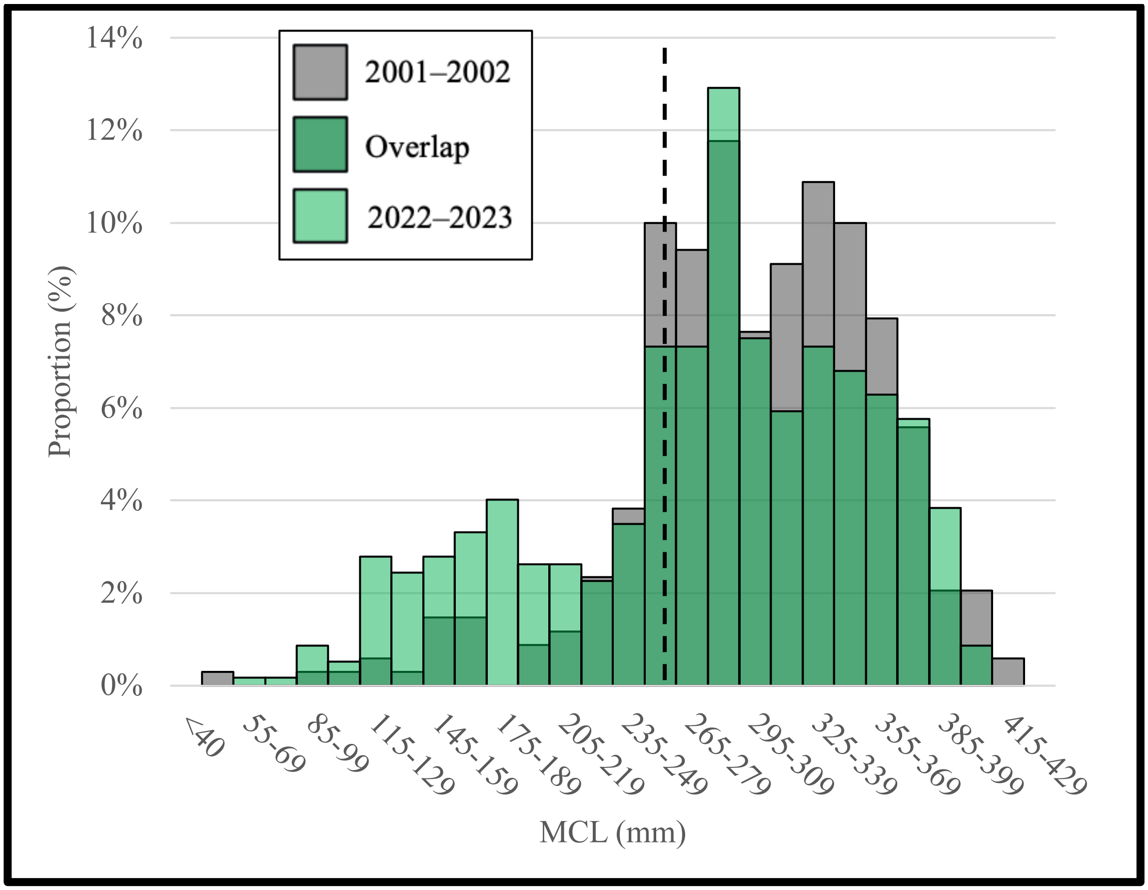

FIGURE 1.14. Snapping Turtle size distribution of 2001–2002 (median = 305 mm, n = 340) and 2022–2023 (median = 288 mm, n = 573) individuals captured in hoop traps. Grey represents 2001–2002, light green 2022–2023, and dark green represents overlap. The y-axis is the percentage of individuals captured and the x-axis is the midline carapace length (mm). Individuals left of the dotted line and part of the 2022–2023 data may have hatched between 2001–2021. Nest protection began in 2001 and therefore has been taking place for 23 nesting seasons. COSEWIC (2014) reported Snapping Turtle growth of 15–20 mm/year (does not specify total carapace length [TCL] or MCL) for the first 11-13 years. This growth rate then drops by 40% until 17–19 years of age before another decrease in growth rate (COSEWIC 2014). Therefore, I used 15 mm/year for 13 years (195 mm) + (.6 x 15) = 9mm/year for the next 6 years (54 mm). Therefore after 19 years I may expect an individual to be approximately 249 mm. For the remaining four years, I used size increases found in Table 1 of Galbraith et al. (1989) which provides mean carapace length of female Snapping Turtles in Algonquin Provincial Park. This gave me (19-20: 3 mm, 20-21: 0.7 mm, 21-22: 4.5 mm, 22-23: 2.7 mm) 2.7 mm/year for the remaining four years (10.8 mm) (Galbraith et al. 1989). Therefore, I placed the dotted line at ~260 mm representing the start of the nest protection program.

Population Size Estimates. — Hoop and basking trap days and site duration were similar (but see Table 1.38 in Appendix for exact dates and duration of each visit).

Marsh Boardwalk and Redhead Pond were the most variable because they were the last sites in 2022 and 2023 meaning the constraint of the field season ending may have inhibited my ability to complete 13 or 14 trap days per trap (Table 1.11).

TABLE 1.11. Trap days per trap type per visit for each site in 2022–2023. Total trap days is nine days less than previously reported in this document because nine hoop trap days in April 2023 were not part of a site visit (six in North DeLaurier and three in South DeLaurier).

	Visit 1		Visit 2		Visit 3		Visit 4		
Site	Bask	Hoop	Bask	Hoop	Bask	Hoop	Bask	Hoop	Total
BP	84	168	78	182	78	156	n/a	n/a	746
EC	85	180	78	174	78	156	n/a	n/a	751
ELP	84.5	175	78	174	78	156	n/a	n/a	745.5
ENB	84.5	166	78	182	78	156	n/a	n/a	744.5
MB	84	221	73	130	81	156	78	132	955
ND	102	252	84	172	91	195	n/a	n/a	896
RH	84	219	51	95	78	156	48	88	819
SD	102	238	84	168	65	169	n/a	n/a	826

I found the highest density of male Snapping Turtles in North DeLaurier and female Snapping Turtles in South DeLaurier (Table 1.12 and 1.13).

TABLE 1.12. Population size and density estimates of male Snapping Turtles for each site as well as within the eight sites combined. Because Marsh Boardwalk and Redhead Pond were visited four times I used the average for total population size estimate. To calculate total male Snapping Turtles/ha I used total surface area (ha) and total population size estimate. See Table 1.38 of Appendix for exact dates of each visit to each site.

Site	Surface area (ha)	Population size estimate	Standard error (±)	95% Confidence intervals	Snapping Turtles/ha
Bush Pond	3.79	33.8	20.7	-6.8, 74.3	8.92
East Cranberry	25.57	31	0	31, 31	1.21
East Lake Pond	63.08	38	15.3	8, 68	0.60
East North Boundary	6.59	28.9	14.8	0, 57.9	4.39
Marsh Boardwalk	3.17	19.5	4.5	10.7, 28.3	6.15

Marsh Boardwalk	3.17	55.2	39.8	-22.8, 133.3	17.41
Marsh Boardwalk avg.	3.17	37.35	n/a	n/a	11.78
North DeLaurier	0.98	18	0	18, 18	18.37
Redhead Pond	14.3	36.7	12.4	12.4, 61.1	2.57
Redhead Pond	14.3	70.3	63.9	-55, 195.5	4.92
Redhead Pond avg.	14.3	53.5	n/a	n/a	3.74
South DeLaurier	1.77	23	0	23, 23	12.99
Cumulative total	119.25	263.55	n/a	n/a	2.21

TABLE 1.13. Population size and density estimates of female Snapping Turtles for six sites as well as the total among these six sites. Because I visited Marsh Boardwalk and Redhead Pond four times I used the average for total population size estimate. To calculate total female Snapping Turtles/ha I used total surface area (ha) and population size estimate. See Table 1.38 of Appendix for exact dates of each visit to each site.

Site	Surface area (ha)	Population size estimate	Standard error (±)	95% Confidence intervals	Snapping Turtles/ha
Bush Pond	3.79	6	4.8	-3.4, 15.4	1.58
East Cranberry	25.57	24.8	33.9	-41.6, 91.1	0.97
East Lake Pond	63.08	13	0	13, 13	0.21
Marsh Boardwalk	3.17	6	0	6, 6	1.89
Marsh Boardwalk	3.17	26.7	29	-30.1, 83.4	8.42
Marsh Boardwalk avg.	3.17	16.35	n/a	n/a	5.16
Redhead Pond	14.3	19.3	7.4	4.7, 33.9	1.35
Redhead Pond	14.3	123.5	141.4	-153.7, 400.7	8.64
Redhead Pond avg.	14.3	71.4	n/a	n/a	4.99
South DeLaurier	1.77	18	0	18, 18	10.17
Cumulative total	111.68	149.55	n/a	n/a	1.34

I estimated 2.21 male Snapping Turtles per hectare and a park wide population size of 741 (2.21 x 335.17 [see Fig. 1.15 in Appendix]). I estimated female population size of 449 (1.34 x 335.17). Therefore, I estimated a park wide adult population size of 1190 Snapping Turtles.

I estimated a park wide adult Painted Turtle population size of 6525 (19.47 x 335.17) (Table 1.14).

TABLE 1.14. Adult Painted Turtle population size and density estimates for each site as well as the total among all eight sites. Because I visited Marsh Boardwalk four times I used the average for total population size estimate. To calculate total adult Painted Turtles/ha I used total surface area (ha) and population size estimate. See Table 38 of Appendix for exact dates of each visit to each site.

Site	Surface area (ha)	Population size estimate	Standard error (±)	95% Confidence intervals	Painted Turtles/ha
Bush Pond	3.79	903	1206.6	-1461.9, 3267.9	238.26
EC/ELP	88.65	405	645.7	-860.6, 1670.6	4.57
East North Boundary	6.59	522	334.5	-133.3, 1178	79.21
Marsh Boardwalk	3.17	66	94	-118.3, 250.3	20.82
Marsh Boardwalk	3.17	31.1	29.2	-26.1, 88.4	9.81
Marsh Boardwalk avg.	3.17	48.55	n/a	n/a	15.32
North DeLaurier	0.98	14	0	14, 14	14.29
Redhead Pond	14.3	21	25.4	-28.8, 70.8	1.47
South DeLaurier	1.77	408	451.1	-476.2, 1292.2	230.51
Cumulative total	119.25	2321.55	n/a	n/a	19.47

(Sentences removed). Based on Browne's (2003) Blanding's population size estimate and the reduced hoop trap CPUE, I estimated there may only be 107 individuals remaining in the park (2022–2023 CPUE [0.008] / 2001–2002 CPUE [0.012] x 2001–2002 population size estimate [160]).

PPNP nest protection program. — Between 2001–2021 882 nests were protected (see Table 3.2 of Chapter 3). By multiplying clutch size (Table 1.15) by number of nests protected between 2001–2021 I estimated that over 13000 Snapping Turtle eggs were protected between 2001-2021 while an estimated 338 Blanding's Turtle eggs were protected. Based on my current estimate of 449 female Snapping Turtles and a clutch frequency of 0.85 (Congdon et al. 1994), we can expect ~382 nests, meaning 22.86 nests protected would represent ~6% of the total annual nests in the park. Using my Blanding's Turtle sex ratio from all capture methods (19 males and 26 females) and an updated population size of 107, I estimated 62 females. Based on a clutch frequency of 0.48 (Congdon et al. 2001) we can expect ~30 nests in the park meaning 1.57 nests protected would represent ~5% of the total annual nests in the park. Based on all capture methods I estimated 32.06% of Painted Turtles are female, meaning there would be 2092 in the park. Based on a clutch frequency of 0.93 (Samson 2003) we can expect 1946 nests in the park meaning 5.9 protected nests would represent ~0.3% of the total annual nests (Table 1.15).

TABLE 1.15. Nests protected per year 2001–2021 (Congdon et al. 1987[1]; Congdon et al. 1994[2]; Congdon et al. 2001[3]; Samson 2003[4]; Ryan and Lindeman 2007[5]; Ernst and Lovich 2009[6]; COSEWIC 2012b[7]; Parks Canada Agency unpubl. data[8]; Wick et al. 2024[9]).

Species	Total nests protected 2001-2021	Average nests protected per year 2001-2021	Expected clutch size per nest	Estimated total eggs protected	Expected annual clutch frequency
BLTU	33[8,9]	1.57	10.25[9]	338	0.48[3]
MATU	209[8,9]	9.95	11.9[5]	2487	n/a
MPTU	124[8,9]	5.9	7.6[6]	942	0.93[4]
MUTU	36[8,9]	1.71	5[7]	180	n/a
SNTU	480[8,9]	22.86	27.9[1]	13392	0.85[2]

While uncommon, nests that are protected can still experience loss beyond that expected based on regular hatching success. Reasons protected nests fail include being poached, predated, boxes removed by park visitors then predated, washed out by wave activity from Lake Erie, and eggs being destroyed by roots (Parks Canada Agency unpubl. data; Wick et al. 2024). For example, while eight Blanding's Turtle nests were protected in 2022–2023, one nest containing an estimated eight eggs was predated by a mole. (Beginning of sentence removed) overall, only 50 Blanding's Turtle hatchlings from an estimated 82 protected eggs were successfully released in 2022–2023.

DISCUSSION

My study was the third comprehensive assessment of the turtle community in PPNP that included trapping. Browne and Hecnar (2007) found lower CPUE of Painted, Snapping, and Blanding's Turtles in Study Period 2 than Study Period 1. In Study Period 3, I found lower CPUE again for Painted and Blanding's Turtles but an increased CPUE for Snapping Turtles since Study Period 2, suggesting that nest protection has been effective for this species.

Nest protection is commonly used in the conservation of turtles (Standing et al. 2000; Riley and Litzgus 2013; Campbell et al. 2020). Standing et al. (2000) found Blanding's Turtle nest protection was successful in mitigating nest predation in Kejimkujik National Park, NS. Snapping Turtles have benefitted the most from the nest protection program at PPNP (480 of 882 nests; 54.42%; ~23/year) among the five species I observed (Parks Canada Agency unpubl. data; Wick et al. 2024). Sex ratio of Snapping Turtles captured in hoop traps was significantly less male biased than 2001–2002. Increased CPUE as well as a more evenly distributed size structure of Snapping Turtles captured in hoop traps and by all capture methods suggest increased juvenile recruitment since 2001–2002. Because juveniles may be underrepresented when using hoop traps (Ream and Ream 1966; Koper and Brooks 1998; Browne and Sullivan 2023), long-term studies have the advantage of reflecting changes in population structure instead of possibly detecting lower catchability of juveniles (Browne and Hecnar 2007; Howell et al. 2019). The size structure histograms which indicate the approximate start of the nest protection program suggest Snapping Turtles are recovering because of nest protection started by Browne (2003).

Northern Map Turtles received the second most nest protection (209 of 882 nests; 23.70%; ~10/year) (Parks Canada Agency unpubl. data; Wick et al. 2024). I was unable to estimate the proportion of Northern Map Turtle nests protected each year because of insufficient data to estimate population sizes. The Northern Map Turtles in the park are likely part of larger population that also use Lake Erie (Browne 2003). (Sentence removed). Browne (2003) found nest predation rates were higher along park roadsides (9 of 9; 100%) than East Beach (21 of 33; 63.6%) or Mersea Rd. E (5 of 8; 62.5%). Phillips (2008) found nest predation rates of Painted and Snapping Turtles were higher in disturbed habitat (west side of the park along the park road and north boundary along Mersea Rd. E) than undisturbed habitat (East Beach). Painted and Snapping Turtle nest predation rates were 78% and 98% respectively in disturbed habitat and 53% and 66% respectively in undisturbed habitat (Phillips 2008).

Basking trap captures are likely the most representative of the PPNP Northern Map Turtle population (Browne and Hecnar 2005). Ream and Ream (1966) suggested hand captures were biased towards juvenile Painted Turtles. Considering the opportunistic approach, I observed juvenile bias for hand captures of Northern Map Turtles as well. In terms of individuals, I captured 33 adults and 1 juvenile in hoop traps and 133 adults and 40 juveniles in basking traps, while hand captures consisted of 12 adults and 41 juveniles.

I used varying types of fish for baiting hoop traps and while Northern Map Turtles are omnivorous, they feed primarily on molluscs, insects, and crayfish (Browne and Hecnar 2005; Ernst and Lovich 2009). Northern Map Turtle size structure results compared with 2001–2002 suggested an increasing population. Along with an improved size structure, I also found an size structure indicative of an increasing population. However, CPUE of basking traps decreased by 16% since 2001–2002. The difference in CPUE could result from a variety of factors. Northern Map Turtles display basking site fidelity in PPNP, and water levels were lower than usual in 2001–2002 (USACE 2024). This could have resulted in decreased access to regular basking sites or individual objects such as logs leading to individuals seeking out alternative basking areas or objects, potentially increasing the effectiveness of the basking traps. Additional support for this explanation is that CPUE in hoop traps increased from 2001–2002 to 2022–2023.

I found a decreased CPUE for Painted Turtles captured in basking and hoop traps. However Painted Turtle size structure appears to suggest increased juvenile recruitment since Rivard and Smith (1973) and Browne (2003). There are two possible explanations for this pattern: 1) recruitment has increased (e.g., due to nest protection) but not enough to stop the population decline, or 2) mortality pressures on adults or larger individuals have increased thus increasing the proportion of juveniles or smaller individuals. An increase in adult removal could be from poaching, road mortality, death from natural causes, or predation. I found that road mortality of adult turtles was much lower than that of hatchlings during natal dispersal (see Chapter 3, Table 3.3). However, my data suggested that in PPNP Painted Turtles experienced the most adult road mortality. Painted Turtle road mortality in the park may be increasing as Browne (2003) calculated road mortality of 5.3/year for Painted Turtles while between 2019–2023 I calculated 8 adults per year (see Chapter 3, MPTU model 1). Karson et al. (2018) found 19 predated individuals (all mature females) of three species (1 Blanding's, 8 Northern Map, and 10 Snapping Turtles) in Rondeau Provincial Park, ON and suggested Raccoons were the most likely predator. It was not especially uncommon for us to capture an individual turtle with a missing leg. I found increased Raccoon density in 2022 compared to Browne (2003) (see Chapter 2). A PPNP park visitor found an adult female Painted Turtle in 2023 with all four limbs bitten as well as a small portion of the tail removed, and this individual was deceased upon arrival at the Ontario Turtle Conservation Centre (OTCC) (Taylor Hamel, pers. comm.; Melanie Lefaive, pers. comm.); this was likely the result of a Raccoon attack.

