TURTLE NEST SURVIVORSHIP AND AN ANALYSIS OF ALTERNATIVES FOR TURTLE CONSERVATION AT POINT PELEE NATIONAL PARK

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PREPARED FOR: THE NATURAL RESOURCE CONSERVATION DIVISION
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ABSTRACT

I investigated turtle nest survivorship in Point Pelee National Park for the 1996 nesting season. Although my work concentrates mainly on mammalian depredation of turtle nests, I also examined some alternatives to managing turtle populations at Point Pelee, and other factors that could cause a population decline in turtles.

This study was a one-year pilot project that collected baseline data and generated testable hypotheses on whether raccoons could be a significant factor in possible declining turtle populations at Point Pelee. The study defines possible future research endeavours and compares techniques were most effective at gathering information.

I selected five expansive sampling areas to study turtle nest depredation: Sanctuary Pond, Camp Henry, the East Beach, Redhead Pond, and eastern ridge of Lake Pond. The search for nests started on 22 May 1996 but the first turtle nest was not discovered until 12 June 1996. The last day of the nesting survey was 15 August 1996. The Lake Pond sample site was the most active nesting area having a total of 101 nests. The second most active area was the East Beach (58 nests) followed by Redhead Pond (38 nests), Sanctuary (29 nests), and Camp Henry (16 nests).

A total of 242 turtle nests were found during the 1996 nesting season with 87% of these nests having been depredated. Park managers should interpret this depredation rate with caution as it is a coarse estimate. The estimate is probably biased because of a small sample size and because some turtle nests (e.g., snapping turtle) were easier to find than others (e.g., painted, musk turtle).

Raccoons may be the major predators of turtle nests in Point Pelee. Unfortunately, there are no estimates of raccoon numbers for the Park, nonetheless, the raccoon population may be high because the raccoon is an edge species and Point Pelee consists primarily of edge habitat.

One option available to managers for controlling the raccoon population at Point Pelee is culling. However, for such a program to be successful, park managers would have to continue to shoot raccoons on a consistent basis. For every raccoon that is removed from the population, a niche will open for another raccoon; therefore, raccoons would probably repopulate the Park in a short time after every shooting.

Management needs to conduct a census to obtain a rough estimate of population trends for raccoons and turtles within the Park. Turtles and raccoons violate many of the assumptions required by mark-recapture techniques to obtain an absolute estimate of a population. However, techniques that measure relative density are cheap and effective ways of detecting large changes in population numbers.

Census data shows raccoon numbers to be increasing while turtle populations decrease, then there may be a causal link between the two phenomena. Even if this is true, turtle populations may be in decline for several other reasons.

Turtles have adapted to compensate for high nest losses resulting from depredation by possessing the ability to reproduce consistently over their long lifespan; thus, requiring only low rates of recruitment to maintain their population. In most turtle populations, it is adult survivorship that allows a population to persist. Turtle populations cannot replace adult losses quickly because of their low recruitment rates; therefore, significant adult losses could quickly lead to the extinction of a species.

Adult and juvenile survivorship are the keys to maintaining turtle populations at Point Pelee. Nest protection may increase the number of hatchlings emerging from nests; however, this is no guarantee that hatchlings will survive. Time and money would therefore be better well spent in attempting to determine and mitigate the factors that could cause unnaturally high mortality to adult turtles within the Park.

RECOMMENDATIONS

1. Should management decide that culling raccoons is a viable option, I strongly recommend that the Park complete a census to monitor changes in the population prior to and following the cull. A census will determine whether the cull was successful at reducing raccoon numbers within the Park.

2. Management should conduct a basking census for turtles and a spotlight census for raccoons. Both techniques will provide a relative index of abundance to help detect major changes in these populations over time. If protocols remain constant and are conducted on a set schedule over a period of 10 years, management should have a reliable estimate of turtle and raccoon population trends at Point Pelee.

3. Further studies on nest depredation will be an ineffective use of Park time and resources Several studies have shown that the amount of depredation on turtle nests varies from year to year for all species. Although nest protection may increase the number of hatchlings emerging from nests, this does not guarantee that all hatchlings will survive.

4. Management should concentrate their efforts on attempting to determine and mitigate the factors that may cause excessively high rates of mortality to adults and juveniles in turtle populations. Possible sources of adult mortality in Point Pelee include: poisoning of turtles by marsh contaminants, car strikes, and illegal collecting.

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1.0 INTRODUCTION

1.1 BACKGROUND

1.1.1 POINT PELEE NATIONAL PARK

Point Pelee National Park, located in the southern part of Essex County in southern Ontario, is a cusp-shaped sandspit that extends approximately 16 kilometers into Lake Erie. Point Pelee is the most southern land in mainland Canada. The shallow Lake Erie moderates the climate and allows many southern forms of flora and fauna to exist (i.e., Carolinean species). Some species of plants and animals in Point Pelee may be found as far south as Mexico and Central America (Canadian Parks Service 1978).

Despite its small size and heavy human use, Point Pelee National Park supports a rich herpetofauna (i.e., a diverse reptile and amphibian population). With Point Pelee's mild climate and extensive marshes, there are more species of reptiles and amphibians in the Park than compared to anywhere else in the national park system (Canadian Parks Service 1995). For this reason, herpetofauna conservation and protection at Point Pelee is a high priority (Canadian Parks Service 1991).

1.1.2 TURTLE SPECIES OF POINT PELEE NATIONAL PARK

Point Pelee is home to nine species of turtles. Seven of these turtles are native to Ontario: the common snapping turtle (*Chelydra serpentina serpentina*), Blanding's turtle (*Emydoidea blandingii*), midland painted turtle (*Chrysemys picta marginata*), common map turtle (*Graptemys geographica*), common musk turtle or Stinkpot (*Sternotherus odoratus*), spotted turtle (*Clemmys guttata*), and the eastern spiny softshell turtle (*Trionyx spiniferus spiniferus*).

The two exotic species include the eastern box turtle (*Terrapene carolina carolina*) and the red-eared slider (*Trachemys scripta troostii*).

The most common turtle species found in Point Pelee National Park are the Blanding's, snapping, painted and map turtles. Although rare in Ontario, the musk turtle is also common to the Park. The two species of turtles that are rare in Point Pelee and listed as endangered in Canada are the spotted and eastern spiny softshell turtles. The introduced red-eared slider and eastern box turtle occur in small numbers within the Park and are not a conservation priority. People no longer wanting to keep turtles as pets most likely released these exotic species into the Park (Canadian Parks Service 1991). In 1971 a park warden intercepted an individual with three box turtles brought specifically for release into Point Pelee (Kraus 1990).

The Canadian Parks Service policy states that all exotic species should be eliminated from the Park; however, to remove these two exotic species would be expensive (Canadian Parks Service 1991). Since the red-eared slider and eastern box turtle do not appear to be a threat to the Point Pelee natural ecosystem (e.g., displacing native turtle species), their removal is not considered to be urgent. (Canadian Parks Service 1991).

1.2 PROJECT RATIONALE

1.2.1 TURTLE SPECIES ABUNDANCE DECLINING IN POINT PELEE

The Natural Resource Conservation Division of the Point Pelee Warden Service suspects that overall turtle abundance and diversity in the Park has been decreasing steadily over the last decade (T.Linke, pers. comm.). Qualitative observations over the last ten years by Park staff and visitors indicate fewer sightings of many turtle species within the Park. Most notably, there has been a great decrease in the sightings of Blanding's, snapping, spiny softshell, and spotted turtles.

1.2.2 THE POINT PELEE HERPTOFAUNA CONSERVATION PLAN

The current herpetofauna conservation plan appears to have been ineffective at protecting, monitoring and managing the herpetile populations of Point Pelee National Park. A total of 11 herpetile species have disappeared from the Point Pelee ecosystem (Canadian Parks Service 1991). Some examples of the most recent extirpated species include the blue racer (*Coluber catenatus*), eastern hognose snake (*Heterodon platyrhinos*), Blanchard's cricket frog (*Acris creptians blanchardi*), and the bullfrog (*Rana catesbeiana*). Other herpetile populations within the Park also appear to be on the decline such as the five-lined skink (*Eumeces fasciatus*), eastern fox snake (*Elaphe vulpina gloydi*), and spotted turtle (*Clemmys guttata*).

The Warden Service intends to publish a new herpetofaunal conservation plan for Point Pelee by 1997. On April 17-18, 1996, Point Pelee held a workshop for herpetologists to discuss plans of action on managing the Park's herpetofaunal community. One suggestion made by several of the participants was the necessity for more detailed studies on turtle ecology and behaviour; this study follows that recommendation and focusses on nest depredation while also investigating possible alternatives to managing turtle populations at Point Pelee.

In examining turtle nesting ecology and survivorship, my study could provide useful information about why turtle abundance appears to be declining within the Park. The information from my study is the first step in helping Park managers draft conservation objectives based on scientific protocols rather than conjecture.

1.2.3 INCREASED DEPREDATION OF NESTS BY RACCOONS CAUSE OF DECLINES?

One belief held by the Warden's Service is that turtles and their nests are being subjected to an unnaturally high rate of predation by the Park's resident raccoon (*Procyon lotor*) population. Over the last five years there has been an increase of raccoon sightings within the Park; this suggests that raccoon numbers are expanding (T.Linke, pers. comm.). There is also evidence that raccoons are captured in urban centers such as Leamington and Kingsville and then illegally released into the Park (B.Stephenson, pers. comm.).

Several publications suggest that fragmented habitats surrounded by human-dominated environments can support higher densities of generalist predator species such as raccoons (Temple 1987; Angelstam 1986; Janzen 1983). Just beyond the north boundary of Point Pelee National Park are agricultural fields and urban settlements which could provide alternative sources of food (i.e., garbage, crops) for raccoons living within the Park.

Increased access to food resources within and outside the Park could therefore support high recruitment rates and a larger raccoon population. Angelstam (1986) found that there was an increase in predation pressure on bird nests in boreal forest habitat islands surrounded by human-dominated environments. This may also apply to turtles in Point Pelee and support the idea that raccoons are the cause of suggested declines in turtle abundance.

1.2.4 BIOGEOGRAPHICAL VARIABILITY MAY YIELD DIFFERENT RESULTS

Many similar studies already exist which have addressed turtle nesting ecology; however, different bioregions may have different factors that influence the behaviour and habits turtles. For example, Point Pelee National Park is a fragmented habitat surrounded by water and agricultural development. The Park is also rehabilitating from heavy human activity in the 1960s and is still in use by the public today. Any of these factors may have a significant influence on the nesting ecology of turtles within the Park.

1.3 PURPOSE AND OBJECTIVES

The purpose of my study was to investigate turtle nest survivorship in Point Pelee National Park. Although my work concentrates mainly on mammalian depredation of turtle nests, I also examined other factors that could cause population declines in turtles, and some alternatives to managing turtle populations at Point Pelee (e.g., obtaining reliable estimates of population density, raccoon control, reducing adult turtle mortality).

My study was a one-year pilot project designed to collect baseline data and generate testable hypotheses on whether raccoons could be a significant factor in possible declining turtle populations at Point Pelee. The study will also help to (1) isolate areas where future research endeavours should be directed and (2) provide ideas of which techniques are most effective at gathering information.

My objectives were:

(1) Find and identify areas in Point Pelee National Park where turtle nesting occurs;

(2) Collect data on the nesting success and depredation rates of turtle nests within the Park;

(3) Determine and plot the time schedule of depredation during the nesting season;

(4) Determine whether raccoons are having a detrimental impact on turtle populations in Point Pelee National Park;

(5) Identify management techniques to use to assist in the conservation of turtles in the Park and to help mitigate predatory impacts (if depredation is found to be a problem); and

(6) Determine what other factors could cause turtles declines in the Park.

2.0 METHODS AND MATERIALS

2.1 SAMPLING AREAS

For this research project I selected five expansive sampling areas to study turtle nest depredation (Figure 1). I have classified the sampling areas into the following zones:

(1) **Sanctuary Pond** -- Includes the stretch of road starting at the entrance to the Park, heading south, and ending at the entrance to the Marsh Boardwalk; Administration Building; Bunkhouse #50; Sanctuary Picnic Area; Blue Heron Picnic Area; Marsh Boardwalk; Trades Compound Restoration Area; the private residence due south of the Marsh Boardwalk; and Bunkhouse #220.

(2) **Camp Henry** -- A campsite consisting of several large open sandy areas. The camp grounds back onto the marsh edge of Girardin Pond.

(3) **East Beach** -- Beginning from where Shuster's Trail exits onto the beach, heading north along the shoreline of Lake Erie and ending at the southern boundary of Lake Pond. The sample area encompasses beach located between the Lake Erie shoreline and eastern vegetative edge of the marsh (consisting of medium sized shrubs and large trees).

(4) **Redhead Pond** -- A medium sized body of water situated south of Lake Pond along the east beach. The pond is separated from the beach by a strip of vegetative growth consisting of medium sized shrubs and some large trees. The open sandy areas between the pond shoreline and vegetation strip of this sample area were divided into four working plots labelled A to D.

(5) **Lake Pond** -- A large sandy zone located along the shoreline of Lake Pond and extending east to the shoreline of Lake Erie.

I chose large areas to sample so that I could obtain a sufficient sample size and a representative sample of nesting activity throughout the different habitats of the Park. I also selected these five

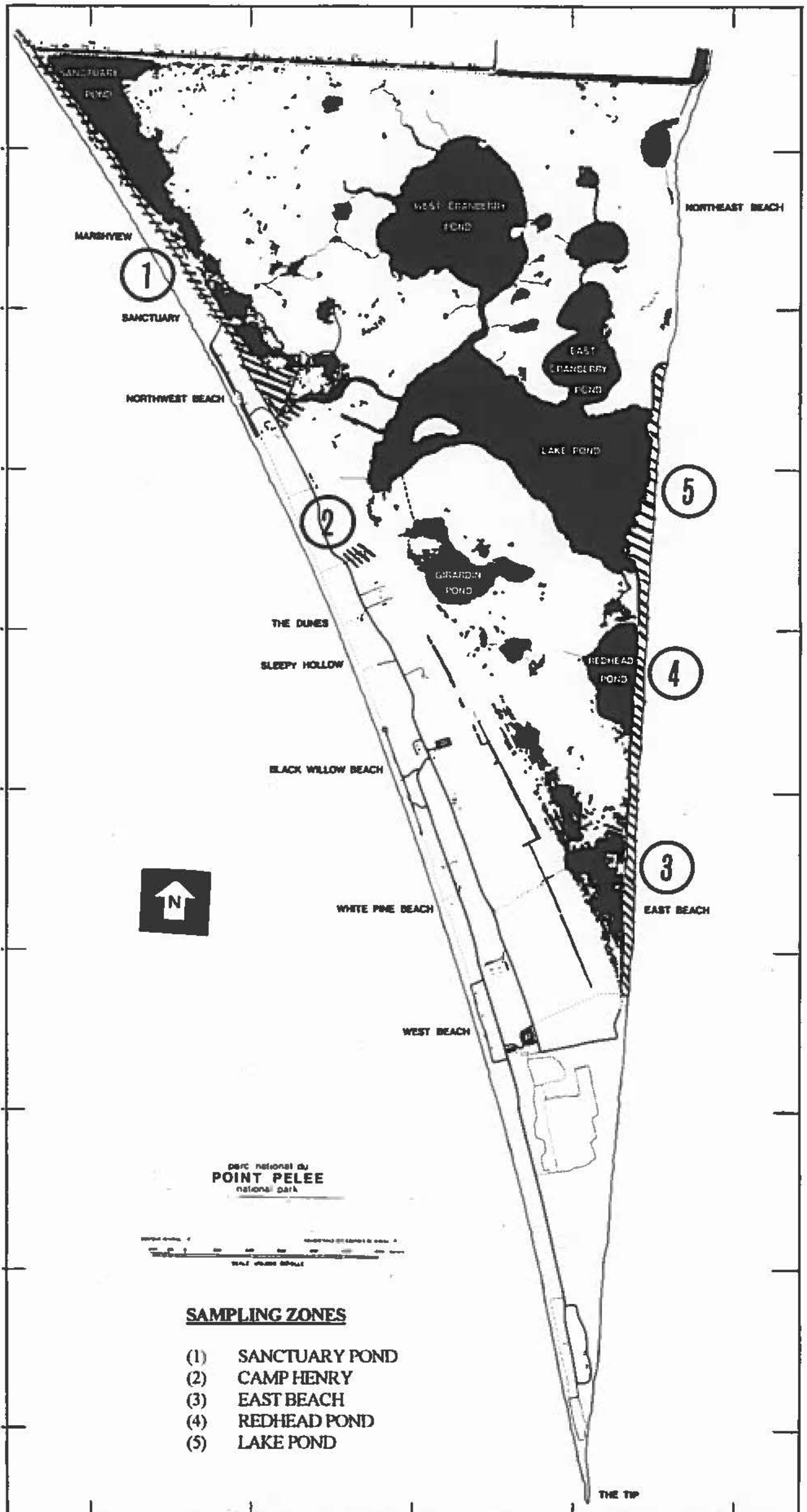


FIGURE 1. POINT PELEE NATIONAL PARK TURTLE STUDY SAMPLING ZONES

sites based on previous herpetological inventories and studies completed by Kraus (1991), Parsons (1982), Rivard and Smith (1973), and other Park records of turtle sightings or nesting activity.

2.2 BIBLIOGRAPHY (APPENDIX 1)

The Resource Conservation Library in Point Pelee provided me with detailed information about the Park's natural history, herpetological inventories and records, and a general background of the ecology and behaviours of turtle species present within the Park. The University of Windsor, which specializes in herpetological studies, had a library containing many of the academic journals that I needed for my study. For research articles that I could not obtain through the university, I contacted the Parks Canada Library Service in Cornwall. With these three services I was able to obtain enough information to a gain a knowledge of the natural history, ecology, and status of the turtle species within the Park.

2.3 FIELD SEASON PREPARATION

Field season preparation mainly consisted of learning how to identify turtles and how to recognize signs of turtle nesting. I taught myself how to identify turtles and turtle nesting activity by referring to the literature, talking to herpetology experts, and speaking with those individuals who had done field identification.

The selection and staking of the sampling areas were another significant task in preparing for the field season. The criteria for selecting the study areas for this project have been mentioned previously (Section 2.1). For each sampling zone, I used neon blue and pink flagging tape, provided by the Warden Service, to mark the boundaries for research. Flagging tape was either attached to a tree or shrub branch to signify a sampling site. The use of neon flagging tape was essential for locating sampling sites in heavily vegetated areas such as Redhead Pond. While marking the zones to be studied, I also had the opportunity to do several trial-runs to see how much time it would take to cover a particular area. A trial-run involved walking the research area in a linear pattern as if I were looking for turtle nests.

2.4 FIELD METHODS AND DATA COLLECTION

Onset of the Turtle Nesting Season at Point Pelee

Kraus (1991) found that the turtles started nesting in the last week of May. In my study, I found turtles nesting later in the season (12 June 1996) because Point Pelee experienced a cool spring. Turtles are ectotherms and as a result their activity is strongly affected by the thermal environment (Obbard and Brooks 1987). A cooler than normal spring may result in a later onset of the turtle nesting season at Point Pelee (J.Edmonds, pers. comm.). Observations made by Park staff during my field season preparation confirmed that nesting did not begin until mid-June 1996 (i.e., there were no observations of turtle nesting activity).

Identification of Turtle Nesting Activity

The search for turtle nests usually started around 0800 h EDT each day and would end between 1700 and 1800 h EDT (I needed 9-10 hours of daylight to survey all sampling areas). Using an ATV (All Terrain Vehicle), I would start the search at Sanctuary Pond, followed by Camp Henry, the East Beach, Redhead Pond, and finish at Lake Pond. I did not want to deviate from my schedule by having to answer questions from tourists about the study; hence, I would start the survey with Sanctuary and Camp Henry (popular tourist areas) because human activity in these areas during the morning was scarce.

I would check sample sites daily for nests by walking in a linear pattern throughout the entire flagged area. The majority of nests were identified by searching for recent signs soil disturbance (e.g., digging). Unusual patches of soil moisture (i.e., a wet patch surrounded by dry soil) also were indicators of nesting since turtles sometimes urinate on their completed nests to make the soil damp so that the eggs do not desiccate (S.De Solla, pers. comm.). I also located nests by observing females laying eggs, indicators of nest depredation (i.e., eggshells scattered about nests), and turtle tracks.

Classification and Marking of Turtle Nests

I categorized nests as "observed nests" or "unobserved nests." In Congdon *et al.* (1987), "observed nests" were those discovered by direct observation of turtles or from evidence of digging; those discovered after being destroyed by predators were referred to as "unobserved nests".

Both intact (observed) and depredated (unobserved) nests found in the field were marked with a numbered blue flag. I placed the flags approximately 0.5 to 1.0 m away from the intact nests to avoid puncturing the eggs with the wire stake. The flags are about 0.6 m in length and after inserting into the soil stood approximately 0.3 m above the soil surface. Flags may affect visitation rates to ground nest sites by predators (Angelstam 1986; Yahner and Wright 1987). However, there is no evidence to suggest that flags attract mammalian predators to ground nests (Tuberville and Burke 1994; Baker 1980, 1978).

For each new nest that I found, I recorded the date when found, turtle species that constructed nest, plot location and position of the nest in the sample area (e.g., open sandy ground, shaded ground, etc.), and description of the habitat surrounding the nest. If a previously intact nest was found depredated, I recorded the date of depredation and, if possible, attempted to identify the predator using available evidence (e.g., tracks).

Depredation and Identification of Mammalian Predators

Marked nests were observed daily for signs of depredation. To identify predators, I smoothed the sand around the marked nests to capture paw prints. Another way to identify a potential predator is to observe the eggshells around a depredated nest. Larger intact eggshells around a depredated nest suggest that the predator was a raccoon, shredded shells suggest a skunk, and no shells suggest a fox (assuming that eggs were previously seen in the nest) (J.Harding, pers. comm.). I also examined the structure of the holes and scats left around the nests to help identify predators. Raccoon holes are small circular to rectangular holes with dirt piled all around the opening (Burger 1977).

Habitat and Spatial Analysis

The criteria for nest site selection in many turtle species remain unknown (Christens and Bider 1987). A nesting area may be selected based on qualities such as: soil type, lack of canopy cover, steepness and exposure of the slope or the type of aquatic environment the hatchlings move to immediately after leaving the nest (Congdon *et al.* 1987). I attempted to determine what parameters turtles in the Park use to select nesting sites.

3.0 RESULTS AND DISCUSSION

3.1 TOTAL NUMBER OF NESTS FOUND IN SURVEY

A total of 242 turtle nests were found during the 1996 nesting season (12 June to 15 August). The search for nests actually started on 22 May 1996 but the first turtle nest was not discovered until 12 June 1996. Figure 2 shows the total number of nests found during each day of the study.

Out of the 242 total nests found, 119 nests (49.2%) appeared to be snapping turtle (*Chelydra serpentina*) nests (Table 1). The remaining 123 nests (50.8%) belonged to "other" turtle species within the Park. I grouped all turtle nests (excluding snapping turtles) into a category called "other" because the nests of these species were often too difficult to distinguish from one another in the field.

The low proportion of nests found belonging to species other than the snapping turtle does not necessarily mean that these populations are in decline. Snapping turtle nests are very easy to find relative to the nests of other turtle species. Female snapping turtles leave large disturbed areas after depositing their eggs where the smaller species, such as the painted and musk turtle, have cryptic nests which are hard to find after nesting. Another limitation to finding nests are the weather conditions. After a rain event any signs of nesting often become undetectable. The number of nests made by species other than snapping turtles are therefore most likely underestimated by this study.

