Monitoring of Eastern Fox Snakes (*Elaphe vulpina gloydi*) in Response to Habitat Restoration at Sterling State Park in Michigan

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Executive Summary

The eastern fox snake (*Elaphe vulpina gloydi*) is a state threatened snake in Michigan that primarily inhabits emergent wetlands along Great Lakes shorelines and associated nearshore areas along southern Lake Huron, the Detroit River and Lake St. Clair, and western Lake Erie. A population of eastern fox snakes occurs in Sterling State Park in Monroe, Michigan. The Michigan Department of Natural Resources (MDNR), Parks and Recreation Bureau, State Park Stewardship Program is in the process of restoring portions of the Park's landscape to native lakeplain prairie and Great Lakes marsh. In 2003, in cooperation with the Parks and Recreation Bureau's State Park Stewardship Program, Michigan Natural Features Inventory (MNFI) initiated a monitoring program for the eastern fox snake in areas undergoing ecological restoration at Sterling State Park. The goal of this monitoring program is to detect a biologically significant change in the eastern fox snake population in areas targeted for management treatments in the park. This project will provide baseline data on presence/absence, relative abundance, movement and habitat use upon which to assess whether the snake populations in areas undergoing active management are increasing, decreasing or remaining constant. This information will be used to help assess the effects of various management treatments on the eastern fox snake population within Sterling State Park.

Surveys for eastern fox snakes were conducted during the summer and early fall of 2003 immediately prior to and during initiation of habitat restoration activities in Sterling State Park. Radio-tracking of eastern fox snakes and collection of blood and tissue samples (i.e., scale clippings) for future genetic analysis also were initiated in 2003. Habitat restoration activities continued during the winter, spring and summer of 2004. To monitor and assess the initial impacts of habitat restoration activities on the eastern fox snake population in the park, surveys and radio-telemetry were conducted during the spring, summer and early fall of 2004.

Line-transect and time-constrained visual encounter surveys were conducted in all nine management units within Sterling State Park from August to September 2004. Additional visual encounter surveys were conducted from May through August 2004. Overall, field surveys in 2004 resulted in a total of 11 eastern fox snake observations, of which nine were new snakes and two were recaptures. More fox snake observations were documented during surveys in 2004 than in 2003. Snakes found in 2004 were located in only two of the nine management units in the park (Interpretive Kiosk and Hunt Club). Snakes were documented in 2003 in these units and one additional unit (Corps Volcano Unit). The habitats in which fox snakes were found included old field, palustrine emergent and palustrine scrub-shrub habitats as well as the paved nature trail and rock riprap and concrete slabs along the shoreline of the open water lagoons. Additional observations of live and dead fox snakes were reported by park staff and visitors.

Four fox snakes were radio-tracked for various lengths of time from April through September 2004. One of the transmittered snakes was tracked in 2003 as well but was lost from the study in July or August 2004, presumably due to predation. The radio-tracked snakes were located in only three of the nine management units (Interpretive Kiosk, Hunt Club and Facilities). Within these units, the snakes primarily utilized old field and palustrine emergent wetland habitats along the edge of the dike and the lagoons. Snakes were generally located 1-3 m from the water's edge. Maximum distances between known locations (i.e., distance between the two farthest documented locations) ranged from about 470-1,022 m (0.3-0.6 mi).

Results from surveys in 2003 and 2004 suggest that eastern fox snake numbers within the park may not have been dramatically impacted by recent habitat restoration activities, although fox snake use of particular management units within the park may have been impacted to some degree. However, sample sizes in 2003 and 2004 were very small, and unfortunately, only one year of pre-treatment data was obtained. These findings combined with limited knowledge of this species' status, distribution and ecology within Sterling State Park make it difficult to effectively assess potential impacts of the restoration efforts on this species at this time. Additional surveys and a long-term monitoring effort are needed to further assess the impacts of habitat restoration efforts on the fox snake population within the park. Eastern fox snake habitat use and ecology also warrant further investigation. Eastern fox snake monitoring and radio-telemetry are planned to continue in 2005.

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Introduction

The eastern fox snake (*Elaphe vulpina gloydi*) is a state threatened species in Michigan that primarily inhabits emergent wetlands and adjacent uplands along Great Lakes shorelines and associated large rivers and impoundments (Appendix I). The species' range is restricted to the shoreline and nearshore areas along southern Lake Huron from Saginaw Bay, Michigan and Georgian Bay, Ontario south to the Detroit River and Lake St. Clair and along northern and western Lake Erie from Norfolk County in Ontario to Wayne and Monroe counties in Michigan and Erie County in Ohio (Harding 1997). The eastern fox snake has drastically declined in many areas where it was once abundant but can be locally common in areas where extensive habitat is still available (Harding 1997). The primary threats to this species are habitat loss and degradation, human persecution and collection for the commercial pet trade (Evers 1994, Harding 1997).

A population of eastern fox snakes is known from Sterling State Park in Monroe County in southeast Michigan. In 2003, the Michigan Department of Natural Resources' (MDNR) State Park Stewardship Program initiated an extensive ecological restoration effort at Sterling State Park to restore a large portion of the Park's landscape to native lakeplain prairie and Great Lakes marsh. Lakeplain prairie and Great Lakes marsh are rare and unique natural communities that provide suitable habitat for a number of rare plant and animal species including the eastern fox snake (Appendix II and III). These natural communities or habitats were once common along the Great Lakes shoreline in southeast Michigan prior to European settlement but have been greatly reduced in acreage and extensively altered due to agricultural, industrial, residential and recreational development (Albert and Kost 1998, Albert 2001). Disruption of natural ecosystem processes, such as altered hydrology and fire suppression, and invasion by exotic plants such as giant bulrush (*Phragmites australis*), purple loosestrife (*Lythrum salicaria*) and reed canary grass (*Phalaris arundinacea*) also have contributed to the loss and degradation of these natural communities (Albert and Kost 1998, Albert 2001). Lakeplain prairie and Great Lakes marsh habitats still occur in Sterling State Park but only in small, degraded remnants due to recreational development, hydrological manipulations and the spread of invasive plants.

In 2003, in cooperation with the State Park Stewardship Program, Michigan Natural Features Inventory (MNFI) initiated a monitoring program for the eastern fox snake in areas undergoing habitat restoration in conjunction with the restoration effort at Sterling State Park. The goal of this monitoring program is to detect a biologically significant change in the eastern fox snake population in areas targeted for management treatments in the Park. This project will provide baseline data upon which to assess whether the snake populations in areas undergoing active management are increasing, decreasing or remaining constant. The specific objectives of this project are (1) survey and document presence/absence, and estimate absolute and relative abundance of eastern fox snakes in all management units within the Park, particularly those undergoing active management; (2) collect baseline population data for statistical comparison with data from subsequent years; (3) collect tissue and/or blood samples for future genetic analysis of the Park's eastern fox snake population; (4) determine movement patterns of eastern fox snakes within the Park; and (5) produce baseline geographically referenced habitat and snake distribution data for comparison with post-management data. This study will provide baseline information with which to assess the effects of the habitat restoration efforts in Sterling State Park on its resident eastern fox snake population and provide data for future adaptive management.

Surveys for eastern fox snakes were conducted during the summer and early fall of 2003 immediately prior to and during initiation of habitat restoration activities in Sterling State Park (Lee and Pearman 2004). Radio-tracking of eastern fox snakes and collection of blood and tissue samples also were initiated during this time period. Habitat restoration activities continued during the winter, spring and summer of 2004. To monitor and assess the initial impacts of these habitat management activities on the fox snake population in the Park, surveys and radio-telemetry were conducted in the spring and summer of 2004. The following report summarizes project activities and associated results in 2004 as well as comparisons with study results from 2003.

Study Area

Sterling State Park is a 405-ha (1,000-acre) park located along the Lake Erie shoreline in Monroe County, Michigan in the southeast corner of the state approximately 61 km (38 mi) south of Detroit and 39 km (24 mi) north of Toledo, Ohio (Figure 1). Based on regional landscape ecosystem classifications of Michigan (Albert 1995), Sterling State Park is located within the Maumee Lake Plain of the Washtenaw sub-section (Figure 2). This region is a flat, clay lake plain dissected by broad glacial drainageways of sandy soil (Albert 1995). Historically (*circa* 1800), much of Sterling State Park was comprised of Great Lakes marsh (Figure 3). Typical plant species in this natural community type included cattail *(Typha spp.),* bulrushes (*Scirpus* spp.), arrowheads (*Sagittaria* spp.), and bur-reeds (*Sparganium* spp.), as well as numerous submergent species such as pondweeds (*Potamogeton* spp.), water-milfoils (*Myriophyllum* spp.), and common waterweed (*Elodea canadensis*) (Albert 2001, Olson 2002). Behind the Great Lakes marsh, a band of wet or lakeplain prairie extended into the northwest portion of the park. This rich and diverse natural community was dominated by species such as blue-joint grass (*Calamagrostis canadensis*), big bluestem (*Andropogon gerardii*), Indian grass (*Sorghastrum nutans*) and sedges (*Carex aquatilis*, *C. stricta*, and *C. lanuginosa*) (Olson 2002). Water levels in the marsh and lakeplain prairie fluctuated seasonally and annually according to water levels in Lake Erie. In addition to wet prairies and marshes, mesic southern forests dominated by American beech (*Fagus grandifolia*), sugar maple (*Acer saccharum*), white oak (*Quercus alba*), American elm (*Ulmus americanus*) and hickory (*Carya* sp.) occurred on the more well-drained portions of the clay lake plain within this sub-section (Albert 1995, Olson 2002). A small area of mesic southern forest historically occurred in the very northwest corner of the park behind the lakeplain prairie.

Alteration of the historical land cover within Sterling State Park has been extensive (Olson 2002). Much of the marsh habitat was dredged to create channels and a diked area that once controlled water levels for hunting and possibly transportation access historically. Extensive dredging in the 1950's and 1960's created the lagoons, the adjacent "island" behind the natural sand spit and other "upland" areas in the park for recreational use (Olson 2002). A confined disposal facility (CDF) also was constructed by the U.S. Army Corps of Engineers in the early 1980's by dredging portions of the marsh in the northeast corner of the park. Soil from the construction of the CDF was placed throughout the park, raising the elevation of portions of the park and creating many spoil piles, berms and a series of small "islands" in the marsh immediately west of the CDF (Olson 2002). The upland areas in the park were once farmed (Olson 2002).

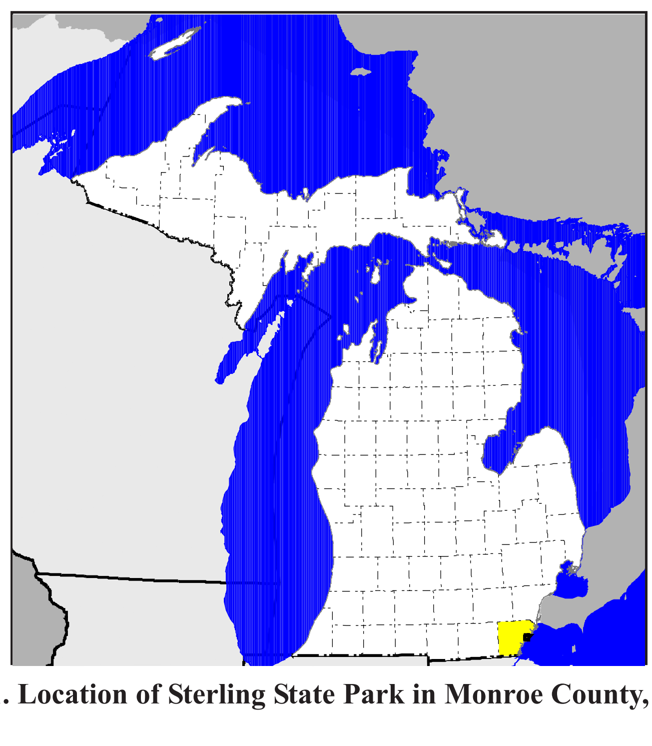

Figure 1. Location of Sterling State Park in Monroe County, Michigan.

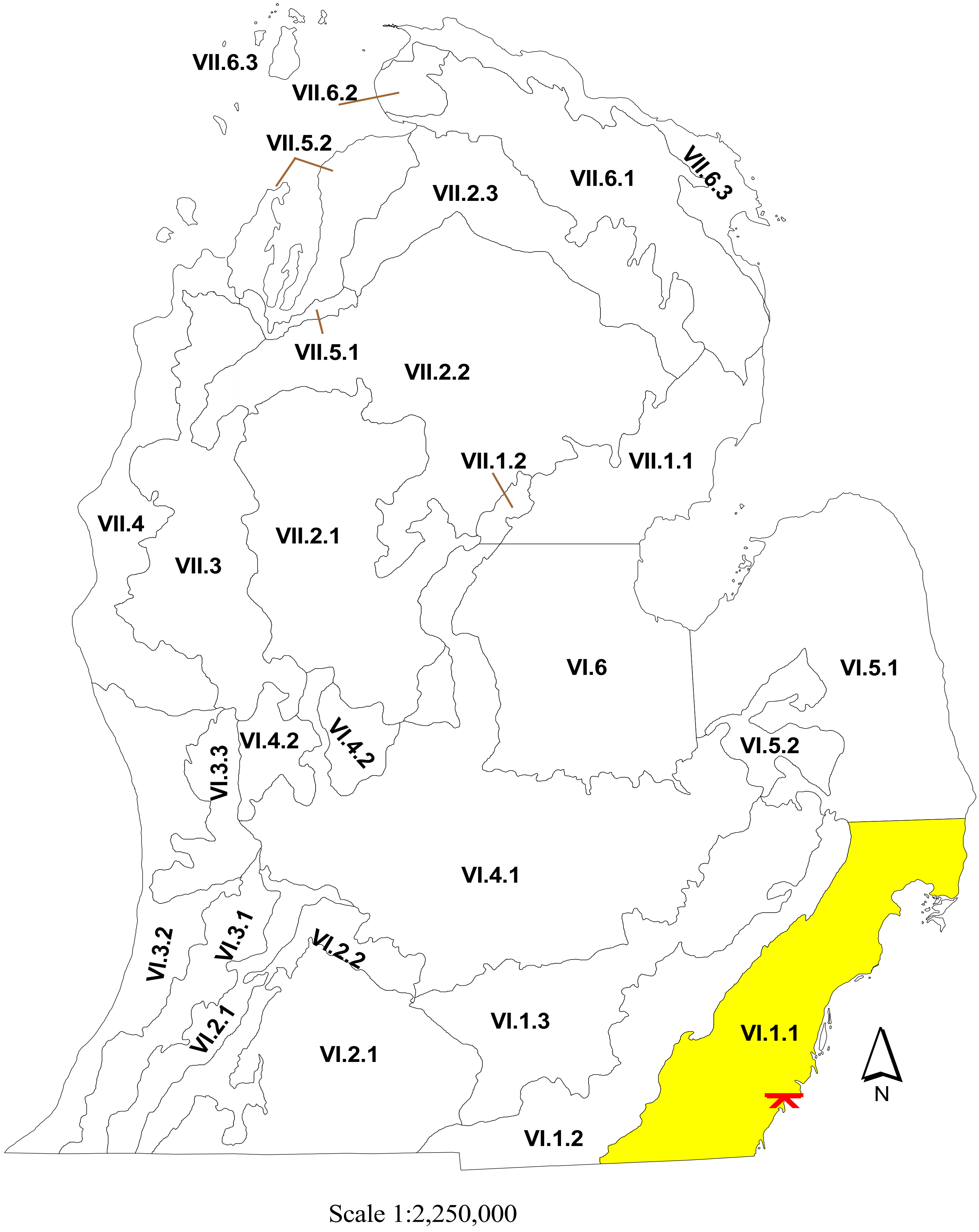

Figure 2. Regional landscape ecosystem classification of Sterling State Park, based on Albert (1995).

Given these widespread alterations, the land cover within the park has dramatically changed (Figure 4). The wetlands currently in the park are a mix of open water, mud flats, floating aquatics and small remnants of Great Lakes marsh and lakeplain prairie. Invasive species such as purple loosestrife and common reed or *Phragmites* can be found in moist areas or wetlands throughout the park. The upland areas in the park are primarily open and comprised of a mix of natural habitat and areas developed or managed for recreational use. The upland or inland areas that once supported lakeplain prairie are now primarily old fields with various spoil piles, berms and debris (Olson 2002). Reed canary grass, *Phragmites* and thistles are commonly found in portions of the old field or grassland habitats in the park. The mesic southern forest that once occupied the farthest inland portions of the park is almost completely gone. The small patches or strips of forest that remain in the park occur along the dike and along the edge or perimeter of open upland and wetland habitats. Sugar maple, boxelder (*Acer negundo*), cottonwood (*Populus deltoides*), willows (*Salix* spp.), ash (*Fraxinus* spp.) and dogwood (*Cornus* spp.) commonly occur in the forested habitats. The park is heavily used for recreation and contains a number of developed or managed recreational areas or facilities including roads, paved parking lots, paved trails, interpretive area, mowed grass, landscaped areas, boat launch, buildings, playground, beach and campground. Water levels are no longer controlled anywhere in the park, although dikes, ditches, culverts and rock riprap along the lagoons and portions of the Lake Erie shoreline continue to influence hydrology within the park.

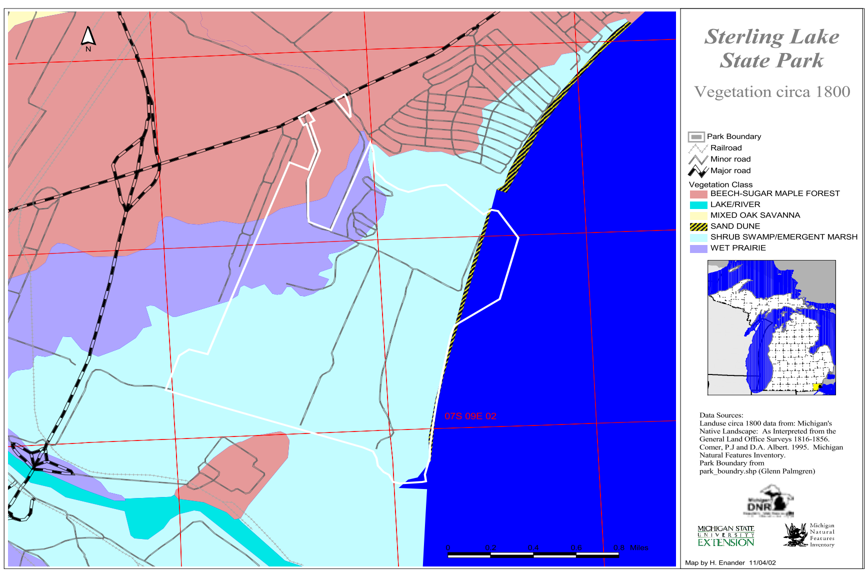

Figure 3. Historical (circa 1800) vegetation of Sterling State Park.

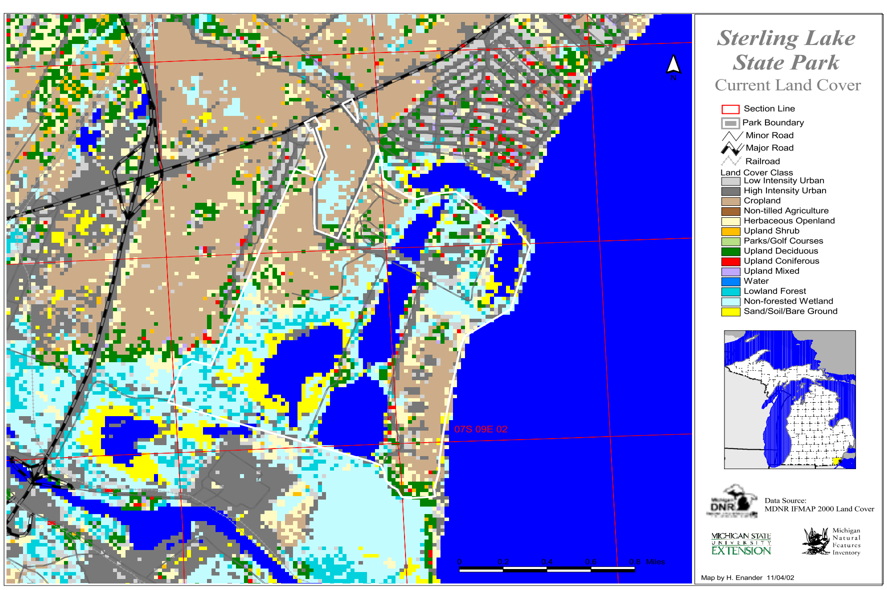

Figure 4. Current land cover within Sterling State Park.

Sterling State Park has been divided into nine management units. These include the following: Headquarters (HQ), Bean Field (BF), Campground Restoration (C), Corps Volcano (V), Hunt Club (HC), Interpretive Kiosk (IK), North Lagoons (NL), Corps CDF (CDF) and Facilities (F) (Figure 5). Of these, the following six units have been targeted for habitat restoration efforts: Bean Field, Corps Volcano, Campground Restoration, North Lagoons, Hunt Club and Interpretive Kiosk. The remaining three management units, Headquarters, Facilities and Corps CDF, currently are not targeted for active restoration. The following summaries provide brief descriptions of habitat conditions in each of the nine management units during the fox snake surveys in 2003 and 2004 prior to and after the initiation of habitat restoration activities.

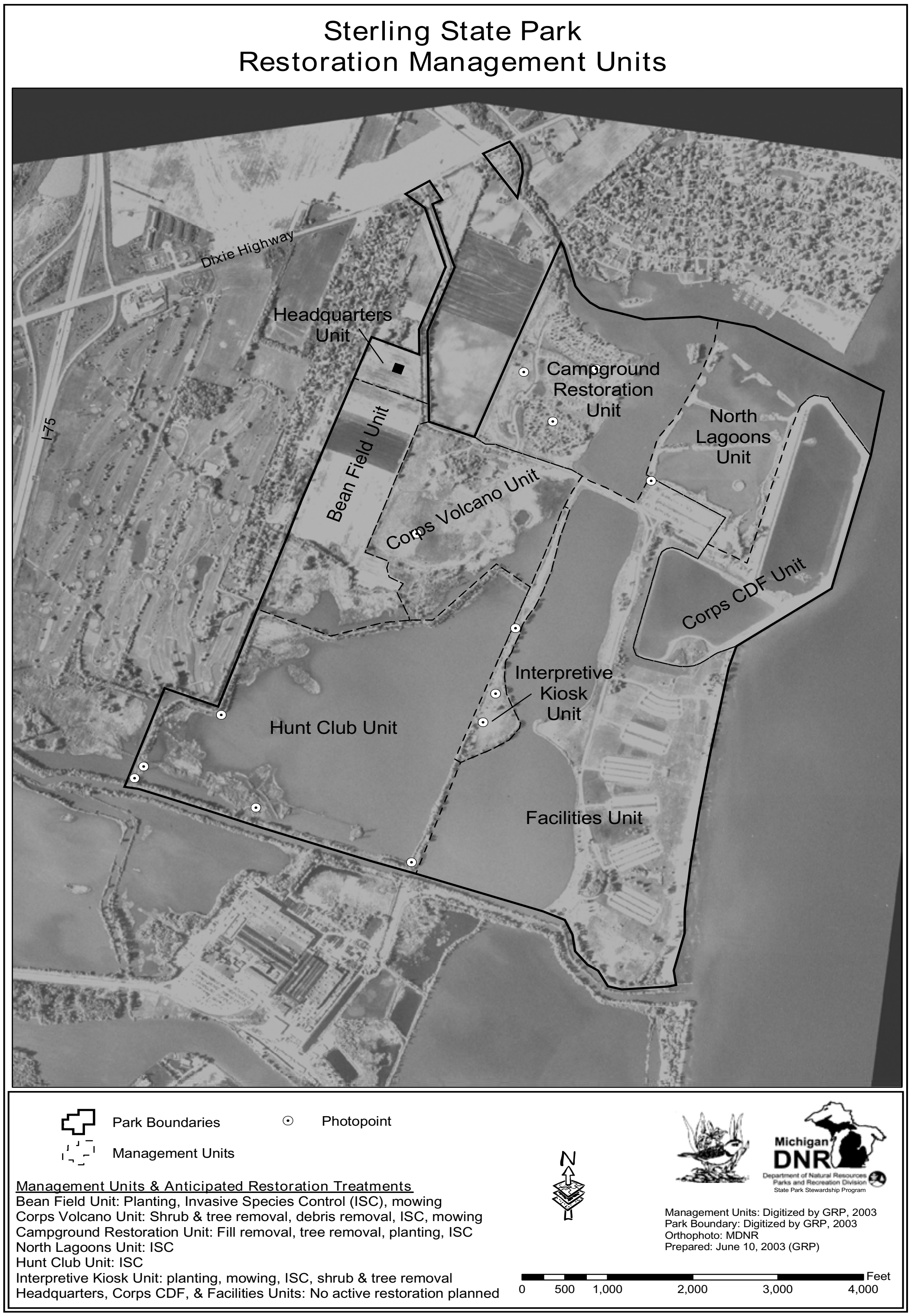

Figure 5. Map of management units in Sterling State Park.

Headquarters Unit

Historically (*circa* 1800), the Headquarters Unit contained beech-sugar maple or mesic southern forest and a small amount of lakeplain prairie in the southeast corner of the unit. The new park headquarters is located in this unit. This unit contains a small office building, a garage, parking lots in front and on both sides of the building, piles of old park supplies and debris and a fence surrounding the complex. Habitats outside the fence include mowed grass, old field bordered by a narrow strip of forest and a ditch along the road (Figure 6). This unit is about 7 ha (17 ac) in size, but habitat available for surveys only covers about half the unit. This unit is currently not targeted for any habitat restoration efforts. However, in 2004, old picnic tables were moved from the Corps Volcano Unit and stacked up along the south side of this unit in the mowed grass and old field habitats (Figure 6). Thus, surveys in 2004 were conducted on either side and/or between the picnic tables where accessible.


Figure 6. Examples of habitat on the north (left photo) and south (right photo) sides of the Headquarters Unit.