There could be an expectation that road mortality contributed to an increasingly male biased sex ratio (Steen and Gibbs 2004; Dupuis-Désormeaux et al. 2017). However, some research suggests road mortality may not lead to male biased sex ratios (Carstairs et al. 2018). Carstairs et al. (2018) noted vehicular collision related admissions of Painted Turtles to the OTCC from 2013–2017 consisted of 541 females and 532 males. However, these admissions represent a large area across southern Ontario (see Fig. 3 in Carstairs et al. 2018) from many places. It is likely in PPNP that females are at increased risk of road mortality. There is only one main road in PPNP which is between the marsh and Lake Erie. Therefore, it is more likely females encounter the roads while searching for a nesting site than males searching for a mate or travelling to foraging or overwintering sites. Painted Turtles were more male biased in Study Period 2 than in my Study Period considering basking, hoop, and all capture methods combined. However, they were more male biased considering hoop and all capture methods combined than in Study Period 1. While the Painted Turtle population is still the most abundant of the five observed native species, the decreased CPUE for a second consecutive Study Period is of concern.

Eastern Musk Turtles are relatively rarely captured in PPNP. Hoop trap CPUE increased from 0.004 to 0.005 from 1972 to 2001–2002. I found it increased again (0.015) in 2022–2023. Analyses indicated no significant changes in sex ratio or size structure since 2001–2002. Eastern Musk Turtles may not be a contemporary concern in PPNP given that I captured many more individuals in hoop traps and found a more evenly distributed size structure as well as an increased CPUE. Compared to Browne and Hecnar (2007) Eastern Musk Turtle rank increased from 4 to 3 when considering hoop traps and 5 to 4 for all capture methods; however, this change may reflect the state of Blanding's Turtles more than an increased Eastern Musk Turtle abundance. Eastern Musk Turtles may have benefitted from the return of Beavers a little over a decade ago as they are known to use Beaver lodges and Muskrat mounds for nesting (Ernst and Lovich 2009). Parks Canada (1980) noted that Beavers were likely in PPNP in "prehistoric times" as "skeletal remains were found in archaeological digs in the park". Increased captures could result from increased abundance in the park; however, their secretive nature could be at least partially responsible. It is possible the increased captures were influenced by the 2023 trap setup compared to Rivard and Smith (1973), Browne (2003), and 2022. While year-to-year variability may have played a role in the increase I had 6 captures of 6 individuals in hoop traps in 2022, and in 2023 had 63 captures of 61 individuals.

Trap type and specifications such as trap setup and size as well as bait are important consideration when comparing studies (Ream and Ream 1966; Mali et al. 2012; Gulette et al. 2019). Ream and Ream (1966), Vogt (1979), and Browne and Sullivan (2023) suggest hoop traps may result in male bias captures for Painted Turtles. The use of a variety of trapping methods helps to reduce trap bias (Ream and Ream 1966; Browne and Hecnar 2007). Using Painted and Snapping Turtles, Gulette et al. (2019) compared two sizes of hoop traps: 91 cm hoop diameter and 76 cm hoop diameter. They found the presence of Snapping Turtles did not significantly change the CPUE of Painted Turtles. Mean straight-line carapace length (SCL) of Snapping Turtles captured in 91 cm diameter traps (277 mm) was significantly larger than 76 cm diameter traps (247.9 mm). For Painted Turtles with a straight-line carapace width (SCW) greater than 80 mm, SCL was not significantly different among 91 cm (139.2 mm) and 76 cm (136 mm) traps. This suggests with greater variability in trap size compared to Rivard and Smith (1973) and Browne (2003) we could expect this to cause an increase but not decrease in the median MCL (mm) of Snapping Turtles captured in hoop traps. Being that compared to Browne (2003) we found a significantly lower median MCL (mm) of Snapping Turtles captured in hoop traps (Fig. 1.14) along with an increased CPUE, this further solidifies the efficacy of nest protection in PPNP.

Rivard and Smith (1973) expressed concern for Spotted and Blanding's Turtle populations, while noting how few Spotted Turtles were observed. Spotted Turtles were last observed in the park in 1994 and are now considered extirpated from PPNP (Hecnar and Hecnar 2004). The first herpetofaunal survey at Point Pelee, conducted in 1913 and predating the establishment of PPNP, reported approximately equal representation of

Spotted and Painted Turtles (Patch 1919). Thus, PPNP Spotted Turtles went from common to extirpated in ~80 years.

Blanding's Turtles may be following a similar trajectory. They were described as abundant by Logier (1925), common in southern Ontario as well as PPNP but of concern by Rivard and Smith (1973), and in decline by Browne (2003). (Remainder of paragraph removed).

Blanding's Turtle CPUE dropped by 78% from 1972 to 2001–2002 and dropped by 33% from 2001–2002 to 2022–2023. Browne and Hecnar (2007) found Blanding's Turtle size structure was more top-heavy than Rivard and Smith (1973) suggesting a declining population with limited juvenile recruitment. I found the size structure of Blanding's Turtles captured in hoop traps was significantly more top heavy than Rivard and Smith (1973). I found no significant change in size structure of captures from hoop traps or all methods since Browne (2003), and CPUE decreased. The lack of improvement in size structure, along with reduced CPUE and captures in fewer sites suggest that Blanding's Turtle persistence is threatened.

Relative and ranked abundance suggested community structure has changed since Rivard and Smith (1973) and Browne (2003) (all capture methods and hoop traps). Blanding's Turtles had dropped rank from three to four from Rivard and Smith (1973) to Browne (2003) and dropped again to five (all capture methods). Hoop trap ranks were the same during Rivard and Smith (1973) and Browne (2003), but Blanding's Turtle rank dropped from three to four in 2022–2023 while Painted Turtles dropped to second with Snapping Turtles ranking first. These differences reflect the number of protected nests between 2001–2021. Blanding's Turtles had the lowest number of protected nests (33 of

882; 3.74%) between 2001–2021 (Wick et al. 2024). Along with Eastern Musk Turtles, Blanding's Turtles may also have the lowest reproductive potential among the extant turtle species in PPNP because of their low clutch frequency (see Table 1.15). Although PPNP had the only documented Blanding's Turtle with two clutches in a single nesting season in Canada (Wick et al. 2023), they generally have a low clutch frequency (0.48; Congdon et al. 2001) and I found a mean clutch size of 10.25 (range 7–15) among eight protected nests in 2022-2023 (see Chapter 3, Table 3.1). Without targeted management, Blanding's Turtles are at risk of being extirpated from the park.

CONCLUSIONS

Blanding's Turtles are the most imperiled extant turtle species in PPNP. Population size structure and CPUE data collected during three study periods show evidence of continued decline over the past 50 years. If mitigation efforts are not increased, Blanding's Turtles could see a similar fate to that of Spotted Turtles in the park. Studies in PPNP have historically reported high Raccoon density and nest predation, which limits juvenile recruitment causing population decline and putting the turtle species of PPNP at risk (Kraus 1991; Whitehead 1997; Browne 2003; Phillips and Murray 2005; Browne and Hecnar 2007; Phillips 2008). Browne and Hecnar (2007) found declining Snapping Turtle and Blanding's Turtle populations with top-heavy size structures suggesting limited juvenile recruitment. I found a significant improvement in Snapping Turtle size structure, suggesting increased juvenile recruitment as well as an improved CPUE since Browne (2003). My results suggest the nest protection program started in 2001 by

Browne (2003) has helped to reverse the decline of Snapping Turtles. With increased effort, nest protection could reverse declines of other turtle species as well.

APPENDIX

Population size estimates.—

FIGURE 1.15. Additional areas used to calculate total number of Snapping and Painted Turtles in the park. Sum of additional areas (highlighted and bordered with blue) is 215.92 ha. The sum of this area plus my eight sites (pink border) is 335.17 ha. Most polygons were created using October 2023 Google Earth Pro imagery however I also

used 2012, 2016, and 2017 imagery to create some polygons. All polygons were then placed on the 2023 map. Map created using Google Earth Pro.

Snapping Turtles.—

TABLE 1.16. Method B table for female Snapping Turtles in Bush Pond

	Sampling period		
Last capture	**1**	**2**	**3**
1	n/a	1	2
2	n/a	n/a	1
Total marked	0	1	3
Total unmarked	10	1	7
Total caught	10	2	10
Total released	10	2	10

TABLE 1.17. Method B table for male Snapping Turtles in Bush Pond

	Sampling period		
Last capture	**1**	**2**	**3**
1	n/a	3	2
2	n/a	n/a	4
Total marked	0	3	6
Total unmarked	13	11	8
Total caught	13	14	14
Total released	13	14	14

TABLE 1.18. Method B table for female Snapping Turtles in East Cranberry

	Sampling period		
Last capture	**1**	**2**	**3**
1	n/a	1	1
2	n/a	n/a	1
Total marked	0	1	2
Total unmarked	16	7	1
Total caught	16	8	3
Total released	16	8	3

TABLE 1.19. Method B table for male Snapping Turtles in East Cranberry

	Sampling period		
Last capture	**1**	**2**	**3**
1	n/a	12	0
2	n/a	n/a	8
Total marked	0	12	8
Total unmarked	30	19	6
Total caught	30	31	14
Total released	30	31	14

TABLE 1.20. Method B table for female Snapping Turtles in East Lake Pond

	Sampling period		
Last capture	**1**	**2**	**3**
1	n/a	5	0
2	n/a	n/a	1
Total marked	0	5	1
Total unmarked	24	8	4
Total caught	24	13	5
Total released	24	13	5

TABLE 1.21. Method B table for male Snapping Turtles in East Lake Pond

	Sampling period		
Last capture	**1**	**2**	**3**
1	n/a	6	1
2	n/a	n/a	6
Total marked	0	6	7
Total unmarked	22	20	5
Total caught	22	26	12
Total released	22	26	12

TABLE 1.22. Method B table for male Snapping Turtles in East North Boundary

	Sampling period		
Last capture	**1**	**2**	**3**
1	n/a	6	2
2	n/a	n/a	3
Total marked	0	6	5
Total unmarked	23	8	10
Total caught	23	14	15
Total released	23	14	15

TABLE 1.23. Method B table for female Snapping Turtles in Marsh Boardwalk

	Sampling period			
Last capture	**1**	**2**	**3**	**4**
1	n/a	3	0	0
2	n/a	n/a	2	2
3	n/a	n/a	n/a	1
Total marked	0	3	2	3
Total unmarked	13	3	5	1
Total caught	13	6	7	4
Total released	13	6	7	4

TABLE 1.24. Method B table for male Snapping Turtles in Marsh Boardwalk

	Sampling period			
Last capture	**1**	**2**	**3**	**4**
1	n/a	5	0	1
2	n/a	n/a	5	3
3	n/a	n/a	n/a	2
Total marked	0	5	5	6
Total unmarked	14	11	8	2
Total caught	14	16	13	8
Total released	14	16	13	8

TABLE 1.25. Method B table for male Snapping Turtles in North DeLaurier

	Sampling period		
Last capture	**1**	**2**	**3**
1	n/a	6	0
2	n/a	n/a	9
Total marked	0	6	9
Total unmarked	7	12	4
Total caught	7	18	13
Total released	7	18	13

TABLE 1.26. Method B table for female Snapping Turtles in Redhead Pond

	Sampling period			
Last capture	**1**	**2**	**3**	**4**
1	n/a	3	1	0
2	n/a	n/a	3	3
3	n/a	n/a	n/a	1
Total marked	0	3	4	4
Total unmarked	12	11	14	4
Total caught	12	14	18	8
Total released	12	14	18	8

TABLE 1.27. Method B table for male Snapping Turtles in Redhead Pond

	Sampling period			
Last capture	**1**	**2**	**3**	**4**
1	n/a	6	6	3
2	n/a	n/a	6	0
3	n/a	n/a	n/a	1
Total marked	0	6	12	4
Total unmarked	24	5	8	2
Total caught	24	11	20	6
Total released	24	11	20	6

TABLE 1.28. Method B table for female Snapping Turtles in South DeLaurier

	Sampling period		
Last capture	**1**	**2**	**3**
1	n/a	3	0
2	n/a	n/a	6
Total marked	0	3	6
Total unmarked	4	15	20
Total caught	4	18	26
Total released	4	18	26

TABLE 1.29. Method B table for male Snapping Turtles in South DeLaurier

	Sampling period		
Last capture	**1**	**2**	**3**
1	n/a	6	0
2	n/a	n/a	10
Total marked	0	6	10
Total unmarked	9	17	8
Total caught	9	23	18
Total released	9	23	18

Painted Turtles.—

TABLE 1.30. Method B table for adult Painted Turtles in Bush Pond

	Sampling period		
Last capture	**1**	**2**	**3**
1	n/a	1	3
2	n/a	n/a	2
Total marked	0	1	5
Total unmarked	35	40	30
Total caught	35	41	35
Total released	35	41	35

TABLE 1.31. Method B table for adult Painted Turtles in East Cranberry and East Lake Pond

	Sampling period		
Last capture	**1**	**2**	**3**
1	n/a	3	1
2	n/a	n/a	1
Total marked	0	3	2
Total unmarked	19	50	7
Total caught	19	53	9
Total released	19	53	9

TABLE 1.32. Method B table for adult Painted Turtles in East North Boundary

	Sampling period		
Last capture	**1**	**2**	**3**
1	n/a	13	2
2	n/a	n/a	7
Total marked	0	13	9
Total unmarked	54	133	19
Total caught	54	146	28
Total released	54	146	28

TABLE 1.33. Method B table for adult Painted Turtles in Marsh Boardwalk

	Sampling period			
Last capture	**1**	**2**	**3**	**4**
1	n/a	1	1	1
2	n/a	n/a	1	0
3	n/a	n/a	n/a	2
Total marked	0	1	2	3
Total unmarked	26	9	11	13
Total caught	26	10	13	16
Total released	26	10	13	16

TABLE 1.34. Method B table for adult Painted Turtles in North DeLaurier

	Sampling period		
Last capture	**1**	**2**	**3**
1	n/a	3	0
2	n/a	n/a	1
Total marked	0	3	1
Total unmarked	31	11	11
Total caught	31	14	12
Total released	31	14	12

TABLE 1.35. Method B table for adult Painted Turtles in Redhead Pond

	Sampling period		
Last capture	**1**	**2**	**3**
1	n/a	1	2
2	n/a	n/a	1
Total marked	0	1	3
Total unmarked	28	4	33
Total caught	28	5	36
Total released	28	5	36

TABLE 1.36. Method B table for adult Painted Turtles in South DeLaurier

	Sampling period		
Last capture	**1**	**2**	**3**
1	n/a	2	3
2	n/a	n/a	2
Total marked	0	2	5
Total unmarked	74	31	11
Total caught	74	33	16
Total released	74	33	16

Blanding's Turtle.—

(TABLE 1.37 removed).

Trapping schedule.—

TABLE 1.38. Trapping schedule 2022-2023 (SB = Small bask, LB = Large bask, LMB = Large metal bask, SH = Small hoop, SOG = Small original hoop, LWH = Large white hoop, LBH = Large black hoop). Trap numbers varied at times once setup in a site due to additions or repairs and such.

Trapping location	Number of traps	Trapping location	Number of traps	Date
North DeLaurier	6 Bask (4 LB, 2 SB), 16 hoop (8 SH, 8 LWH)	South DeLaurier	6 Bask (4 LB, 2 SB), 16 hoop (8 SH, 8 LWH)	May 2 – May 19, 2022
Marsh Boardwalk	6 Bask (5 LB, 1 SB), 16 hoop (8 SH, 8 LWH)	Redhead Pond	6 Bask (4 LB, 2 SB), 16 hoop (8 SH, 8 LWH)	May 22 – June 9, 2022
East Cranberry	6 Bask (5 LB, 1 SB), 16 hoop (8 SH, 8 LWH)[1]	East Lake Pond	6 Bask (4 LB, 2 SB), 16 hoop (8 SH, 8 LWH)[1]	June 12 – June 29, 2022
Bush Pond	6 Bask (5 LB, 1 SB), 12 hoop (6 SH, 6 LWH)	East North Boundary	6 Bask (5 LB, 1 SB), 12 hoop (6 SH, 6 LWH)	July 1 – July 21, 2022
North DeLaurier	6 Bask (5 LB, 1 SB), 12 hoop (6 SH, 6 LWH)[2]	South DeLaurier	6 Bask (5 LB, 1 SB), 12 hoop (6 SH, 6 LWH)	July 22 – August 10, 2022
Marsh Boardwalk	6 Bask (6 LB), 12 hoop (6 SH, 6 LWH)	Redhead Pond	6 Bask (5 LB, 1 SB), 12 hoop (6 SH, 6 LWH)	August 10 – August 26, 2022
North DeLaurier	2 Hoop (1LBH, 1 SOG)	South DeLaurier	1 Hoop (1 SOG)	April 25 – April 28, 2023
Bush Pond	6 Bask (2 LB, 2 SB, 2 LMB), 14 hoop (6 SH, 6 LBH, 2 SOG)	East North Boundary	6 Bask (2 LB, 2 SB, 2 LMB), 14 hoop (6 SH, 6 LBH, 2 SOG)	May 1 – May 16, 2023
East Cranberry	6 Bask (2 LB, 2 SB, 2 LMB), 14 hoop (6 SH, 6 LBH, 2 SOG)	East Lake Pond	6 Bask (2 LB, 2 SB, 2 LMB), 14 hoop (6 SH, 6 LBH, 2 SOG)	May 18 – June 2, 2023
Marsh Boardwalk	6 Bask (2 LB, 2 SB, 2 LMB), 12 hoop (6 SH, 5 LBH, 1 SOG)[3]	Redhead Pond	6 Bask (2 LB, 2 SB, 2 LMB), 12 hoop (6 SH, 5 LBH, 1 SOG)[3]	June 2 – June 17, 2023
North DeLaurier	7 Bask (2 LB, 3 SB, 2 LMB), 15 hoop (7 SH, 6 LBH, 2 SOG)	South DeLaurier	5 Bask (2 LB, 1 SB, 2 LMB), 13 hoop (5 SH, 6 LBH, 2 SOG)	June 21 – July 6, 2023
Bush Pond	6 Bask (2 LB, 2 SB, 2 LMB), 12 hoop (6 SH, 5 LBH, 1 SOG)	East North Boundary	6 Bask (2 LB, 2 SB, 2 LMB), 12 hoop (6 SH, 5 LBH, 1 SOG)	July 11 – July 26, 2023
East Cranberry	6 Bask (2 LB, 2 SB, 2 LMB), 12 hoop (5 SH, 5 LBH, 2 SOG)	East Lake Pond	6 Bask (2 LB, 2 SB, 2 LMB), 12 hoop (5 SH, 5 LBH, 2 SOG)	July 29 – August 12, 2023
Marsh Boardwalk	6 Bask (2 LB, 2 SB, 2 LMB), 12 hoop (5 SH, 5 LBH, 2 SOG)	Redhead Pond	6 Bask (2 LB, 2 SB, 2 LMB), 12 hoop (5 SH, 5 LBH, 2 SOG)	August 14 – August 27, 2023

[1]Reduced to 6 LWH and 6 SH while at sites. [2]Added an extra small hoop for 4 trap days.
[3]Removed a LBH and replaced with a SOG 10 June.

