Status of the Eastern Massasauga Rattlesnake at Indiana Dunes National Lakeshore

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January 10, 2005

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Abstract

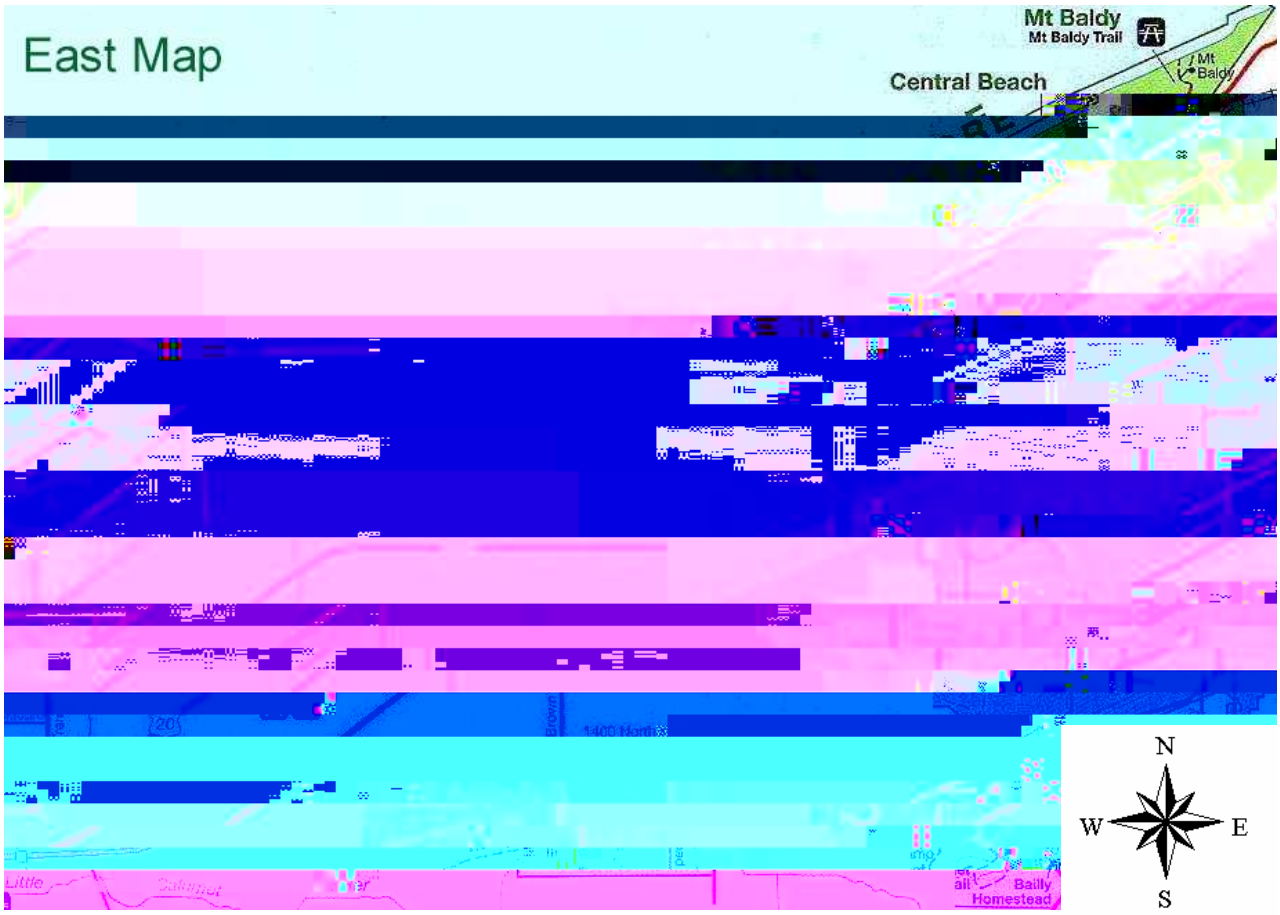
The eastern massasauga rattlesnake (*Sistrurus catenatus catenatus*) is listed as threatened or endangered in ten of the eleven states and provinces in which it currently is found. Records suggest that the eastern massasauga was frequently encountered in the vicinity of present-day Indiana Dunes National Lakeshore (INDU) until the 1930s. Since establishment of INDU in 1966, confirmed massasauga sightings within the park's vicinity have been rare and no confirmed sightings were made within the official boundary of the park. To examine the current status of the eastern massasauga rattlesnake at INDU, both active searching and passive collection were used. A three-phase survey process, including visual searching, drift fencing, and the use of artificial cover objects, was employed to search for the massasauga within INDU. The objective of the surveys was to document presence of massasaugas at sites within Indiana Dunes National Lakeshore where the snakes were thought most likely to occur. Visual searching, drift fencing, and artificial cover objects yielded twenty-three species of amphibians and reptiles. Among these were nine frog and toad, five salamander, two turtle, one lizard, and six snake species. One eastern massasauga rattlesnake was captured in a drift fence. Within INDU, a combination of fire suppression in upland areas and the draining of the Great Marsh has led to an influx of woody vegetation in both upland and wetland areas. This has significantly limited open habitats within the East Unit of INDU. While the surveys have established that an individual *S. c. catenatus* exists within the boundary of Indiana Dunes National Lakeshore, further monitoring is needed to determine the snake's status, to further identify critical habitat, and to provide park managers the information necessary to properly insure the long-term survival of the species at INDU.

Introduction

The eastern massasauga rattlesnake (*Sistrurus catenatus catenatus*) is a candidate for federal listing as a threatened or endangered Distinct Population Segment (DPS) (U.S. FWS 2003). Although the massasauga rattlesnake is thought to be in decline throughout much of its range, only the eastern subspecies (*Sistrurus c. catenatus*) is currently under consideration for listing. The eastern subspecies has been described as historically ranging from central New York and southern Ontario, southwest to Iowa and Missouri (Johnson 1995, Minton 2001). This eastern subspecies encompasses all *S. catenatus* residing north and east of the Missouri River.

The eastern massasauga is listed as threat

along with other records, suggest that the historic occurrence of the eastern massasauga in INDU was concentrated in the Great Marsh section of the East Unit. The East Unit covers about 3,265 ha (51%) of the park's 6,350 ha. Although much of the Great Marsh remains intact, it has been extensively drained and has suffered significant encroachment of woody vegetation over the past 75 years (Cook and Jackson 1978, Applied Ecological Services 1984).



Since the establishment of INDU in 1966, the authors are aware of only fifteen reported sightings of the massasauga within or near the park boundary (Figure 2). Of these, only three are considered confirmed, none of which were within the official park boundary. Two of these sightings, an adult in the mid-1990s and a juvenile in 2000, occurred within about 200 m of each other, along the power line corridor near the railroad station of the town of Beverly Shores, an inholding within INDU's East Unit. The third sighting was a road-killed specimen found at the eastern end of Beverly Drive, at the eastern end of Beverly Shores, in the early 1990s. Each of these sightings was within 50 m of INDU's property boundary. The objective of this study was to document the presence, and