3.2 PEAK OF NESTING SEASON

In the first two weeks of the nesting season (12 June to 27 June), the total number of nests found each day steadily increased (Figure 2). Turtle nesting activity at Point Pelee usually begins in late May and peaks during the second and third weeks in June (Kraus 1991). The peak of nesting activity for the 1996 nesting season was difficult to determine because of the gaps in surveying information (i.e., when the Park was not surveyed for several consecutive days) (Figure 2). Although I found the greatest number of nests on 3 July that suggests a peak in nesting activity; in fact, some of these nests were probably constructed sometime in the four consecutive days that I did not survey (28 June - 1 July). However, the distribution of the data still suggests that the peak occurred during either the first or second week of June. Figure 4 provides an estimated schedule of when turtles at Point Pelee begin their nesting season.

The onset of the nesting season was later in 1996 (12 June) compared to when Kraus (1991) did his study (31 May). Turtle activity is strongly affected by the thermal environment and cooler than normal spring temperatures may result in a later start to the nesting season (Obbard and Brooks 1987). I suspect that the spring temperatures in 1991 were probably warmer than 1996; thus, probably explaining why nesting started later in 1996.

3.3 DISTRIBUTION OF NESTS THROUGHOUT THE PARK

The distribution of the 242 nests among the five major sampling areas is illustrated in Figure 3. The Lake Pond sample area had the most nests with 101 (42%), followed by East Beach with 58 (24%), Redhead Pond with 38 (16%), Sanctuary with 29 (12%), and Camp Henry with 16 (7%). In both the Lake and Redhead Pond sample sites, nests were predominately concentrated near the shoreline of the marsh. Most nests in the Sanctuary sample area were also close to the shoreline, concentrated mainly around the marsh boardwalk and in the backyards of private residences. Nests along East Beach tended to be constructed at the edge of the vegetation and in Camp Henry nests were mainly located around the sandy volleyball pit. Locations of the nests in each sample area are in Appendix 2

The data suggest that extensive heavy human visitation may deter turtles from using some areas as nesting sites. Sanctuary and Camp Henry had the lowest nest counts and the highest visitation compared to any of the other sites surveyed. All turtle species present in the Park will either lay their eggs early in the morning, late afternoon, or evening (Ernst *et al.* 1994). Unfortunately, it is during these times human activity is greatest (e.g., at Sanctuary and Camp Henry). Other than the snapping turtle, most turtle species will abandon their nest sites prior to or during oviposition if they detect humans (G.Whitehead, pers. obser.; Linck *et al.* 1989; Congdon *et al.* 1983).

On several occasions, painted, snapping and Blanding's turtles were seen crossing the roadway heading from east (away from the Sanctuary Pond waterways) to west (towards the west beach). Many turtle species may travel considerable distances (50–3000 m) in search of a suitable nesting site (Petit *et al.* 1995; Brown *et al.* 1994; Ernst *et al.* 1994; Obbard and Brooks 1980). Although not a sampling area, I occasionally would observe the west beach for signs of turtle nesting activity. I often would find turtle tracks on the west beach originating from the edge vegetation. I suspect that many of the turtles from Sanctuary Pond travel to the west beach, or stop in open sandy areas on route (e.g., roadside, sandy parking lots, etc.), to lay their eggs.

Of course, the reason that Lake Pond, East Beach and Redhead Pond may have more nests could simply be because of the ample and high quality nesting habitats that exist on that side of the Park. The sample areas on the east side are also relatively free of human disturbance. I also found it easier to locate nests on the east side (i.e., sand substrate more readily held turtle tracks, expansive open areas provided clear lines of sight, etc.) which may partially explain the higher nest numbers.

3.4 PREFERRED NESTING HABITAT

Temperature affects how an embryonic turtle will develop. Temperature can affect the "hatching success, duration of incubation, sexual differentiation, and size and composition of hatchlings" (Gutzke and Packard 1987). The selection of nesting sites is strongly dependent on temperature. Most species prefer open sites having well-drained sandy substrates and minimal vegetation cover (J.Harding, pers. comm.; Ernst *et al.* 1994; Christens and Bider 1987; Temple 1987; Burger 1977). However, turtles will use less than optimal sites (e.g., grassy and gravelly substrates) if preferred habitat is not available (J.Harding, pers. comm.). All nests found during this study generally were consistent of these nesting criteria.

3.5 NEST DEPREDATION

3.5.1 RATES

The depredation rate for turtle nests found in this study for the 1996 nesting season was approximately 87% (Table 1). The overall depredation rate for snapping turtle nests was 77%; for all other species, the depredation rate was 97% (Table 1).

Warden staff must be cautious when interpreting these calculated rates. The rates provided from this study are initial, relative estimates of nest depredation. I believe that the number of nests detected are not representative of the entire turtle population at Point Pelee. Results may be severely biased because some turtle nests were easier to find than others (i.e., not representative). The small sample size (n=242) could also skew results; however, sample size was not as much of a problem than attempting to find nests of different turtle species. Depredation rates may also differ between species; this could create interpretation problems if management decides to analyze all nests as a whole (i.e., grouping all species together could artificially inflate or lower nest depredation rates of a given species).

3.5.2 PREDATORS

The major mammalian predator of turtle nests in North America appears to be the raccoon (*Procyon lotor*) (Christens and Bider 1987; Congdon *et al.* 1987, 1983; Petokas and Alexander 1980; Fowler 1979; Burger 1977; Davis and Whiting 1977). Other potential predators of turtle nests include foxes, coyotes, opossums, dogs, gulls, and crows. Ants also account for the loss of eggs in the nests of painted and snapping turtles (Burger 1977).

Evidence from the survey suggests that raccoons depredated the majority of the turtle nests within the study areas. Depredated nests often had raccoon tracks embedded in the surrounding sand. Many of the dug holes were small and circular, having eggshells that were still fairly intact; thus, suggesting that the predator was a raccoon (J.Harding, pers. comm.; Burger 1977). However, in the Lake Pond sample area there were some nests that had very large dug holes surrounded by tracks that probably belonged to either a dog or a coyote. Sightings of opossums in the Sanctuary sample area also indicate that some nests were probably disturbed by this predator.

3.5.3 TIMING OF DEPREDATION THROUGHOUT NESTING SEASON

In many species, most nest depredation occurs within the first 24 to 48 hours following oviposition (D.Seburn, pers. comm.; Congdon *et al.* 1987, 1983; Petokas and Alexander 1980; Fowler 1979). The fresh scents of eggs, the female turtle, and the recently disturbed earth cue predators; this explains why most nests are probably depredated during the first 48 hours (J.Harding, pers. comm.). In my study, 184 nests (76%) were depredated within 48 hours following their construction. However, I did observe some nests that remained intact for as long as eight days before being depredated.

Whether nest depredation decreases over time because of dissipating olfactory cues is controversial. Robinson and Bider (1988), Congdon *et al.* (1983), and Tinkle *et al.* (1981) concluded that depredation at their study sites was not constant throughout the year and found that as nest age increased, chances of depredation of nests decreased. Conversely, Snow (1982) found no evidence to support the hypothesis that nest cues gradually weaken with age thus allowing nests to go undetected. A study of Blanding's turtles in northern Michigan found that depredation remained relatively constant throughout the nesting season (Tinkle *et al.* 1981). Some believe that depredation pressure throughout the season may have more to do with predator foraging patterns rather than with dissipating olfactory cues (Snow 1982; Petokas and Alexander 1980).

At the beginning of the Point Pelee nesting season, I found more new intact nests as compared to depredated nests (Figure 2). I believe that in the early stages of the nesting season predators had not yet established effective foraging routes and therefore missed several areas containing nests. As the season progressed, I began to find many more depredated nests than intact nests. During this time I believe that predators had become fixed in set routes that passed though major nesting areas. As a result, any new nests constructed in these patrolled areas were more susceptible to depredation than nests in marginally productive areas (i.e., non-foraging zones such as areas having low nest densities).

3.5.4 IS NEST DEPREDATION CAUSING TURTLE POPULATIONS TO DECLINE?

Several studies show that the amount of depredation on turtle nests varies from year to year for all species (Congdon *et al.* 1987; Galbraith and Brooks 1986; Petokas and Alexander 1980; Burger 1977; Davis and Whiting 1977). Congdon *et al.* (1983), found that depredation on Blanding's turtle nests, in Michigan ranged from 42% to 93% over a four year period. In Cootes Paradise (Ontario) nest depredation on snapping turtle nests is very high (95%); however, this site has densest population of snapping turtles ever recorded in Canada (S.De Solla, pers. comm.; Galbraith *et al.* 1988).

Research suggests that nest depredation does have a significant impact on turtle reproduction; however, high rates of depredation have probably occurred at Point Pelee in the past. Turtles may have adapted to high nest depredation by using a strategy referred to as *bet-hedging*. Bet-hedging theory predicts that long-lived animals in populations that have high juvenile and low adult mortality can compensate for high juvenile losses by being able to reproduce steadily, albeit at low rates, over an extended period of their lives (Stearns 1976).

Because turtles are long-lived, slow growing animals with late sexual maturity and a long reproductive life-span, they require only low rates of recruitment into their populations to persist (Brooks *et al.* 1991). Although nest depredation may be high, only a few clutches need to survive over a female's reproductive life to maintain a population (J.Edmonds, pers. comm.; J.McLendon, pers. comm.; D.Seburn, pers. comm.). The outcome of reproduction for a turtle in a single season is therefore of far less consequence than is the case in short-lived reptiles (Tinkle *et al.* 1981).

Further studies on nest depredation probably would not be an effective use of Park time and resources given literature on nesting dynamics. I suggest that time would be better spent doing surveys to determine population viability; that is, finding out how many turtles there are in Point Pelee.

4.0 CENSUSING POPULATIONS AT POINT PELEE

4.1 MARK-RECAPTURE TECHNIQUES

Mark-recapture-release techniques are designed to measure the absolute density of a population (for example, an exact number of animals per given unit of area). All mark-recapture techniques rest on the basic idea that, "If you capture animals, mark and release them, in subsequent samples taken from this population the proportion of animals marked should be representative of the proportion of animals marked in the entire population" (Krebs 1994). The simplest mark-recapture technique for estimating population is the Petersen method (Krebs 1994). Most other mark-recapture models are just extensions of this basic model. The equation for the Petersen method is:

$$m_2/n_2 = n_1/N$$

where,
n_1 = number of animals first marked and released
n_2 = number of animals in second sample
m_2 = number of marked animals recaptured in the second sample
N = size of population

Several models exist for capture-recapture estimation; however, all of these models make four critical assumptions (*sensu* Smith, 1997):

1. Marks on animals are not lost or overlooked.
2. Marking does not affect emigration or death rates.
3. All animals in the population are equally trappable; that is, marking does not affect their subsequent chance of recapture. This has two components:
    3.1 inherent catchability, which should not change as a result of being captured and marked (i.e., change in animal behaviour due to trapping); and
    3.2 dispersion, which should remain unaltered as a result of marking.

4. The population is sampled at random with respect to age, sex, and physiological condition of the animals.

A fifth criterion which applies to all mark-recapture models other than the Jolly-Seber method is:

5. The population is closed. That is, the model assumes that there are no gains (births or immigration) or losses (deaths or emigration) during the course of the study.

The Jolly-Seber mark-recapture method assumes the population to be "open"; that is, the population is subject to gains (births or immigration) or losses (deaths or emigration) during the course of the study (Sutherland 1996).

Violating any of these five assumptions will result in a seriously biased population estimate. Assumption 3 (equal catchability) is the most difficult one to meet. Animals will often become trap-happy (especially if traps are baited) or trap-shy (i.e., animals may be reluctant to the enter the trap, avoid the location, or even leave the area completely). The impact of equal catchability is so great that researchers must use statistical tests to ensure that the equal catchability assumption is being met (Sutherland 1996). Trap-happy and -shy animals will result in the overestimation and underestimation of the population size, respectively.

For those interested in planning a mark-recapture study, I have provided a list of references on how to estimate the size of animal populations in Appendix 3 (*sensu* Smith, 1997).

4.2 VIOLATIONS OF MARK-RECAPTURE ASSUMPTIONS

4.2.1 TURTLES

Turtles violate many of the assumptions required by mark-recapture techniques for obtaining reliable population estimates of absolute density. In the spring, with the start of the nesting season, turtles never maintain a closed population. Female turtles will travel great distances (50–3000 m) from their home ranges in search of suitable nesting habitat (Petit *et al.* 1995; Ernst *et al.* 1994; Obbard and Brooks 1981). Obbard and Brooks (1980) found that one female snapping turtle travelled a round-trip distance of 16 km from her home range to a nesting site. A mark-recapture study during the nesting season would also yield sex specific results; the majority of turtles caught should predominately be female.

After the nesting season, some turtle species (such as the snapping turtle) do become sedentary (i.e., limited movement) (R.Brooks, pers. comm.). However, movement between ponds by both male and female turtles during the summer season is common with most species. Painted turtles will sometimes occasionally wander on land for days at a time from one waterbody to another (MacCulloch and Secoy 1983). Gordon and MacCulloch (1980) also found that map turtles do not always remain in the same place throughout its annual activity period. Even musk turtles, considered to be a sedentary species, occasionally move overland from pond to pond (Ernst *et al.* 1994). Movement can also be age- and sex-specific. For example, in Michigan, 43% of adult female Blanding's turtles travelled distances over 100 m than did males (14%) and juvenile females (19%) (Ross 1989).

Studies have also demonstrated that different age-classes in a turtle population are not equally catchable. Age-classes in most painted turtle populations are skewed towards adults because juvenile turtles are more difficult to catch (Ernst *et al.* 1994). Researchers have noted the rarity or absence of small Blanding's turtles in samples (Congdon and van Loben Sels 1991). Some turtles species are more likely to be captured than others. Snapping, spotted, and spiny soft-shell turtles are secretive and may not be attracted to baits in traps as readily as other species (Ernst *et al.* 1994). Brooks (1997, pers. comm.) found that snapping turtles eventually learned how to escape from hoop nets.

Many studies also report biased sex ratios towards either males or females in a population (Ernst *et al.* 1994). Do these results truly reflect the ratio of males to females in a population or is one sex easier to catch than another? Ream and Ream (1966) state that, "Sex bias may be introduced in population studies if only one collecting method is used and it favours a particular sex."

The assumption that turtle populations at Point Pelee are closed and that individuals have the same chance of being captured is doubtful. Violations of these assumptions make mark-recapture methods an expensive and unreliable means of obtaining absolute estimates of turtle density.

4.2.2 RACCOONS

As with turtles, raccoons violate the mark-recapture assumptions of equal catchability and closed populations. No techniques will provide an accurate estimate of a raccoon population for a given area (Sanderson 1987). Absolute population densities for raccoons are almost impossible to obtain because it is difficult for managers to know (1) what size area the raccoons are utilizing within the Park and (2) what percentage of the population has been counted (Sanderson 1987). Raccoons are not a closed population. Raccoon movement patterns and the size of their home ranges vary depending on sex and age, habitat, food sources, and other factors. Male raccoons tend to have larger home ranges than females and the home ranges of females with young are smaller compared to females without young. Time of season also dictates the movements of raccoons. In the summer months, raccoons move constantly between habitats; however, raccoon densities are usually highest in habitats which are close to water such as bottom-land forests along streams, hardwood swamps, and marshes. The colder weather of winter restricts raccoon movement substantially. Raccoons are most active at night; however, activity patterns of the raccoon will change depending on the availability of food and water.

Individuals in a raccoon population are unlikely to have the same chance of being captured. Juveniles and parous (has already given birth at least once) females travelling with young are often more vulnerable to capture than other raccoons. Raccoons are also extremely intelligent animals and research has proven that the raccoon is a quick learner with the ability to retain images and have ideas. Davis (1907) reported that raccoons could remember certain tasks for up to a year or more without practice. After being trapped, Smith (pers comm.) believes that raccoons would not disperse randomly and would adjust their patterns of movement to avoid areas having traps. However, if the traps are baited raccoons could also become trap-happy.

Sanderson (1987) has attempted several mark-recapture studies with raccoons but always has derived the same results: the returns were always too small to provide valid population estimates.

Management would probably be wise to use a technique other than mark-recapture to obtain a reliable estimate of raccoon densities in Point Pelee National Park (see Section 4.3.2).

4.3 RELATIVE ESTIMATES OF POPULATION SIZE

The relative density of a population is a measurement that represents some unknown but constant relative relationship to the true size of that population, which is obtained through the sampling of a given variable (e.g., number of bird calls heard, number of muskrat lodges observed, etc.). Relative densities provide an index (a measurement that is related to the actual total number of animals) of abundance rather than an absolute estimate of population density. For example, if we observed 50 raccoons in the Park for 1997 and then counted only 30 in 1998 we could conclude, for this limited period of time, than raccoon densities in the Park have probably decreased over that two year period.

Relative density measurements are cost-effective ways of picking up large changes in population density. Some examples of programs that use relative density measurements are breeding bird and marsh monitoring surveys (e.g., Long Point Bird Observatory Marsh Monitoring Program). Table 2 provides an example of how to record census data to obtain a index of relative density.

Table 2. An example of how to record census data for raccoons and turtles.

Week	Time Period	Year			
		1995	1996	1997	1998
1	Mar.09 - Mar.15	5	10	15	25
2	Mar.16 - Mar.22	7	9	20	19
3	Mar.23 - Mar.29	8	15	26	32
4	Mar.30 - Apr.05	5	8	19	23
5	Apr.06 - Apr.12	5	7	21	20
Sum		**30**	**49**	**101**	**119**

Surveyors must use the same techniques for each census so that the comparison of relative densities between two time periods is valid. The census needs to be standardized; that is, the same observer conducts the census under similar weather conditions at the same time of day during each counting period. Multiple transects should be sampled simultaneously to ensure the standardization of factors. Standardization of census techniques helps to reduce variability in collected data caused by environmental factors and observer subjectivity. Site managers may also find it useful to monitor environmental variables such as temperature and wind at the time of the census. Managers could then detect changes in environmental variables and relate them to changes in monitored populations.

If protocols remain fixed and are conducted on a set schedule, over a period of 10 years management should begin to get a reliable estimate of turtle and raccoon population trends at Point Pelee (S.Smith, pers. comm.).

4.3.1 BASKING CENSUS FOR TURTLES

Brooks (pers. comm.) tested several censusing techniques for turtles and found that basking surveys yielded the most accurate results. A basking census requires observers to count the number of turtles seen basking at a given sample site. The optimal time to conduct a basking census is in the spring when turtles are just emerging from hibernation. Turtles are usually sluggish at this time and are less wary of disturbance, thereby making them easier to count. Table 3 provides a summary of basking habits and peaks for turtles at Point Pelee.

Managers should attempt to sample as many turtle populated areas as possible. Larger sample sizes (i.e., greater number of sampled habitats) will provide a relative index that is more representative of turtle densities throughout the Park. The census should revolve around sun-times rather than clock-times because most turtle activity begins and ends with the sun. Observers should also record air temperature at sample sites since temperature is the most important factor in determining turtle activity (R.Brooks, pers. comm.).

Candidate sites for a basking census in Point Pelee include (ranked in order of importance): Redhead Pond, east beach of Lake Pond, the Marsh Boardwalk, Girardin Pond, the DeLaurier Trail canals, Sanctuary Pond, and possibly the seasonal ponds of the Woodland Nature Trail (for the spotted turtle).

4.3.2 STRIP TRANSECT COUNTS FOR RACCOONS

Strip transects are similar to but are not the same as line transects. Where a line transect measures the distance to an observed animal from a line, "...strip transects counts all the animals in a strip across a study area assuming that every individual in the strip is detected" (Sutherland 1996). Line transects are more suitable for open areas having large animals where strip transects are better designed for counting smaller species in dense habitats such as forests. Essentially, a strip transect is one long and narrow quadrat. Strip transects may either run parallel or perpendicular to an environmental gradient; for example, through one habitat type (parallel) versus several habitat types (perpendicular).

In practice, most strip transects are usually set up along already established routes such as roads and trails. A strip census involves moving along the transect and counting the numbers animals observed at a set distance from each side of the line into the habitat (i.e., the strip). Most strip transects use a set distance of 200 to 400 m, depending on the habitat and the species being counted. The surveying of these transects is often carried out from a motorized vehicle. To walk the transect would be slow, and many animals that could be seen from a vehicle would most likely run away from walking observers before being counted. To obtain a reliable index of relative abundance, the vehicle needs to be driven at a set speed under a set of standardized conditions (e.g., same time every census period).

One technique that utilizes the strip transect is a spotlight census. Developed by Rybarczyk (1978), the spotlight survey has been used as an index for raccoon abundance in Iowa and Illinois. Observers would drive along a 40 km stretch of habitat at 16-24 km/hour while shining 100 000-candlepower spotlights off to the side of the road to count raccoons. The wardens could also do this type of survey in Point Pelee using a headlight and a car battery for a spotlight. The wardens could spot the raccoons by looking for the reflection of the light from the back of the animal's retina. Because there is forested habitat lining the roadway from the gateway to the tip, the census should use a set distance of 400 m to count raccoons (Figure 6). The census should start at dusk since raccoons become most active from this time onward. The optimal time for a raccoon census is in late March to early June when the raccoons are emerging from their semi-dormant state to search of food.

A census that uses a strip transect is subject to some biases. Strip transects will underestimate the densities of inconspicuous species or species that flee before the observer can count them. However, we must remember that this census is only an estimate of relative density. Observers must also consider whether the transect is representative of all habitats that raccoons use at Point Pelee. To mitigate this problem additional transects could be established along Shuster's trail, the DeLaurier trail, or the Woodland Nature trail.

5.0 MANAGEMENT OF TURTLE POPULATIONS AT POINT PELEE

5.1 RACCOON CONTROL

Raccoons have been steadily increasing their numbers at Point Pelee since the turn of the century. In 1918, raccoons were either rare or extirpated from the Park (Hough, Stansbury and Associates Limited 1978). Raccoons were soon classified as being uncommon (Halliday, Senn and Lewis Limited 1939) and by 1969 the raccoon had become a permanent inhabitant in Point Pelee (Menefy 1969). The suspected increase in raccoons at Point Pelee parallels a continent-wide population explosion that began in the 1943 breeding season (Sanderson 1987). At present there are 15-20 times as many raccoons in North America than there were during the 1930s (Sanderson 1987).

The raccoon has been very successful in North America for several reasons. Raccoons are one of the most omnivorous animals known to exist and will eat carrion, garbage, birds, mammals, reptiles and amphibians, invertebrates, a variety of grains, fruits, fish, and plant materials. Raccoons are very mobile and can disperse into new productive habitats quickly and are well adapted to the human environment. Other than humans, the raccoon has relatively few natural predators left in North America.

One option that is available to managers for controlling the raccoon population at Point Pelee is to have a raccoon cull. For such a program to be successful, management would have to continue to cull raccoons on a consistent basis. The problem with a cull is that for every raccoon that is removed from the population, a niche will open for another raccoon to survive (S.Smith, pers. comm.). For example, removing an adult raccoon from the population may provide a new opportunity for a juvenile to survive. Managers will never be able to cull all the raccoons within the Park and there will always be new raccoons entering into the population to occupy freed niche space. Across North America, raccoon populations have withstood substantial increases in mortality from culls (Sanderson 1987).