Size structure histogram.—

(FIGURE 1.16 and caption removed).

CHAPTER 2.— TURTLE NEST PREDATION RATES AND RACCOON RELATIVE ABUNDANCE DECLINE FOLLOWING A DISTEMPER OUTBREAK IN POINT PELEE NATIONAL PARK

INTRODUCTION

Turtle populations at Point Pelee National Park (PPNP) face many threats including road mortality, loss and erosion of nesting habitat, contaminants, invasive species, poaching, and most notably subsidized predators. Habitat loss and persecution by humans have caused declines of apex predators globally, helping mesopredators flourish (Prugh et al. 2009). Mesopredators found in PPNP include Coyote (*Canis latrans*), Red Fox (*Vulpes vulpes*), Striped Skunk (*Mephitis mephitis*), and Raccoon (*Procyon lotor*) (Browne 2003; Prugh et al. 2009). Each of these species are known predators of turtle nests (Snow 1982; Spencer and Thompson 2005; Urbanek et al. 2016; Edmunds et al. 2018; Lovemore et al. 2020). Raccoons are the main source of turtle nest predation in PPNP (Kraus 1991; Whitehead 1997; Browne 2003; Browne and Hecnar 2007; Phillips 2008). Phillips and Murray (2005; cited in Browne and Hecnar 2007) reported that Raccoon density in PPNP was four times higher than the rural Ontario average.

Risk of disease outbreak among Raccoon populations increases with density (Prange et al. 2003). Present in Ontario for over a half century, canine distemper is a highly contagious disease that can infect mammals of PPNP including Coyotes, American Mink (*Neovision vision*), Skunks, and Raccoons (Government of Ontario 2023). Large or dense Raccoon populations are more susceptible to distemper outbreaks (ODFW 2003).

Distemper is commonly fatal and symptoms including discharge from eyes and nose, emaciated appearance, and aimless wandering or other strange behaviours generally get progressively worse (ODFW 2003). A distemper outbreak in PPNP began near the end of my 2022 field season, with the first individual from the park being euthanized in August 2022.

My general goal was to survey the predator community and turtle nesting activity to provide an update on the status of PPNP turtle populations. Specific objectives for this chapter included determining and comparing nest predation rates and Raccoon relative abundance with previous studies (Browne 2003; Phillips 2008). My study timing coincidentally occurred before and after a distemper outbreak. This gave me a unique opportunity to compare the relationship with raccoon abundance and predation rates of turtle nests before and after impact in addition to comparisons with data collected 20 years ago.

METHODS

Study Area.— PPNP (41.9628°N, -82.5184°W) is in Essex County, Ontario and represents the southernmost point of Canada's mainland (Browne 2003). With over 97% of Essex Region converted agriculture, industry, and urban development, PPNP is an ecologically significant portion (Parks Canada Agency 2016). More than 50% of the original marsh system of Point Pelee was converted to agricultural land (Hecnar and Hecnar 2004). Established in 1918, PPNP is Canada's second smallest (15.5 km^2) national park (Parks Canada Agency 2016). Bordered by Lake Erie (~80%) and agricultural land (~20%), PPNP is functionally an island (Browne 2003). PPNP has one main road (Point Pelee Drive) running along the west side of the park between Lake Erie and the PPNP marsh system (Fig. 2.1). Approximately 70% of the north boundary is bordered by a road (Mersea Rd. E) with the remaining northeast end bordered by a dike separating the marsh from agricultural land. My predator surveys focused on Point Pelee Drive (in the park) and Mersea Rd. E (north boundary of the park) (Fig. 2.1).

(FIGURE 2.1 and caption removed).

Predator Surveys.— Using the same routes, day, time, and methodology as Browne (2003), I conducted predator surveys by slowly driving the same route once per week for a total of 16 weeks from 4 May to 24 August (excluding 29 June) in 2022. In 2023, I drove the same route once per week for a total of 12 weeks from 10 May to 16 August (excluding 28 June, 19 July, 26 July). These driving surveys were conducted on Wednesdays and consisted of a drive from the park gate to the Visitor Centre (Point Pelee Drive; 7 km) and back, and a drive down Mersea Rd. E (park gate to east north boundary; 3 km) and back. I recorded year, date, time, weather, site, predator species, GPS coordinates of predator location, relevant additional information such as location description, and crew for each survey.

Turtle nests.— I searched the park and/or Mersea Rd. E/north boundary for turtle nests daily from early June to mid-July 2022 and late May to mid-July 2023. Locations of Snapping Turtle (*Chelydra serpentina*) and Painted Turtle (*Chrysemys picta*) nests were marked inconspicuously using metal pegs with laminated labels attached to the top.

Markers were placed between 90 and 255 cm from the nest in varying directions. The markers should not have influenced predation rates (Tuberville and Burke 1994; Edmunds et al. 2018). If I did not see an individual nest but suspected a Snapping Turtle nest to be present, I did not excavate to confirm nest presence until the end of the field season, and only if necessary to avoid influencing the likelihood of predation. I determined that some marked suspected nests were not nests upon excavation at the end of each field season. I also found nests of Northern Map (*Graptemys geographica*) and Blanding's Turtles (*Emydoidea blandingii*) but covered these nests with protective boxes or cages as part of the park's ongoing stewardship work (see Chapter 1). If I did not see a female nesting but suspected nest presence of a species other than Snapping Turtle, I carefully dug in to confirm egg presence prior to protecting. If I excavated a nest for any reason, it was protected regardless of species, thus Painted or Snapping Turtle nests were sometimes protected. See Chapters 1 and 3 for more details regarding turtle nest protection.

Previously located nests were checked as often as possible for signs of disturbance (for example partially or fully predated). Beginning early August, I checked nest boxes daily for hatchlings. In 2022, any boxes that remained when I left the park were removed by park staff prior to the winter. In 2023, I stayed into early October and eight marked Snapping Turtle nests were protected prior to departure. Three of these nests had not yet started hatching. Those nest boxes were removed 13 October 2023 due to park staff shortage and winter preparation. Six of these eight nests were located and excavated in 2024 (Taylor Hamel, pers. comm.). Two of the three nests that had not started hatching were found in 2024, and upon excavation many eggs appeared pipped, but no hatchlings were alive (Taylor Hamel, pers. comm.). While several hatchlings of the other four nests survived overwintering in their nest those that did appeared unlikely to exit the nest without human excavation and many were deformed and partially still within their eggshells (Taylor Hamel, pers. comm.). Each of these nests were in hard roadside gravel which may have influenced hatchling development or emergence.

Upon marking or protecting a nest, I recorded: year, month, day, time, species, coordinates, location description, marker or box/cage number, marker placement, weather, additional information, and crew. In 2023 I began regularly recording if I observed the nesting event (saw turtle (y/n)).

I recorded all observed predated nests. Upon finding a predated nest I recorded: year, month, day, time, species (if known), coordinates, location description, number of eggs found, marker or box number (unlikely to be a previously protected nest), weather, additional information, suspected predator (if known), and crew. In 2023 I regularly recorded substrate type for marked and predated nests.

Data Analyses.— I used Google Earth Pro 7.3.6.9796 (64-bit) and ArcGIS online to create maps showing where I conducted predator surveys and predator observation locations, as well as marked and predated nests. I used statistical software R version 4.2.2 along with RStudio version 2023.12.0+369 to analyze data. I considered a P value of < 0.05 significant. I compared Raccoon observations to those from Browne (2003) as well as 2022 with 2023 using the Fisher's exact test. I also compared nest predation from Browne (2003), Phillips (2008), 2022, and 2023 using the Fisher's exact test.

RESULTS

Predator Surveys.— During 2022 driving surveys, I observed a total of 152 potential predators (72 Raccoons, 34 domestic cats, 17 Opossums (*Didelphis virginiana*), 4 Skunks, 2 dogs, 1 Mink, 22 unknowns). In 2023, a total of 52 observations of potential predators were made (21 cats, 9 Raccoons, 9 Opossums, 4 Skunks, 1 Mink, 1 Ermine (*Mustela erminea*), and 7 unknowns; Fig. 2.2).

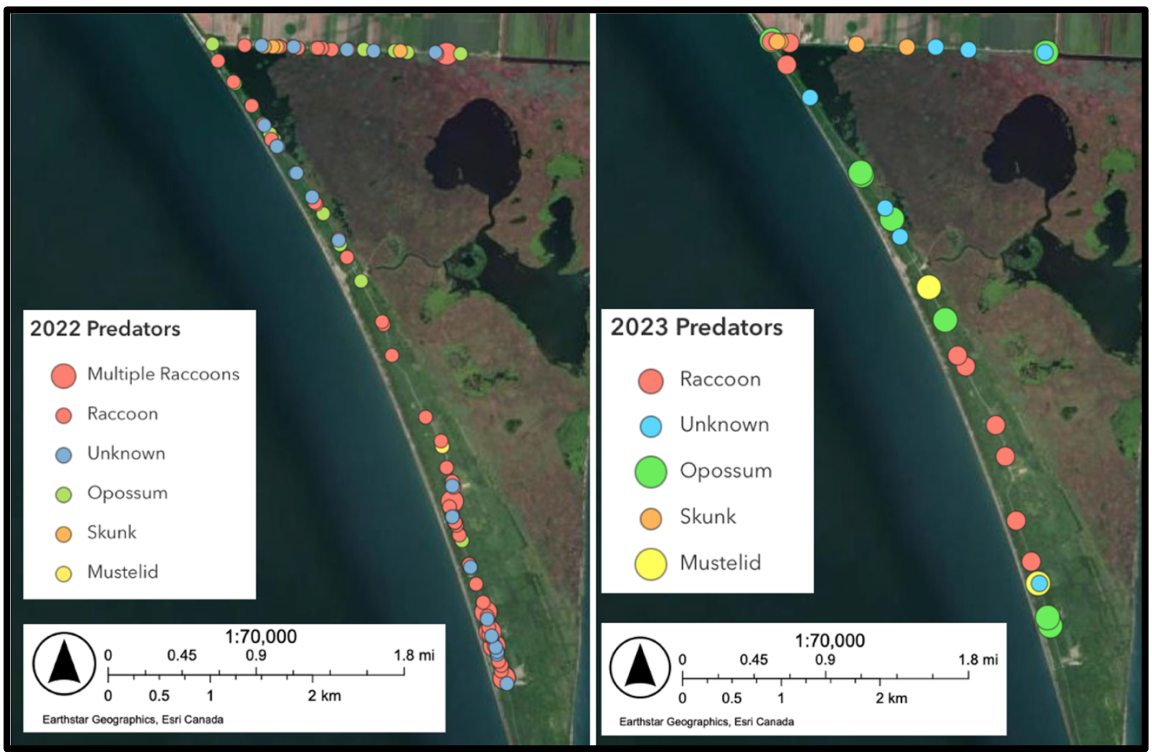

FIGURE 2.2. Predator locations in 2022 and 2023. While this shows consistent predator observations throughout our routes there is a noticeable increase in 2022 Raccoon observations in the area surrounding Camp Henry (bend in the road through to the Visitor Centre). Mink and Ermine were lumped for mustelids. Not included here are observations without coordinates (May 4 2022: 4 Raccoons, 1 Opossum; May 11 2022: 1 unknown), cats, and dogs. Multiple Raccoons can refer to 2-4 Raccoons. 2022 observations included: 47 Raccoon, 7 multiple Raccoons, 21 unknown, 16 Opossum, 4 Skunk, and 1 mustelid. 2023 observations include: 9 Raccoon, 9 Opossum, 7 unknown, 4 Skunk, and 2 mustelids. Because of the lower number of predators observed in 2023 each individual observation is visible on the map. Both maps were created with ArcGIS Online using the Imagery map.

In 2022, a total of 30 observations were made on Mersea Rd. E (13 Raccoons, 8 Opossums, 4 Skunks, and 5 unknown). A total of 86 observations were made in the park (59 Raccoons, 9 Opossums, 1 Mink, and 17 unknown). In 2023 a total of 12 observations were made on Mersea Rd. E (4 Skunks, 3 Opossums, 2 Raccoons, and 3 unknown). A total of 19 observations were made in the park (7 Raccoons, 6 Opossums, 1 Mink, 1 Ermine, and 4 unknown). These do not include observations of cats (2022: 29 on Mersea Rd. E, 5 in the park; 2023: 18 on Mersea Rd. E, 3 in the park) or dogs (2022: 2 on Mersea Rd. E). The unknown predators in 2022 and 2023 were likely Raccoon or Opossum. In 2022, predator observations per km had increased in the park and on Mersea Rd. E since Browne (2003) (Table 2.1).

I used total km driven and Raccoon observations in PPNP and compared each study period using the Fisher's exact test. I did not observe significantly more Raccoons in PPNP in 2022 than in 2001–2002 ($P = 0.5331$). Significantly more Raccoons were observed in PPNP in 2001–2002 ($P < 0.001$) and 2022 ($P < 0.001$) than in 2023 (Table 2.1).

TABLE 2.1. Raccoons and total predators in 2001–2002, 2022, and 2023. Total predators included Raccoons, Opossums, Skunks, mustelids, and unknowns. Unknown were likely Raccoons or Opossums.

Time period	Location	Total km driven	Raccoons	Raccoons/ km	Total predators	Total predators/km
2001-2002	PPNP	126	28	0.222	38	0.302
2022	PPNP	224	59	0.263	86	0.384
2023	PPNP	168	7	0.042	19	0.113
2001-2002	Mersea Rd. E	54	7	0.13	7	0.13

2022	Mersea Rd. E	96	13	0.135	30	0.313
2023	Mersea Rd. E	72	2	0.028	12	0.167

I observed fewer Raccoons/km in PPNP and along Mersea Rd. E in 2023 than 2001–2002 and 2022. This likely resulted from a distemper outbreak in PPNP that began in 2022 and led to the euthanasia of 20 Raccoons between August 2022 and February 2023 (Parks Canada Agency unpubl. data).

Turtle nests.— A total of 45 potential nests of three species (Snapping, Painted, and Blanding's Turtles) were marked/protected 6 June – 29 July 2022. A total of 99 potential nests of 4 species (Snapping, Painted, Blanding's, and Map Turtles) were marked/protected 1 June – 7 July 2023. Seventy Snapping (20 in 2022 and 50 in 2023) and 12 Painted Turtle nests (9 in 2022 and 3 in 2023) were marked and left unprotected to examine predation rates in 2022–2023. I recorded whether the nesting event was observed for 64 Snapping and 8 Painted Turtle nests (Table 2.2).

Table 2.2. Predation rates of nests separated into nesting event observed and not observed (P = predated, NP = not predated, PR = predation rate).

Species and year	Observed nesting			Not observed nesting			Not recorded		
	P	NP	PR	P	NP	PR	P	NP	PR
SNTU 2022	3	0	100%	7	5	58%	2	3	40%
SNTU 2023	10	5	67%	13	21	38%	0	1	0%
MPTU 2022	2	3	40%	0	0	n/a	2	2	50%
MPTU 2023	0	3	0%	0	0	n/a	0	0	n/a

I protected eight Blanding's Turtle nests (remainder of sentence removed). I found 313 predated nests (135 in 2022 and 178 in 2023). This consisted of 166 SNTU, 141 unknown, 5 MPTU, and 1 BLTU nests. (Sentence removed) (Fig. 2.3). A predated nest was found in the side of a likely swan nest constructed along the edge of Round Pond in the marsh.

(FIGURE 2.3 and caption removed).

Predator observations and turtle nests.— To compare predation rates relative to Raccoon observations, I combined data for PPNP and Mersea Rd. E. In 2022, I observed 72 Raccoons across 320 km and in 2023 I observed 9 Raccoons across 240 km. I multiplied 2022 Raccoon observations and km driven by 0.75 (i.e., 240 km/ 320 km) to make the km driven the same for each year and therefore used 54 Raccoon observations (72 x 0.75) across 240 km for 2023.

For Snapping Turtles, this gave me 54 Raccoon observations and a nest predation value of 60 in 2022 and 9 Raccoon observations with a nest predation value of 46 in 2023. The Fisher's exact test was significant ($P < 0.001$). This suggests the 2023 Snapping Turtle nest predation rate was significantly higher than expected and the significant drop in Raccoons did not significantly reduce the Snapping Turtle nest predation rate.

For 2022 Painted Turtles I used 54 Raccoon observations with a nest predation value of 44 and in 2023 had 9 Raccoon observations along with a nest predation value of 0. The Fisher's exact test was significant ($P = 0.0099$), suggesting the 2023 Painted Turtle nest predation rate was significantly lower than expected and the significant drop in Raccoons significantly reduced the Painted Turtle nest predation rate. Both total predator and

Raccoon observations decreased markedly in 2023, coinciding with reduced nest predation rates (Table 2.3).

TABLE 2.3. 2022–2023 marked nests and predation rates for Painted (MPTU) and Snapping Turtles (SNTU) along with Raccoons/km.