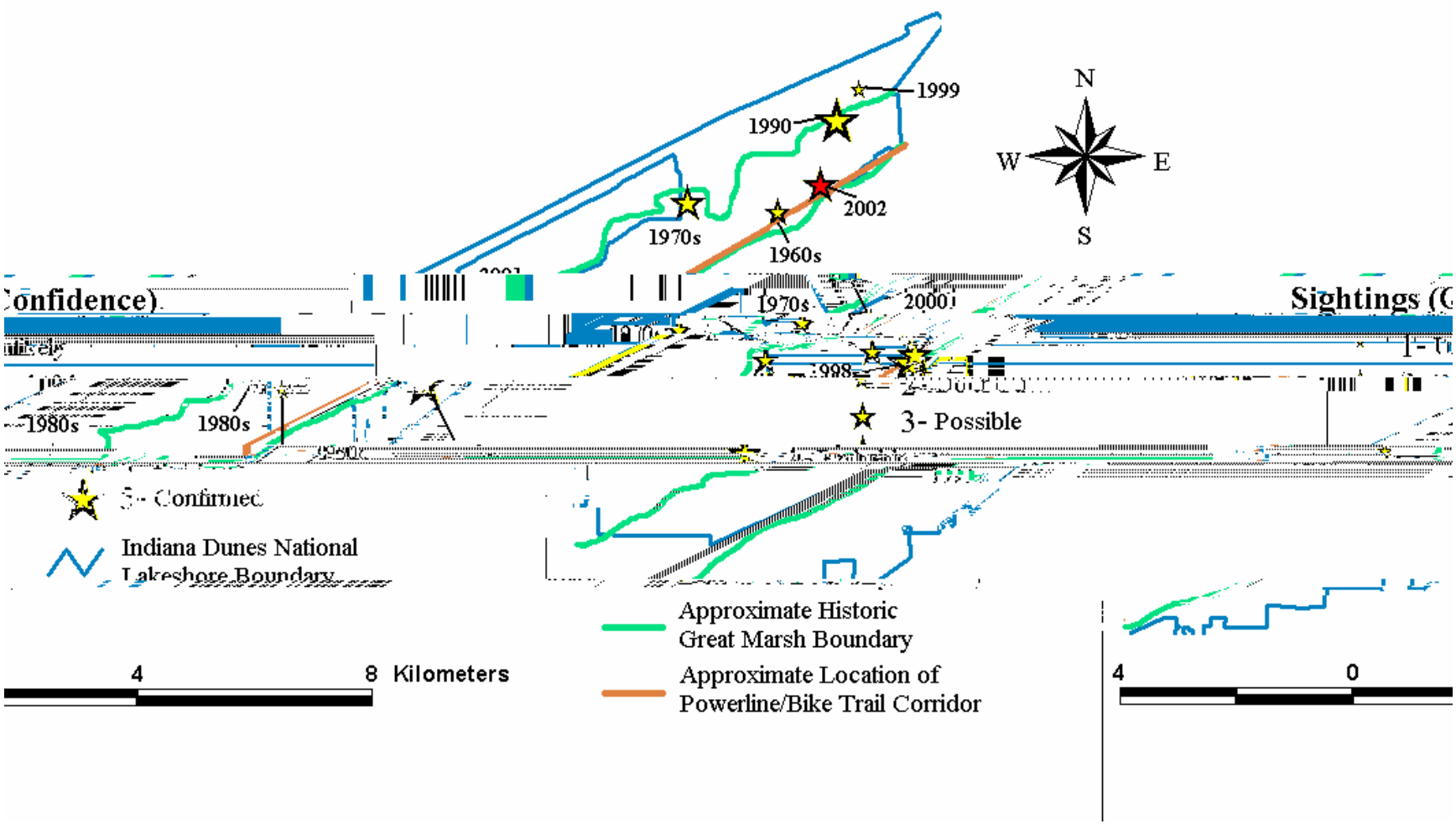
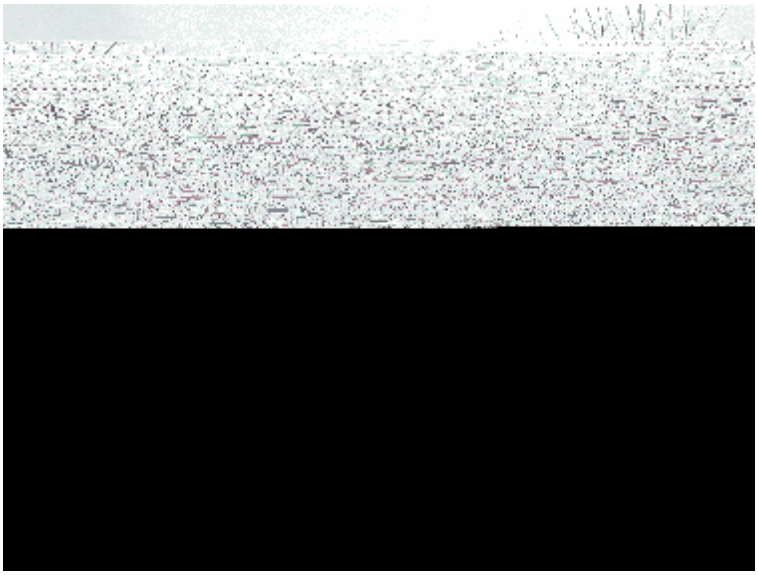


Figure 2. Reported sightings of the eastern massasauga rattlesnake since establishment of Indiana Dunes National Lakeshore in 1966. Confidence of sighting scale estimated by authors based on frequency of sightings in the area, expertise of observer, and quality of habitat where purported sighting occurred. The 2002 sighting represents a potential sighting by Gary Glowacki as report in Results.

potentially provide information on the distribution, of the eastern massasauga rattlesnake at the Indiana Dunes National Lakeshore.

Materials and Methods



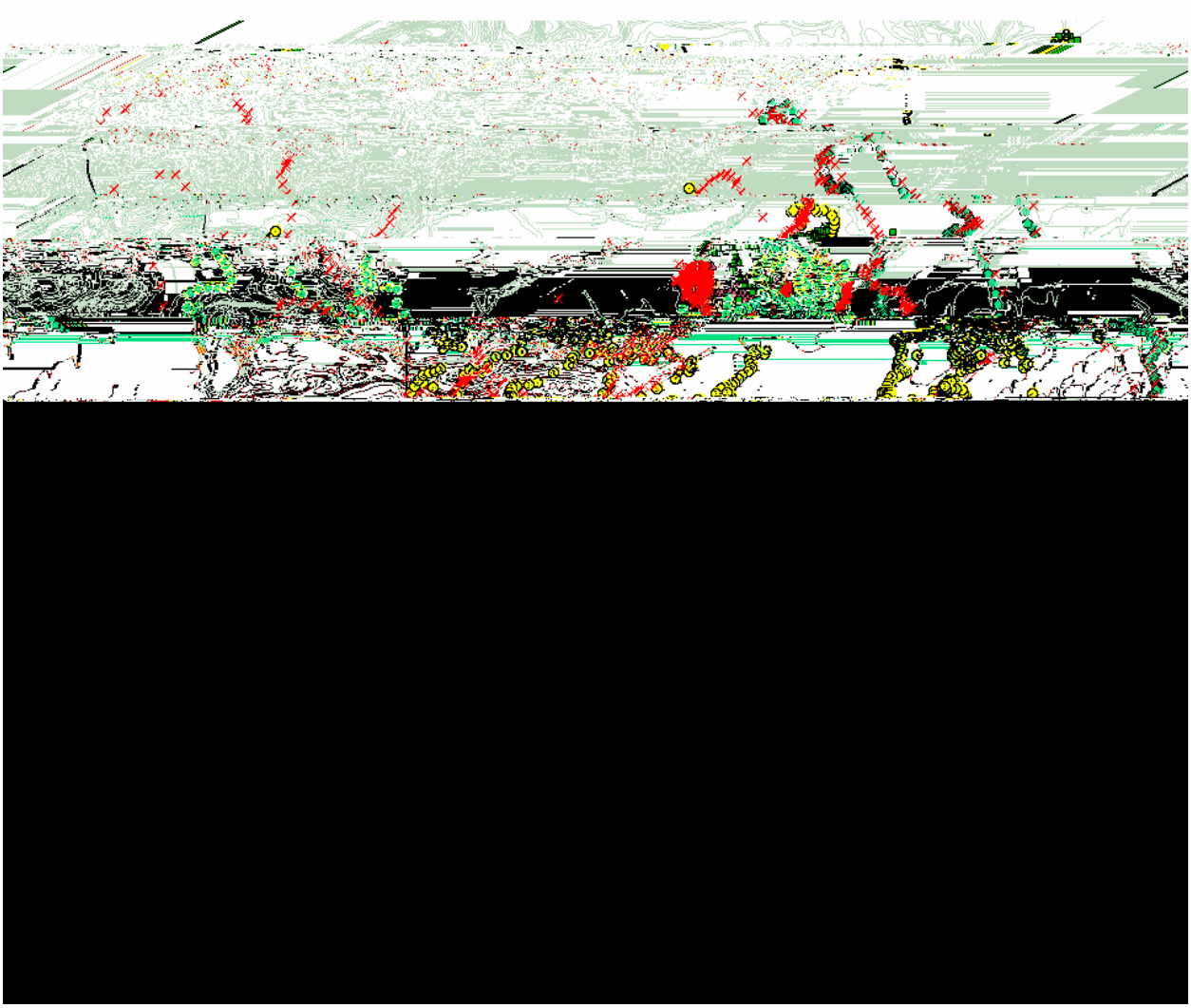


Figure 4. Visual search tracks for the eastern massasauga rattlesnake from one section of Indiana Dunes National Lakeshore, 2002-2003. Points along a given track were recorded at < 30 second intervals.

Track points were recorded at intervals of less than 30 seconds. Search locations were chosen to maximize coverage within the East Unit of Indiana Dunes National Lakeshore. Areas that had historical sightings, or habitat conducive to the massasauga, were checked on multiple occasions. Temperature, humidity, and wind (Beaufort scale) were measured before and after a visual search was undertaken. Locations of crayfish burrows, sphagnum moss, and other habitat elements massasaugas are known to use (marshes, sedge meadows, open or open-shrub habitats) were also recorded using GPS.

Survey Methods: Drift Fences

Fourteen drift fences (Figure 5) were placed across the East Unit of the park. The fences were constructed of aluminum window screen (0.9 m wide, 12 m long) with funnel traps at both ends for collecting animals. Funnel traps (Figure 6) consisted of a 25 cm diameter funnel with an 0.8 m long cylinder of window screen attached around the perimeter of the funnel. The opposite end of the screen cylinder was held shut with clothespins. The neck of the funnel was removed to maintain an opening larger than an adult massasauga's body diameter. Snakes meeting

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The drift fences were placed at interfaces between suitable wetland and upland habitats, in areas with historical sightings, and in other areas that were thought likely to harbor massasaugas (Figure 7). Drift fence sampling in 2002 took place from April 1 - October 31. In 2003, four fences that were thought least likely to be successful were moved to new locations (Figure 7). Fences in 2003 were opened from March 19 - May 12 and September 17 - October 1, periods when massasaugas might be captured while moving between overwinter sites and upland habitats (Bruce Kingsbury, personal communication) and were monitored by National Park Service personnel. Drift fences were left open for trapping continuously during the indicated time periods and were checked 2-3 times per week for captured animals. Amphibians and reptiles captured during each visit were identified, measured (snout to vent length), marked, and released.