To justify a raccoon cull, managers must show that the method used (e.g., rifles) is effective (i.e., removing raccoons from the Park helps to alleviate declines in the populations of their prey species such as turtles). The present lack of information on turtle and raccoon populations at Point Pelee will make this relationship less defensible. Managers will find obtaining a correlation between turtle declines and increased raccoon populations difficult. A correlation between two variables does not necessarily mean that one variable has caused a response in the other variable; that is, increased raccoon populations may not be the cause of turtle declines. Turtle populations may have changed for other reasons.

As with the deer culls at Point Pelee, culling raccoons will probably engender opposition from the public. Mangers should consider whether a cull would be worth potential opposition given that the raccoons will probably repopulate the Park in a short time after the shooting. Less controversial alternatives for controlling raccoon populations at Point Pelee could include sterilization or the management of factors which dictate raccoon success (e.g., den and ground burrow availability).

Should management decide that culling raccoons is a viable option, I strongly recommend that the Park undertake a census to monitor changes in the population prior to and following the cull. A census will provide an idea of whether the cull was successful at reducing raccoon numbers within the Park.

5.2 LIMITING THE LOSS OF ADULTS FROM A POPULATION IS VITAL FOR THE CONSERVATION OF TURTLES AT POINT PELEE

Egg survivorship is very low in turtles because of high rates of nest depredation (Linck *et al.* 1989; Brooks *et al.* 1988; Christens and Bider 1987; Congdon *et al.* 1987, 1983; Tinkle *et al.* 1981). However, turtles compensate for these losses by possessing the ability to reproduce consistently over their long lifespan; thus, requiring only low rates of recruitment to maintain their population. Congdon *et al.* (1987) report that in most turtle populations it is adult survivorship which allows the population to persist; if adult loss is greater than the natural mortality rate then there may be drastic impacts on the population as a whole. Turtle populations cannot replace adult losses quickly because of their low recruitment rates; therefore, significant adult losses could quickly lead to the extinction or extirpation of a species (Brooks *et al.* 1991). Turtle populations that experience high adult losses will be slow to recover if the population does not compensate itself by either increasing fecundity, growth rates, or juvenile survivorship (Brooks *et al.* 1991).

Adult and juvenile survivorship are the keys to maintaining turtle populations at Point Pelee. Nest protection may increase the number of hatchlings emerging from nests; however, this is no guarantee that hatchlings will survive. The rate of mortality is often high for hatchlings even after they reach the water (S.De Solla, pers comm.). For Point Pelee, the protection of nests could be a costly exercise yielding little results. Time and money would be better spent in attempting to determine and mitigate the factors that could cause excessive mortality to adult turtles within the Park (e.g., car strikes, illegal collecting).

6.0 CONCLUSIONS

1. A total of 242 turtle nests were found during the 1996 nesting season with 87% of these nests having been depredated. Management should interpret this depredation rate with caution as it is a very coarse estimate of what the actual rate might be. The estimate is probably severely biased because of a small sample size and the fact that some turtle nests were easier to find than others (i.e., not representative).

2. The Lake Pond sample site was the most active nesting area having a total of 101 nests. The second most active area was the East Beach (58 nests) followed by Redhead Pond 38 nests), Sanctuary (29 nests), and Camp Henry (16 nests).

3. Raccoons appear to be the major predators of turtle nests in Point Pelee. Although there are no actual estimates of raccoon numbers for the Park, the population may be naturally high because the raccoon is an edge species and Point Pelee consists primarily edge habitat.

4. Management needs to conduct a census to obtain a rough estimate of population trends or raccoons and turtles within the Park. Turtles and raccoons violate many of the assumptions required by mark-recapture techniques to obtain an absolute estimate of a population. However, techniques that measure relative density are cheap and effective ways of detecting large changes in population numbers.

5. Census data that shows raccoon numbers to be increasing while turtle populations decrease may suggest a causal link between the two phenomena; although this may be the case, turtle populations may be in decline for several other reasons.

6. One option that is available to managers for controlling the raccoon population at Point Pelee is to have a raccoon cull. However, for such a program to be successful management would have to continue to shoot raccoons on a consistent basis. For every raccoon that is removed from the population a niche space will open for another raccoon to survive; therefore, raccoons would probably repopulate the Park in a short time after every shooting.

7. Turtles have adapted to compensate for high nest losses resulting from depredation by possessing the ability to reproduce consistently over their long lifespan; thus, requiring only low rates of recruitment to maintain their population. In most turtle populations it is adult survivorship which allows a population to persist. Turtle populations cannot replace adult losses quickly because of their low recruitment rates; therefore, significant adult losses could quickly lead to the extinction of a species.

8. Adult and juvenile survivorship are the keys to maintaining turtle populations at Point Pelee. Nest protection may increase the number of hatchlings emerging from nests; however, this is no guarantee that hatchlings will survive. Time and money would therefore be better well spent in attempting to determine and mitigate the factors that could cause unnaturally high mortality to adult turtles within the Park.

7.0 LITERATURE CITED

Angelstam, P. 1986. Predation on ground-nesting birds' nests in relation to predator densities and habitat edge. Oikos 47: 365-373.

Baker, B.W. 1980. Hair-catchers aid in identifying mammalian predators of ground-nesting birds. Wildlife Society Bulletin 8: 257-259.

________. 1978. Ecological factors affecting wild turkey nest predation on South Texas range-lands. Proceedings of the Annual Conference of Southeastern Association of Fish and Wildlife Agencies 32: 126-136.

Brooks, R.J. Department of Zoology, University of Guelph. Personal Communication. 11 April 1997.

Brooks, R.J., G.P. Brown, and D.A. Galbraith. 1991. Effects of a sudden increase in natural mortality of adults on a population of the common snapping turtle (*Chelydra serpentina*). Canadian Journal of Zoology 69: 1314-1320.

__________, D.A. Galbraith, E.G. Nancekivell, and C.A. Bishop. 1988. Developing management guidelines for snapping turtles. In Management of Amphibians, Reptiles and Small Mammals in North America, United States Department of Agriculture Forest Service, July 19-21, Flagstaff Arizona. General Technical Report RM-166, pp. 174-179.

Burger, J. 1977. Determinants of hatching success in Diamondback Terrapin, *Malaclemys terrapin*. American Midland Naturalist 97: 444-464.

Canadian Parks Service. 1995. Point Pelee National Park Management Plan. Department of Canadian Heritage, Parks Service, Ontario Region. 64 pp.

__________. 1991. Park Conservation Plan: Point Pelee National Park. Environment Canada, Parks Service, Ontario Region. 161 pp.

Christens, E. and J.R. Bider. 1987. Nesting activity and hatching success of the painted turtle (*Chrysemys picta marginata*) in Southwestern Quebec. Herpetologica 43: 55-65.

Congdon, J.D. and R.C. van Loben Sels. 1991. Growth and body size in Blanding's turtles (*Emydoidea blandingi*): Relationships to reproduction. Canadian Journal of Zoology 69: 239-245.

__________, G.L. Breitenbach, R.C. van Loben Sels, and D.W. Tinkle. 1987. Reproduction and nesting ecology of snapping turtles (*Chelydra serpentina*) in southeastern Michigan. Herpetologica 43: 39-54.

_________, D. W. Tinkle, G. L. Breitenbach, and R. C. van Loben Sels. 1983. Nesting ecology and hatching success in the turtle *Emydoidea blandingi.* Herpetologica 39: 417-429.

Davis, G. E. and M. C. Whiting. 1977. Loggerhead sea turtles nesting in Everglades National Park, Florida, USA. Herpetologica 33: 18-28.

Davis, H.B. 1907. The raccoon: a study in animal intelligence. American Journal of Psychology 18: 447-489.

De Solla, S. Department of Zoology, University of Guelph. Personal Communication. (ssolla@uoguelph.ca). 22 January 1996.

Edmonds, J. Department of Zoology, University of Guelph. Personal Communication. (jedmonds@uoguelph.ca). 22 April 1996.

Ernst, C.H., R.W. Barbour, and J.E. Lovich. 1994. Turtles of the United States and Canada. Washington: Smithsonian Institution Press.

Fowler, L.E. 1979. Hatching success and nest predation in the green sea turtle, *Chelonia Mydas*, at Tortuguero, Costa Rica. Ecology 60: 946-955.

Galbraith, D.A., C. A. Bishop, R. J. Brooks, W. L. Simser and K. P. Lampman. 1988. Factors affecting the density of populations of common snapping turtles (*Chelydra serpentina serpentina*). Canadian Journal of Zoology 66: 1233-1240.

_________ and R.J. Brooks. 1986. Survivorship of adult females in a northern population of common snapping turtles, *Chelydra serpentina*. Canadian Journal of Zoology 65: 1581-1586.

Gordon, D.M. and R.D. MacCulloch. 1980. An investigation of the ecology of the map turtle, *Graptemys geographica* (LeSueur), in the northern part of its range. Canadian Journal of Zoology 58: 2210-2219.

Gutzke, W.H. and G.C. Packard. 1987. The influence of temperature on eggs and hatchlings of Blanding's turtles, *Emydoidea blandingii.* Journal of Herpetology 21: 161-163.

Halliday, Senn and Lewis Limited. 1939. Conservation Report: Point Pelee National Park. Unpublished report prepared for the Canadian Parks Service, Ontario Region, Point Pelee National Park, Leamington, Ontario.

Harding, J. Herpetologist, Michigan State University Museum. Personal Communication. (jharding@museum.cl.msu.edu). 15 April 1996.

Hough, Stansbury and Associates Limited. 1978. Point Pelee National Park: Resource Atlas. Unpublished report prepared for the Canadian Parks Service, Ontario Region, Point Pelee National Park, Leamington, Ontario.

Janzen, D.H. 1983. No park is an island: increase in interference from outside as park size decreases. Oikos 41: 402-410.

Kraus, D. 1991. Turtle nest predation study: Point Pelee National Park. Unpublished report for the Canadian Parks Service, Ontario Region, Point Pelee National Park, Leamington, Ontario. 23 pp.

_________. 1990. Herptile Management Plan Review Volume II: Species Accounts. Unpublished report for the Canadian Parks Service, Ontario Region, Point Pelee National Park, Leamington, Ontario. 124 pp.

Krebs, C.J. 1994. Ecology. 4th ed. New York: HarperCollins College Publishers. 801 pp.

Linck, M.H., J.A. DePari, B.O. Butler, and T.E. Graham. 1989. Nesting behaviour of the turtle *Emydoidea blandingi*, in Massachusetts. Journal of Herpetology 23: 442-444.

Linke, T. Park Warden, Resource Management, Point Pelee National Park. Personal Interview. January 1996.

MacCulloch, R.D. and D.M. Secoy. 1983. Movement in a river population of *Chrysemys picta bellii* in southern Saskatchewan. Journal of Herpetology 17: 283-285.

McLendon J.P. Harvard University. Personal Communication. (McLendon@aol.com). 26 January 1996.

Menefy, R.J. 1969. Muskrat Survey: Point Pelee National Park. Unpublished report prepared for the Canadian Parks Service, Ontario Region, Point Pelee National Park, Leamington, Ontario.

Obbard, M.E. and R.J. Brooks. 1987. Prediction of the onset of the annual nesting season of the common snapping turtle, *Chelydra serpentina*. Herpetologica 43: 324-328.

_________ and _________. 1981. A radio-telemetry and mark-recapture study of the activity in the common snapping turtle. Copeia 3: 630-637.

_________ and _________. 1980. Nesting migrations of the snapping turtle (*Chelydra serpentina*). Herpetologica 36: 158-162.

Parsons, H.J. 1982. Natural Resource Management Plan: Amphibians and Reptiles Point Pelee National Park. Unpublished report prepared for the Canadian Parks Service, Ontario Region, by Bufo Incorporated, Ecosystem Analysis and Scientific Communications, Ottawa, Ontario. 106 pp.

Pettit, K.E., C.A. Bishop, and R.J. Brooks. 1995. Home range and movements of the Common Snapping Turtle, (*Chelydra serpentina serpentina*), in a coastal wetland of Hamilton Harbour, Lake Ontario, Canada. Canadian Field-Naturalist 109: 192-200.

Petokas, P.J. and M.M. Alexander. 1980. The nesting of *Chelydra serpentina* in Northern New York. Journal of Herpetology 14: 239-244.

Ream, C. and R. Ream. 1966. The influence of sampling methods on the estimation of population structure in painted turtles. American Midland Naturalist 75: 325-338.

Rivard, D.H. and D.A. Smith. 1973. A Herpetological Inventory of Point Pelee National Park, Ontario. Unpublished report for the Canadian Parks Service. Department of Biology, Carleton University, Ottawa, File No. 33/5-R2-9, Contract No. 72-30. 107 pp.

Robinson C. and J. R. Bider. 1988. Nesting synchrony -- a strategy to decrease predation of snapping turtle (*Chelydra serpentina*) nests. Journal of Herpetology 22: 470-473.

Ross, D.A. 1989. Population ecology of painted and Blanding's turtles (*Chrysemys picta* and *Emydoidea blandingi*) in central Wisconsin. Wisconsin Academy of Science and Arts Letter 77: 77-84.

Rybarczyk, W.B. 1978. Evaluation of a spotlight survey technique as an index to Iowa white-tailed deer and raccoon populations. M.S. Thesis, Iowa State University. 54 pp.

Sanderson, G.C. 1987. Raccoons. In Wild Furbearer Management and Conservation in North America, eds. J.A. Baker, M.E. Obbard, and B. Malloch. Ontario Ministry of Natural Resources.

Seburn, D. Consultant, Seburn Ecological Services. Personal Communication. (aw964@freenet.carleton.ca). 12 April 1996.

Smith, S.M. Professor, Biology Department, University of Waterloo. Personal Communication. 7 April 1997.

Snow, J.E. 1982. Predation on painted turtle nests: nest survival as a function of nest age. Canadian Journal of Zoology 60: 3290-3292.

Stearns, S.C. 1976. Life-history tactics: a review of the ideas. Question and Review Biology. 51: 3-47.

Stephenson, W. Conservation Biologist, Department of Canadian Heritage, Parks Canada, Ontario Region. Personal Communication. March 1996.

Sutherland, W.J. 1996. Ecological census techniques. Cambridge University Press.

Temple, S.A. 1987. Predation on turtle nests increases near ecological edges. Copeia 1: 250-252.

Tinkle, D.J., J.D. Congdon, and P.C. Rosen. 1981. Nesting frequency and success: Implications for the demography of painted turtles. Ecology 62: 1426-1432.

Tuberville, T.D. and V.J. Burke. 1994. Do flag markers attract turtle predators? Journal of Herpetology 28: 514-516.

Yahner, R.H. and A.L. Wright. 1985. Depredation on artificial ground nests: effects of edge and plot age. Journal of Wildlife Management 49: 508-513.

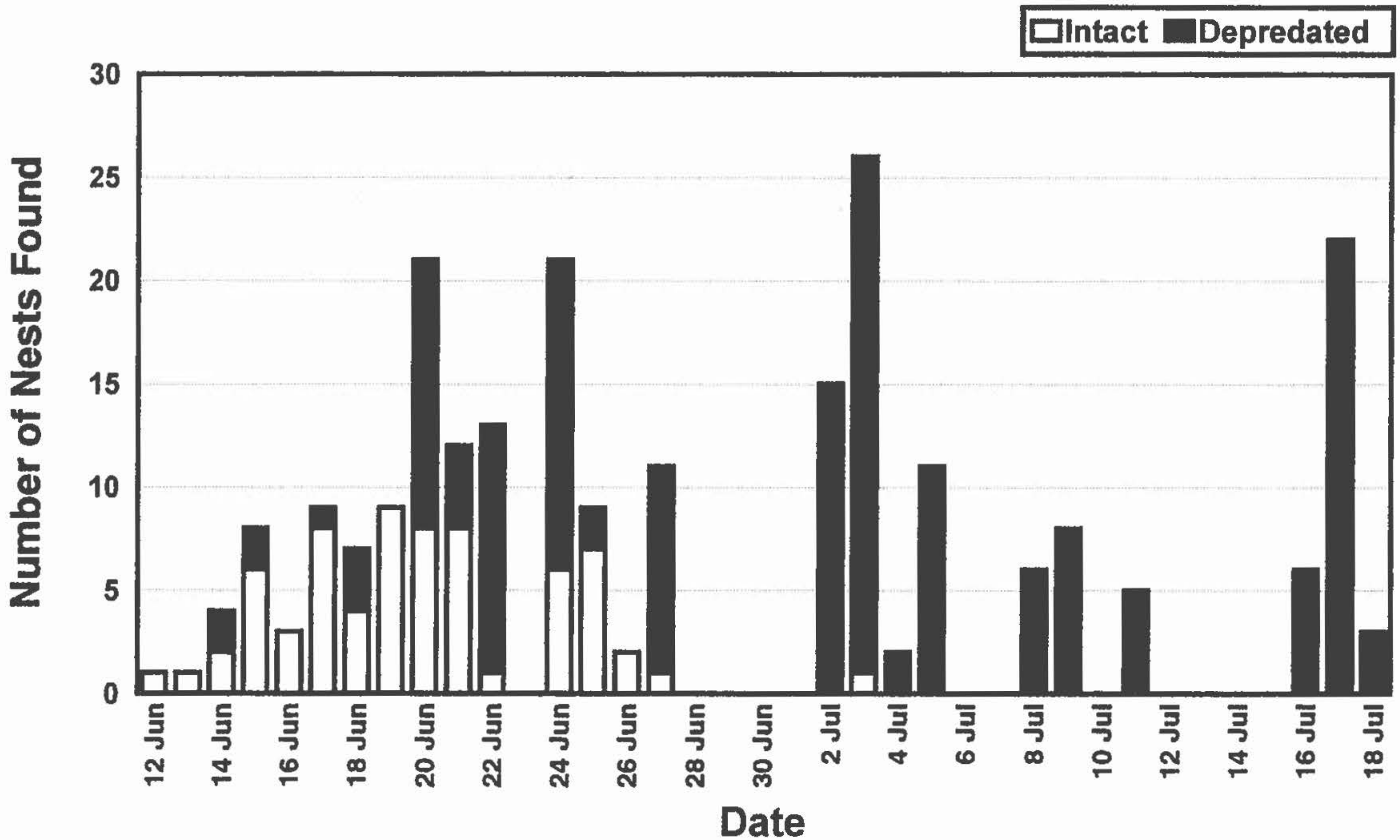


Figure 2. Total number of new turtle nests found (all species combined) for each day of nesting survey, Point Pelee National Park, Leamington, Ontario, Canada. The author did not survey on the days where the graph indicates no nests found. The seven nests found between 19 July and 15 August are also absent from the graph.

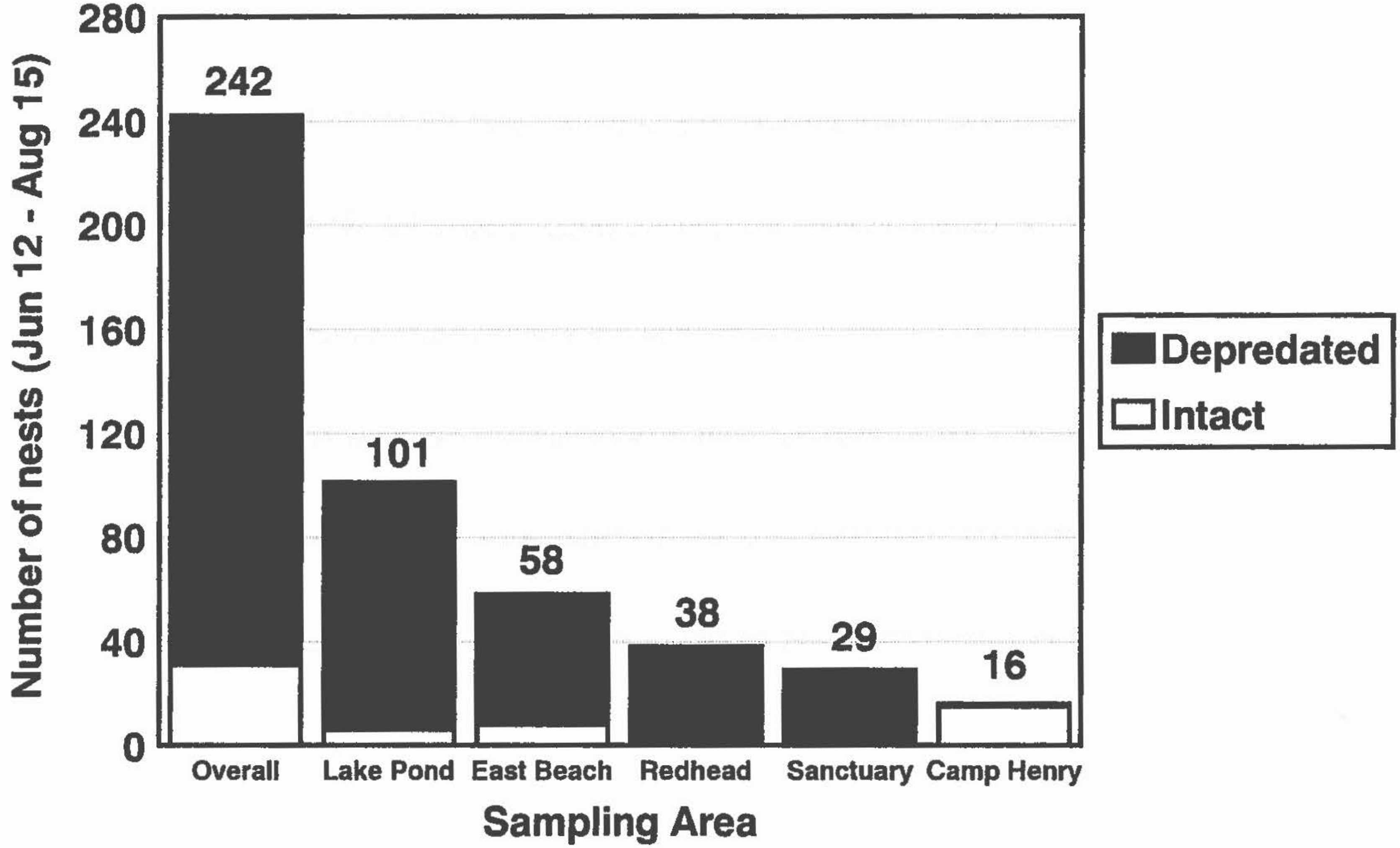
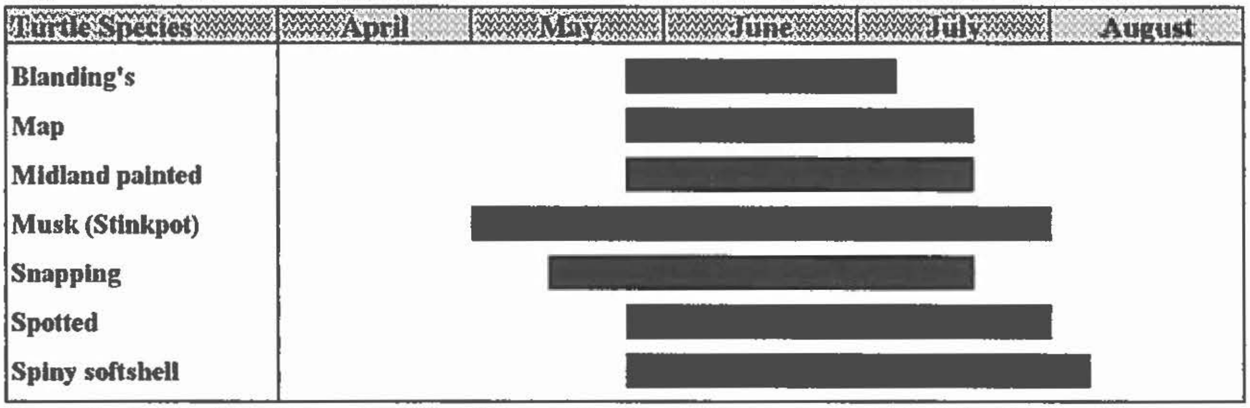


Figure 3. Total number of turtle nests found (all species combined) in each major sampling area, Point Pelee National Park, Leamington, Ontario, Canada.