Year	SNTU nests	MPTU nests	SNTU predation rate	MPTU predation rate	Raccoons/ km	Predated nests
2022	20	9	60%	44.4%	0.263	135
2023	50	3	46%	0%	0.042	178

Using my park wide annual nest estimate for Snapping Turtles (all Snapping Turtle nests in the park), I then compared park wide predated nests from 2022 and 2023. Based on my population size estimates along with clutch frequency of each species I estimated 382 nests in the park annually for Snapping Turtles (See Chapter 1 results). Using my predation rates, I can estimate park wide predated Snapping Turtle nests of 229 in 2022 and 176 in 2023. This would suggest significantly more nests were predated park wide in 2022 than 2023 ($P = 0.036$).

I then compared data from Browne (2003), Phillips (2008), and 2022 with 2023 using marked and predated nests. There was significantly higher predation of Snapping Turtle nests during the Phillips (2008) study (Table 2.4).

TABLE 2.4. Marked and predated nests from Browne (2003), Phillips (2008), 2022, and 2023. The blue shaded cell indicates significance.

Time period	SNTU marked	SNTU predated	Fisher's exact test *P* value compared to 2023	MPTU marked	MPTU predated	Fisher's exact test *P* value compared to 2023
Browne (2003)	35	24	0.281	15	11	0.269
Phillips (2008)	198	166	0.028	94	54	0.553

2022	20	12	0.654	9	4	0.529
2023	50	23	n/a	3	0	n/a

DISCUSSION

More Raccoons were observed in 2001-2002 and 2022 than in 2023. Raccoon observations increased from 0.22/km to 0.26/km when comparing Browne (2003) to 2022, suggesting increased Raccoon abundance. However, numbers fell markedly in 2023 (0.04/km). The decrease in Raccoon observations was likely caused by a distemper outbreak that began in 2022. Twenty Raccoons were euthanized from August 2022 to February 2023 (Parks Canada Agency unpubl. data) and many more would have died without detection. I observed several deceased Raccoons in areas unfrequented by humans in the spring of 2023. Prior to the euthanasia of these 20 Raccoons in a 7-month span, a Raccoon from the park had not been euthanized because of distemper since May 2019 (Parks Canada Agency unpubl. data.). Animals infected with distemper can act as a vector for up to 90 days following infection and even when signs are not visible (Government of Ontario 2023).

In addition to reduced Raccoons per km in 2023, I found nest predation rates of Painted and Snapping Turtles dropped. In 2022, I found predation rates of Painted and Snapping Turtle nests of 44% (4/9) and 60% (12/20), respectively, while in 2023 the values dropped to 0% (0/3) for Painted Turtles and 46% (23/50) for Snapping Turtles. When considering only marked nests, predation rate in 2023 was significantly lower for Painted Turtles but not Snapping Turtles. When considering park wide nests, the Fisher's exact test indicates a significant decrease in predated Snapping Turtle nests. However, when considering only marked and predated nests, there was only a significant decrease when comparing Snapping Turtle nests of Phillips (2008) with 2023. Although I did observe more predated nests in 2023, this was likely due to increased search effort and familiarity with the park.

Previous studies have found very high nest predation rates in PPNP. Kraus (1991) found very high nest predation on East Beach with a total 84 predated and 3 intact nests recorded. Most predated nests were recorded between the Shuster Trail exit and the north end of Redhead Pond and Kraus (1991) stated that predation rates along East Beach could be as high as 80%. This is also the area where I found the most predated nests (Fig. 2.3). Whitehead (1997) found 242 nests in the park, 87% of which were predated. In 2002 Browne (2003) examined predation rates using 15 Painted and 35 Snapping Turtle nests. Seventy-three percent (11/15) of Painted Turtle nests and 69% (24/35) of Snapping Turtle nests were predated (Browne 2003). Phillips (2008) found predation rates of 57% (54 of 94 predated) and 84% (166 of 198 predated) for Painted and Snapping Turtles respectively. Nest predation rates were higher for both species in disturbed habitat (west side of park and Mersea Rd. E) than in undisturbed habitat (East Beach)(Painted: 78% vs 53%; Snapping: 98% vs 66%)(Phillips 2008). Phillips (2008) found Raccoon density was higher in the disturbed habitat of the park. Phillips (2008) suggested nest predation was largely opportunistic and not dependent on nest density; however with higher predator densities, each nest is more likely to be located.

Previous studies have suggested Raccoons are the main predator of turtle nests in the park (Kraus 1991; Whitehead 1997; Browne 2003; Browne and Hecnar 2007; Phillips 2008). While generally considered nest predators, Raccoons will also prey upon adult turtles (Karson et al. 2018). Karson et al. (2018) found 19 individuals predated (in

Rondeau Provincial Park, Chatham-Kent County, Ontario, Canada; all mature females) of three species (1 Blanding's, 8 Northern Map, and 10 Snapping Turtles) and suggested that Raccoons were the most likely predator. A PPNP park visitor found an adult female Painted Turtle in 2023 with all four limbs bitten as well as a small portion of the tail removed, and this individual was deceased upon arrival to the Ontario Turtle Conservation Centre (OTCC) (Taylor Hamel, pers. comm.; Melanie Lefaive, pers. comm.). This was likely the result of a Raccoon attack.

Christiansen and Gallaway (1984) found Raccoon removal reduced nest predation as well as hatchling predation during natal dispersal (in Big Sand Mound, Iowa, USA). Kuhns (2010) conducted a nest predation study in Spring Bluff Nature Preserve, in Illinois, USA (makes up a portion of the study area of Urbanek et al. 2016 below) using artificial nests. Nests were placed in a known Blanding's Turtle nesting area and 21 of 25 nests were fully predated along with one partially predated (21.5/25 = 86%) (Kuhns 2010). Urbanek et al. (2016) found evidence to support that Raccoon removal can reduce turtle nest predation rates, particularly of Blanding's Turtles. Urbanek et al. (2016) studied Blanding's Turtle nest predation near Lake Michigan around the Illinois-Wisconsin border; this area had a 92% (12/13) predation rate of documented unprotected Blanding's nests before Raccoon removal. Raccoons were removed in April-May 2013 and 2014 (~83 – 89% of the population) (Urbanek *et al.* 2016). Urbanek *et al*. (2016) reported Blanding's Turtle nest predation rates of 14% (1/7 partially predated; none fully) in 2013 and 60% (9/15) in 2014.

However, a one-time Raccoon removal effort would not be a long-term solution to nest predation or Raccoon density, however, as within one to two years Raccoon population density can return to similar pre-reduction levels (Rosatte et al. 2007; Urbanek et al. 2016). Urbanek et al. (2016) removed Raccoons in 2013 and 2014 and despite removing an estimated 83% of the population in 2013, the pre-removal density estimate was just 37.5% less in 2014 than 2013. Urbanek et al. (2016) suggested Raccoon removal would be required before each nesting season to replicate year after year success observed in their study.

CONCLUSIONS

Raccoons pose a significant threat to turtle populations (Christiansen and Gallaway 1984; Standing et al. 2000; Engeman et al. 2005; Kuhns 2010; Urbanek et al. 2016). Nest protection can help prevent nest predation by Raccoons. Standing et al. (2000) found that nest protection was successful in mitigating Blanding's Turtle nest predation in Kejimkujik National Park, NS. Only one of eight protected Blanding's nests (12.5%) were predated (by a mole) in my study and no protected nests were predated by Raccoons. My study suggests that turtle populations can benefit from distemper outbreaks in Raccoon populations via lowered nest predation rates. However, allowing the overabundance of Raccoons knowing they are threatening turtle populations while also aware the overabundance is putting them at higher risk of disease outbreak, seems unethical. Phillips and Murray (2005; cited in Browne and Hecnar 2007) reported that PPNP Raccoon density was four times higher than the rural Ontario average. In a journal article about range expansion of Raccoons, Larivière (2004) cited Seton (1909) when stating "at the turn of the nineteenth century, the northernmost boundary of their distribution was somewhere near the Canada-United States border, and Raccoons occurred infrequently in Canada". Managing Raccoon populations and lowering their numbers closer to historical levels could help reduce unnaturally high turtle nest predation, while also reducing disease outbreak and suffering for Raccoons.

CHAPTER 3.— POPULATION MODELS: NEST PROTECTION AND ROAD MORTALITY CAN HAVE PROFOUND EFFECTS ON THE TRAJECTORY OF TURTLE POPULATIONS IN POINT PELEE NATIONAL PARK

INTRODUCTION

Anthropogenic threats can profoundly impact turtle populations, as many are unable to persist with even a small, sustained adult mortality increase of ~3% (Brooks et al. 1991; Congdon et al. 1994; Gibbs and Shriver 2002; Enneson and Litzgus 2008; Howell and Seigel 2019). Road mortality and nest predation are two of the main threats to Point Pelee National Park (PPNP) turtle populations. Browne and Hecnar (2007) suggested heavy nest predation by Raccoons in PPNP was limiting juvenile recruitment in Blanding's (*Emydoidea blandingii*) and Snapping Turtle (*Chelydra serpentina*) populations, causing a shift in size structures.

Raccoons are the main turtle nest predator in PPNP (Kraus 1991; Whitehead 1997; Browne 2003; Browne and Hecnar 2007; Phillips 2008). Phillips (2008) found nest predation rates of 57% (54 of 94 predated; 53% in undisturbed and 78% in disturbed habitat) for Painted Turtles (*Chrysemys picta*) and 84% (166 of 198 predated; 66% in undisturbed and 98% in disturbed habitat) for Snapping Turtles in PPNP. In 2001, Browne (2003) started a turtle nest protection program to help mitigate the effect of nest predation in PPNP. Browne (2003) created population trajectory models using RAMAS EcoLab to project the possibel effects of road mortality, nest predation, and nest protection on the PPNP turtle populations. Those population models suggested that, while low nest success was the most serious threat to PPNP turtle populations, road mortality could cause population declines in some species (Browne 2003).

The negative effects of roads on turtle populations is well documented (Ashley and Robinson 1996; Gibbs and Shriver 2002; Ashley et al. 2007; Langen et al. 2012; Seburn and McCurdy-Adams 2019). Road mortality is not always accidental, as Ashley et al. (2007) found 1.8% of drivers would intentionally target a turtle on a road. Aside from protected areas and large waterbodies, there is no place in southern Ontario further than 1.5 km from a road (Gunson et al. 2012). Generally reproductive output increases with age for most turtle species (Congdon and Gibbons 1985; Congdon et al. 2001; Iverson et al. 2019), meaning road mortality can cause the loss of individuals during the years of highest reproductive output (Gibbs and Steen 2005) along with hatchlings during natal dispersal (Parks Canada Agency unpubl. data). My data suggests road mortality in PPNP appears to impact hatchlings during natal dispersal more heavily than adult turtles.

My goal was to use life history data of Blanding's, Painted, and Snapping Turtles reported in the literature, along with data from previous PPNP studies and my data, to provide an update on the status of PPNP turtle populations as well as their trajectories. Specific objectives included constructing models to determine the effects of road mortality and nest predation as well as how nest success, hatching success, and nest protection may affect the persistence of PPNP turtle populations.

METHODS

Study area.— PPNP (41.9628°N, -82.5184°W) in Essex County, Ontario is the southernmost portion of Canada's mainland. PPNP is a heavily visited national park that averaged 335,897 visitors annually (range 197,204 – 565,236) from 1991–2023 (Parks Canada Agency unpubl. data). There is one main road (Point Pelee Drive) in PPNP which runs along the west side of the park and is near all five main habitats in PPNP (beach, dry forest, marsh, savannah, and swamp forest; Parks Canada 2023b). This road is often busy with traffic that can threaten turtles, especially nesting females and hatchlings during natal dispersal. The PPNP marsh is an internationally recognized Ramsar site (meaning it is a wetland of international importance) and covers approximately 70% of the park (Parks Canada 2023b). Located within the Carolinian Zone, PPNP is the most ecologically diverse national park in Canada and historically had the greatest freshwater turtle diversity in Canada (Browne and Hecnar 2002; COSEWIC 2015; Parks Canada 2023a; Fig. 3.1).

FIGURE 3.1. Map of disturbed (salmon line) and undisturbed (green line) turtle nesting habitat from Phillips (2008). The salmon line follows the main road in PPNP and Mersea Rd. E along the north boundary. The green line is along East Beach. I used August 2014 imagery in Google Earth Pro (adapted from Fig. 1 in Phillips 2008).

Turtle nests.— Protected nests were covered with protective boxes or cages. A protective nest box was ~ 61 cm x 61 cm x 9 cm high and placed over top of a nest while a nest cage (range from ~ 35.5 x 35.5 cm to ~ 50.8 x 50.8 cm) can be placed over top or require excavation as it can encompass the entirety of the nest. Nest boxes were constructed primarily of ~ 3.8 x 9 cm "2x4" lumber and ~0.64 cm galvanized steel mesh. Some boxes had ~1.3 cm mesh for the top barrier. Nest cages are constructed primarily of metal mesh and held together using cable ties.

Nest boxes were held in place using pegs pushed into the ground through the metal mesh skirt that surrounds the wooden box and by placing bricks on the corners to prevent predators from lifting the boxes. I moved nests that were at risk of being washed out. If a nest was found in an area that I could not guarantee it could be checked daily it was moved or protected with a nest box equipped with hatchling escape doors (2.54 cm tall x 5.08 cm wide on each side).

Refer to Chapter 1 and 2 for additional information regarding predator surveys, nest predation data, the nest protection program 2001–2021, and nest protection photos.

Road Mortality surveys.— All observed incidents of turtle road mortality were recorded. I recorded year, month, day, time, species, GPS coordinates, sex, location description, direction facing, weather, and crew, as well as any relevant additional information. In 2023, I began regularly recording the side of the road on which the injured or dead animal was observed. After an individual was recorded, they were placed off the road among roadside vegetation to ensure they were not double counted.

Data Analyses.— I used ArcGIS Online and Google Earth Pro 7.3.6.9796 (64-bit) to create maps showing locations of road mortality and of nests protected since 2001. I used RAMAS EcoLab 2.0 along with life history data from the literature and my data to create population trajectory models. For each model I used 50 time steps, 1000 replications, demographic stochasticity, and did not ignore constraints or include standard deviations for fecundity and survivorship values. I provided the population trajectory summary for each model. To ensure replicability I provided input parameters showing all decimal places, regardless of length. I incorporated road mortality using the harvest/emigration management action. I incorporated nest protection and/or predation in nest success to calculate survival at age zero.

RESULTS

Turtle nests.— I found and protected four unknown nests (2 in 2022 and 2 in 2023). The fate of one remains unknown as the box was removed in 2022 prior to hatching. The other unknown nest in 2022 was found open but not excavated by a predator. It appeared that an individual had constructed a nest cavity and laid eggs, but did not fill it in. It was as if the female had walked away or been removed by a human or predator during or immediately following oviposition. Upon hatching this nest was confirmed to be from a Painted Turtle, and the hatchlings included a hypo-melanistic individual (Taylor Hamel, pers. comm.). The two unknown nests from 2023 were likely Painted Turtle nests but the eggs did not survive. One was washed out along with the nest box, and in the other all eggs were unsuccessful after being laid in soggy sand; both had been protected because I did not observe the nesting event and upon discovery using tracks, I excavated each to confirm nest presence.

Not all hatchlings released from nest boxes or found on roads in 2022–2023 were processed and recorded. For example, 50 Blanding's hatchlings were added to the population from nest boxes, and I recorded standard measurements for 32. I recorded standard measurements for an additional four Blanding's hatchlings which were found on the road in 2023. I recorded data from 189 hatchlings (114 SNTU, 36 BLTU, 33 MATU, 6 MPTU) from nest boxes, roads, or that were thought captured during natal dispersal before entering the water. These individuals were excluded from earlier analyses. Additional information about hatchlings from marked nests can be found in my marked nests data. (Sentence removed). I found five of the six Painted Turtle hatchlings on the west side of the park, with the sixth at East North Boundary. Forty of 114 Snapping Turtle hatchlings in my capture data were from marked nests with the remaining 74 found in various locations (See Appendix Fig. 3.19). I protected eight Blanding's Turtle nests in 2022–2023. (Remainder of paragraph along with TABLE 3.1 and caption removed).

A total of 882 nests (480 SNTU, 209 Map, 124 MPTU, 36 MUTU, and 33 BLTU) were protected in the park between 2001 and 2021 (Table 3.2). (Sentence removed).

TABLE 3.2. Protected nests 2001–2021. Protected nests lost before hatching are included. While not common, it does take place. Reasons protected nests do not make it to hatching include being poached by visitors, predated, box removed by visitors then predated, washed out by wave activity, and eggs being destroyed by roots (Table created using multiple nesting data files provided by PPNP; Browne 2003 unpubl. data; Hickson 2003; Huebert 2004, 2005, 2007, 2008, 2009; Hillier 2010, 2011; Watson and Degazio 2013; Parks Canada Agency unpubl. data. n.d.).

Year	**Species**					**Total**
	BLTU	**MATU**	**MPTU**	**MUTU**	**SNTU**	
2001	1	0	3	0	38	42
2002	2	18	16	3	43	82
2003	1	6	4	1	20	32
2004	5	21	0	14	0	40
2005	6	25	0	14	0	45
2006	6	36	15	2	40	99
2007	2	50	21	0	41	114
2008	5	46	27	0	54	132
2009	0	1	8	1	36	46
2010	0	0	1	0	17	18
2011	0	0	2	1	25	28
2012	0	5	2	0	11	18
2013	0	0	4	0	18	22
2014	0	1	3	0	26	30
2015	1	0	0	0	9	10
2016	1	0	1	0	8	10
2017	0	0	1	0	13	14
2018	0	0	0	0	20	20
2019	1	0	0	0	7	8
2020	1	0	6	0	19	26
2021	1	0	10	0	35	46
Total	33	209	124	36	480	882

Road mortality surveys.— I observed 211 turtles dead on roads in the park and on Mersea Rd. E in 2022-2023. In 2022 a total of 98 turtles of three species were observed dead on roads: 78 Snapping (77 hatchlings, 1 not recorded), 18 Painted (16 hatchlings, 2 adults), and 2 Northern Map (1 hatchling, 1 adult). In 2023 a total of 113 turtles of four species were observed dead on roads: 81 Snapping Turtle hatchlings, 24 Painted Turtles (21 hatchlings, 3 adults), 7 Blanding's Turtle hatchlings, and 1 adult Northern Map Turtle (Table 3.3 and Fig. 3.2).