Bean Field Unit

Historically, the Bean Field Unit was primarily comprised of lakeplain prairie with Great Lakes marsh in the southern third of the unit and some beech-sugar maple forest in the northwest corner of the unit. In 2003, the Bean Field Unit primarily consisted of old field habitat, of which portions were wet or mesic (Figure 7). The unit is bordered by a narrow strip of forest and private residential homes. This unit has been targeted for planting, invasive species control and mowing. In 2004, the northern and central portions of the unit were planted with native grasses to provide a local seed source for ongoing and future restoration efforts (Figure 7). Scattered piles of large and small woody debris are found along the eastern edge and in the southeast corner of the unit. Areas within this unit that currently do not contain suitable habitat for fox snakes may support suitable habitat in the future due to restoration efforts, so surveys were conducted throughout the whole unit.



Figure 7. Examples of old field (left and center) and planted field habitats in the Bean Field Unit.

Corps Volcano Unit

Historically, the western half of the Corps Volcano Unit was lakeplain prairie and the eastern half was Great Lakes marsh. The old Sterling State Park headquarters was located in this unit. In 2003, the Corps Volcano Unit contained the two old park headquarter buildings, old field habitat, emergent marsh dominated by tall, dense reed canary grass and *Phragmites* along the eastern edge of the unit, and small patches of forest (Figure 8). A ditch, mowed grass and a paved road border the north side of the unit. A small hill (i.e., “volcano”), constructed from the spoils derived from the dredging of the Army Corps CDF, occurs in or near the center of the unit. Prior to and during the surveys in 2003, this unit also contained a large amount of debris including wood piles, wooden and metal boards (e.g., old doors and signs), picnic tables, concrete curbs and platforms, old tires, old blankets, building materials and old docks and associated metal supports.

This unit has been targeted for shrub and tree removal, debris removal, invasive species control and mowing. In late 2003 and prior to surveys in 2004, the old park headquarter buildings, trees and shrubs near the buildings and a significant amount of debris within the unit were removed. The emergent marsh was sprayed for invasive species control and later burned. Some debris piles in the unit also were burned. Surveys in 2004 were concentrated in the old field habitats within the unit as in 2003. Portions of the unit, particularly areas of emergent marsh, were still too dense to survey effectively in 2004 as in 2003. Some debris was still available in the unit in 2004 including several large woody debris piles, old docks and associated metal debris, large concrete slabs or platforms, large rock piles and boulders, rolls of plastic walkway, old blankets and plastic sheets, several old tires and scattered, small sheets of wood, metal or cardboard. The entire unit was considered potential habitat for fox snakes.

Figure 8. Old field and shrub habitats in the Corps Volcano Unit.

Campground Restoration Unit

This unit is the site of the old campground. The old campground was constructed in the late 1960’s on what was historically a natural gradient from lakeplain prairie to Great Lakes marsh (Olson 2002). Additionally, soil derived from the construction of the Army Corps CDF was used to raise the elevation of portions of the old campground in the 1980’s (Olson 2002). In 2003, the old campground had been removed, and available habitat within the unit primarily consisted of old field with scattered trees, dense emergent marsh dominated by *Phragmites*, small areas of bare dirt and a narrow band of forest along the northern end of the unit (Figure 9). The whole unit was considered potential habitat for fox snakes, although some areas within the unit contained dense vegetation and could not be surveyed in 2003.

The Campground Restoration Unit has been targeted for fill removal, tree removal, planting and invasive species control. Habitat conditions in this unit changed dramatically after surveys in 2003. In late 2003, most of the trees in this unit were removed, and the emergent marsh was sprayed for invasive species control. In 2004, the Campground Restoration Unit was re-graded down to historical contours in an attempt to restore Great Lakes marsh grading inland to lakeplain prairie (Figure 9). During late winter, spring and early summer, fill was removed from a substantial portion of the unit, and native lakeplain prairie vegetation was planted. In the spring, some of the emergent marsh was burned for invasive species control. During surveys in 2004, most of the unit was comprised of bare dirt with some old field habitat and emergent marsh along the northern, eastern and southern edges of the unit (Figure 9). Some natural and artificial debris or cover were found primarily in the emergent marsh. Erosion-control silt fences were located throughout the unit bordering the areas from which fill had been removed.

Figure 9. Old field, emergent wetland habitats and restoration areas in Campground Restoration Unit in 2004.

North Lagoons Unit

Great Lakes marsh historically comprised the North Lagoons Unit. This unit is currently comprised of several small open water lagoons separated by a series of small “islands” that were created from soils derived from construction of the adjacent CDF. Available habitat within this unit is primarily emergent marsh, dominated by cattail and *Phragmites,* and floating aquatic vegetation (Figure 10). A small area of old field and forest also occur in the southeast corner of the unit (Figure 10). This unit also borders the boat launch area. This unit has been targeted for invasive species control. The emergent marsh was aerially sprayed in 2003. Similar habitats were surveyed in 2003 and 2004.

Figure 10. Emergent wetland and forested habitat in North Lagoons Unit by boat launch.

Corps CDF Unit

The Corps CDF Unit is the confined disposal facility that was constructed by the Army Corps of Engineers in the 1980's by dredging the Great Lakes marsh habitat that historically occurred in this area. The CDF now contains contaminated sediments from the Raisin River delta and Lake Erie (Olson 2002). The unit is surrounded by a gate and fence and is not accessible to the public. The unit consists of two large open water lagoons and old field habitat along the perimeter near the fence. Emergent marsh, old field with short and tall, dense vegetation, mowed grass, and a paved trail border the unit outside the fence (Figure 11). A large, rock riprap wall is located along the Lake Erie shoreline outside the fence on the northeast side of the unit. No active restoration has been planned for this unit.

Figure 11. Mowed grass and old field habitats outside the Corps CDF Unit.

Facilities Unit

The Facilities Unit is comprised of two large, open water fishing lagoons and an adjacent "island" that is heavily used for recreation. This unit was created in the 1950's and 1960's by dredging the extensive Great Lakes marsh habitat that dominated this area historically. The Facilities Unit is largely developed or managed for recreational use and contains the new campground, a paved trail, paved parking lots, a boat launch, fishing piers, a playground, a campground office, restroom and picnic facilities and a 0.5-mile stretch of sandy beach. Natural or undeveloped habitats are mainly confined to narrow bands along the perimeter of the unit, particularly along the western, southern and southeastern edges of the unit. The rest of the perimeter along the eastern and northern edges of the unit consist of sandy beach, rock riprap, paved road and boat launch area. The open water fishing lagoons on the west side of the unit are bordered by rock riprap, emergent wetlands, old field habitat, mowed grass, small forest patches and a paved trail (Figure 12). Portions of the emergent wetland and old field habitats are dominated by *Phragmites* and reed canary grass (Figure 12). Mowed grass, old field and some lowland forest occur along the southern end of the unit, and open sand and mowed grass occur along the eastern edge of the unit along Lake Erie (Figure 12). Landscaped areas of mowed grass and planted vegetation occur throughout the unit (Figure 12). No active habitat restoration has been planned for this unit, although some patches of *Phragmites* along the lagoons were sprayed in 2003.

Figure 12. Habitats along southern (left) and western (right) perimeters of the Facilities Unit.

Interpretive Kiosk Unit

The Interpretive Kiosk Unit is a narrow, linear unit located between lagoons and consists of a paved trail primarily bordered by areas of bare dirt, old field, emergent marsh and small patches of forest. Rock riprap comprised of large boulders also occurs along portions of the shoreline along the lagoons (Figure 13). A pavilion and a foot bridge to the Facilities Unit are located at the southern end of this unit (Figure 13). Great Lakes marsh comprised this unit historically. The Interpretive Kiosk Unit has been targeted for planting, mowing, invasive species control, and shrub and tree removal. In 2002, a small area by the bridge and pavilion was planted to local-genotype, warm-season grasses and forbs to create a demonstration lakeplain prairie and future seed source (Olson 2002) (Figure 13). Areas with emergent marsh were sprayed for invasive species control in 2003. In 2004, portions of the old field and emergent marsh habitats along the trail and near the bridge and pavilion contained tall, dense vegetation and were difficult or impossible to survey.

Hunt Club Unit

The Hunt Club Unit was historically Great Lakes marsh. Currently, the Hunt Club Unit is comprised of a large, open water lagoon bordered by an extensive dike, which is now a 2.8-mile paved nature trail. The dike of trail is bordered by emergent marsh, degraded lowland forest and shrub-dominated openings, mud flats and floating aquatic vegetation (Figure 14). In 2003, extensive areas of emergent marsh were dominated by *Phragmites* in this unit. Debris in terms of broken concrete slabs or culverts and woody debris also are found along portions of the dike. Small islands created from soils derived from construction of the CDF also are found in this unit. These islands contain emergent marsh and old field habitats. Power line towers also are located on some of these islands. This unit has been targeted for invasive species control, and a significant portion of the emergent marsh in this unit was sprayed and burned in 2003. Portions of this unit contained extremely dense and tall vegetation in 2004 and could not be surveyed effectively.

Figure 13. Examples of habitats along paved trail in the Interpretive Kiosk Unit.

Figure 14. Examples of habitats along paved trail/dike in the Hunt Club Unit.

Methods

Visual Encounter Surveys

Similar to surveys conducted in 2003, surveys for the eastern fox snake in 2004 were conducted in all nine management units within Sterling State Park including the six units that have been targeted for restoration (i.e., Bean Field, Corps Volcano, Campground Restoration, North Lagoons, Hunt Club and Interpretive Kiosk) and the three units not currently targeted for active restoration (i.e., Headquarters, Facilities and Corps CDF). Due to the lack of access to the interior of the Corps CDF Unit, surveys were conducted outside the fence along the perimeter of the unit. Surveys in the North Lagoons Unit were conducted only along the southern and eastern perimeters of the unit due to limited access (i.e., narrow strips of dense emergent vegetation separated by deep water in the lagoons). Surveys in the Facilities Unit were concentrated along the western and southern boundaries of the unit and generally avoided areas that are highly developed or heavily used for recreation (e.g., campground, playground, parking lot, etc.). Surveys in the Hunt Club Unit were conducted along the dike or paved trail and in areas with habitat that were accessible along the edge of the lagoon.

Eastern fox snakes were surveyed in 2004 using line-transect and time-constrained visual encounter surveys (VES) similar to those that had been conducted in 2003. For the line-transect VES, multiple transects of 150 m were systematically placed and surveyed within each unit. Sampling effort in terms of the number of survey transects within each unit was proportional to the size of the unit or the amount of suitable and accessible habitat within each unit (i.e., ~1 transect per 1.5 ha) (Table 1). Survey transects were geographically distributed throughout each unit and in areas that represented the range of habitat types within each unit whenever possible. The location of each survey transect was recorded using a hand-held Global Positioning System (GPS) unit (Garmin 12XL) in 2003 (Appendix IV and V). The same transects were located and surveyed in 2004. In several of the management units (i.e., Campground Restoration, Interpretive Kiosk, Corps Volcano, Hunt Club and Facilities), one or two transects or portions of transects had to be moved to nearby habitat due to incorrect transect lengths or the presence of tall, dense vegetation (see Appendix IV and V for locations of new transects or portions of transects). Transects were located and marked with plastic flagging and wire flagging stakes from 15-18 August 2004 for field surveys.

In 2004, line-transect visual encounter surveys were conducted from 18 August to 13 September. A total of four transect surveys were conducted in each management unit during this time period (Table 1). The surveyor and the order in which management units were surveyed were randomly assigned to minimize survey bias. Transect surveys consisted of one or two surveyors slowly walking along the transect and visually searching for basking individuals as well as individuals under cover on both sides of the transect. Transect surveys were conducted by two surveyors walking side by side during the first survey visit in all management units and during the second visit in the Headquarters, Interpretive Kiosk, Facilities and Corps Volcano units. All remaining transect surveys were conducted by one surveyor walking along the transect. All transects in each unit were surveyed during each visit.

Time-constrained visual encounter surveys also were conducted in each management unit in 2004 during the same time period as the line-transect surveys. A total of four time-constrained VES were conducted in each management unit (Table 1). Time-constrained surveys were generally conducted immediately after transect surveys within each unit. Time-constrained surveys consisted of one or two surveyors meandering or slowly walking through areas with suitable habitat within each unit and visually searching for basking individuals as well as individuals under cover for a prescribed period of time per survey. Time-constrained survey durations ranged from 0.5 to 1.7 person-hours (i.e., 30-100 minutes) and were generally proportional to the size of the unit and the amount of available habitat within the unit (Table 1). The time limits set in 2004 were standardized for the units and were slightly higher but comparable to time constraints utilized in 2003 (i.e., 20-90 minutes).

Additional visual encounter surveys for eastern fox snakes were conducted in 2004 on 10, 12, 17 and 24 May, 17 June, 6 July, and 23 August (Table 1). These surveys were generally conducted during the radio-telemetry portions of the study. The purpose of these surveys was to find additional fox snakes for the radio-telemetry study, population estimation and tissue and blood sample collection. These surveys were generally conducted in the spring to investigate the effectiveness of spring surveys compared to late summer/early fall surveys. These surveys were conducted primarily in the Hunt Club and Interpretive Kiosk units but also in the Facilities, Volcano and Campground Restoration units. These surveys generally consisted of 1-2 surveyors walking through areas with suitable habitat and visually searching for snakes above ground and under cover.

All visual encounter surveys were conducted between 8 am and 7 pm during appropriate weather and survey conditions when the snakes were likely to be active or visible. An eastern fox snake monitoring field form was developed and completed for each survey visit (Appendix VI). Information on survey dates, times, duration, weather conditions, transects, habitat descriptions and snake observations was recorded on these field forms.

Snake Observations

All eastern fox snakes and other snakes observed during field surveys were documented. Similar data were recorded in 2004 as in 2003. The behavior, estimated length and age class of each observed snake were recorded whenever possible. The macro- and microhabitats in which each snake was found also were recorded. The behavioral, macrohabitat and microhabitat classifications used in this study have been used in other snake studies (Kingsbury 2001, Kingsbury et al. 2001). Snake behavioral classifications included basking, resting, courting, mating, foraging, traveling and unknown. Macrohabitat classifications were based on National Wetland Inventory (NWI) classifications (Cowardin et al. 1979) and included palustrine forested wetland (PFO), palustrine scrub-shrub wetland (PSS), palustrine, sedge-dominated emergent wetland (SDG), palustrine, cattail-dominated emergent wetland (CAT), upland forest (UFO), upland scrub-shrub (USS) and old field (OLD). Microhabitat classifications included shrub, sedge, grass, rock, log, herb (herbaceous/not grass), bare, island (small hummock in open water), detritus and other. More specific macro- and microhabitat information (e.g., natural community type, dominant plant species) was recorded when possible.

Locations of eastern fox snakes were recorded using a hand-held GPS unit. Observed fox snakes were captured, measured, weighed and sexed, when possible. Total length, snout-vent length (SVL) and tail length were measured and recorded for all captured fox snakes. Total length was used to designate age class with adult snakes ranging from about 90 – 170.5 cm (35-67 in), sub-adults or juveniles ranging from 32 – 89 cm (13- 35 in) and newly hatched or young snakes ranging from 26 – 31 cm (10-12 in) (Harding 1997). Adult fox snakes were individually marked with PIT (passive integrated transponder) tags in the field or in the lab (i.e., for snakes implanted with transmitters). The PIT tags were injected subcutaneously dorsal to the vent (i.e., cloacal opening) using a 10-gauge sterile syringe pre-loaded with the microchip. A tissue sample (i.e., scale clipping) and a blood sample also were collected from adult and juvenile fox snakes, when possible, and stored appropriately for future genetic analysis. A scale clipping was obtained from a ventral scale dorsal to the vent using sterilized surgical scissors. Approximately 0.1-0.2 ml of blood was collected from a caudal (tail) vein using a sterile needle and syringe. Photographs were taken of each captured fox snake for documentation. After all processing and data collection were completed, snakes were released at their respective capture sites. MNFI special animal survey forms were completed for surveys with fox snake observations (Appendix VII).

Radio-telemetry

One eastern fox snake was radio-tracked in 2003 and was relocated and radio-tracked again for part of the field season in 2004. This adult male was captured and implanted with a radio-transmitter in August of 2003. The snake was radio-tracked to its hibernation site in November of 2003. The snake was relocated on 24 April 2004 and was tracked weekly or bi-weekly until 23 August 2004.

Three additional fox snakes were captured and implanted with radio-transmitters in 2004. Two of the snakes were captured during additional visual encounter surveys on 10 and 17 May, and the third snake was captured during time-constrained VES on 24 August 2004. Two of these snakes are adult males, and the third snake is a juvenile snake (sex unknown, possibly male). These snakes were transported to the laboratory of Dr. Bruce Kingsbury, Biology Department Chair at Indiana-Purdue University at Ft. Wayne, who surgically implanted the radio-transmitters in the snakes using the following protocol. Each snake was anesthetized by placing it into a sealed chamber with a small container of isoflurane which vaporizes and permeates the chamber. The snake was measured, weighed and sexed once it was anesthetized. Also, while the snake was anesthetized, a scale clipping and blood sample were obtained, and the snake was PIT-tagged. Transmitters were implanted using a technique modified from Reinert and Cundall (1982). A small lateral incision was made on the ventral side of the body cavity approximately two-thirds of the way down the body. The incision was placed slightly above the surface that slides across the ground when the snake moves. Rather than cut through the body wall, the body wall was easily separated with little or no blunt dissection, and the peritoneum (body cavity membrane) was punctured and enlarged by cutting with scissors. A radio-transmitter was then inserted into the body cavity. Radio-transmitters weighing 9 grams (1 cm wide x 3 cm long cylinder, 20 cm whip antenna, 18-month life span, Holohil Systems Ltd.) were used in the adult snakes, and a smaller transmitter weighing 5 grams (0.95 cm wide x 2 cm long cylinder, 12-month life span, Holohil Systems Ltd.) was used in the juvenile snake. The antenna was placed subcutaneously along the body of the snake, anterior to the initial incision through a second, small incision. The primary incision was closed with PDS absorbable suture and surgical skin glue. The second incision was simply glued closed with skin glue.

After recovery from the anesthesia, the snakes were moved to a housing area. The housing area was kept at 80-82 degrees F, which is the temperature many snakes seek in the field during the summer months based on previous studies. When the temperature fell below this level, a heat source (light bulb or heating pad) was placed near or under the terrarium in order to establish a thermal gradient along the terrarium's length. This allowed the snakes to behaviorally thermo-regulate by moving towards or away from the heat source. The photo period of the room was 14:8 day:night. Each snake was held individually in a clean terrarium, away from other animals that might act as a source of pathogens. The snakes were inspected several times a day. Handling of the snakes during the recovery period was kept to a minimum. Water was provided, but food was not. The snakes were held for observation for 3-6 days (7 days maximum) after the surgery and then released at their respective capture sites in the park.

Once released, these snakes were radio-tracked on a weekly or bi-weekly basis throughout the field season. To date, two of the snakes have been radio-tracked from 17 and 24 May to 23 September, and the third snake was tracked from 8-23 September 2004. The snakes were located during different times of the day during the radio-tracking period between 9 am and 8:30 pm. The position of each location was recorded using a hand-held GPS unit and plotted on an aerial photo of the park using ArcView GIS (ESRI Inc.). At each location, the macro- and microhabitats in which the snake was found, the behavior of the snake, and weather conditions were recorded. The pulse interval of the radio-transmitter also was recorded and was used to estimate the body temperature of the snake. A visual confirmation of the radio-tracked snake was obtained when possible. The snakes will be radio-tracked to their hibernation sites this fall.

Table 1. Summary of eastern fox snake visual encounter survey (VES) effort at Sterling State Park in 2004.

Management Unit	Area	Line -Transect VES		Time-Constrained VES		Additional VES	
	ha (ac)	# Transects	Dates	Time (mins)	Dates	# Surveys	Dates
Headquarters	7 (17)	2	8/24, 8/25, 9/2, 9/8	30	8/24, 8/25, 9/2, 9/8	0	
Bean Field	32 (80)	16	8/19, 9/1, 9/2, 9/13	60	8/19, 9/1, 9/2, 9/13	0	
Corps Volcano	35 (88)	20	8/18, 8/26, 9/5, 9/6	90	8/18, 8/26, 9/5, 9/6	2	5/10, 5/12
Campground Restoration	44 (109)	14	8/23, 9/1, 9/3, 9/8	60	8/23, 9/1, 9/3, 9/8	1	5/12
Interpretive Kiosk	7 (16)	7	8/18, 8/25, 9/2, 9/7	50	8/18, 8/25, 9/2, 9/7	6	5/10, 5/12, 5/24, 6/17, 7/6, 8/23
Hunt Club*	92 (226)	11	8/24, 8/31, 9/2, 9/7	100	8/24, 8/31, 9/2, 9/7	6	5/10, 5/12, 5/17, 5/24, 6/17, 8/23
North Lagoons*	35 (86)	3	8/18, 9/1, 9/3, 9/7	30	8/18, 9/1, 9/3, 9/7	0	
Corps CDF*	39 (97)	4	8/19, 9/1, 9/3, 9/7	40	8/19, 9/1, 9/3, 9/7	0	
Facilities*	122 (303)	14	8/19, 8/25, 9/3, 9/8	80	8/19, 8/25, 9/3, 9/8	3	5/12, 7/6, 8/23
Total		91		540		18	

*Denotes management units with significant portions that were inaccessible, developed and/or did not contain suitable habitat for eastern fox snakes

Results

Surveys

In 2004, MNFI conducted a total of about 100 hours of field surveys for the eastern fox snake in Sterling State Park, with approximately 34 hours of line-transect visual encounter surveys, about 36 hours of time-constrained surveys and about 29 hours of additional visual encounter surveys. Given that some surveys were conducted by multiple individuals, a total of about 159 person-hours of surveys were conducted, with about 47 person-hours of line-transect surveys, about 49 person-hours of time-constrained surveys, and about 64 person-hours of additional visual encounter surveys. Overall, field surveys in 2004 resulted in 11 fox snake observations of which nine were new snakes and two were recaptures (Table 2). All fox snake observations in 2004 occurred in the Interpretive Kiosk and Hunt Club units. Four new fox snakes were observed during additional visual encounter surveys in these two units (i.e., 2 snakes in each unit) on 10 and 17 May and 17 June 2004. The other five new snakes and one of the recaptured snakes were found in the Hunt Club Unit on 24 August, of which four were observed during the line-transect survey and two were observed during the time-constrained survey. The recaptured snake was likely one of the transmittered snakes in the study based on its general appearance and location (i.e., snake was radio-tracked to this location the day before). The second recaptured snake also was found in the Hunt Club Unit during the time-constrained survey on 31 August. This snake was one of the new snakes captured on 24 August. Figure 15 provides an aerial photograph of the Park with the locations of the fox snakes observed during all visual encounter surveys in 2004. The locations of the fox snakes found during surveys in 2003 also are shown for comparison.

Relative abundance estimates or detection frequencies were derived for the park as a whole based on the number of fox snakes observed and survey effort in terms of survey hours and/or person-hours. Relative abundance estimates or detection frequencies could only be calculated for the line-transect and time-constrained visual encounter surveys. A total of four snake observations was documented in about 34 hours of line-transect surveys, resulting in a relative abundance estimate or detection frequency of 0.12 fox snake observations/survey hour. Three fox snake observations were documented in about 36 hours of time-constrained surveys, resulting in a relative abundance estimate of 0.08 snake observations/survey hour. Overall, line-transect and time-constrained visual encounter surveys combined documented a total of 7 fox snake observations in about 70 survey hours, resulting in a relative abundance estimate or detection frequency of 0.10 fox snake observations/survey hour for the park as a whole in 2004. If only observations of new fox snakes were considered (i.e., no recaptures), the overall relative abundance estimate would be 0.07 fox snakes/survey hour.

Table 2. Summary of eastern fox snakes and other snakes observed during visual encounter surveys in 2004.

Management Unit	Eastern fox snake	Eastern garter snake	Butler's garter snake	Northern water snake	Northern ribbon snake	Brown snake	Unidentified snake	Total
Bean Field							1	1
Campground Restoration		1						1
Corps CDF			1					1
Corps Volcano			6			1	1	8
Facilities		10	2	2			2	16
Headquarters		1	1					2
Hunt Club	9	8	3	12	1		1	34
Interpretive Kiosk	2	2	2	9			1	16
North Lagoons						1		1
Total	**11**	**22**	**15**	**23**	**1**	**2**	**6**	**80**

Figure 15. Locations of eastern fox snake observations during visual encounter surveys at Sterling State Park in 2004 and 2003. The red dots represent locations of new fox snake captures in 2004. The green dots represent locations of fox snake recaptures in 2004. The light blue dots represent locations of fox snake captures in 2003.

Of the nine new fox snakes that were found in 2004, six were considered adults with total lengths ranging from about 89–130 cm (35-51 in) and weights ranging from 160–379 g (Table 3). The remaining three fox snakes were considered sub-adults or juveniles with total lengths ranging from 67-78 cm (26-31 in) and weights ranging from 82–135 g. No newly hatched or young fox snakes were observed during surveys in 2004. Two of the captured fox snakes were probed in the lab and were identified as males. The other fox snakes were not probed in the field, and it was difficult to determine the sex of these snakes because external sex differences in fox snakes are not obvious and some of the snakes were small. Tissue samples (i.e., scale clippings) were collected from all nine snakes found in 2004, and blood samples were obtained from six of the snakes. All of these snakes were marked with a PIT tag except for the smallest juvenile snake which was only marked with white liquid paper near the tip of its tail. A total of 11 individual fox snakes have been marked with PIT tags as part of this study over the two years (Table 3).

The fox snakes observed during field surveys in 2004 were found in five different habitats or microhabitats (Table 3). One adult snake was observed traveling in grass in old field habitat in the Interpretive Kiosk Unit by the pedestrian bridge that connects the Kiosk Unit with the Facilities Unit. A juvenile and an adult snake were observed traveling and basking, respectively, on the large rocks or rip-rap along the open water lagoon under the pedestrian bridge in the Interpretive Kiosk Unit. A juvenile and an adult snake were found basking and traveling in the open on the paved nature trail on the dike in the Hunt Club Unit. One adult snake was found basking on gravel in the open along the paved nature trail adjacent to a foot bridge and palustrine forest habitat in the Hunt Club Unit. The remaining two adult fox snakes and a juvenile snake were found resting under large concrete slabs adjacent to palustrine emergent wetland within 1-2 m of open water along the lagoon on the east side of the dike in the Hunt Club Unit (Figure 16). These three snakes were found under adjacent concrete slabs within a 5-7 m stretch along the dike, and the juvenile and one of the adult snakes were found together under the same concrete slab. The two fox snake recaptures also were found resting under concrete slabs in this same stretch along the dike in the Hunt Club Unit.