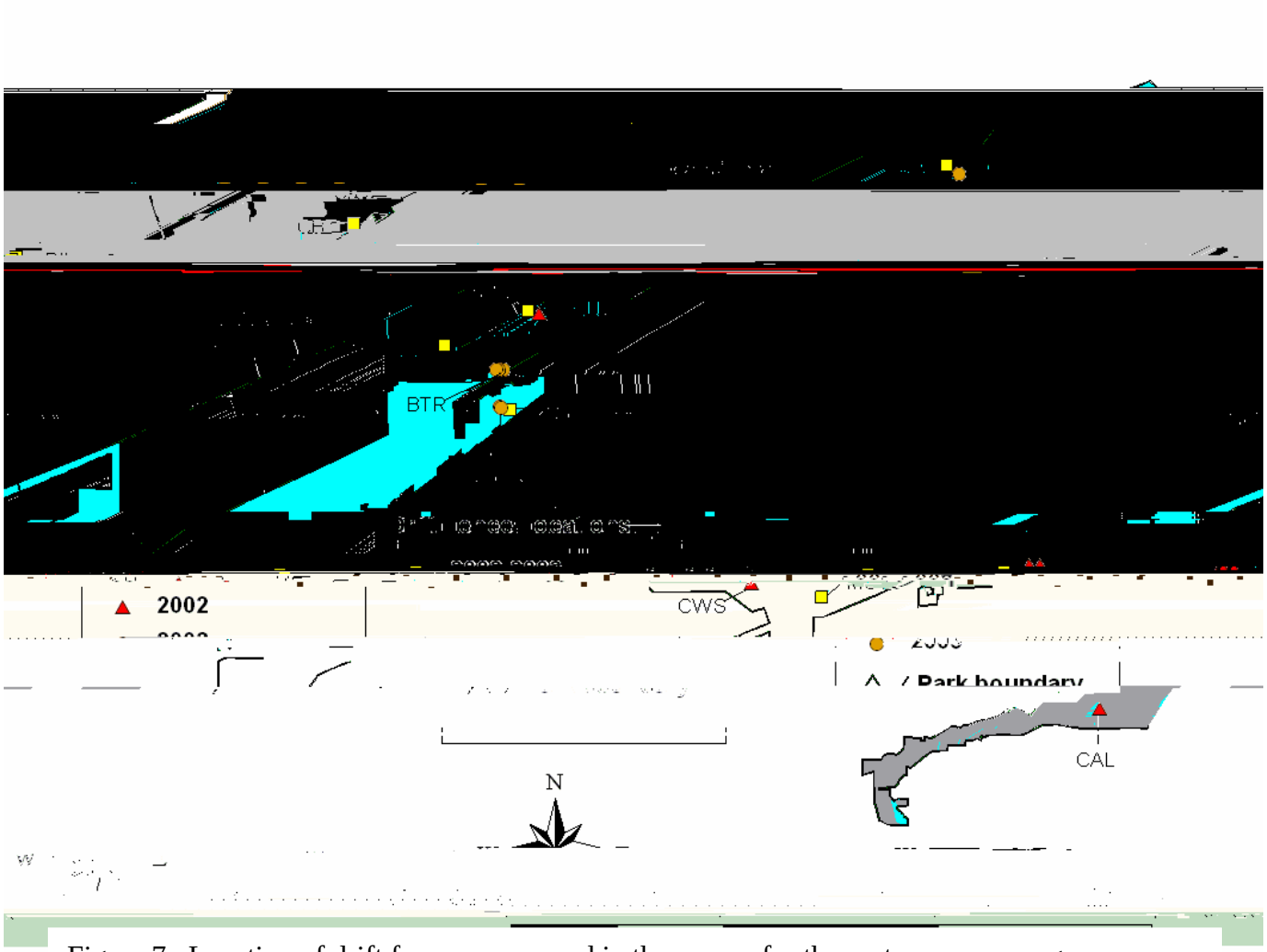
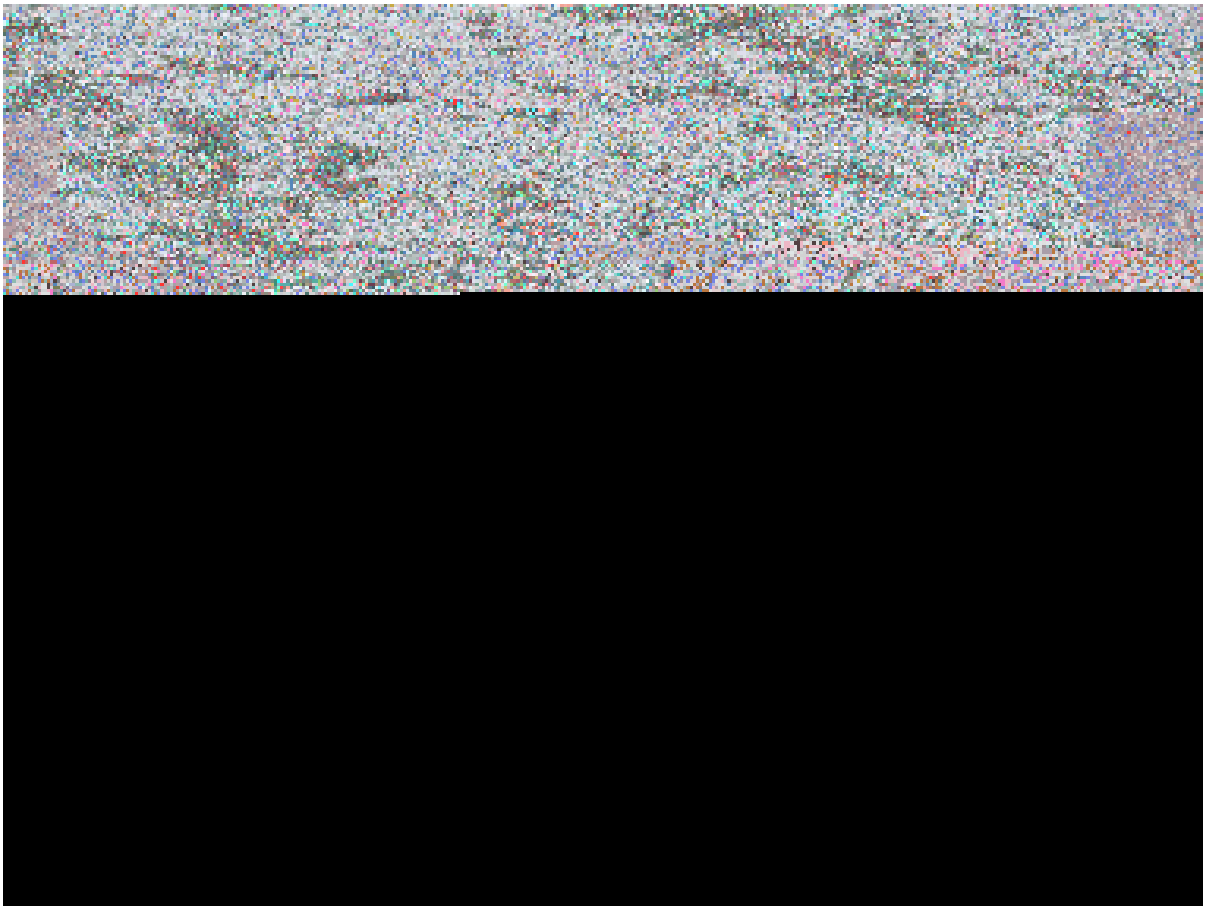
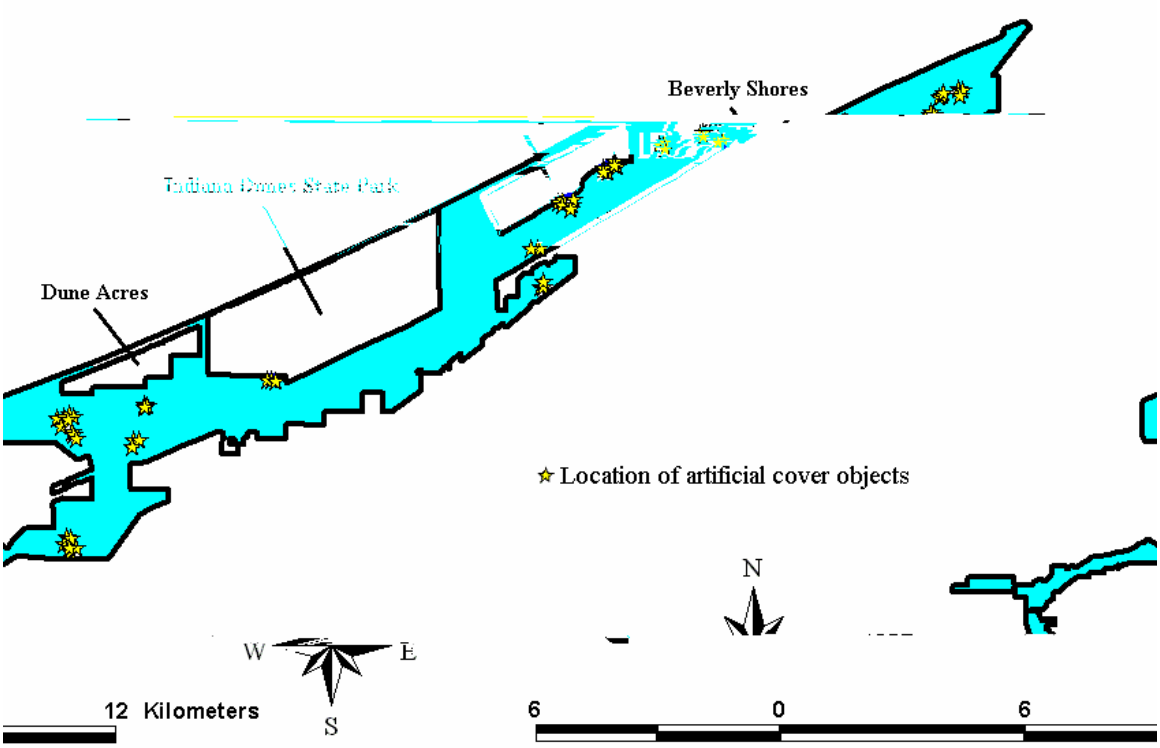