TABLE 3.3. Turtles recorded dead on roads in the park and on Mersea Rd. E in 2022–2023. This does not include additional species recorded such as Eastern Foxsnakes (*Pantherus vulpinus*), or 2022–2023 road mortality recorded by Park staff. No juveniles of any turtle species were recorded dead on roads in PPNP or on Mersea Rd. E.

Species	2022		2023		Total
	Adult	Hatchling	Adult	Hatchling	
Snapping Turtle	0	78	0	81	159
Painted Turtle	2	16	3	21	42
Blanding's Turtle	0	0	0	7	7
Northern Map Turtle	1	1	1	0	3

(FIGURE 3.2 and caption removed).

Population models.—

Blanding's Turtles.—

BLTU Model 1.— Each time step in this model represents 1 year. I used data reported by Kraus (1991), Congdon et al. (1993, 2001, 2008), Whitehead (1997), Browne (2003), Herman et al. (2003), Kuhns (2010), Gillingwater unpubl. data (from COSEWIC 2016), and Parks Canada Agency unpubl. data, as well as my data to build the model. Life stages were broken into 14 stages: (1) Hatchlings 0-1, (2) juveniles age 1-6, (3) juveniles age 7-12, (4) juveniles/young adults age 13-18, (5) young adults age 19-24, (6) young adults age 25-30, (7) adults age 31-36, (8) adults age 37-42, (9) adults age 43-48, (10) adults age 49-54, (11) adults age 55-60, (12) adults age 61-66, (13) adults age 67-72, (14) adults age 73+. These life stages were meant to best fit varying survival of each age, and female age of maturity as well as clutch size and frequencies at different ages while also including a hatchling category and one year time steps. Congdon et al. (2001) reported 17.5 (range 14-20) years for the average age of maturity of Blanding's Turtles in Edwin S. George Reserve in Michigan. Herman et al. (2003) reported the Blanding's Turtles of Nova Scotia delay maturity until age 20-25. I began incorporating fecundity in stage 5 (young adults ages 19-24).

Browne (2003) estimated population size to be 642 but suggested this was likely an overestimate because it was based on population estimates of North and South DeLaurier (appeared to be "hotspots") and suggested 160 was more accurate. CPUE for Blanding's Turtles captured in hoop traps in 2001–2002 was 0.012 and in 2022–2023 was 0.008. Therefore I used a population size of 107 ([0.008/0.012] x 160). I captured 26 females and 19 males (58% females). I also captured 7 juveniles, but it is presumed they will follow this same sex ratio. Females in the population were calculated to be 62 (0.58 x 107). Using 48% for clutch frequency (Congdon et al. 2001) there would be 30 clutches/year in the park.

I protected 4 Blanding's Turtle nests in each of the 2022 and 2023 field seasons meaning 13% of the Blanding's Turtle nests in the park were protected each year. I also considered that one 2022–2023 protected Blanding's nest was predated. This means that in 2022–2023 combined I successfully protected 12% (7 of 60) of the Blanding's nests in the park.

Of non-Snapping Turtle nests, Krause (1991) found a predation rate of 83.33% in two sample plots combined (5 of 6 predated). Whitehead (1997) categorized four non-Snapping Turtle nests as "observed" meaning they were discovered because of direct observation or evidence of the nesting female; all 4 of these nests were predated for a 100% predation rate. Kuhns (2010) conducted a nest predation study in Spring Bluff Nature Preserve using artificial nests. Nests were placed in a known Blanding's Turtle nesting area resulting in 21 of 25 nests fully predated and another partially (21.5/25 = 86%) (Kuhns 2010). I combined Kraus (1991) and Whitehead (1997) (9/10 = 90%), then used the midpoint compared with Kuhns (2010) (88%), which is a nest success of 12%. Therefore, incorporating realistic nest protection, I calculated nest success as 0.221 ((nest success [0.12] x proportion of nests unprotected [0.867]) + proportion of nests successfully protected [0.117]). In the seven successfully protected Blanding's Turtle nests, 50 hatchlings of 74 eggs (68%) were successfully released. Survival at age 0 (stage 1) was calculated to be 0.1493297 (hatching success [0.6757] x nest success [0.221]).

I used 78.26% for survival at ages 1-13 (Congdon et al. 1993). Congdon et al. (1993) reported survival of ages 14+ to be 96%. Congdon et al. (2008) reported adult survival exceeds 94%. I used the midpoint of 95% for survival of ages 14+ (Congdon et al. 1993, 2008). Therefore, survival per year at stage 4 (ages 13–18) was calculated to be (0.7826 + (0.95 x 5))/6 = 0.9221.

I calculated the proportion of individuals growing into the next stage each year for stages 2 (ages 1–6) and 3 (ages 7–12) as 0.7826/6 = 0.1304 and the proportion of individuals remaining was calculated as 0.7826 – 0.1304 = 0.6522. For stage 4 (ages 13–18) the proportion of individuals growing into the next stage each year was calculated as 0.9221/6 = 0.1537 and the proportion of individuals remaining was calculated as 0.9221 – 0.1537 = 0.7684. For each of stages 5-13 (ages 19–72) the proportion of individuals growing into the next stage each year was calculated as 0.95/6 = 0.1583 and the proportion of individuals remaining was calculated as 0.95 – 0.1583 = 0.7917. For stage 14 (ages 73+) the proportion of individuals remaining in that stage each year was entered as the survival (0.95).

For adults aged 21-48, I used 9.85 as clutch size and for adults aged 49+ I used 10.9 (Congdon et al. 2001). I used 0.46 for clutch frequency of adults aged 21-48 and 0.58 for adults aged 49+ (Congdon et al. 2001). Fecundity for stages 5-9 (ages 19–48) was calculated as 9.85 (clutch size) x 0.46 (clutch frequency) x 0.58 (proportion of female) = 2.63. Fecundity for stages 10-14 (ages 49+) was calculated as 10.9 x 0.58 x 0.58 = 3.67.

At five years of age, Blanding's Turtles will be ~100 mm (Gillingwater unpubl. data cited in COSEWIC 2016). My 2022–2023 Blanding's Turtle captures not including hatchlings from nests or roads began at 111 MCL (mm). Therefore, I placed this individual in stage 2 using my size distribution of all Blanding's Turtle captures (see Chapter 1, Fig. 1.11 and 1.12) determined the number of individuals in each stage. Using the population size estimate of 107 along with the number of individuals I captured (52), I multiplied each stage by 2.06 (107/52). Therefore, for each stage I multiplied the number of individuals by 2.06 and rounded to the nearest whole number. This gave me 2 Blanding's Turtle individuals in stage 2, 14 in stage 3, 0 in stage 4, 8 in stage 5, 6 in stage 6, 21 in stage 7, 14 in stage 8, 21 in stage 9, 14 in stage 10, 6 in stage 11, and 0 in stage 12, 13, and 14. I added the 50 hatchlings that were successfully released in 2022-2023 to stage 1. I also accounted for the fecundity prior to running the model by multiplying the number of individuals by fecundity in each stage (8 x 2.63) + (6 x 2.63) + (21 x 2.63) + (14 x 2.63) + (21 x 2.63) + (14 x 3.67) + (6 x 3.67) = 258. Therefore, the individuals in stage 1 prior to running the model was 258 + 50 = 308. Population abundance at model beginning was 308+106 = 414.

I found 0 dead hatchlings on the park road in 2022 and 7 in 2023. Park staff found an additional 1 in 2023 (Parks Canada Agency unpubl. data). Between 2010 and 2021 there were 13 Blanding's Turtle hatchlings and 2 adults dead on roads. However, hatchlings are difficult to see, and I expect these would be more likely to be underrepresented in opportunistic data than adults. Therefore, I added harvest values of 8/2 = 4 (road killed hatchlings per year) in stage 1. I used 2/14 = 0.143 (road killed adults per year) for stage 5 (Fig. 3.3).

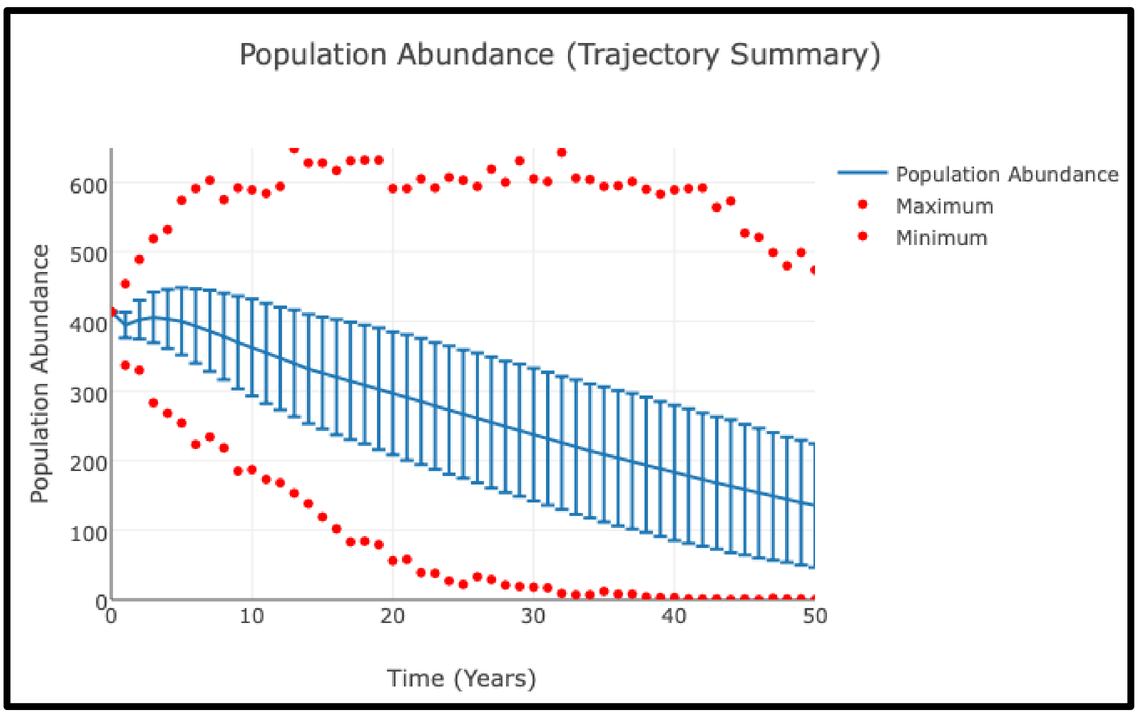

FIGURE 3.3. Each time step represents 1 year. Estimated population trajectory for Blanding's Turtle if 13.3% of nests are protected each year but one of those is lost to predation and unprotected nests have 12% success rate. Under this scenario the population appears to be in decline. In 50 years, the estimated abundance becomes 135 ± 89 (range 0-474) from 414. Applying that decline along with estimated population size of 107 (see Chapter 1 results) that would suggest 35 (135/414 x 107) individuals could remain in 50 years. That is a 67% decline. Applying that level of decline to the following 50 years would suggest ~12 (35 x 0.33) individuals could remain in 100 years.

BLTU Model 2.—I then explored changing survival in stage 1 that will need to take place to prevent the extirpation of Blanding's from PPNP. I used almost all the same parameters outlined in model 3. I changed the number of protected nests each year to 8 (8/30 = 0.267) or ~26.7%/year and did not account for any protected nest predation. This changed my nest success to 0.355 ([0.12 x 0.733] + 0.267). I then used hatching success of 78.43% used by Browne (2003). This gives me a survival in stage 1 of 0.27843 (0.7843 x 0.355). This not only stabilizes the population but also allows for it to begin slowly increasing, illustrating the importance of both hatching success and nest protection for the Blanding's Turtles of PPNP (Fig. 3.4).

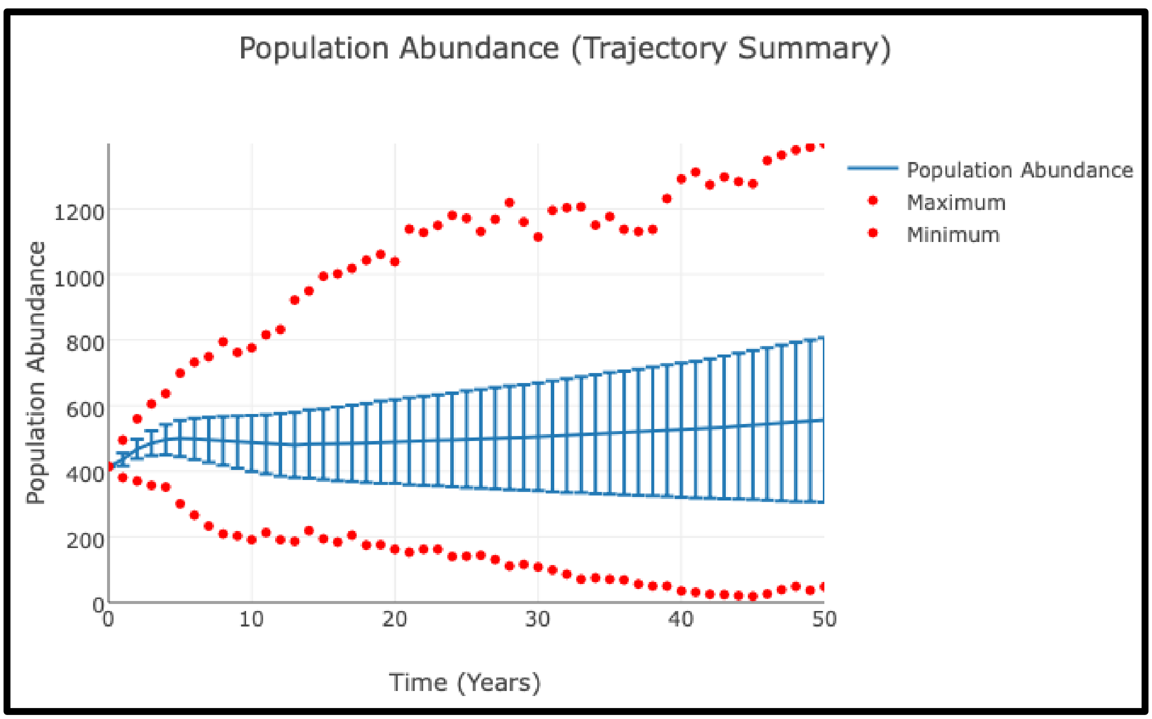

FIGURE 3.4. Each time step represents 1 year. Estimated population trajectory for Blanding's Turtle if 26.7% of nests are protected each year and unprotected nests have 12% success rate. I also increased hatching success from 0.6757 to 0.7843. Under this scenario the population appears to stabilize and begin slowly increasing. In 50 years, the estimated abundance becomes 556 ± 250 (range 48-1398) from 414. Applying that increase along with an estimated population size of 107 (see Chapter 1 results) would suggest 144 (556/414 x 107) individuals could be in PPNP in 50 years.

BLTU Model 3.— Using the parameters of model 3, I then explored the potential benefits of very high hatching success (91%) in protected nests (possibly achievable with artificial incubation; David Seburn, pers. comm.). I used a hatching success of 91% for protected nests and 67.57% for unprotected nests. I changed the number of protected nests each year to 10 (10/30 = 0.33) or 33% per year and did not include predation of protected nests. This changed survival in stage 1 to 0.35462628 ((0.12 [survival rate of unprotected nests] x 0.67 [proportion of nests left unprotected] x 0.6757 [hatching success of unprotected nests]) + (0.33 [proportion of nests protected] x 0.91 [hatching success of protected nests])). This illustrates the potential benefit of using artificial incubation in helping the Blanding's Turtle population to recover (Fig. 3.5).

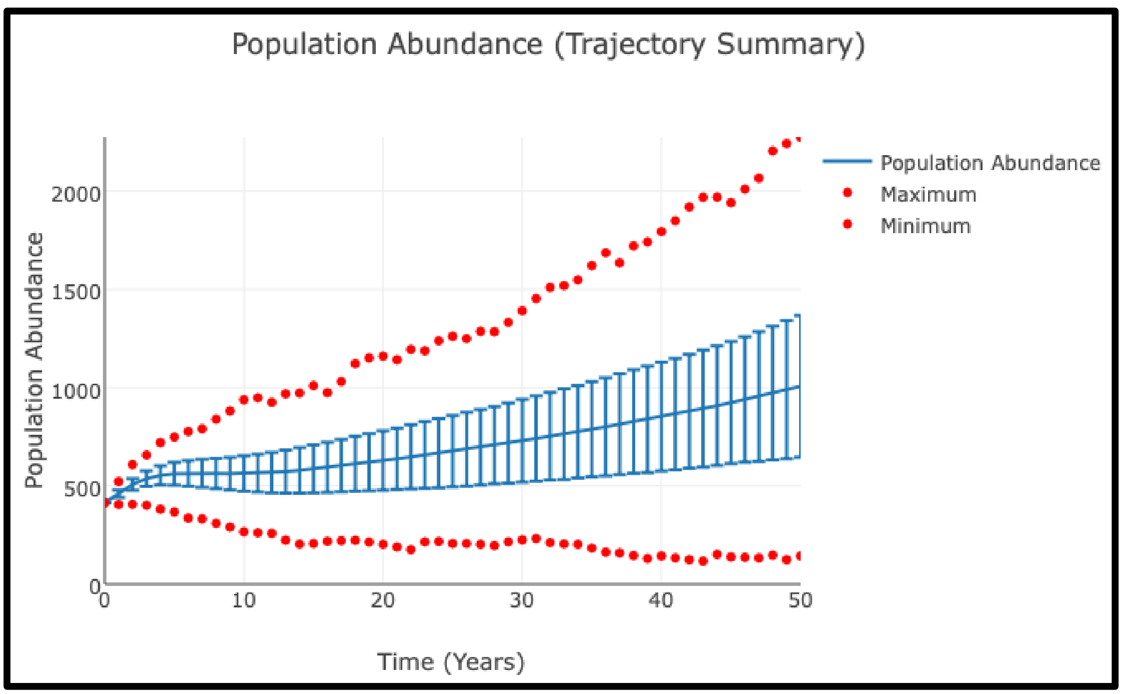

FIGURE 3.5. Each time step represents 1 year. Estimated population trajectory for Blanding's Turtle if 33.3% of nests are protected each year and unprotected nests have 12% success rate. I also made hatching success of protected nests 91% and unprotected 67.57%. Under this scenario the population appears to begin increasing. In 50 years, the estimated abundance becomes 1007 ± 361 (range 143–2274) from 414. Applying that increase along with estimated population size of 107 (see Chapter 1 results) would suggest 1007/414 x 107 = 260 individuals could be in PPNP in 50 years.