Additional fox snake observations were reported by Sterling State Park and State Park Stewardship Program staff, private contractors working in the management units and park visitors. Stewardship Program staff and private contractors working in the Campground Restoration Unit observed an adult fox snake along the edge of that unit in the spring or early summer. On 15 August, a Sterling State Park staff member reported untangling and releasing a fox snake that had been caught in a net with fish in a park visitor's boat. The snake appeared unharmed. Park visitors reported two fox snake observations to park staff on 16 August. These observations included a fox snake seen crossing the entrance road into the park (the visitor apparently helped the snake cross the road) and a fox snake seen along the west side of the road in the Facilities Unit across from the Corps CDF Unit. Park visitors in the campground also reported a couple of fox snake observations in the Facilities Unit. However, fox snake reports from park visitors should be verified by a reliable source or with a photograph. Finally, a Sterling State Park staff member reported seeing possibly over 40 fox snakes in the park over the spring and summer of 2004.

In addition to the snakes observed during MNFI's surveys and incidental reports, at least five dead fox snakes were reported in 2004. Interestingly, one specimen was found by MNFI surveyors on 17 June on Dixie Highway near the entrance to the Holiday Inn Express located approximately 1.1 km (0.7 mi) west of the entrance to Sterling State Park and about 320 m (0.2 mi) west of the intersection of Dixie Highway and I-75 (see Figure 15). The other four specimens were found in the park by Sterling State Park staff or State Park Stewardship Program staff. The State Park Stewardship Program staff found a dead snake in the Bean Field Unit in June which may have been killed accidentally by heavy equipment use during a planting operation. The State Park Stewardship Program staff found two other dead fox snakes this summer, of which one was found in a portable bathroom in the park. Another specimen was an injured snake that was alive when it was picked up by Sterling State Park staff but died the following day. Three of the five specimens were collected and frozen for future genetic analysis. Four of the five dead snakes were checked for PIT tags, and none were marked. The fifth snake was checked to see if it was a transmittered snake, and it did not have a radio-transmitter.

In addition to eastern fox snakes, a total of 69 observations of other snake species were documented during field surveys in 2004. These included 22 eastern garter snake (*Thamnophis sirtalis sirtalis*) observations, 15 Butler's garter snake (*Thamnophis butleri*) observations, 23 northern water snake (*Nerodia sipedon*) observations, 1 northern ribbon snake (*Thamnophis sauritus septentrionalis*) observation, 2 brown snake (*Storeria dekayi*)

Table 3. Summary of locations, age classes, sizes, PIT tag identification numbers, behaviors and habitats of eastern fox snakes observed during visual encounter surveys in Sterling State Park in 2004.

Date	Management Unit	Survey Type[1] (LTS, TCS, AVS)	Capture (C)/ Recapture (R)	PIT tag ID #	Age class[2] (A, J, Y)	TL/SVL[3] (cm)	Weight (g)	Sex[4] (M, F, U)	Latitude	Longitude	Macrohabitat[5]	Microhabitat	Behavior	Radio-transmittered?
05/10/2004	Interpretive Kiosk	AVS	C	087 303 894	A	130/109	379	M	41.91142	-83.341073	Old field	Grass, forbs	Traveling	Y
05/17/2004	Interpretive Kiosk	AVS	C	052 563 549	J	77/64	99	U	41.909757	-83.344093	Rock riprap shoreline	Rock	Basking/ traveling	Y
06/17/2004	Hunt Club	AVS	C	087 320 616	A			U	41.91153	-83.340742	PSS/PFO along dike/lagoon	Rock	Basking	N
06/17/2004	Hunt Club	AVS	C	087 305 347	A	103		U	41.907972	-83.351118	On dike/paved trail between PSS	Paved trail	Traveling	N
08/24/2004	Hunt Club	LTS	C	087 291 593	A	89/78	160	U	41.908817	-83.344517	PEM	Rock/ concrete slab	Resting	N
08/24/2004	Hunt Club	LTS	C	087 360 294	A	90/77	160	U	41.9088	-83.3446	PEM	Rock/ concrete slab	Resting	N
08/24/2004	Hunt Club	LTS	C	087 305 379	J	78/68	135	U	41.9088	-83.3446	PEM	Rock/ concrete slab	Resting	N
08/24/2004	Hunt Club	LTS	C	087 353 314	A	102/86	260	M	41.908367	-83.35245	In the open on the side of paved trail adjacent to PEM/PSS	Rock/ gravel	Basking	Y
08/24/2004	Hunt Club	TCS	C	No pit tag	J	67/59	82	U	41.916683	-83.342333	Paved trail on dike adjacent to PFO/PSS	Paved trail	Basking/ traveling	N
08/24/2004	Hunt Club	LTS	R?	087 303 894	A			M	41.908867	-83.344587	PEM	Rock/ concrete slab	Resting	Y
08/31/2004	Hunt Club	TCS	R	087 291 593	A			U	41.909389	-83.341861	PFO/PSS	Rock/ concrete slab	Resting	N

[1]Survey type: LTS = line-transect visual encounter survey, TCS = time-constrained visual encounter survey, and AVS = additional visual encounter survey
[2]Age class: A = adult, J = juvenile/sub-adult, Y = young
[3]TL/SVL: TL = total length, SVL = snout-vent length
[4]Sex: M = male, F = female, U =unknown
[5]Macrohabitat: OLD = old field, PEM = palustrine emergent wetland, PSS = palustrine scrub-shrub, and PFO = palustrine forest

 

Figure 16. Example of eastern fox snake habitat - i.e., concrete slab (left) in palustrine emergent wetland habitat (right) along the dike/paved trail in the Hunt Club Unit.

observations, and 6 unidentified snake observations (Table 2). Of the total number of snakes observed, 38 observations were made during the line-transect and time-constrained visual encounter surveys, and 31 observations were made during additional visual encounter surveys. During the line-transect and time-constrained surveys, the highest numbers of observations of other snake species were documented in the Hunt Club and Facilities units with 12 and 10 observations, respectively, followed by the Corps Volcano and Interpretive Kiosk units with 6 and 4 observations, respectively. Additionally, approximately equal numbers of snake observations were documented during the line-transect and time-constrained surveys (i.e., 20 and 18 observations, respectively). It is important to note that these observations likely do not all represent separate individuals since repeated surveys of the same areas were conducted and observed animals were not marked. It also is interesting to note that significantly fewer individuals of other snake species were found during surveys in 2004 than in 2003. All but one unit had fewer observations of other snake species in 2004 than in 2003 with the most significant reductions in snake observations in the Facilities, Hunt Club, Corps CDF and Corps Volcano units.

An eastern massasauga (*Sistrurus catenatus catenatus*) observation also was reported in 2004 by two Sterling State Park staff members. The snake was observed on or along the road in the park. The snake apparently appeared injured, and the park staff moved the snake to the side of the road. Unfortunately, the snake was not documented with a photograph. Confirmation of eastern massasaugas at Sterling State Park would be significant as this species has not been recorded previously in Monroe County and has been documented from only one site in the Maumee Lake Plain region along Lake Erie, according to the MNFI database. Other park staff and members of the general public also have reported massasaugas in the park or in the vicinity of the park. These reports require further investigation.

Other amphibian and reptile species also were observed during field surveys. These included at least 10 northern leopard frog (*Rana pipiens*) observations, 1 bullfrog (*Rana catesbeiana*) observation and 2 common map turtle (*Graptemys geographica*) observations. Also, an eastern box turtle (*Terrapene carolina carolina*) was found in late August crossing the park entrance road near the Bean Field and Corps Volcano units heading toward the private land on the other side of the road from these units. The turtle was picked up and released in the same area by Sterling State Park staff. This observation would represent a new element occurrence record for this species according to the MNFI database. This occurrence warrants additional surveys to determine the location, extent, status and habitat use of the box turtle population in the area.

In addition to amphibians and reptiles, other interesting animal species were encountered or noted during field surveys. An American bittern (*Botaurus lentiginosus*), a state special concern species, was observed in emergent marsh habitat at the southern end of the Corps Volcano Unit on 10 May 2004. Individuals of this species have been observed previously in the park by park staff, but this species nesting in the park has not yet been confirmed. Several small mammals (i.e., mice and shrews) were found under cover boards in the Corps Volcano Unit.

Although crayfish were not seen, numerous crayfish burrows with and without chimneys were observed in the Bean Field and Corps Volcano units. These burrows may provide suitable habitat for eastern fox snakes and other snakes.

Radio-telemetry

The adult male fox snake that was radio-tracked in 2003 (PIT tag #: 066 856 597, hereafter referred to as M59703) was radio-tracked to seven different locations from 24 April to 20 July 2004 (Table 4). (Note: GPS locations are available for only five of these points due to technical difficulties with our GPS units.) However, from 20 July to 14 August, the snake was tracked to the same location on four consecutive occasions. On 23 August, the radio-transmitter that had been implanted in M59703 was found in the grass at this location. The antenna of the transmitter was curled up, but no bite marks or scratches were evident, and the transmitter was still functional. Based on the condition of the transmitter (i.e., absence of bite or teeth marks), the snake may have been taken by an avian predator such as a great blue heron or bird-of-prey.

When M59703 was first located on 24 April, the snake was found on the east side of the dike or paved nature trail in the Hunt Club Unit about 200 m (0.1 mi) from where it had hibernated (Figure 17). On 10 May, the snake was located about 10 m (33 ft) further north along the dike in the Hunt Club Unit. From 17 May to 17 June, the snake continued north along the dike and was located north of the pavilion in the Interpretive Kiosk Unit. A week later, the snake was located and visually observed on 24 June on the other side of the lagoon along the western edge of the Facilities Unit. It is unknown how the snake crossed the lagoon to get to the Facilities Unit from the Interpretive Kiosk Unit (i.e., whether the snake swam directly across the lagoon or whether the snake traveled north or south along the edge of the lagoon). On 20 July, M59703 (or at least its transmitter) was tracked to its last known location further north along the western edge of the Facilities Unit. Interestingly, the last documented location for this snake was where it was originally captured in 2003. The maximum distance between documented locations for this snake (i.e., the distance between the two farthest locations) was 830 m (0.5 mi) for the locations along the dike in the Hunt Club and Interpretive Kiosk units from 24 April to 17 June. The maximum distance between documented locations for this snake using the first observation on 24 April and the last known location in the Facilities Unit on 27 July (i.e., straight-line distance between locations) was about 1,022 m (0.6 mi). These distances should be considered underestimates or minimum estimates of the total distance a snake can travel within its home range because the snake was not tracked daily and because snakes don't necessarily just travel in one direction in a straight line between two points.

M59703 was located in several different macro- and microhabitats (Table 4). Of the seven locations in 2004, this snake was found in palustrine emergent/ palustrine scrub-shrub on four occasions (57%), in old field habitat on two occasions (29%), and in palustrine forest on one occasion (14%). In terms of microhabitats, the snake was found resting and foraging in a shrub on two occasions, resting in/under grass on two occasions, and resting near/in a downed log, in a patch of jewelweed adjacent to a patch of dense *Phragmites*, and under a large concrete slab along the edge of the lagoon on the other three occasions (see Figure 16). The snake was generally found along the edge of the lagoons within 1-3 m of the water's edge. The snake was visually confirmed at 6 of the 7 locations from 24 April to 24 June, and on one occasion, the snake was "fat" around the middle and likely had recently consumed a meal.

The radio-tracked fox snake that was initially captured during additional surveys on 10 May 2004 was an adult male that weighed 379 g and was 130 cm (51 in) in total length (SVL = 109 cm/43 in, tail length = 21 cm/8 in) at the time of the surgery. The transmitter was implanted on 31 May, and the snake was released at its point of capture in an open grassy area near the paved trail and foot bridge in the Interpretive Kiosk Unit on 17 May. After its release, a total of 13 locations was obtained for this snake (PIT tag ID: 087 303 894, hereafter referred to as M89404) from 24 May to 23 September (Table 5). This snake also was believed to have been observed during a line-transect survey in the Hunt Club Unit on 24 August. After the snake was released at its initial capture site in the Interpretive Kiosk Unit, the snake moved southward and apparently remained along the dike within the Hunt Club Unit during the radio-tracking period, based on known locations (Figure 18). The snake moved north and south along the dike, and on two occasions (6 July and 31 August), the snake's radio-transmitter's signals indicated the snake may have been on an island in the southeast corner of the lagoon (see Figure 18). The island is located about 240 m west and about 60-80 m north of the dike in the Hunt Club Unit's lagoon. The island could not be accessed during the study to confirm the snake's occurrence on the island. On one of these potential "island excursions," M89404 was located along the dike and shoreline of the lagoon during the previous

Table 4. Summary of radio-telemetry locations and habitats for Fox Snake M59703 in Sterling State Park in 2004.

Location	Date	Time	Unit	Habitat*	Microhabitat	Visual?	Behavior	Latitude	Longitude	Weather	Comments
1	04/24/2004	8:21 PM	Hunt Club	PEM	Under rock/concrete slab on bare soil	Y	Resting	41.90881667	-83.34451667	45-50F, cloudy, windy	Along dike/edge of lagoon within 1-2 of water, ~30 ft. N. of 11/13/03 hibernation site
2	05/10/2004	12:04 PM	Hunt Club	PEM/PSS	In shrub	Y	Resting	No GPS		70-75F, sunny, 5-15 mph wind	Along dike N. of 4/24/04 location within 2-3 m of water.
3	05/12/2004	4:00 PM	Hunt Club/ Interpretive Kiosk			N				70-75F, cloudy with intermittent sun/rain, 0-10 mph wind	Did not locate the snake due to rain but still in Hunt Club or Interpretive Kiosk
4	05/17/2004	11:53 AM	Interpretive Kiosk	PFO	Near downed log	Y	Resting	41.91279352	-83.34170052	70-75F, sunny, little wind	Snake climbed inside of a dead tree.
5	05/24/2004	1:30 PM	Interpretive Kiosk	OLD	Under grass	Y	Resting	41.91555083	-83.34023603	65-69F, mostly cloudy, windy	Snake was fat around the middle, likely had a recent meal.
6	06/17/2004	11:14 AM	Interpretive Kiosk	PSS	In shrub	Y	Foraging	41.91421861	-83.34110817	75F, cloudy, some wind	
7	06/24/2004	4:11 PM	Facilities	PEM	Herbaceous/patch of jewelweed adjacent to patch of Phragmites	Y	Resting	No GPS		65-70F, overcast, 15-25 mph wind	Got visual but jumped into water and thick Phrag patch; location near trees where snake was originally caught.
8	07/20/2004	1:49 PM	Facilities	OLD	Under/in grass; underground?	N	Unknown	No GPS		85F, partly cloudy	
9	07/30/2004	9:24 AM	Facilities	OLD	Under/in grass; underground?	N	Unknown	No GPS		68F, foggy , overcast	Same area as 7/20/04; signal seemed to get strong and weak.
10	08/06/2004	3:45 PM	Facilities	OLD	Under/in grass; underground?	N	Unknown	No GPS		71F, mostly sunny, windy	Same area as 7/20 & 7/30; signal seemed to get strong and weak.
11	08/14/2004	4:30 PM	Facilities	OLD	Under/in grass; underground?	N	Unknown	41.91590488	-83.33667406	71-72F, p.sunny, 60% cloud cover, 5-10 mph wind	Locations from 7/20-8/14 all in same area.
12	08/23/2004	12:16 PM	Facilities	OLD	Grass	N		41.91588333	-83.3367	80F, 90% sun, 0-5 mph wind	Snake dead, transmitter found

*Habitat: PEM = palustrine emergent wetland, PSS = palustrine scrub-shrub, PFO = palustrine forest; OLD = old field

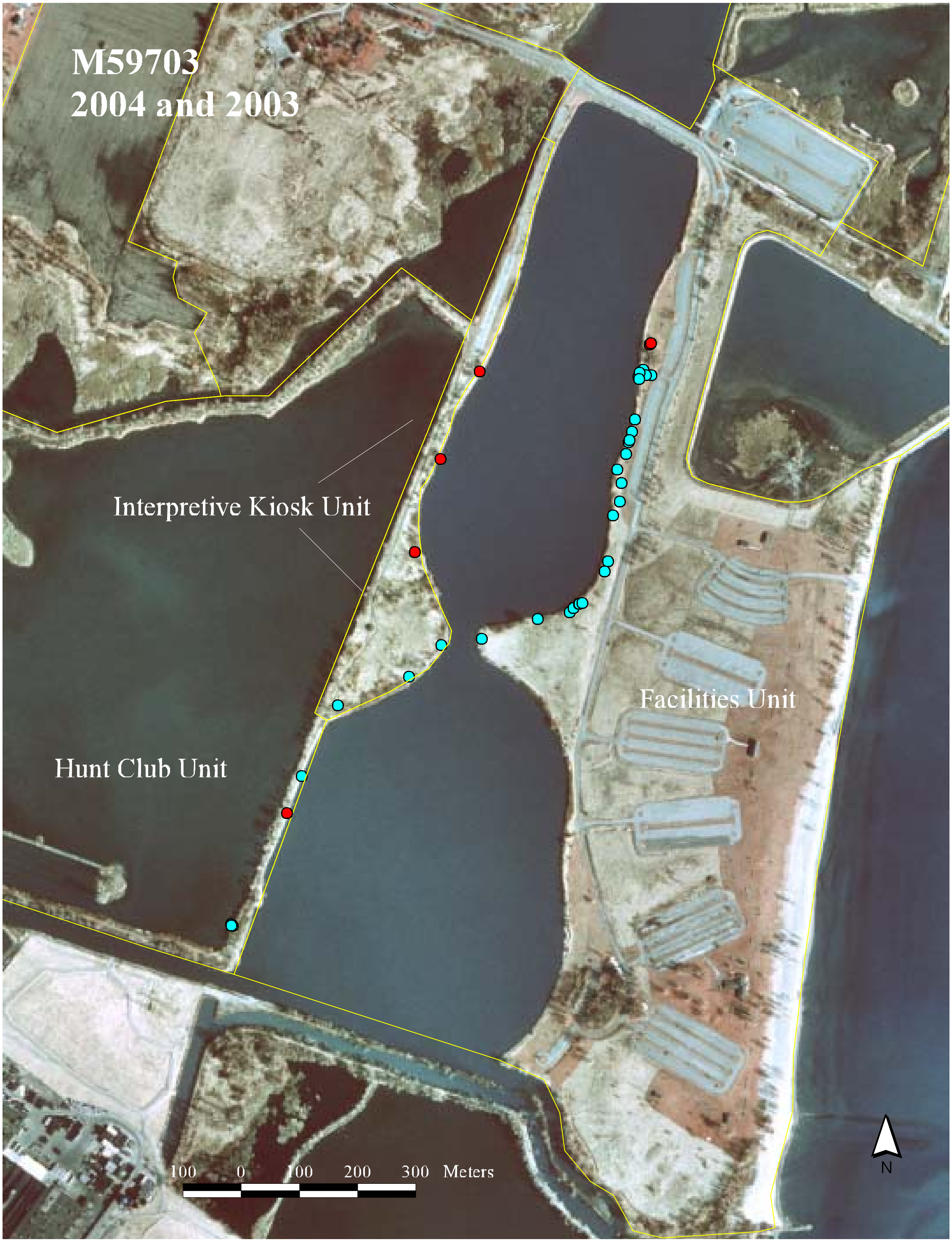

Figure 17. Map of radio-telemetry locations for Fox Snake M59703 in Sterling State Park in 2004 (red dots) and 2003 (light blue dots).

Table 5. Summary of radio-telemetry locations for Fox Snake M89404 in Sterling State Park in 2004.

Location	Date	Time	Unit	Habitat*	Microhabitat	Visual?	Behavior	Latitude	Longitude	Weather	Comments
1	05/10/2004	4:15 PM	Interpretive Kiosk	OLD	Grass	Y	Basking	41.91142023	-83.34107288	70-80F, 95-100% sun, 0-5 mph wind	Original capture location.
2	05/17/2004	11:09 AM	Interpretive Kiosk	OLD	Grass/thistles	NA	Traveling	41.91154361	-83.34146448	72F, sunny, little wind	Release site after surgical implantation of transmitter.
3	05/24/2004	12:09 PM	Interpretive Kiosk	OLD	Grass	Y	Foraging/ traveling	41.90975726	-83.34409305	Partly sunny, windy	Along dike
4	06/17/2004	11:56 AM	Interpretive Kiosk	PSS	Shrub	Y	Basking	41.90911646	-83.34441776	75F, cloudy, windy	On dike
5	06/24/2004	2:10 PM	Hunt Club	PEM	Under rock/concrete slab	N	Resting	No GPS		70F, 10-15 mph wind, hazy	Snake was under concrete slab; did not get visual
6	07/06/2004	2:36 PM	Hunt Club/ Island?	Unknown	Unknown	N	Unknown	No GPS		70F, sun, 0-5 mph wind	Snake appears to be on island by powerline towers based on signal triangulation from dike.
7	07/30/2004	10:15 AM	Hunt Club	OLD	Unknown	N	Unknown	No GPS		68F, overcast, humid	Receiver battery went dead so exact location unknown.
8	08/14/2004	5:55 PM	Hunt Club	PEM	Under rock/large concrete slab	N	Resting	41.90884531	-83.34453293	69F, cloudy-70%	
9	08/23/2004	1:05 PM	Hunt Club	PEM	Under rock/large concrete slab	N	Resting	41.90886676	-83.34458658	80F, 60% sun, 0-5 mph wind	Same area as on 8/14/04
10	(08/24/2004)	11:27 AM	Hunt Club	PEM	Under same concrete slab as on 8/23/04	Y	Resting	41.90886676	-83.34458658	81F, 60% sun, 0-5 mph	Found snake during transect survey; identified snake as 151.199 based on location and size of snake
11	08/31/2004	11:25 AM	Hunt Club/ Island?	Unknown	Unknown	N	Unknown	No GPS		75F, 100% sun, 0-5 mph	Snake appears to be on island with 2 powerline towers.
12	09/02/2004	5:19 PM	Hunt Club	PFO	Tree roots & embankment along dike	N	Unknown	41.90780461	-83.34533759	80F, 100% sun, 0-10 mph	Snake is probably under embankment near/under clump of cottonwood roots.
13	09/08/2004	11:39 AM	Hunt Club	PSS	Unknown	N	Unknown	41.90812111	-83.34498354	Low 70's, windy 5-15 mph, 10% sun	No visual on snake; moved to east side of dike into very thick shrubs.
14	09/13/2004	1:28 PM	Hunt Club	PEM	Unknown	N	Unknown	41.90741301	-83.34531077	80F, breezy, sunny	No visual; snake in thick veg w/ log.
15	09/23/2004	9:50 AM	Hunt Club	PSS	Under rock/ concrete slab	Y	Resting	41.9090867	-83.34438809	75F, 100% sun, no wind	

*Habitat: PEM = palustrine emergent wetland, PSS = palustrine scrub-shrub, PFO = palustrine forest; OLD = old field

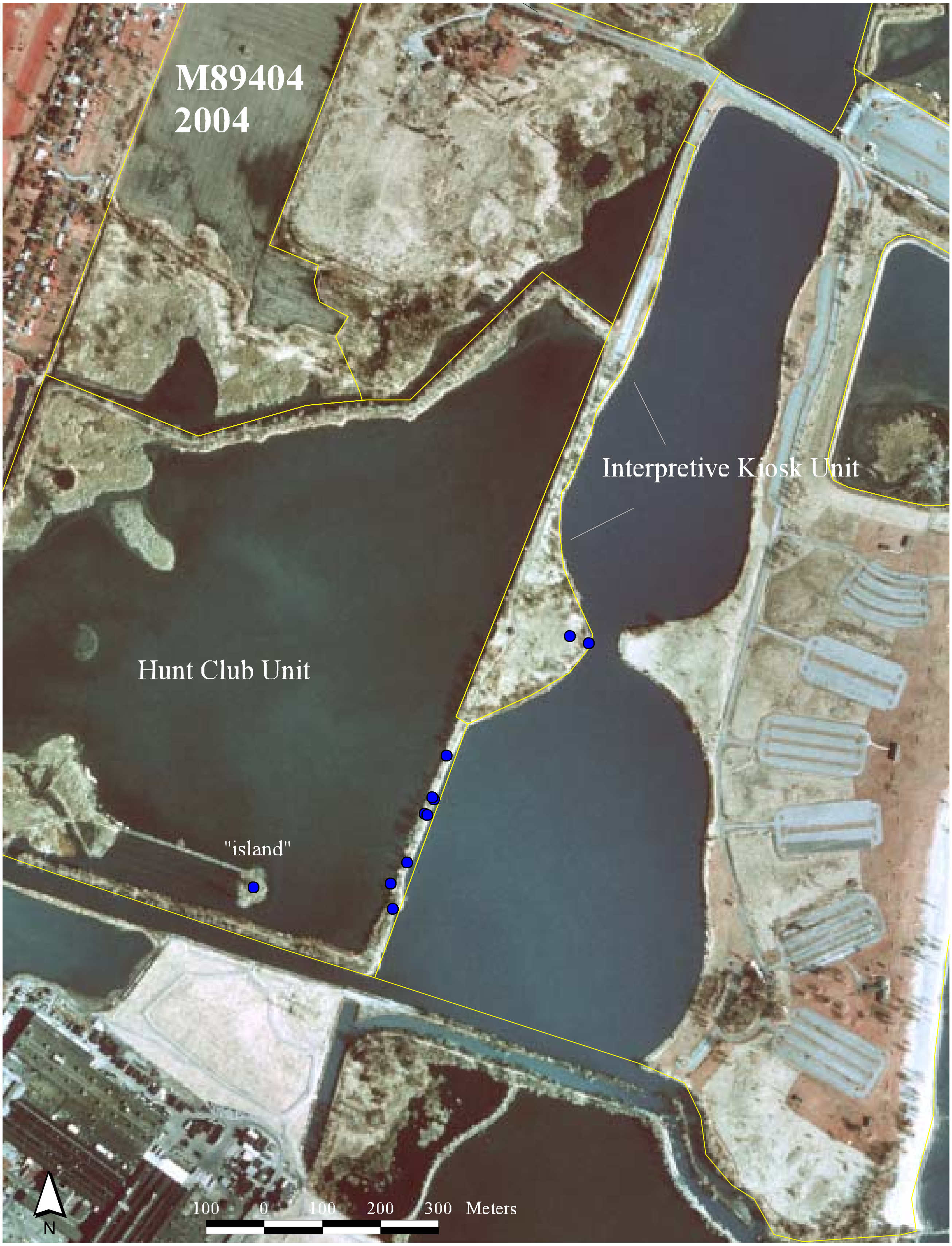

Figure 18. Map of radio-telemetry locations for Fox Snake M89404 in Sterling State Park in 2004.

week and was back along the dike two days after the signal indicated the snake might have been on the island. The maximum distance between the two farthest documented locations (i.e., between the original capture/release site in the Interpretive Kiosk Unit and the southernmost location along the Hunt Club Unit) was about 560 m (0.3 mi). The maximum distance between locations if the snake had been on the island would have been about 830 m (0.5 mi).