Figure 4. Range of nesting periods for turtles in the northern latitudes of North America



Source: Ernst *et al.* 1994. Turtles of the United States and Canada. Washington: Smithonian Institution Press.

TABLE 1. TURTLE NESTING SITE SUMMARY -- POINT PELEE NATIONAL PARK, 1996

SANCTUARY POND

Specific Location	Overall Nest Statistics				
	Total Nests	Observed	Unobserved	Depredated	Rate
West Beach/Gate	1	0	1	1	100%
Administration	2	1	1	2	100%
Bunkhouse #50	2	0	2	1	50%
Sanctuary Picnic	1	0	1	1	100%
NWB Sign	4	3	1	4	100%
Blue Heron Picnic	3	2	1	3	100%
Marsh Boardwalk	7	1	6	7	100%
Trades Compound	1	0	1	1	100%
Private Residence	5	2	3	5	100%
Bunkhouse #220	2	2	0	2	100%
Unknown	1	0	1	1	100%
Total	**29**	**11**	**18**	**28**	**97%**

SANCTUARY POND

Nest Statistics by Turtle Species					
Snapping	Depredated	Rate	**Other**	Depredated	Rate
1	1	100%	0	0	nil
1	1	100%	1	1	100%
1	1	100%	1	0	0%
1	1	100%	0	0	nil
4	4	100%	0	0	nil
3	3	100%	0	0	nil
3	3	100%	4	4	100%
1	1	100%	0	0	nil
4	4	100%	1	1	100%
1	1	100%	1	1	100%
0	0	nil	1	1	100%
20	**20**	**100%**	**9**	**8**	**89%**

CAMP HENRY

Specific Location	Overall Nest Statistics				
	Total Nests	Observed	Unobserved	Depredated	Rate
Volleyball Pit	5	5	0	0	0%
Unknown	12	6	6	1	8%
Total	**17**	**11**	**6**	**1**	**6%**

CAMP HENRY

Nest Statistics by Turtle Species					
Snapping	Depredated	Rate	**Other**	Depredated	Rate
5	0	0%	0	0	0%
11	1	9%	0	0	0%
17	**1**	**6%**	**0**	**0**	**0%**

EAST BEACH

Specific Location	Overall Nest Statistics				
	Total Nests	Observed	Unobserved	Depredated	Rate
Shuster's-Redhead	19	1	18	15	79%
Redhead	10	1	9	7	70%
Redhead-Lake Pond	3	0	2	3	100%
Cedar Savanna	12	0	12	12	100%
Unknown	14	0	14	13	93%
Total	**58**	**2**	**55**	**50**	**86%**

EAST BEACH

Nest Statistics by Turtle Species					
Snapping	Depredated	Rate	**Other**	Depredated	Rate
19	15	79%	0	0	nil
5	2	40%	5	5	100%
2	2	100%	1	1	100%
5	5	100%	7	7	100%
11	11	100%	3	2	67%
42	**35**	**83%**	**16**	**15**	**94%**

REDHEAD POND

Specific Location	Total Nests	Observed	Unobserved	Depredated	Rate
	Overall Nest Statistics				
Plot A	10	1	9	10	100%
Plot Ba	10	1	9	9	90%
Plot Bb	3	0	3	3	100%
Plot C	8	0	8	8	100%
Plot D	7	0	7	7	100%
Total	**38**	**2**	**36**	**37**	**97%**

REDHEAD POND

Nest Statistics by Turtle Species					
Snapping	Depredated	Rate	**Other**	Depredated	Rate
3	3	100%	7	7	100%
3	2	67%	7	7	100%
1	1	100%	2	2	100%
1	1	100%	7	7	100%
2	2	100%	5	5	100%
10	**9**	**90%**	**28**	**28**	**100%**

LAKE POND

Specific Location	Total Nests	Observed	Unobserved	Depredated	Rate
	Overall Nest Statistics				
Northern	17	1	16	13	76%
Central	79	0	79	78	99%
Southern	5	0	5	4	80%
Total	**101**	**1**	**100**	**95**	**94%**

LAKE POND

Nest Statistics by Turtle Species					
Snapping	Depredated	Rate	**Other**	Depredated	Rate
13	9	69%	4	4	100%
15	15	100%	64	63	98%
3	3	100%	2	1	50%
31	**27**	**87%**	**70**	**68**	**97%**

POINT PELEE NATIONAL PARK

Specific Location	Total Nests	Observed	Unobserved	Depredated	Rate
	Overall Nest Statistics				
Sanctuary	29	11	18	28	97%
Camp Henry	16	11	5	1	6%
East Beach	46	2	43	38	83%
Redhead Pond	38	2	36	37	97%
Red Cedar Savanna	12	0	12	12	100%
Lake Pond	101	1	100	95	94%
Total	**242**	**27**	**214**	**211**	**87%**

POINT PELEE NATIONAL PARK

Nest Statistics by Turtle Species					
Snapping	Depredated	Rate	**Other**	Depredated	Rate
20	20	100%	9	8	89%
16	1	6%	0	0	nil
37	30	81%	9	8	89%
10	9	90%	28	28	100%
5	5	100%	7	7	100%
31	27	87%	70	68	97%
119	**92**	**77%**	**123**	**119**	**97%**

Table 3. Habitat requirements, basking behaviour, and seasonal activity of turtle species found in Point Pelee National Park.

Turtle Species	Habitat	Start	Most active	End	Basking
NATIVE TO PARK					
Blanding's Turtle (*Emydoidea blandingii*)	Productive eutrophic habitats with clean shallow water, a soft but firm organic bottom, and abundant aquatic vegetation.	late March early April	Throughout spring and summer Daytime (peak 0700 and 1600)	September	Fond of basking. Found basking on muskrat lodges, steep banks of dikes and ditches, stumps, logs, sedge clumps and cattail debris. Will bask with other Blanding's or painted turtles.
Common Map (*Graptemys geographica*)	Typically inhabitants of large bodies of water such as rivers and lakes. Usually avoids areas with emergent vegetation. Prefers areas where basking sites are abundant	April	Diurnal. Forages in morning and late afternoon and basks at midday.	late October early November	Females soon begin to bask after emerging in April. Basking activity is bimodal with peaks occurring in May-June and August. Sites are offshore, near deep water and exposed to sun. Are extremely wary when basking and will dive into water at slighest disturbance
Midland Painted (*Chrysemys picta marginata*)	Prefers slow-moving water, as in ponds, lakes, sloughs, oxbows, and creeks. Areas having a soft bottom, several basking sites and aquatic vegetation are preferred.	February early March	Diurnal. Most active in morning. Spends night sleeping at the bottom or on a partially submerged object	October	Basking is well developed in all age groups; as amny as 50 turtles can be seen on a log at one time. Basking usually lasts 2 hours peaking in the early morning around 11 A.M. Basking most frequent from April through September.
Common Musk (Stinkpot) (*Sternotherus odoratus*)	Resides in almost any waterway with a slow current and soft bottom such as rivers, streams, lakes, ponds, sloughs, canals, swamps, and oxbows.	April	Mainly nocturnal. During the day-light hours it is usually inactive, remaining buried in the mud or resting at the bottom. Most activity from 0400-1100 and 1700-2100.	October	Basking habit is poorly developed since turtle is seldomly found out of water. Most basking occurs while the turtle rests in shallow water with just the top of the carapace exposed to the sunlight. Occasionally will climb onto the bank or onto a fallen tree to bask.
Common Snapping (*Chelydra serpentina*)	Found in almost every kind of fresh-water habitat within its range. Prefers slow-moving water with a soft mud or sand bottom and abundant aquatic vegetation or an abundance of submerged brush and tree trunks.	April early May	Spring: evening and night; however, in northern Ontario nocturnal activity is rare. Most summer activity is in the morning or the evening. Juveniles in lab were most active between 0500-0600 and 0800-0900 and least active between 1200-1300 and 2300-2400.	late October	Arerial basking is restricted by intolerance to high temperatures and rapid loss of moisture; however, common in Ontario because of the cooler environment. Basking occurs while floating at the surface with just the head and top of the carapace exposed or on some low perch close to water.

Turtle Species	Habitat	Start	Most active	End	Basking
NATIVE TO PARK					
Spotted (*Clemmys guttata*)	Occupy a wide variety of shallow wetland habitats including swamps, bogs, fens, wet pastures, marshes, and small woodland streams. Requirements also include a soft substrate and some aquatic vegetation. In May, occupies flooded areas in fields and ecotones between forest and marsh. In mid-May, turtles leave pools and burrow into mats of decaying vegetation at the edge of fields.	late February early March	During daylight hours; only nesting females are active after dark. Daily activiy begins at sun-rise and peaks from around noon in March to early morning in the summer.	late October November	Not available
Eastern spiny softshell (*Trionyx spiniferus spiniferus*)	Primarily a riverine species but also inhabits marshy creeks, oxbows, lakes, and impoundments. A soft bottom with some aquatic vegetation seems essential, and sandbars and mud flats are usually present. Also found around fallen trees with spreading underwater limbs.	May	Daily activity takes place during daylight hours; at night the turtle sleeps buried in the bottom substrate or among the branches of submerged trees.	September	Seldom begins before 10 A.M. Spends much time basking on rocks, logs, mud, sandbanks, or floating debris. When basking on shore they are usually turned facing the water, ready to make a quick escape.
EXOTIC TO PARK					
Eastern box (*Terrapene carolina carolina*)	Predominately a species of open woodlands, although it also occurs in pastures and marshy meadows.	early April	May and June are most active months. In summer, activity is largely restricted to mornings and after rain.	October	In spring, most basking occurs in the morning.
Red-eared slider (*Trachemys scripta troostii*)	Occupies most freshwater habitats but prefers quiet waters with soft bottoms, an abundance of aquatic plants, and suitable basking sites	April	Diurnal; at night sliders sleep by resting on the bottom or floating at the surface.	November	Most conspicuous part of the daily activity cycle is basking; the habit is well developed. Basking begins at about 0800 and peaks between 1000-1100.

Source: Ernst *et al.* 1994. Turtles of the United States and Canada. Washington: Smithonian Institution Press.

APPENDIX 1 -- BIBLIOGRAPHY

Andrén, H., P. Angelstam, E. Lindström and P. Widén. 1985. Differences in predation pressure in relation to habitat fragmentation: an experiment. Oikos 45: 273-277.

Angelstam, P. 1986. Predation on ground-nesting birds' nests in relation to predator densities and habitat edge. Oikos 47: 365-373.

_________, E. Lindström, and P. Widén. 1984. Role of predation in short-term population fluctuations of some birds and mammals in Fennoscandia. Oecologia 62: 199-208.

Baker, B.W. 1980. Hair-catchers aid in identifying mammalian predators of ground-nesting birds. Wildlife Society Bulletin 8: 257-259.

_______. 1978. Ecological factors affecting wild turkey nest predation on South Texas rangelands. Proceedings of the Annual Conference of Southeastern Association of Fish and Wildlife Agencies 32: 126-136.

Balser, D. S., H.H. Dill, and H.K. Nelson. Effect of predator reduction on waterfowl nesting success. 1968. Journal of Wildlife Management 32: 669-682.

Berner, A. and L.W. Gysel. 1967. Raccoon use of large tree cavities and ground burrows. Journal of Wildlife Management 31: 706-714.

Bider, J. R. and W. Hoek. 1971. An efficient and apparently unbiased sampling technique for population studies of painted turtles. Herpetologica 27: 481-484.

Bigler, W.J. and G.L. Hoff. 1973. Anesthesia of raccoons with ketamine hydrochloride. Journal of Wildlife Management 38: 364-366.

Bowman, B.G. and L.D. Harris. 1980. Effect of spatial heterogeneity on ground-nest depredation. Journal of Wildlife Management 44: 806-813.

Brooks, R.J., G.P. Brown, and D.A. Galbraith. 1991. Effects of a sudden increase in natural mortality of adults on a population of the common snapping turtle (*Chelydra serpentina*). Canadian Journal of Zoology 69: 1314-1320.

_________, D.A. Galbraith, E.G. Nancekivell, and C.A. Bishop. 1988. Developing management guidelines for snapping turtles. In Management of Amphibians, Reptiles and Small Mammals in North America, United States Department of Agriculture Forest Service, July 19-21, Flagstaff Arizona. General Technical Report RM-166, pp. 174-179.

Brown, G.P., C.A. Bishop, and R.J. Brooks. 1994. Growth rate, reproductive output, and temperature selection of snapping turtles in habitats of different productivities. Journal of Herpetology 28: 405-410.

Burger, J. 1977. Determinants of hatching success in Diamondback Terrapin, *Malaclemys terrapin*. American Midland Naturalist 97: 444-464.

Canadian Parks Service. 1995. Point Pelee National Park Management Plan. Department of Canadian Heritage, Parks Service, Ontario Region. 64 pp.

_________. 1991. Park Conservation Plan: Point Pelee National Park. Environment Canada, Parks Service, Ontario Region. 161 pp.

_________. 1978. Investigating Canada's Deep South. Environment Canada, Parks Service, Ontario Region. 86 pp.

Christens, E. and J.R. Bider. 1987. Nesting activity and hatching success of the painted turtle (*Chrysemys picta marginata*) in Southwestern Quebec. Herpetologica 43: 55-65.

Clark, W.R., J.J. Hasbrouck, J.M. Kienzler, and T.F. Glueck. 1989. Vital statistics and harvest of an Iowa raccoon population. Journal of Wildlife Management 53: 982-990.

Congdon, J.D. and R.C. van Loben Sels. 1991. Growth and body size in Blanding's turtles (*Emydoidea blandingi*): Relationships to reproduction. Canadian Journal of Zoology 69: 239-245.

_________, G. L. Breitenbach, R. C. van Loben Sels, and D. W. Tinkle. 1987. Reproduction and nesting ecology of snapping turtles (*Chelydra serpentina*) in southeastern Michigan. Herpetologica 43: 39-54.

_________, D. W. Tinkle, G. L. Breitenbach, and R. C. van Loben Sels. 1983. Nesting ecology and hatching success in the turtle *Emydoidea blandingi*. Herpetologica 39: 417-429.

Conner, M.C. and R.F. Labisky. 1985. Evaluation of radioisotope tagging for estimating abundance of raccoon populations. Journal of Wildlife Management 49: 326-332.

Conover, M.R. 1990. Reducing mammalian predation on eggs by using a conditioned taste aversion to deceive predators. Journal of Wildlife Management 54: 360-365.

_________. 1989. Potential compounds for establishing conditioned food aversions in raccoons. Wildlife Society Bulletin 17: 430-435.

Cook, F.R., J.D. Lafontaine, S. Black, L. Luciuk and R.V. Lindsay. 1980. Spotted turtles (*Clemmys guttata*) in eastern Ontario and adjacent Quebec. Canadian Field Naturalist 94: 411-415.

Corn, P.S. and R.B. Bury. 1990. Sampling methods for terrestrial amphibians and reptiles. General Technical Report PNW-GTR-256, Portland, Oregon, USA, Department of Agriculture, Forest Service, Pacific Northwest Research Station, 34 pp.

Damas and Smith Ltd. 1982. An Assessment of Amphibian and Reptile Roadway Mortality and Reduction Measures: Point Pelee National Park. Unpublished report for the Canadian Parks Service, Ontario Region, Point Pelee National Park, Leamington, Ontario. 35 pp.

Davis, G. E. and M. C. Whiting. 1977. Loggerhead sea turtles nesting in Everglades National Park, Florida, USA. Herpetologica 33: 18-28.

Davis, H.B. 1907. The raccoon: a study in animal intelligence. American Journal of Psychology 18: 447-489.

Dodd Jr., C. K. 1985. Conserving sea turtles: constructive criticism still needed. Herpetologica 41: 103-111.

Duebbert, H.F. and J.T. Lokemoen. 1980. High duck nesting success in a predator-reduced environment. Journal of Wildlife Management 44: 428-437.

Endres, K.M. and W.P. Smith. 1993. Influence of age, sex, season and availability on den selection by raccoons within the Central Basin of Tennessee. American Midland Naturalist 129: 116-131.

Ernst, C.H., R.W. Barbour, and J.E. Lovich. 1994. Turtles of the United States and Canada. Washington: Smithsonian Institution Press.

_________ and G.R. Zug. 1994. Observations on the reproductive biology of the spotted turtle, *Clemmys guttata*, in Southeastern Pennsylvania. Journal of Herpetology 28: 99-102.

Ewert, M.A. and C.E. Nelson. 1991. Sex determination in turtles: diverse patterns and some possible adaptive values. Copeia 1: 50-69.

Fowler, L.E. 1979. Hatching success and nest predation in the green sea turtle, *Chelonia Mydas*, at Tortuguero, Costa Rica. Ecology 60: 946-955.

Frederick, P.C. and M.W. Collopy. 1989. The role of predation in determining reproductive success of colonially nesting wading birds in the Florida Everglades. The Condor 91: 860-867.

Fritzell, E.K, G.F. Hubert, Jr., B.E. Meyen, G.C. Sanderson. 1985. Age-specific reproduction in Illinois and Missouri raccoons. Journal of Wildlife Management 49: 901-905.

_________ and R.J. Greenwood. Mortality of raccoons in North Dakota. The Prairie Naturalist 16: 1-4.

_________. 1978. Aspects of raccoon (*Procyon lotor*) social organization. Canadian Journal of Zoology 56: 260-271.

_________. 1978. Habitat use by prairie raccoons during the waterfowl breeding season. Journal of Wildlife Management 42: 118-127.

Galbraith, D.A. and R.J. Brooks. 1989. Age estimates for snapping turtles. Journal of Wildlife Management 53: 502-508.

_________, C. A. Bishop, R. J. Brooks, W. L. Simser and K. P. Lampman. 1988. Factors affecting the density of populations of common snapping turtles (*Chelydra serpentina serpentina*). Canadian Journal of Zoology 66: 1233-1240.

_________ and R.J. Brooks. 1986. Survivorship of adult females in a northern population of common snapping turtles, *Chelydra serpentina*. Canadian Journal of Zoology 65: 1581-1586.

Gehrt, S.D. and E.K. Fritzell. 1996. Sex-biased response of raccoons (*Procyon lotor*) to live traps. American Midland Naturalist 135: 23-32.

Geomatics International Inc. 1992. Ecosystem Management Program: Point Pelee National Park (Volume 1 of 2). Unpublished report prepared for the Canadian Parks Service, Ontario Region, Point Pelee National Park, Leamington, Ontario. 52 pp.

Gibbons, J.W. 1987. Why do turtles live so long?. Bioscience 37: 262-269.

_________. 1982. Reproductive patterns in freshwater turtles. Herpetologica 38: 222-227.

_________. 1970. Terrestrial activity and the population dynamics of aquatic turtles. The American Midland Naturalist 83: 404-414.

_________. 1968. Population structure and survivorship in the painted turtle, *Chrysemys picta*. Copeia 2: 260-267.

_________. 1968. Observations on the ecology and population dynamics of the Blanding's turtle, *Emydoidea blandingi*. Canadian Journal of Zoology 46: 288-290.

Glueck, T.F., W.R. Clark and R.D. Andrews. 1988. Raccoon movement and habitat use during the fur harvest season. Wildlife Society Bulletin 16: 6-11.

Gordon, D.M. and R.D. MacCulloch. 1980. An investigation of the ecology of the map turtle, *Graptemys geographica* (LeSueur), in the northern part of its range. Canadian Journal of Zoology 58: 2210-2219.

Grau, G.A., G.C. Sanderson and J.P. Rogers. 1970. Age determination of raccoons. Journal of Wildlife Management 34: 366-371.

Greenwood, R.J. 1986. Influence of striped skunk removal on upland duck nest success in North Dakota. Wildlife Society Bulletin 14: 6-11.

_________, A.B. Sargeant, and D.H. Johnson. 1985. Evaluation of mark-recapture for estimating striped skunk abundance. Journal of Wildlife Management 49: 332-340.

Gutzke, W.H. and G.C. Packard. 1987. The influence of temperature on eggs and hatchlings of Blanding's turtles, *Emydoidea blandingii*. Journal of Herpetology 21: 161-163.

Halliday, Senn and Lewis Limited. 1939. Conservation Report: Point Pelee National Park. Unpublished report prepared for the Canadian Parks Service, Ontario Region, Point Pelee National Park, Leamington, Ontario.

Hamilton Jr., W. J. 1940. Observations on the reproductive behaviour of the snapping turtle. Copeia 2: 124-127.

Hanners, L.A. and W.E. Southern. A management alternative? Aversive conditioning of predators on colonially breeding birds. In Proceedings: Conference of the Colonial Waterbird Group, South-western Louisiana University, Lafayette, La., October 25-27, 1979, 3: 245-254.

Hasbrouck, J.J., W.R. Clark and R.D. Andrews. 1992. Factors associated with raccoon mortality in Iowa. Journal of Wildlife Management 56: 693-699.

Hoffman, C.O. and J.L. Gottschang. 1977. Numbers, distribution, and movements of a raccoon population in a suburban residential community. Journal of Mammalogy 58: 623-636.

Hough, Stansbury and Associates Limited. 1978. Point Pelee National Park: Resource Atlas. Unpublished report prepared for the Canadian Parks Service, Ontario Region, Point Pelee National Park, Leamington, Ontario.

Iverson, J.B. 1982. Biomass in turtle populations: a neglected subject. Oecologia 55: 69-76.

Janzen, D.H. 1983. No park is an island: increase in interference from outside as park size decreases. Oikos 41: 402-410.

Johnson, D.H, A.B. Sargeant, and R.J. Greenwood. 1988. Importance of individual species of predators on nesting success of ducks in the Canadian Prairie Pothole Region. Canadian Journal of Zoology 67: 291-297.

_________. 1979. Estimating nest success: the Mayfield method and an alternative. The Auk 96: 651-661.

Judson, J.J., W.R. Clark, and R.D. Andrews. 1994. Post-natal survival of raccoons in relation to female age and denning behaviour. Journal of Iowa Academic Science 101: 24-27.

Kissell Jr., R.E. and M.L. Kennedy. 1992. Ecologic relationships of co-occurring populations of opossums (*Didelphis virginiana*) and raccoons (*Procyon lotor*) in Tennessee. Journal of Mammalogy 73: 808-813.

Kraus, D. 1991. Turtle nest predation study: Point Pelee National Park. Unpublished report for the Canadian Parks Service, Ontario Region, Point Pelee National Park, Leamington, Ontario. 23 pp.

__________. 1990. Herptile Management Plan Review Volume II: Species Accounts. Unpublished report for the Canadian Parks Service, Ontario Region, Point Pelee National Park, Leamington, Ontario. 124 pp.

Krebs, C.J. 1994. Ecology. 4th ed. New York: HarperCollins College Publishers. 801 pp.

Krebs, C.J. 1989. Ecological Methodology. New York: Harper and Row.