Figure 7. Location of drift fence arrays used in the survey for the eastern massasauga rattlesnake at Indiana Dune

Survey Methods: Artificial Cover Objects

Artificial cover objects (ACOs) were also used to survey for massasaugas, as





Habitat Mapping

Individual habitat polygons > 10 m^2 in area were mapped within a 200 m radius of each drift fence (Figure 10). The polygons were initially delineated using National Park Service aerial photographs and further verified and corrected by ground truthing. Definitions of the thirteen habitat types are summarized below and in Figure 11. We estimated percent open water, floating vegetation, emergent vegetation, herbaceous vegetation, woody vegetation, and standing water in wetland habitat types, and percent canopy cover, herbaceous vegetation, bare ground, and litter cover in other habitat types. Habitat boundaries were mapped as polygons on

Mapped Habitat Types

1) Non-Oak Savanna
Non-oak savannas have canopy cover 10 - 90%; typical woody species are not oaks (*Quercus* spp.). Little woody vegetation exists below the tree canopy (< 5 m)

2) Oak Savanna or Woodland
Oak savannas have canopy cover of 10 - 90% with nearly all trees oaks (*Quercus velutina, Q. rubra, Q. alba,* or *Q. palustris*). Little woody vegetation exists below the tree canopy (< 5 m).

3) Oak Scrub Woodland
Oak scrub woodlands are habitats dominated by oaks (*Q. velutina, Q. rubra, Q. alba,* or *Q. palustris*) at multiple vertical strata. Canopy cover of *Quercus* spp. is at least 50%, of which oak trees > 5 m makes up at least 25% of the total canopy and oak saplings < 5 m also comprise at least 25% of the total canopy.

4) Non-Oak Scrub
Non-oak scrub is a habitat dominated by woody vegetation other than oaks (*Q.* spp.) at multiple vertical strata. Canopy cover is at least 50%, of which trees > 5 m makes up at least 25% of the total canopy and other woody vegetation < 5 m also comprises at least 25% of the total canopy.

5) Non-Oak Woodland/Forest
Canopy cover is > 80%. The canopy contains multiple tree species, not dominated by *Q.* spp. Non-oak woodlands contain multiple w

9) Open
Open habitats are primarily composed of herbaceous vegetation with < 10% woody vegetation cover. Open sites are not wetlands and do not contain wetland obligate or facultative vegetation.

10) Human
Human habitats contain man-made elements such as homes, buildings, paved roads, unpaved roads or old railroad beds, and railroads. These habitats generally lack a significant amount of vegetation, although some may persist in lawns and landscaping.

11) Permanent Wetland
Permanent wetlands contain hydrophytic vegetation, hydric soils, and wetland hydrology. Permanent wetland habitats are differentiated from ephemeral and ephemeral edge habitats by retaining standing water throughout the year.

12) Ephemeral Wetland
Ephemeral wetlands contain hydrophytic vegetation, hydric soils, and wetland hydrology. Ephemeral wetland habitats are differentiated from permanent wetlands in that they typically dry out during the summer months.

13) Ephemeral Edge Wetland
Ephemeral edge wetlands occur around the fringe of ephemeral wetlands. While this habitat also contains hydrophytic vegetation and hydric soils, clear wetland hydrology may be lacking in dry years. Ephemeral edge wetlands are a transition from ephemeral wetlands to drier, upland areas and thus often contain elements of both.

Statistical Analyses

The objective of this study was to document the presence, and potentially provide information on the distribution, of the eastern massasauga rattlesnake at Indiana Dunes National Lakeshore. Surveys were purposefully conducted at locations where history and habitat structure suggested the massasauga might most likely be found. Random sampling of habitats, and extensive evaluation of habitat structure, was not included in the study design. However, the authors have completed a separate study of amphibians and reptiles at seventeen upland INDU sites,

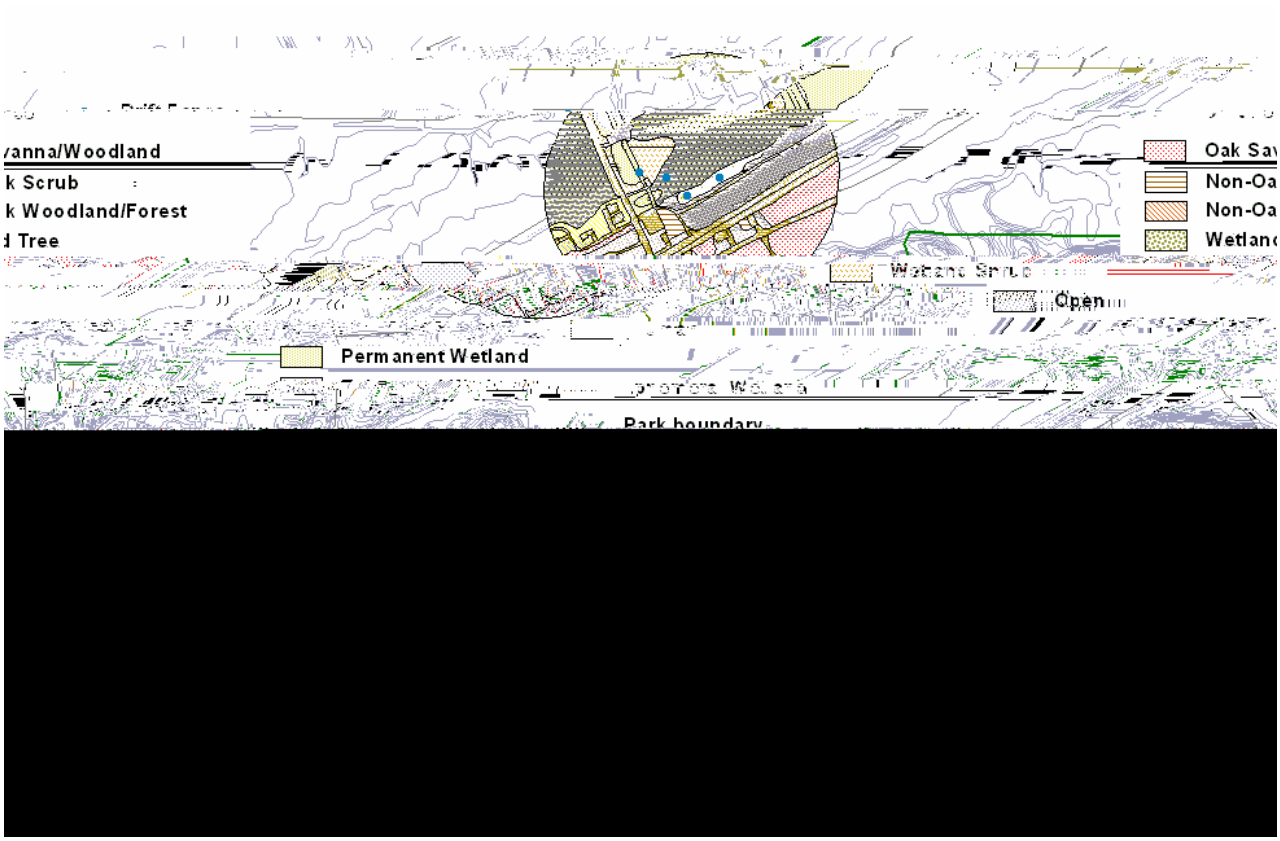


Figure 10. Sample of habitat mapping within 200 m of drift fences used in the survey for the eastern massasauga rattlesnake at the Indiana Dunes National Lakeshore, 2002-2003.