M89404 was primarily found in palustrine emergent, palustrine scrub-shrub, and old field habitats (Table 5). The snake was initially found travelling in grassy, old field habitat in the Interpretive Kiosk Unit and in similar habitat along the dike in the Hunt Club Unit on two other occasions (3 of 11 confirmed locations, 27%). Of the remaining eight confirmed locations, four (36%) were located in palustrine emergent wetland habitat, three (27%) were in palustrine scrub-shrub, and one (9%) was in palustrine forest. Within the palustrine emergent habitats along the dike in the Hunt Club Unit, this snake was often found under large slabs of concrete, and occasionally under the same slab of concrete, within 1-2 m of the shoreline of the open water lagoon. Other microhabitats in which this snake was found include grass, shrub and roots of a cottonwood tree and/or embankment along the dike. The specific microhabitats for five of the snake locations were unknown because the exact location of the snake could not be confirmed due to thick, shrubby vegetation, the potential island locations, and dead batteries in the radio-telemetry receiver. The snake was visually confirmed on 24 May and 17 June when the snake was foraging in grass and basking in a shrub, respectively, and also on 23 September when the snake was found under a large concrete slab. The snake also may have been visually observed during surveys in the Hunt Club Unit on 24 August when surveyors found a similar-sized fox snake under a large, concrete slab to which this snake had been tracked the day before. The snake was not captured or checked with a PIT tag reader or radio-telemetry receiver, so this observation can not be confirmed. On 24 August, surveyors also lifted two adjacent concrete slabs and found three new fox snakes.

The third fox snake that was added to the radio-telemetry study was captured during additional visual encounter surveys in the Interpretive Kiosk Unit on 17 May 2004. This snake was a juvenile (sex unknown) that weighed 99 g and was approximately 77 cm (30 in) in total length (SVL = 64 cm/25 in, tail length = 13 cm/5 in). Because this snake was a juvenile, a 5-g radio-transmitter instead of a 9-g transmitter was surgically implanted into the snake. The snake (PIT tag ID: 052 563 549, hereafter referred to as J54904) was released on 24 May at the initial capture site. J54904 was then radio-tracked to 11 locations from 17 June to 23 September, of which three were not recorded with a GPS unit (Table 6 and Figure 19). J54904 was located in the Interpretive Kiosk Unit in the vicinity of the initial capture site from 17 June to 6 August. On 14 August and 23 August, the snake was located on the other side of the lagoon in the Facilities Unit near the foot bridge. On 31 August and 2 September, the snake was found back in the Interpretive Kiosk Unit at the south end of the unit just south of the pavilion. On 13 September and 23 September, the snake was located about 200 m north on the west side of the paved trail just north of the pavilion in the Interpretive Kiosk Unit. The total or maximum distance between the documented locations for J54904 (i.e., between the location in the Facilities Unit and the southernmost location in the Interpretive Kiosk Unit) was approximately 470 m (0.3 mi). This distance should be considered an underestimate of the total movements this snake can travel within its home range.

Similar to the other snakes, J54904 was found in several, primarily open habitat types (Table 6). J54904 was initially found traveling amongst the large boulders that comprise the rock riprap shoreline of the lagoon under the foot bridge in the Interpretive Kiosk Unit. The snake was found basking and hiding in this rocky habitat and microhabitat on two other occasions (i.e., 3 of 12 locations including capture site, 25%). J54904 was found in old field habitat on four occasions (33%). The snake was basking, resting or moving in or under the grass and perhaps even underground in the old field habitats. J54904 also was found in palustrine emergent wetland/scrub-shrub habitats (3 of 12 locations, 25%) and palustrine forest (2 of 12 locations, 17%). J54904 was visually confirmed at only three locations in May and June when the snake was basking, resting or traveling in rock riprap and old field habitats. The snake was generally found along the dike and shoreline of the lagoons within 1-2 m of open water or emergent marsh, but it also utilized habitat further inland up to 10-15 m from the water's edge.

The last fox snake that was captured and added to the radio-telemetry study in 2004 was an adult male that weighed 260 g and was 102 cm (40 in) in total length (SVL = 86 cm/34, tail length = 16 cm/6 in) at the time of the surgery. This snake (PIT tag ID: 087 353 314, hereafter referred to as M31404), was initially captured on 24 August along the paved trail in the Hunt Club Unit. After the surgery, the snake was released at its capture site on 2 September and was located three times between 8 and 23 September. The snake was initially found basking in the open on gravel along a piece of wood on the side of the paved trail in the Hunt Club Unit (Table 7 and Figure 20). The habitat in the vicinity of this location is palustrine emergent wetland and palustrine scrub-shrub. From 8 September to 23 September, the snake was radio-tracked to the same location near the site where it was originally captured and released. This location was comprised of emergent wetland habitat with dense *Phragmites,* which was chemically treated with an herbicide in mid-September. The snake was not visually observed during the radio-tracking period due to dense vegetative cover and chemical treatment of the site. As a result, specific microhabitat use by this snake could not be documented. When the snake was radio-tracked on 13 September, the snake's radio-transmitter signal seemed to vary, providing some evidence that the snake was likely still alive. The status of this snake will be further investigated this fall.

Discussion

Survey results from 2004 were generally similar to those in 2003, although there were some differences and new discoveries. Surveys in 2004 documented a higher number of fox snake observations and higher relative abundance estimates or detection frequencies than did surveys in 2003. Surveys in 2004 documented 11 fox snake observations overall, of which 9 were new snakes and 2 were recaptures. Also, of the total, seven observations were documented during line-transect and time-constrained visual encounter surveys (4 and 3, respectively). In 2003, only six fox snakes were documented (all new snakes) during surveys (Lee and Pearman 2004). Of these, four were documented during line-transect and time-constrained surveys (3 and 1, respectively), and two were documented during additional visual encounter surveys. Relative abundance estimates or detection frequencies for surveys in 2004 were 0.12 fox snake observations/survey hour for line-transect surveys, 0.08 observations/survey hours for time-constrained surveys, and 0.10 observations/survey hour overall for both surveys combined (0.07 if only including new fox snake observations). Relative abundance estimates for surveys in 2003 were much lower, with 0.05 fox snake observations/survey hour for line-transect surveys (based on 3 snakes in 61 survey hours), 0.03 snake observations/survey hour for time-constrained surveys (i.e., 1 snake in 31 survey hours), and 0.04 fox snakes/survey hour overall for the two surveys combined (i.e., 4 snakes in 92 hours). However, if only new snakes are considered, the numbers of fox snake observations and relative abundance estimates or detection frequencies for line-transect and time-constrained surveys in 2004 and 2003 would be very similar (i.e., 5 fox snakes and 0.07 snake observations/survey hour in 2004 compared to 4 snakes and 0.04 snake observations/survey hour in 2003). It is important to consider, though, that 6 of the 11 fox snakes observed in 2004 were found during a single survey in August, and 4 of the 6 snakes were found under three large concrete slabs, which may not have been examined in 2003. Also, although relative abundance estimates or detection frequencies were not specifically calculated for additional visual encounter surveys conducted in 2003 and 2004, it is interesting to note that additional surveys in 2004 documented only a few more fox snakes than did additional surveys in 2003 but in a much shorter time frame (i.e., 4 fox snakes in 29 survey hours in 2004 compared to 2 fox snakes in 198 survey hours in 2003). This may have been at least partly due to the timing of these surveys since the additional surveys in 2004 were conducted primarily in the spring (May and June), whereas additional surveys in 2003 were conducted during late summer and early fall. Surveyors were different in 2004 than in 2003, which also may have contributed to higher numbers of snakes found in 2004.

Although surveys in 2004 documented more fox snakes than in 2003, the total numbers of fox snakes found during surveys in 2004 and over the two years of the study are still fairly small. Several potential factors may be responsible or may have contributed to the small numbers of fox snakes that have been documented during surveys. First, the eastern fox snake population within Sterling State Park and/or individual management units may be fairly small. Secondly, aspects of the fox snake's biology and/or ecology may make them difficult to detect, or the survey methodology may not have been appropriately designed or implemented for the species. Snakes are often cryptic in color and behavior and are also patchy in their distributions, both spatially and temporally (Ministry of Environment, Lands and Parks 1998). Both these factors can contribute to low detection rates during visual encounter surveys. Eastern fox snakes can be cryptic in color, behavior and habitat use (see discussion on this later in this section) and also may have a patchy distribution temporally and spatially given the distribution of available habitat within the park. Also, as mentioned earlier, timing of the surveys may be an important factor that has contributed to the small numbers of fox snakes that have been documented during surveys. The best time to survey

Table 6. Summary of radio-telemetry locations for Fox Snake J54904 in Sterling State Park in 2004.

Location	Date	Time	Unit	Habitat*	Microhabitat	Visual?	Behavior	Latitude	Longitude	Weather	Comments
1	05/17/2004	1:00 PM	Interpretive Kiosk	Rock riprap shoreline	Rocks	Y	Basking/ traveling	41.90975726	-83.34409305	72F, mostly sunny, light wind	Original capture location; rocks under foot bridge.
2	05/24/2004	10:33 AM	Interpretive Kiosk	Rock riprap shoreline	Rocks	NA	Active	41.91279352	-83.34170052	63F, partly sunny, windy	Release site after surgical implantation of transmitter
3	06/17/2004	12:20 PM	Interpretive Kiosk	Rock riprap shoreline	Rocks	Y	Basking	41.91152961	-83.34074188	80F, partly sunny, windy	
4	06/24/2004	1:28 PM	Interpretive Kiosk	OLD	Grass	Y	Basking/ traveling	No GPS		70F, partly sunny, 10-15 mph wind	In lakeplain prairie demonstration planting area
5	07/06/2004	3:17 PM	Interpretive Kiosk	Rock riprap shoreline	Rocks	N	Unknown	41.91150069	-83.34109434	85F, 70% sun, 5-10 mph winds	
6	07/30/2004	10:02 AM	Interpretive Kiosk	PEM	Herbaceous/ tall burdock	N	Unknown	No GPS		68F, overcast, humid	Thick vegetation along bank of lagoon
7	08/06/2004	4:15 PM	Interpretive Kiosk	OLD	Tall grass	N	Moving	No GPS		71F, mostly sunny, windy	Signal got very strong then weakened quickly.
8	08/14/2004	7:25 PM	Facilities	OLD	Tall grass	N	Unknown	41.91106617	-83.33995172	68F, 60% sun, 0-10 mph	Strong signal, but unable to see snake; in thick grass or possibly underground
9	08/23/2004		Facilities	OLD	Tall grass	N	Unknown	41.91110373	-83.33997318	80F	Possibly in burrow
10	08/31/2004	10:55 AM	Interpretive Kiosk	PFO	Tree roots	N	Unknown	41.91044444	-83.34375	70F, 100% sun, 0-5 mph	Probably underground
11	09/02/2004	5:00 PM	Interpretive Kiosk	PFO	Tree roots	N	Unknown	41.91044444	-83.34375	80F, 100% sun, 0-10 mph wind	In same location as on 8/31/04
12	09/13/2004	2:20 PM	Interpretive Kiosk	PEM/PSS	Herbaceous/ thick shoreline vegetation	N	Unknown	41.91213906	-83.34274122	85F, 100% sun, 0-5 mph wind	Radio seems weak
13	09/23/2004	9:20 AM	Hunt Club	PEM/PSS	Burrow in herbaceous/ thick shoreline vegetation	N	Unknown	41.91213906	-83.34274122	72F, 100% sun, no wind	Snake in same location in burrow; radio seems very weak.

*Habitat: PEM = palustrine emergent wetland, PSS = palustrine scrub-shrub, PFO = palustrine forest; OLD = old field

Figure 19. Map of radio-telemetry locations for Fox Snake J54904 in Sterling State Park in 2004. (Note: Map only includes confirmed observations located with a GPS unit.)

Table 7. Summary of radio-telemetry locations for Fox Snake M31404 in Sterling State Park in 2004.

Location	Date	Time	Unit	Habitat*	Microhabitat	Visual?	Behavior	Latitude	Longitude	Weather	Comments
1	08/24/2004	3:16 PM	Hunt Club	Opening on/along trail adjacent to PEM/PSS	Rock/gravel	Y	Basking	41.90836667	-83.35245	79-81F, 60% sun, 0-10 mph wind	Original capture location; in the open along/on side of paved trail
2	09/08/2004	12:01 PM	Hunt Club	PEM	Unknown/ herbaceous? (Patch of thick Phragmites)	N	Unknown	41.90859318	-83.35219332	70F, cloudy, windy	Snake in very thick Phragmites near release point.
3	09/13/2004	1:50 PM	Hunt Club	PEM	Unknown/ herbaceous? (Patch of thick Phragmites)	N	Unknown	41.90859318	-83.35219332	85F, sunny, breezy	Snake was in same location as on 9/8/04. Signal seemed to vary indicating snake still alive.
4	09/23/2004	10:45 AM	Hunt Club	PEM	Unknown/ herbaceous? (Patch of thick Phragmites)	N	Unknown	41.90859318	-83.35219332	80F, 100% sun, no wind	Snake in same location; area recently sprayed with herbicides for invasive species control

*Habitat: PEM = palustrine emergent wetland, PSS = palustrine scrub-shrub.

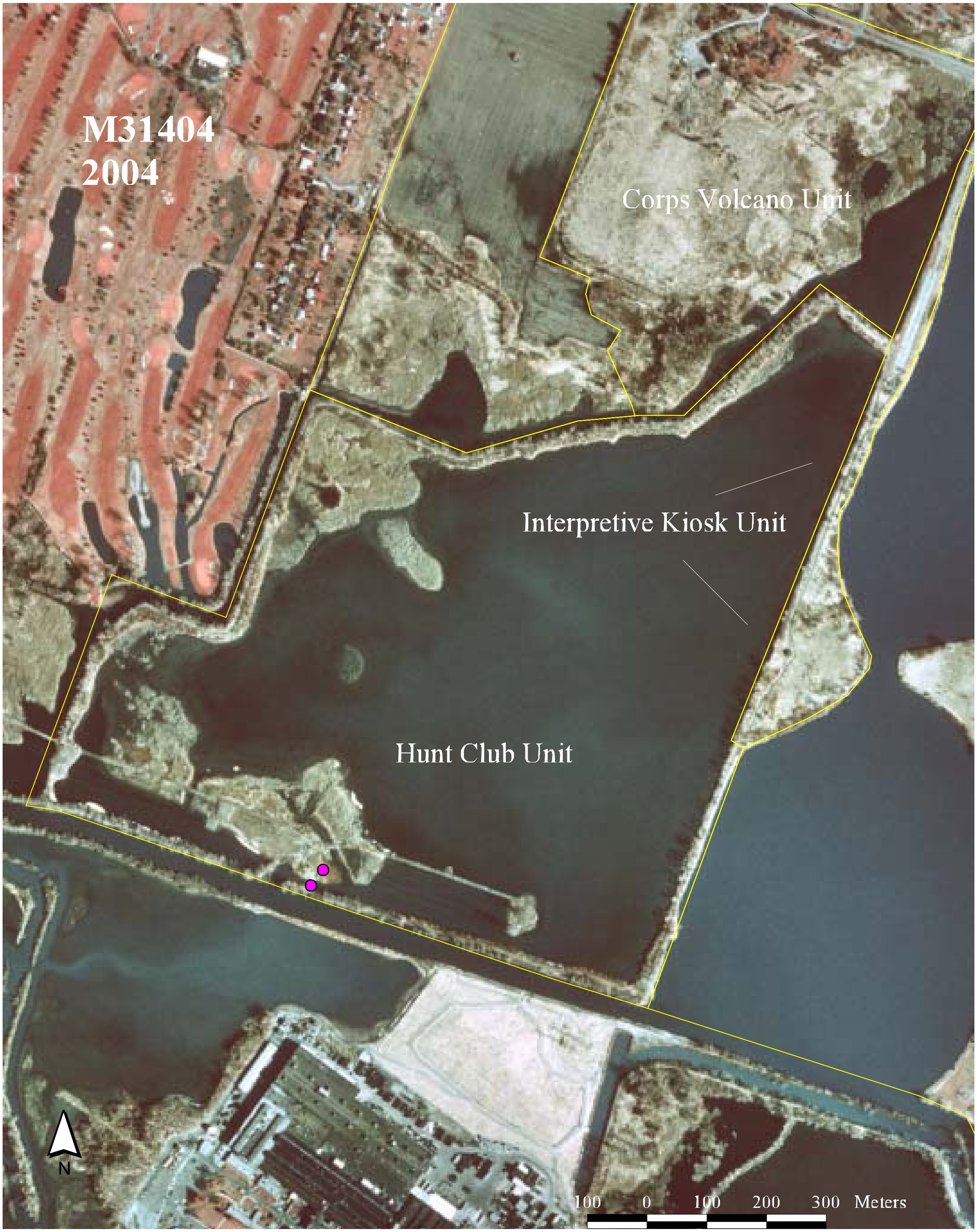

Figure 20. Map of radio-telemetry locations for Fox Snake M31404 in Sterling State Park in 2004.

for fox snakes is typically May and June when the snakes are most active and most visible since the vegetation is generally shorter and/or less dense (Harding 1997, Lee 2000). Also, eastern fox snakes are generally active throughout the day, but during periods of intense heat, fox snakes may become more nocturnal (Evers 1994). Other researchers have reported difficulty in seeing or finding fox snakes during late summer and early fall (Bekker pers. comm.). A Sterling State Park staff member also reported more fox snake observations (i.e., possibly >40) earlier in the summer. These results suggest that spring surveys may be more productive than late summer or early fall surveys. This warrants further investigation and should be considered in future monitoring efforts for this species. However, despite the small number of fox snakes that were found during surveys in 2004, snakes of different age classes were found, although no newborn or young snakes were observed as in 2003. This finding provides evidence that some reproduction or recruitment has occurred in the fox snake population in the park.

Survey and radio-telemetry portions of the study were able to document eastern fox snakes in only three of the nine management units (i.e., Hunt Club, Interpretive Kiosk and Facilities) in Sterling State Park in 2004. In fact, most of the fox snakes documented during surveys in 2004 (i.e., 9 of 11) were found along the dike in the Hunt Club Unit. The surveys and radio-telemetry efforts in 2003 documented eastern fox snakes in these three management units as well as the Corps Volcano Unit. Prior to this study, eastern fox snakes had been documented in these management units and other units in the park such as the Campground Restoration Unit. Fox snakes also have been reported along the beach and in the campground area at the southern end of the Facilities Unit in the past. Survey and radio-telemetry efforts in 2003 and 2004 have not documented fox snakes in the Campground Restoration Unit or the southern end of the Facilities Unit. However, park staff, contractors and the general public have reported seeing fox snakes in these areas in 2003 and 2004. Recent habitat restoration efforts have dramatically changed the landscape in some of the management units, such as the Campground Restoration Unit. Restoration efforts in the Campground Unit have removed a significant amount of the soil, vegetation and available cover in this unit which may have impacted fox snakes' use of this area. Similarly, fox snakes were historically seen quite frequently in the Corps Volcano Unit by the old park headquarters and the park entrance booth. Three fox snakes, including a young-of-the-year, were found in this unit during surveys in 2003. However, no fox snakes were found in this unit in 2004. Restoration efforts in this unit have included shrub and tree removal and debris removal which have greatly reduced the amount of cover in this unit. These activities may have impacted fox snakes' use of this area and/or surveyor's ability to detect these snakes (i.e., by reducing cover to look under during surveys). Some studies that have examined snake population responses to habitat restoration efforts have reported at least an initial modification or reduction in use of areas undergoing restoration (Kingsbury and Sage pers. comm.). For example, a study investigating eastern massasaugas' response to habitat restoration efforts at a site in southeast Michigan found that most snakes in the study initially did not use the area undergoing active restoration and utilized adjacent habitats even though the snakes had historically been reported to use the restored area. However, more snakes started to utilize the restored area once intensive management activities subsided and some vegetation was present (Kingsbury and Sage pers. comm.). Continued monitoring of eastern fox snakes at Sterling State Park will help provide insight into potential impacts of current and ongoing restoration efforts on the fox snake population.

It also is interesting to note that significantly fewer observations of other snake species were found during surveys in 2004 than in 2003. Over 270 observations of other snake species were documented during surveys in 2003, while only 69 observations of other snake species were documented during surveys in 2004. The Facilities, Hunt Club, Corps Volcano and Corps CDF units contained the highest numbers of observations of other snake species in 2003. In 2004, 80-97% fewer observations of other snake species were documented in these four units, and 33-95% fewer in the other units. This may have been due to impacts from the restoration activities, climatic conditions during the spring and summer of 2004 (i.e., cool, wet spring followed by cool, dry summer) and/or different surveyors. Observations of other snake species should continue to be documented and monitored during future surveys.

The radio-telemetry portion of the study continued to provide some interesting and new insights into eastern fox snake ecology and use of Sterling State Park. This discussion will focus on the three fox snakes (M57903, M89404 and J54904) that were radio-tracked during the entire radio-tracking period during the spring, summer and early fall of 2004. These three snakes were originally captured either in the Facilities Unit or Interpretive Kiosk Unit and were located only in these units and the Hunt Club Unit throughout the radio-tracking period. These snakes were all located primarily along the dike or along the edge of the lagoons and generally near the water or emergent marsh's edge (i.e., generally within 1-3 m but further away in some cases). Maximum distances between known or documented locations for these three snakes over the 3-4 month radio-tracking period in 2004 were fairly similar and ranged from about 470-1,022 m (0.3-0.6 mi). The maximum distance between documented locations for the fox snake that was radio-tracked in 2003 (M57903) was approximately 1,300 m (0.8 mi) over a 2.5-month radio-tracking period. The maximum distance between documented locations for this snake in 2004 was about 1,022 m (0.6 mi). However, this snake was lost, probably to predation, sometime in the middle of the summer and was not radio-tracked for the entire time period. Limited home range studies of eastern fox snakes in the past have indicated individual movements of up to several hundred feet (Rivard 1976, Freedman and Catling 1979). These results seem to indicate that eastern fox snakes in Sterling State Park may have fairly small or limited home ranges. It is important to note that these maximum distances may underestimate the total distances fox snakes can move within a home range since snakes were not located daily or over their entire active period, but these distances can provide an initial approximation of these snakes' potential home range sizes. These distances also can provide preliminary information to help guide management of these snakes (e.g., safe distances within which snakes can be moved if necessary).

Similar to survey and radio-telemetry results in 2003, the eastern fox snakes that were found during surveys or radio-tracked in 2004 primarily utilized open upland and wetland habitats such as old field, palustrine emergent wetland and palustrine scrub-shrub habitats. Snakes were often found in or under open or thick grass, shrubs or dense emergent vegetation. Snakes also were found on or along the side of the paved nature trail as well as underground in tree root networks, burrows or the embankment along the dike. Fox snakes also were documented in 2004 utilizing rock riprap and concrete slabs along the shoreline of the lagoons. The radio-tracked snakes and several of the snakes documented during the surveys were frequently found under large, concrete slabs along the dike which may provide important cover for these animals, particularly in the absence or limited availability of suitable natural cover items such as large woody debris. However, fox snakes' use of concrete slabs can make it more difficult to find some of these snakes during surveys or get visual confirmation of radio-tracked snakes since these concrete slabs can be rather large and may be too heavy for some surveyors to lift.

The most important habitat feature required by snakes is cover or shelter (Ministry of Environment, Lands and Parks 1998). The use of cover, dense vegetation and underground retreats by eastern fox snakes may represent an important strategy or adaptation for coping with hot weather conditions, avoiding detection by predators and/or surviving in heavily used or disturbed habitats. However, this species' frequent use of these types of habitats also made it generally difficult to obtain visual confirmation of these snakes during the radio-tracking period in 2004 as in 2003. For all three radio-tracked snakes, visual observation or confirmation of snakes was obtained only for locations documented in April, May and June. None of the three snakes were visually observed or confirmed during radio-tracking efforts in July, August and September except on one occasion when one of the radio-tracked snakes was found under a concrete slab and the slab was lifted. These results again suggest that fox snakes may be more easily observed or have a greater likelihood of being detected in the spring and early summer compared to late summer and early fall. Also, this snake's use of artificial cover suggests that placing cover boards in areas with suitable habitat may be an effective survey technique for this species.