Linck, M.H., J.A. DeParl, B.O. Butler, and T.E. Graham. 1989. Nesting behaviour of the turtle *Emydoidea blandingi*, in Massachusetts. Journal of Herpetology 23: 442-444.

Lokemoen, J.T. and R.O. Woodward. 1993. An assessment of predator barriers and predator control to enhance duck nest success on peninsulas. Wildlife Society Bulletin 21: 275-282.

Lowell, K.N., T.E. Hoffman, and C.R. Gustavson. 1982. Taste aversion conditioning in free ranging raccoons (*Procyon lotor*). Northwest Science 56: 165-169.

MacCulloch, R.D. and D.M. Secoy. 1983. Movement in a river population of *Chrysemys picta bellii* in southern Saskatchewan. Journal of Herpetology 17: 283-285.

Mayfield, H.F. 1975. Suggestions for calculating nest success. The Wilson Bulletin 87: 456-466.

McClearn, D. 1992. Locomotion, posture, and feeding behaviour of kinkajous, coatis, and raccoons. Journal of Mammalogy 73: 245-261.

Mech, D.L., D.M. Barnes and J.R. Tester. 1968. Seasonal weight changes, mortality, and population structure of raccoons in Minnesota. Journal of Mammalogy 49: 63-73.

__________, J.R. Tester, and D.W. Warner. 1966. Fall daytime resting habits of raccoons as determined by telemetry. Journal of Mammalogy 47: 450-466.

Meeks, R.L. 1990. Overwintering behaviour of snapping turtles. Copeia 3: 880-884.

Menefy, R.J. 1969. Muskrat Survey: Point Pelee National Park. Unpublished report prepared for the Canadian Parks Service, Ontario Region, Point Pelee National Park, Leamington, Ontario.

Moore, D.W. and M.L. Kennedy. 1985. Factors affecting response of raccoons to traps and population size estimation. American Midland Naturalist 114: 192-197.

Nicolaus, L.K. 1987. Conditioned aversions in a guild of egg predators: implications for aposematism and prey defense mimicry. American Midland Naturalist 117: 405-419.

Obbard, M.E. and R.J. Brooks. 1987. Prediction of the onset of the annual nesting season of the common snapping turtle, *Chelydra serpentina*. Herpetologica 43: 324-328.

_________ and _________. 1981. A radio-telemetry and mark-recapture study of the activity in the common snapping turtle. Copeia 3: 630-637.

_________ and _________. 1980. Nesting migrations of the snapping turtle (*Chelydra serpentina*). Herpetologica 36: 158-162.

Pappas, M.J. and B.J. Brecke. 1992. Habitat selection of juvenile Blanding's turtles *Emydoidea blandingii*. Journal of Herpetology 26: 233-234.

Parker, S. 1995. Herpetofaunal Conservation Plan: Bruce Peninsula National Park and Fathom Five National Park. Unpublished report prepared for the Canadian Parks Service, Ontario Region, Bruce Peninsula National Park, Tobermory, Ontario. 49 pp.

Parsons, H.J. 1982. Natural Resource Management Plan: Amphibians and Reptiles Point Pelee National Park. Unpublished report prepared for the Canadian Parks Service, Ontario Region, by Bufo Incorporated, Ecosystem Analysis and Scientific Communications, Ottawa, Ontario. 106 pp.

Petokas, P.J. and M.M. Alexander. 1980. The nesting of *Chelydra serpentina* in Northern New York. Journal of Herpetology 14: 239-244.

Pettit, K.E., C.A. Bishop, and R.J. Brooks. 1995. Home range and movements of the Common Snapping Turtle, (*Chelydra serpentina serpentina*), in a coastal wetland of Hamilton Harbour, Lake Ontario, Canada. Canadian Field-Naturalist 109: 192-200.

Point Pelee National Park Warden Service. 1996. Park Road Kill Records: 1979-1996. Point Pelee National Park, Leamington, Ontario. Unpublished.

Pritchard, P.C.H. 1980. The conservation of sea turtles: practices and problems. American Zoologist 20: 609-617.

Proulx, G. and R.K. Drescher. 1994. Assessment of rotating-jaw traps to humanely kill raccoons (*Procyon lotor*). Journal of Wildlife Diseases 30: 335-339.

Richardson, T. 1987. Turtle species may be in danger. Windsor Star. August 1.

Ream, C. and R. Ream. 1966. The influence of sampling methods on the estimation of population structure in painted turtles. American Midland Naturalist 75: 325-338.

Rivard, D.H. and D.A. Smith. 1973. A Herpetological Inventory of Point Pelee National Park,Ontario. Unpublished report for the Canadian Parks Service. Department of Biology, Carleton University, Ottawa, File No. 33/5-R2-9, Contract No. 72-30. 107 pp.

Robb, J.R and T.A. Bookhout. 1995. Factors influencing wood duck use of natural cavities. Journal of Wildlife Management 59: 372-383.

Robinson C. and J. R. Bider. 1988. Nesting synchrony – a strategy to decrease predation of snapping turtle (*Chelydra serpentina*) nests. Journal of Herpetology 22: 470-473.

Rolley, R.E. and L.E. Lehman. 1992. Relationships among raccoon road-kill surveys, harvests, and traffic. Wildlife Society Bulletin 20: 313-318.

Ross, D.A. 1989. Population ecology of painted and Blanding's turtles (*Chrysemys picta* and *Emydoidea blandingi*) in central Wisconsin. Wisconsin Academy of Science and Arts Letter 77: 77-84.

__________. 1988. *Chrysemys picta* (Painted Turtle) predation. Herp Review 19: 85-86.

Rowe, J.W. and E.O. Moll. 1991. A radiotelemetric study of activity and movements of the Blanding's turtle (Emydoidea blandingi) in Northeastern Illinois. Journal of Herpetology 25: 178-185.

Rybarczyk, W.B. 1978. Evaluation of a spotlight survey technique as an index to Iowa white-tailed deer and raccoon populations. M.S. Thesis, Iowa State University. 54 pp

Sanderson, G.C. 1987. Raccoons. In Wild Furbearer Management and Conservation in North America, eds. J.A. Baker, M.E. Obbard, and B. Malloch. Ontario Ministry of Natural Resources.

Schnell, J.H. 1970. Rest site selection by radio-tagged raccoons. Journal of the Minnesota Academy of Science 36: 83-88.

Schwarzkopf, L. and R.J. Brooks. 1986. Annual variations in reproductive characteristics of painted turtles (*Chrysemys picta*). Canadian Journal of Zoology 64: 1148-1151.

Semel, B. and L.K. Nicolaus. 1992. Estrogen-based aversion to eggs among free-ranging raccoons. Ecological Applications 2: 439-449.

Simberloff, D. and L.G. Abele. 1982. Refuge design and island biogeographic theory: effects of fragmentation. The American Naturalist 120: 41-50.

Smith, R.L. 1992. Elements of Ecology. 3d ed. New York: HarperCollins Publishers Inc.

Smith, S.M. 1997. Population biology. Biology 456 Lecture Supplements, Department of Biology, University of Waterloo, Waterloo, Ontario, Canada. 130 pp.

Smith, W.P., D.L. Borden, and K.M. Endres. 1994. Scent-station visits as an index to abundance of raccoons: an experimental manipulation. Journal of Mammalogy 75: 637-647.

Snow, J.E. 1982. Predation on painted turtle nests: nest survival as a function of nest age. Canadian Journal of Zoology 60: 3290-3292.

Sokal, Robert R. and F. James Rohlf. 1995. Biometry. 3d ed. New York: W.H. Freeman and Company. 850 pp.

Stearns, S.C. 1976. Life-history tactics: a review of the ideas. Question and Review Biology. 51: 3-47.

Stevens, J., C. Nixon, and J. Suver. 1995. Some aspects of raccoon life history in Lee County, Illinois. Illinois State Academy of Science 88: 49-59.

Stubbs, D., I.R. Swingland, A. Hailey, and E.Pulford. 1985. The ecology of the Mediterranean Tortoise *Testudo hermanni* in Northern Greece (The effects of a catastrophe on population structure and density). Biological Conservation 31: 125-152.

Sutherland, W.J. 1996. Ecological census techniques. Cambridge University Press.

Temple, S.A. 1987. Predation on turtle nests increases near ecological edges. Copeia 1: 250-252.

__________ and B.A. Wilcox. 1986. Introduction: predicting effects of habitat patchiness and fragmentation. In Wildlife 2000: Modeling Habitat Relationships of Terrestrial Vertebrates, J. Verner, M.L. Morrison and C.J. Ralph, eds, pp. 261-262. The University of Wisconsin Press: Based on an International Symposium Held at Stanford Sierra Camp, Fallen Leaf Lake, California, 7-11 October, 1984.

Tester, J.R. 1953. Fall food habits of the raccoon in the South Platter Valley of Northeastern Colorado. Journal of Mammalogy 34: 500-502.

Tinkle, D.J., J.D. Congdon, and P.C. Rosen. 1981. Nesting frequency and success: Implications for the demography of painted turtles. Ecology 62: 1426-1432.

__________. 1979. Long-term field studies. BioScience 29: 717.

Tuberville, T.D. and V.J. Burke. 1994. Do flag markers attract turtle predators? Journal of Herpetology 28: 514-516.

Whilhoft, D. C., M. G. Del Baglivo, and M. D. Del Baglivo. 1979. Observations on mammalian predation of snapping turtle nests. Journal of Herpetology 13: 435-438.

Wilcove, D.S. 1985. Nest predation in forest tracts and the decline of migratory songbirds. Ecology 66: 1211-1214.

Woodbury, A.M. 1953. Methods of field studies in reptiles. Herpetologica 9: 87-91.

Yahner, R.H. and A.L. Wright. 1985. Depredation on artificial ground nests: effects of edge and plot age. Journal of Wildlife Management 49: 508-513.

Yntema, C. L. 1970. Observations on females and eggs of the common snapping turtle, (*Chelydra serpentina*). The American Midland Naturalist 84: 69-76.

APPENDIX 2

MAPS OF NEST LOCATIONS IN EACH OF THE SAMPLING AREAS IN POINT PELEE NATIONAL PARK

TURTLE NESTING SITE SUMMARY -- POINT PELEE NATIONAL PARK, 1996

SANCTUARY POND SAMPLING AREA

Site # (O/U)*	Date Found	Specific Location	Date Depredated	# Days **	Turtle Species	Suspected Predator
SP1 (O)	12-Jun	NWB Sign	16-Jun	4	Snapping	Raccoon
SP2 (U)	13-Jun	West Beach/Gate	Unknown	?	Snapping	Raccoon
SP3 (U)	15-Jun	NWB Sign	16-Jun	1	Snapping	Raccoon
SP4 (U)	15-Jun	Blue Heron	When Found	Nil	Snapping	Raccoon
SP5 (U)	14-Jun	Private Res.	When Found	Nil	Snapping	Raccoon
SP6 (U)	16-Jun	Sanc. Picnic	21-Jun	5	Snapping	Raccoon
SP7 (O)	18-Jun	Admin./Road	19-Jun	1	Snapping	Raccoon
SP8 (O)	17-Jun	NWB Sign	18-Jun	1	Snapping	Raccoon
SP9 (O)	19-Jun	NWB Sign	19-Jun	0	Snapping	Raccoon
SP10 (O)	19-Jun	Bunkhouse #220	23-Jun	4	Painted	Raccoon
SP11 (O)	19-Jun	Bunkhouse #220	20-Jun	1	Snapping	Raccoon
SP12 (U)	19-Jun	Not Recorded	26-Jun	7	Other	Raccoon
SP13 (U)	20-Jun	Bunkhouse #50	21-Jun	1	Snapping	Raccoon
SP14 (U)	21-Jun	Private Res.	When Found	Nil	Snapping	Raccoon
SP15 (O)	21-Jun	Private Res.	22-Jun	1	Snapping	Raccoon
SP16 (O)	21-Jun	Private Res.	25-Jun	4	Painted	Raccoon
SP17 (O)	21-Jun	Blue Heron	22-Jun	1	Snapping	Raccoon
SP18 (U)	21-Jun	Private Res.	24-Jun	3	Snapping	Raccoon
SP19 (U)	25-Jun	Marsh Boardwalk	Unknown	Nil	Other	Raccoon
SP20 (U)	25-Jun	Trades Compound	Unknown	Nil	Snapping	Raccoon
SP21 (O)	26-Jun	Boardwalk, Park Lot	Unknown	Unknown	Snapping	Raccoon
SP22 (U)	11-Jul	Blue Heron	When Found	Nil	Snapping	Raccoon
SP23 (U)	11-Jul	Marsh Boardwalk	When Found	Nil	Other	Raccoon
SP24 (U)	11-Jul	Marsh Boardwalk	When Found	Nil	Snapping	Raccoon
SP25 (U)	11-Jul	Marsh Boardwalk	When Found	Nil	Other	Raccoon
SP26 (U)	11-Jul	Admin. Building	When Found	Nil	Other	Raccoon
SP27 (U)	16-Jul	Bunkhouse #50	Nil	Nil	Painted	Nil
SP28 (U)	18-Jul	Marsh-Bunk. #220	When Found	Nil	Other	Raccoon
SP29 (U)	30-Jul	Marsh Boardwalk	When Found	Nil	Snapping	Raccoon

* (O/U) = Observed / Unobserved

** The number of days between time that nest was constructed and when nest was found depredated

CAMP HENRY

Site # (O/U)*	Date Found	Specific Location	Date Depredated	# Days **	Turtle Species	Suspected Predator
CH1 (O)	17-Jun	Volleyball Pit	Nil	Nil	Snapping	Nil
CH2 (O)	17-Jun	Volleyball Pit	Nil	Nil	Snapping	Nil
CH3 (O)	17-Jun	Volleyball Pit	Nil	Nil	Snapping	Nil
CH4 (O)	20-Jun	Volleyball Pit	Nil	Nil	Snapping	Nil
CH5 (O)	20-Jun	Volleyball Pit	Nil	Nil	Snapping	Nil
CH6 (O)	20-Jun	Septic Bed Hill	Nil	Nil	Snapping	Nil
CH7 (O)	20-Jun	Septic Bed Hill	Nil	Nil	Snapping	Nil
CH8 (O)	20-Jun	Septic Bed Hill	Nil	Nil	Snapping	Nil
CH9 (U)	21-Jun	Grass Field	Nil	Nil	Snapping	Nil
CH10 (O)	24-Jun	Volleyball Pit	Nil	Nil	Snapping	Nil
CH11 (O)	24-Jun	Septic Bed Hill	Nil	Nil	Snapping	Nil
CH12 (O)	24-Jun	Septic Bed Hill	Nil	Nil	Snapping	Nil
CH13 (U)	24-Jun	Grass Field	When Found	Unknown	Snapping	Raccoon
CH14 (U)	25-Jun	Grass Field	Nil	Nil	Snapping	Nil
CH15 (U)	25-Jun	Volleyball Pit	Nil	Nil	Snapping	Nil
CH16 (U)	25-Jun	Edge of Bunkhouse	Nil	Nil	Snapping	Nil
CH17 (U)	25-Jun	Volleyball Pit	Nil	Nil	Snapping	Nil

* (O/U) = Observed / Unobserved

** The number of days between time that nest was constructed and when nest was found depredated

EAST BEACH SAMPLING AREA

Site # (O/U)*	Date Found	Specific Location	Date Depredated	# Days **	Turtle Species	Suspected Predator
EB1 (U)	14-Jun	Btw. Shuster's and Redhead	Nil	Nil	Snapping	Nil
EB2 (U)	14-Jun	Btw. Redhead and Lake Pond	Nil	Nil	Other	Nil
EB3 (U)	16-Jun	Btw. Shuster's and Redhead	24-Jun	8	Snapping	Raccoon
EB3 (O)	26-Jun	Btw. Shuster's and Redhead	2-Jul	6	Snapping	Raccoon
EB4 (U)	16-Jun	Btw. Redhead and Lake Pond	Unknown	Unknown	Snapping	Raccoon
EB5 (U)	17-Jun	Outside Redhead	Unknown	Unknown	Snapping	Raccoon
EB6 (U)	17-Jun	Outside Redhead	Nil	Nil	Snapping	Nil
EB7 (U)	19-Jun	Btw. Shuster's and Redhead	Nil	Nil	Snapping	Nil
EB8 (U)	19-Jun	Btw. Shuster's and Redhead	20-Jun	1	Snapping	Raccoon
EB9 (U)	19-Jun	Outside Redhead	Nil	Nil	Snapping	Nil
EB10 (U)	20-Jun	Btw. Shuster's and Redhead	When Found	Nil	Snapping	Raccoon
EB11 (U)	20-Jun	Btw. Shuster's and Redhead	When Found	Nil	Snapping	Raccoon
EB12 (U)	20-Jun	Btw. Shuster's and Redhead	When Found	Nil	Snapping	Raccoon
EB13 (U)	20-Jun	Btw. Shuster's and Redhead	When Found	Nil	Snapping	Raccoon
EB14 (U)	20-Jun	Btw. Shuster's and Redhead	When Found	Nil	Snapping	Raccoon

EAST BEACH SAMPLING AREA

Site # (O/U)*	Date Found	Specific Location	Date Depredated	# Days **	Turtle Species	Suspected Predator
EB15 (U)	20-Jun	Btw. Shuster's and Redhead	When Found	Nil	Snapping	Raccoon
EB16 (U)	20-Jun	Btw. Redhead and Lake Pond	When Found	Nil	Snapping	Raccoon
EB17 (U)	21-Jun	Btw. Shuster's and Redhead	Nil	Nil	Snapping	Nil
EB18 (U)	21-Jun	Btw. Shuster's and Redhead	When Found	Nil	Snapping	Raccoon
EB19 (U)	21-Jun	Btw. Shuster's and Redhead	When Found	Nil	Snapping	Raccoon
EB20 (U)	21-Jun	Outside Redhead	Nil	Nil	Snapping	Nil
EB21 (U)	21-Jun	Outside Redhead	When Found	Nil	Snapping	Raccoon
EB22 (U)	22-Jun	Btw. Shuster's and Redhead	Nil	Nil	Snapping	Nil
EB23 (U)	22-Jun	Btw. Shuster's and Redhead	When Found	Nil	Snapping	Raccoon
EB24 (U)	22-Jun	Btw. Shuster's and Redhead	When Found	Nil	Snapping	Raccoon
EB25 - EB26 (U)	22-Jun	Btw. Shuster's and Redhead	When Found	Nil	Snapping	Raccoon
EB27 - EB28 (U)	24-Jun	Btw. Shuster's and Redhead	When Found	Nil	Snapping	Raccoon
EB29 (U)	24-Jun	Btw. Redhead and Lake Pond	When Found	Nil	Snapping	Raccoon
EB30 (U)	24-Jun	Btw. Redhead and Lake Pond	When Found	Nil	Snapping	Raccoon
EB31 - EB32 (U)	24-Jun	Btw. Redhead and Lake Pond	When Found	Nil	Snapping	Raccoon
EB33 (U)	24-Jun	Btw. Redhead and Lake Pond	Nil	Nil	Map	Nil
EB34 (U)	24-Jun	Outside Redhead	When Found	Nil	Other	Raccoon
EB35 (O)	25-Jun	Outside Redhead	27-Jun	2	Painted	Raccoon
EB36 (U)	2-Jul	Outside Redhead	When Found	Nil	Snapping	Raccoon
EB37 - EB38 (U)	2-Jul	Btw. Redhead and Lake Pond	When Found	Nil	Other	Raccoon
EB39 (U)	2-Jul	Btw. Redhead and Lake Pond	When Found	Nil	Other	Raccoon
EB40 - EB43 (U)	3-Jul	Btw. Shuster's and Redhead	When Found	Nil	Snapping	Raccoon
EB44 - EB46 (U)	8-Jul	Btw. Redhead and Lake Pond	When Found	Nil	Other	Raccoon

RED CEDAR SAVANNA SAMPLING AREA (Included in East Beach statistics)

Site # (O/U)*	Date Found	Specific Location	Date Depredated	# Days **	Turtle Species	Suspected Predator
RCS1 (U)	24-Jun	Not Recorded	When Found	Nil	Other	Raccoon
RCS2 - RCS3 (U)	24-Jun	Not Recorded	When Found	Nil	Snapping	Raccoon
RCS4 - RCS8 (U)	2-Jul	Not Recorded	When Found	Nil	Other	Raccoon
RCS9 - RCS10 (U)	2-Jul	Not Recorded	When Found	Nil	Snapping	Raccoon
RCS11 (U)	4-Jul	Not Recorded	When Found	Nil	Snapping	Raccoon
RCS12 (U)	4-Jul	Not Recorded	When Found	Nil	Other	Raccoon

* (O/U) = Observed / Unobserved

** The number of days between time that nest was constructed and when nest was found depredated

LAKE POND SAMPLING AREA

Site # (O/U)*	Date Found	Specific Location	Date Depredated	# Days **	Turtle Species	Suspected Predator
LP1 (U)	14-Jun	Not Recorded	When Found	Nil	Other	Raccoon
LP2 (U)	15-Jun	Not Recorded	16-Jun	1	Other	Raccoon
LP3 (U)	15-Jun	Not Recorded	16-Jun	1	Other	Raccoon
LP4 (U)	15-Jun	Not Recorded	Unknown	?	Snapping	Raccoon
LP5 (U)	15-Jun	Not Recorded	Nil	Nil	Map	Nil
LP6 (U)	17-Jun	Not Recorded	2-Jul	16	Snapping	Raccoon
LP7 (U)	17-Jun	Not Recorded	When Found	Nil	Snapping	Raccoon
118 (O)	18-Jun	Not Recorded	Unknown	Nil	Snapping	Nil
LP8 (U)	17-Jun	Not Recorded	When Found	Nil	Snapping	Raccoon
LP9 (U)	18-Jun	Not Recorded	Nil	Nil	Snapping	Nil
LP10 (U)	18-Jun	Not Recorded	When Found	Nil	Snapping	Raccoon
LP11 (U)	18-Jun	Not Recorded	When Found	Nil	Snapping	Raccoon
LP12 (U)	18-Jun	Not Recorded	When Found	Nil	Other	Raccoon
LP13 (U)	20-Jun	Not Recorded	When Found	Nil	Other	Raccoon
LP14 (U)	20-Jun	Not Recorded	When Found	Nil	Snapping	Raccoon
LP15 (U)	20-Jun	Not Recorded	Nil	Nil	Snapping	Nil
LP16 (U)	20-Jun	Not Recorded	Nil	Nil	Snapping	Nil
LP17 (U)	20-Jun	Not Recorded	When Found	Nil	Snapping	Raccoon
LP18 (U)	20-Jun	Not Recorded	When Found	Nil	Snapping	Raccoon
LP19 (U)	21-Jun	Not Recorded	15-Aug	Nil	Snapping	Coyote
LP20 - LP21 (U)	22-Jun	Not Recorded	When Found	Nil	Snapping	Raccoon
LP22 (U)	22-Jun	Not Recorded	When Found	Nil	Other	Raccoon
LP23 (U)	22-Jun	Not Recorded	When Found	Nil	Snapping	Raccoon
LP24 (U)	22-Jun	Not Recorded	When Found	Nil	Snapping	Raccoon
LP25 (U)	22-Jun	Not Recorded	When Found	Nil	Snapping	Raccoon
LP26 (U)	24-Jun	Not Recorded	Nil	Nil	Other	Nil
LP27 (U)	24-Jun	Not Recorded	When Found	Nil	Other	Raccoon
LP28 (U)	24-Jun	Not Recorded	When Found	Nil	Snapping	Raccoon
LP29 - LP30 (U)	24-Jun	Not Recorded	When Found	Nil	Snapping	Raccoon
LP31 (U)	25-Jun	Not Recorded	When Found	Nil	Snapping	Raccoon
LP32 (U)	25-Jun	Not Recorded	When Found	Nil	Other	Raccoon
LP33 (U)	25-Jun	Not Recorded	27-Jun	2	Snapping	Raccoon
LP34 (U)	27-Jun	Not Recorded	2-Jul	5	Snapping	Raccoon
LP35 (U)	27-Jun	Not Recorded	When Found	Nil	Other	Raccoon
LP36 - LP40 (U)	27-Jun	Not Recorded	When Found	Nil	Other	Raccoon
LP41 - LP43 (U)	27-Jun	Not Recorded	When Found	Nil	Other	Raccoon
LP44 (U)	27-Jun	Not Recorded	When Found	Nil	Snapping	Raccoon
LP45 - LP46 (U)	2-Jul	Not Recorded	When Found	Nil	Other	Raccoon
LP47 (U)	2-Jul	Not Recorded	When Found	Nil	Snapping	Raccoon
LP48 (U)	2-Jul	Not Recorded	When Found	Nil	Other	Raccoon