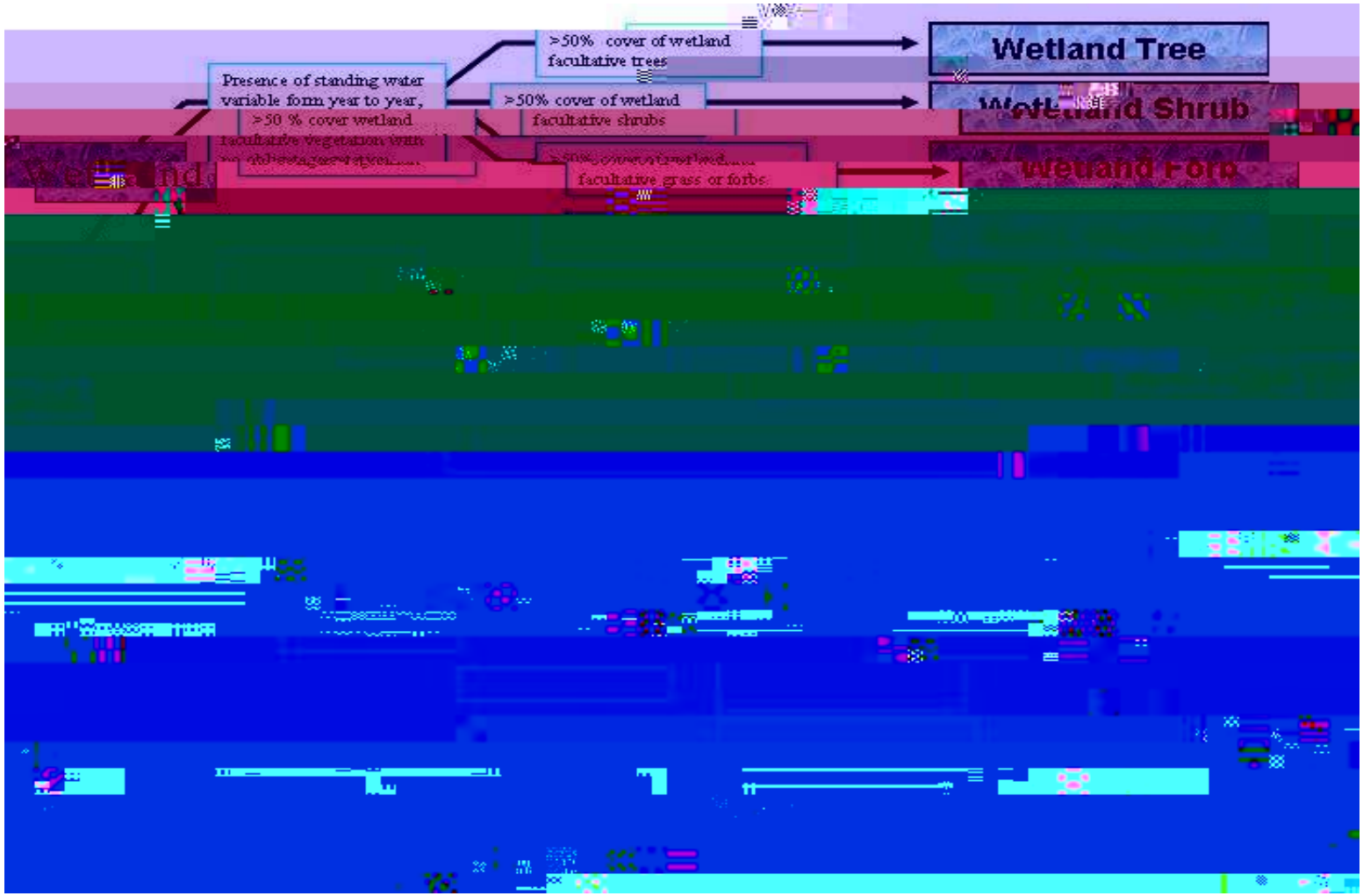


Figure 11. Flow chart demonstrating the key characteristics of the thirteen habitat types used in the habitat mapping around drift fence arrays used in the survey for the eastern massasauga rattlesnake at Indiana Dunes National Lakeshore, 2002-2003.

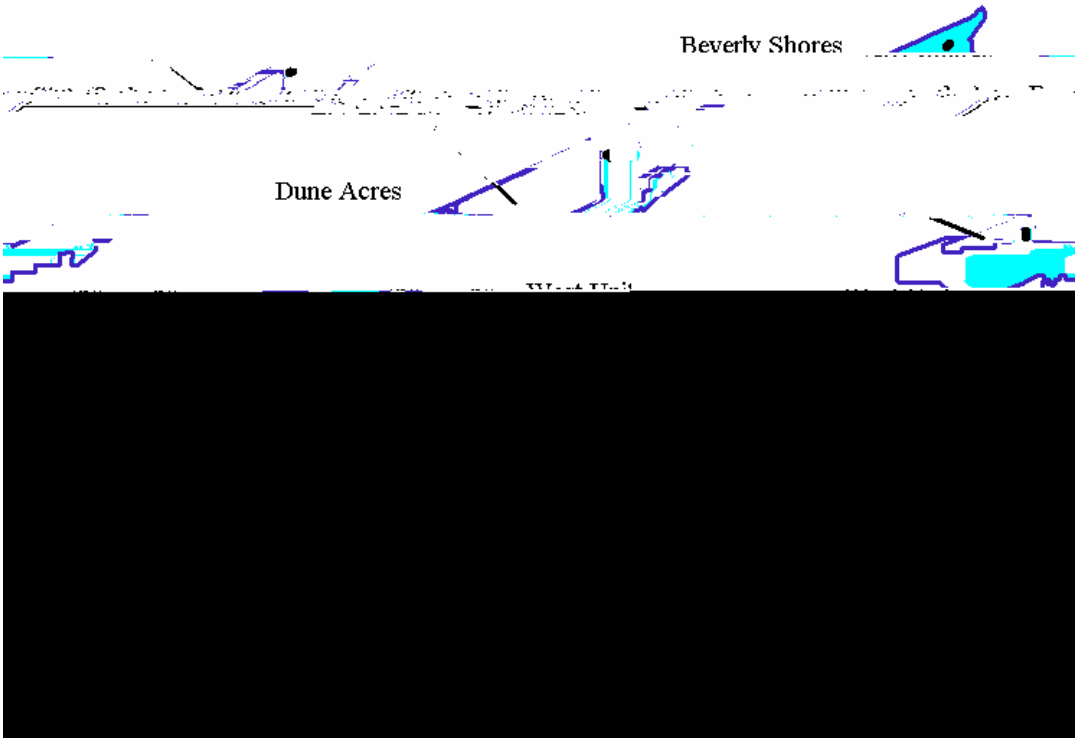


Figure 12. Location of drift fences used in three-year study (2000-2002) of herpetofauna at the Indiana Dunes National Lakeshore.

study was not designed as an investigation of massasauga habitat preferences. Sample sizes and capture rates are not adequate to provide any manner of statistical validation to the brief analyses carried out below. Furthermore, we do not know whether the occupied site represents preferred habitat. Therefore, the reader should approach the analyses with caution recognizing that they are a cursory attempt to compare a site with massasaugas to other sites that may, or may not, have massasaugas.

Results

Twenty-three species of amphibians and reptiles were encountered during visual searching, drift fence surveys, and under artificial cover objects. Among these were nine frog and toad, five salamander, two turtle, one lizard, and six snake species, including the eastern massasauga rattlesnake (Tables 1 and 2).

A single massasauga was captured on September 24, 2002 in a drift fence near the Beverly Shores train station (BTR, Figure 7; photo of captured snake on cover). The massasauga, a juvenile, measured 262 mm snout-vent length and weighed 20.6 grams. Another eastern massasauga was possibly encountered during a visual search (at UTM: 4616021 E; 505193 N) on July 10, 2002. However, that snake was not captured and positive identification could not be made. As that snake was approached, it moved off the Calumet Bike Trail (CBT, Figure 7), where it was observed, into brush, leaving behind a dead rodent presumed to be its prey. While the snake was not captured and positively identified, only one other snake found in the park, the northern water snake (*Nerodia sipedon*), is similar in appearance to the massasauga. However, the northern water snake does not typically feed on small rodents (Harding 1997) and adults are rarely found this far (> 300m) away from a permanent body of water.

For three years (2000-2002), an additional 41 drift fences were deployed across INDU's East and West Units, mainly at upland sites, for approximately six months per year, as part of a separate study. Although data from that study are not yet published and are not presented here, we note that no massasaugas were captured in any of those drift fences (Figure 12).

Table 1. List of amphibian and reptile species found using different survey methods at Indiana Dunes National Lakeshore during surveys for the eastern massasauga rattlesnate, 2002-2003.

		Survey Method		
Scientific Name	Common Name	Drift Fence	Cover Board	Visual Search
Pseudacris triseriata	Chorus Frog	x	x	x
Pseudacris crucifer	Spring Peeper	x	x	x
Hyla versicolor	Gray Tree Frog	x		
Bufo americanus americanus	Eastern American Toad	x	x	x
Bufo fowleri	Fowler's Toad	x		
Rana catesbeiana	Bullfrog	x		
Rana clamitans	Green Frog	x	x	x
Rana pipiens	Leopard Frog	x	x	x
Rana sylvatica	Wood Frog	x	x	x
Ambystoma jeffersonianum Complex				

Data Analysis

Drift Fence Arrays

Results of NMS ordination of the fourteen arrays, based on habitat within 200 m

Table 3. Sørenson similarity between BTR and other arrays based on habitat composition within 200 m of array. Two arrays with the same habitat composition would have similarity = 1 while two arrays with no habitat types in common would have similarity = 0.

Site	Similarity with BTR
BIL	0.24
BIU	0.23
CBT	0.55
CAL	0.48
CMP	0.32
CRN	0.61
CNE	0.20
CNW	0.21
CWS	0.29
DBY	0.39
MAC	0.21
MST	0.25
WEL	0.16

Table 4. Correlations between habitat types and NMS axis values in Figure 13.

	Correlation with		
Habitat Type	Axis 1	Axis 2	Axis 3
Oak Savanna or Woodland	0.21	-0.78	-0.32
Oak Scrub Woodland	0.30	-0.26	0.38
Non-Oak Woodland/Forest	-0.82	-0.10	0.13
Non-Oak Savanna	0.30	-0.26	0.38
Non-Oak Scrub	0.09	<0.01	0.61
Open	0.04	0.02	0.79
Human	0.41	-0.04	0.60
Wetland Tree	-0.21	-0.06	0.80
Wetland Shrub	<0.01	-0.19	0.49
Wetland Forb	0.23	0.49	-0.16
Ephemeral Wetland	-0.92	-0.40	-0.08
Ephemeral Edge Wetland	-0.12	-0.49	-0.36
Permanent Wetland	0.60	0.89	-0.42

Table 5. Percent habitat composition within 200 m of each site used in the survey for the eastern massasauga rattlesnake at Indiana Dunes National Lakeshore, 2002-2003.