Although study results from Sterling State Park in 2003 and 2004 indicate that eastern fox snakes can inhabit highly disturbed and actively managed sites, the long-term viability of this population remains unknown. The fox snake population within the park continues to face a number of threats including highly degraded and limited habitat (at least currently), population isolation, road mortality, intentional and unintentional killing, harassing or disturbance by people, incidental take or impacts due to park management activities (e.g., mowing of large areas reduce or minimize areas with sufficient cover for shelter, foraging, dispersal, and safe passage or protection from predators), and predation. While ongoing restoration efforts may create additional habitat for fox snakes in the future, these efforts also can pose threats to the park's fox snake population in the short term through various management activities. These include application of chemical herbicides, removal of natural and artificial cover or shelter, use of heavy equipment and associated incidental impacts (e.g., removal of cover could cause reduction in the prey base or shelter areas for protection from predators). In 2004, one of the transmittered fox snakes was lost probably due to predation, and at least four dead snakes or specimens (and likely more) were reported and/or collected by park staff. Given that little is currently known about the status and structure (i.e., recruitment rate, sustainable mortality rate, etc.) of the fox snake population in Sterling State Park, efforts should be taken to minimize threats to the population and the snake mortality rate within the park. Since fox snakes have been found primarily in the Hunt Club, Interpretive Kiosk and Facilities units during this study and historically, consideration of management activities and ways to minimize potential adverse impacts of these activities on eastern fox snakes is especially warranted in these units.

Finally, little is known about the status, distribution and ecology of the eastern fox snake population within Sterling State Park and across the species' range. Results from surveys in 2003 and 2004 suggest that eastern fox snake numbers within the park may not have been dramatically impacted by recent habitat restoration activities, although fox snake use of particular management units within the park may have been impacted somewhat based on historical reports, changes in habitat conditions and survey and radio-telemetry results. However, sample sizes in 2003 and 2004 were very small, and unfortunately, only one year of pre-treatment data was obtained. These findings combined with limited knowledge of this species' status and ecology make it difficult to effectively assess potential impacts of the restoration efforts within the park on this species. Additional surveys and a long-term monitoring effort are needed to assess the impacts of habitat restoration efforts on the fox snake population within the park. Eastern fox snake habitat use and ecology also warrant further investigation.

Eastern fox snake monitoring and radio-telemetry are planned to continue in 2005 to further examine potential impacts of ongoing habitat restoration efforts. Survey and monitoring efforts in 2005 will basically utilize the same methodology and revise as needed. Surveys in 2005 will occur during the same time period as surveys in 2003 and 2004. Surveys also will be conducted in the spring and early summer to compare with results from late summer surveys to evaluate timing and effectiveness of surveys and to try to increase the numbers of fox snake observations. The radio-telemetry portion of the study will be expanded with new snakes added to the study in the spring of 2005. More detailed data summary and analyses will be provided after the 2005 field season.

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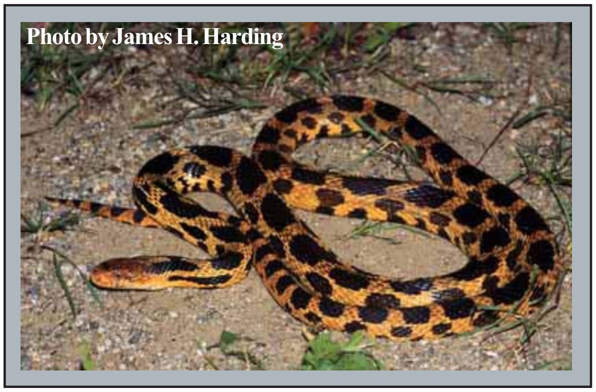
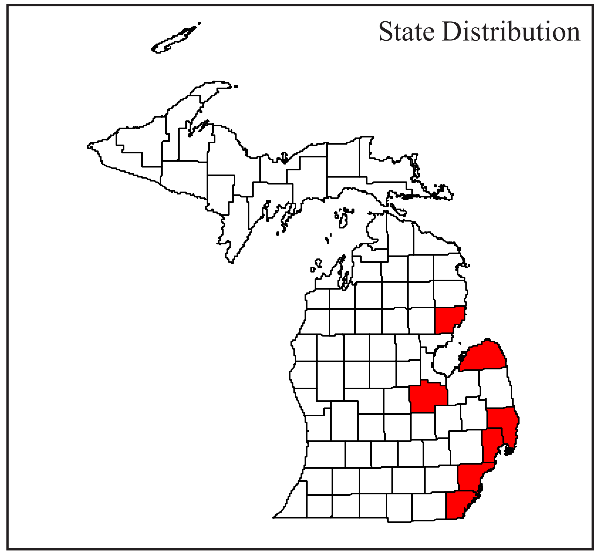
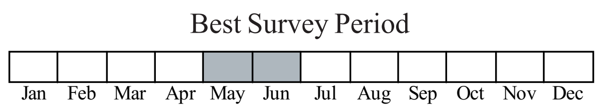
Appendices

Elaphe vulpina gloydi Conant — eastern fox snake







Status: State threatened

Global and state rank: G5T3/S2

Family: Colubridae

Range: The eastern fox snake resides entirely within the Great Lakes basin. This species is restricted to the shoreline and near shore areas along southern Lake Huron from Saginaw Bay, Michigan and Georgian Bay, Ontario south to the Detroit River and Lake St. Clair, and along western Lake Erie from Monroe and Wayne counties in Michigan to Norfolk County, Ontario and Erie County, Ohio (Harding 1997). Eastern fox snakes also have been documented from Pelee Island and some of the smaller islands in Lake Erie. The more common western subspecies (*Elaphe vulpina vulpina*) occurs in the western Great Lakes basin from the central Upper Peninsula in Michigan west and south through Wisconsin, southeastern Minnesota and Iowa to northwestern Indiana, northern Illinois and eastern portions of South Dakota, Nebraska and Missouri.

State distribution: Historically, eastern fox snakes have been known to occur in seven counties in southern Michigan. However, the species has not been reported from Huron County since 1936, and the report from Iosco County is outside the species' historical range and needs to be verified. These snakes have been documented along the shoreline of lakes Erie, St. Clair and Huron, as well as along the Raisin, Detroit, Clinton and Shiawassee rivers and their tributaries. A survey for the eastern fox snake in 1986 documented four main, isolated populations in southern Michigan, two in Monroe County along Lake Erie, one in St. Clair County along Lake St. Clair, and one in Saginaw County associated with the Shiawassee River and its tributaries (Weatherby 1986).

Recognition: The eastern fox snake is boldly patterned with a row of **large dark brown or black blotches down the middle of the back** and **smaller, alternating blotches on the sides** on a **yellowish to light brown background**. The head varies in color from yellow or light brown to reddish brown, usually with a **dark band between the eyes**, a **band extending downward from the eye to the mouth**, and a **band extending backwards from the eye to the corner of the mouth** (Harding 1997). The **underside** is **yellowish with irregular rows of dark squarish spots**. The scales are keeled (i.e., have a raised ridge), and the anal plate (i.e., enlarged scale that partly covers the anal or cloacal opening) is divided. Adults range in length from 3 to 5.5 feet (Harding 1997). Juvenile eastern fox snakes are paler in color than the adults, and have gray or brown blotches bordered in black on the back and more distinctive head markings.

Several snakes in Michigan are similar in appearance and may be confused with the eastern fox snake. Western fox snakes do not overlap in range, although they are similar in size and have a greater number of smaller blotches on the back (range 32 to 52, average 41, as opposed to 28 to 43, average 34 on the eastern fox snake) (Harding 1997). Juvenile black rat snakes (*Elaphe obsoleta obsoleta*, State special concern) are

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strongly patterned and have a very similar body pattern and coloration to the eastern fox snake (see Harding 1997); the only way to distinguish the juveniles of the two species is by counting the scales on the underside of the snake (Evers 1994) (216 or fewer in eastern fox snake and 221 or more in black rat snake) (Conant and Collins 1998). Young blue racers (*Coluber constrictor foxi*) also have dark blotches but they have smooth scales and no line from the eye to the corner of the mouth (Harding 1997; see Conant and Collins 1998). Several species have similar-looking adults. The adult northern water snake *(Nerodia sipedon*) has crossbands instead of blotches. The adult eastern hog-nosed snake (*Heterodon platyrhinos*) has an upturned snout and occurs in sandy environments. Eastern milk snakes (*Lampropeltis triangulum triangulum*) have smooth scales and undivided anal plates. Eastern massasaugas (*Sistrurus catenatus catenatus*, state special concern) have a rattle at all ages.

Best survey time: The best time to survey for this species is May and June when the snakes are most active and most visible. Eastern fox snakes are active during all hours of the day, with peak activity from 1100 to 1900 hours (Kraus and Schuett 1982). Currently, the best way to survey for this species is to conduct visual surveys for basking or dispersing individuals. They are often found basking on artificially created dikes, muskrat houses, road embankments or other elevated sites (Conant 1938, Weatherby 1986). They also are often found along the edge of marshes. Following exceptionally hot days, eastern fox snakes can be found at night on roads (Weatherby 1986).

Habitat: The eastern fox snake inhabits emergent wetlands along Great Lakes shorelines and associated large rivers and impoundments (Evers 1994). They prefer habitats with herbaceous vegetation such as cattails (*Typha* spp). Although primarily an open wetland species, eastern fox snakes also occupy drier habitats such as vegetated dunes and beaches, and occasionally wander along ditches and into nearby farm fields, pastures, and woodlots (Harding 1997). Eastern fox snakes on Lake Erie islands occupy rocky areas and open woodlands.

Biology: Fox snakes are the least known of the North American snakes in its genus (Ernst and Barbour 1989). Little is known about the life history of the eastern fox snake; much of it is presumed to be similar to that of the better known western fox snake and other snakes in its genus (Evers 1994). Eastern fox snakes typically are active from mid-April to late October with peak activity in May and June (Evers 1994, Harding 1997). Eastern fox snakes are active throughout the day, but during intense heat, may become more nocturnal (Evers 1994). Eastern fox snakes are seldom found far from water, and are capable of swimming long distances over open offshore waters and between islands (Harding 1997). Limited home range studies have indicated individual movements of up to several hundred feet (Rivard 1976, Freedman and Catling 1979). This species hibernates in abandoned mammal burrows, muskrat lodges or other suitable shelters (Ernst and Barbour 1989, Harding 1997). These snakes may congregate and share overwintering sites.

Eastern fox snakes probably breed annually, beginning at two (Evers 1994) or three to four years of age (Harding 1997). Mating occurs in June and early July (Ernst and Barbour 1989). Eggs are usually laid in late June or July, and possibly into August. Eggs are deposited in the soil, hollow logs, rotting stumps, sawdust piles and mammal burrows, as well as under logs, boards and mats of decaying vegetation. Clutch size averages 15 to 20 eggs per clutch (Ernst and Barbour 1989). Hatching occurs from mid-August to early October (Harding 1997).

Eastern fox snakes feed primarily on small mammals, particularly meadow voles (*Microtus*) and deer mice (*Peromyscus*) (Harding 1997). They also will eat bird eggs and nestlings, earthworms, insects and frogs. Natural predators include egrets, herons, hawks, raccoons, foxes and mink. Juvenile fox snakes have additional predators such as large fish and frogs, turtles, shrews, weasels, and even rodents (Harding 1997). Young-of-the-year fox snakes experience high mortality, and generally remain under cover. When disturbed, young fox snakes may strike and bite, but older snakes rarely bite, even when handled; instead they shake or "rattle" their tail vigorously and may spray a musky-smelling anal secretion (which is supposedly foxlike and hence its name).

Conservation/management: The eastern fox snake has drastically declined in many areas where it was once abundant but can be locally common in areas where extensive habitat is still available (Harding 1997). The primary threats to this species are continued habitat loss and degradation of Great Lakes coastal marshes, human persecution and illegal collection for the pet trade (Evers 1994, Harding 1997). Much of this species' habitat has been ditched and drained for agriculture, residential and industrial development. The remaining suitable wetlands and waterways are currently threatened by the same factors as well as pollution and other forms of degradation. Although the four known populations in Michigan occupy sites that are partially owned and protected by state or federal government, public access and use of these sites are still relatively unrestricted. In addition to habitat loss, this species is often mistaken for venomous species such as the eastern massasauga and copperhead snake (which is not found in Michigan) and many fox snakes are killed as a result. Eastern fox snakes also are threatened by increased road traffic and road density associated with development.

Protection and management of remaining populations and habitat is crucial for conservation of this species in Michigan. Management of emergent wetlands should include limiting disturbance on dike areas (e.g., restricting mowing between mid-June and mid-October) and microhabitat enhancement such as providing adequate nesting sites as well as refugia for young snakes by maintaining, creating or transporting woody debris (e.g., hollow logs) at/to a site (Weatherby 1986). Prescribed burning of suitable habitat should be conducted before the snakes emerge from hibernation (i.e., typically before mid-April) or on days when the snakes are unlikely to be basking or above ground (e.g., on cloudy/overcast days with air temperatures below 55°F). In addition to habitat protection, public education is needed to help facilitate proper identification of this snake, to demonstrate the value and benefits of maintaining this species (e.g., its consumption of rodents makes it useful in agricultural areas) and to discourage illegal persecution and harassment (Evers 1994). In Michigan, the eastern fox snake is protected by the Michigan Endangered Species Act and the Director's Order No. DFI-166.98, Regulations on the Take of Reptiles and Amphibians, which is administered by the Michigan Department of Natural Resources' Bureau of Fisheries. It is unlawful to take an eastern fox snake from the wild except as authorized under a permit from the Director (legislated by Act 165 of the Public Acts of 1929, as amended, Sec.302.1c (1) and 302.1c (2) of the Michigan Compiled Laws). Public land managers and the general public should be informed that this species is protected and should not be collected or harmed. Any suspected illegal collection of eastern fox snakes should be reported to local authorities, conservation officers, or wildlife biologists.

Research needs: An assessment of the species' current distribution and abundance in the state is needed. More information on this species' life history, particularly its habitat requirements, activity patterns, home range, dispersal capability and reproductive biology, should be obtained to develop appropriate management recommendations. The species' distribution and associated habitat should be analyzed at a landscape-scale to help determine habitat requirements and assess connectivity among populations. Long-term population studies including viability analyses are needed to better understand fox snake population dynamics and to identify parameters that determine and indicate population viability. This information would be useful for developing effective monitoring protocols and assessing this species' status in the state. The effectiveness of current methods for detecting and monitoring this species should be evaluated, and alternative survey methods investigated if current methods are not effective or yield inconsistent or unreliable results. Impacts of management and land use practices such as mowing, prescribed burning and residential development should be further investigated. The need and potential for successfully relocating, reintroducing or headstarting individuals in order to conserve or increase wild populations of this species should be investigated. The genetic diversity of extant populations needs to be examined. Effective methods to educate the public also need to be researched and implemented.

Related abstracts: eastern massasauga, Great Lakes marsh, eastern prairie fringed orchid

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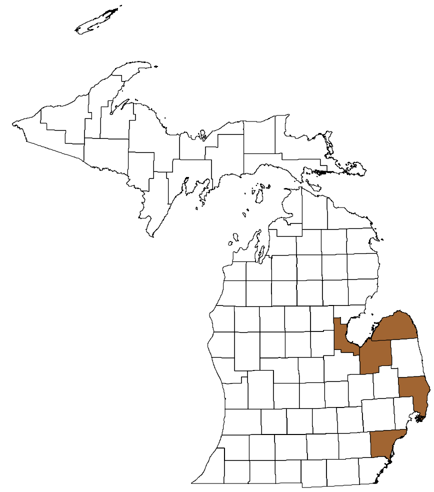
Appendix II. MNFI Abstract for Lakeplain Wet Prairie.

Lakeplain Wet Prairie — Community Abstract

Photo by Susan R. Crispin

State Distribution



Range: Lakeplain wet prairies occur on the glacial lakeplains of the Great Lakes in southeastern Wisconsin, northeastern Illinois, northern Indiana, southern Michigan and southern Ohio; and in southern Ontario, Canada. Michigan's lakeplain wet prairies occur along the shoreline of Lake Huron in Saginaw Bay, within the St. Clair River Delta, and near Lake Erie.

Global and State Rank: G2G3/S2

Rank Justification: Lakeplain wet prairies are a globally imperiled natural community with major reductions in acreage in all of the states and provinces mentioned above. In Michigan the size and number of lakeplain wet prairies have been reduced so that today less than 1% of the original community remains. A total of 14 lakeplain wet prairies have been located in Michigan, ranging in size from 2 to 200 acres (1 to 80 hectares) and totaling 511 acres (204 hectares).

Landscape Context: Sediments of pro-glacial lakes formed Michigan's glacial lakeplains at the margins of melting lobes of the Wisconsin ice sheet. In southeast Lower Michigan glacial lake deposits of clay are up to 100 meters thick over Paleozoic bedrock, with deposits thickest at their inland extremes and thinnest along the Lake St. Clair and Lake Erie shorelines (Albert 1995). Poorly drained mineral soils characterize most of the clay plain. These clay plains extend inland 30 to 40 miles (50 to 66 km) along the margins of Lake Erie, Lake Michigan, Lake St. Clair, and Lake Huron's Saginaw Bay. Within the clay lakeplains several broad sand channels formed where glacial meltwater streams carried sand into shallow pro-glacial lakes. These sand channels can be several miles wide, but the sand in them is typically only one to three meters thick. A series of sand beach ridges and dunes are found throughout these lakeplains. The soils of the beach ridges are often excessively drained, whereas those in adjacent swales are poorly drained. A large glacial delta with both clay and sand deposits is located at the mouth of the St. Clair River.

Lakeplain wet prairie occurs on level, sandy glacial lakeplains and on deposits of dune sand in clay glacial lakeplains. The soils are medium to fine textured, moderately alkaline (pH6-8) sands, sandy loams, or silty clays with poor to moderate water retaining capacity. Lakeplain prairies typically experience seasonal flooding and include small pockets that remain wet throughout the year. Lakeplain prairies are among the most diverse plant communities in Michigan, with as many as 200 plant species found within a single prairie remnant.

Historically, these prairies occurred in complex mosaics with lakeplain oak openings, pin oak-swamp white oak sand flatwoods, and elm-ash-maple swamps, all typical of poorly drained lakeplain. Lakeplain wet prairie often occupies a transition zone between emergent marsh and lakeplain wet-mesic prairie (Comer et al. 1995b).

Patch size characteristics for this community are variable. *Circa* 1800 patch sizes of lakeplain prairie mosaics (including wet, wet-mesic, and mesic sand prairies) in Michigan varied from <100 acres to over 15,000 acres (40 to 6000 hectares) (Comer et al. 1995b).

Natural Processes: Many factors influence the development and maintenance of prairies on Michigan's lakeplain. Hubbard (1888) speculated that the extensive wet prairies of Wayne and Monroe counties were the result of beaver activity prior to their localized extirpation by the fur trade. His view was based on communications with Native Americans and the prevalence of abandoned beaver dams on the flat lakeplain landscape. Other important factors probably include both soil moisture regimes and periodic wildfires. The combination of 1-3 meters of highly permeable sand over clay sets up a characteristic hydrological regime with spring flooding followed by drought conditions during the growing season. This characteristic water level fluctuation is common to nearly all extant examples of Michigan's lakeplain prairies, and is possibly the most significant physical process in their establishment and maintenance (Minc 1995, Albert et al. 1996). Such extreme variation in the soil moisture regime prevents woody vegetation from becoming established (Hayes 1964; Roberts et al. 1977). In addition to the dramatic seasonal fluctuations in surface and ground water levels, Great Lakes water level cycles also produce fluctuations in the water table of these prairies. Wet prairies originally occupied the position on the landscape between emergent marsh and adjacent uplands. Based on the original surveyors' notes from the Saginaw Bay shoreline, the boundary between prairie and marsh was not static, but moved inland or lakeward across the landscape, depending on the stage of the Great Lakes water-level cycle.

The combination of accumulation of organic material within these wetlands and drought conditions during the growing season made lakeplain prairies prone to wildfires, which limited the encroachment of woody vegetation. However, it remains unclear whether lighting strikes or Native American activities had a more significant role in the maintenance of lakeplain prairie (Hayes 1964; Faber-Langendoen & Maycock 1987). It is clear, however, that Native Americans utilized dune ridges on the lakeplain for settlements and trails (Jones & Knapp 1972; Comer et al. 1995a). As elsewhere in the state, it is quite likely that fires periodically resulted from this use, spreading to adjacent savanna and grassland. One indication of the significance of fire on the lakeplain is the fact that many of the historical oak savannas located along the beach ridges have become closed-canopy oak forests during the last century of fire suppression.

Vegetation Description: The vegetation of this community typically includes tallgrass prairie species up to 1 meter high. Trees are uncommon and bare ground is scarce. Characteristic plant species include: *Calamagrostis canadensis* (blue-joint grass), *Spartina pectinata* (cordgrass), *Juncus balticus* (rush), *Carex stricta* (sedge), *Carex aquatilis* (sedge), *Cladium mariscoides* (twig-rush), and *Potentilla fruticosa* (shrubby cinquefoil). Historically, these prairies occurred in complex mosaics with lakeplain oak openings, pin oak-swamp white oak sand flatwoods, and elm-ash-maple swamps, all typical of poorly drained lakeplain.

Michigan Indicator Species: *Calamagrostis canadensis, Spartina pectinata, Juncus balticus, Carex stricta, Carex aquatilis, Carex pellita* (sedge), *Cladium mariscoides, Potentilla fruiticosa,* and *Asclepias incarnata* (swamp milkweed).

Other Noteworthy Species: Rare animals associated with lakeplain wet prairie include: *Elaphe vulpina gloydi* (Eastern fox snake), *Erynnis baptisiae* (wild indigo dusky wing), *Ixobrychus exilis* (least bittern), *Papaipema sciata* (culvers root borer), *Papaipema silphii* (Silphium borer moth), *Prosapia ignipectus* (red-legged spittlebug), and *Rallus elegans* (King rail).

Rare plants associated with lakeplain wet and wet-mesic prairie include: *Agalinis gattingeri*, (Gattinger's gerardia), *Agalinis skinneriana* (Skinner's gerardia), *Angelica venenosa* (hairy angelica), *Aristida longispica* (three-awned grass), *Asclepias hirtella* (tall green milkweed), *A. sullivantii* (Sullivant's milkweed), *Astragalus neglectus* (Cooper's milk-vetch), *Baptisia leucophaea* (creamy wild indigo), *Cacalia plantaginea* (prairie Indian-plantain), *Carex festucacea* (fescue sedge), *Conobea multifida* (conobea), *Cyperus flavescens* (yellow nut-grass), *Cypripedium candidum* (white lady's-slipper), *Fimbristylis puberula* (chestnut sedge), *Hemicarpha micrantha* (dwarf-bulrush), *Hypericum gentianoides* (gentian-leaved St. John's-wort), *Juncus biflorus* (two-flowered rush), *Juncus brachycarpus* (short-fruited rush), *Juncus vaseyi* (Vasey's rush), *Lechea minor* (least pinweed), *Ludwigia alternifolia* (seedbox), *Lycopodium appressum* (appressed bog clubmoss), *Panicum leibergii* (Leiberg's panic-grass), *Platanthera ciliaris* (yellow fringed orchid), *Platanthera leucophaea* (prairie fringed orchid), *Polygala cruciata* (cross-leaved milkwort), *Pycnanthemum verticillatum* (whorled mountain-mint), *Rotala ramosior* (tooth-cup), *Scirpus clintonii* (Clinton's bulrush), *Scleria pauciflora* (few-flowered nut-rush), *Scleria triglomerata* (tall nut-rush), *Tradescantia virginiana* (Virginia spiderwort), and *Triplasis purpurea* (sand grass).

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Conservation/Management: Lakeplain prairies have been lost and degraded via conversion to agriculture, residential and industrial development, alterations of ground water hydrology, and fire suppression. The construction of extensive drainage networks to promote agriculture and residential development has lowered the water table in most of the historical range of lakeplain prairies. That, and the suppression of natural and cultural fires allow the community to succeed to shrub and forest communities. Of nearly 160,000 acres (64,000 ha) of lakeplain prairie in Michigan *circa* 1800 less than 0.5% remain today.

Research Needs: *Inventory status:* Lakeplain wet prairie is a moderately well inventoried community throughout its range. Additional data on some sites are needed to fully evaluate condition, size, and landscape context criteria for quality ranking. Current data are sufficient to prioritize site acquisition and management objectives.
Regional distribution: Variation in the characteristic plant and animal species between coastal and inland sites needs further description and assessment for refinement of community classification. The differences in characteristic plant and animal species between ecoregion sections and subsections needs further study across the entire range of this community (Minc 1995, Albert et al. 1996).
Site design issues: To adequately preserve a prairie remnant the hydrological regimes must remain intact. This will require protecting the lands surrounding the remnant from hydrological alterations.
Stewardship issues: The ability to restore these systems given typical alterations needs long-term research, including determining when and how restoration actions should be undertaken.

Similar Communities: Lakeplain wet-mesic prairie, southern wet meadow, and emergent marsh.

Other Classifications:

The Nature Conservancy National Classification:

CODE: (V.A.5.N.j.)
Temporarily Flooded Temperate or Subpolar Grassland
ALLIANCE: *Spartina pectinata* Herbaceous Alliance
ASSOCIATION: *Spartina pectinata-Carex spp.-Calamagrostis canadensis* Lakeplain Herbaceous Vegetation
COMMON NAME: Lakeplain Wet Prairie

Related abstracts: Lakeplain wet prairie, lakeplain wet-mesic prairie, appressed bog clubmoss, eastern prairie fringed-orchid, purple milkweed, Sullivant's milkweed, blazing star borer, culver's root borer, red-legged spittlebug.

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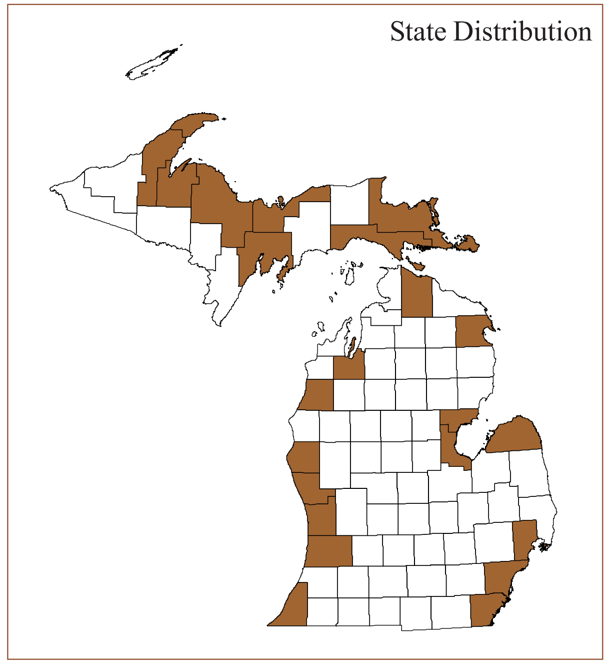
Appendix III. MNFI Abstract for Great Lakes marsh.