LAKE POND SAMPLING AREA

Site # (O/U)*	Date Found	Specific Location	Date Depredated	# Days **	Turtle Species	Suspected Predator
LP49 - LP51 (U)	3-Jul	Not Recorded	When Found	Nil	Other	Raccoon
LP52 - LP53 (U)	5-Jul	Not Recorded	When Found	Nil	Other	Raccoon
LP54 - LP59 (U)	5-Jul	Not Recorded	When Found	Nil	Other	Raccoon
LP60 (U)	5-Jul	Not Recorded	When Found	Nil	Other	Raccoon
LP61 (U)	5-Jul	Not Recorded	When Found	Nil	Other	Raccoon
LP62 (U)	5-Jul	Not Recorded	When Found	Nil	Other	Raccoon
LP63 (U)	9-Jul	Not Recorded	When Found	Nil	Other	Raccoon
LP64 (U)	9-Jul	Not Recorded	When Found	Nil	Other	Raccoon
LP65 (U)	9-Jul	Not Recorded	When Found	Nil	Snapping	Raccoon
LP66 (U)	9-Jul	Not Recorded	When Found	Nil	Other	Raccoon
LP67 (U)	9-Jul	Not Recorded	When Found	Nil	Other	Raccoon
LP68 (U)	9-Jul	Not Recorded	When Found	Nil	Other	Raccoon
LP69 (U)	9-Jul	Not Recorded	When Found	Nil	Other	Raccoon
LP70 (U)	9-Jul	Not Recorded	When Found	Nil	Other	Raccoon
LP71 (U)	9-Jul	Not Recorded	When Found	Nil	Other	Raccoon
LP72 (U)	9-Jul	Not Recorded	When Found	Nil	Snapping	Raccoon
LP73 - LP94 (U)	17-Jul	Not Recorded	When Found	Nil	Other	Raccoon
LP95 - LP96 (U)	18-Jul	Not Recorded	When Found	Nil	Other	Raccoon
LP97 (U)	2-Aug	Not Recorded	When Found	Nil	Other	Raccoon
LP98 (U)	16-Aug	Not Recorded	When Found	Nil	Snapping	Raccoon
LP99 (U)	18-Jun	Not Recorded	When Found	Nil	Snapping	Raccoon
LP100 (U)	24-Jun	Not Recorded	When Found	Nil	Map	Nil
LP101 (U)	3-Jul	Not Recorded	When Found	Nil	Other	Raccoon

* (O/U) = Observed / Unobserved

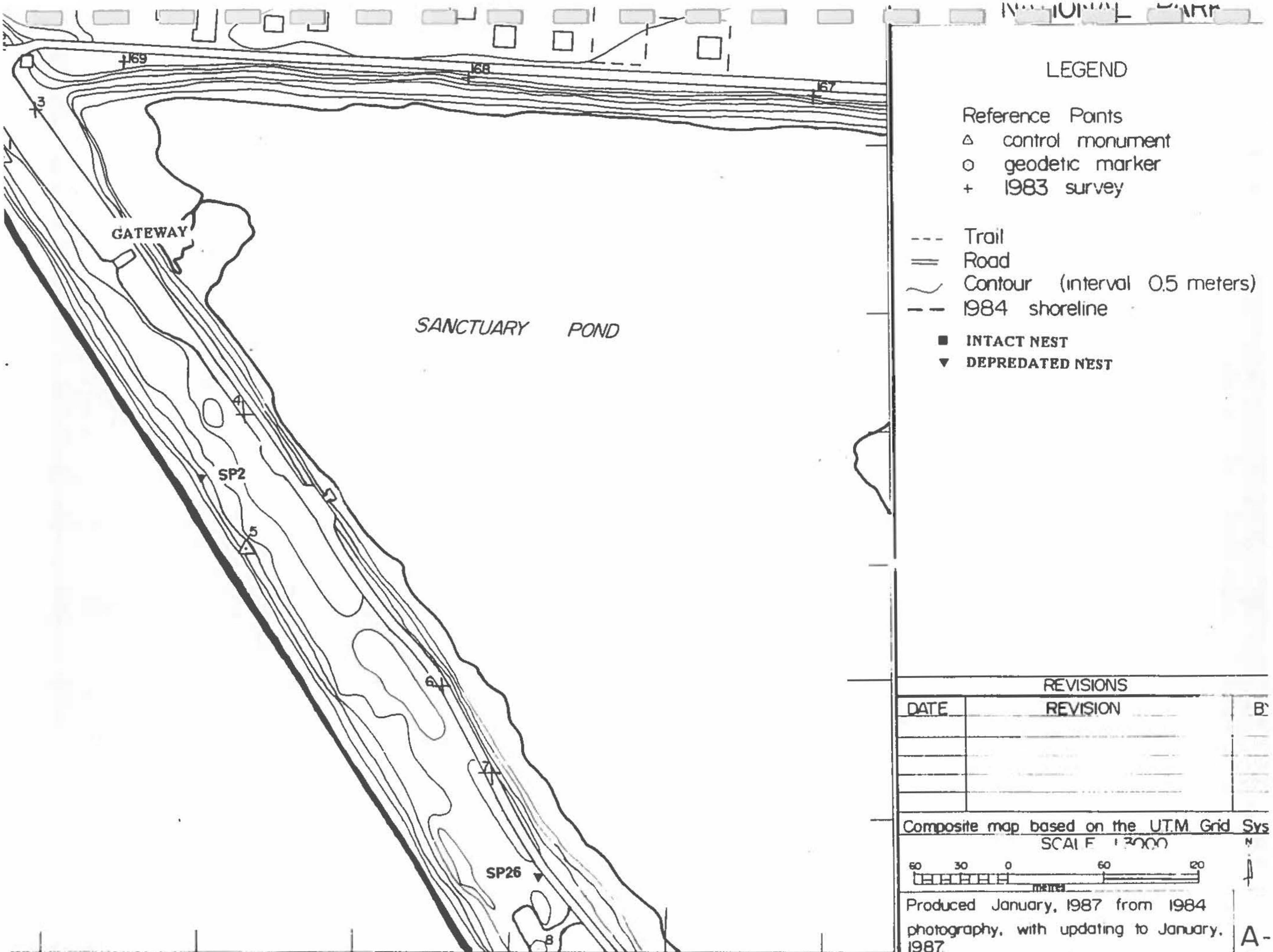
** The number of days between time that nest was constructed and when nest was found depredated

REDHEAD POND SAMPLING AREA

Site # (O/U)*	Date Found	Specific Location	Date Depredated	# Days **	Turtle Species	Suspected Predator
RH1 (U)	15-Jun	Plot A	When Found	Nil	Snapping	Raccoon
RH2 (U)	15-Jun	Plot A	17-Jun	2	Snapping	Raccoon
RH3 (O)	18-Jun	Plot B	Nil	Nil	Snapping	Nil
RH4 (U)	19-Jun	Plot B	22-Jun	3	Snapping	Raccoon
RH5 (U)	19-Jun	Plot B	22-Jun	3	Snapping	Raccoon
RH6 (U)	20-Jun	Plot C	When Found	Nil	Other	Raccoon
RH7 (U)	20-Jun	Plot D	When Found	Nil	Snapping	Raccoon
RH8 (U)	22-Jun	Plot D	When Found	Nil	Snapping	Raccoon
RH9 (U)	22-Jun	Plot C	When Found	Nil	Snapping	Raccoon
RH10 (U)	22-Jun	Plot A	24-Jun	2	Snapping	Raccoon
RH11 (U)	24-Jun	Plot B	25-Jun	1	Snapping	Raccoon
RH12 - RH15 (U)	3-Jul	Plot D	When Found	Nil	Other	Raccoon
RH16 - RH20 (U)	3-Jul	Plot C	When Found	Nil	Other	Raccoon
RH21 - RH22 (U)	3-Jul	Plot B	When Found	Nil	Other	Raccoon
RH23 - RH27 (U)	3-Jul	Plot B	When Found	Nil	Other	Raccoon
RH28 (O)	3-Jul	Plot A	4-Jul	1	Painted	Raccoon
RH29 (U)	3-Jul	Plot A	When Found	Nil	Other	Raccoon
RH30 (U)	8-Jul	Plot A	When Found	Nil	Other	Raccoon
RH31 (U)	8-Jul	Plot C	When Found	Nil	Other	Raccoon
RH32 (U)	8-Jul	Plot D	When Found	Nil	Other	Raccoon
RH33 - RH34 (U)	16-Jul	Plot B	When Found	Nil	Other	Raccoon
RH35 - RH37 (U)	16-Jul	Plot A	When Found	Nil	Other	Raccoon
RH38 (U)	15-Aug	Plot A	When Found	Nil	Other	Raccoon

* (O/U) = Observed / Unobserved

** The number of days between time that nest was constructed and when nest was found depredated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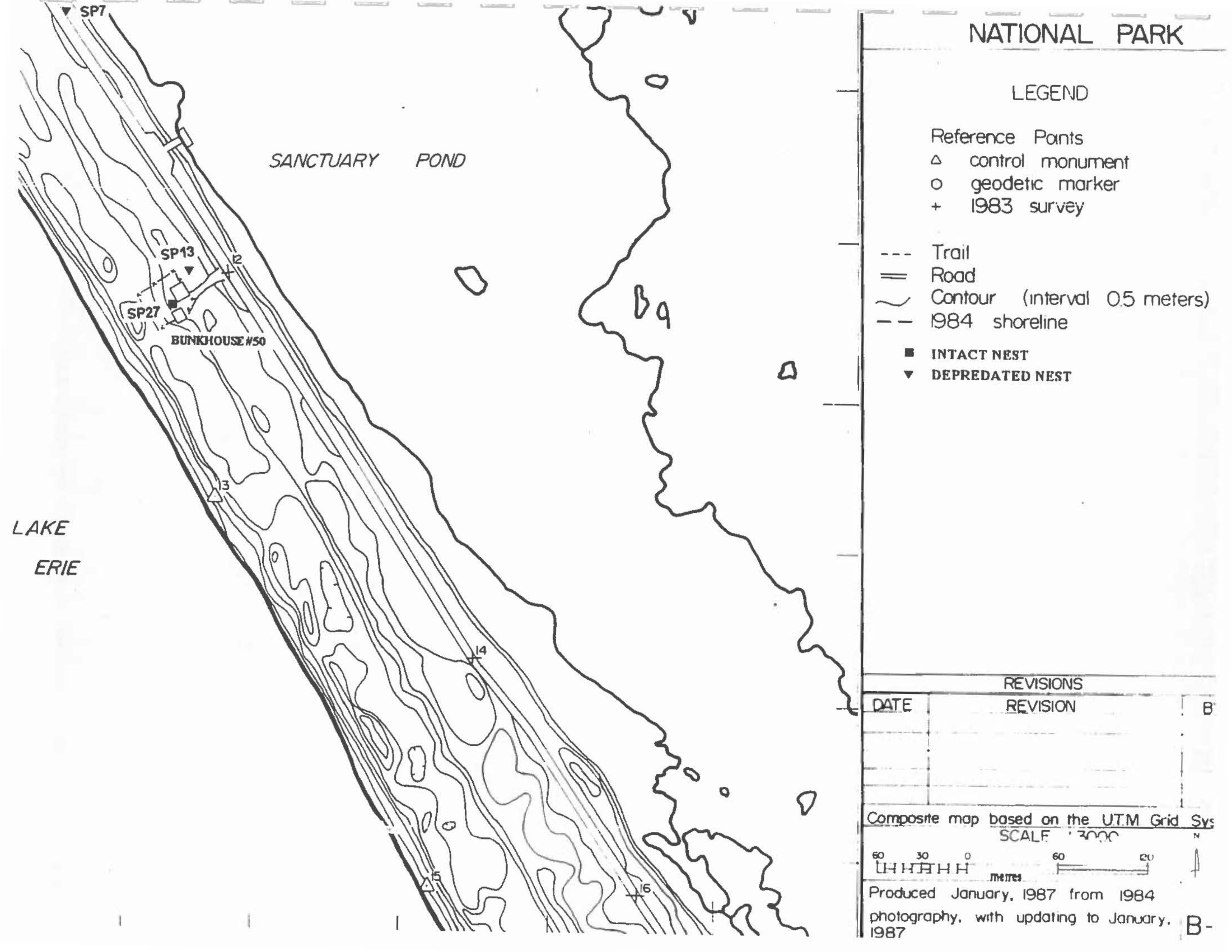
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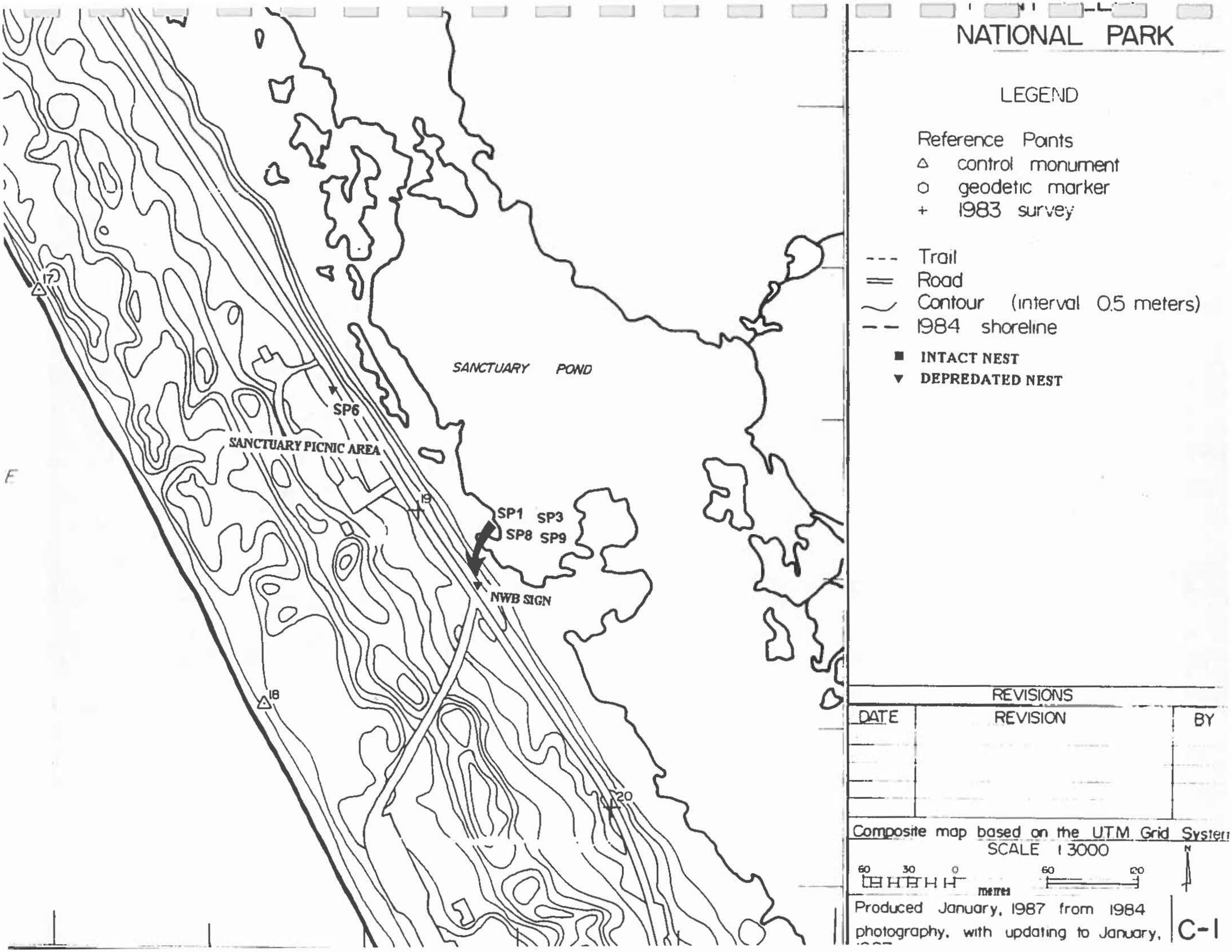

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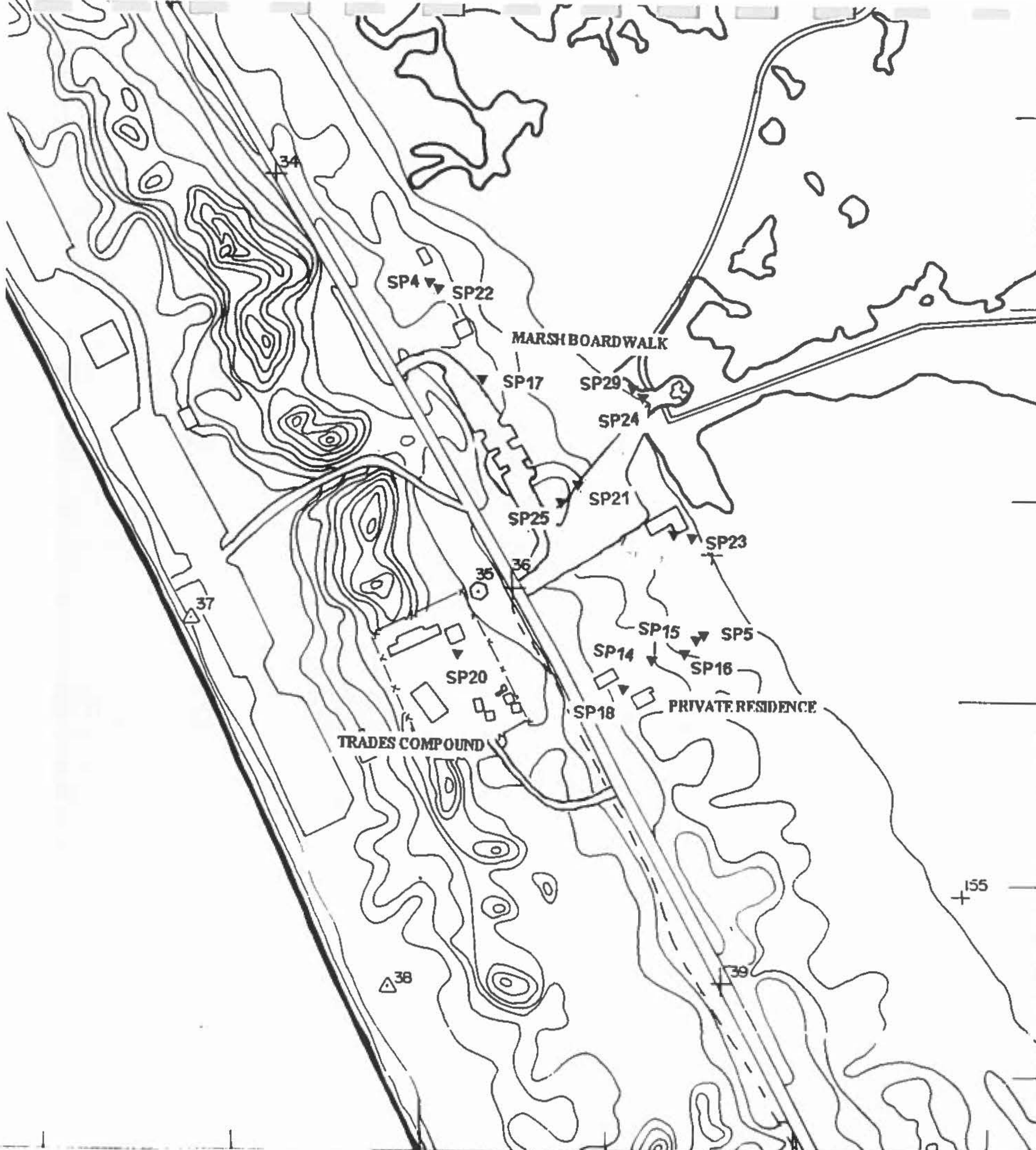

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LEGEND

Reference Points
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○ geodetic marker
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▼ DEPREDATED NEST

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Composite map based on the U.T.M. Grid Syst

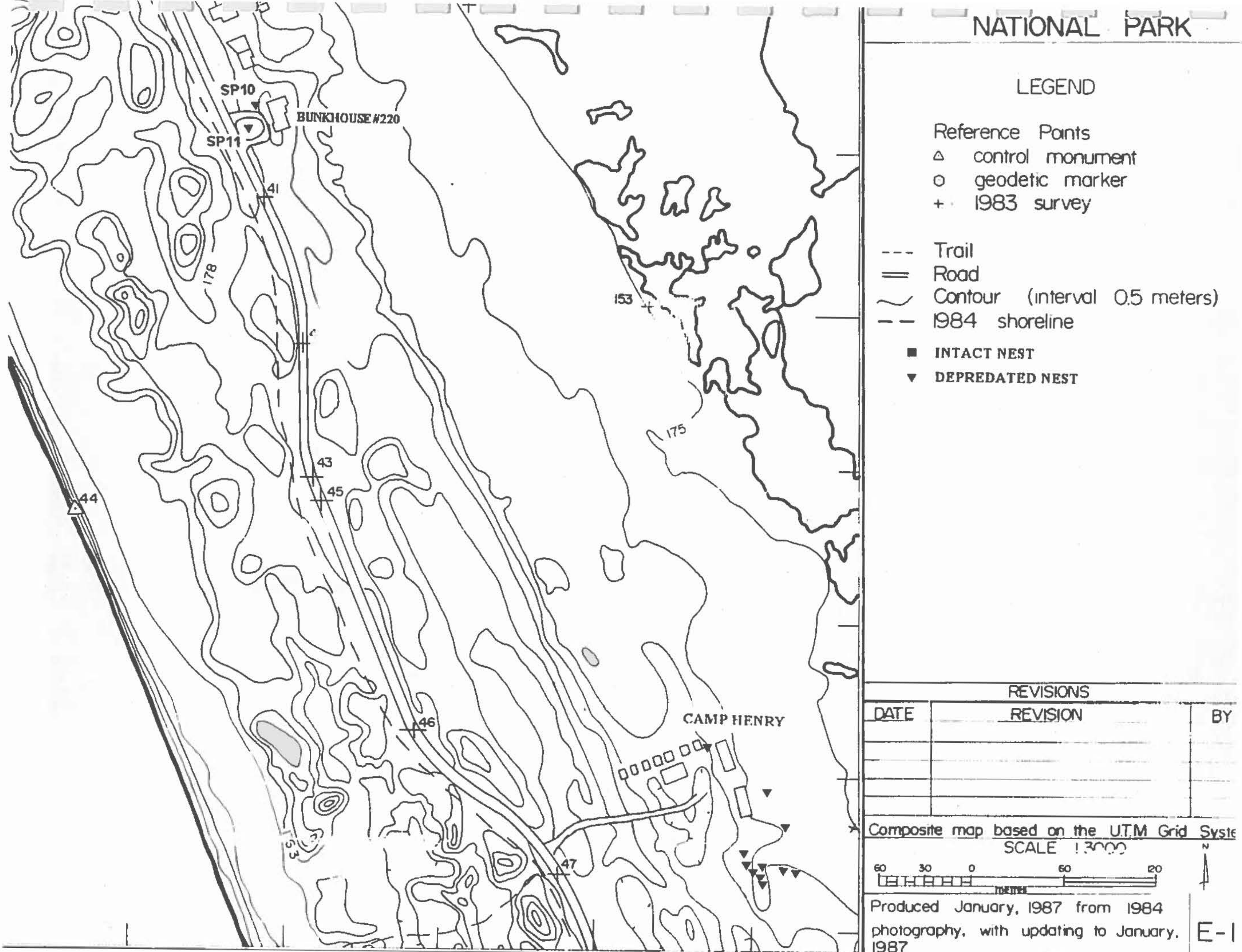
SCALE 1:3000

60 30 0 60 120
metres

N

Produced January, 1987 from 1984 photography, with updating to January, 1987.