Habitat Type	BIL	BIU	BTR	CBT	CAL	CMP	CRN	CNE	CNW	CWS	DBY	MAC	MST	WEL	Mean[1]
Oak Savanna or Woodland	14.0	18.1	**14.9**	36.0	0	69.0	22.2	70.4	36.9	45.5	39.4	2.4	0.7	0	27.3
Oak-Scrub Woodland	0	0	**0**	3.9	0	0	0	0	0	0	0	0	0	0	0.3
Non-Oak Woodland/Forest	33.3	35.9	**2.3**	4.6	22.3	0	0	0	0	0	0	0	0	0	7.4
Non-Oak Scrub	0	0	**1.3**	0	0	0	0	0	0	0	0	0	0	0	0
Non-Oak Savanna	0	0	**0**	0.6	0	0	0	0	0	0	0	0	0	0	0
Open	0	0	**17.7**	16	15.9	1.7	1.5	0	0	0	1.5	0	8.2	0	3.4
Human	4	3.4	**19.6**	37	0	5	5.5	0	0	0	3.5	10	5.4	8.0	6.3
Wetland Tree	0	0	**29.7**												

From ordinations of sites based on frequencies of each amphibian and reptile species at a site, several sites were similar to BTR (Figure 14). r^2 between ordination distances and Sørenson distances between arrays were 0.79 and 0.09 for Axis 1 and Axis 2, respectively, indicating that differences

Table 6. Correlations between species frequency of capture and NMS axis values in Figure 14. Data obtained from survey of the eastern massasauga rattlesnake at Indiana Dunes National Lakeshore, 2002.

Species	Axis 1	Axis 2
Pseudacris triseriata	0.52	0.10
Pseudacris crucifer	0.75	0.03
Hyla versicolor	0.27	0.38
Bufo americanus americanus	-0.22	-0.19
Bufo fowleri	0.24	0.14
Rana catesbeiana	0.36	-0.34
Rana clamitans	0.66	-0.67
Rana pipiens	0.49	-0.57
Rana sylvatica	0.54	-0.14
Ambystoma jeffersonianum Complex	0.12	-0.48
Ambystoma laterale	0.56	-0.24
Hemidactylium scutatum	0.43	-0.29
Plethodon cinereus	-0.30	-0.33
Notophthalmus viridescens	0.12	0.43
Clemmys guttata	0.19	-0.20
Cnemidophorus sexlineatus	-0.09	-0.11
Nerodia sipedon	-0.02	0.16
Storeria dekayi	0.48	-0.24
Thamnophis sirtalis	0.50	0.33
Coluber constrictor	0.02	0.38
Heterodon platyrhinos	-0.35	0.28
Sistrurus catenatus catenatus	0.19	-0.20

NMS Axis 1 in Figure 14 is most highly correlated with frequency of *Pseudacris crucifer* (spring peeper, $r = 0.75$) and *Rana clamitans* (green frog, $r = 0.66$) (Table 6). Among the snakes, site ordination scores on Axis 1 were most strongly correlated ($r = 0.50$) with *Thamnophis sirtalis* (eastern garter snake) capture frequency. BTR exhibited 51- 66% similarity in species composition with all other arrays except Calumet Fen (CAL, 18%) and Carolina Bike Trail (CBT, 33%) (Table 7).

Discussion

We know that at least one site, BTR, possessed characteristics amenable to the presence of massasaugas, although we cannot say whether BTR represents a high quality site. CBT and CRN were the two sites most similar to BTR in habitat composition. However, while CRN was 63% similar to BTR in species captured, CBT and BTR were only 33% similar, suggesting that BTR and CRN shared more key habitat elements for amphibian and reptile species than did BTR with CBT. CBT is along the Calumet Bike Trail as is BTR. CRN is at the eastern end of the East Unit and is very close to the location where an adult road killed massasauga was found in 1991 and where a possible sighting was made by the survey crew in 2002. Although we do not fully understand which landscape parameters may predict the presence of the massasauga, these two sites, and especially CRN, may be prime locations for intensified surveying or restoration in the future. As noted, one feature BTR and CRN share is a relatively high percentage of areas dominated by wetland obligate or facultative trees within 200 m of the array. Massasaugas have been found overwintering in tree root masses in wet soil (Conant 1951, Prior 1991 *in* Szymanski 1998). BTR and CBT, on the other hand, share relatively high percentages of open habitats, which are potentially good foraging habitats, within 200 m of the fence.

Three habitat elements commonly occur at known massasauga sites: (1) open areas with intermixed sunlit and shaded regions, (2) a water table near the surface, and (3) availability of both lowland and upland areas (Szymanski 1998). Intermixed, sunlit and shaded regions provide proper thermoregulatory conditions for massasaugas. Moist soil, facilitated by water near the surface, helps massasaugas avoid desiccation during the winter. Lowland and upland habitat provide both foraging and overwintering areas. The Great Marsh area of INDU, located in a low area between two dune ridges paralleling Lake Michigan, might fulfill requirements (2) and (3) in the prescription above. What appears to be missing from most sites in the East Unit are sunlit open, upland areas with a herbaceous vegetation layer that is sufficiently open to allow sunlight to penetrate to the ground. A combination of fire suppression in upland areas and draining of the Great Marsh has led to an influx of woody vegetation in both upland and wetland areas. Such shrubby habitat is not suitable for massasaugas. While several small areas of open habitat exist in the East Unit, only the powerline corridor, within which the Calumet Bike Trail runs, contains a large amount of open habitat (Figure 2). Although this corridor is not Indiana Dunes National Lakeshore property, it is located along the southern boundary of the park's East Unit. Overgrowth of woody vegetation has not occurred in this corridor because powerline and railroad companies have maintained its openness. Furthermore, the most reputable massasauga reports seem to be centered on this corridor, especially near the Beverly Shores Train Station (Figure 2). To what degree this represents an observer bias is unclear, as the Calumet Bike Trail, particularly near the Beverly Shores Train Station, generally has more human traffic than most of the East Unit.

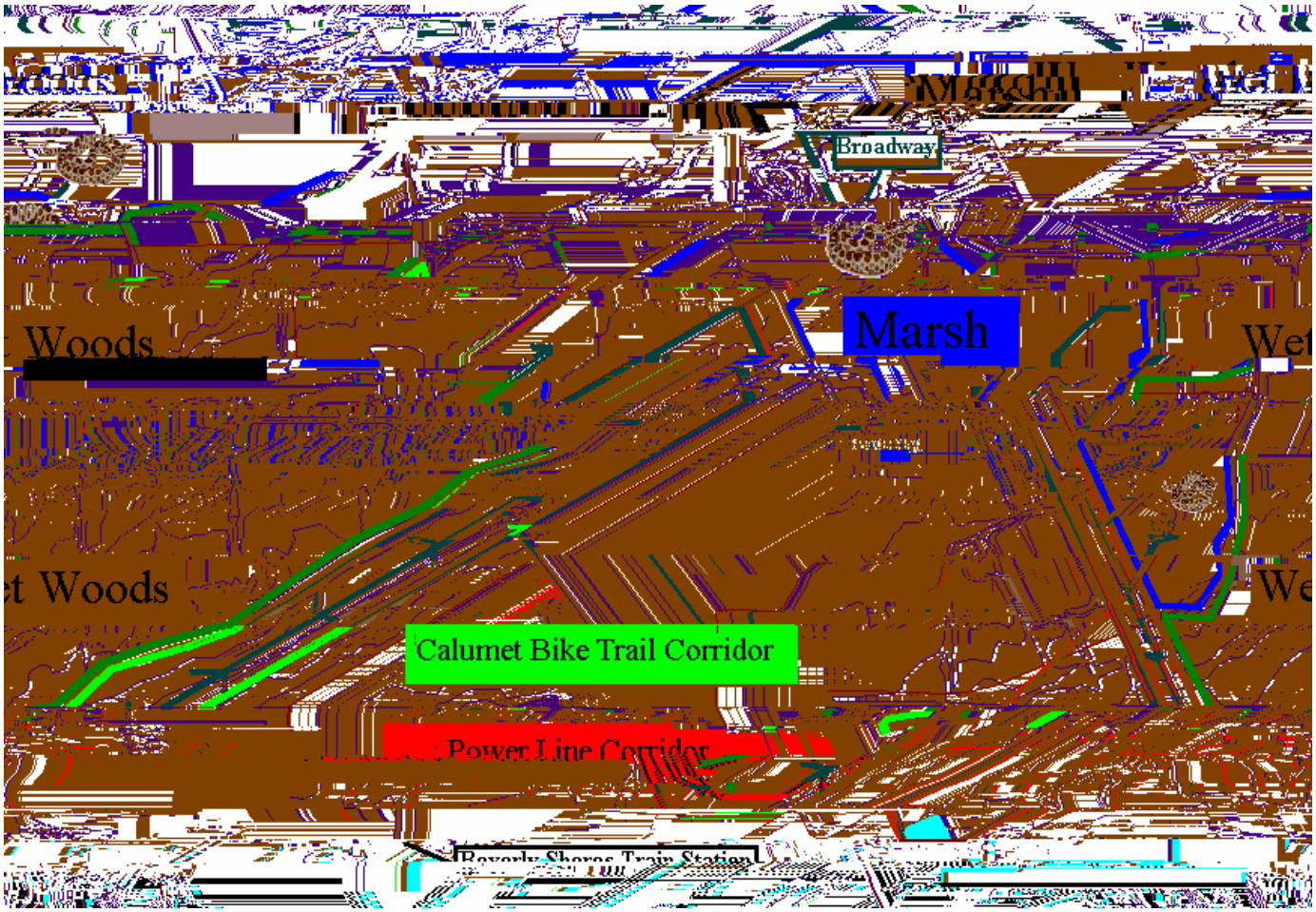


Figure 15. Possible dispersal corridors for massasaugas near the Beverly Shores Train Station at Indiana Dunes National Lakeshore.