Great Lakes marsh — Community Abstract

Photo by Ted Cline



Overview: Great Lakes marsh is an herbaceous wetland community restricted to the shoreline of the Great Lakes and their major connecting rivers.

Global and State Rank: G2/S2. A finer classification of Great Lakes marshes has been developed on the basis of a combination of physical and floristic descriptors (Minc 1997c, Minc and Albert 1998). In this classification, some subtypes have a G1/S1 status. The physical factors and floristic differences of several subtypes are described below (See Vegetation Descriptions below).

Range: Great Lakes marshes occur along all of the Great Lakes, including Lake Erie, Huron, Michigan, Ontario, St. Clair, and Superior, and along the connecting rivers, including Detroit, Niagara, St. Clair, St. Lawrence, and St. Marys. Only Michigan's Great Lakes marshes are shown on the map.

Rank Justification: Great Lakes wetlands are restricted to shorelines of the Great Lakes and connecting rivers. The ranking of marshes is based on comprehensive field surveys conducted along the entire U.S. shoreline of the Great Lakes (Albert et al 1987, Albert et al. 1988, Albert et al. 1989, Minc 1997a, Minc 1997c, Minc and Albert 1998). Coastal wetlands have been degraded as the result of numerous forms of human management, including conversion to industrial, residential, or recreational uses, wetland fill, modification of near-shore currents, chemical pollution, sedimentation, and nutrient loading from agriculture or sewage plants.

Landscape and Abiotic Context: *Surficial Bedrock:* The physical and chemical characteristics of different surficial bedrock types affect both wetland location and species composition (Minc 1997c, Minc and Albert 1998). The major bedrock distinction in the Great Lakes Basin is between Precambrian igneous and metamorphic bedrock (including granite, basalt, and rhyolite) and younger Paleozoic sedimentary bedrock (including sandstone, shale, limestone, and dolomite). Igneous and metamorphic bedrocks form the north shore of Lake Superior and Georgian Bay, and line much of the St. Lawrence River; they are locally present along the southern shore of western Lake Superior as well, where they co-occur with younger sedimentary rock, primarily sandstone. In contrast, the softer, sedimentary bedrock types underlie Lakes Michigan, Huron, St. Clair, Erie, and Ontario, as well as the large rivers connecting the Great Lakes.

The physical structure of each bedrock type determines the distribution of coastal wetlands at a regional scale. Along the rugged Lake Superior shoreline of sandstone,

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igneous, and metamorphic rocks; coastal wetlands exist only behind protective barrier beaches or locally at stream mouths. In contrast, the horizontally-deposited marine and near-shore sedimentary rocks underlying Lakes Michigan, Huron, St. Clair, Erie, and Ontario, provide broad zones of shallow water and fine-textured substrates for marsh development.

Where bedrock is at or near the surface, bedrock chemistry affects wetland species composition. Soils derived from much of the Precambrian crystalline bedrock are generally acid and favor the development of poor fen or bog communities. In contrast, soils derived from marine deposits, including shale and marine limestone, dolomite, and evaporites, are typically more calcareous (less acid); where these bedrock types are at or near the surface, their alkalinity creates the preferred habitat for calciphilic aquatic plant species.

Aquatic System: Major aquatic systems, defined largely on water flow characteristics and residence time (Sly and Busch 1992), are applicable to the Great Lakes Basin; each has a different influence on associated coastal wetlands.

Lacustrine systems are controlled directly by waters of the Great Lakes, and involve wetlands of the Great Lakes shoreline strongly affected by littoral (longshore) currents and storm-driven wave action. Lacustrine habitats generally experience the greatest exposure to wind and wave action and to ice scour, the primary agents responsible for shore erosion and redeposition of sediments.

Connecting channels refer to the major rivers linking the Great Lakes, including the St. Marys, Detroit, St. Clair, Niagara, and St. Lawrence rivers. Connecting channels are characterized by a large flow, but seasonally stable hydrology; their shallowness and current result in earlier spring warming and better oxygenation than in other aquatic systems. All the connecting channels have been modified to accommodate shipping, resulting in changes in water level and increased shoreline erosion.

Riverine aquatic systems refer to smaller rivers tributary to the Great Lakes whose water quality, flow rate, and sediment load are controlled in large part by their individual drainages. But these rivers are also strongly influenced by the Great Lakes near their mouth. The portion of the tributary controlled by fluctuations in lake level have been called **freshwater estuaries** or **buried river mouths**. Here, there is a zone of transition from stream to lake within which water level, sedimentation, erosion, and biological processes are controlled by fluctuations in lake level.

Glacial Landform: Glacial landforms, in combination with recent longshore transport processes, create the prevalent physiographic features along much of the Great Lakes shoreline. Their characteristic differences in substrate, soils, slope, and drainage conditions largely determine both natural shoreline configuration and sediment composition. These, in turn, generate distinctive contexts for wetland development that vary in their exposure and resilience to lake processes, and in their floristic composition.

The major morphometric types are presented below. Several morphometric types can co-occur, while others are gradational. Many of these geomorphic features are unique to the Great Lakes coasts and are typically overlooked in national wetland classification schemes (Herdendorf et al. 1981). Since the floristic diversity of a wetland is dependent on the diversity of wetland habitats, the variety of morphometric types represented is significant for understanding the vegetational characteristics of a site.

Morphometric Types of Great Lakes Coastal Wetlands

Ia. Lacustrine - Open embayment. Embayment open to the lake, but shallow water depth reduces wave height and energy. Wetland are limited to a narrow fringe of emergent vegetation.

Ib. Lacustrine – Protected embayment. Deep indentation or embayment in upland shoreline provides protection from wind and wave energy, allowing extensive emergent wetland development.

Ic. Lacustrine – Barrier-beach lagoon. Sand and gravel deposition create a barrier bar across the mouth of an embayment resulting in the formation of a shallow pond or lagoon. Extensive shallow water emergent vegetation; composition reflects degree of connectivity with Great Lakes.

Id. Lacustrine – Sand-spit embayment and Sand-spit swale. Sand spits projecting along the coast create and protect shallow embayments on their landward side; large compound sand spits also enclose small swales. Sheltered embayments allow for sediment accumulation and wetland development.

Ie. Lacustrine – Dune and swale complex. Low sand dunes or beach ridges alternate with swales, often forming large wetland complexes. Swales adjacent to lake may contain herbaceous wetlands and/or open water. Further inland the wetlands are typically treed.

If. Lacustrine – Tombolo. An island connected to the mainland by a beach ridge or series of beach ridges. Enclosed lagoons can contain dense growth of aquatic vegetation, and there is occasionally a fringe of emergent vegetation outside of the tombolo.

IIa. Connecting Channel – Channel-side wetland. Stream-side wetland along main channel of river is exposed to current and wave action. Vegetation is frequently limited to a thin fringe paralleling the shore.

IIb. Connecting Channel – Channel embayment. Embayment along the conecting river channel provides protection from erosion. Extensive wetland development can occur.

IIIa. Riverine – Delta. Stream sediments are deposited at mouth of a river, creating multiple channels, low islands, and abandoned meanders. Deltas associated with both large connecting channels and smaller tributaries. Extensive, diverse wetlands typically develop.

IIIb. Riverine – Lacustrine estuary (Drowned river mouth). Drowned river mouths occur at the mouth of tributary streams where water levels are under the influence of the Great Lakes. Drowned river mouths can be completely open to the lake or separated from the lake by a sand bar (Barred estuary), but most are currently maintained open by navigation channels. The portion of the stream affected by the Great Lakes water level can extend several miles upstream, thus producing extensive, fertile wetland habitat.

Climate: Regional patterns of climatic variability within the Great Lakes Basin are largely determined by latitude, with the modifying influence of the lakes (i.e. lake effect) operating at a more local level (Derecki 1976; Eichenlaub et al. 1990). The strong latitudinal gradient from southern Lake Erie to northern Lake Superior creates marked differences in length of growing season. These differences are reflected in the regional distributions of a number of species common to Great Lakes wetlands. While most aquatic macrophytes are widely distributed, species with known southern or northern affinities also occur. Lake Erie wetlands, for example, are rich in southern marsh species at the northern edge of their range; a southern wet-prairie floristic element is present as well (Stuckey 1989; Keddy and Reznicek 1985, 1986). Both of these southern floras differ significantly from the complex of boreal, subarctic, and arctic species found in the northern portions of Lakes Huron, Michigan, and Superior. Other species common to many Great Lakes coastal wetlands reveal regional concentrations corresponding to a north-south gradient (Minc 1997c).

Natural Process: Fluctuations in water levels are one of the most important influences on Great Lakes wetlands. These fluctuations occur over three temporal scales: (1) **short-term fluctuations (seiche)** in water level caused by persistent winds and/or differences in barometric pressure; (2) **seasonal fluctuations** reflecting the annual hydrologic cycle in the Great Lakes basin; and (3) **interannual fluctuations** in lake level as a result of variable precipitation and evaporation within their drainage basins (Minc 1997b, Minc and Albert 1998).

All of these scales contribute to the dynamic character of coastal wetlands, although interannual fluctuations result in the greatest wetland variability. These extreme lake-level fluctuations can range from 3.5 to 6.5 feet (1.3-2.5 m), and occur with no regular periodicity. In general, as water levels rise and fall, vegetation communities shift landward during high-water years and lakeward during low-water years. However, fluctuating lake levels effect not only a change in water depth, but a broad range of associated stresses to which plants must respond, including changes in water current, wave action, turbidity (clarity or light penetration), nutrient content or availability, alkalinity, and temperature, as well as ice scour and sediment displacement. Since individual species display different tolerance limits along one or more of these dimensions, species composition can also change dramatically within a zone.

Coastal wetland systems are adapted to and require periodic inundation. Water-level regulation has significantly reduced the occurrence of extreme high and low water levels on Lake Ontario and to a lesser degree on Lake Superior. This disruption of the natural cycle favors species intolerant of water-depth change, excludes species requiring periodic exposure of fertile substrates, and potentially leads to a reduction of species diversity. The dominance of cat-tails in many Lake Ontario marshes suggests a trend toward reduced species diversity following a reduction in the amplitude of natural water-level fluctuations (Wilcox et al. 1993).

Vegetation Description: This classification is based on field surveys conducted along the entire U.S. shoreline of the Great Lakes (Albert et al 1987, Albert et al. 1988, Albert et al. 1989, Minc 1997a, Minc 1997c, Minc and Albert 1998). The preceding abiotic variables (including aquatic system, water level fluctuations, surficial bedrock, glacial landform, and climate) combine to determine the distribution, as well as the morphology, species composition, and floristic quality of Great Lakes coastal wetlands. The final, synthetic classification of Great Lakes coastal wetlands (based on both abiotic and vegetation analyses) identified nine groups, each with distinctive floristic characteristics and a restricted geographic distribution (Minc 1997c, Minc and Albert 1998). Vegetation zonation and key species are discussed below.

(1) Lake Superior Poor Fen. This group contains most of the wetlands sampled along the Lake Superior shoreline (Albert et al 1987, Minc 1997a, Minc 1997c). Since marshes cannot develop along unprotected stretches of Lake Superior's harsh shoreline, these wetlands occupy sheltered sites, including barrier-beach lagoons, estuaries, and tributary river deltas. These sites are characterized by fairly acidic, sandy soils and an extreme northern climate. As a result, organic decomposition is retarded and deep organic soils develop. Most of the marshes found along the Canadian shoreline of Lake Superior and on the granitic bedrock of the North Channel and Georgian Bay also fall into this class.

Characteristic vegetation includes northern poor fen in the herbaceous zone grading into poor shrub fen at the inland wetland periphery. The poor fen is typically the most extensive zone within Lake Superior wetlands. Species showing strong preferences for this habitat include *Sphagnum* spp., the forbs *Sarracenia purpurea* (pitcher-plant), *Menyanthes trifoliata* (buckbean), *Rhynchospora alba* (beak-rush), *Triadenum fraseri* (marsh St. John's-wort), *Pogonia ophioglossoides* (rose pogonia), and the shrubs *Chamaedaphne calyculata* (leatherleaf), *Andromeda glaucophylla* (bog rosemary), *Myrica gale* (sweet gale), *Vaccinium macrocarpon* (large cranberry) and *V. oxycoccus* (small cranberry). Continuity in species composition for northern poor fen is strong across a considerable range of lake levels (Minc 1997b).

The emergent zone, typically only a narrow fringe, contains species associated with clear, well-aerated waters, including a low-density mix of *Eleocharis smallii* (spike-rush), *Sparganium fluctuans* (bur-reed), *Schoenoplectus subterminalis* (bulrush), *Nuphar variegata* (yellow pond-lily), *Brasenia schreberi* (water shield), *Megalodonta beckii* (water-marigold), and *Potamageton gramineus* (pondweed).

(2) Northern Rich Fen. This group is concentrated near the Straits of Mackinac and located on marly substrates. In Ontario, many of the wetlands found on Cockburn and Manitoulin Islands, as well as the Bruce Peninsula can also be classed as rich fens. Most of these sites occupy sandy embayments where limestone bedrock or cobble is at or near the surface. These sites have calcareous soils (with a pH as high as 8.2), resulting either from calcareous substrates, water flow off adjacent limestone bedrock or limestone-rich till, or algal precipitation of calcium carbonate in the relatively warm, carbonate saturated waters. The result is the formation of distinctive "marly flats" and an associated complex of calciphile plant species.

The calciphiles *Chara* sp. (muskgrass) and *Eleocharis rostellata* (spike-rush) frequently dominate the emergent zones, along with *Schoenoplectus acutus* (hardstem bulrush). Overall species diversity is low. The herbaceous zone — the most distinctive and diagnostic zone — is consistently a northern rich fen. *Calamagrostis canadensis* (blue-joint grass) can dominate, but the calciphiles *Carex viridula* (sedge) and *Lobelia kalmii* (Kalm's lobelia) are key species for this group. Other fen species include *Cladium mariscoides* (twig-rush), *Potentilla anserina* (silverweed), *Panicum lindheimeri* (panic grass), *Triglochin maritimum* (common bog arrow-grass), and *Hypericum kalmianum* (Kalm's St. John's-wort). Common woody species include *Myrica gale*, *Potentilla fruticosa* (shrubby cinquefoil), and *Larix laricina* (larch). This characteristic suite of calciphiles make the Northern

Rich Fen type readily recognizable across a range of lake-level fluctuations (Minc 1997b).

(3) Northern Great Lakes Marsh. This group includes all marshes along the St. Marys River, as well as circumneutral sites of Lake Superior and northern Lake Michigan and Lake Huron; it is the largest group of Great Lakes wetlands sampled (Albert et al 1987, Albert et al. 1989, Minc 1997a). Marshes of this type occur on a diversity of glacial landforms and substrates, including clay lakeplain, sand lakeplain, and sandy ground moraine. Sites vary: Lake Superior northern marshes typically inhabit open water and stream margins, often within a larger poor fen complex, while those of northern Lakes Michigan and Lake Huron are typically found in relatively protected coastal embayments. The largest group of sites, however, is the channel-side wetlands and embayments along the St. Marys River. For Ontario, this type is expected to be common on the Canadian portion of the St. Marys River, including the eastern side of St. Joseph Island.

The open emergent zone features *Schoenoplectus acutus* (hardstem bulrush), *Eleocharis smallii* (spike-rush), *Schoenoplectus subterminalis*, *Equisetum fluviatile* (water horsetail), *Najas flexilis* (slender naiad), and *Sparganium eurycarpum* (common bur-reed), along with the submergent pondweeds *Potamageton gramineus* and *P. natans*. The herbaceous zone is consistently a northern wet meadow dominated by *Calamagrostis canadensis* (blue-joint grass), and the sedges *Carex stricta* and *C. lacustris*; key forbs include *Campanula aparinoides* (marsh bell-flower) and *Potentilla palustris* (marsh cinquefoil). A narrow band of shrubs includes *Spiraea alba* (meadowsweet), *Salix petiolaris* (meadow willow), *Alnus rugosa* (speckled alder), and *Myrica gale*.


Photo by Dennis A. Albert

Northern Great Lakes Marsh type

(4) Green Bay Disturbed Marsh. This Lake Michigan group contains a small number of relatively well-protected sites, including deltaic channels, estuarine channels, and sheltered sand-spit embayments, primarily within Green Bay, WI. These sites are located near the **tension zone** and display both northern and southern vegetation characteristics. These sites share a highly disturbed habitat. The adjacent flat, poorly drained clay lakeplain has been intensively farmed with row crops, and waters of Green Bay are generally characterized as quite turbid, owing both to erosion from agricultural activities and to industrial and urban pollution.

Emergent zone dominants are species associated with quiet, nutrient-rich waters, and typically more abundant in the southern Great Lakes. Key species include *Ceratophyllum demersum* (coontail), *Elodea canadensis* (common waterweed), *Lemna minor* (small duckweed), *Spirodela polyrhiza* (great duckweed), *Nymphaea odorata* (sweet-scented waterlily), and *Sagittaria latifolia* (common arrowhead). The herbaceous zone is a wet meadow of *Calamagrostis canadensis*, *Carex stricta*, and *C. lacustris*. Wet meadow species more characteristic of the south include *Impatiens capensis* (spotted touch-me-not) and *Typha angustifolia* (narrow-leaved cat-tail), as well as the exotics *Lythrum salicaria* (purple loosestrife), *Phragmites australis* (giant bulrush), and *Phalaris arundinacea* (reed canary grass). A distinct shrub zone was seldom encountered in sampling transects (Minc 1997a) due to heavy disturbance in the uplands.

Owing to the relatively flat topography, fluctuations in Lake Michigan's water level considerably alter the size of these coastal wetlands as well as their species composition (Harris et al. 1977). Receding high waters expose substantial portions of sandy beach and open mud flats, which are quickly colonized by dense stands of *Schoenoplectus tabernaemontani* (softstem bulrush), *Bidens cernuus* (nodding bur-marigold), and one or more species of *Polygonum* (smartweed). Over a period of several years, these colonizing species decline and are replaced by a sedge meadow consisting primarily of *Carex* spp. and *Calamagrostis canadensis* (Harris et al. 1981).

(5) Lake Michigan Lacustrine Estuaries (Buried River Mouth). This group consists of barred lacustrine estuaries of western Lower Michigan, generally south of the **tension zone**. All of the major rivers along this stretch have lacustrine estuaries at their mouths (Albert et al. 1988, Albert et al. 1989, Minc 1997c, Minc and Albert 1998). Most are partially to largely barred by longshore sand transport, and many have artificially maintained channels to Lake Michigan. These estuarine systems can extend for a considerable distance inland, where the rivers occupy linear floodplains cut into surrounding glacial moraines and sand lakeplain. Sites of this group are well protected from wind and wave action, owing to their long, narrow configuration and partial separation from Lake Michigan. This protection results in deep accumulations of organic deposits (mucks and peats) throughout the emergent and herbaceous vegetation zones. Open stream channels are generally shallow and nutrient rich, owing to the input of fine sediments and the presence of deep underlying organic substrates. While the site type (barred lacustrine estuary) occurs on Ontario portions of Lakes Ontario and Erie, the characteristic assemblage of plants may not occur.

In the emergent zone, *Nuphar advena* (yellow pond-lily) and *Peltandra virginica* (arrow-arum) are characteristic of these muck soils, while the large cover values for the floating species *Ceratophyllum demersum* and the duckweeds *Spirodela polyrhiza*, *Lemna trisulca*, and *L. minor* reflect relatively protected waters with a high nutrient content. *Nymphaea odorata* can form particularly dense beds in these sites.

The herbaceous zone conforms to the southern wet meadow type. *Calamagrostis canadensis* is a frequent dominant, but key southern species include *Impatiens capensis*, *Rorippa palustris* (yellow cress), *Polygonum lapathifolium* (nodding smartweed), and *Leersia oryzoides* (cut grass). The shrub zone includes *Alnus rugosa*, *Cornus stolonifera* (red-osier dogwood), along with *Fraxinus pennsylvanica* (red ash) and *Osmunda regalis* (royal fern).

(6) Saginaw Bay Lakeplain Marsh. This group contains most sites from Saginaw Bay. Formed by a flat glacial lakeplain that slopes gently into Lake Huron, Saginaw Bay is very shallow with a thin veneer of sand over clay. Wetland morphological types range from protected sand-spit embayments to open coastal embayments.

Wetlands in this group contain a mix of northern and southern species; this dual affinity may reflect the location of the climatic **tension zone** across Saginaw Bay. In addition, most sites contain ample floristic evidence of surrounding intensive agricultural land-use. This vegetation assemblage may not be found on Ontario's Great Lakes shoreline, as the equivalent, large, protected embayment does not occur along the Canadian G. L. shoreline this far south.

Along more open stretches of the bay, *Schoenoplectus pungens* (three-square bulrush) typically forms a dense fringe of emergent marsh, apparently due to its greater tolerance of extreme wave action. In more protected sites, the emergent zone contains *Schoenoplectus acutus* and *Eleocharis smallii*, although not in great densities. Excessive sedimentation and turbidity appear to exclude many submergent species typically found within northern emergent marshs, including most pondweeds. *Schoenoplectus pungens*, *Schoenoplectus tabernaemontani*, *Typha angustifolia*, and *Najas flexilis* are frequently present.

The southern wet meadow has a high percentage of early successional and disturbance species, including *Bidens cernuus*, *Impatiens capensis*, *Rorippa palustris*, *Schoenoplectus tabernaemontani*, and *Polygonum lapathifolium*. Common exotics include *Lythrum salicaria*, *Phragmites australis*, *Phalaris arundinacea*, and *Polygonum persicaria* (lady's thumb). The absence of a distinct shrub swamp zone for this group may reflect the intensity of land-use in this area, in which fertile lacustrine soils are farmed as close to G. L. coastal wetlands as possible.

(7) Lake Erie-St. Clair Lakeplain Marsh. This group includes all sites from the glacial lakeplain of western Lake Erie and Lake St. Clair. Although the lakeplain

formerly supported extensive marsh and wet prairie communities, the predominant remaining wetlands are the lacustrine estuaries formed at the mouths of rivers drowned by the postglacial rise in lake level.
The St. Clair River delta is a unique site in the Great Lakes, and its vegetation differs significantly from sites of Saginaw Bay to the north and Lake Erie to the south. The St. Clair River delta has higher submergent plant diversity than most sites on either Saginaw Bay or Lake Erie. All remaining marshes reflect high levels of agricultural disturbance characteristic of the fertile, flat lakeplain soils, along with heavy manipulation of the shoreline through diking and rip-rap. The Long Point, Ontario and Presque Isle, Pennsylvania sandspits share many habitats and species.

All of the wetlands occupy fairly protected sites (estuaries, barrier-beach lagoons, or sand-spit embayments); in addition, the Lake Erie sites enjoy the most moderate climate of the Great Lakes region. As a result, the emergent marshes and wet meadows of both Lake Erie and Lake St. Clair feature a relatively southern flora with a high proportion of disturbance species.

Common species of the emergent zone include the floating duckweeds (*Lemna minor* and *Spirodela polyrhiza*), *Ceratophyllum demersum*, *Elodea canadensis*, and *Nuphar advena* (Albert et al. 1988, Minc 1997a, Minc 1997c, Minc and Albert 1998). *Sagittaria latifolia*, *Schoenoplectus tabernaemontani*, *Typha angustifolia*, and *T.* x *glauca* (hybrid cat-tail) are common edge species. *Nelumbo lutea* (American lotus) attains very high densities at selected Lake Erie sites.

The southern wet meadow zone is dominated by *Calamagrostis canadensis*, *Phalaris arundinacea*, *Typha angustifolia*, and *Polygonum lapathifolium*. The standard suite of early successional species (*Bidens cernuus*, *Impatiens capensis*, *Rorippa palustris*) and common exotics (*Lythrum salicaria* and *Phragmites australis*) are present as well. As in the case for Saginaw Bay, fertile lacustrine soils are farmed as close to coastal wetlands as possible, resulting in the absence of a distinct shrub swamp.

(8) Lake Ontario Lagoon Marshes. U.S. wetlands along eastern and southeastern Lake Ontario are primarily barrier-beach lagoons (Minc 1997a, Minc 1997c, Minc and Albert 1998). In Ontario, exposed Prince Edward Island and Wolfe Island sites share similar vegetation. These sites share protected conditions and dampening of natural lake-level fluctuations.

Three distinct shoreline areas contain barrier-beach lagoons. Along the north shore on Prince Edward and Wolfe islands in Ontario, NE-SW oriented drumlins are protected by low barrier beaches, as are the N-S oriented drumlins along the southern shore of Lake Ontario. The shallow lagoons on the south shore include East Bay, Black Creek, and Sterling Creek. Along eastern Lake Ontario, sand accumulation has created a low shoreline of bays with barrier beaches and sand dunes rising up to 30 m above the lake. The barrier beaches create a string of shallow lagoons and wetlands, including Deer Creek, Cranberry Pond, South Colwell Pond, and Lakeview Pond.

The emergent zones support submergent species such as *Ceratophyllum demersum*, *Elodea canadensis*, *Spirodela polyrhiza*, *Lemna trisulca*, *Nuphar advena*, *Nymphaea odorata*, and *Potamogeton zosteriformis* (flat-stemmed pondweed). All of these reflect the well-protected and nutrient-rich waters of the lagoons.

The herbaceous zone is a broad wet meadow of *Typha angustifolia*, along with *Calamagrostis canadensis* and *Thelypteris palustris* (marsh fern). Cat-tail's dominance in Lake Ontario corresponds historically to the recent period of lake-level regulation. In contrast, species adapted to the cyclical exposure of shoreline mud flats are poorly represented in these sites.