D-


NATIONAL PARK
SP10
BUNKHOUSE #220
SP11
41
178
153
175
43
45
44
46
47
CAMP HENRY
LEGEND
Reference Points
△ control monument
○ geodetic marker
+ 1983 survey
--- Trail
═ Road
Contour (interval 0.5 meters)
— — 1984 shoreline
■ INTACT NEST
▼ DEPREDATED NEST
REVISIONS
DATE
REVISION
BY
Composite map based on the U.T.M. Grid Syste
SCALE
60 30 0 60 120
N
Produced January, 1987 from 1984 photography, with updating to January, 1987
E-1


CAMP HENRY
1
2
3
5
6
7
8
9
10
11
12
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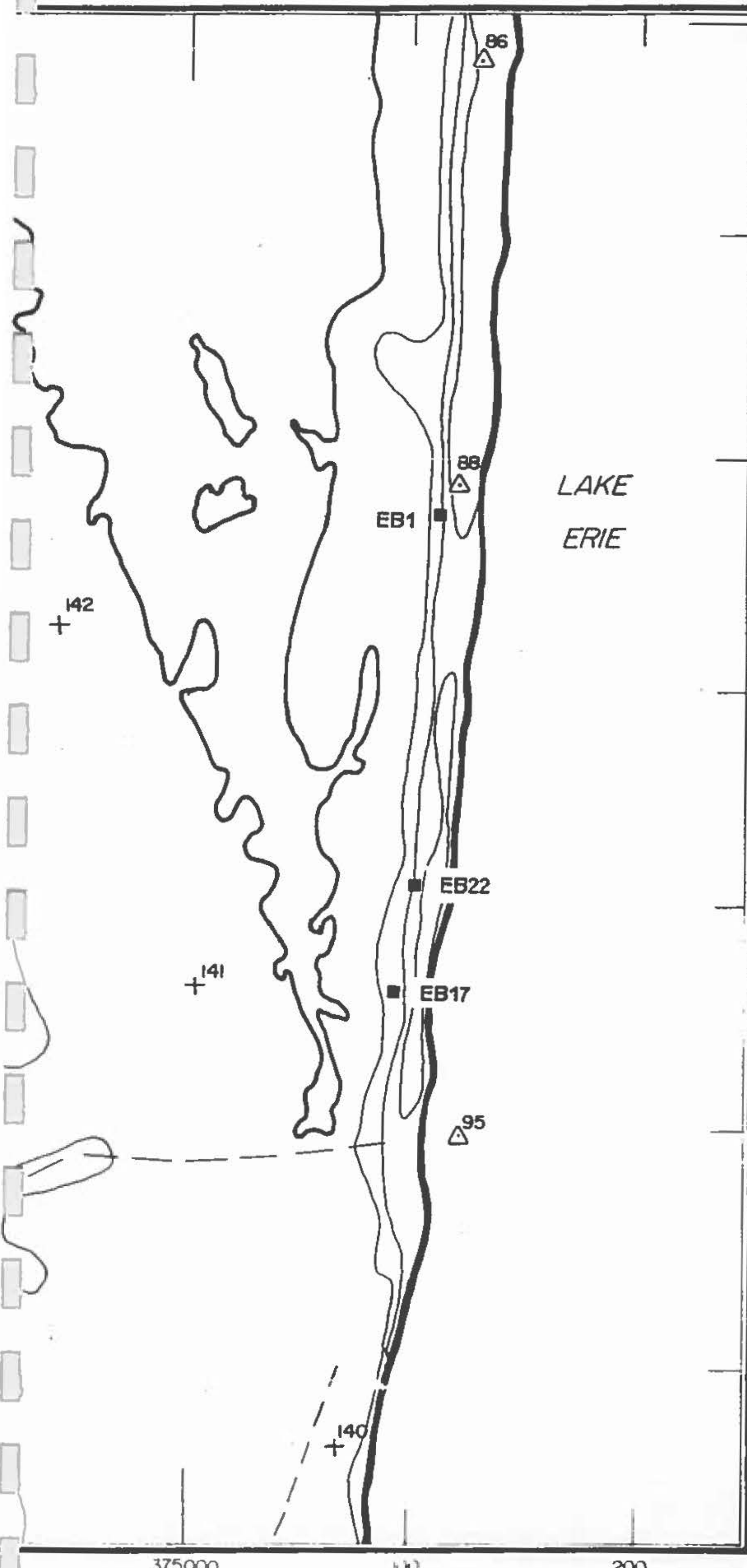
14
15
16
17



POINT PELEE NATIONAL PARK

LEGEND

Reference Points
- △ control monument
- ⊙ geodetic marker
- \+ 1983 survey

- --- Trail
- ═ Road
- ~ Contour (interval 0.5 meters)
- — — 1984 shoreline

- ■ **INTACT NEST**
- ▼ **DEPREDATED NEST**

REVISIONS

DATE	REVISION	BY

Composite map based on the U.T.M. Grid System

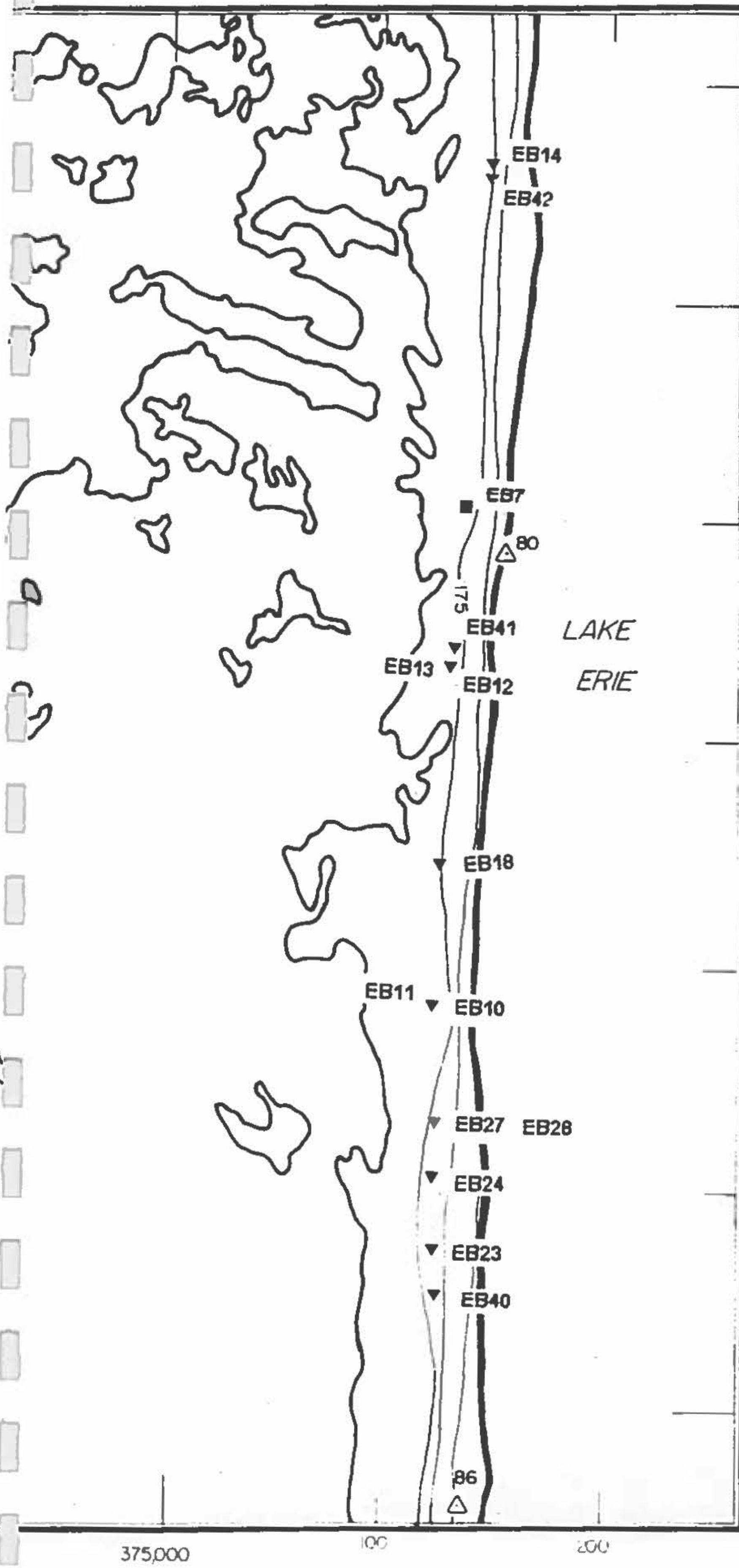
SCALE 1:3000

60 30 0 60 120 metres

N

Produced January, 1987 from 1984 photography, with updating to January, 1987

I-2



POINT PELEE NATIONAL PARK

LEGEND

Reference Points
- △ control monument
- o geodetic marker
- + 1983 survey

- --- Trail
- ═ Road
- ~ Contour (interval 0.5 meters)
- — — 1984 shoreline
- ■ INTACT NEST
- ▼ DEPREDATED NEST

REVISIONS

DATE	REVISION	BY

Composite map based on the U.T.M. Grid System

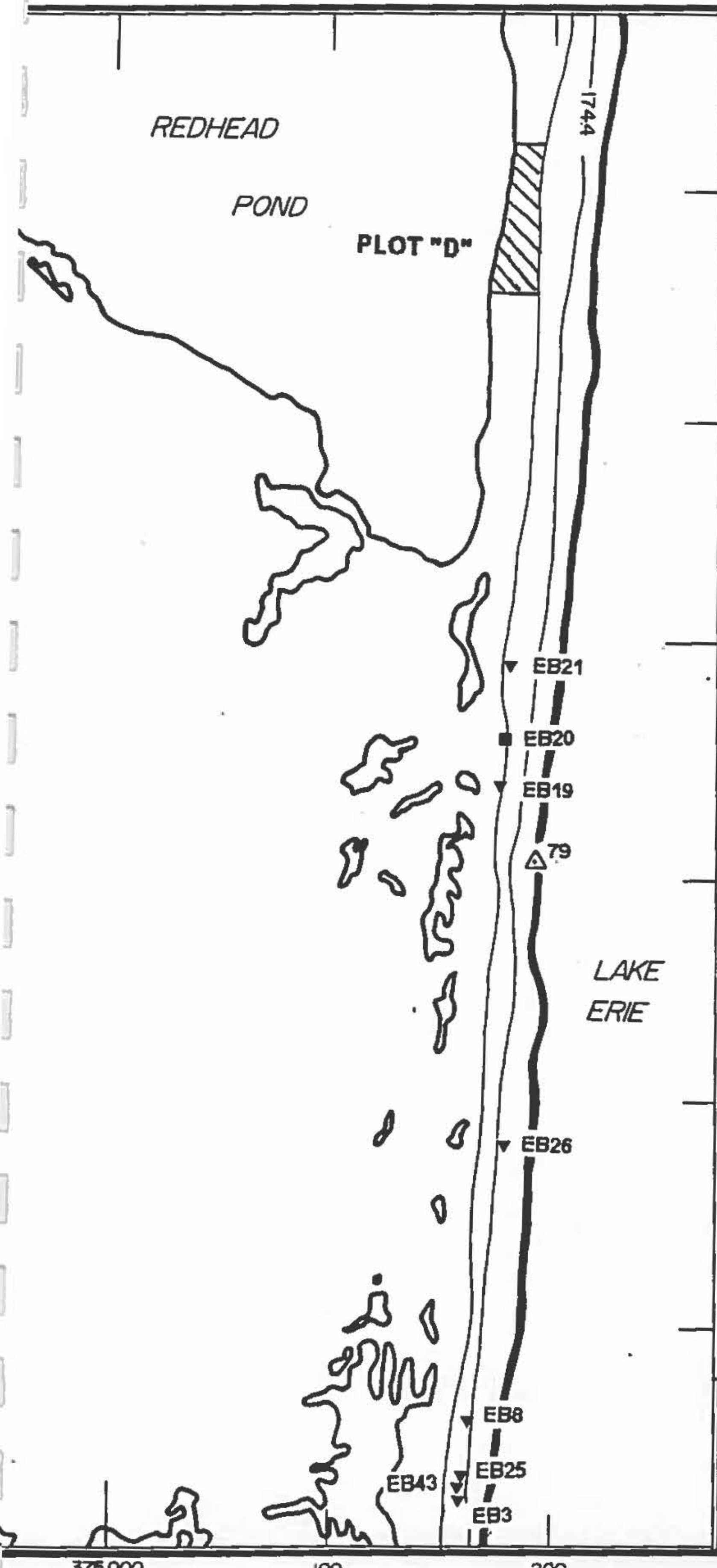
SCALE 1:3000

60 30 0 60 120 metres

N

Produced January, 1987 from 1984 photography, with updating to January, 1987

H-3



POINT PELEE NATIONAL PARK

LEGEND

Reference Points
- △ control monument
- ⊙ geodetic marker
- \+ 1983 survey

- --- Trail
- ═ Road
- ~ Contour (interval 0.5 meters)
- — — 1984 shoreline

- ■ INTACT NEST
- ▼ DEPREDATED NEST

REVISIONS

DATE	REVISION	BY

Composite map based on the U.T.M. Grid System

SCALE 1:3000

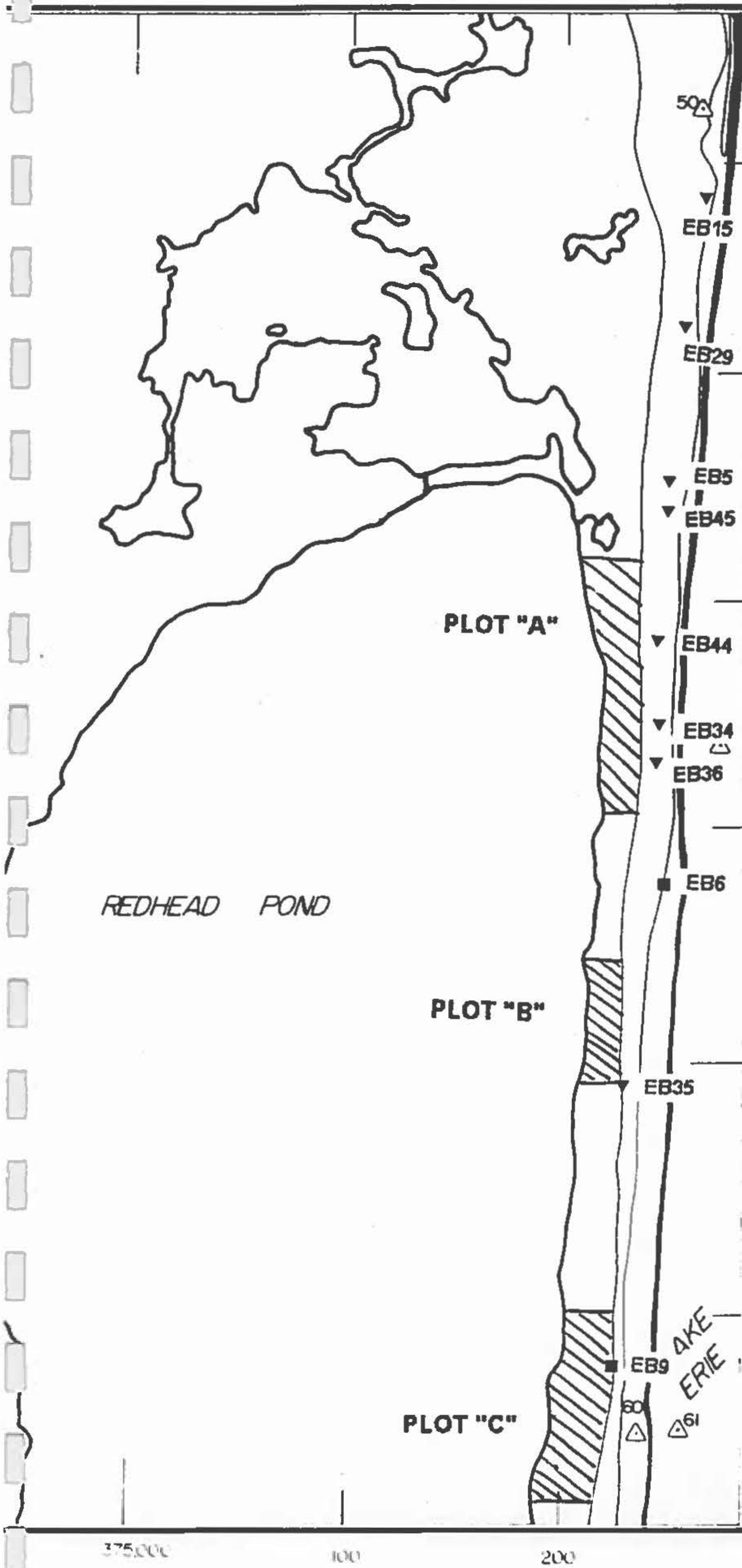
60 30 0 60 120

metres

N

Produced January, 1987 from 1984 photography, with updating to January, 1987.

G-3



POINT PELEE NATIONAL PARK

LEGEND

Reference Points
- △ control monument
- ⊙ geodetic marker
- \+ 1983 survey

- --- Trail
- ═ Road
- ~ Contour (interval 0.5 meters)
- — — 1984 shoreline
- ■ INTACT NEST
- ▼ DEPREDATED NEST