BLTU Model 4.— Using many of the same parameters as in model 3, I explored the effects of protecting one (3.3%) nest per year with an unprotected nest predation rate of 80%. I used the average of predation rates among non-Snapping Turtle nests from Kraus (1991) (83.33%), Whitehead (1997) (100%), Browne (2003) (73.33%), Phillips (2008) (57.4%), and Kuhns (2010) (86%) for an unprotected nest predation rate of 80%. One protected and not predated nest per year would give us a nest success of 0.2264 ((unprotected nest success [0.2] x proportion of nests left unprotected [0.967]) + proportion of nests protected [0.033]) and a survival in stage 1 of 0.6757 x 0.2264 = 0.15297848 (Fig. 3.6).

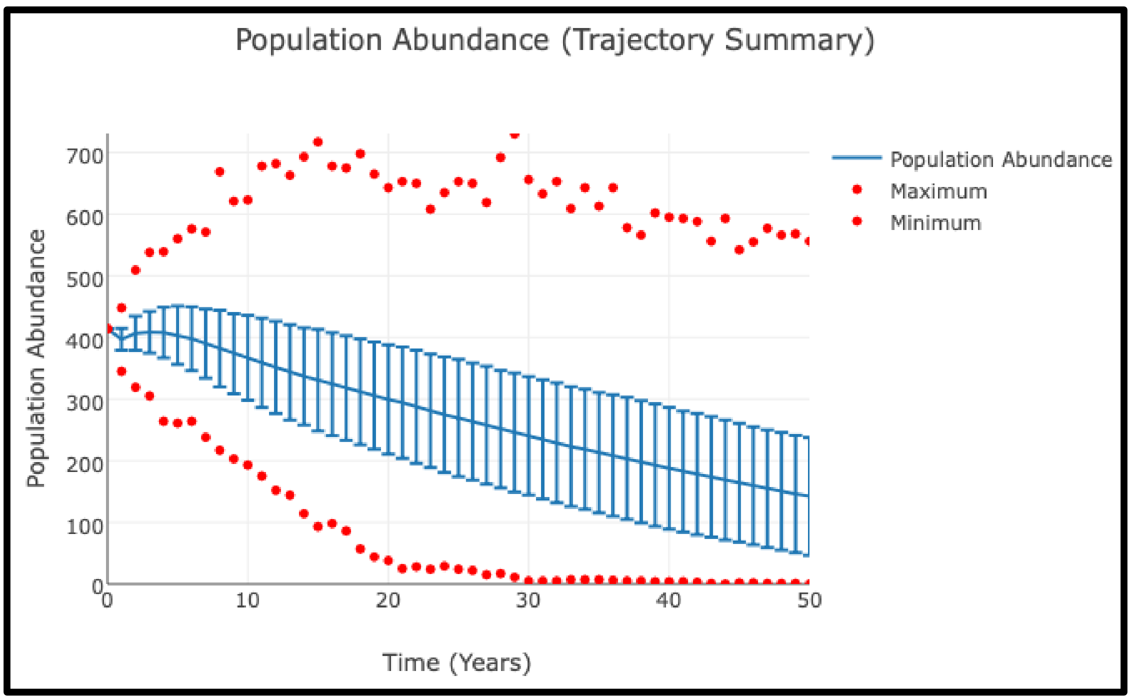

FIGURE 3.6. Each time step represents 1 year. Estimated population trajectory for Blanding's Turtle if 3.3% of nests are protected each year and unprotected nests have 20% success rate. I made hatching success 67.57%. Under this scenario the population will decline. In 50 years, the estimated abundance becomes 142 ± 96 (range 0-556) from 414. Applying that increase along with estimated population size of 107 (see Chapter 1 results) would suggest 142/414 x 107 = 37 individuals could remain in 50 years. Applying that level of decrease to 37 individuals suggests under this scenario ~13 individuals ([142/414] x 37) could remain in 100 years.

Painted Turtles.—

MPTU Model 1.— Each time step represents one year. I used life history data reported by Tinkle et al. (1981), Christens and Bider (1987), Mitchell (1988), Ron Brooks pers. comm. (from Browne 2003), Browne (2003), Samson (2003), Phillips (2008), Ernst and Lovich (2009), and Parks Canada Agency unpubl. data, as well as my data. Samson (2003) reported 14.2 for the average age of maturity of females and 8.3 for the average age of maturity for males. Browne (2003) considered age 8–15 young adults. I used 9 for age of maturity and separated life stages into 13 categories: (1) hatchlings 0-1 (2) juveniles age 1-4, (3) juveniles age 5-8, (4) young adults age 9-12, (5) young adults age 13-16, (6) adults age 17-20, (7) adults age 21-24, (8) adults age 25-28, (9) adults age 29-32, (10) adults age 33-36, (11) adults age 37-40, (12) adults age 41-44, (13) adults age 45+.

In 2002, 11 of 15 (73.33%) Painted Turtle nests were predated (Browne 2003). In 2004 and 2005, 57.4% of Painted Turtle nests were predated (Phillips 2008). Therefore, I used the average of these two values for a nest predation rate of 65.37%. Christens and Bider (1987) reported that in addition to predation, 25% of nests failed due to flooding and hatchlings failing to emerge when studying Midland Painted Turtles in southwestern Quebec. In 2022–2023, I found 2/16 (12.5%) Painted nests succumbed to flooding/wash-out. Therefore, I used 22.13% for average nest success (100 – nest predation rate [65.37] – flooding/wash-out rate [12.5]). I used 88% for hatching success (Tinkle et al. 1981; Browne 2003).

I calculated survival for age 0 (stage 1) to be 0.194744 (nest success [0.2213] x hatching success [0.88]). I used 45.7% for the survivorship of juveniles ages 1-5

(Mitchell 1988). Therefore, I used 0.457/4 = 0.11425 for the proportion of individuals entering the next stage each year for stage 2 (juveniles ages 1-4) and 0.457-0.11425 = 0.34275 for the proportion of individuals remaining each year.

Mitchell (1988) reported female adult survivorship as 96.3% and male adult survivorship as 95.6%. Browne (2003) used 98% for adult survivorship (cited Ron Brooks, pers. comm.; Samson 2003). I calculated survivorship to be 0.96975 (the average of survivorship in Mitchell (1988) and Samson (2003)) for ages 6 and up.

For stage 3 (juvenile ages 5-8) I used 0.457 + (0.96975 x 3)/4 = 0.8415625 for survivorship. Therefore 0.8415625/4 = 0.210390625 enter the next stage each year and 0.631171875 remain. For stage 4-13 (ages 9-45+) the proportion of individuals entering the next stage each year was calculated to be 0.96975/4 = 0.2424375 and remaining was calculated to be 0.96975 – 0.2424375 = 0.7273125.

I captured 479 males and 226 females (32% females) when considering all capture methods. I used 7.6 for clutch size (Ernst and Lovich 2009) and 0.93 for clutch frequency (Samson 2003). I calculated fecundity for each of stages 4-13 (ages 9 and up) to be 2.26 (proportion female [0.32] x clutch size [7.6] x clutch frequency [0.93]).

I divided the adult population size estimate of 6525 by 10 and placed 653 in each of stage 4-13. To calculate juvenile population size, I used my adult population size estimates and past protected nest numbers. An average 5.9 nests/year protected is 39.46 hatchlings (nests/year [5.9] x clutch size [7.6] x hatching success [0.88]) added to the population annually. I estimated that 1941.84 Painted Turtle nests are laid in the park each year using a clutch frequency of 0.93 and an estimated 2088 females (population size [6525] x proportion female [0.32]). Thus, an average 1935.94 nests per year would be unprotected. Using survival at age 0 of 0.194744 results in 2865.297 hatchlings (number of unprotected nests [1935.94] x clutch size [7.6] x survival at age 0 [0.194744]) from unprotected nests each year. That is a total of 2904.76 hatchlings each year (2865.297 + 39.46). For stage 1 (age 0-1) I also accounted for fecundity prior to running the model by multiplying the number of individuals in each stage by the fecundity value for that stage: (Individuals per adult stage [653] x fecundity value per adult stage [2.26]) x number of adult stages [10] = 14758. Therefore, the total individuals I placed in stage 1 (age 0-1) at model beginning was 17663 (hatchlings per year [2905] + prior accounting for fecundity [14758]). Using the Mitchell (1988) survivorship values used above, I included 2338 individuals in stage 2 (ages 1-4) and 221 in stage 3 (ages 5-8).

To incorporate realistic road mortality, I used adult road mortality data from 2019-2023 and 2022-2023 hatchling data. Forty adults or 8/year were recorded and 76 hatchlings were recorded for 38/year (includes Parks Canada Agency unpubl. data). Therefore, I included the removal of 38 individuals per year from stage 1 and 1 from each of stages 4-11 (Fig. 3.7).

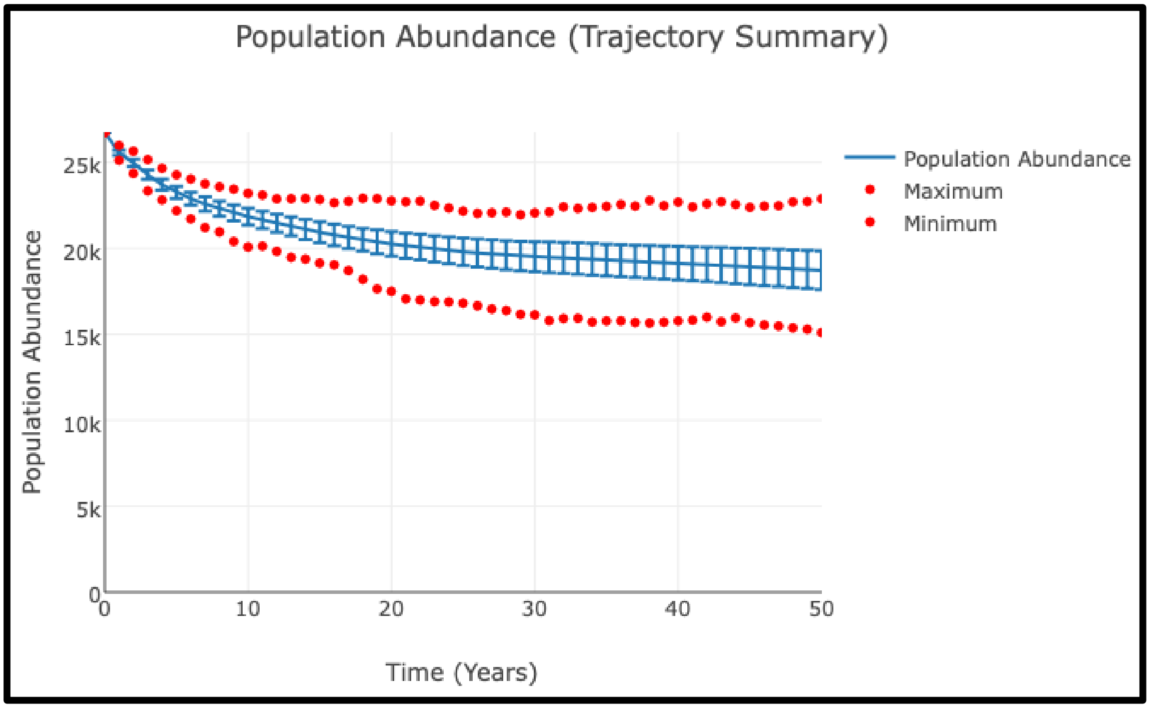

FIGURE 3.7. Each time step represents 1 year. Estimated population trajectory for Painted Turtle with no nest protection and realistic road mortality. Under this scenario the population appears to be in a slow decline.

MPTU Model 2.— I used the same parameters as model 1 except I incorporated nest protection. I used an estimated 1942 nests in the park each year. I targeted the protection of 2% of nests (n = 39). Therefore, incorporating realistic nest protection, I calculated nest success to be 0.236874 ((unprotected nest success [0.2213] x proportion of nests unprotected [0.98]) + proportion of nests protected [0.02]). Again using 88% for hatching success, I calculated survival at age 0 to be 0.236874 x 0.88 = 0.20844912 (Fig. 3.8).

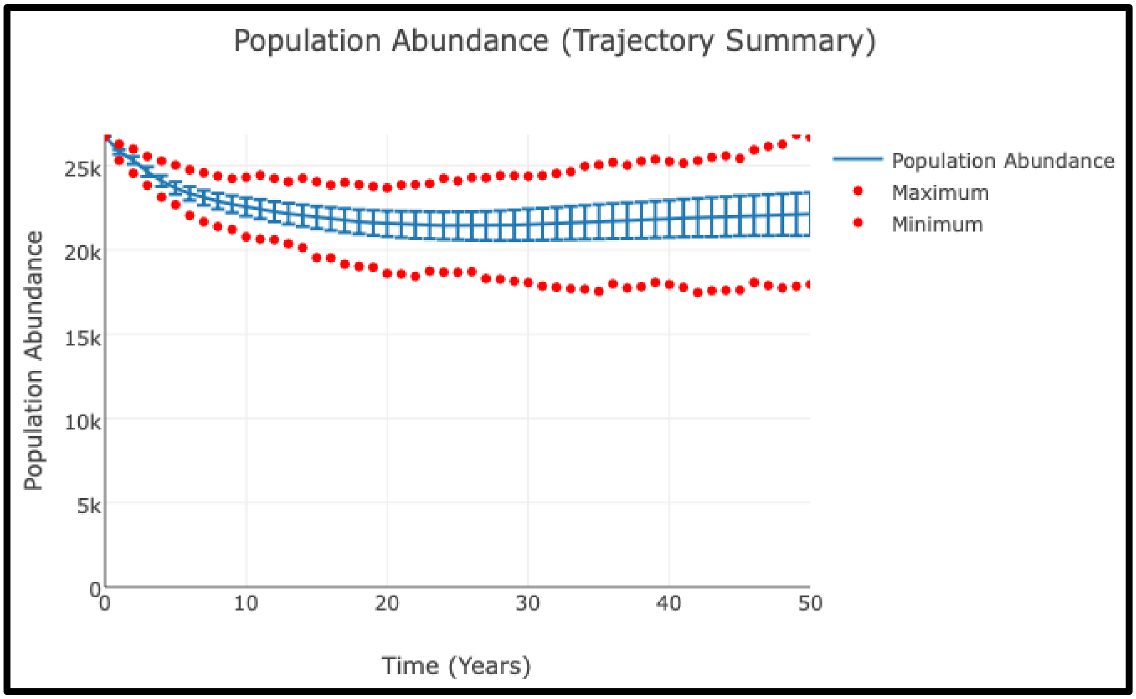

FIGURE 3.8. Each time step represents 1 year. Estimated population trajectory for Painted Turtle with 2% of nests protected and realistic road mortality. Under this scenario the population appears to stabilize and begin increasing slightly.

MPTU Model 3.— I used the same parameters as model 2 except removed road mortality (Fig. 3.9).

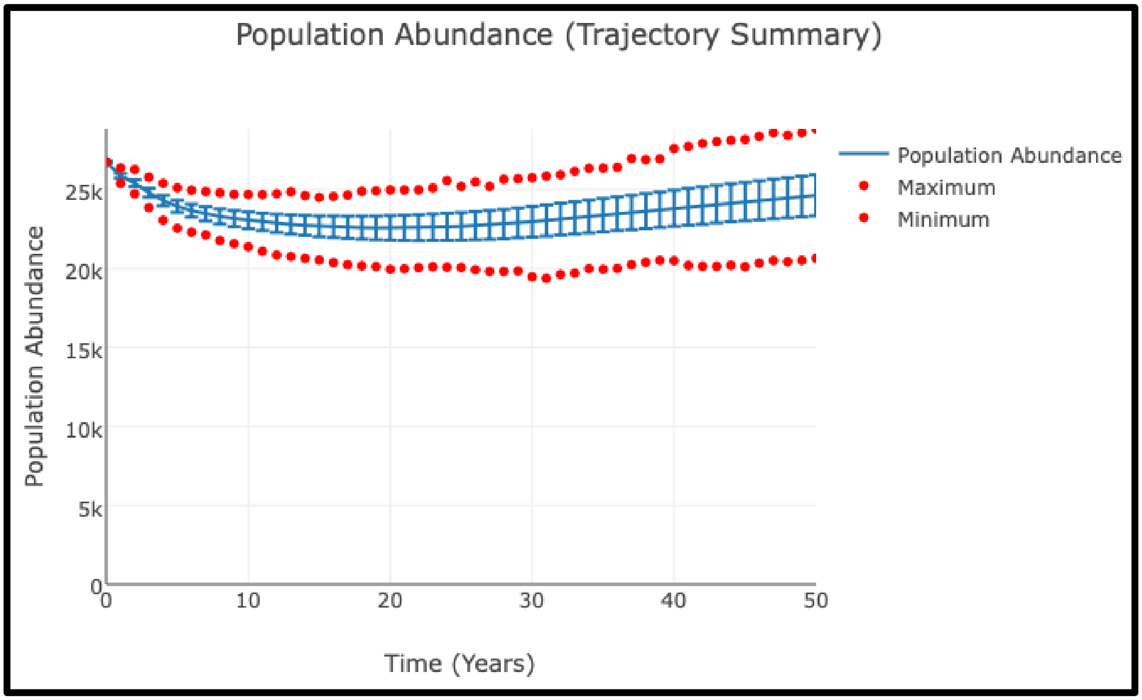

FIGURE 3.9. Each time step represents 1 year. Estimated population trajectory for Painted Turtle with 2% of nests protected and no road mortality. Under this scenario the population appears to stabilize and begin increasing.

MPTU Model 4.— I used the same parameters as model 2 except reduced nest protection to 1.5% (n = 29). I calculated nest success to be (0.2213 x 0.985) + 0.015 = 0.2329805. Again using 88% for hatching success, I calculated survival at age 0 to be 0.2329805 x 0.88 = 0.20502284 (Fig. 3.10).