The shrub zones divide into two distinct types. The more common type was buttonbush thicket with *Cephalanthus occidentalis* (buttonbush), *Decodon verticillata* (swamp loosestrife), and *Alnus rugosa*. These wetlands typically contained *Thelypteris palustris* and *Peltandra virginica* in mucky openings. The other type, poor shrub fen was encountered in areas of low water flow behind barriers, typically distant from the active stream channel. Here, poor fen shrubs (*Chamaedaphne calyculata*, *Myrica gale*, *Vaccinium macrocarpon*, and *Andromeda glaucophylla*) dominate, while *Sphagnum* spp. and *Sarracenia purpurea* attain high cover values in the groundcover.

(9) St. Lawrence River Estuaries (Buried River Mouth). These sites occur only along the upper reaches of the St. Lawrence River where the river is strongly influenced by Lake Ontario. This stretch features both granitic islands and bedrock knobs on the adjacent mainland.

Small streams or rivers occupy preglacial valleys cut through the rounded bedrock knobs and ridges which have been partially filled in by outwash and alluvial deposits to form fairly broad, flat basins. Extensive wetlands (up to 1 km wide) line the lower reaches of the streams for several kilometers inland. Crooked Creek is one of the best examples of this wetland community along this stretch of the St. Lawrence River (Herdendorf et al. 1981), while those of nearby Chippewa and Cranberry creeks are also of considerable importance to fish and wildlife (Geis and Kee 1977). It is expected that the wetlands on the nearby Canadian islands and mainland are similar.

The emergent zone is characterized by high densities of floating species, including *Utricularia vulgaris* (great bladderwort), *Lemna trisulca*, *Spirodela polyrhiza*, *Ceratophyllum demersum*, *Elodea canadensis*, *Potamogeton zosteriformis*, *P. friesii* (Fries's pondweed), and *Zizania aquatica* (wild rice) (Minc 1997a, Minc 1997c, Minc and Albert 1998). The exotic *Hydrocharis morsus-ranae* (frog's bit) is abundant. The herbaceous zone is a broad wet meadow zone with deep organic soils (often > 4 m), featuring a broad band of *Typha angustifolia*, with a narrow band of *Calamagrostis canadensis*, *Thelypteris palustris*, and *Impatiens capensis* near shore. Dominance of cat-tail reflects the reduction of natural lake-level fluctuations.

Michigan Indicator Species: *Schoenoplectis acutus*, *Schoenoplectis pungens*, *Eleocharis palustris* (*E. smallii*). A large number of other species could be treated as indicators for the several geographically or geomorphically distinct marsh types found along the Great Lakes (see vegetation description).

Other Noteworthy Species: Rare plants include *Sagittaria montevidensis* (arrowhead), *Nelumbo lutea* (American lotus), *Hibiscus palustris* (rose mallow), and *Zizania aquatica* var. *aquatica* (wild rice). Rare animals include *Chlidonias niger* (black tern), *Rallis elegans* (king rail), *Sterna forsteri* (Forster's tern), *Cistothorus palustris* (marsh wren), *Nycticorax nycticorax* (black-crowned night-heron), *Ixobrychus exilis* (least bittern), *Botaurus lentiginosus* (American bittern), *Circus cyaneus* (northern harrier), *Xanthocephalus xanthocephalus* (yellow-headed blackbird), *Falco columbarius* (merlin), *Elaphe vulpina gloydi* (eastern fox snake), *Emydoidea blandingi* (Blanding's turtle), and *Somatochlora hineana* (Hine's emerald).

Conservation/Management: Great Lakes coastal wetlands provide important habitat for insects, fish, waterfowl, water birds, and mammals. Over 50 species of fish were documented to utilize the coastal wetlands of northern Lake Huron (Gathman and Keas 1999), including several game fish. Fish utilize coastal wetlands in all parts of their life cycle, including egg, larval, immature, and adult stages. A broad range of invertebrates occupy this habitat, providing food for fish and birds (Gathman and Keas 1999). Coastal wetlands have long been recognized as critical habitat for the migration, feeding, and nesting of waterfowl. The Great Lakes and connecting rivers are parts of several major flightways. Many other shore birds also feed, nest, and migrate in and through these wetlands. During spring migration, when few alternative sources of nutrients are available, terrestrial migratory songbirds feed on midges from the G.L. marshes (Ewert and Hamas 1995). Mammals utilizing coastal wetlands include *Castor canadensis* (beaver), *Ondatra zibethicus* (muskrat), *Lutra canadensis* (river otter), and *Mustela vison* (mink).

Both urban and agricultural development have resulted in severe degradation and loss of coastal marshes through pollution, land management, and ecosystem alteration:

Urban development has impacted coastal wetlands in the following ways:

- Armoring of the shoreline and dredging of channels to create harbors has resulted in marsh elimination.
- Dumping of waste materials such as sawdust and sewage, and a wide variety of chemicals has mechanically and chemically altered the shallow-water marsh environment, increasing turbidity, reducing oxygen concentrations, and altering the pH.
- Shipping traffic has mechanically eroded shoreline vegetation.

- Water-level control of the Great Lakes and connecting rivers has altered natural wetland dynamics.

Agriculture has had the following impacts on coastal wetlands:

- Drainage has eliminated large areas of marshes and coastal wetlands.
- Sedimentation has greatly increased turbidity, eliminating submergent species requiring clear water.
- Nutrient loading has locally reduced oxygen levels, prompted algal blooms, and led to the dominance of high-nutrient tolerant species such as cat-tails.
- Heavy agricultural sedimentation has led to the deposition of rich organic mud in the wet meadows and along the shoreline, favoring the dominance of early successional species.
- Introduction of exotic plants has altered macrophyte species composition.

Several exotic plants and animals pose a threat to the integrity of coastal wetlands. Exotics often outcompete native organisms, as well as altering their habitat (Hart et al. 2000). Significant exotic plants include *Lythrum salicaria*, *Phragmites australis*, *Phalaris arundinacea*, *Myriophyllum spicatum* (Eurasian milfoil), *Potamogeton crispus* (curly-leaf pondweed), and many less aggressive species. *Hydrocharis moris-ranae*, an aggressive floating-leaved plant, is expanding westward from the St. Lawrence River and Lake Ontario into Lake Erie and the Detroit River, and has recently been documented in Michigan.

Exotic animals include *Dreissena polymorpha* (zebra mussel), *Cyprinus carpio* (common carp), *Neogobius* spp. (gobies), and *Bythotrephes cederstroemi* (spiny water flea), to name but a few. Many exotics arrive in shipping ballast and many others were purposefully introduced.

Research Needs: An important research need is the comparison of the biota of inland wetlands to Great Lakes coastal wetlands. There is ongoing research to document the faunal diversity of coastal wetlands, with research concentrated on invertebrates and fish (Brazner and Beals 1997, Burton et al. 1999, Gathman et al. 1999, Minns et al. 1994). Both faunal groups are being investigated as potential indicators of wetland quality. The effect of exotics on community dynamics and ecological processes also needs investigation, as does the effect of global warming. Further research on hydrological restoration is needed for degraded systems.

Similar Communities: Submergent marsh, emergent mrsh, northern wet meadow, southern wet meadow, interdunal wetland, lakeplain wet prairie, lakeplain wet-mesic prairie, northern fen, northern shrub thicket, southern shrub-carr, wooded dune and swale complex.

Other Classifications:

Michigan Natural Features Inventory (MNFI) Presettlement Vegetation:
6222 (Great Lakes Marsh)

Michigan Department of Natural Resources (MDNR):
N (marsh), Z (water)

Michigan Resource Information Systems (MIRIS):
621 (Aquatic bed wetland), 622 (Emergent wetland), 624 (Deep marsh)

The Nature Conservancy (Code, Alliance, Common Name):

V.C.2.N.a; Potamogeton gramineus – Potamogeton natans Northern Great Lakes Shore Herbaceous Vegetation; Grassy Pondweed- Floating Pondweed Northern Great Lakes Shore Herbaceous Vegetation.

V.C.2.N.a; Potamogeton zosteriformis – Ceratophyllum demersum – Elodea canadensis Southern Great Lakes Shore Herbaceous Vegetation; Flat-stem Pondweed – Coontail – Canadian Waterweed Southern Great Lakes Shore Herbaceous Vegetation.

V.C.2.N.a; Schoenoplectus acutus – Schoenoplectus subterminalis – Eleocharis palustris – (Schoenoplectus americanus) Northern Great Lakes Shore Herbaceous Vegetation; Hardstem Bulrush – Water Bulrush – Marsh Spikerush – (Chairmaker's Bulrush) Northern Great Lakes shore Herbaceous Vegetation.

V.C.2.N.a; Typha spp. – Schoenoplectus tabewrnaemontani – Mixed Herbs Southern

Great Lakes Shore Herbaceous Vegetation; Cattail Species – Softstem Bulrush – Mixed Herbs Southern Great Lakes Shore Herbaceous Vegetation.

Related Abstracts: Interdunal wetland, lakeplain wet prairie, lakeplain wet-mesic prairie, wooded dune and swale complex, wild rice, eastern fox snake, Blanding's turtle, Hines emerald, Forster's tern, black tern, northern harrier, and king rail.

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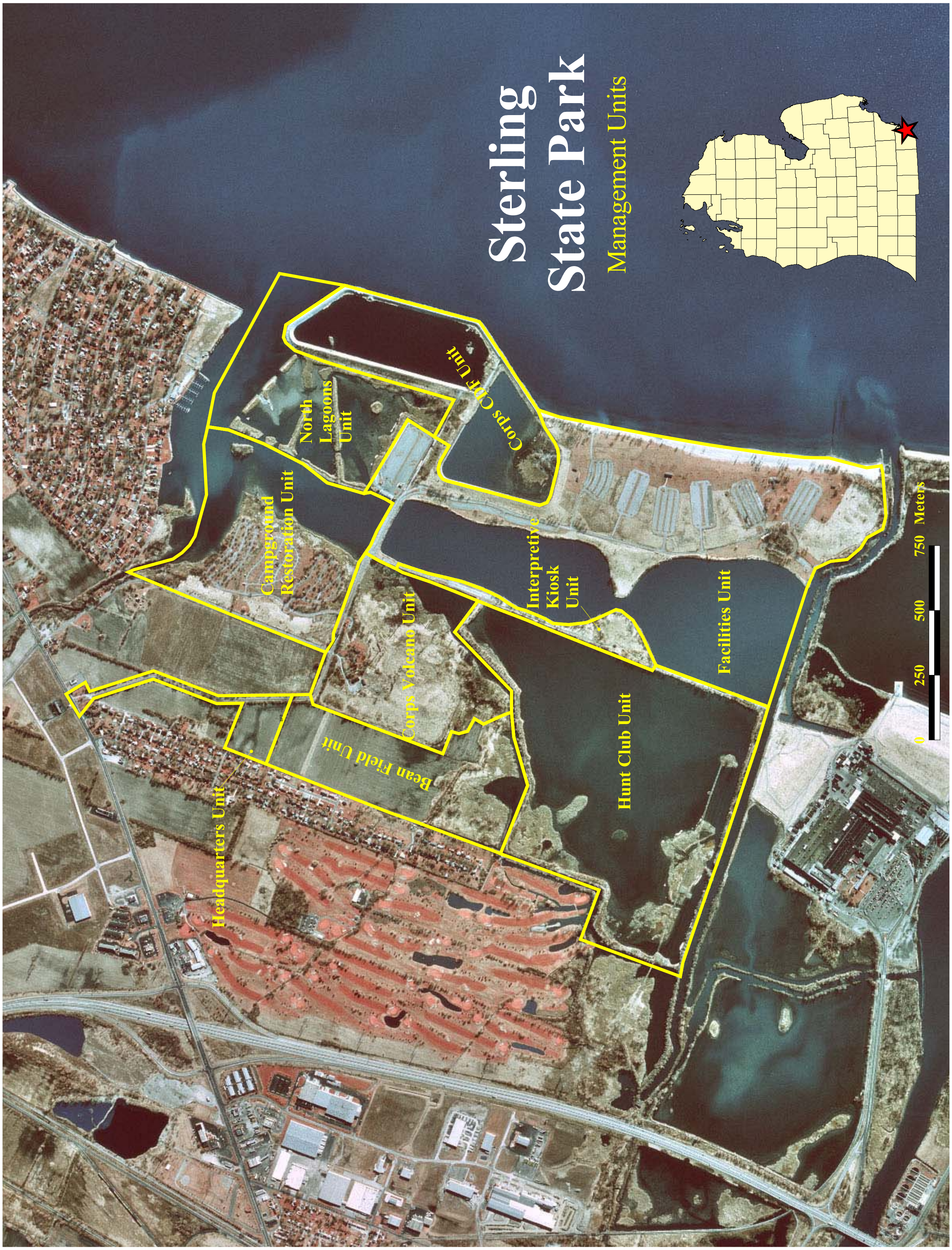
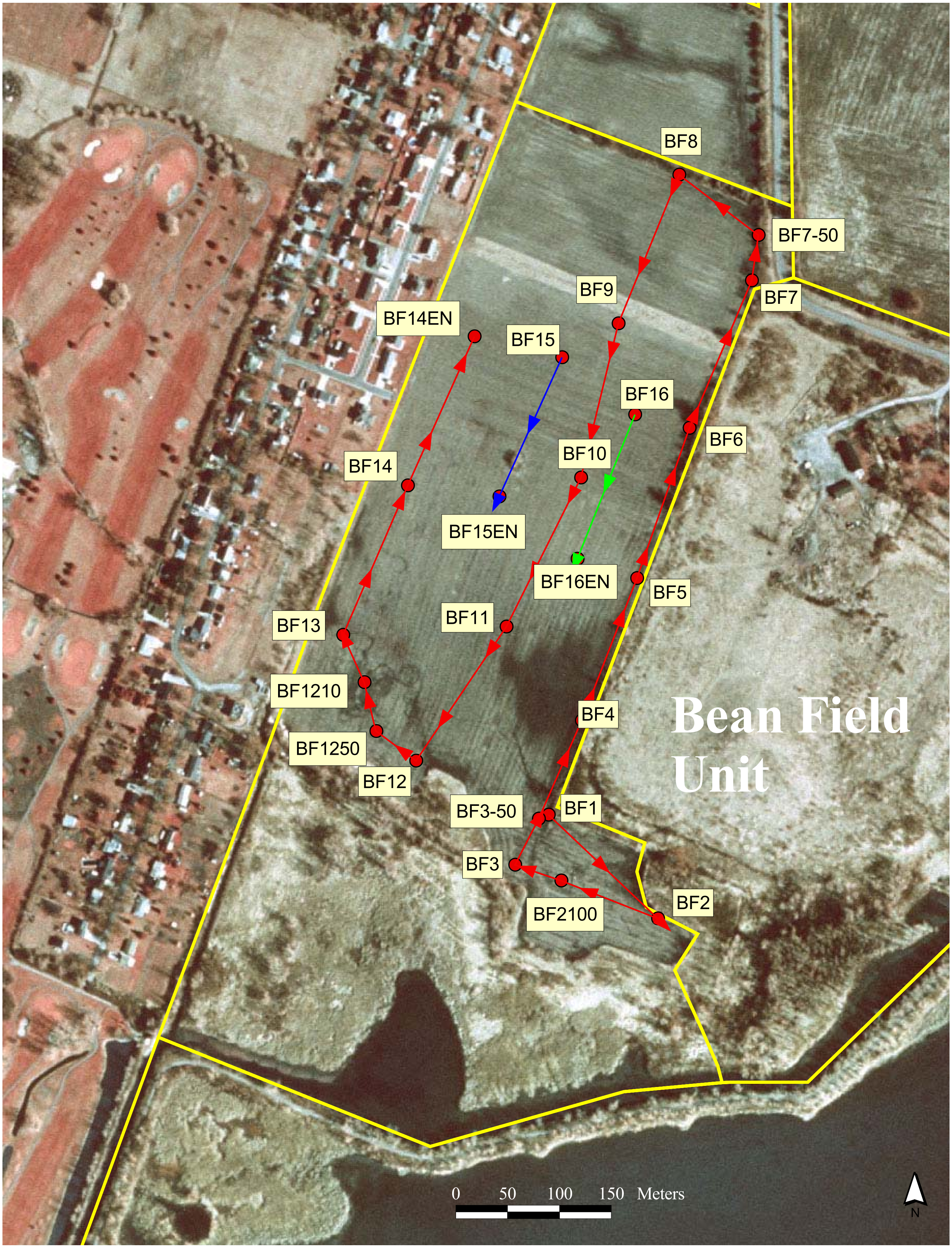
Phone: 517-373-1552

Appendix IV. Maps of the locations of the line-transect visual encounter surveys in all nine management units in Sterling State Park.

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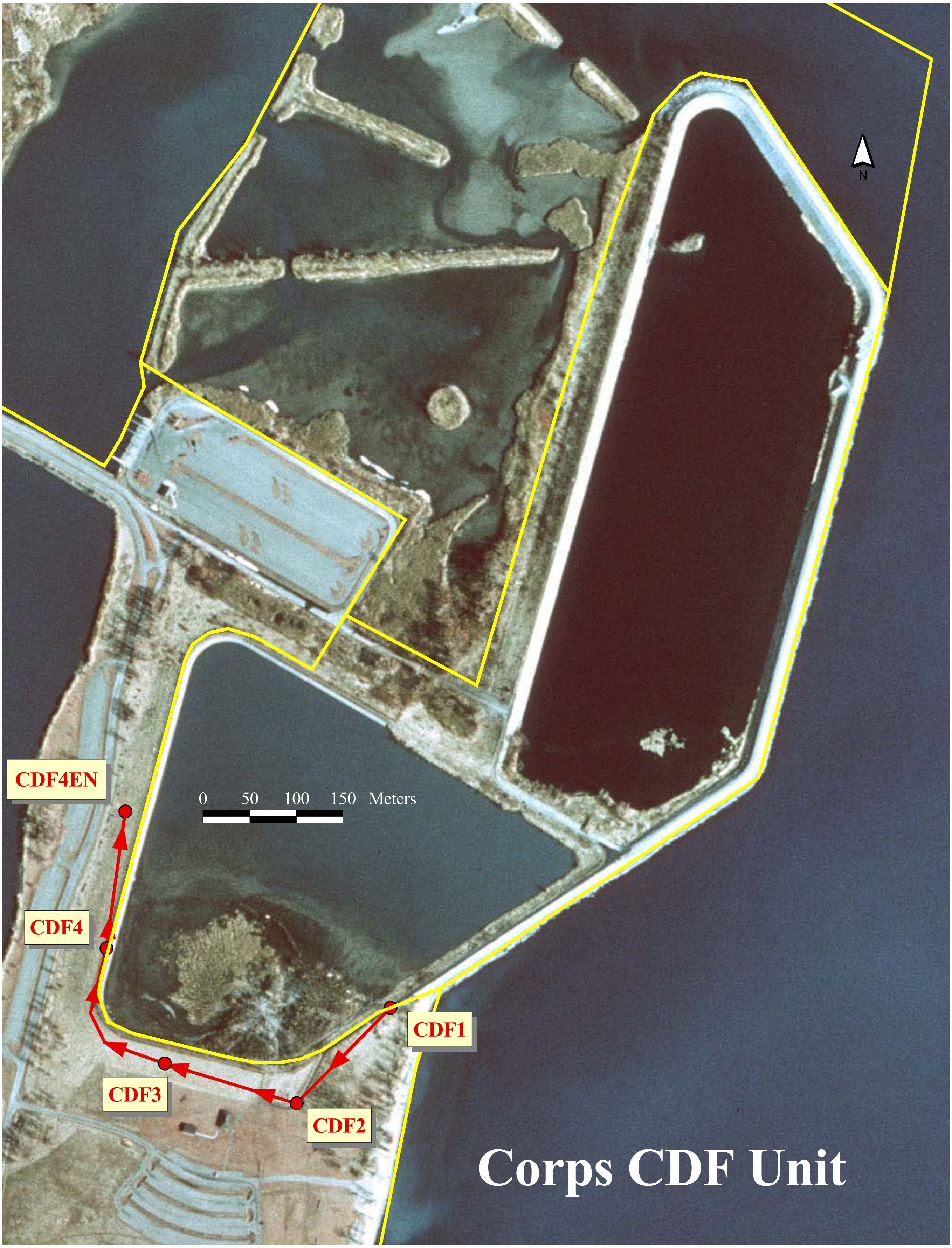
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C4
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C11CON
C8
C12
C8-CON
C12END
C11
C12CON
C9
C12-CT
C14
C9-CON
C13
C10
C14END
Campground Restoration Unit
N
0 50 100 150 Meters


F1
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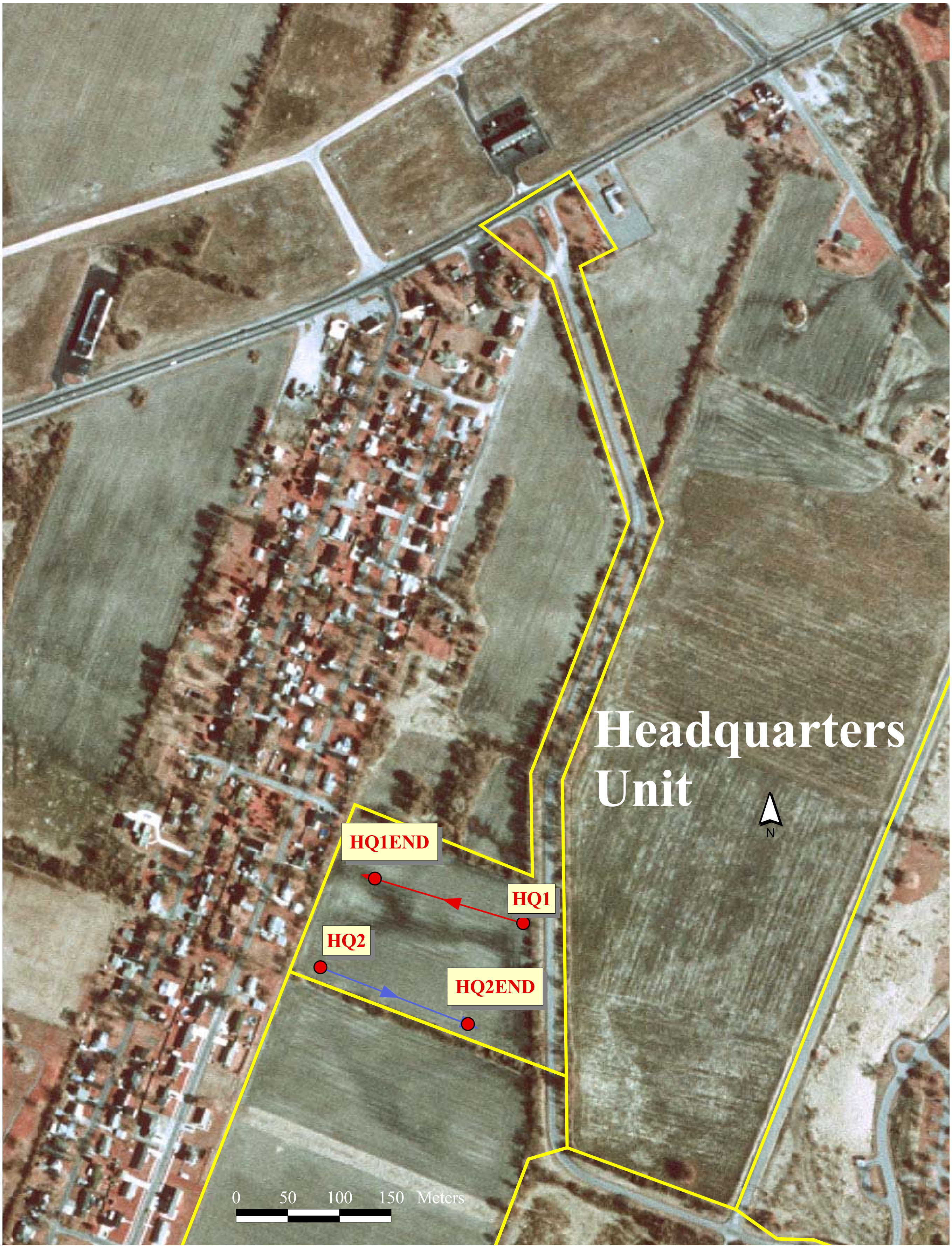

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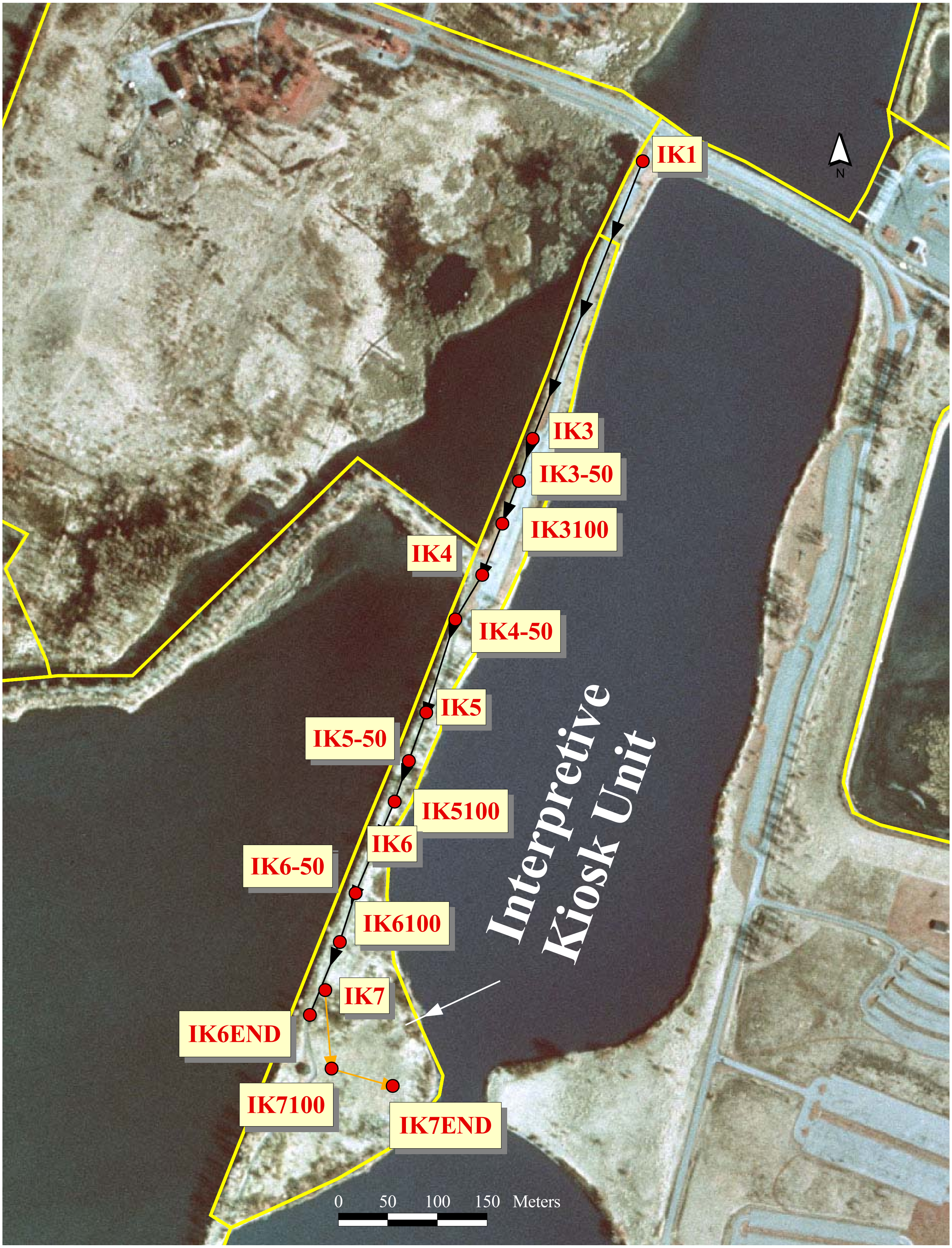