REVISIONS

DATE	REVISION	BY

Composite map based on the UTM Grid System

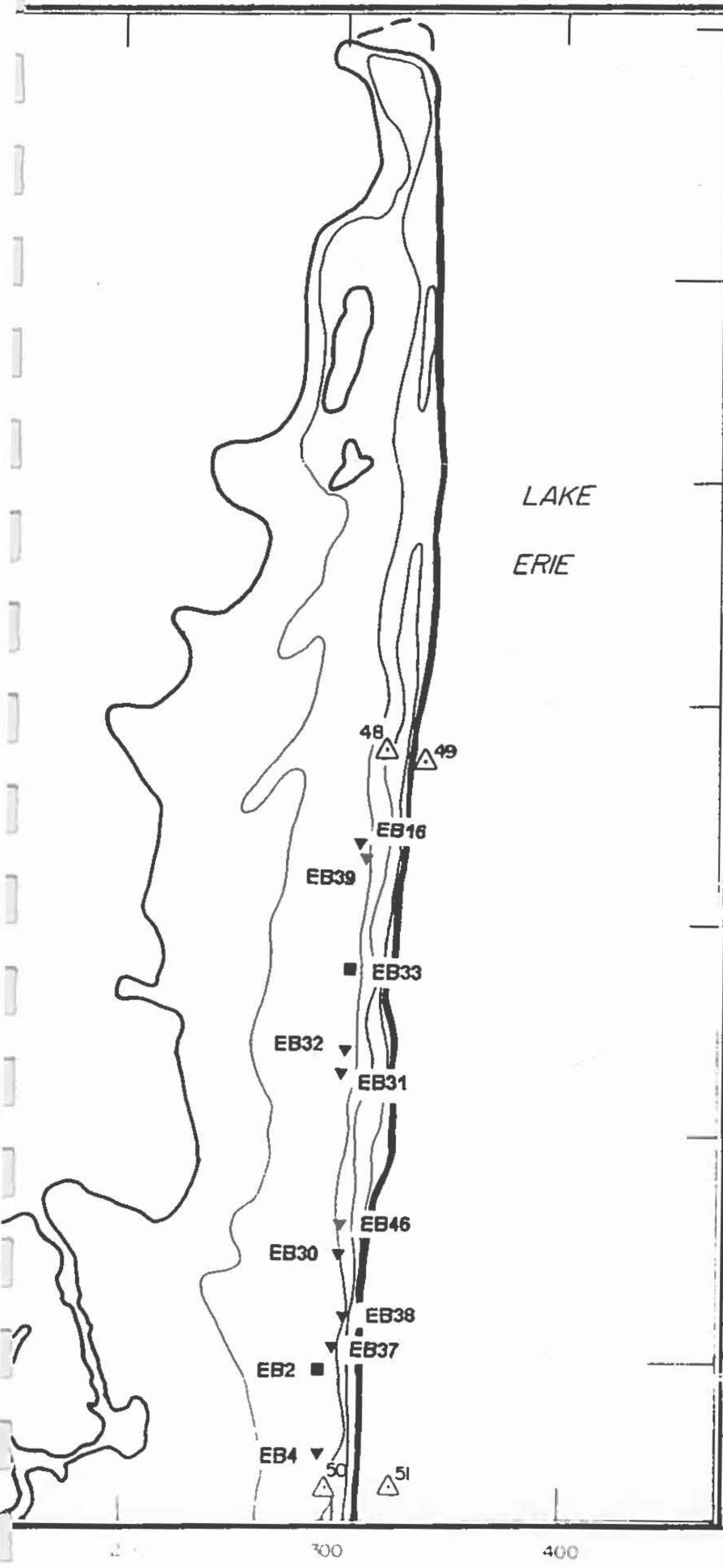
SCALE 1:3000

60 30 0 60 120 metres

N

Produced January, 1987 from 1984 photography, with updating to January, 1987

F-3



POINT PELEE NATIONAL PARK

LEGEND

Reference Points
- △ control monument
- ⊙ geodetic marker
- + 1983 survey

- --- Trail
- ═ Road
- ~ Contour (interval 0.5 meters)
- — — 1984 shoreline

- ■ INTACT NEST
- ▼ DEPREDATED NEST

REVISIONS

DATE	REVISION	BY

Composite map based on the U.T.M. Grid System

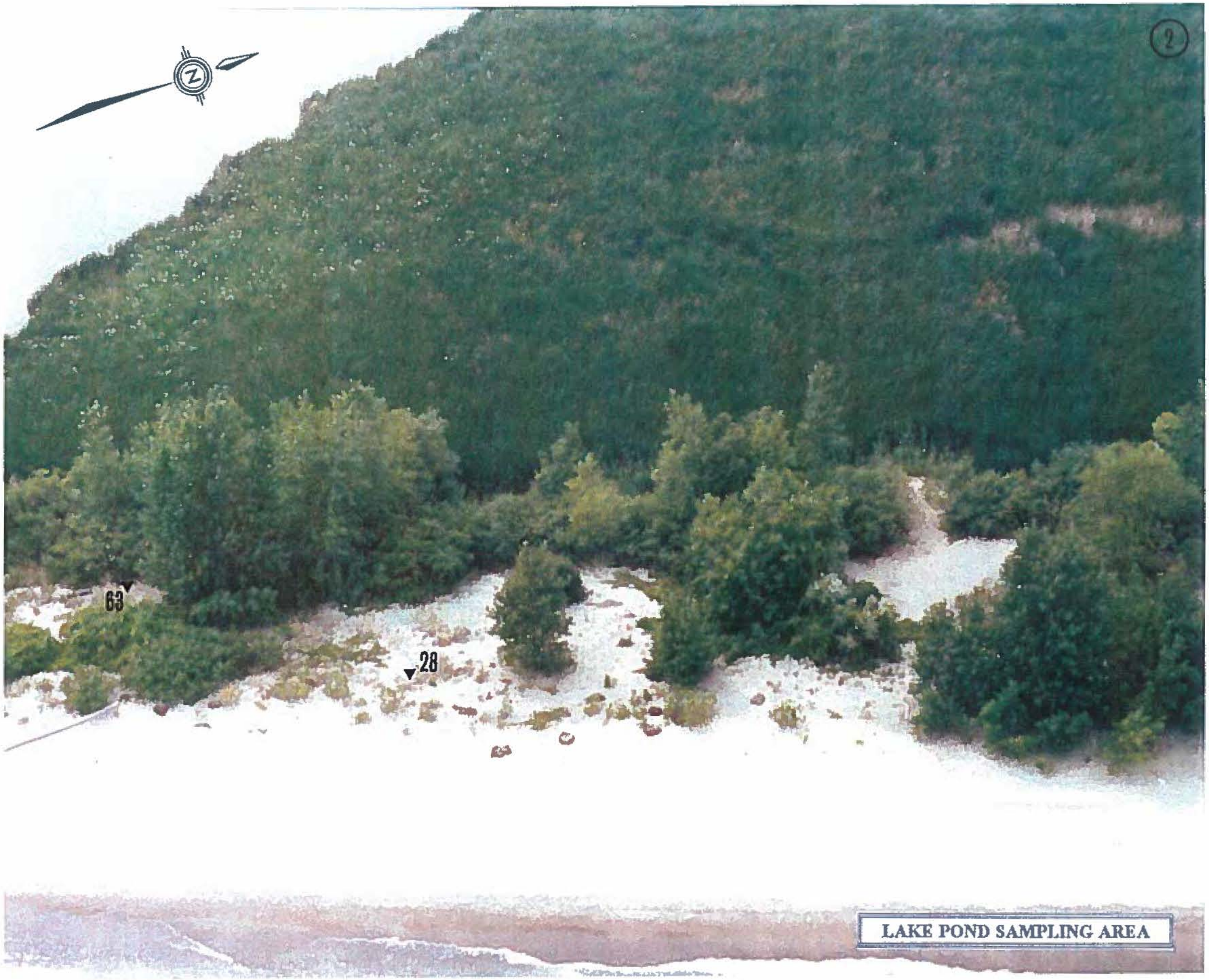
SCALE 1:3000

60 30 0 60 120
metres

Produced January, 1987 from 1984 photography, with updating to January, 1987

E-4

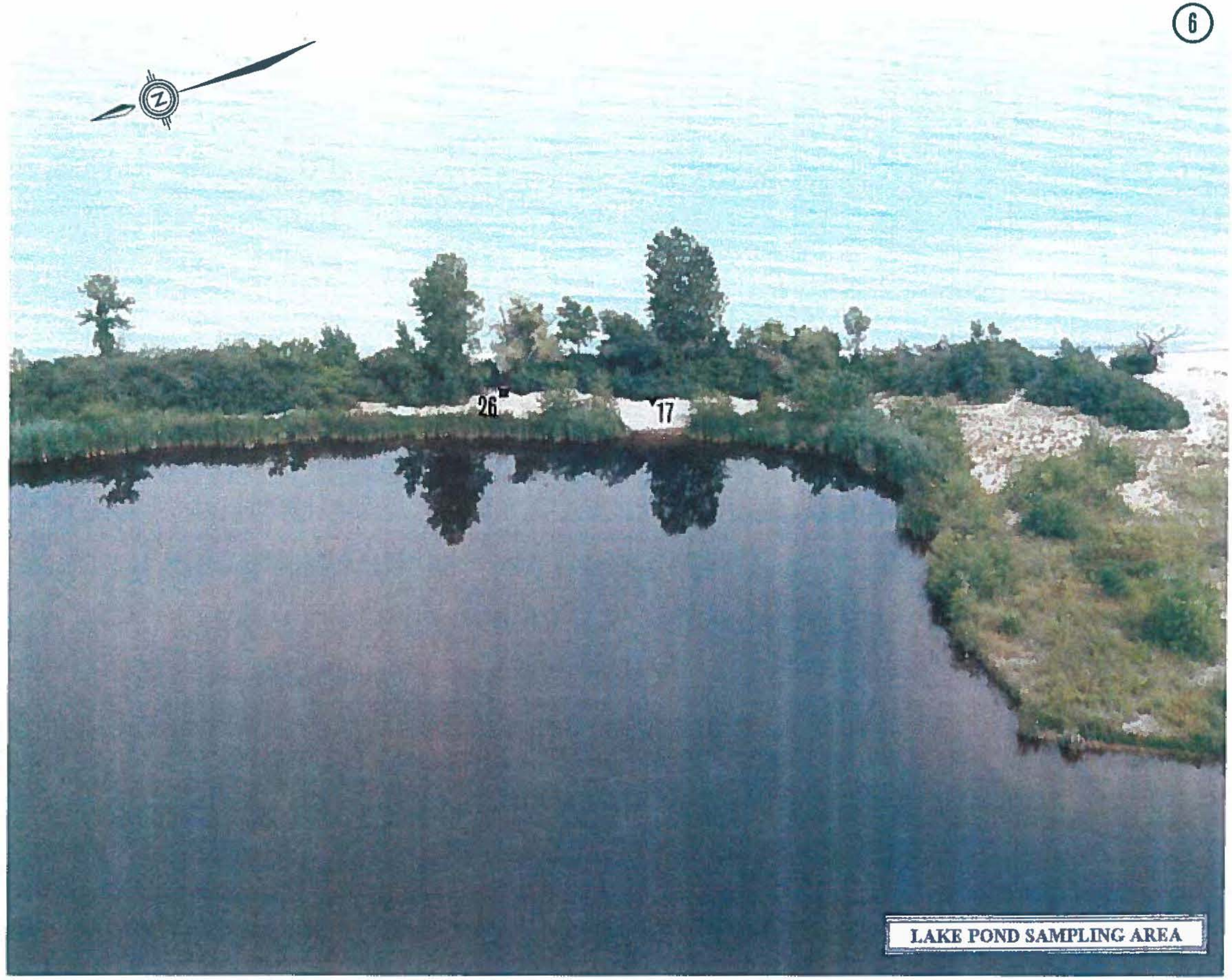

1
N
LAKE POND SAMPLING AREA

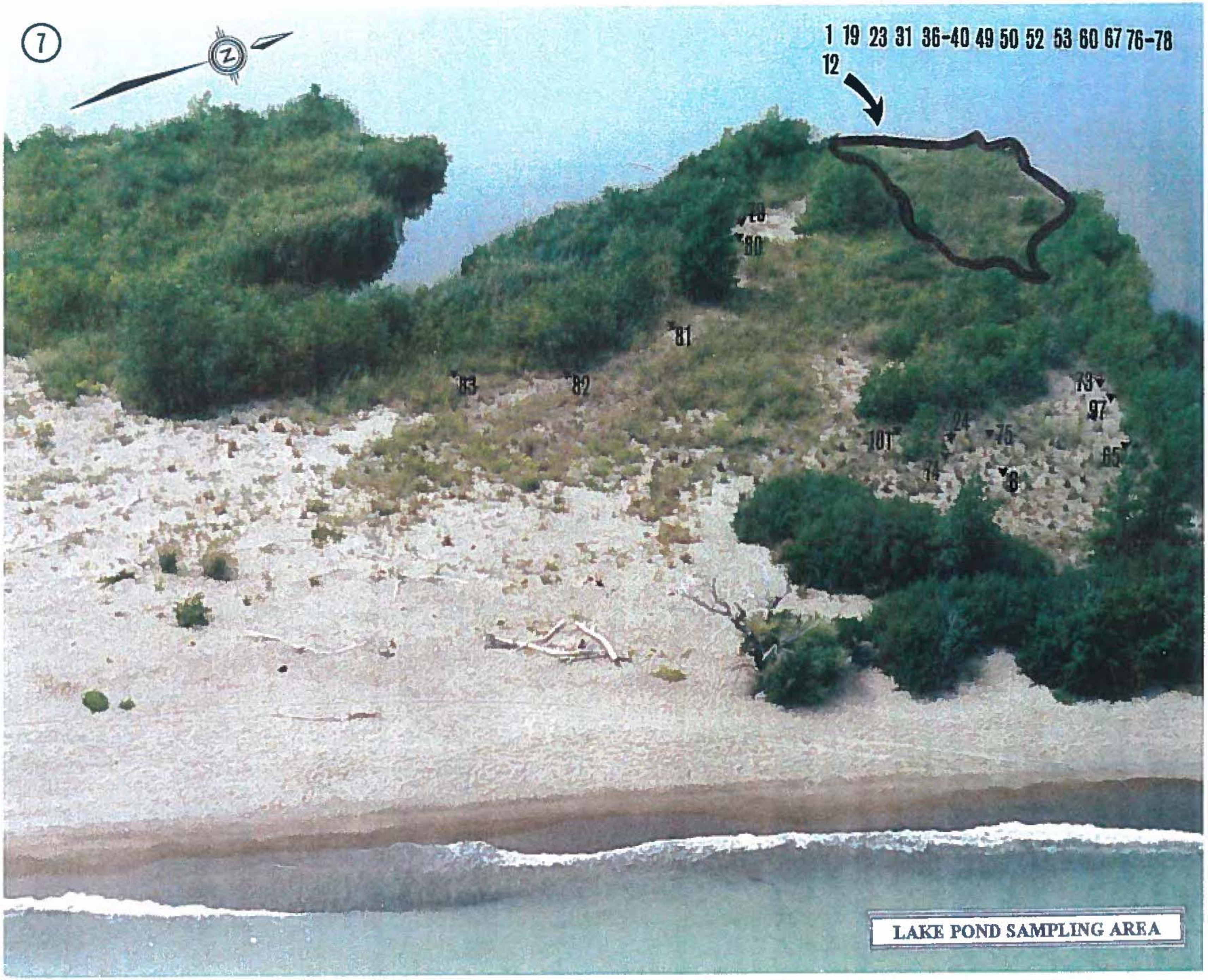

2
Z
63
28
LAKE POND SAMPLING AREA

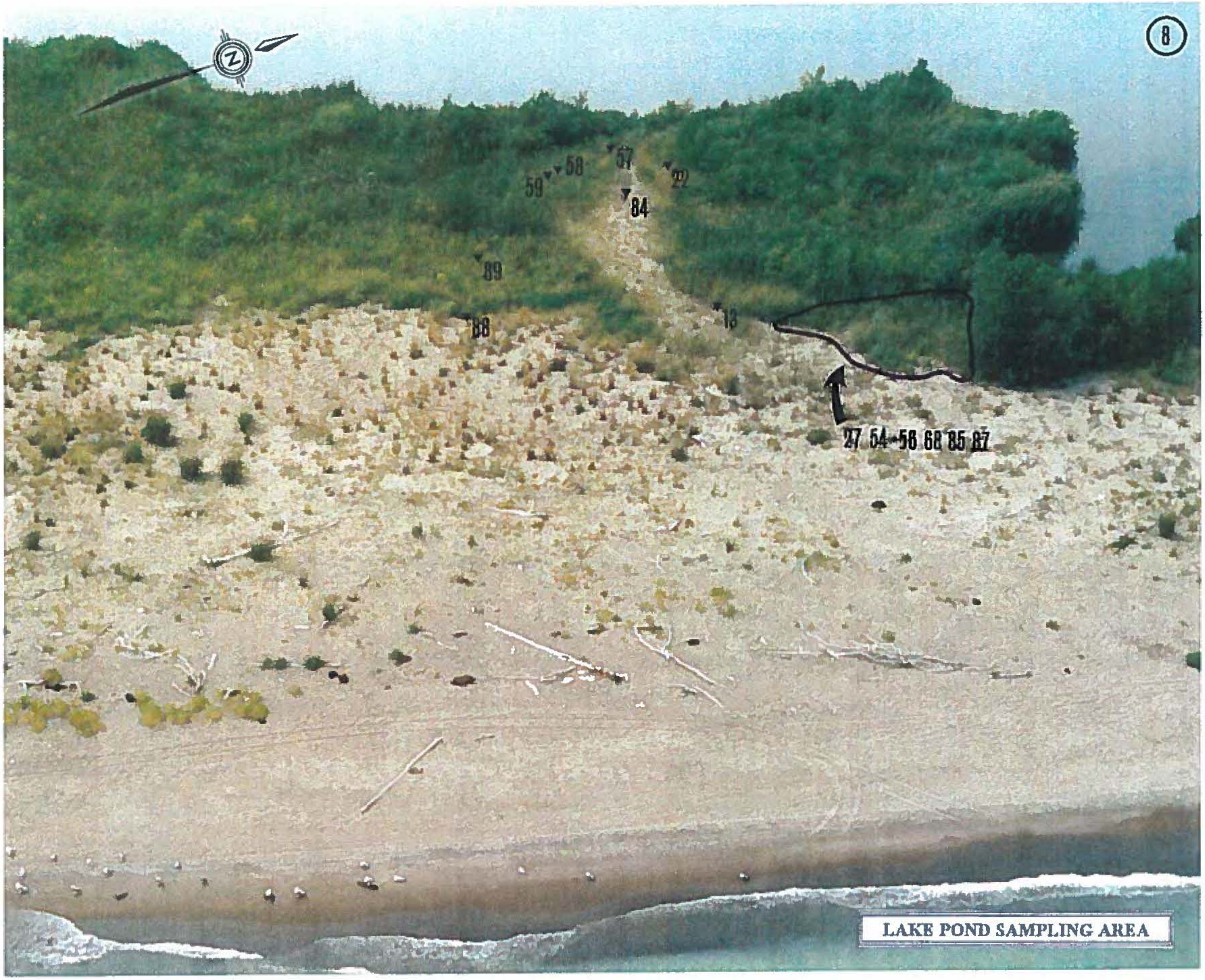

3
N
34
6
15
LAKE POND SAMPLING AREA


4
N
64
47
48
3
16
2
10
LAKE POND SAMPLING AREA

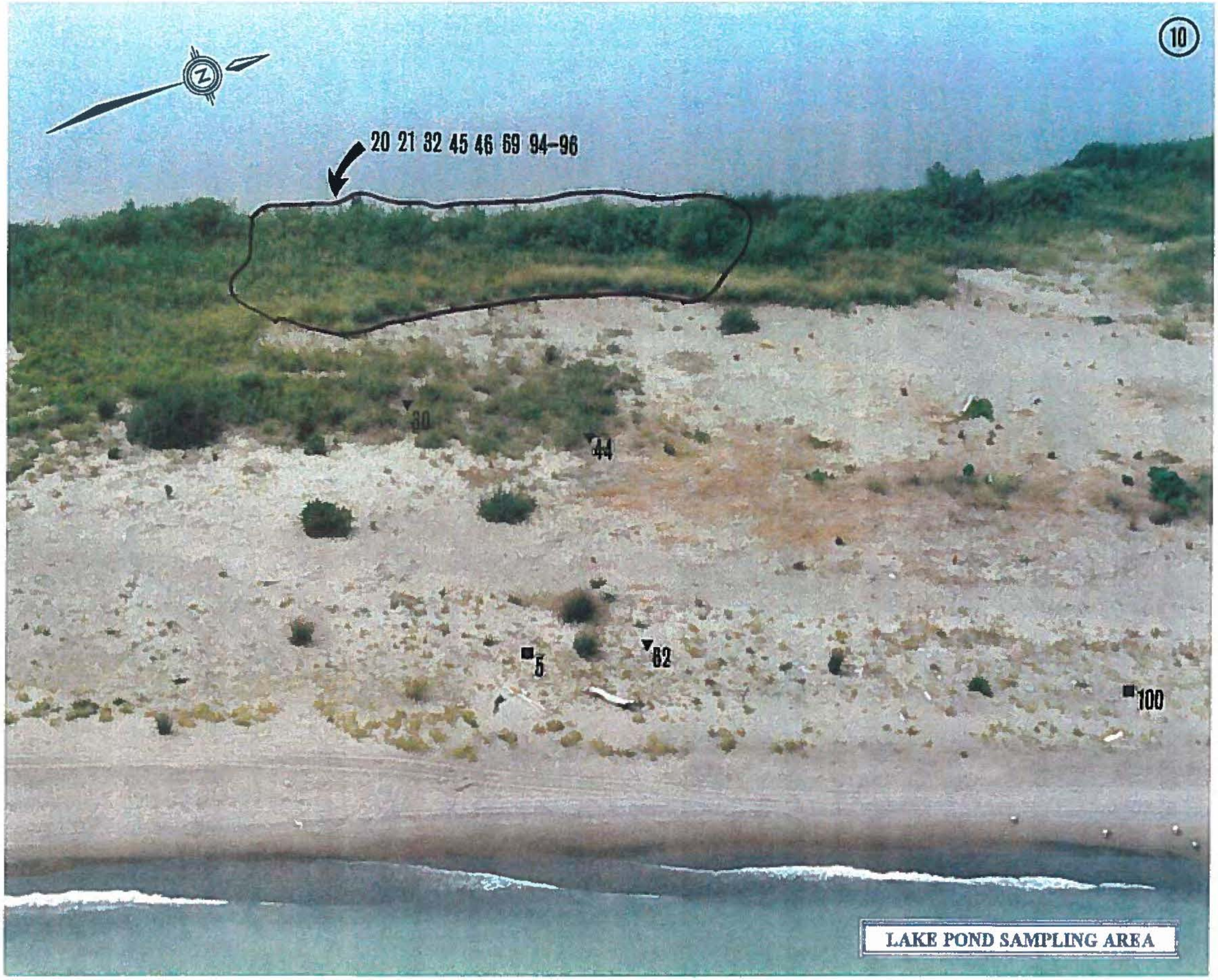
5
N
35
9
11
33
99
LAKE POND SAMPLING AREA


6
N
26
17
LAKE POND SAMPLING AREA


7
N
1 19 23 31 36-40 49 50 52 53 60 67 76-78
12
80
81
82
83
73
97
101
24
75
65
74
8
LAKE POND SAMPLING AREA


8
Z
57
58
59
22
84
89
13
88
27 54-56 68 85 87
LAKE POND SAMPLING AREA


9
41-43 51 61 93
N
92
91
18
90
100
LAKE POND SAMPLING AREA


10
N
20 21 32 45 46 69 94-96
30
44
5
62
100
LAKE POND SAMPLING AREA


11
N
4
LAKE POND SAMPLING AREA

APPENDIX 3

Some References on Estimating the Size of Animal Populations

Anganuzzi, A., Hilborn, R. and Skalski, J.R. 1994. Estimation of size selectivity and movement rates from mark-recovery data. *Can. J. Fish. Aquatic Sci.*, **51**: 734–742.

Begon, M. 1979. *Investigating animal abundance. Capture-recapture for biologists.* Edward Arnold, London. A straightforward, rather brief, but readable account of mark-release-recapture models.

Blower, J.G., Cook, L.M. and Bishop, J.A. 1981. *Estimating the size of animal populations.* George Allen & Unwin Limited, London. A very nice introduction, with some instructive, carefully illustrated worked examples. A good place to start.

Buckland, S.T. and Garthwaite, P.H. 1991. Quantifying precision of mark-recapture estimates using the bootstrap and related methods. *Biometrics*, **47**: 255–268. A discussion of computer-intensive methods for placing standard errors on mark-recapture estimates.

Buckland, S.T., Anderson, D.R., Burnham, K.P. and Laake, J.L. 1993. *Distance sampling. Estimating abundance of biological populations.* Chapman & Hall, London. A super introduction to one of the most active areas of research on estimating animal abundance by line-transect methods. Free software available from the authors.

Cormack, R.M. 1992. Interval estimation for mark-recapture studies of closed populations. *Biometrics*, **48**: 567–576. A discussion of methods for confidence limits that don't rely on asymptotic normal theory.

Cormack, R.M. 1993. Variances of mark-recapture estimates. *Biometrics*, **49**: 1188–1193.

Cormack, R.M. 1994. *Unification of mark-recapture analyses by loglinear modeling. In*: Fletcher, D.J. and Manly, B.F.J. eds. *Statistics in environmental monitoring*. pp. 19–32. University of Otago Press, Dunedin. Recent research by one of the pioneers in the field of mark-release-recapture.

Fletcher, D.J. 1994. A mark-recapture model in which sighting probability depends on the number of sightings on the previous occasion. *In*: Fletcher, D.J. and Manly, B.F.J. eds. *Statistics in environmental monitoring*. pp. 105–110. University of Otago Press, Dunedin. An illustration of how models of mark-release-recapture are increasing in statistical complexity, reflecting the characteristics of field data.

Jolly, G.M. 1979. *A unified approach to mark-recapture stochastic models. In*: Cormack, R.M., Patil, G.P. and Robson, D.S. eds. *Sampling biological populations*. pp. 277–282. International Co-operative Publishing House, Fairland, MD. A glimpse at some of Jolly's continuing research on mark-release-recapture models.

Krebs, C.J. 1989. *Ecological methodology*. Harper & Row, Publishers, New York. A reasonably-up-to-date, critical account of methodology. Accompanied by programs in FORTRAN (available on the network) to do many of the computations.

Labelle, M. 1994. A likelihood method for estimating Pacific-salmon escapement based on fence counts and mark-recapture data. *Can. J. Fish. Aquatic Sci.*, **51**: 552–566.

Neal, A.K., White, G.C., Gill, R.B., Reed, D.F. and Olterman, J.H. 1993. Evaluation of mark-resight model assumptions for estimating mountain-sheep numbers. *J. Wildlife Mgmt.*, **57**: 436–450.

Robson, D.S. 1979. *Approximations to some mark-recapture sampling distributions. In*: Cormack, R.M., Patil, G.P. and Robson, D.S. eds. *Sampling biological populations*. pp. 257–275. International Co-operative Publishing House, Fairland, MD.

Schnute, J.T. 1992. Statistical analysis of embedded replicates in mark-recovery experiments. *Can. J. Fish. Aquatic Sci.*, **49**: 432–442. An example of the intensive Canadian work on mark-release-recapture for fish populations.

Seber, G.A.F. 1982. *The estimation of animal abundance and related parameters*. Hafner Press, New York. The authoritative source. Tough slugging. Definitely not the place to begin your studies!

Seber, G.A.F. 1986. A review of estimating animal abundance. *Biometrics*, **42**: 267–292.

Seber, G.A.F. 1986. A review of estimating animal abundance. II. *Int. Stat. Rev.*, **60**: 129–166.

Sutherland, W.J. 1996. *Ecological census techniques*. Cambridge University Press.