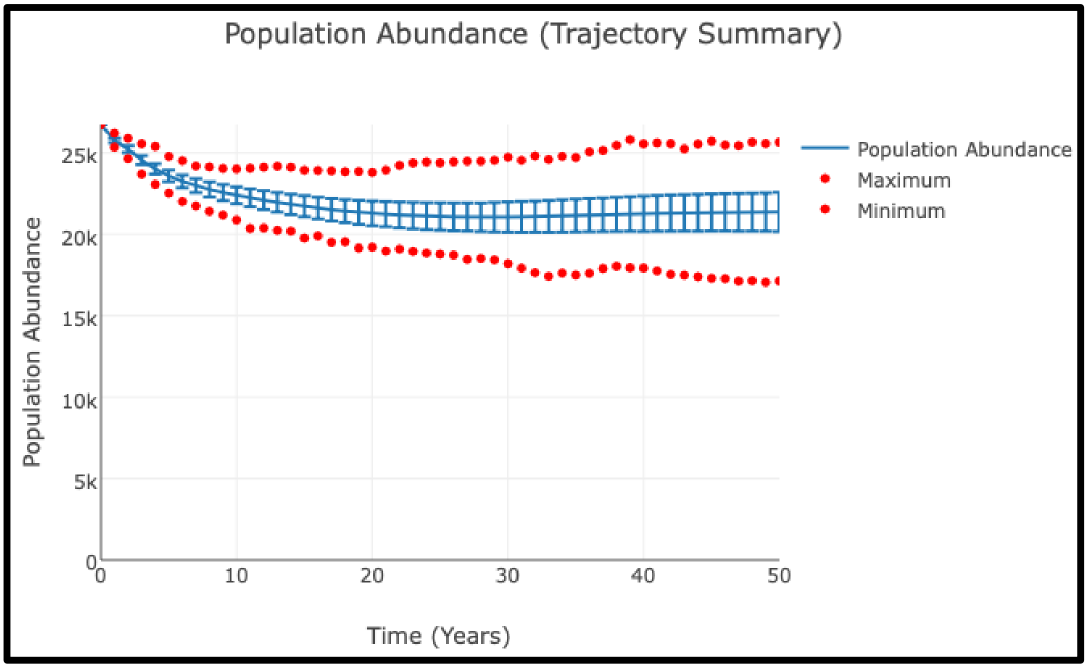

FIGURE 3.10.— Each time step represents 1 year. Estimated population trajectory for Painted Turtle with 1.5% of nests protected and realistic road mortality. Under this scenario the population appears to stabilize and begin increasing slightly.

Snapping Turtle.—

SNTU Model 1.— Each time step in this model represents one year. I used life history data reported by Congdon et al. (1987, 1994), Galbraith et al. (1989), Browne (2003), Phillips (2008), and Parks Canada Agency unpubl. data, as well as my data. Galbraith et al. (1989) reported 17-19 years of age for an individual's first nesting event. Therefore, I began incorporating fecundity at stage 4. Life stages were broken into 16 categories: (1) hatchlings age 0-1, (2) juveniles age 1-8, (3) juveniles age 9-16 (4) young adults age 17-24, (5) young adults age 25-32, (6) adults age 33-40, (7) adults age 41-48, (8) adults age 49-56, (9) adults age 57-64, (10) adults age 65-72, (11) adults age 73-80, (12) adults age 81-88, (13) adults age 89-96, (14) adults age 97+.

Phillips (2008) found 83.8% of Snapping Turtle nests predated. Therefore, I used 16.2% for average nest success. Browne (2003) reported a hatching success of 71.1%. Using nest success and hatching success, I calculated survival for age 0 to be 0.115182 (hatching success [0.711] x nest success [0.162]). I then included the average number of protected nests in the park from 2001-2021 (22.86 nests/year). With an adult female population size estimate of 449 (see Chapter 1 results) and a clutch frequency of 0.85 (Congdon et al. 1994), we can expect 382 nests in the park annually. An average of 22.86 protected annually is ~6% of all the Snapping Turtle nests in the park each year. Therefore, I calculated nest success to be 0.21228 ((nest success [0.162] x proportion of nests unprotected [0.94]) + proportion of nests protected [0.06]). Using a hatching success of 0.711, I calculated survival of age 0 to be 0.711 x 0.21228 = 0.15093108.

I used 47% for survival of yearlings (Congdon et al. 1994; Browne 2003). I used 71.5% for survival of juveniles ages 2-5 (Congdon et al. 1994). I used 79.33% for survival of juveniles ages 6-11 (Congdon et al. 1994). I used 82% for survival at age 12 and 93% at ages 13+ (Congdon et al. 1994).

I calculated survival in stage 1 (age 0-1) to be 0.15093108 (hatching success [0.711] x nest success [0.21228]). Survival of stage 2 (ages 1-8) was calculated to be 0.7137375 (((survival of yearlings [0.47]) + (survival of ages 2-5 [0.715] x 4) + (survival of ages 6-8 [0.7933] x 3))/8). Therefore, the proportion of individuals entering the next stage each year from stage 2 was 0.0821719 (average annual survival in stage 2 [0.7137375] divided by the number of years in stage 2 [8]) and 0.62452031 (0.7137375 – 0.0821719) was the proportion of individuals remaining. I used 0.8649875 (((survival for ages 9-11 [0.7933] x 3) + survival for age 12 [0.82] + (survival for ages 13+ [0.93] x 4))/8) for survival in stage 3 (ages 9-16). Therefore, the proportion of individuals entering the next stage each year for stage 3 (ages 9-16) was 0.10812344 (average survival in stage 3 [0.8649875]/8) and the proportion of individuals remaining was 0.75686406 (average survival [0.8649875] – proportion of individuals moving to the next stage [0.10812344]). For each remaining stage (stages 4–14) I used 0.11625 for the proportion of individuals moving to the next stage each year (survival for ages 13+ [0.93] divided by the number of years in that stage [8]) and 0.81375 for the proportion remaining (0.93 – 0.11625).

I used a clutch size of 27.9 (Congdon et al. 1987). I used a clutch frequency of 0.85 (Congdon et al. 1994). I estimated 449 females and 741 males in the park. Therefore, fecundity for each adult stage was calculated to be 8.95 (clutch size [27.9] x clutch frequency [0.85] x female proportion [0.3773]).

I divided my adult population size estimate of 1190 evenly among stage 4 through 14 for 108 each. I used my population size estimates, past nest protection data, and a life table from Congdon et al. (1994) to calculate juveniles in each stage. With 22.86 nests/year protected, a hatching success of 0.711, and a clutch size of 27.9, that is 453.47 hatchlings successfully added to the population from protected nests each year. Given with a female population size of 449 and clutch frequency of 0.85, there would be 382 nests in the park, that leaves a remaining 359.14 nests unprotected. Using the survival at age 0 of 0.115182 that gives me an additional 1154 (359.14 x 27.9 x 0.115182) hatchlings for a total 1154 + 453 = 1607 in stage 1 (age 0-1). For stage 1 I also accounted for fecundity prior to running the model by multiplying the number of individuals in each stage by the fecundity value for that stage: (108 x 8.95) x 11 = 10633. Therefore, the total individuals I placed in stage 1 at model beginning was 1607 + 10633

= 12240. Using the estimate of 1607 along with the life tables in Congdon et al. (1994) that I placed 2566 individuals in stage 2 (1-8), and 350 in stage 3 (9-16) (See Table 3.4 in Appendix for further outline).

I then incorporated realistic road mortality. I did not observe any adult Snapping Turtle road mortality in 2022-2023; however, road mortality data from the park had 1 from each of 2018 and 2021 (Parks Canada Agency unpubl. data). Therefore, I included 2 every 6 years. I placed 0.33 in stage 4. Based on my road mortality results I started with 162 hatchlings, 3 of which were likely stepped on or hit by a bicycle. I included an additional 52 recorded by park staff. That is 214 hatchlings removed over two years or 107/year (Fig. 3.11).

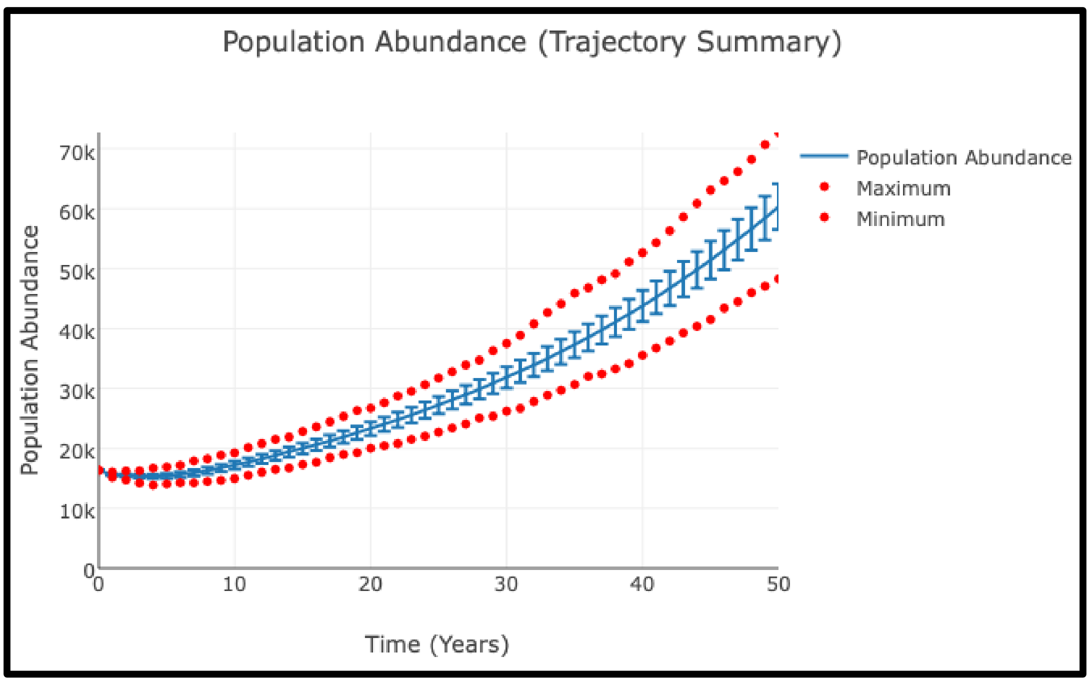

FIGURE 3.11. Each time step represents 1 year. Estimated population trajectory for Snapping Turtles with 6% nest protection and realistic road mortality. Under this scenario the population appears to be increasing.

SNTU Model 2.— I used the same parameters as model 1 except removed nest protection meaning I used 0.115182 for survival at age 0. This model suggests the population is still increasing without nest protection, so considering Rivard and Smith (1973) and Browne (2003) along with previous analyses, something must be unaccounted for because the population was known to be decreasing without nest protection (Fig. 3.12).

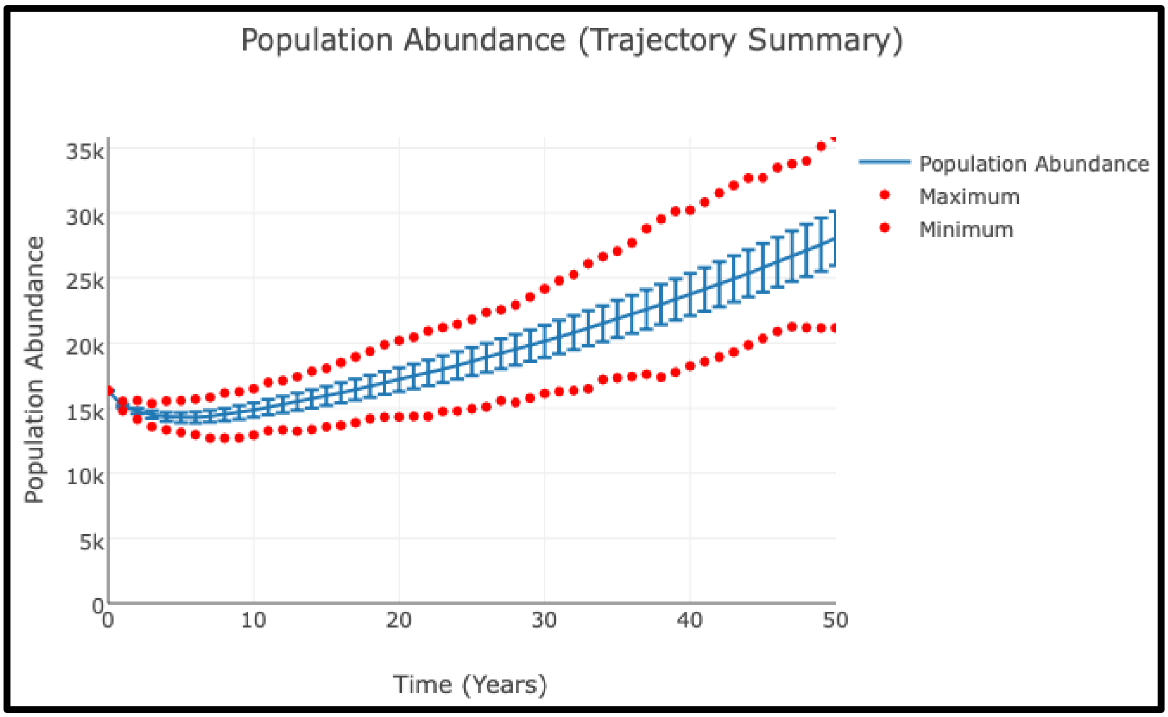

FIGURE 3.12. Each time step represents 1 year. Estimated population trajectory for Snapping Turtles with no nest protection and realistic road mortality. Under this scenario the population appears to be increasing.

SNTU Model 3.— I used the same parameters as model 2 except reduced survival at age 0 by increasing nest predation to 90% (although in reality many factors could be influencing survival at age 0 to be lower than presented in models 1 and 2) and increased road mortality of hatchlings during natal dispersal. This resulted in a survival at age 0 of 0.1 x 0.711 = 0.0711. I multiplied the hatchlings per year of 107 by 2 and used 214 per year. This is plausible given that hatchling turtles are not easily observed dead on roads and can be removed by predators before being recorded (Fig. 3.13).

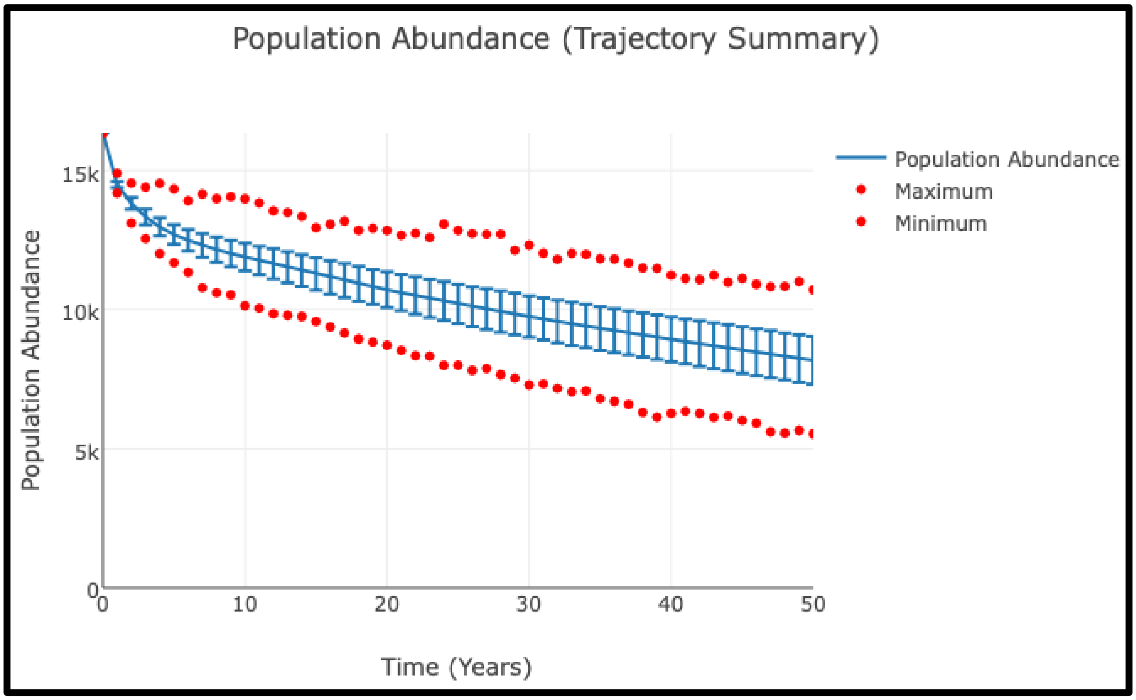

FIGURE 3.13. Each time step represents 1 year. Estimated population trajectory for Snapping Turtles with no nest protection, 10% nest success, and road mortality. Under this scenario the population would be decreasing.

SNTU Model 4.— I used the same parameters as model 3 except incorporated nest protection of 6%/year, resulting in a survival at age 0 of (0.1 x 0.94) + 0.06 = 0.154 x 0.711 = 0.109494 (Fig. 3.14).

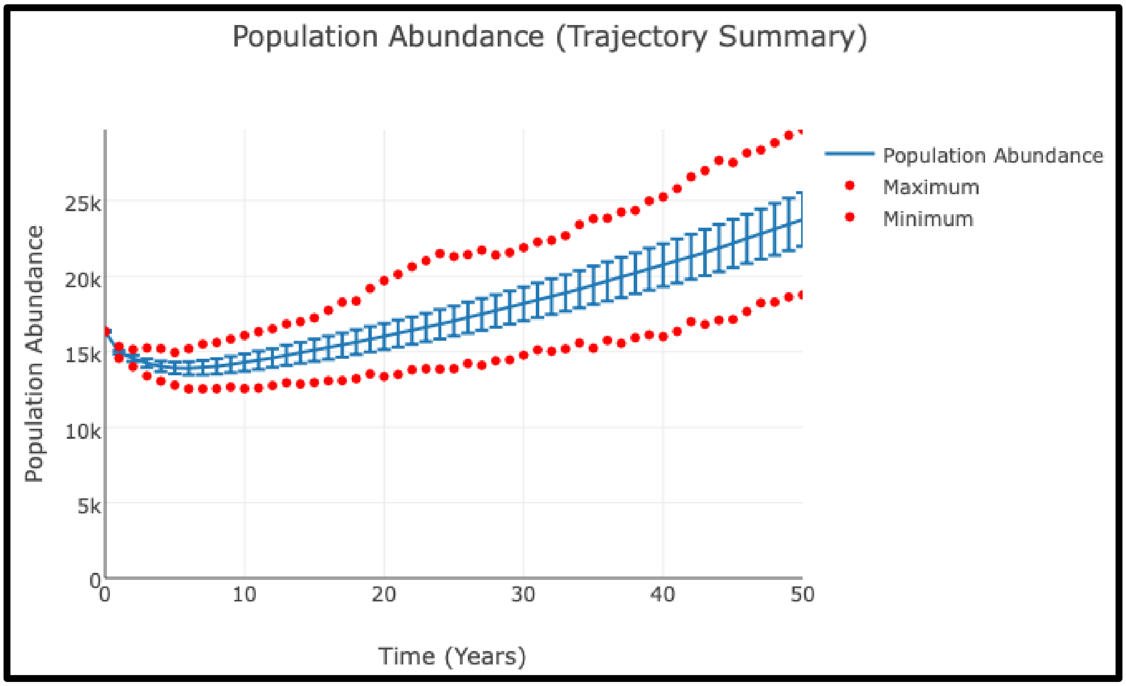

FIGURE 3.14. Each time step represents 1 year. Estimated population trajectory for Snapping Turtles with 6% nest protection, 10% nest success, and road mortality. Under this scenario the population would be increasing.