While other sites along the Calumet Bike Trail contain elements suitable for

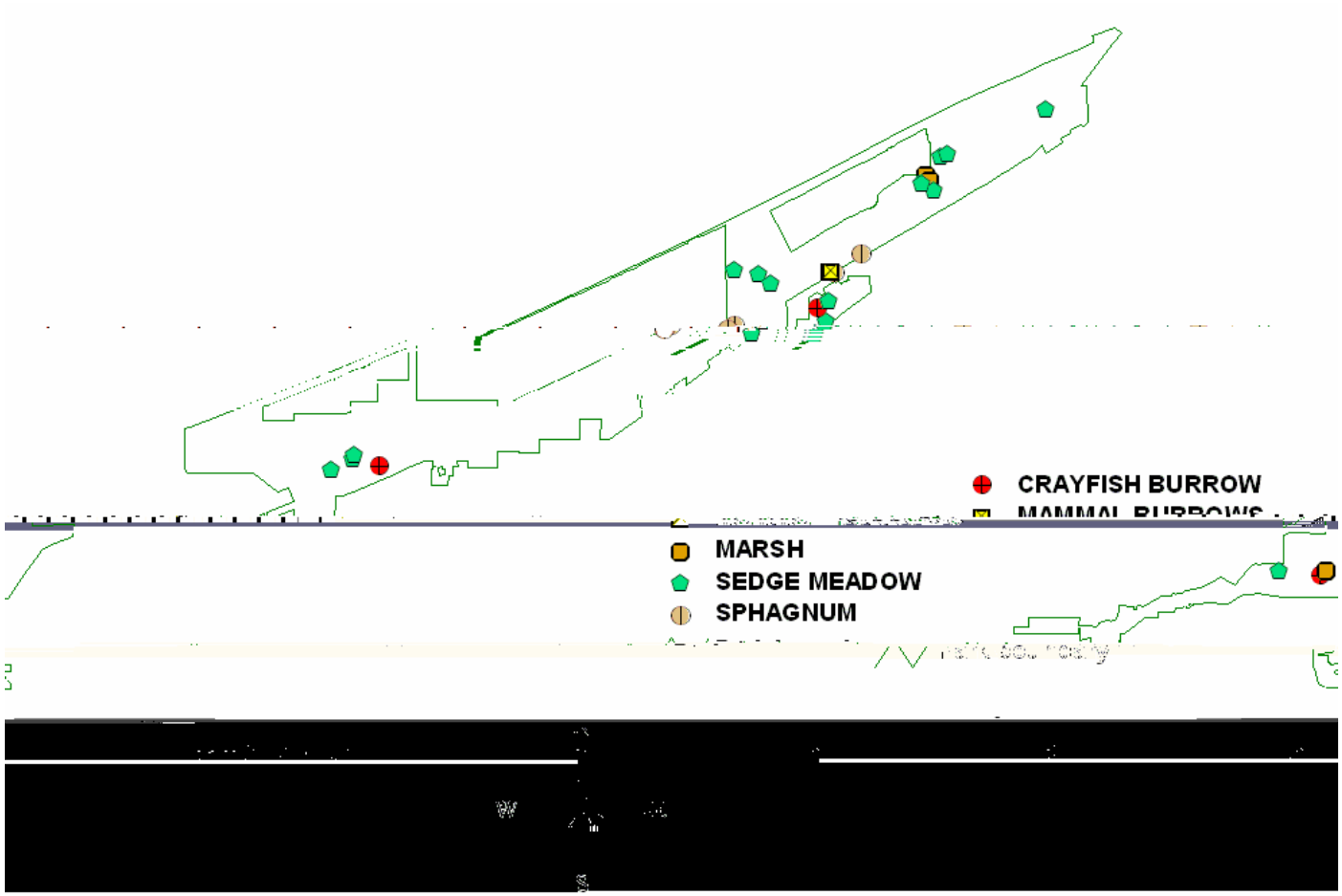


Figure 16. Potential massasauga hibernacula habitat elements encountered during visual searches within the East Unit of Indiana Dunes National Lakeshore, 2002-2003.

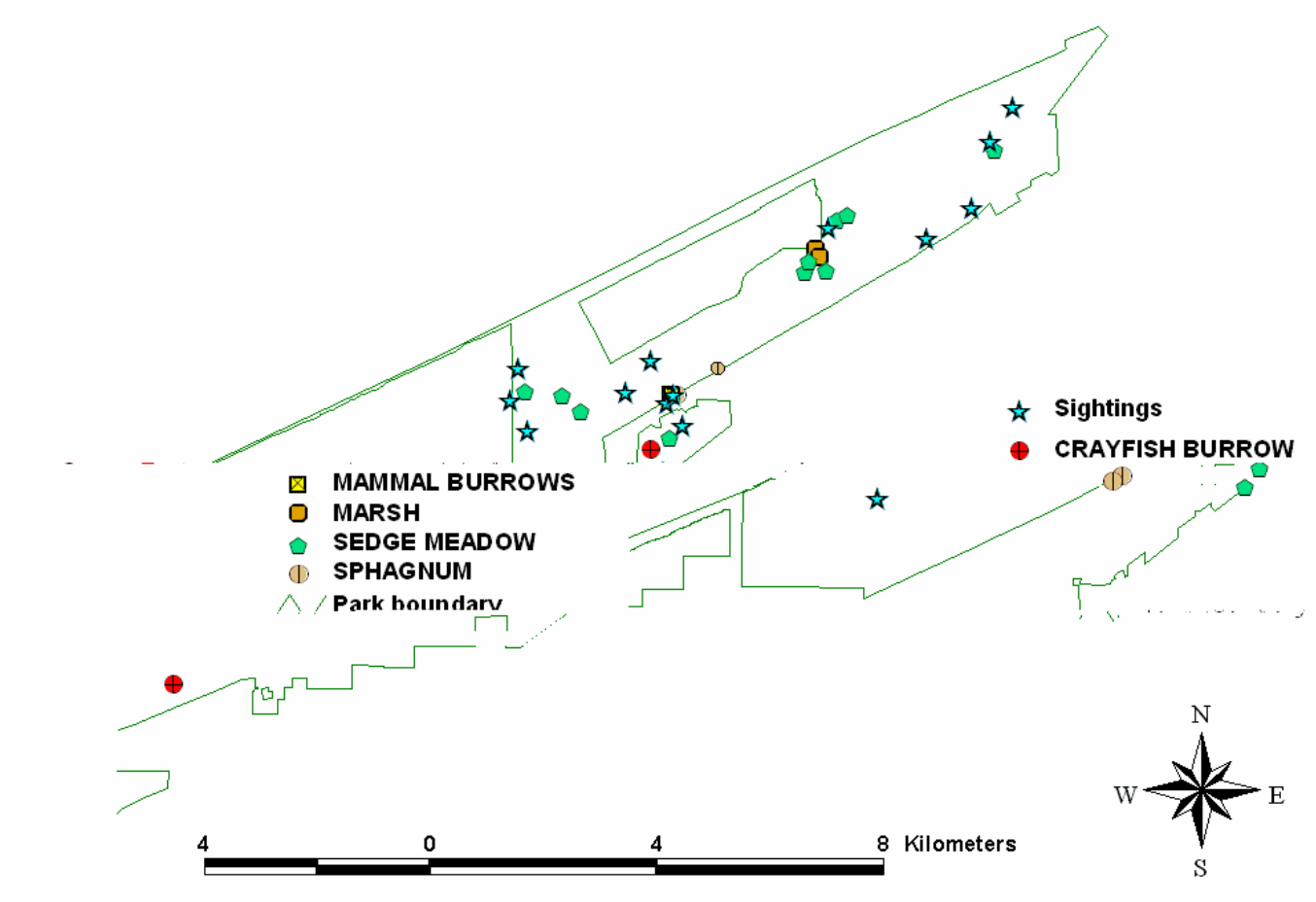


Figure 17. Hibernacula habitat elements and reported massasauga sightings since establishment of Indiana Dunes National Lakeshore in 1966.

Summary and Recommendations

Our surveys established that *S. c. catenatus* exists within the boundary of Indiana Dunes National Lakeshore. Further monitoring is needed to determine the snake's status, to identify critical habitat, and to provide park managers with information necessary to properly ensure the long-term survival of the species. Our surveys emphasized maximizing coverage throughout the East Unit of the park. Surveys in the future should focus on areas with historical massasauga sightings and in areas identified as potential habitat. Visual searches during the summer months, when vegetation was dense, were not successful, in part, because the eastern massasauga is a cryptic species. Future visual searches, if undertaken, should be limited to early spring and late fall when vegetation is less dense, or should be conducted in areas with less dense vegetation throughout the year.