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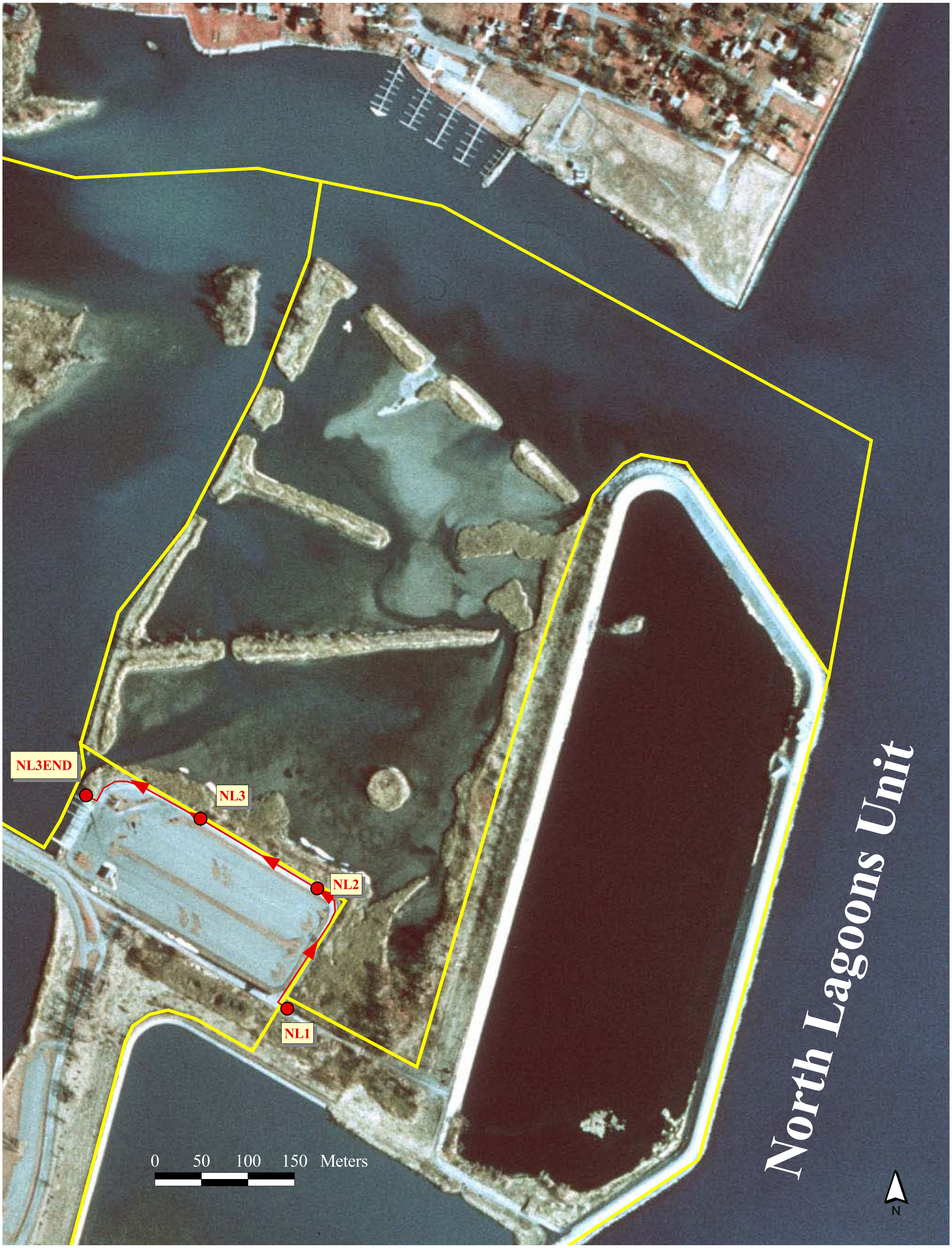
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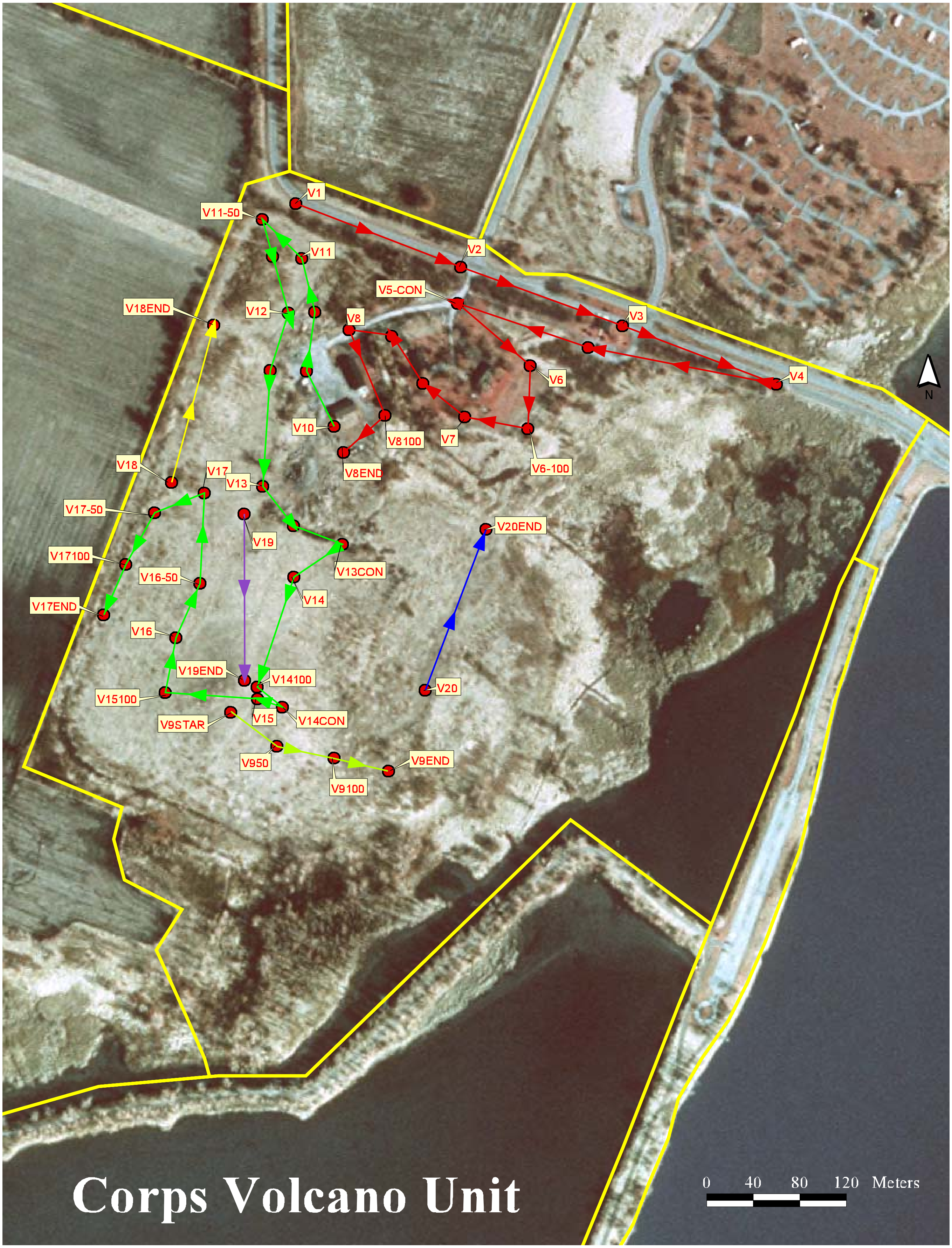

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V11
V11-50
V12
V13
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V14100
V14CON
V15
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Hunt Club Unit
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HC11
HC11EN
HC7END
HC7
HC7STR
2003 Points
HC6END
HC6100
HC6-50
HC6
HC6EN
HC6STR
HC5END
HC5
HC4END
HC4
HC3END
HC2
HC1
HC1-50
HC1100
HC1END
2004 Points

Appendix V. GPS coordinates for locations of line transects for eastern fox snake monitoring surveys in Sterling State Park.

Line-Transect Waypoint	Latitude	Longitude	Comments
Bean Field Unit			
BF1	41.91766977	-83.34754773	
BF2	41.91673636	-83.34631392	
BF2100	41.91709042	-83.34742435	
BF3	41.91724062	-83.34795543	
BF3-50	41.91763759	-83.34766039	
BF4	41.91847980	-83.34712395	
BF5	41.91970289	-83.34643194	
BF6	41.92099571	-83.34576138	
BF7	41.92226171	-83.34498354	
BF7-50	41.92265332	-83.34488698	
BF8	41.92320049	-83.34578821	
BF9	41.92192376	-83.34654995	
BF10	41.92059338	-83.34704348	
BF11	41.91931665	-83.34796616	
BF12	41.91817403	-83.34907123	
BF1210	41.91887140	-83.34963986	
BF1250	41.91844225	-83.34952184	
BF13	41.91928983	-83.34987053	
BF14	41.92057192	-83.34906586	
BF14EN	41.92184865	-83.34823438	
BF15	41.92164481	-83.34722050	
BF15EN	41.92044854	-83.34800371	
BF16	41.92112446	-83.34639438	
BF16EN	41.91988528	-83.34711858	
Campground Restoration Unit			
C1	41.92647815	-83.33899685	
C1-CON	41.92574859	-83.33838531	
C2	41.92537844	-83.33803662	
C3	41.92469716	-83.33658286	
C4	41.92355454	-83.33679744	
C5	41.92415535	-83.33844968	
C6	41.92469716	-83.34010192	
C7	41.92346871	-83.34093341	
C8	41.92274988	-83.33932408	
C8-CON	41.92224026	-83.33837994	
C9	41.92187548	-83.33799371	
C9-CON	41.92148387	-83.33794543	
C10	41.92100644	-83.33894857	
C11	41.92219198	-83.33983907	
C11CON	41.92273915	-83.34072956	
C12	41.92250848	-83.34088513	

Line-Transect Waypoint	Latitude	Longitude	Comments
C12-CT	41.92195058	-83.34166297	
C12CON	41.92212224	-83.34099242	
C12END	41.92211151	-83.34166833	
C13	41.92150533	-83.34206530	
C14	41.92191303	-83.34033259	
C14END	41.92090452	-83.33916315	
Corps CDF Unit			
CDF1	41.91386640	-83.33225914	
CDF2	41.91297591	-83.33350905	
CDF3	41.91339970	-83.33519884	
CDF4	41.91453159	-83.33590695	
CDF4EN	41.91584587	-83.33560654	
Corps Volcano Unit			
V1	41.92202032	-83.34444174	
V2	41.92148924	-83.34275731	
V3	41.92099571	-83.34109970	
V4	41.92050755	-83.33952793	
V5	41.92083478	-83.34146448	
V5-CON	41.92121029	-83.34280022	
V6	41.92071140	-83.34207066	
V6-100	41.92022324	-83.34211358	
V7	41.92033052	-83.34276267	
V7-50	41.92059875	-83.34318646	
V7-100	41.92097425	-83.34349223	
V8	41.92103326	-83.34393212	
V8100	41.92036271	-83.34358879	
V8END	41.92008376	-83.34402868	
V9STAR	41.91810429	-83.34528395	Added in 2004
V950	41.91783071	-83.34481725	Added in 2004
V9100	41.91772342	-83.34422716	Added in 2004
V9END	41.91761076	-83.34366926	Added in 2004
V10	41.92028761	-83.34411987	
V10-50	41.92072213	-83.34438809	
V10100	41.92117810	-83.34428080	
V11	41.92159653	-83.34439882	
V11-50	41.92190766	-83.34479579	
V11100	41.92161798	-83.34469923	
V12	41.92117810	-83.34455439	
V12-50	41.92073822	-83.34476360	
V13	41.91984236	-83.34487625	
V13-50	41.91953123	-83.34457048	

Line-Transect Waypoint	Latitude	Longitude	Comments
V13CON	41.91937566	-83.34407159	
V14	41.91913426	-83.34458658	
V14100	41.91829205	-83.34499964	
V14CON	41.91813111	-83.34474751	
V15	41.91820085	-83.34499964	
V15100	41.91827059	-83.34595450	
V16	41.91869438	-83.34582576	
V16-50	41.91910744	-83.34555754	
V17	41.91980481	-83.34548243	
V17-50	41.91966534	-83.34600278	
V17100	41.91927373	-83.34631928	
V17END	41.91888750	-83.34656605	
V18	41.91989601	-83.34582039	
V18END	41.92110300	-83.34533223	
V19	41.91963315	-83.34508010	
V19END	41.91834569	-83.34512838	
V20	41.91822767	-83.34326156	
V20END	41.91945612	-83.34258028	
Facilities Unit			
F1	41.91560984	-83.33670088	
F2	41.91429555	-83.33714076	
F3	41.91297591	-83.33752700	
F4	41.91184402	-83.33839604	
F5	41.91146314	-83.34007510	
F6	41.91061020	-83.33918461	
F7	41.90940320	-83.33853551	
F8	41.90811038	-83.33861061	
F9	41.90672100	-83.33868572	
F10	41.90547109	-83.33932945	
F10CON	41.90490782	-83.34009656	
F11	41.90468788	-83.33937773	
F12	41.90355062	-83.33878228	
F13	41.90250993	-83.33758601	
F14	41.90259039	-83.33588012	
F14EN	41.90356135	-83.33497890	New end of F14; added in 2004
F14END	41.90355062	-83.33505937	Old end of F14 from 2003
Headquarters Unit			
HQ1	41.92423582	-83.34492990	
HQ1END	41.92466497	-83.34664115	
HQ2	41.92390859	-83.34730634	
HQ2END	41.92337215	-83.34561118	

Line-Transect Waypoint	Latitude	Longitude	Comments
Hunt Club Unit			
HC1	41.90982699	-83.34408232	
HC1-50	41.90940320	-83.34430226	
HC1100	41.90897405	-83.34454366	
HC1END	41.90856099	-83.34478506	
HC2	41.90718770	-83.34557899	
HC3END	41.90690339	-83.34697911	
HC4	41.90706968	-83.34788569	
HC4END	41.90753102	-83.34966131	
HC5	41.90774024	-83.35035332	
HC5END	41.90815330	-83.35208603	
HC6	41.90880775	-83.35255274	Survey transect in 2003
HC6-50	41.90905452	-83.35278877	Survey transect in 2003
HC6100	41.90925837	-83.35340568	Survey transect in 2003
HC6END	41.90947831	-83.35393139	Survey transect in 2003
HC6STR	0.00000000	0.00000000	New transect added in 2004
HC6EN	41.90878630	-83.35439810	New transect added in 2004
HC7	41.91013813	-83.35741826	Old start of transect from 2003
HC7STR	41.90967679	-83.35763284	New start of HC7; added in 2004
HC7END	41.91087842	-83.35724660	
HC8	41.91294909	-83.35346469	Old start of transect from 2003
HC8STR	41.91376984	-83.35309454	New start of HC8; added in 2004
HC8EN	41.91496611	-83.35251519	
HC9	41.91558301	-83.35148522	
HC9END	41.91491246	-83.34970423	
HC10	41.91469789	-83.34884592	
HC10EN	41.91504121	-83.34696301	
HC11	41.91519678	-83.34459730	
HC11EN	41.91613555	-83.34308454	
Interpretive Kiosk Unit			
IK1	41.91979945	-83.33822438	
IK3	41.91731036	-83.33967277	
IK3-50	41.91692948	-83.33985516	
IK3100	41.91654861	-83.34007510	
IK4	41.91608727	-83.34033796	
IK4-50	41.91569030	-83.34068128	
IK5	41.91485345	-83.34107288	
IK5-50	41.91441894	-83.34130355	
IK5100	41.91405416	-83.34149131	
IK6	41.91364110	-83.34174880	
IK6-50	41.91323340	-83.34200093	

Line-Transect Waypoint	Latitude	Longitude	Comments
IK6100	41.91279352	-83.34221014	
IK6END	41.91213906	-83.34260711	
IK7	41.91235900	-83.34240862	
IK7100	41.91164553	-83.34236034	
IK7END	41.91146851	-83.34162542	
North Lagoons Unit			
NL1	41.91756248	-83.33266147	
NL2	41.91871583	-83.33222159	
NL3	41.91942394	-83.33370217	
NL3END	41.91968679	-83.33517202	

Appendix VI. Eastern fox snake survey form.

EASTERN FOX SNAKE MONITORING AT STERLING STATE PARK

Date: ____ County: ____ Unit: ____ Unit #: ____ Visit #: ____

TimeBeg: ____ T, R, S: ____

TimeEnd: ____ Surveyor(s): ____ Survey type: ____

Duration: ____ Weather Summary: Beg Tair: ____ Sun: ____ Wind: ____ Precip.: ____

Transect/Area: ____ End Tair: ____ Sun: ____ Wind: ____ Precip.: ____

SUMMARY: EFS ____ EGS: ____ NWS: ____ NRS: ____ OTHER: ____

Time	Transect #	Habitat Description	Species	GPS	Behav	Microhab	Length	Age/Sex	Photo #	Comments
		Macros: PFO, PSS, SDG, CAT, UFO, USS, OLD	EFS, NWS, EGS, NRS, UNK		B, R, C, M, F, T, U	Shrub, Sedge, Grass, Rock, Log, Herb, Bare, Island, Detritus, Other; incl. species				

COMMENTS (Draw or attach site map showing macrohabitats and transects on back):

MNFI, 10/25/2004

Appendix VII. Michigan Natural Features Inventory (MNFI) Special Animal Form.

MICHIGAN STATE UNIVERSITY EXTENSION

SPECIAL ANIMAL SURVEY FORM

Michigan Natural Features Inventory

SURVEYOR INFORMATION

Survey date: __ __ __ __ - __ __ - __ __	Time from: _______ to: _______ am or pm (circle)	Sourcecode: F __ __ __ __ __ __ __ M I U S

Surveyors (principal surveyor first, include first & last name): ____

____

Weather conditions: ____

Revisit to this EO needed? ___yes ___no Why?: ____

ELEMENT INFORMATION

Scientific name:	Data sensitive? Y N	EOID:	Occ.# (if known):

FILING

SURVEYSITE:	SITENAME:
QUADCODE:	QUADNAME:

LOCATIONAL INFORMATION

Was the Landowner contacted? Yes ______ No ______ Landowner Name: ____

Owner Type: ______________________________ Note:____

DIRECTIONS: Provide detailed directions to the observation (rather than the survey site). Include landmarks, roads, towns, distances, compass directions.

____

____

____

Township/Range/Section ____

County ______________________________ Managed area ______________________________

Was GPS used? Yes ______ No ______ Type of unit ______________________________ Unit number __________

Waypoint name/# (when using Garmin) ______________________________ File name (when using Trimble) ______________________________

OPTIONAL: Latitude ______________________________ Longitude ______________________________

FEATURE INFORMATION (mandatory) Point: <12.5 m in both dimensions, Line: >12.5 m in one dimension, Polygon: >12.5m in both dimensions

Source Feature: Single Source EO _____ Multi-Source EO _____ Conceptual Feature Type: Point _____ Line _____ Polygon _____

TOPOGRAPHIC MAP (mandatory, the website topozone.com can be used as a source for these maps)

1. Attach a photocopy of the appropriate part of a USGS topographic map (1:24,000 scale if available) and write the map scale on the photocopy. Please do NOT enlarge or reduce the map.
2. Indicate on the map the exact location of the observation(s):
   a. When the observed area is ***no larger than a pen point*** on the map (i.e., only a small number of individuals or extremely small patches), place small points on the map indicating the location(s) of the individuals or patches, and label each point with an arrow so they are more easily seen.
   b. When the observed area is ***larger than a pen point*** on the map, (e.g., a population of plants, foraging birds):
      (1) Draw a thin solid boundary line showing the extent of the observed area occupied by the individuals.
      (2) Indicate disjunct patches (polygons) by drawing the boundary for each patch separately.
      (3) If the boundary follows the edge of a lake, stream, road, marsh or other feature, draw the boundary precisely on the edge of the feature.

(4) Where needed, add notes to the map with instructions on where the boundary line is located or if the boundary is shared with other observations.

3. A hand drawn sketch may be included for finer details.

LOCATIONAL CERTAINTY

Is your depiction of the observed area on the map within 6.25 **m (approximately 20ft)** of its actual location on the ground? Y N
If **N,** complete the following:

a. Estimate of uncertainty distance: based on landmarks, elevation, etc., the location of the observed area on the map is accurate to within ___________ meters kilometers feet miles of its actual location on the ground.

b. Is the observed area known to be located within some feature(s) on the map (e.g., wetland boundary, lake, road, trail, highway, contour lines)? Y N

If Y, indicate the boundary within which the observed area is known to be located on the map line, and if applicable, identify the feature (e.g., marsh).

IDENTIFICATION

Photograph/slide taken? ___yes ___no If yes, will a copy be submitted to Heritage? ___yes ___no MNFI office: Added to collection?____ (check)

Specimen collected? ___yes ___no Collection # and repository: ______________________________

Identification problems? ___yes ___no If necessary, describe the important animal characteristics you used for identification: ______________________________

____

SIZE OF ELEMENT OCCURRENCE

Size is a quantitative measure of the area and/or abundance of an occurrence. Components of this factor are 1) area of occupancy, 2) population abundance, 3) population density and 4) population fluctuation.

Type of observation: ___sight ___ song/vocalization ___ road kill ___ trapped ___ other (explain):______________________________

Abundance (number of pairs, chicks, nests, adults, juveniles, hatchlings, behavior, sex, size of each individual, etc.):

Actual number observed:______________________________

____

____

Number estimated and basis for estimate:______________________________

____

____

____

Population density (if practical): number:______________ per area unit:_________________ (i.e., meters^2, kilometers^2, miles^2, etc.)

Does population fluctuate? (May be particularly relevant to invertebrates):

___ yes ___ no ___ unknown. Explain: ______________________________

Area of occupancy (fill in one):_______meters ________acres ________miles Type of measurement (check one): ___ Precise ___ Estimate

ASSOCIATED SPECIES

List other species observed at this site. Note especially listed species and potential competitors, predators, and prey. Mark appropiate columns.

Species	ID +	ID ?	Number Observed	Notes, observations, etc.

CONDITION:

Condition is an integrated measure of the quality of biotic and abiotic factors, structures and processes within the occurrence, and the degree to which they affect the continued existence of the occurrence. Components of condition for species are: 1) reproduction and health, 2) ecological processes, 3) species composition and biological structure, 4) abiotic physical/chemical factors. Factors to consider: evidence of regular successful reproduction, habitat degradation, disturbance, presence of exotic species, the degree to which ecological processes are sustaining the habitat. Where possible include a comparison to other occurrences.

EVIDENCE OF REPRODUCTION:______________________________

____

____

EVIDENCE OF DISEASE/PREDATION:______________________________

CONDITION (continued)

HABITAT DESCRIPTION: Describe the specific habitat or micro habitat where this animal occurs. Convey a mental image of the habitat and its features including: land forms, aquatic features, vegetation, slope, aspect, soils, associated plant and animal species, natural disturbances.

LANDSCAPE CONDITION: Describe the condition of the landscape surrounding the elements habitat (i.e., farmland, residential area, pristine forest)

CURRENT THREATS to this occurrence (i.e., grazing, logging, mining, plantations, ATVs, dumping, etc.) Discuss exotics in the next section.

POTENTIAL THREATS to this occurrence:

EXOTICS PRESENT? ___yes ___no. If yes, describe their impacts to the occurrence.

PAST IMPACTS to the occurrence (i.e., logging, , etc.):

TOPOGRAPHY	Aspect:	Slope:	Light:	Position:	Moisture:
Elevation:______ft. If elevation is a range: Minimum: ______ft. Maximum:______ft.	___N ___NE ___E ___NW ___S ___SE ___W ___SW	___flat ___0-10 ___10-35 ___35+ ___vertical	___open ___partial ___filtered ___shade	___crest ___upper slope ___mid slope ___lower slope ___bottom	___Inundated ___saturated (wet-mesic) ___moist (mesic) ___dry-mesic ___dry (xeric)

MANAGEMENT AND PROTECTION

MANAGEMENT, MONITORING AND RESEARCH NEEDS for this occurrence (e.g. burn periodically, open the canopy, ensure water quality, control exotics, keep out the ATV's, study effects of browsing)

AREAS IN NEED OF PROTECTION: (e.g. the entire marsh, the slope and crest of slope, the fen and upland, etc.)

If you have any questions regarding this form and its methodology please contact MNFI at (517) 373-1552.

P:\nfi\field forms\special_animal_form.doc
Rev. 10/2003