SNTU Model 5.— I used much of the same parameters as model 1 except I used a lower survival at age 0 and did not include nest protection. Brooks et al. (1988) reported that Obbard (1983) found a mean rate of Snapping Turtle hatchling emergence of 6.35% of eggs from 142 nests across five years. Therefore, I used 0.0635 for survival at age 0 (Fig. 3.15).

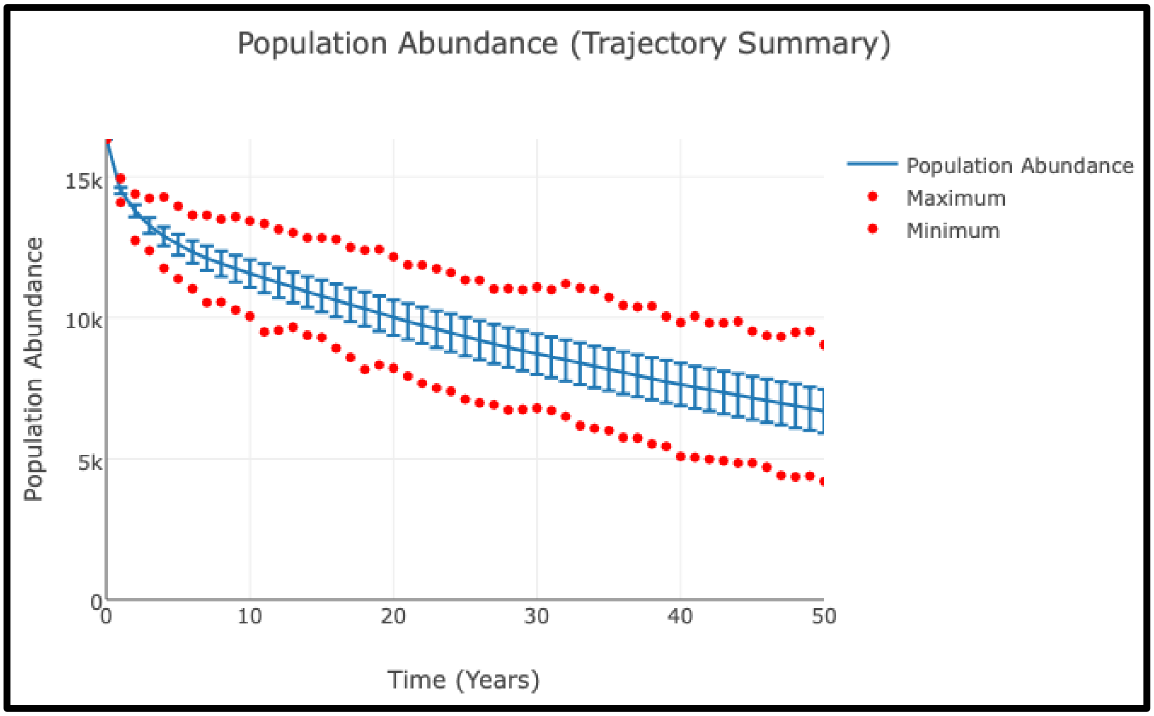

FIGURE 3.15. Each time step represents 1 year. Estimated population trajectory for Snapping Turtles with a 6.35% survival at age 0. Under this scenario the population would be decreasing.

SNTU Model 6.— I used the same parameters as model 5 except I included nest protection of 5% or ~19 nests annually, resulting in a survival at age 0 of 0.0635 + (0.05 x 0.711) = 0.09905 (Fig. 3.16).

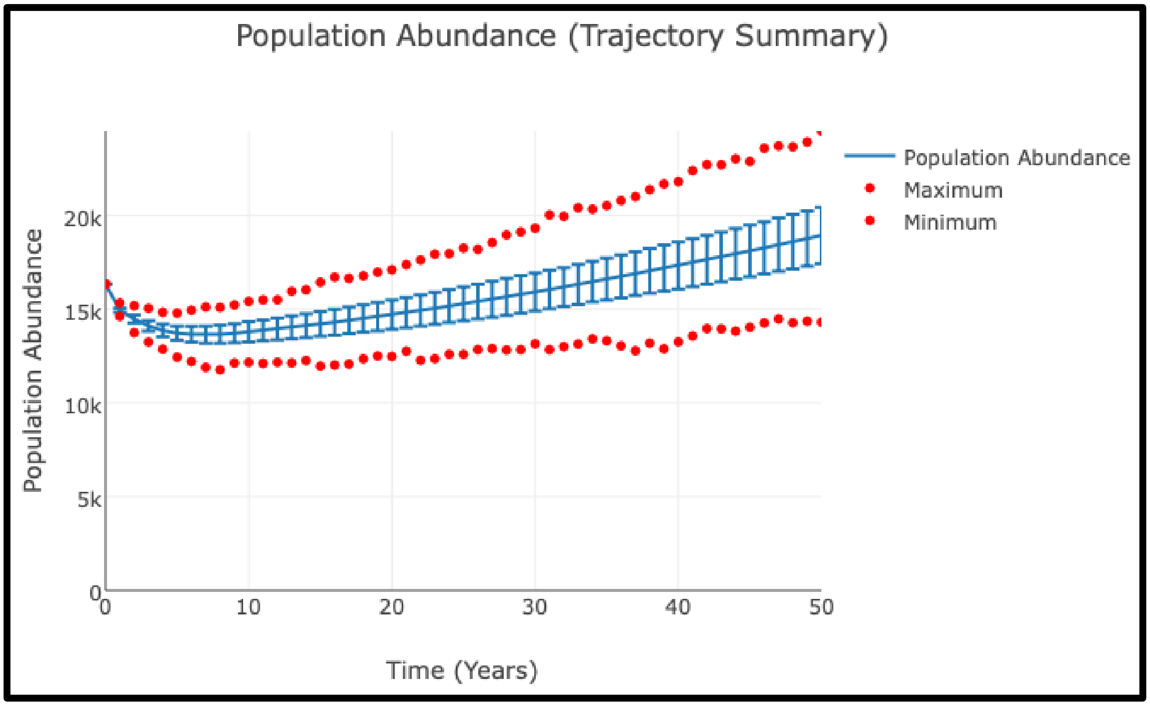

FIGURE 3.16. Each time step represents 1 year. Estimated population trajectory for Snapping Turtles with a survival at age 0 of 6.35% for unprotected nests and 5% of nests protected with a 71.1% protected nest hatching success.

DISCUSSION

Road mortality was much more common for hatchlings during natal dispersal than adults. Painted Turtles were the most commonly struck adults. I observed no adult Blanding's Turtles or Snapping Turtles killed by vehicles in the park. Keevil et al. (2023) suggested that while road mortality of adults is often the subject of more concern, the effect it can have on all life stages is an important consideration in turtle conservation. This includes turtles with slow life histories such as Snapping Turtles and Blanding's Turtles (Keevil et al. 2023).

Seburn and McCurdy-Adams (2019) suggested turtle signs alerting drivers are not as effective as other road mortality mitigation measures and may only alert some drivers. However, Seburn and McCurdy-Adams (2019) noted that road signs may be more effective in areas that have lower speed limits and Farmer and Brooks (2012) recommended lowering speed limits to reduce road mortality. This suggests signage in PPNP may be more effective than some areas because the speed limit is 40 km/hr. Additionally, Seburn and McCurdy-Adams (2019) note that signage can also be a valuable component of public education.

Preventing road mortality of hatchlings is more challenging than of adults because small hatchling size makes them more difficult for drivers to see. Roadside nest protection helps reduce not only nest predation but also road mortality of hatchlings during natal dispersal. This transcends hatchlings that had their nest protected. While monitoring roadside nest boxes, hatchlings from unprotected nests can be opportunistically found and moved to wetlands so that they are not struck by vehicles. Small roadside turtle fences could reduce hatchling road mortality during natal dispersal (Christiansen and Gallaway 1984; Wick et al. 2024).

Some areas of PPNP including park roadsides and Blue Heron picnic area/septic field may be at increased risk of compaction which can reduce hatching success (Kudo et al. 2003). Kudo et al. (2003) studied emergence success of Loggerhead Sea Turtles (*Caretta caretta*) on Ngata Beach, Yakushima Island, Japan. Kudo et al. (2003) compared emergence success of two areas: one that was freely accessible to the public and one that restricted public access, and found significantly lower emergence success (free: 77.9% ± 18.9; restricted: 87.8% ± 12.4) as well as significantly higher mortality at pipping (free: 14.0% ± 13.0; restricted: 7.0% ± 7.5) in the free access area than the restricted area.

The population models suggest survival at age 0 of each species can have profound effects on the trajectory of populations. The decline in Blanding's Turtles in PPNP has been a growing concern and earlier analyses suggested the need for targeted management (Rivard and Smith 1973; Browne 2003; Browne and Hecnar 2007; Wick et al. 2024). My Blanding's Turtle models suggest annual protection of one or four nests along with unprotected nest success of 20% and 12%, respectively, may leave fewer than 40 individuals remaining in the park in 50 years. However, protecting 26.7% of nests in the park (n = 8) may help stabilize the population. If 33.3% were protected (n = 10) and protected nests had high hatching success (91%; 67.57% in unprotected nests), then the number of individuals in the park could be ~81% higher after 50 years than if eight nests were protected (protected and unprotected hatching success of 78.43%).

I used a hatching success of 71.1% for Snapping Turtles (Browne 2003). Riley and Litzgus (2013) reported hatching success of 85.2% for nests (n = 21) protected by below-ground cages, 82.2% for nests (n = 23) protected by above-ground cages, 73.2% for nests (n = 10) protected by wooden-sided cages, and 73% for unprotected nests (n = 20). Therefore, overall hatching success was [(0.852 x 21) + (0.822 x 23) + (0.732 x 10) + (0.73 x 20)]/74 = 79.35%. Browne (2003) studied the effects of contaminants on hatching success in the park and found eggs from contaminated areas had significantly lower hatching success. Snapping Turtle hatching success from each area was 98.3% on East Beach (n = 10), 63.7% on Mersea Rd. E (n = 10), 63.0% along park roadsides (n = 5), and 32.0% in the contaminant site (n = 4) (Browne 2003).

I used 93% (Congdon et al. 1994) for adult Snapping Turtle annual survivorship which may be conservative. Congdon et al. (1994) noted the 93% compensated for an emigration rate of 0.5% and noted adult female Snapping Turtle annual survivorship ranged from 88 – 97%. Galbraith and Brooks (1987) reported an average 96.6% survivorship for adult female Snapping Turtles in an Algonquin Park population.

Snapping Turtles models support earlier analyses that suggested nest protection is helping to reverse the declining population trend and improve size structure. However, to observe a need for nest protection, I lowered the survival at age 0 from Fig. 3.11 and 3.12 in Fig. 3.13–3.16. This may suggest that survival at age 0 in PPNP is lower than expected. I increased the nest predation rate in my model, but in reality, lower survival at age 0 could result from several factors including nest predation, compaction, flooding or wash out, contaminants, or failure to emerge. (Sentence removed). These factors could be reducing nesting habitat and nest success while also increasing predation; contributing to a lower percentage of eggs surviving to emergence than expected.

I found 12.5% (2 of 16; 3 of which unconfirmed but very likely Painted Turtle nests) of Painted Turtle nests in the park succumbed to flooding or wash-out (both located on East Beach) in 2022–2023. My models support earlier analyses that the Painted Turtle population may currently be in decline. Population models suggest nest protection can help, and as little as 1.5% of nests protected (n = 29) may help stabilize the Painted Turtle population (Fig. 3.10).

CONCLUSIONS

Like the population trajectory models created by Browne (2003), my models suggest road mortality can have a negative effect on the turtle populations of PPNP but survival at age 0 is the main concern for the turtle populations of PPNP. Spotted Turtles (*Clemmys guttata*) were last observed in the park in 1994 joining five snake species extirpated from the park in the 1900s (Hecnar and Hecnar 2004). If more Blanding's Turtle nests are not protected annually, then Blanding's Turtle may see a similar fate and no longer persist in PPNP. Standing et al. (2000) found Blanding's Turtle nest protection was successful in mitigating nest predation in Kejimkujik National Park and my models suggest nest protection can help prevent the Blanding's Turtle population from being extirpated from PPNP.

The models are based on many variables, and I may have underestimated, overestimated, or missed some factors. While I used data directly from PPNP for some parameters, I also used data from other studies. These models should be considered merely inferences, considered with caution, and accompanied by additional data when used for contributing to management decisions. However, based on the models as well as previous analyses, if PPNP continues to protect ~20 Snapping Turtle nests annually, their recovery should continue. If ~30 Painted Turtle nests and eight Blanding's nests are protected annually, that may help stabilize their populations. All analyses have suggested that decline of the Blanding's Turtle population is a major concern, so work is required toward increasing their population. Therefore, it may be best to target the protection of 10 Blanding's nests each year while also considering ways to increase hatching success such as artificial incubation. Based on previous analyses, the opportunistic protection of Northern Map and Eastern Musk Turtle (*Sternotherus odoratus*) nests should suffice until a future study of the populations is undertaken. However, it would be beneficial to gather additional information regarding Eastern Musk Turtle nesting in PPNP as only 36 nests have been protected since 2001.

Appendix

Snapping Turtle hatchling locations.—

(FIGURE 3.17 and caption removed).

Protected nests of each species.—
Blanding's Turtle.—

(FIGURE 3.18 and caption removed).

Eastern Musk Turtle.—

(FIGURE 3.19 and caption removed).

Northern Map Turtle.—

(FIGURE 3.20 and caption removed).

Painted Turtle.—

(FIGURE 3.21 and caption removed).

Snapping Turtle.—

(FIGURE 3.22 and caption removed).

TABLE 3.4. Outline of how I determined juvenile estimates for Snapping Turtles in each stage using Congdon et al. (1994) survival estimates at each age.

Age	Estimate	Survival	Age	Estimate
0	1607		0-1	1607
1	755.29	0.47		
2	611.7849	0.81		
3	397.660185	0.65		
4	258.47912	0.65		
5	193.85934	0.75		
6	143.455912	0.74		
7	116.199289	0.81		
8	89.4734522	0.77	1-8	2566.2022
9	71.5787617	0.80		
10	58.6945846	0.82		
11	48.1295594	0.82		
12	39.4662387	0.82		
13	36.703602	0.93		
14	34.1343498	0.93		
15	31.7449454	0.93		
16	29.5227992	0.93	9-16	349.974841

General Conclusions

Well managed protected areas are critical to the protection of biodiversity and species at risk such as turtles; particularly when isolated and surrounded by areas densely populated by humans like PPNP. Rivard and Smith (1973) noted that Spotted Turtles were disappearing from PPNP and suggested further research. While Spotted Turtles were as abundant as Painted Turtles at Point Pelee in the early 1900s (Patch 1919), they were last observed in PPNP in 1994 (Hecnar and Hecnar 2004) and are now presumed to be extirpated.

Although Blanding's Turtles were common in the park in the early 1970s, Rivard and Smith (1973) noted they may experience heavy nest predation. Browne (2003) found nest predation was limiting juvenile recruitment, causing a top-heavy size structure along with a hoop trap CPUE that dropped from 0.054 to 0.012 (78% decline) since Rivard and Smith (1973). I found size structure had not changed significantly since Browne (2003) but that CPUE had dropped again from 0.012 to 0.008 (33% decline).

Browne (2003) also found that nest predation was limiting juvenile recruitment of Snapping Turtles. This caused a top-heavy size structure as median MCL (mm) increased from 276 mm to 305 mm and CPUE fell from 0.172 to 0.108 (37% decline) compared with Rivard and Smith (1973). Browne (2003) started the nest protection program that helped protect over 880 turtle nests between 2001–2021, 480 of which were Snapping Turtle nests. I found Snapping Turtle hoop trap CPUE increased to 0.130 (+20%) since Browne (2003) while their median MCL (mm) decreased significantly to 288 mm. Along with their size structure histogram showing the approximate start of nest protection (Fig. 1.14 of Chapter 1), this suggests nest protection has helped reverse Snapping Turtle decline in the park.

There are numerous threats to PPNP turtle populations including road mortality, erosion on East Beach causing nest wash-out, flooding, or reduced nesting habitat, and most notably nest predation. Raccoons are still the main nest predator in the park, and I observed the highest density in the area surrounding Camp Henry (DeLaurier to Visitor Centre). (Sentence removed). Eggs of nests that survive still face threats including contaminants or compaction that may impede development or emergence.

The changes observed in the Snapping Turtle population shows nest protection can be an effective tool in turtle conservation and help mitigate nest predation in PPNP. Blanding's Turtles have not had sufficient protection to reverse their declines, but the models presented here now provide clear targets to be met. Blanding's Turtles have fallen into an incredibly precarious state, but an honest claim of ignorance will not be possible if they are allowed to become extirpated from PPNP. While additional research investigating specific habitat use patterns of adult female Blanding's Turtles may be necessary to help managers find enough nests, the main barrier to reversing their population trend and ensuring their persistence in PPNP will likely be conservation effort.

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