Cover boards were ineffective in 2002, attracting few amphibians or reptiles. It is unclear whether the low capture rate represents general ineffectiveness of cover objects at these particular locations or of the particular material used. The compressed fiberboard that was used may not have provided the proper thermoregulatory conditions to attract herpetofauna or perhaps the composition of the fiberboard repelled the animals. If cover board monitoring is to continue, different material, such as sheet metal or rough-cut wood, should be selected (Fitch 1992, Grant *et al*. 1992, Reading 1997).

Drift fences proved to be the most successful survey method. Future fences should be placed primarily in areas that have had historic sightings and that have been identified as potential massasauga habitat (Figure 17).

In addition to future searches, it is important to incorporate potential massasauga habitat into the park's management plans. The East Unit has probably lost much open-canopy land over the past century due to decreases in wildfires and periodic flooding (Applied Ecological Services 1984). Expos

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Since the completion of the surveys outlined in this report, two likely massasauga sightings have occurred. On August 21, 2004, the Beverly Shores Police Department reported a "rattlesnake" sunning itself on the concrete pavement located at the southwest corner of the Beverly Shores Train Station. Indiana Dunes National Lakeshore Visitor Protection Ranger Steve Chorba investigated the sighting. He described the snake as approximately 24-28 inches (60-71 cm) in length, brown with darker brown irregular spots, and a rattle. Mr. Chorba had previous experience handling rattlesnakes while working on a resource management project at Delaware Water Gap National Recreation Area so his identification of the snake as a rattlesnake is very likely correct. This adult snake was found ~ 20 m from the confirmed sighting of a juvenile in 2000, and is also within 100 m of the juvenile captured in the fall of 2002 in the current study. Although no photographs were taken, the knowledge of the observer and the proximity to other sightings, lend particular credence to its confirmation. This recent report further verifies the presence of massasaugas in the area around the Beverly Shores Train Station.

A second and more unexpected observation occurred on October 1, 2004. A local resident reported the discovery of a shed rattlesnake skin to Randy Grass of the National Park Service. Randy Grass found the shed skin adjacent to Roskin Road, just east of Wabash Avenue, in Porter, Indiana (Figure 18). The skin was ~5 cm long segment and contained the rattle and enough pattern to confirm it as a rattlesnake and consistent with being a massasauga. Additionally, the resident reporting the skin also mentioned to Mr. Grass that another neighbor has frequently seen rattlesnakes throughout the years, both large and small, in the vicinity of the shed skin. This particular unit of the Park was not searched during the survey as no historical records indicated the presence of the massasauga, nor did the habitat appear particularly conducive to massasauga survival. Furthermore, during a separate amphibian and reptile study, mentioned previously, two drift fences were operated at Howes Prairie, within 200 m of the site where the shed skin was found. In four years of continuous spring to fall sampling, no massasaugas were captured. Upon discovery of the shed skin, technicians Gary Glowacki and Krystal Potts investigated the nearby area. Oak forest was the dominant habitat at the immediate location the shed skin was found. Roughly 250 m south, exists several low-lying mesic prairies/grasslands dominated by *Panicum virgatum* and to a lesser extent *Calamagrostis canadensis* (Figure 19). These low-lying grasslands are subject to periodic flooding (Pavlovic *e.6n4of the shed skin. T)6.1(1)0.n 0 phv0egl00.t TcTtr.0.0003ildrift fprohe sheeffpers upshed skve6.*

system of sedge hummocks as well as sphagnum moss and crayfish burrows, all known characteristics of massasauga hibernacula. While this area is rather far from the location the shed skin was found (~1 km), massasaugas have been known to travel in excess of 2.7 km (Johnson 1995, Johnson *et al*. 2000).

Both of these new discoveries warrant additional investigation. The shed skin found near Howes Prairie demonstrates the lack of understanding we have regarding the distribution of the snake within the park, what habitat elements are important to the snake, and what elements are essential. The third documented observation of a massasauga near the Beverly Shores Train Station in the last four years exemplifies the need to gain more understanding of the massasaugas at the Indiana Dunes National

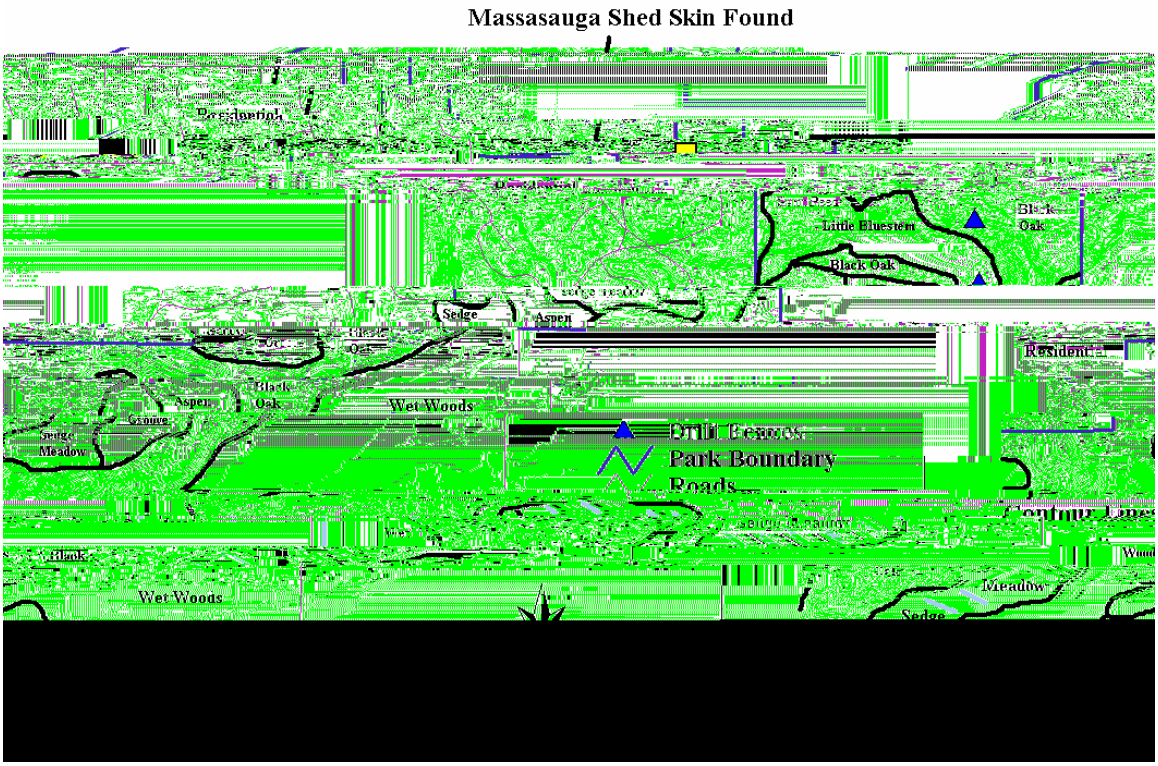

Figure 19. Topographic map of Howes Prairie and the vicinity of the shed eastern massasauga rattlesnake skin discovered on October 1, 2004. Important habitat features discovered while investigating the location were mapped by technicians Gary Glowacki and Krystal Potts. The sedge meadow regions shaded with diagonal lines may be an important overwintering site used by the massasauga.

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Appendix

Two sets of data are included as appendices with this report – 1) Geographic Information System (GIS) layers describing survey locations and paths. Presented in ArcView 3.3 (ESRI 2002). 2) A database of site descriptive data and capture data from 2002. Presented in Microsoft Access 2000 (Microsoft Corporation 1999). Components of these two data sets include:

(1) ArcView 3.3 layers:

Massasaugaarray (.dbf, .htm, .met, .sbn, .sbx, .shp): Documents locations of drift fences.

Massasaugamapping (.dbf, .htm, .met, .sbn, .sbx, .shp): Maps habitat types within 200 m of each array.

Surveyhab (.dbf, .htm, .met, .sbn, .sbx, .shp): Locations of potential massasauga preferred habitat elements encountered during surveys.

Masssurvey2002 (.dbf, .htm, .met, .sbn, .sbx, .shp): Area covered during visual searches in 2002.

Sightings (.dbf, .htm, .met, .sbn, .sbx, .shp): Locations of reported massasauga sightings in the vicinity of Indiana Dunes National Lakeshore since the formation of the park.

Aco (.dbf, .htm, .met, .sbn, .sbx, .shp)**:** Locations of artificial cover objects.

In addition, several reference layers are provided. These include:

Contour east: Contour lines for Indiana Dunes National Lakeshore East Unit.
Park Boundary: Boundary of Indiana Dunes National Lakeshore East Unit.
Railroad: Railroad lines within Indiana Dunes National Lakeshore East Unit.
Road: Roads within Indiana Dunes National Lakeshore East Unit.

Reference layers are included as a background for the massasauga survey and habitat mapping layers. These reference layers were provided by Indiana Dunes National Lakeshore and are not documented with metadata. All layers produced expressly for this study are documented with metadata.

(2) Database (Indiana Dunes Massasauga Survey 2002):

Note: All variables within database tables are described within the table under "Design View". To access Design View from the Microsoft Access menu, select "View" and then "Design View".

ACO Database: List of species found under artificial coverboard objects during each visit to the ACO's.

ACO Locations: Size and UTM coordinates of each ACO.

Drift Fence Capture Database: List of species captured in drift fence arrays during each visit to an array.

Drift Fence Locations: UTM coordinates and habitat composition within 200 m of each drift fence array.

Observer: List of participants in massasauga surveys.

ParkCode: List of national park codes.

Project: Massasauga rattlesnake survey.

Species Code: List of four letter species codes used in study and associated common and scientific names.